FINAL REPORT

Part II of

KOICA-WorldBank Joint Study on Solid Waste Management in Punjab, Pakistan

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KOREA INTERNATIONAL COOPERATION AGENCY

KOREA ENVIRONMENT INSTITUTE

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I. Introduction

This is the Final Report for the Project of KOICA-World Bank Joint Study on Punjab SWM (Solid Waste Management) in Pakistan: Part II, hereinafter referred to as the Project, and written by Team II that is a consortium by KEI (Korea Environment Institute) and SLC (Sudokwon[1] Landfill Site Management Corporation). The purpose of this report is: 1) to present scientific inputs of Team II and to provide interim outputs for the purpose of the Project, 2) to summarize pieces of information and data that have been collected since the inception of the Project, and 3) to invite feedback and suggestions from stakeholders in order to revise the overall presentations and outputs.

1. Background of the project

In Pakistan, urbanization and economic growth are regarded to have advanced drastically in recent decades. More people have migrated into urban areas, and the expansion of urban population in present-day Pakistan seems to be growing at a rate from 3.7% to 7.4% in cities while the overall population growth rate in Pakistan is only at 2.8% (JICA, 2005: 6-7). Such an expansion in urban population consequently leads to problems that encompass urban poverty, destitute people or informal squatters, housing and transportation, water and sanitation, waste generation and other problems related to the congestion of cities and urban infrastructure.

In the case of Punjab, the region regarded in the project, one of the most critical problems emerging from its rapid urban expansion is waste generation and disposal without treatment. The amount of solid waste generated in urban Pakistan is more than 55,000 tons per day, and waste collection in cities currently averages only 50% of waste generation (JICA, 2005: 4). In Punjab's urban areas, 40% of the total amount of waste generated which is more than 16,000 tons per day is collected(Nasir, 2006).

Moreover, none of the municipalities run landfill sites in Punjab, only two municipalities –

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[1] The Korean word 'Sudokwon' means SMR (Seoul Metropolitan Area). Currently, the population size of SMR is almost half of the total population in Korea, while the area of SMR is only 12% out of the total area of South Korea. SLC is a public corporation founded by Ministry of the Environment, Korea in 2000 for the purpose of implementation, management and development of SWM and relevant facilities in SMR.

Lahore and Faisalabad - out of the nine[2] considered in the Project own lands where open dumping of solid waste is being done. It is known that uncollected waste is placed in or beside common places and roads. It is widely accepted that waste untreated and dumped close to living spaces may cause contamination of surface and ground water and threaten human health directly and indirectly.

The problems related to solid waste and its management in Punjab are not merely an outcome of urban resource restrictions. More fundamentally, they arise from the lack of a comprehensive waste management system and strategy that encompasses functions of governance, institutions, finance and technology. The span of the problems includes:

- Insufficient legal and regulatory establishment,
- Lack of awareness among municipal residents regarding solid waste handling and treatment due to short of experience of environmental policy and management,
- Lack of comprehensive SWM administration and institutional arrangements,
- Financial and technological difficulties to build and operate waste treatment facility and equipment,
- Manpower shortage (SWM experts and municipal collectors/scavengers),
- Absence of private sector and community participations,
- Lack of research in the solid waste sector, etc.

It is thus urgent to tackle these problems with comprehensive and interdisciplinary approaches. Legal and institutional implementation is primarily dealt with in the Project, and moreover, environmental, technological and economic methodologies have to be applied to build an appropriate SWM system designed for Punjab, as well as to analyze the validity/impact of considerable alternative SWM systems and facilities.

As well, social and policy approach to promote Punjab's comprehensive SWM system is recommended in order to address the low level of public awareness regarding SWM in Punjab. Finally, training programs for Punjab's SWM staff and manpower have to be introduced and carried out. It is needless to say that an effort to promote the quality of field staff is important for policy success, building the concepts of waste treatment/management and learning the theory and practice of it.

[2] The rests are Sialkot, Multan, Sargodha, Rawalpindi, Gujranwala, DG Khan, and Bahawalpur.

2. Development and purpose of the project

The Government of Pakistan embarked on a Devolution Program that is supposed to address institutional deficiency for urban service delivery at the local government level. As a result, the provincial Government of Punjab (GoPunjab) has prepared for a capacity enhancement program for the two levels of local government, namely the larger City District Governments (CDGs) and smaller urban Tehsil Municipal Administrations (TMAs)[3]. Within the context of municipal service delivery, GoPunjab has identified service areas, including SWM, to be of critical concern to the population.

The World Bank (hereafter the Bank) has responded to the Government's devolution and urban development program on several fronts. The Project, as a part of it, was initiated in order to facilitate the improvement of SWM in the Province. Moreover, the Bank proposed that the Project receive technical assistance through funds of the Public-Private Infrastructure Advisory Facility (PPIAF), complemented by other donor financing if available. The specific objectives of the Project are as follows:

- To develop technical, institutional, financial, private sector, and public involvement frameworks to support the Government of Punjab to improve SWM,
- To review comprehensively existing municipal, provincial and national regulatory frameworks regarding designations of SWM services, including responsibilities, authorities, empowerments, and incentives/disincentives available for use by these various government levels,
- To enable local officials to choose among and make municipal-specific decisions regarding comparative technical, land area, labor requirement, skill level, energy demand, fuel consumption, emission, and cost information about various solid waste technical systems that are potentially applicable to Punjab, and
- To provide locally appropriate (most attainable relative to Pakistan regulations and the World Bank guidance) performance specifications for each applicable technical system, in order to enable local governments to develop municipal-specific tendering specifications for private services and/or municipally conducted services that are comparable to private sector services.

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[3] Among the nine in Punjab, one form of local administration is CDG in Lahore, Multan, Gujranwala, Rawalpindi, and Faisalabad; the other is TMA in Sialkot, Sargodha, DG Khan, and Bahawalpur.

Moreover, the Korea International Cooperation Agency (KOICA) agreed to award a grant to the Pakistan Government to develop institutional/financial arrangements as well as procedures and materials for the promotion of public awareness and access in the SWM sector. Therefore, the Project has been split into two parts, one part of which is performed by the consultant of the Bank and the PIAFF, namely Team 1 as a consortium by Ernst Basler + Partners Ltd. in Switzerland and ICEPAK in Pakistan, and the other is by the consultant of KOICA, namely Team 2 by KEI and SLC in Korea, who is responsible for this report.

The focus of the each part of the Project was discussed and adjusted during the Inception Workshop held in Lahore on Sep. 4, 2006 and the international Conference Call on Nov. 21, 2006, in which the five main stakeholders, namely GoPunjab, the Bank/PPIAF, KOICA, Team 1 and Team 2 took part. The role or focus of each part can be briefly described as follows:

Team 1: 1) Baseline reconnaissance surveys,
2) Legal and regulatory framework,
3) Technical and planning support,
4) Private sector participation in SWM, and
5) Report and workshops.

Team 2: 1) Baseline reconnaissance survey for the two case cities, Lahore and Sialkot
2) Pre-feasibility study for SWM system and/or facilities in the 2 cities,
3) Financial and institutional arrangements for SWM in the 2 cities,
4) Promotion of public awareness of SWM,
5) Report and workshops, and
6) Training programs for field staff of SWM in Punjab.

3. Detailed scope of the work and contents of the report by Team II

The aim of the Project in short is: to improve the solid waste management of Punjab in accordance with the National Environmental Policy in Pakistan; to foster international cooperation between the two countries and constituent municipalities; to set relevant laws and standards; and to help to facilitate environmental amenities of municipalities.

The scope of the Project by Team II described above is: to find appropriate arrangements for the financing and institutionalization of SWM; to provide comprehensive and feasible guidelines for a waste management system as well as for enhancement programs regarding public awareness for the two case cities of Lahore and Sialkot; and to participate in workshops and hold training programs. Thus the second part of the Project is to undertake the following tasks.

3.1 Task 1: Baseline reconnaissance survey for the two case cities: Lahore and Sialkot

The main scope of Team II has been revised through the workshops and the conference call and is now focused on conducting case studies on master plans and practice guidelines for the two case municipalities as models for CDGs and TMAs in Punjab. The case studies includes pre-feasibility studies of SWM systems and facilities, and policy suggestions for financial/institutional arrangements and public awareness programs; thus the first task of Team II is to collect relevant information and data in and around the case municipalities.

This task includes visiting and surveying economic and industrial, commercial, residential and other relevant sites located in the 2 municipalities to fully understand their SWM systems and issues, and to visit and survey solid waste workshops, collection zones, treatment facilities, recycling organizations and disposal facilities, and if possible, also to visit solid waste services provided by NGO's and the private sector.

Team II has gathered and reviewed previously-collected data and published materials related to SWM since the Inception of the project, and suggested in late October 2006 the list of needed data/information to the Urban Unit and the Bank. Team II also visited Lahore and other municipalities in Punjab twice to collect data/information during Dec 4-9 and Jan 15-20, as detailed in Section I of this report.

The main output of the collected data/information is provided in Chapters 2-4 and the Annexes of this report. The basic information and issues related to Punjab’s SWM is to be given in Chapter 2 of this section. Moreover, the current status and relevant data in Lahore and Sialkot are to be provided in Chapter 3 and 4, respectively.

3.2 Task 2: Pre-feasibility study for SWM systems and/or facilities in the two cities

The second task is a kind of feasibility study for the overall practical options of SWM in the two municipalities. The task is to assess practical options for a waste management system and/or facilities, which are technically and environmentally appropriate to the municipalities. It is also to examine environmental impact in the process of waste collection, transportation and disposal and set optimal methods and standards for them. The evaluation is to cover (sanitation and non-sanitation) waste landfill, compost, incineration, etc. Chapters 3 and 4 of this report contain the output as of the publication date of this report.

3.3 Task 3: Financial and institutional arrangements for SWM in the two cities

The case studies include selection among a range of available options for technological, financial and other institutional conditions. Elaborating on comprehensive and practical SWM options for the model municipalities, the third task is to make a draft of comprehensive and effective SWM financial and institutional arrangements fitted to the subject area and the technical options.

Institutional arrangements therefore are to define the respective mandate, the organizational structure, needed resources and training for separate, but complementary, provincial and municipal units that would provide technical assistance, training, regulatory reform, design, tendering, contracting, licensing, financing, monitoring, and oversight.[4] Financial arrangements are to address financial issues related to the technical and institutional options and to find

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[4] Examples of service by Team II are noted below, but not limited to:

§ Managing/conducting strategic planning for municipal/inter-municipal facility and service needs, selection among a range of available technologies, management and participation in siting and development of inter-municipal service agreements, involvement of the public for facility planning, siting, and design, access of carbon finance or implementation of other similar economic instruments, protection of worker health and safety, control of environmental emissions and related impacts.

§ Training of TMAs/CDGs for the procurement of PSP facility/equipment investments and services, supervision and operations performance monitoring of private sector participation services, environmental monitoring of facilities.

§ Developing/conducting widespread media activities to develop public awareness and public education on SWM topics. Determine how the provincial government could play a better role to promote the role of solid waste professional associations and the exchange of relevant materials/information.

§ Recommending institutional arrangements to optimize tender specifications, competitive procurement, performance monitoring, and contract management.

§ Identify from the planning and political wills that will benefit from building a regional landfill rather than an individual landfill in each municipality. Also, recommend a concrete action plan to build it (e.g., drafting inter-jurisdictional agreements, etc). Recommendations should be consistent with criteria established by Team 1.

§ Identify a municipality that will potentially benefit from private sector participation in solid waste collection. Suggest the optimal division of collection zones within the municipality and recommend how these zones should be contracted out to private sector to increase competition. Recommendations should be consistent with the framework developed by Team 1.

appropriate solutions by means of taking cost-effective and cost-benefit analyses by engineering costing and other beneficial accounting methods.[5] The details in Lahore and Sialkot are to be presented in Chapters 3 and 4, respectively, while overall policy suggestions are in Chapter 5 of this section.

3.4 Task 4: Promoting public awareness regarding SWM

This study suggests principles and Good Practice Guides (Ernst Basler + Partners and ICEPAK, 2006: 34-36) that generate public awareness of necessity for SWM in municipalities and inspire cooperation of municipal citizens. Specifically, the fourth task, as to be suggested in Chapter 5 in this section, is to propose a set of measures for raising public awareness of solid waste system requirements for public cooperation with regards to service delivery and cost recovery, educating the public on the need for transfer and sanitary landfill facilities as part of an environmentally sustainable system. It is also to develop public participation procedures for strategic planning, willingness and affordability assessments, site screening and selection, facility design criteria, proposed facility mitigation measures, environmental impact assessment, development of tariffs and cost recovery mechanisms.

Practical guidelines proposed in this part are to contain environmental education in schools, support to non-governmental organizations, etc. It outlines the public awareness and education materials, media programs, workshop sessions, and public meetings that would be appropriate to optimize public involvement in each of the above aspects of public awareness and access.

3.5 Task 5: Reports and workshops

The fifth is to complete reports and to participate in workshops as scheduled in consultation with the relevant stakeholders. Team II already presented regarding their own works, both at the Inception Workshop on Sep 1-5, 2006 and the Institutional Workshop on Jan 19-20, 2007. Refer to Section I for further information about the activities of Team II as of this publication date. Team II is also planning to present its own final outputs of the Project in the final workshop scheduled for late May, 2007.

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[5] Moreover, financial arrangements specifically stands for recovering investment and operation cost by pricing waste collection and/or treatment services, by tariff structures relative to the ability and willingness to pay of various consumers and types of services, and by implementation of financial incentives, such as carbon financing and other forms of public finance, etc.

Team II also published the Inception Report on Oct 10, 2006 and revised its contents on the way to this Interim Report following feedback from the Bank and the Urban Unit in GoPunjab. The contents of this report reflect the comments of the stakeholders. The pre-final report is currently planned to be released at the end of April or in early May, 2007, in which the contents are to be revised after consultations with the stakeholders, especially reflecting comments from the final workshop, and to be released at the end of June, 2007.

3.6 Task 6: Training programs for SWM field staff in Punjab

The final mission of this study is to design and conduct an educational program including training workshops in Pakistan and Korea. In order to transfer the operational knowledge and experiences of Korea, Team II is to dispatch experts to Pakistan to present the principles of SWM in general, and lead discussions with the Pakistani SWM staffs. Team II is also to provide lectures, focusing on more practical guidelines, and to give the participants a chance to visit landfill sites and other SWM related facilities in Korea.

During Jan. 15-18, the first training program took place in Lahore for the 40 participants listed in Annex II of this report and completed in success as described in Section I of this report. The second training program is scheduled for six days of a specific week in early April 2007. Refer to the Section I of this report for a detailed plan regarding the second workshop.

II. A Brief Review of SWM Issues in Punjab

This chapter presents general information about Punjab and the fundamental data about SWM. Because the report by Team II was supposed to focus on the case municipalities, which were Lahore and Sialkot, this chapter will briefly review SWM issues in Pakistan, particularly Punjab, through giving emphasis to help understand the problems of the two cities. For more details of Punjab, refer to the results of baseline reconnaissance survey (Team I).

This chapter was composed as follows: 2-1 subchapter outlined the general Punjab situation; 2-2 subchapter presented the generation and treatment on solid waste; 2-3 subchapter presented the finance and institutions of solid waste; and lastly; 2-4 subchapter addressed the social issues such as measures for sweepers and scavengers and inducements to a public participation.

1. General profile of Punjab

Punjab is Pakistan's second largest province with an area of 205,344 km² (79,284 square miles) and is located at the northwestern edge of the geologic Indian plate in South Asia. The provincial level-capital and main city of the Punjab is Lahore, which has been the historical capital of the region. Other important cities include Multan, Faisalabad, Gujranwala, and Rawalpindi.

The province is home to six rivers: the Indus, Beas, Sutlej, Chenab, Jhelum, Ravi. Nearly 60% of Pakistan's population lives in the Pakistani Punjab, it is the nation's only province that touches Balochistan, North-West Frontier Province, Sindh and Azad Kashmir, and contains the federal enclave of the national capital city at Islamabad.

Most areas in Punjab experience fairly cool winters, often accompanied by rain. By mid-February the temperature begins to rise; springtime weather continues until mid-April, when the summer heat sets in. The onset of the southwest monsoon is anticipated to reach Punjab by May, but since the early 1970s the weather pattern has been irregular. The spring monsoon has either skipped over the area or has caused it to rain so hard that floods have resulted.

Fig. II-1 Map of Punjab province, Pakistan

Source: World Atlas, MSN Encarta (http://encarta.msn.com/map_701515833/Punjab.html)

1.1 Demographics

Population booms do not only result in economic upheaval in developing countries; they are also the primary cause of environmental degradation in them. Given a relatively small population, a correspondingly small quantity of waste could be readily absorbed by the environment. As the population grows, however, rising amounts of waste present a problem for that society to deal with.

Increasing population has presented itself as a major problem in Punjab for several decades.[6] The population of Punjab was estimated to be 86,084,000[7] in 2005 and is home to over half of the population of Pakistan. Although annual growth rate of Pakistan becomes lower continuously to be at 1.9% in 2005, the population of urban areas increased rapidly until 1998. Table.II-1 below reveals that the population in the researched municipalities increases faster than the average growth rates in Punjab. Notably, the population of Lahore is highest and increases faster than in other cities. However, the population density is 358 persons/km², which is the highest in any province except Islamabad, while the average population density in Pakistan is 166 persons/km².

[6] Being a developing country, Pakistan faces the problem of over population. During the past 25 years, cultivable land has increased by 27% compared to a 98% increase in population (Government of Pakistan. 2006: 188).
[7] Population census organization

Table. II-1 Population growth in Pakistan and Punjab since 1951

(unit: thousand persons,%)

	1951	1961	1972	1981	1998	2004	2005
Pakistan	33,740	42,880	65,309	84,253	132,352	151,574	154,454
		(2.4)	(3.8)	(2.9)	(2.7)	(2.3)	(1.9)
Urban	5,985	9,654	16,593	23,841	43,014	49,188	50,597
		(4.9)	(5.0)	(4.1)	(3.5)	(2.3)	(2.9)
Rural	27,754	33,225	48,715	60,412	89,338	102,386	103,857
		(1.8)	(3.4)	(2.5)	(2.3)	(2.2)	(1.4)
Punjab	20,540	25,463	37,607	47,292	73,621	84,562	86,084
		(2.2)	(3.5)	(2.6)	(2.6)	(2.3)	(1.8)
Urban	3,568	5,475	9,182	13,051	23,019	26,439	26,915
		(4.4)	(4.7)	(4.0)	(3.4)	(2.4)	(1.8)
Rural	16,972	19,988	28,424	34,240	50,602	58,123	59,169
		(1.8)	(3.1)	(2.2)	(2.3)	(2.3)	(1.8)

Source: Population census organization; Development statistics 2005

Table. II-2 Population growth in major cities of Punjab since 1981

(unit: thousand persons,%)

	1981	1998	2004	2005
Lahore	2,953	5,144	5,943	6,131
		(3.3)	(2.5)	(3.2)
Faisalabad	1,104	2,009	2,306	2,347
		(3.6)	(2.4)	(1.8)
Rawalpindi	795	1,410	1,630	1,660
		(3.4)	(2.5)	(1.8)
Multan	732	1,197	1,391	1,418
		(2.9)	(2.5)	(1.9)
Gujranwala	601	1,126	1,417	1,442
		(3.8)	(3.8)	(1.8)
Sargodha	291	458	538	550
		(2.7)	(2.6)	(2.2)
Sialkot	302	422	474	481
		(2.0)	(1.9)	(1.5)
Bahawalpur	180	408	482	492
		(4.9)	(2.9)	(2.1)

Source: Population census organization; Development statistics 2005
Note: ( ) is annual average population growth rate.
Data on DG khan was not available

1.2 Economy

Pakistan's economy continued to maintain a solid pace of expansion for the forth year in a row in the fiscal year 2005-06 despite facing headwinds from rising oil prices at $70-75 per barrel and the widespread damage caused by the earthquake of October 8, 2005.

The composition of the GDP has undergone considerable changes during the last several years. The commodity producing sector (CPS), which accounted for almost 62% of the GDP in 1969-70, has seen its share decline to almost 48% in 2005-06; a decline of 14%. The decline in the share of the CPS, however, is fully accounted for by the equal rise in the share of the services sector. Within the CPS the contribution of agriculture has been shrinking over the years. It has declined from almost 39% in 1969-70 to 21.6% in 2005-06; a decline of 17% in three and a half decade. The share of agriculture in GDP has declined by 4.3% in the last 6 years alone.

Punjab is the most industrialized province of Pakistan, having more than 48,000 industrial units. Its manufacturing industries produce textiles, sports goods, machinery, electrical appliances, surgical instruments, metals, bicycles, rickshaws, floor coverings, and processed foods. Small and cottage industries are in abundance. There are 39,033 small and cottage industrial units. The number of textile units is 11,820. The ginning industries are 6,778. There are 6,355 units for the processing of agricultural raw materials including food and feed industries. In 2003, the province manufactured 90% of all paper and paper boards, 71% of fertilizers, 65% of sugar and 40% of all cement in Pakistan. Lahore and Gujranwala Divisions have the largest concentration of small light engineering units. The district of Sialkot excels in the manufacturing of sporting goods, surgical instruments and cutlery.

1.3 Society and education

The major language spoken in the Punjab is Punjabi (which is written in Perso-Arabic script, known as Shahmukhi, in Pakistan) and Punjabis comprise the largest ethnic group (and overlap into neighbouring India). Punjabis themselves are a heterogeneous group comprising different tribes and communities, although caste in Pakistani Punjab has more to do with traditional occupations such as blacksmiths or artisans as opposed to rigid social stratifications. Over 99% population of Punjab (Pakistan) is Muslim with a Sunni majority and Shia minority. There are small non-Muslims groups of Hindus, Christians, and Sikhs.

The literacy rate has increased greatly since independence. In 2003, over 53% of the population of the province was estimated to be literate by the Labour Force Survey.[8] It should be noted that the higher education market in Punjab is dominated by homeopathic medical colleges. This is a chart of the education market of Punjab estimated by the government in 1998.

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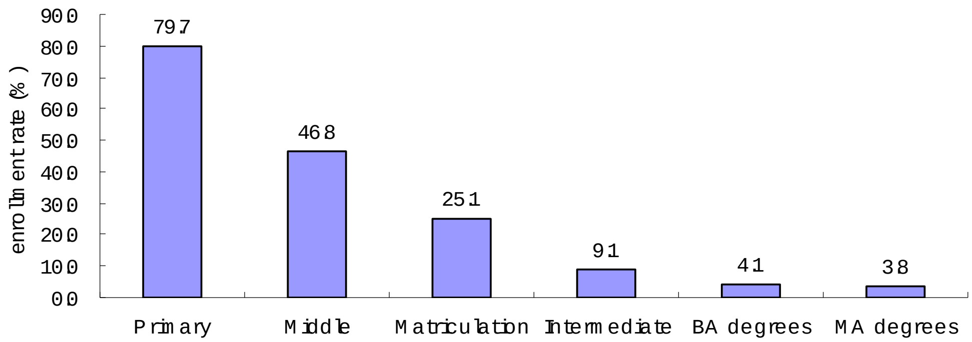
[8] Development statistics 2005, (Punjab statistics, Punjab gateway, government portal, *http://203.215.180.58/portal/docimages/9323education.pdf)*

Fig. II-2 Education in Pakistan



Source: GoPunjab, 1998, education market of Punjab
(http://www.statpak.gov.pk/depts/pco/statistics/pop_education/pop_education_rural_urban.html*)*

1.4 Legal and administrative structures

The Constitution of Pakistan assigns the services and functions to be performed by the federal government and the provincial governments. For example, GoPunjab, as shown in the table below, is responsible for the preparation of development plans and allocation of resources; whereas CDGs and DGs are in charge of development authorities and SWM bodies.

At the federal level, laws and regulations for environmental protection provide general goals but only limited specific discharge or design standards. Provinces take the responsibility of enforcement of existing laws. Municipalities and union councils have clear ownership of the solid wastes placed outside for collection. They also are clearly given authority to contract for any services under their responsibility, including solid waste management.

Table. II-3 SWM Duties and responsibilities at different levels of government

Level	Duties and responsibilities
Federal government	§ Specific duties and functions assigned in the constitution of Pakistan such as defense, foreign affairs, law and order, etc. § Power to promulgate laws relating to environment and related issues such as solid waste management § Power to levy and collect taxes § Power to borrow money to till the gap between expenditures and receipts § Transfer funds to provincial governments according to national finance commission award
Provincial government	§ Specific duties and functions assigned in the constitution of Pakistan such

	as law and order, courts, universities § Power to levy and collect taxes § Power to borrow money to fill the gap between expenditures and receipts § Power to promulgate laws with respect to local governments § Transfer funds to local governments according to provincial finance commission award
District government	§ Service delivery function such as education, health, social welfare, work and services, coordination. In the case of CDGs solid waste management as well
Tehsil municipal administration	§ Service delivery function such as water supply, sewerage, sanitation/solid waste management, roads, streets and steet lighting, fire fighting and administration of (??)parks and open spaces § Power to levy taxes and user fees on functions assigned to them under local government ordinance § Power to promulgate by-laws for their functions § TMAs cannot borrow money
Union administration	§ Registration of births, deaths, marriages, etc. § Power to levy user fees on functions assigned to them § Cannot borrow money

Source: Ernst Basler + Partners and ICEPAK (2006a).

Environmental laws in Pakistan are divided into three levels: federal, provincial and local. At the federal level, The Factories Act (1934) was first legislated to incorporate effective arrangements for the disposal of waste and effluent in factories. The Pakistan Environmental Protection Act (PEPC, 1997) is the overarching text for air, water, waste, and so on. It covers all social and economic conditions affecting community life. At the provincial level, GoPunjab legislated the Punjab Local Government Ordinance (2001) to declare SWM as within the competences of the Local Governments. In addition, every local-level government enacts various regulations related waste management issues. Details are tabulated as follows

Table. II-4 Legal and regulatory arrangements for federal government in Punjab

Laws / By-Laws	Years	Scopes and Issues
PEPA (Pakistan Environmental Protection Act)	1997	§ Protection of the environment: air, water, etc. § Deals with municipal, hospital, industrial, agricultural and hazardous waste; organic and inorganic matters and living organisms, buildings, etc. § All social and economic conditions affecting community life
Environmental Sample Rules	2001	§ Implementation of PEPA 1997
Hazardous Substance Rules	2003	§ Waste management plan pertaining to hazardous waste
Review of IEE/EIA Regulations		§
Hospital Waste Management Rules	2005	§ Holds health care establishment responsible for proper waste management § Sets duties and responsibilities; e.g. planning, segregation, collection, storage, reuse, etc.
NEQS (National Environmental Quality Standard) Regulations	2000	§ Test and analyze waste samples sent by factories or persons authorized by the Federal or Provincial Agency to ensure they meet NEQS regulations
NEQS Rules	2001	§ Self monitoring and reporting by industries
The Factories Act	1934	§ Requirement of effective arrangements for the disposal of waste and effluent in every factory

Source: Ernst Basler + Partners and ICEPAK (2006: 6); Presentation Materials by Team I and II in the Institutional Workshop held in Lahore on Jan 19-20, 2007.

Table. II-5 Legal and regulatory arrangements for provincial and local governments

Laws / By-Laws	Year	Scopes and Issues
Provincial		
Punjab Local Government Ordinance	2001	Local Governments' establishments and scope of services Declares SWM as within the competences of the Local Governments
Local		
LGOs in CDGs and TMAs	2001	Waste collection, transportation, and disposal
Lahore SWM By-Laws	2005	Declares CDGL responsible for the sanitation of the area within its jurisdiction Sets duties and responsibilities such as collection, removal, and prohibition from depositing refuse, building materials, etc., in public places
Police Order CDG Lahore	2002	Establishment of CCB (Citizen Community Boards) participating in local governance

Source: Ernst Basler + Partners and ICEPAK (2006a), p.6; Presentation Materials by Team I and II in the Institutional Workshop held in Lahore on Jan 19-20, 2007.

SWM services are carried out across multiple jurisdictions, which makes devolution of SWM service responsibilities somewhat complicated. For instance, CDGL takes responsibilities for some municipal services (transport and solid waste) that have been devolved to TMAs elsewhere in the Punjab. Therefore, CDGL's expenditure responsibilities are much greater than that of other provincial Districts', while its revenue sources are limited to those assigned to Districts.

Table. II-6 Devolution of SWM service responsibilities

Authorities	Roles and Functions
Government of Punjab	Responsibility for the preparation of development plans and allocation of resources
CDGs (City District Governments)	Control of the development authorities and SWM bodies (Sect. 182 LGO)
Zila Council in a CDG	Review of development of solid waste disposal (Sect. 40 LGO)
Town Municipal Administration	Provision, management, operation and maintenance of solid waste collection and conveyance to transfer stations, but excluding treatment and disposal of waste (Sect. 54A LGO)
TMAs (Tehsil Municipal Administrations)	Provision, Management, Operation, and Maintenance of solid waste collection and sanitary disposal of solid, liquid, industrial and hospital wastes (Sect. 54 LGO)
UCs (Union Councils)	Sweeping of the streets, primary collection of garbage from the residential / commercial units, shifting of waste to the containers / skips

Source: Presentation Materials by Team I and II in the Institutional Workshop held in Lahore on Jan 19-20, 2007

2. Generation and treatment of solid waste in Punjab

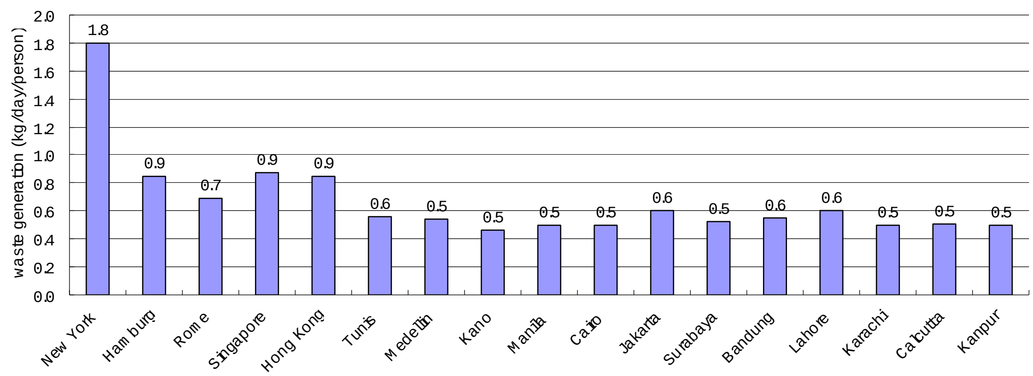
2.1 Quantity and composition of waste

The amount of waste generated strongly depends on the level of consumption and lifestyle besides population. That in Pakistan shows a particular trend that increases in waste generation has occurred in accordance with the city's social and economic development (JICA, 2005: 8). The Ministry of Environment and Urban Affairs Division, Government of Pakistan (1996) revealed that the average rate of waste generation from municipalities varies from 0.283 kg/capita/day to 0.613 kg/capital/day or from 1.896 kg/capita/day to 4.29 kg/capita/day in all the selected cites from Sibi to Karach. In related to 9 cities, the average of waste generation from 9 cities ranges from 115 ton/day of DG Khan to 5,000 ton/day of Lahore (Fig. II-3, Annex-3).[9]

[9] Waste generation is roughly estimated based on the population and an estimated average generation rate of 0.6 kg/capita/day, since no detailed study on the nine cities in the Punjab is

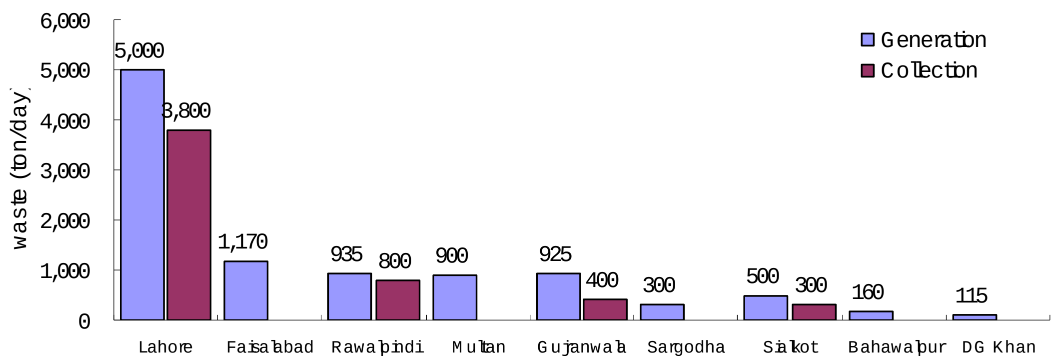
Solid waste in Punjab is generally composed of plastic and rubber, metal, paper and cardboard, textile waste, glass, food waste, animal waste, leaves, grass, straws and fodder, bones, wood, stones and fines to various extents. A typical distribution of waste fractions is given in the following Fig.II-3. This shows that organic materials account for more than a half of total waste even though the composition of waste changes from the point of generation to final disposal sites.

Fig. II-3 Waste generation in major cities



Source: S.J. Cointreau, Environmental Management of Urban Soild Waste in Developing Countries: Project G Guide, Washington D.C(1982.6), The World Bank.

Fig. II-4 Solid waste generation in nine cities



Source: Ernst Basler+Partber, Icepak (2007), p. 72.

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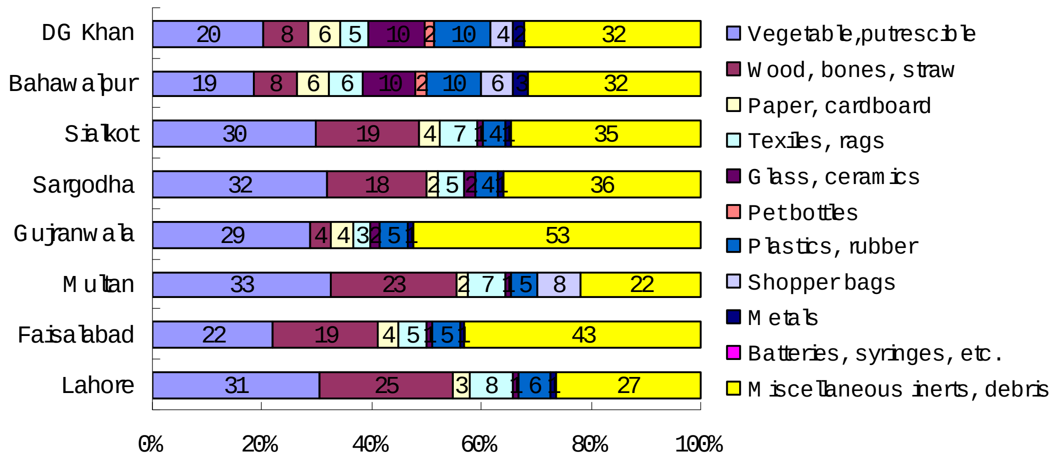
available.

Fig. II-5 Composition of solid waste in the nine cities*



Source: Ernst Basler+Partber, Icepak, 2007, p.71
Note: *Year of sampling - Faisalabad 1996 / Lahore, Gujranwala, 2005 / Multan, DG Khan 2006 / Sargodha, Bhawalpur 2007; Data for Faisalabad is not available.

2.2 Municipal waste collection services

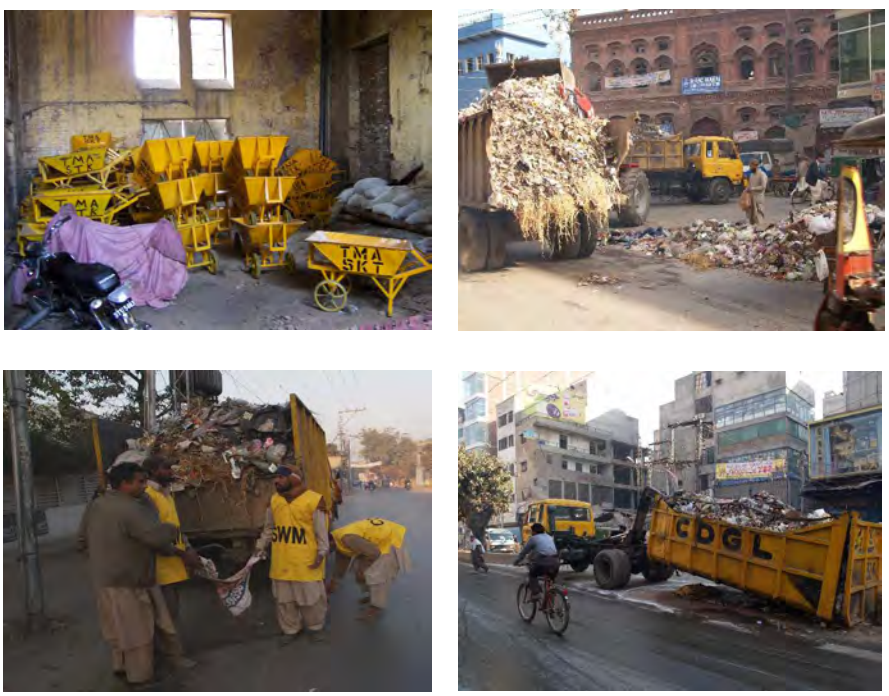
The responsibility of solid waste management rests basically with the municipalities. Traditionally, in Pakistan's large cities, the local government collects waste from households in middle to high-income areas and is in charge of street sweeping. Solid waste collection services by government in Punjab's cities averages only 50 percent of waste generated; however, for cities to be relatively clean, at least 75 % of these quantities should be collected. The uncollected waste remains on street or road corners, open spaces and vacant plots, etc., polluting the environment continuously. The rate and amount of the waste collected in all the selected cities are given in the following table (JICA, 2005: 11-12).

The available fleet for waste collection and transport typically is composed of handcarts, donkeys and bulla carts for primary collection; and open trucks, tractor/trolley systems, arm roll containers/trucks for secondary collection and transport. A number of municipalities have hired the sweepers and sanitary workers. Workers collect solid waste from small heaps and dustbins with the help of wheelbarrows and brooms, and store it at formal and informal depots and then carry out the sweeping of streets and roads.

The proportion of waste collected is much less in many other areas of the country, particularly in poorer areas, where the only means of solid waste disposal is often informal scavenging by people and animals, and local self-help for disposal to informal (technically illegal) dumping sites.

Fig. II-6 Waste litter in a residential area of Sialkot

Fig. II-7 Waste collection equipment in Lahore



2.3 Solid waste recycling

In fact, presently none of the municipalities have a formal recycling system in place. The mostly informal classification activities take place at various step of the cycle, from the source to the disposal site. What happens normally is that the main recyclable items such as paper, plastic, glass and metals are retained by the people themselves, which are later sold to street hawkers or waste dealers for recycling.

The recyclable mixed with discarded waste are picked up by the scavengers who make trips to two to three different dumps and earn approximately Rs 80 to 200/day. As a whole, however, according to estimates the amount of recyclable waste varies from 1,000 tones/years in Sibi to 513,743 tons/year in Karachi. The city-wise potential for waste recycling is given in the following table (JICA, 2005: 12).

Fig. II-8 Recycling by waste pickers

Table. II-7 Potential for Waste Recycling

City	Percentage Recyclabes (%)	Weight (Tons)	Gross Income (Million Rs)	Net Income (Million Rs)
Gujranwala	**17.20**	**42,518**	**352.5**	**176.7**
Faisalabad	**18.10**	**50,189**	**547.4**	**273.7**
Karachi	26.55	313,743	3,515.6	1,757.8
Hyderabad	16.55	48,444	269.5	134.7
Peshawar	15.30	37,147	232.2	116.1
Quetta	14.20	10,800	7.4	3.7
Bennu	20.50	23,247	127.2	63.6
Sibi	19.60	1.000	4.7	2.4

Source: EPMC Estimates, 1996
Note: Research municipalities are written in bold letters.

Fig. II-9 Waste dealer shop near a Sialkot landfill site

2.4 Solid waste treatment

Besides there being a great number of illegal dumping sites at any open space, the "official" disposal sites are far from being acceptable from an environmental point of view. Delivered garbage is dumped without any base protection from potential leachate infiltration into ground water, leachate collection and treatment nor collection and control or gas evacuation / flaring system – those being the minimum requirements for an acceptable practice. The presence of waste pickers on the sites is hindering a more efficient operation of them and is critical from a public health perspective(IP: 14-5).

Treatment and disposal technologies such as sanitary land filling, composting and incineration are comparatively new concepts in Pakistan. Open dumping is the most common practice throughout Pakistan and dumpsites are commonly set on fire to reduce the volume of accumulating waste, hence adding to the air pollution caused by the uncovered dumped waste itself.

The practice of sanitary land filling is still in its infancy in Pakistan and the first site has yet to be developed. At present, there are no landfill regulations or standards that provide a basis for compliance and monitoring, but national guidelines for these standards are being prepared by the consultant under the National Environmental Action Plan Support Program (NEAPSP).

3. Institutions and budget of solid waste management

3.1 Organizational infrastructure of solid waste management

The following figures show the basic institutional structure of SWM in Lahore and a typical structure at town level. The District Nazim, CDGL, heads the Solid Waste Management Department. For administration and public convenience, the city has been divided into 6 towns. Each town is headed by the ADO. The organization chart of the Solid Waste Management is as follows:

Fig. II-10 Organizational structure of SWM in a metropolitan city: the case of Lahore

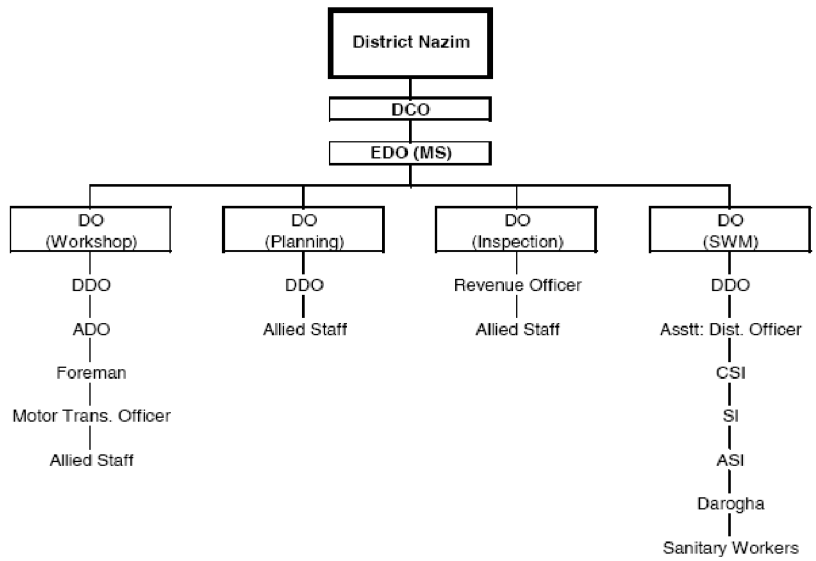
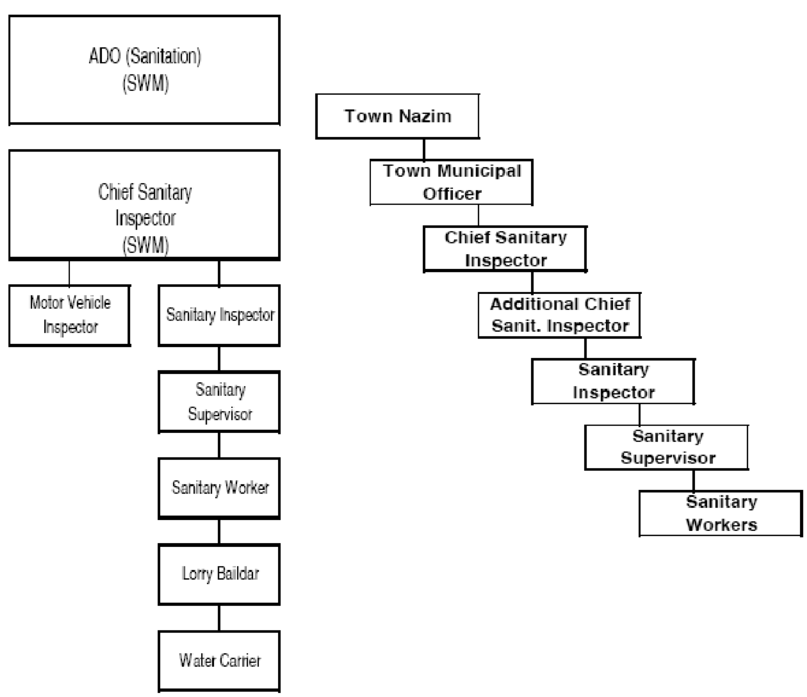


Fig. II-11 Organizational structure of SWM at town level



The section 35-36 & 54-A of the Punjab GO-2001 and No.so-Admin-1 (LG) 1-68-05 notify the organization for SWM of CDGs & TMAs as below:

- CDGs in Punjab including Lahore : EDO (Executive District Officer) for Municipal Services, and DO (District Officer) for Transport, Spatial Planning, Environment & SWM (including collection & transport, treatment & disposal, landfill sites, recycling plants and industrial/toxic waste treatment and disposal),
- Staff at Tehsil level in Lahore : ADO (Assistant District Officer) for sanitation & SWM, CSI (Chief Sanitary Inspector), Sis, SSs (Sanitary Supervisors), SW (Sanitary Workers), and etc,
- In Sialkot, TO (Tehsil Officer) for I & S, and ATOs (Assistant TO) for sanitation & mechanics, and CSI, SIs, SSs; and SWs on daily wage basis.

3.2 Revenues and expenditure for solid waste management

The expenditure exclusively used for waste management services can be difficult to extract from financial records, as it might be combined with other public accounts such as water supply, sewage treatment, or health. Most of nine cities do not properly allot budget to SWM and usually covered by general budget fund of the local governments (Ernst Basler+Partber and Icepak, 2007: 93). It infers that municipalities wouldn't recognize breakdowns for SWM expenditure and they are hard to control them.

The expenditures on SWM range from 20% in Multan to 4% in Sialkot of total CDG/TMA budget. The more than 80% of the budget is spent on salaries and pension for sanitation staffs while the maintenance and equipment costs are relatively low around 5%. The labor cost of DG Khan accounts for 90% of total SWM expenditures but the maintenance cost is just 2%. It shows SWM of nine cities largely depend on manual work.

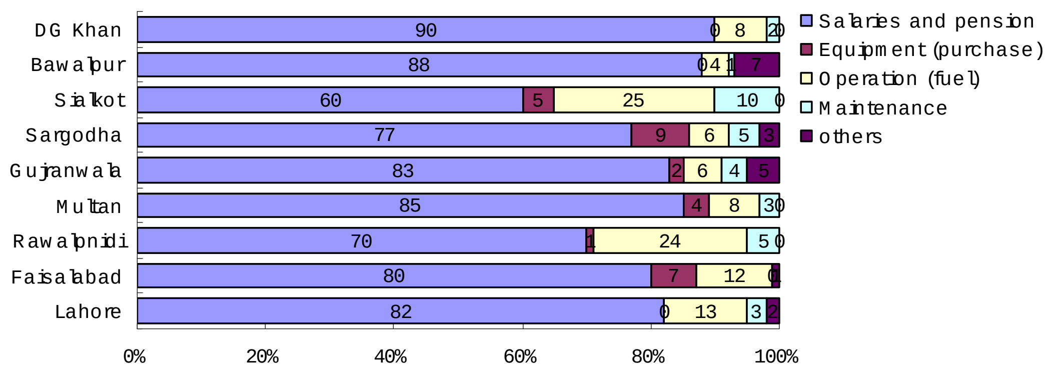
Table. II-8 Share of expenditures on SWM and cost recovery rates, 2006-2007*

(unit: million Rs.,%)

	Lahore	Faisalabad	Rawalpindi	Multan	Gujranwala	Sargodha	Sialkot	Bawalpur	DG Khan
Total budget	9,206	4,803	3,350	852	3,901	370	811	90**	515
Total expenditures on SWM (%)	1,459 (16)	304 (6)	243 (7)	173 (20)	157 (4)	45 (12)	30 (4)	39 (43)	40 (8)
Recovery through user fees (%)	120 (8)	0 (0)	5 (2)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)

Source: Ernst Basler+Partber, Icepak, 2007, p.93.
Note: * Fiscal year begins on July 1 of the previous calendar year and ends on June 30 of the following year
** The data on total budget is not credible compared to total budget of similar TMAs

Fig. II-12 Expenditure breakdowns on SWM



Source: Ernst Basler+Partber, Icepak, 2007, p.93.

Most municipalities do not levy the waste collection fee at proper level except Lahore and Rwalpindi. In Lahore, the local authority imposes 30% solid waste fee on water bill. Cost recovery is under 10 % of total cost. In Rawalpindi, a household is obliged to pay 180 Rs. Per month for solid waste services, while it is not collected in commercial areas. Therefore, direct cost recovery through user fee/charge is very low.

Most Pakistanis might agree with the principle that the general public should not bear all the costs of government services in cases where private parities derive a benefit from a service. However, there isn't fairly charging standard critical to introduce cost recovery.

4. Privatization of SWM in Punjab

The private sector has participated in the waste management of Punjab for about 15 years. Since municipal government could not afford to provide sufficient sanitary service to small communities out of the municipal jurisdiction, they made a contract with the private sectors. CDGs and TMAs still suffer from lack of proper equipment and manpower and explore the privatization as alternatives (Ernst Basler+Partber, Icepak, 2007: 127). A few municipalities such as Lahore and Rawalpindi hired private companies to manage the waste issues as a pilot test. Some of them were very successful to continue the contract until now while some ended up in the failure (Ernst Basler+Partber, Icepak, 2007: 127-63).

A representative successful case is the Lahore Sanitation Program which is begun Dec. 1996 and still in operation. There was no formal waste service in Lahore Cantonment areas, the Cantonment board just cleaned the communal waste points once a week. As the population grew, the area was in the desperate need of waste service. The Residents Association made a franchise contract with Waste Busters, a private company. The company began to collect the garbage from each household and transport it to the disposal site. And it provided 30 garbage bags per month, 2,000 households were supposed to discharge their waste into it. Waste Buster directly charged Rs. 100 per month from each household for the service and the Cantonment Board didn’t take a part in charging.

Out of many successful factors in the case, the critical ones are the residential need and awareness on the private waste service and cost, and the company motivation to satisfy the customer through the communication between the residents and the private contractor. The residents played a leading role in launching the program and reflecting the residents’ complains to the company: the Resident Association organized the meetings with the Waste Busters and the Cantonment Board Executives; the price of the sanitary service was set under their agreement. They also made a Resident Committee to monitor the performance and reflect the result to the payment. The company should do what it is supposed to do avoid the nonpayment. The Resident Association functioned as an arbitrator between the company and residents with the Cantonment Board. Through the active residential participation and communication, both of them, residents and the company might understand their roles in the waste treatment like proper discharging or punctual collection.

Moreover, the private sectors hired the social motivators or organizers during the initiative period. They were responsible for the 200~500 households and let the residential know how to discharge or recycle the waste. In the case of Lahore Sanitation Program, social motivators convinced the residents to use the plastic bag the company provided. In Chakalala, Rawalpindi, the private contractor hired 20 female social organizers and trained them on aspects of community mobilization. So they could interact with the housewives in the area and educate them the waste service could be continued only when they pay for it.

On the contrary, non-cooperation of stakeholders and lack of experience lead the private sector participation to failure. TMA Gujrat introduced the private sector to the waste management to improve the sanitary environment as a new Nazim's commitment. The TMA Gujrat advertised it in the National Press and contracted the lowest bidder in Feb. 2004. It was the first contract of SWM under the new Local Government Ordinance 2002. The service period was one year and could be renewal up to 2 years. All waste management activities from medical, industrial and municipal waste to the sludge from the drainage were handed over to the private sector but the contract didn't mention specified types waste to be collected. Even it failed to consider the inflation or fluctuation in fuel and labor cost. The company had to pay additional cost, 72% , 20% increase in fuel cost and salary respectably which was announced by Federal Government.

When the private contractor kicked off the service, it faced the disagreement of the Labor union. Labor union of sanitary workers who belonged to the municipality thought the privatization would risk their employment or lower the salary and benefits. The union went on the strike. Councilors or Union Council Nazims who preciously had charge of the sanitary workers in their Union Council were also not satisfied with loss of their authority over the workers. Even the press gave a criticism on the media. Such non-cooperation of stakeholders caused the company the additional cost to appease their resentment.

The company didn't have proper methods to supervise and inspect workers. Drivers often sold the fuel of the waste vehicle and dump waste into open plots near the city instead of going to the landfill sites. Sanitary workers sometimes did their personnel tasks not doing what they are supposed to do during the duty hour.

The private sector participation is on the initiative step in Punjab, Pakistan although people expect the private sector would be better in the sanitary performance than the municipality. First of all, the level of public awareness needs to be incubated. The majority of the households who received and don't receive the service indicate that they need service to continue. Actually, efforts to convince the need to charge for the service should be taken.

Table. II-9 Privatization of waste management in Pakistan

	Model	Services	Area served	Cost	Contract period
Gujrat sanitation program	Management contract	Primary & secondary collection, transportation and final disposal of solid waste (construction waste, healthcare waste, industrial waste, sewage sludge, etc.)	§ Urban population mix of low-middle income group § 15 union councils comprising of 30,000 households	Rs. 38.4 million /yr	Feb. 2004 - 2006
Lahore sanitation program	Franchise	Door-to-door collection of household waste daily delivery of 30 garbage bags per month Transportation of waste to disposal site	§ High-middle income urban areas of Lahore cantonment. § 10,000 households	Rs. 100/month /household	Dec. 1996 - Present
Cantonment board Lahore	Management contract	Waste collection, street sweeping, drain cleaning, garden waste collection , commercial area cleaning	§ Urban areas falling under Lahore cantonment within the administrative control of the Cantonment board Walton, Lahore § 50,000 households		Apr. 1999 - Present
Clifton cantonment board, Karachi	Management contract	Waste collection, transport, final disposal Construction waste			
Awam sanitation program, Faisalabad	Franchise	Collection, transportation, final disposal			
Chaklala waste management program, Rawalpindi	Service contract	Clean up of waste dumps, community awareness program, capacity building of union council, door-to-door waste collection	§ Low income urban population, living in Dhok Munshi, Chaklala, Rawalpindi § 1 union council, 4500 households		Apr. 2005. - Oct. 2005
Solid waste & environment enhancement project, Rawalphindi	Management contract	Collection, transportation, final disposal Construction waste	§		
Lahore compost plant, Lahore	BOT/ Concession	Establish of a compost plant	§ Municipal solid waste collected in Lahore § 1,000 MT/day		Mar.2005 - Present
Composting project, Multan	BOT	Recycling, final disposal	§		

Source: Source: Ernst Basler+Partber, Icepak, 2007, p.129-93.

5. Sociology of solid waste management

5.1 Gender and solid waste collection services

The handling of waste in the Punjab is a task for the poorest, socially neglected minorities. Very low prestige and lack of other, e.g. monetary incentives lead to difficulties in finding motivated and qualified staffs. This applies not only for sanitary workers and supervisors, but is particularly true for the professional and managerial level.

In this regard of interest is also the gender issue; i.e., the different roles assumed by men and women regarding the handling of garbage. According to discussions held at a meeting with representatives from different community organizations in Multan – attended by both men and women – the major responsibility for garbage as far as the household is concerned is assumed by the women.

Women publicly carrying garbage to a collection point, however, is said to be a cultural taboo; men apparently doing it neither. Most participants of the meeting are confident, that once facilities are in place and people more aware of the need, change of that culture and behavior will take place.

5.2 Scavengers and waste recycling

Waste picking is a widespread activity in nearly all cities of developing countries. Men, women and children, namely scavengers, make their living by collecting the valuables from wastes that households and enterprises throw away.

Some waste pickers collect materials from factories, offices, stores, schools, hospitals and residential areas, and dumpsters (large waste receptacles) that hold an abundance of valuable waste. Others work on dumpsites where huge amount of wastes is gathered. The materials collected by scavengers include such items as food, paper, scrap metals, cloth, household goods and building materials, etc.

Waste pickers and sweepers are likely to be formed by the marginalized group such as ethnic or religious minorities or rural migrants. The low social status of people dealing with rubbish is associated with caste. Many of the waste pickers in Punjab are Hindus, Christian or animist origin.

Their hereditary occupational status falls under the generic category *Pakhiwas,* a nomenclature than embraces all the indigenous nomadic tribes of Punjab, and groups that in India would be classified as scheduled tribes. Pakistanis hold that waste workers involving the scavengers are particular categories of people who work with dirt.

Fig. II-13 Waste pickers of Lahore: collecting the valuables from a waste truck (left), removing waste from a landfill site (middle), and in landfill site (right)

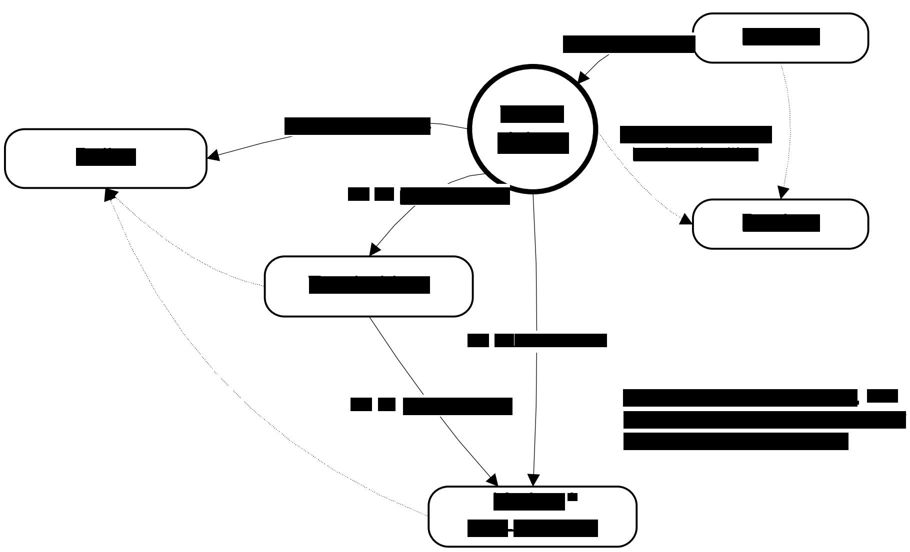
Fig. II-14 A waste pickers' habitat near a landfill site in Sargohda

Informal connection between sweepers, police and scavengers is found in some areas while landfill site managers plot waste pickers working in a dumping site. Of course, some of them do not care waste pickers work in the area. Waste on the street contains more valuable materials than in dumpsite and attracts waste pickers. In some areas, it was reported that official waste sweepers and police who have authority to manage the area engaged to plot and allow them to collect wastes (Box. II-1).

Box. II-1 A dumping site case in Karachi

At Jamchakro, a dumping site in Karachi, local authorities and privately owned trucks bring waste and dump it in designated areas in accordance to individual plots rented by waste pickers within the site. There is an informal landlord locally known as a vadera. The vadera allows waste pickers to work in the landfill site for approximately Rs. 50/month. The waste pickers pay truck drivers about Rs. 50/truck to dump waste on their particular site. The following figure describes the complicated financial connections among actors. (Rouse 2006)

Schematic of actors and financial interconnections



Source: Rouse (2006), p.748
Note: * an informal landlord in a landfill site is locally known as vadera.

Box. II-2 Health issues amongst scavengers

The waste work is demeaning, unpleasant and dangerous. Waste pickers expose themselves to health risks in such an unsanitary environment. Sometimes waste is mixed with excreta and abattoir and clinical waste carrying a high risk of infection. Waste is burned in order to retrieve the few remaining recyclable materials contained within, and left to smolder for 2 or 3 days. This has negative effects on the respiratory systems of the waste pickers, and few can afford to travel to a hospital. Reported diseases included tuberculosis, gastric problems, respiratory problems, skin infections and boils (Rouse, 2006: 746). They have poor housing, and very limited access to infrastructure and services. Most are uneducated and do not have, and may not be able to afford to gain, skills necessary for other jobs.

In many countries municipalities take measures to formalize waste collection and recycling activities by organizing the labor often in teams or enforcing registration procedures. However, waste pickers are not provided with any benefits such as health insurance or personal security, thus remaining extremely vulnerable to a variety of social and health risks.

6. Problems in municipal solid waste management in Punjab

6.1 Lack of appropriate collection services

The solid waste collection rates of most cities in Punjab are around 50 percent of waste quantities generated far below the 75 % that is required to maintain a city clean. Unfortunately, none of the cities in Punjab has a proper solid waste management system right from collection of solid waste up to its final disposal. There is no proper door-to-door collection system, placement of containers or mutually agreed designated transfer stations/secondary collection points (IP: 13).

Public waste collection is usually not efficient and mainly they do not have sufficient funds. Therefore, there is now a trend towards subcontracting a substantial part of waste collection and street sweeping services to private companies has so far not been fully practiced in Pakistan. Furthermore, there are a number of NGOs like Waste Buster that are active in waste collection and have done remarkable work.

It has been noted that the service of street/road sweeping is not regular and mainly limited to administrative, commercial and other industrial areas. Further, the number of formal collection bins such as masonry enclosures, containers and trolleys are too less to accommodate their waste generated in these cities. Further these points are not located according to population and area requirements. It is the reason that a large number of people opening heaps are found in some cities (JICA, 2005: 10).

6.2 Improper solid waste disposal facilities

The waste is disposed off without any treatment except the separation of the recyclables by scavengers. Current disposal practice is by open dumping, primarily on flood plains and into ponds, causing significant environmental damage. The land is also hired or leased on long basis for disposal.

Moreover, the least mitigating measures have also not been reported from any municipality. Much of the uncollected waste poses a serious risk to public health through clogging of drains, formation of stagnant ponds, and providing breeding ground for mosquitoes and flies with consequent risks of malaria and cholera.

In addition, because of the lack of adequate disposal sites, much of the collected waste also finds its way in dumping grounds, open pits, ponds, rivers and agricultural land. Environmental degradation is not only well advanced already, but also is getting progressively worse as the country's population, urbanization and industrialization increase, and as its economy develops generally.

6.3 Poor institutional and financial arrangements

Existing institutional arrangements for solid waste management are fragmented, leading to inefficiencies. At the federal level, laws and regulations for environmental protection provide general goals but only limited specific discharge or design standards.

At provincial level, the enforcement of existing environmental laws is lacking. Understaffing, lack of precise standards, lack of information, limited transport and monitoring equipment, inadequate sanctions and corruption under and corruption undermine enforcement; thus, disreputable waste generators and transporters practicing clandestine or unsafe disposal have a competitive economic advantage.

Sanctions for littering and clandestine dumping are too small to provide disincentives;

processing of arrests is slow due to heavy case loads and the low priority assigned by magistrates (World Bank, 1997:44).

From the organization perspective, it can be noted that too many organizational hierarchy may result in the inefficiency of solid waste services.

6.4 Lack of reliable data for municipal waste management

It is important to note that there can be a big difference in Pakistan between solid waste generation and the amounts reaching final disposal sites. In developed countries, the two figures are usually the same since most waste generated must be collected and officially treated (although there are moves towards the segregation of some components of waste at the source in number of countries).

In developing countries, including Pakistan, significant portion of waste generated are recovered informally, mostly by scavengers, before it reaches to the final disposal point. For any figures related to the quantification of waste the difference the scavengers cause must be interpreted with the foregoing in mind. Also, estimating the amount and composition of waste produced by households and then finally reaching at disposal systems, the statistics can be unreliable.

The situation is made worse in Pakistan as there are no weighing facilities at most of the disposal sites and no continuous practices of waste sampling and analysis. However, the situation is changing and municipalities are realizing the importance of weighing and recently weighing facilities has been installed at Mehmood Booti landfill site in Lahore.

Furthermore, the types and quantities of waste generated and reclaimed vary with the locality and, to some extent, with the season; and areas with more traditional lifestyle trend to generate relatively small quantities of waste, and segregation and reclamation practices are more widespread(JICA, 2005: 7-9).

6.5 Challenges pertaining to the presence of scavengers

Changes in collection and disposal practices of solid waste management systems can profoundly affect waste pickers and their livelihoods. Closing existing dumps and opening new ones further away, and mechanizing collection can restrict if not eliminate many opportunities for waste picking, causing extreme hardship for people who are poor and vulnerable. Closing dumps can also displace families who cannot afford other places to live. Waste pickers are among the key stakeholders of MSWM systems.

Municipal authorities face two main issues in developing policies for waste picking. First, waste picking poses substantial health and safety risks to its practitioners. Governments and others share the aim of enhancing the quality of life for waste pickers, by helping them improve their working and living conditions, increase their incomes, expand their employment options, and improve access to social services.

Second, waste pickers can impede cities' collection and disposal operations in a number of ways. At landfills, they can interfere with the work of heavy equipment, delaying compaction and soil covering. Waste pickers can light fires, creating a danger to the environment, landfill employees and themselves. Waste pickers looking for valuables in rubbish bins sometimes empty and scatter their contents, contributing to urban litter and significantly increasing costs of collection by adding to the time it takes collectors to complete their rounds.

In the past, governments have often tried to solve the problems associated with waste picking by outlawing the activity. However, because waste picking provides an essential safety net for people with few alternative means of survival, this approach has largely failed. Attempts to control access by force have led waste pickers to light fires at dumps, storm city halls and knock over garbage containers.

6.6 Low level of public understanding and support

Unlike any other municipal services such as e.g. centralized water supply or waste water collection systems, solid waste management does always require a minimum of participation by households (IP: 21). Residents' active participation and understanding on the importance of proper waste treatment are fundamental for the success of SWM.

There can be observed an almost complete lack of awareness of households and commercial premises regarding the need to contribute by participating in collection. With some reason they argue that it is the municipalities' responsibility to take the garbage out of the streets and the city. And their reported reluctance to pay or contribute is reinforced by the poor or non-existent service.

III. Policy Implications and Suggestions

1. Introductory remarks

This institutional part contains policy suggestions to streamline the organizational accountability for solid waste management and induce private sector participation. The following points are being considered and developed in this chapter:

- § Recycling to reduce the volume of waste for landfills
- § Simplification of the fragmentation of responsibilities, especially through the establishment of public corporations or private participation
- § Conditions for private sector participation; strategic planning of private sector participation of public corporations in the long term;
- § Public awareness and capacity building program
- § Social program for waste pickers

2. Special considerations in setting a SWM strategy

2.1 Special emphasis on composting

2.1.1 Composting as a sustainable waste disposal method

Composting is ranked 4th in the hierarchy of food waste management, which is followed by reduction, feeding hungry people and animal feed. Composting involves a relatively simple but very effective process that will prove very effective in reducing waste in Punjab. Over 50% of an average city's waste stream in Punjab is organic and could be readily composted, thereby shifting waste disposal from trash removal to recycling. Also, by sorting organic waste from disposable waste, people would become more aware of what is being thrown away and in turn reduce their own level of waste generation. Moreover, composting is effective in helping to reduce soil erosion and degradation and also helps soil retain moisture. Thus, composting is strongly recommended for Pakistan, whose soil is dry and highly degraded, especially in areas relatively close to major cities. If the compost produced is of high enough quality and the market exists, the product can be sold. Environmentally, the process of composting is preferable to landfill processes.

2.1.2 Three different scales of composting

There are three different scales of composting which could be applied in Pakistan: i) the residential level, ii) the decentralized community level, and iii) the centralized large-scale (municipality-wide) level (World Bank, 2000: 5).

Firstly, residential composting is recommended when a significant number of houses have individual or collective yards or gardens and there is sufficient space (World Bank, 2000: 5). It can be adopted where small scale agriculture is found in great abundance close to urban areas, or where limited garden space is found within the city itself. The design and operation of the composters should not attract rodents, insects, or other scavenging animals. The best way to keep pests away from the composting unit is to disclude large quantities of meat, fish and fatty food.

Box. III-1 Apartment composting in India

Patna, India has a population of about one million with little door-to-door waste collection nor any composting facilities or sanitary landfills. On average a three person household generates 2.1 kg of food waste each week. Backyard composting is used by some households, but this is not an option for those living in apartments. A composting method was developed for apartment dwellers to use their balconies and window sills. Excess water is drained from the organic waste and placed in clay pots. Soil supplemented with floor sweepings and dried moss from roof tops is added to equal amounts of waste. The compost matures in 3 to 4 months and is used directly for planting without further additions of fertilizer of chemicals. Flowers, ornamental plants, spinach, and tomatoes are successfully grown in the compost (Mazumdar, 1992)

Secondly, decentralized composting on a neighborhood scale provides small groups a way to compost at a relatively low cost. Households, commercial establishments, and institutions like small markets, government buildings, or schools in an area generating between five and 50 tons of organic waste per day can compost on vacant land, beside community gardens, or in public parks. Local governments can support the project through public education, providing land for the facility, assisting with start-up costs, transporting and disposing of rejected wastes to local landfills and using the final compost in public parks. To ensure the composting operation is environmentally and socially acceptable, UNEP (1996) recommends the following requirements for the site:

§ To be accessible to all individuals who want to use it
§ To be clearly designated with signs which all users and non-users can understand
§ To have approval from all surrounding land users
§ To have adequate controls to prevent it from becoming an area for local dumping
§ To have appropriate soil and drainage to accommodate the leachate

Lastly, the quantity of waste treated by centralized composting ranges from 100 tons/day to more than 500 tons/day. Since centralized composting is on a significantly larger scale, environmental, social and technical considerations should be approached in a more formal manner and address the following requirements:

§ Institutional consideration
Formal evaluation and site selection process that involves all relevant stakeholders
Formal agreement made between all municipalities within the jurisdiction for siting, design, financing, operations, maintenance, environmental compliance, and billing for service and waste delivery
Establishment of a marketing strategy for the compost

§ Technical consideration
- Separate collection and/or pre-processing system to ensure that unwanted materials do not enter the composting system; special attention paid to the informal sector in pre-processing the waste and recovery of non-compostable materials
- Enforceable protocols for the quality and composition of the compostable materials delivered to the facility
- Technical assessment of the area, soil, and geographic characteristics of potential sites
- Inclusion of engineering and design professionals in site selection and facility design
- Program to minimize and/or compensate for nuisance effects of traffic, order, leachate, and noise produced by the composting operations
- Designated routes for the delivery of organic materials to the facility
- Environmental assessment of the site

Out of the three, a combination of community and large-scale composting rather than strictly adhering to only one option would help to reduce municipal costs for composting when the distribution of population and types of housing in Punjab are considered.

Even though organic decomposition is a natural process, health and safety issues for workers and neighboring residents exist and need to be addressed. Establishing compost standards and taking precautions in the facility design and operations should assist in the mitigation of any negative health and safety impacts.

2.1.3 Research for the composting approach

To introduce and adapt to composting as a waste treatment method in Punjab, the following tasks should be completed:

- § Task 1: Analyze the market conditions associated with composting waste generated in Punjab;
- § Task 2: Estimate the quantity of food waste that would be generated by pilot program participants;
- § Task 3: Research and summarize at least one country-wide food waste composting project;
- § Task 4: Estimate the cost of collecting, transporting and composting food waste from pilot program participants.

The first step in developing a composting approach is to assess all existing and potential markets. This requires knowledge of the product, potential uses, limitations of use, and estimating the value of the product to the user. It is also important to adapt a marketing strategy to meet local requirements by considering soil characteristics, agricultural practices, social customs, climate, transportation cost, seasonal variations, etc.

A pilot program helps to estimate the quantity of food waste in different sectors: residential areas, markets, and restaurants. This information on a daily, weekly or monthly basis by each sector is essential for designing a collection system. Furthermore, proper handling is established on the information on conditions during storage, transport and processing of the food waste.

Research on country-wide food waste composting projects is to help our understanding of the overall process of composting, expected challenges, and setting the direction for the project. Furthermore, the composting operation must produce a stable and consistent quality product in order to meet market requirements.

Although theoretically, there is an unlimited market for good quality compost, the cost of production, transportation and application of compost can exceed the benefits. Therefore, good marketing programs should be accompanied with it based on municipal support. The critical issue is not so much finding a use for the completed compost but rather finding cost-effective applications. Many past failures can be attributed to poor marketing strategies and inadequate attention to long term financing. The other critical aspect of a compost marketing strategy is to adequately include avoided collection and disposal costs that would be spent if the organic matter was not being composted.

2.2 Plastic waste collection and treatment

There is considerable plastic content in the solid waste generated in Pakistan. Plastic waste is released during all steps of production and after consumption of every plastic product. Both the quantity and quality of plastic waste is related to environmental problems. Quantitatively, post-consumption plastic waste is more important, as it is found in large volumes but with less weight. While this waste is taken care of in the formal recycling sector, the much more heterogeneous domestic waste stream is left to the mercy of the private sector. Some of the environmental issues of plastic waste are litter, emissions of hydrogen chlorides and dioxins from incinerators and contamination from chemical additives. Plastic waste also presents a direct hazard to wildlife. The quantity of plastic waste will rapidly increase as the economy and industry develops although the current amount of plastic waste generated only ranges between 5 to 10% of the total amount of waste. Pakistan needs to introduce a plastic waste recycling system as soon as possible.

The ultra-thin plastic bag is one of the most bothersome problems related to plastic waste. It is extensively consumed, notably in markets selling fresh food. In most cases, as they are thin and contaminated, they are usually not being reused. These discarded plastic bags that are littered along the streets, in rivers or hanged on trees, cause considerable nuisance.

To reduce the amount of used and discarded ultra-thin plastic bags, their sale and use should be prohibited. Shopping center management staff should monitor and assist retailers in accomplishing this legislation requirement. Due to their cheap cost, it is common practice for retail shops to give out free plastic shopping bags to customers. It is expected that if retailers are only allowed to use higher quality and more expensive plastic bags, they would in effect tend to charge customers instead of giving away plastic bags for free. Shops that do not give out plastic bags may be perceived as less attractive for customers. To account for this, a law should be enacted that prohibits the distribution of thin plastic bags. Upon return of the more high quality plastic bag to the shop, the customer should receive a refund. This method will foster the reuse of plastic bags and a reduction of the total amount of plastic bags being originally consumed. Further, customers will be more inclined to use alternatives such as paper or textile bags.

The promotion of such a policy may not be immediate effective for inducing people to minimize their consumption of plastic bags. One reason is that the plastic bag product serves the function of providing convenient and hygienic protection of purchased goods. [10] Another reason is that the production of ultra-thin plastic shopping bags only requires simple techniques and machinery, there are many producers in operation, and most of them are operating on a small scale. Low density polyethylene (LDPE) is the most common raw material for the production of plastic shopping bags. As in other countries, the task of dealing with the over-use and subsequent disposal problem of plastic bags is always arduous. In most cases, recycling involves costly collection and laborious pre-processing, such as sorting and cleaning. However, campaigns to persuade consumers to reduce their use of plastic bags for environmental reasons should be conducted continuously for an extended period until consumers recognize that the usage of plastic bags is costly.

[10] Handing out free plastic bags to consumers has become a well accepted norm in retailing business in the cities of China. Even the discussion of White Pollution has drawn the attention of a high proportion of Beijing citizens, yet it is still not widely acceptable for consumers to pay for plastic bags. Despite the higher cost incurred in using thicker plastic bags, retailers in Beijing would still rather give out free plastic bags in order to maintain their competitiveness. This explains why smaller shops, considering the higher cost of thicker plastic bags and understanding consumers' preferences, would bear the risk of violating the bylaw and continue using the lower cost ultra-thin plastics bags (Fung, 1999).

Box. III-2 Promotional campaigns on the use of textile bags in China

A series of promotional campaigns on the use of textile bags was launched right before the enforcement of the bylaw on the ban of ultra-thin plastic bag and the use of plastic containers in specific places in Beijing. For instance, the mayor of Beijing distributed a public letter to every Beijing household informing them about the retails of the regulation and urging citizens to use more reusable bags or shopping baskets. A large promotional campaign was also organised on the day before the implementation of the law. The city government together with the Beijing Environmental Protection Foundation (BEPF) set up counters in front of main shopping centres in the four main districts of Beijing where they collected plastic bags after use and distributed nylon bags in return. About 100,000 nylon bags were distributed and more than 200,000 plastic bags were collected on that day.

The campaign was broadly covered by the media, including newspaper, television news reports, and a special television feature. In particular, it provoked considerable discussions in different newspapers by academics and government officials regarding the solution for White Pollution.

Source: Fung(1999), p 45.

2.3 Waste Separation

A cost-effective and environmentally sound waste management program requires waste separation. Composting and recycling cannot be optimized without source separation of organic waste, and recycling revenues are optimized only if recyclable secondary materials remain clean through the source separation. The amount of waste requiring landfill would likely double without up-front waste diversion programs. Waste separation usually involves asking waste generators to place their waste out for collection in either two or three streams. Waste quantity generated in Punjab is expected to increase continuously and the cost for collection, transportation, and disposal is also expected to take a large fraction from municipal budgets. More formal waste segregation will be required.

Table. III-1 Two stream vs. Three stream waste segregation

Streams	Category	Waste	Strength & weakness
Two Stream	Organics (wet)	Organics, (food waste), horticultural contaminated dry waste (soiled packaging), disposable diapers	§ Cheaper to collect § Usually minimizes waste diversion
	Inorganics (dry)	Recyclables (paper and metal), Non-recyclable dry waste (packaging, consumer products such as electronics	§ No distinction made in waste generators on what is recyclable, compostable and what is waste § Recyclables and compost may be more contaminated
Three Stream	Organics (compostable)	Organic waste for composting	§ Easier composting and recycling programs, less up-front screening required § Maybe able to take 'waste' fraction directly to disposal facility § Requires more training and participation of the public § Higher collection costs § Compostable organics and recyclables may be placed in the 'waste' stream
	Recyclables	Paper, metals, come plastics	
	Other waste	Soiled packaging, ash dry waste	

Source: WorldBank(2005. 5), p. 33.

As in Table III-1, the three stream method reduces additional work to take recyclables and volumes of wastes to be sent to the landfill sites while it requires more training and participation of the people and higher cost to collect sorted wastes. Under the two stream method, on the other hand, all wastes except organic waste are usually landfilled without any further steps to sort wastes so it costs less to collect waste than under the three stream method.

Punjab's cities currently suffer from a lack of sufficient resources - manpower and equipment to collect waste, infrastructure to recycle waste - and public awareness is low. With this in mind, the two stream segregation system is preferable to the three stream system. After adopting the two stream segregation system and becoming accustomed to it, cities could then begin to develop a more sophisticated waste segregation system.

Inorganic materials contained in combustible waste could be incinerated. However, this method is usually recommended to large cities where space for landfill may be limited and siting of landfills outside of city jurisdictions may be politically difficult. And incineration is also constrained by three key aspects; very high cost, potentially toxic emissions and an incinerator's ability to act as a disincentive to other more economically and environmentally sound waste disposal options.

3. Issues of private sector participation

3.1 Conditions for successful privatization

As the public desire for a clean environment increases, a society needs adequate waste collection services and waste treatment/disposal facilities. Regardless, the provision of municipal solid waste services is a costly and vexing problem; the extensiveness of service coverage is often low, resources are insufficient, and uncontrolled dumping is commonly widespread, resulting in environmental problems. Moreover, often local governments can not afford to provide the service to everyone. Thus, one solution commonly proposed is to contract service provision with the private sector in the belief that service efficiency and coverage will improve, and environmental protection will also be enhanced.

However, despite the efficiency of private participation, privatization is not a clear-cut solution to issues surrounding waste management service, especially in developing countries such as Pakistan where sanitation services should meet both efficiency and social welfare objectives. Private sector participation is successful only when the capacity of the private and public sectors is able enough to be charge in the waste management service. Before involving the private sector in public service, it needs to determined whether or not, or to what extent privatization is critical to achieving the goal for safe, accessible and affordable waste services (Moon, 1994: 126-30).

3.1.1 Capability of the private sector

To involve the private sector in SWM, the private contractors must have enough technology and capital investment to run the waste management service. The environmental industry, including the waste management industry, covers comprehensive technological realms from engineering and facilities/construction to equipment maintenance. When they are well situated to draw on local and international experience in the waste management field and introduce proven and cost effective technologies along with management expertise, customers could take advantage of private sector participation. In case of landfill sites or large-scale incinerators, the builder and operator of the facility should have appropriate technology and skilled technicians to control methane gas and prevent environmental contamination from leachate.

In addition, there should be a sufficient number of qualified service companies that are able to provide waste management service and competition should be created among them. Studies of privatization have found that competition is generally more important than ownership itself in explaining improvements in performance in developing countries (Kirkpatrick, Parker, & Zang, 2006: 145). This competition is expected to lead to optimization of waste service as well as lower prices.

3.1.2 Institutional capacity to meet social needs

The institutional requirements to ensure that private companies perform well are likely to be missing in many developing countries. This represents a further difficulty to significantly improving conditions in the short term through waste privatization.

Privatized waste service contracts can be set up as service contracts for the leasing and management of existing facilities, operating existing facilities without new private-sector investment, concessions requiring private-sector investment in facilities, divestitures sale by the state of some or all of the equity state enterprises, and Greenfield investments (including build-operate-transfer schemes. Thus, the local government should be able to prepare the whole process for the tendering and contract: to write competent documents for the privatization of solid waste services and to prepare government estimates for tendering. For that the former, the local governments should have information on the technical aspects of solid waste management and procurement procedures. For the latter, the local government should carefully consider the full range of costs that the private sector needs to bear including debt service on investment, insurance, registration, fair worker wages and benefits, worker uniforms and protective gear, marketing and the provision of an acceptable profit margin.

Second, the local governments should be able to control the tendering process and keep it transparent. In several South Asian countries, some form of competitive bidding was employed in public service delivery. Nevertheless, it is reported that contractor cartels were operating in many cases (Davis, 2004: 57-8.). A group of contractors have a list of contracts being offered by the official and the pre-determined winner bids for the contract. Next, the others place an even higher bid. Sometimes the winner of the contracts reimburses the losers for their bidding fees. Cartels subvert the goals of competitive bidding by deciding the outcome of such ex ante processes among their members. Elected politicians might put pressure upon an official to skew the selection of contractors. As the quid pro quo for assistance in winning tenders, the contractor gives politicians payment ranging between 1~6% of the contract value. To prevent such corruption and cartel-like behavior in bidding, the government should be able to suggest clear and transparent selection criteria and guidelines and have strong auditing procedures in place.

The government should monitor service delivery. The service provider is always motivated to reduce the cost of waste collection/treatment/disposal. After taking the garbage from the waste dischargers, it might dump the waste in undesignated places or inadequately treat the waste in order to minimize cost. Thus, the government needs to inspect and supervise the service that is being provided. Waste that is not properly treated and dumped ultimately results in more spending, considering the additional costs of treating the environmental problems that are created. Thus, the local government should be able to be vigilant in monitoring the contractor, in case of a break of the standards and regulation. Of course, it has to appropriate regulatory framework.

3.2 Strategy for the private sector participation

3.2.1 Types of contracts

The local government is responsible for the management of its wastes. In Punjab, many local governments provide the waste services by themselves. Generally, the government collection system takes public benefit as a priority more than any other considerations. Under this system, local government sanitary workers collect wastes in areas under its jurisdiction using government owned equipments. Vocational status of sanitary staffs is guaranteed as official although sanitary workers could be part time workers. The level of collection fee, service quality, and the collection area are determined through a political decision making process. The government collection system takes care of sanitary problems and environmental management more than any other organizations and performs the job at a lower cost. However, it could be sensitive to the demands of the higher government rather than that of its residents. The government system could potentially waste revenues due to unbalanced income sheet and expenditure and lack of expertise (Lee, 1983: 223-52).

Most activities undertaken by government can be done with some level of private sector participation. Solid waste collection should be a privatization priority because it is typically inefficiently done if there is no competition to government service. Furthermore, solid waste services are considered relatively easy for the private sector to undertake, considering the level of skills required, the magnitude of the needed investment, and investment risk. Maintenance of vehicles and sweeping are given top consideration for private participation. Although waste collection and transportation services comparatively require less capital investment, the government could support it financially and institutionally to attract the private sector: tax abatement.

However, in case the private sector is not capable enough to handle the collection service, a public corporation for waste collection could be an alternative to complement the weakness of the local government collection system: lack of expertise and low efficiency (Lee, 1983: 223-52). The public corporation could take over unsatisfactory companies and prevent a monopoly situation (KEI et al, 2007: 22). The income source of the public corporation would be the collection fee from households or the subsidy of the local government, nevertheless, the accounting is independent and separate from the administration. Generally, an auditing and monitoring commission is established to determine the quality of collection services. As in the government collection system, the corporation's staffs are guaranteed quasi-official status. Under the public corporation system, both efficiency and public responsibility could be secured. It can perform the service stably with expertise. In case the corporation is not able to improve efficiency and is caught in undesirable mannerism, the local government will be obliged to intervene in its operations. Frequent government interventions will eventually cause the corporation to lose its autonomy. When the monitoring commission does not function properly, the public corporation system could even be more inefficient than the government collection system.

Whereas competition is feasible in waste collection, maintenance and sweeping, it is usually cost inefficient in the market for waste treatment/disposal service. Competition in the provision of waste treatment is normally ruled out by the scale of investment in facilities and landfills. The cost of constructing a landfill and operating it is far higher, placing a serious limitation on competition. In case of a (sanitary) landfill site, it generally takes 10 or more years to cover the investment. In other words, the technology of waste treatment and the nature of the product severely restrict prospects for competition in the market and the efficiency that can result from encouraging competition after privatization. In result, it is recommended to involve the private sector in the collection and transportation step by step.

The Punjab has attempted private sector participation in large cities although Pakistan does not have enough experiences in the fields of public service provision. In Lahore, 43% of people want private sector involvement and 39% want government control (Akhtar Nazir, Country report, CDGL). 83% people are not satisfied with the present condition of solid waste collection, now the efforts is required to make the private sector more effectively involved in Punjab. However, a combination of government and private service is desirable. To achieve competitiveness, the government would provide collection service to some areas and the private sector would provide it to other areas.

Generally, franchising is the preferred method of privatizing solid waste collection in low-income countries that have very constrained government revenues. In middle-income and high-income countries, contracting for household collection services is preferred over franchising and private subscription (Cointreau-Levine, Sandra & Coad, Adrian, 2000: 18). 83% of residents in Lahore have conveyed a willingness for franchising (Akhtar Nazir, Country report, CDGL). Theoretically, individuals paying for a service under franchise arrangements have limited bargaining power with the franchisee and little influence on the quality of the service, because the franchisee has a zonal monopoly. However, franchisees are financially motivated to satisfy their customers in order to be paid, and experience indicates that franchisees are very responsive to the demand of customers.

3.2.2 Tendering

To attract potential bidders, the local government should provide reliable information on the condition of the area, market conditions, and the contract subject targets to be achieved during the contract period: frequency of collection service, location where collection service is provided, transportation and dumping provision after the collection. The specifications should focus on performance requirements and not constrain the bidder from innovation or efficiency.

While the targets should represent substantial improvements over existing service levels, they must be reasonable in light of existing conditions. The information on the existing conditions should be adequate to allow potential bidders to evaluate the cost of achieving the target and decide if they will participate in the bidding. Lack of information or an unreasonable target is likely to discourage bidders or result in excessively costly service.

When a bid is invited for waste collection service, the local government can prequalify the potential bidders. The purpose of a prequalification is to ensure that bidders meet minimum qualification criteria for the contract. The main advantages of conducting prequalification are to avoid the cost of bidding by non-qualified firms, the cost of evaluating those bids and to confirm the interest of qualified bidders. Further, the process reduces the number of competing bidders and therefore increases the chances for the remaining bidders, which in turn strengthens the bidders' interest in the process. Prequalification should be kept simple and should not normally require the preparation of a detailed proposal or commitment of specific individuals. The criteria for qualification should be specific and limited in number. Typical criteria include:

- Minimum indicators of financial performance and solvency or waste collection/transfer performance capacity;
- Description of equipment (collection and transportation vehicles)

The local government will evaluate qualified bidders to select a service provider for the area. To ensure that the evaluation of bids is transparent and objective, the local government should set the evaluation criteria and open it to the bidders. The engagement of reputable international consultants to assist in the preparation of background documentation and draft contracts contributes to their credibility and helps to place governments in a strong position to negotiate with private operators.

Table. III-2 Evaluation criteria on sanitation project in Korea

Sector	Criteria	Grade	Marks
Technical performance (5)	Environmental technician or relevant technician	Least technical manpower secured Not secured	0.5 0.25
	Equipment (one day collection capacity)	More than 100%	1
		50~100%	0.8
		Less than 50%	0.6
Financial performance (5)	Debt ratio (borrowed capital/owner's capital)	Less than 100%	5.0
		100~200%	4.0
		200~300%	3.0
		More than 300%	2.0
	Current ratio (current asset/current liability)	More than 100	5.0
		75~100%	4.5
		50~75%	4.0
		25~50%	3.5
		Less than 25%	3.0
Bidding price (90)			*
	Total (100)		

*90-20/(88/100 – tendering price/estimate price) * 100

3.2.3 Regulation

Efficient and effective service delivery, even by the local government, can be achieved when performance is regularly monitored and appropriate incentives and disincentives are applied. The monitoring and regulatory capacity of each city needs to be strengthened. The contractors and the government service areas should be monitored by an independent consulting company to optimize contestability.

The key control node of the solid waste system is the unloading point. Check points in the collection service area and along the main route to the transfer and disposal sites are also advisable. For performance monitoring of public versus private services in urban environment, records of all load volumes and weights delivered at these points are essential. For comparable performance monitoring of public versus private service, creation of an independent arrangement has merit. To this end, a separate monitoring office within local government could be created or a private consulting firm could be contracted. In Bogota, government maintained over 30 percent of the city area for its service efforts for nearly five years and the service delivery performance of both government and the private firms were comparatively monitored by an independent consulting company. The independent consulting company operates the weighbridge at the disposal site as part of its contract requirements.

All private sector waste collectors and transporters should be charged a tipping fee at their unloading point (e.g., at the transfer or disposal site). To safeguard against clandestine dumping, prohibition of clandestine dumping and vigilant enforcement would be essential. Such a program has been successfully implemented in Izmer, Turkey. Initially, tipping fees are set at a low enough rate to encourage full compliance with safe disposal. Eventually, once the discharge records of all generators and haulers are clearly established, tipping fees should cover the full costs for transfer, disposal and vigilance against illegal dumping.

Lastly, the government should provide the service for the poor. Waste management service is a kind of common good. Nobody should be excluded from the service. Nevertheless, low-income households cannot afford to consume the service. The government can consider the following in order to not exclude the poor and relieve their burden from paying for waste management service:

- § To differentiate the service rate based on the income classes;
- § To provide subsidy or tax abatement to the private contractors who provide the service to low income households;
- § To give free service tickets to the low income class.

4. Economic and financial issues of solid waste management

4.1 Economic approach to solid waste management

Economics is a “science which studies human behavior as a relationship between ends and scarce means that have alternative uses” (Robbins). There are two distinctive human behaviors which economics usually deals with: production and consumption of goods and services. Consumers are confronted with the decision of how to allocate their scarce resources to various needs; in more ‘economic’ terms, how to allocate their limited incomes to various goods and services that meet those needs. They have to decide which goods and services to buy, and how many, but this decision is subject to budget constraints. On the other hand, producers are faced with the question of which goods and services to produce, and which goods and services for production factors. What, then, are the criteria that consumers and producers apply in making decisions pertaining to consumption and production? Economists normally assume that they are ‘rational’, and the rational economic agents should maximize their ‘satisfaction’ from consumption, or their profits from production. The maximization of satisfaction or profit is the decision-making criterion of rational agents.

If a product were freely available, then people would consume the product so long as its consumption continued to provide satisfaction. What about waste? If waste was free to dispose of, then the economic agents would pay no money for a waste treatment service. Furthermore they have no incentive to reduce waste or to buy a product that leads to less waste. While waste disposal costs nothing for the individual economic agent, it is a cost factor for the whole society, as the uncontrolled disposal of waste does damage to environment and other people. Therefore a society has a different situation of decision-making than individual agents and has to weigh the costs of treatment and the environmental and health impacts of untreated wastes. The fundamental issues of the economic approach to waste management are to find an economically efficient method of waste treatment and a financing scheme of waste treatment.

4.2 Efficient solid waste treatment

The basic idea is to find an economically efficient method by balancing costs and benefits. Because the best treatment method is a method with the highest benefit-cost ratio (BCA), we need a benefit-cost analysis for every treatment method. The first step of the BCA is to identify all benefit and cost factors. At the second step both factors are quantified, and at last, a monetary value is attributed to the non-monetary factors. For all treatment methods the benefits are identical; the avoided environmental and health damages from untreated wastes.[11] For the choice of a treatment method we should therefore focus on the cost side. The costs comprise of two components, monetary and non-monetary components, which correspond to private and external costs. The private, monetary costs include construction and operating costs. Operating costs are regularly recurring costs of resources that are used over a short period of time (less

[11] We may count other factors as benefits, for example revenues from various waste charges. But this familiar practice makes it difficult to compare the project to the no-action option.

than 1year) and routinely reacquired in order to support ongoing operations. Operation costs generally include the following: Personal wages, salaries, benefits, Building and vehicle maintenance, Power and fuel, Rent and leases, Contract service, interest (including mortgage interest). Personal wages are normally the highest point of expenditure in waste management operation costs.

The second type of costs is non-monetary externalities. For example, the landfilling and incineration of waste results in gaseous emissions of various forms. One category is greenhouse gases, contributing to global warming. Landfilled waste emits carbon dioxide (CO2) and methane (CH4), two significant greenhouse gases. Where the CH4 is captured and burnt for energy production it oxidizes to CO2. Incineration of waste results in CO2 emissions, but also 'conventional' air pollution in the form of sulfur dioxide (SO2), nitrogen oxides (NO*x*), and particulates (TSP). Further air pollution in the form of CO2, NO*x*, and TSP is caused by the transportation of waste from the catchment areas to the disposal facilities. Where energy recovery is carried out, the electricity generated (it is assumed that energy is recovered in the form of electricity rather than as heat or combined heat and power) displaces that generated by other fuels. The externalities associated with old power generation will be reduced in proportion to the energy saved. Thus energy recovery *saves* emissions of CO2, NO*x*, SO2, TSP, and CH4. In addition to pollution of air, the landfilling of waste also results in pollution of land and water in the form of leachate, which is the product of the infiltration of precipitation into the landfill, coupled with the biochemical and physical breakdown of wastes. This leachate can percolate down through the landfill and there is a danger that it might enter aquifers and surface waters and contaminate drinking water supplies. Externalities other than pollution of air, land, and water include safety and congestion impacts of the transportation of waste. The health impacts from traffic emissions are of increasing concern, especially with the generally reported rise in asthma in urban areas. Another externality is the incidence and cost of casualties associated with waste transport. Finally, landfill sites as well as incineration plants have a number of local impacts. Areas of concern raised at public inquiries on the siting of landfill sites included increased volumes of traffic, odour, health risks, wind blown litter, loss of visual amenity, and noise. With respect to incineration plants, the concern is particularly related to the health effects of emissions. These factors can affect the value of local properties. The degree of value reduction and the spatial extent of its influence are open to debate. Several US studies have sought to identify this external cost. Clearly the magnitude of this disamenity will depend in the first instance on whether we are dealing with an existing site or a proposed new site. The property blight effect is likely to be more marked in the latter than the former situation.

The next step is to attach monetary values to non-monetary benefits and costs; what is called ‘economic valuation’ of non-market goods. There are two major techniques available. One, called the contingent valuation method, involves asking people directly, via sophisticated questionnaires, how much they would pay/accept for reduced/increased health risks. This approach makes it possible to estimate the benefits and costs of programs for which other techniques are generally inapplicable. However, this approach has its limitations. One is that it often requires individuals to place dollar values on things they are unused to viewing in economic terms. As a result, their responses may not be as reliable as we would like. Also, responses to surveys are hypothetical; economists prefer values revealed in actual market transactions. Another approach is to observe how much people are willing to pay for goods that have an environmental quality component. For example, houses in unpolluted neighborhoods sell for more than those in polluted areas. Using statistical techniques to hold constant the other characteristics of houses and the neighborhoods in which they are located, it is possible to identify a "clean air premium." This provides important information on the value to individuals of air quality improvement/deterioration. A similar approach for estimating how much people value pollution control and other public policies that reduce health risks is to estimate how much of a wage premium they are paid to work in jobs that pose health risks. Still other techniques infer values from such things as the time and money people spend traveling to and from desirable recreation sites.

Before we sum up the benefits and costs in monetary term, we should ask if a dollar is of the same value if it appears at a different date. Because people prefer a dollar today to one ten years from now (see interest), BCA typically discounts future benefits and costs back to present values. Not only are there technical disagreements among economists about the interest rate (or rates) at which these future impacts should be discounted, but discounting raises ethical problems as well. At a discount rate of 10 percent, for instance, $1 million in benefits to people fifty years from now has a present value of only $8,500. This powerful effect of discounting is of concern when BCA is applied to the evaluation of policies with significant intergenerational effects, such as those pertaining to the prevention of global climate change or the disposal of high-level radioactive wastes (which will be lethal for hundreds of thousands of years). But a positive discounting rate has also a rationale, because a dollar, or more precisely, a dollar’s worth of resources, can be invested and if invested wisely, will return more than a dollar’s worth of resources in the future. Despite all critiques, it is a standard in BCA to use a positive rate to discount future benefits and costs. We calculate the net present value (NPV):

$$NPV = \sum_{t=0}^{t=T} \frac{B_t - C_t}{(1+r)^t}$$

where B_t and C_t are benefit and cost at time at time t , respectively. T is a project lifetime, and r is a discount rate. We choose a treatment method the NPV of which is greater than 0 and than that of other methods.

4.3 Financing solid waste treatment

After having chosen a treatment method, we have to decide how to finance the treatment. There are two general criteria in choosing the financing scheme: efficiency and effectiveness. A financing scheme is efficient if it gives the payer an incentive to reduce wastes; and it is effective if it has no negative effect on the waste treatment. For example, an incentive-based financing scheme such as the unit pricing system is efficient, but can be ineffective under certain circumstances, because it can lead the low-income payer to illegal dumping which hinders the full treatment of waste. We will discuss various charging schemes in view of these two criteria.

4.3.1 Product Charges[12]

A product charge system is designed to minimize waste at the production step by imposing charges on the producers and importers of products. It can assign collection and disposal costs, private as well as external, to individual products. An advantage of the product charge is that it signals to the consumers, not only the cost of production, but also the cost of disposal, thus allowing the total costs of different product to be compared. This system is also expected to encourage producers to make an effort to develop products that generate less waste and to consider waste minimization when making decisions on product design, types of raw material, and production methods. Thus the product charge achieves source reduction, recycling, and a lower environmental impact via changes in the mix of products available in the market without mandating arbitrary recycling targets. However, although a product charge has the advantage, as pointed out earlier, that it allows consumers to compare the total production and disposal costs of different products and thus offers them an incentive to adjust their behavior accordingly, it has the disadvantage that high levels of information are essential. It is necessary to assign a different cost element to each product, which can become a very complex task. Therefore, it is common practice to assign only private monetary costs of collection and disposal that are relatively easy to calculate. But the efficiency criterion is then not fully satisfied.

[12] Summarized from Pearce/Brisson (1995).

In Korea, we had a product charge system which is called waste treatment charge. This charge system was established to curb consumption of products and containers which are difficult to collect, treat, or recycle, or likely to render waste management generally difficult. It imposes charges on firms that produce these types of products.

Charges have been imposed on manufacturers of several particular products since July 1993. Several products which had previously been subject to the deposit system were added to the charge list in 1993 and came into effect from January 1994. In all, the products now affected by the charge system, be they imported or domestically manufactured, include confectionery products, anti-freeze, fluorescent lamps, chewing gum, disposable diapers, insecticides, butane gas products, toxic substance containers, cosmetics, and batteries, among others. Synthetic resins were also added to the list in April 1994.

4.3.2 Manufacturer Take–Back Programs[13]

Manufacturer Take-Back Programs also focus on the producer. Firms are required to accept their own packaging and products back from the consumer, after use, and then dispose of it. In many OECD member countries producers are subject to Extended Producer Responsibility (EPR) provisions that require them to take partial or complete responsibility for the packaging and product waste resulting from their business activities. This policy should give firms the proper incentive to reduce packaging and to design more recyclable products. However, this policy alone may not do enough. If the firm is only responsible for the private cost of waste disposal, it still does not internalize the full social cost. Therefore, firms may still need to be made to pay the full marginal external damages of disposal. If firms internalize this cost, then they have the right incentive without requiring taxes on packing, disposal-content charges, recycled-content standards, or subsidies for “eco-design”.

4.3.3 User Charges[14]

Unit Pricing System

A unit pricing system requires households to purchase a special bag, container, or sticker for every unit of garbage they generate. Instead of viewing garbage collection as free, households face positive price for every garbage bag. Theoretically, this system can stimulate households to recycle more of their waste. (Cf. OECD.2004) With the bag system used generally, refuse is placed in easily identifiable bags offered for sale by the local government or by a vendor.

[13] Summarized from OECD (2004).
[14] Summarized from Prete (1991).

Consumers may purchase bags at supermarkets, convenience store and other locations. Often, a fee is charged by the merchant to cover handling costs, however most merchants will recognize the benefit in selling a mandatory product, which increases traffic in their store. The price of each bag reflects the cost of collection and disposal of the waste and of the recycling programs. The incentive is to cut costs by reducing the number of bags set out for each collection is relatively simple for accounting and administrative departments. Because consumers pay for bags immediately upon purchase, there is no billing or data entry necessary. With the use of the variable size of container system, refuse can be set out in one of several size containers made available by the government or by a vender. Different rates are charged for different size containers, creating the incentive to use the smallest container practical.[15]

Fig. III-1 Garbage bags (left) and wheeled containers (right)

With the sticker system for bulky waste, refuse is collected in the same manner as in the past-in

[15] A similar type of unit pricing is a differential and variable rate scheme (DVR), as used in Germany. Before adopting DVR, a household using a 120 litre bin was charged 170 euro per annum. Because of changes in the law regarding waste disposal, a sudden increase in costs of around 25% was being anticipated. In 1997, the country decided to take additional steps to reduce costs through the quantity of waste for disposal. They reduced waste for disposal through improving incentives for management/reduction of waste by household. The charging system was improved and it is based upon a three-part tariffs. The three-part tariffs are: (1) A fixed fee. this was intended to cover the fix costs of collection infrastructure, the collection of types, fridges, special waste, etc. This fixed element does vary with the size of residual waste bin chosen (the fixed fee is only linked to the refuse bin). For a 120*l* bin, in 2002, the fee was EUR 8 per month, and for a 240*l* bin, the fee was EUR 16 per month. The minimum bin size is 120*l*. It is felt that the smaller bin is unlikely to lead to optimized collection of the different fractions. (2) A fee per emptying of any bin. The basis for the ‘emptying charge’ is the amount saved by not emptying a bin. This was calculated as EUR 0.20 per emptying. (3) A weight-based fee. This was set at EUR 0.25/kg for waste and EUR 0.15/kg for bio-waste in 2002. Under the system, though collections are only fortnightly, the set out rate is close to 50%. In other words, on average, many householders set out bins approximately once a month and the set out rate tends to be lower to those using smaller bins. Cf. OECD.2006.

the same or new containers, but collected only if the container displays a sticker or tag purchased by the resident from government or private service provider. The cost of the sticker varies according to the size and type of item being discarded. The incentive is to reduce the cost of waste disposal by reducing the number of stickers purchased which can be accomplished by setting out fewer containers. Administratively, stickers work well because they are small, convenient, and require no record keeping or data entry.

A unit pricing system would only be fully efficient if the price reflects the full social costs of waste treatment. Therefore a uniform price on all types of waste would be theoretically inefficient, because the materials in the garbage bag have usually different social costs: for example, the social disposal costs of an empty battery would easily exceed those of old newspapers. But a variable unit pricing system based on the social costs of the contents of the garbage bag is practically impossible. Another problem with the unit pricing system is illegal dumping and inclusive private burning. Available data doesn’t provide clear evidence as to whether unit pricing has a significant effect on illegal dumping practice (cf. OECD. 2004). But the possibility of illegal dumping should depend not only on the magnitude of price rate, but also on institutional factors such as citizen awareness and governmental enforcement capability.

User Charges for Revenue Raising

There are several user charge systems that don’t stimulate consumers to reduce wastes and only serve to raise revenue for waste treatment. One of such charges is the flat-rate charge; all residential customers are charged the same price, which is based on the cost of the provision of service. The basic problem with the flat rate charge, whether charged by local government or a private contractor, is that the bill received by the citizen in no way reflects the volume or types of materials discarded into the waste stream. With this approach citizens have no incentive to change their consumption patterns or to purchase products which are more durable or recyclable. In addition, this system provides no incentive for participating in any excising recycling programs. Another charge system for revenue raising is the charge based on property tax; the citizen pay waste treatment charge that is proportional to their property tax expenditure. This charge system also gives no price signal to reduce wastes. Only for the revenue raising, it is also possible to finance the waste treatment by raising other taxes that don’t have any relation to waste generation or treatment. A gain in efficiency can’t be expected under such revenue raising charges.

Box. III-3 Volume-based waste fee (VBWF) system in Korea

Until 1994, fixed amount of waste collection fee was imposed on household according to the number of households or property tax. This system gives the generator incentives for source separation and reduction of waste. There are volume-based waste fee system came into effect across the country on January 1, 1995. All of the households and small scale generators of commercial sector and industry are required to buy trash bags, which are supplied by local municipality, in order to emit garbage which is not recyclable.

This system was developed with the objectives of reducing the volume of wastes discharged by households and small businesses, and promoting recycling by imposing a waste fee based on the volume of wastes discharged.

The fee applies only on wastes from households and small business. Resort area such as mountain parks and beaches are included in the system and thus tourists must purchase the designated bags at the entrance to those areas. The waste fee is included in the price of the plastic bags that are produced in the city of the county. The prices of the plastic bags vary as each city or county is responsible for determining the price of the collection fees, in regards to the district's financial situation, cost of treatment etc. The bags are only useful within the district in which they have been produced.

The fee does not apply to burnt coal briquettes, recyclable wastes, or big home appliances such as discarded refrigerators. Recyclable materials such as newspaper, metal cans, glass bottles and PET bottles are exempted from using designated bags. Firms, buildings and shopping arcades producing more than 300kg/day have to treat wastes on their own expenses and thus they are not included in the system.

In cases where the designated plastic bags are not used and wastes are disposed indiscriminately in inappropriate sites such as mountain areas or are illegally incinerated, a maximum fine of KRW 1 million (USD 950 as of June. 2007) will be imposed on violators.

4.3.4 Deposit-Refund System[16]

Under the deposit-refund schemes (DRSs) distributors (or manufacturers) levy a certain amount of deposit on the retailers. Retailers in turn include this amount in their sales price; for example, the customer can obtain a 5¢ refund by returning the container to any retailer that sells the product or to a redemption center. DRSs are relevant usually in a limited number of cases as it would hardly be feasible to operate a DRS for all waste. Also, economics tells us that DRSs should only be employed where the benefits outweigh the costs (cf. benefit-cost-analysis). This can either be the case in a market-generated system, *e.g.* beverage containers, where the costs of operating the system are less than the expected overall revenues to the producer. This is usually because V (the net reuse value of the scrap item) is positive, or because the refund, R, stimulates a significant increase in demand, sufficient to offset a negative value of V. Alternatively, schemes can be imposed by law in cases where the social benefit of retrieving a product outweighs the costs of operating the system. This is particularly relevant in the case of hazardous materials, which, if disposed together with ordinary mixed waste, can create unacceptable hazards. A DRS will help retrieve such materials for safe disposal. The administrative cost might be quite low if the DRS is implemented implicitly by the use of a sale tax on all purchased commodities at the same rate, together with a subsidy to all recycling and proper waste disposal. This practice is currently followed in the US, since local governments do impose local sales taxes and they do provide free collection of curbside recycling and garbage.

Evidence from a number of DRSs for beverage containers has also indicated that return rates are not very sensitive to the size of the deposit. A much more important factor in this context has been the number, knowledge, and convenience of container return points. Inconvenience costs to consumers may well fall over time as individual adjust to the returnable system. Government/legislation could mandate the required number and type of returning points which, in turn, would boost return rates. The downside of this approach is that the greater the number of returning points the higher will be the overall system costs for handling, storage, and transport of returns.

The objectives of deposit-refund system is to reduce the volume of waste and to encourage retrieval of reusable items. Producers and importers of recyclable goods are required to make cash deposits of set amounts, and they will be reimbursed according to their performance in retrieval and treatment. Since deposit is charged to producers instead of consumers, main objective is to induce producers to reuse and recycle materials. This is the major difference

[16] Summarized from OECD (2004) and Pearce/Brisson(1995).

from the consumer’s deposit system which focuses on recycling and littering prevention.

4.3.5 Federal Grants

In most countries local governments are responsible for waste treatment. The federal grants that are provided for financially weak municipalities represent an additional, significant financial source for them. But federal grants not only compensate for the weak financial basis of local governments; they also sometimes enhance the allocation efficiency. Let’s consider a land-filling project which a municipality plans to implement. It made a benefit-cost analysis and found that the costs are less than the social benefits, but exceed the benefits for its residents. From the viewpoint of the whole society the municipality should carry out the project, but not for itself. In this case a federal grant which corresponds to the ‘external’ benefits (i.e. spill-over effects on the neighboring municipalities) can revive the project.

4.4 Policy Suggestions

Costs for solid waste management are currently covered by general budget revenue of local governments. But this financing scheme is not sustainable, because demand for local public services including waste treatment increase rapidly, while the financing sources such as property tax and federal grants are usually limited. In addition, the scheme is not efficient, as it can provide the waste generator with no incentive to reduce waste. Most countries now employ economic instruments to stimulate prescribed behavior via incentives and/or raise revenue. In principle, one of the main advantages of economic instruments is that they provide a continuous incentive effect which stimulates waste generators to seek out the least-cost combination of disposal, recycling and reuse that is available to them. However, the efficiency and environmental effectiveness of such instruments depends on the institutional condition under which instruments are applied. Many developing countries including Pakistan lack an extensive and effective waste and pollution control system (legislation, facilities, manpower and infrastructure). In such an institutional context it is very probable that any new substantial charging system, for example, will merely provide waste generators with an increased incentive for avoidance and stimulate more 'illegal' dumping of wastes. The end effect will be a significant increase in costs, both in terms of increased health hazards and increased monitoring and enforcement costs, which developing economies can ill afford. Therefore, in that situation we should give more attention to the revenue raising function than to the incentive effect of economic instruments.

The current financing scheme should be replaced stepwise by a user charge system. Economic instruments such as user charges, provided they are set at relatively modest rates, can provide much needed finance for the enhancement of waste treatment facilities and infrastructure. In the short run cities need a user charge system that can raise revenues for waste treatment, but that neither requires excessive enforcement costs nor gives incentives to illegal dumping. Such a user charge system is based on the size of the residential houses and commercial buildings. This system can be easily implemented, because local governments have already collected necessary expertise and information with the property taxation system. Under this charge system users pay for public waste services, but have no incentives to dispose their wastes illegally, as the payment is independent of the amount of waste generated. For the same reason they also have no motivation to curb waste generation. That is why the financing scheme should be moved in the long run into incentive charges, for example, the unit pricing system. But the change in financing scheme requires not only new legislation or an improved infrastructure, but also extensive capacity building in terms of enforcement agencies and increased public awareness in waste issues.

Table. III-3 Stepwise introduction of financing instruments

	Short -term	Mid – term period	Long – term
MSW	General revenue; added at Property tax depending upon housing size	Low rate of user fee on households using separate waste bill-property tax	Unit pricing Volume based Waste fee
Purpose	Revenue raising	Rev + Incent	Incentive effect
Recyclable waste	Free collection	Free collection	Free collection
	Pilot implementation of separation at some target regions	Extend target regions which separate recyclables	Extend whole area of Punjab

To adopt the user charge system in waste management, the SWM revenue and expenditure account should be managed separately from general budget revenue of the local government. The account should include the items in the table below:

Table. III-4 SWM account for revenue expenditure and income

Description	Account
Revenue	Provincial grants User charge

Expenditure	Facility construction	Landfill Composting facility Others
	Collection and transport	Labor cost Transport cost Equipment maintenance Equipment purchase Contract cost Waste treatment facility operation cost

5. Collection zoning

As suggested earlier, the collection system should be determined according to the characteristics of the area. Some areas have roads wide enough for the collection vehicles and have spacious yards for garbage bins while other areas have narrow streets and residents who can not afford to put garbage bags or can in the house. In this study, residential areas are divided into four zones according to its population density, types of houses and accessibility. These are Zones I, II, III and IV.

Table. III-5 Definition of collection zones

	Zone I	Zone II	Zone III	Zone IV
Types of houses	Single family homes or townhouses	Single or multi family homes	High density	No property
Population density	Low	Middle	High	Rights, tents
Access road	Wide	Wide to narrow	Narrow	-

Zone I consists of individual houses like mansions or apartments. The population density in this type of area is low and the roads leading to the houses are wide. The road network is well developed making it possible for the vehicles to get to the entrance of each house. Therefore, door-to-door collection is recommended with compactors and open trucks as collection vehicles. A compactor is expected to cut the transportation expenditures because it reduces volume of wastes. An open truck could pick up large volumes of wastes, both residential and those that were illegally dumped. The most of Zone I already adopted waste collection services and some of them even practice waste segregation and recycling. Zone I has much more room for waste segregation than any other Zones. Zone II is composed of single or multi-family homes, which include residential-complexes, where the income is at mid-level. Door-to-door collection is also applicable in this zone using a compactor. Arm roll container could be used for areas where door-to-door collection is not applicable due to poor accessibility. Zone III covers areas with narrow alleys. The alleys are too narrow for door-to-door collection. For this type of areas, arm roll truck and open truck are suitable. Zone IV is composed of slums where people live in tents without property rights. Their scavenging behavior and unsettled domicile renders the area unsuitable for door-to-door collection. It is, however, applicable to install arm roll containers in the area. Door-to-door collection could be implemented later as living standards and waste disposal methods are improved in these areas.

6. Community capacity building for SWM

Incubating public awareness is a key to successful waste management. Waste is the result of human activities and everyone needs to have a proper understanding of waste management issues, without which the success of even the best conceived waste management plan becomes questionable.

In order to create and enhance public awareness, the public must be aware of the environmental impact and economics of waste management. First, education and advertisements should provide the information that illegal dumping and inadequate disposal cause environmental pollution on air, soil, ground water, and influence public health negatively causing diseases. It can be approached by suggesting a vision of a clean and pleasant city. Emphasis should also be placed on the economics of the waste management. Public education and social activities would make people consider the notion that recycling saves natural resources and creates profits for the public and society.

6.1 Responsibility of governments

First of all, recognizing the importance of the waste issue and its responsibility for it, the District/Tehsil government should set a vision, goals, and a strategic plan to implement them.

To promote the sub-government participation, each District/Tehsil government should give the guidance to waste management in town/union administration and cooperate with them that their practice such as cleaning campaigns, and host contests to increase civil participation.

The educational campaign for encouraging waste separation and recycling may require additional effort to generate more far-reaching effects. According to experience from other countries, such as Sweden and Japan, discussion and education on solid waste problems seems to be always the first step in raising public concern of the environment, and could also result in the long-term effect of changing people’s consumption behavior.

For example, Japan has been practicing a comprehensive source-separation and recycling program for a long time. The main driving forces of which are the shortage of available land for building new landfills, the country’s heavy reliance on imported primary raw materials and the rising concern about pollution from landfills and incinerators. Community participation is highly regarded for facilitating a highly coordinated solid waste program, with the involvement of not only residents, but also other actors like local industries and citizens’ organization. For achieving this, a wide range of public educational methods was designed to promote communal participation.

In Pakistan, creative efforts should be made to involve local formal and informal communities such as the women folk or village boards in recycling or cleaning a village and even self-monitoring on illegal disposal. Municipal governments could appoint a civil inspector in the community, cooperate with non-governmental organizations and train women folk on aspects of community mobilization, or give financial or administrative incentives (e.g. sending representatives of the communities on field trips to SWM sites and an advanced model city) to a best practice community. A communication channel between a municipal authority and grass root residents (I don’t know this term) through such programs could and should be formed.

6.2 Educating solid waste management officers

In order to guide citizens and properly operate a solid waste management system, officials in charge of waste management should properly understand not only the policy and strategy of waste management but also its environmental impact and social values. Punjab government needs a comprehensive environmental education organization that provides training programs for the SWM staffs and NGOs in Punjab. After the education program stays on track, it could function as an education organization for students and citizens or a comprehensive waste management organization paving the way for the stable operation of national or provincial waste management policies or establishing an infrastructure for comprehensive waste management from the generation of waste to its financial treatment through promotion of waste reduction, recycling, and proper treatment.

6.3 Public awareness building

All residents should contribute to managing the waste they produce. It is necessary to give the public knowledge on what they could and should do to improve their own and their neighbors' environment. Information to be provided to the public is as below:

§ current general situation of waste generation
§ environmental impact of illegal dumping and littering
§ penalty like fine when waste is illegally discharged
§ economic benefits from appropriate treatment and recycling
§ guidance to adequate waste management
§ successful examples as inspiration

Generally, poster campaigns are cheap and effective in terms of public education and are considered to be the most effective means of communicating sustainable waste management. Leafleting and postering in public places, such as mosques and PCOs (Public Call Offices) are effective to give people the message that antisocial waste management practices are not acceptable in a civilized society and useful to promote awareness of the issues of sustainable solid waste management.

Fig. III-2 Guide to waste management, Halifax regional municipality in Canada

Mass media including TV, radio and newspapers should be considered. Campaigns and television advertisements aired on Punjab cable networks are powerful communication mediums that could provoke considerable discussions.

Teaching children about the cost and environmental impact of waste management and the need to "Reduce, Reuse, and Recycle" their waste will benefit future generations, particularly if they are encouraged to consider the environmental impacts inherent in their shopping patterns. Educating children not to throw away their waste irresponsibly will be informally transferred to their parents, thereby spreading the message. Cleaning a school classroom and separating wastes by themselves as a regular practice will help to form a degree of consciousness of waste management as a part of their daily lives.

Events arouse attention from people in the initial steps. Contests of students' art works or essays with a recycling theme will spark an interest in waste issues among both students and parents. Lectures, photo exhibitions and informational displays on recyclable products at mosques or community centers are also effective in attracting attention.

Fig. III-3 Palette and bucket by used PET bottles and caps

In addition, environmental awareness campaigns are also needed for waste workers. Because the public often perceives waste pickers as social outcasts and thus a marginalized and stigmatized segment of the general population, policy makers at the municipal level should organize sensitization and awareness raising campaigns aimed at making the city's population aware of the useful tasks the waste pickers perform in the waste cycle.

6.3.1 Responsibility for maintaining cleanliness

Deserted garbages can often be found in vacant lots in urban areas. In order to prevent such act of negligence by the owner of the building or land or act of mal conscience by wrong doers, responsibility for maintaining cleanliness was introduced. In this scheme, mayor or the head of provincial and local government can issue an order to the owner of the land or premise to clean-up deserted waste or incinerated (burnt) waste. If the order is not complied within a month of issuance, the owner of the land can be fined for act of negligence.

This scheme was introduced through the revision of the article 7 of the Waste Management Act, in 1999 in Korea. The Act emphasizes the need for cleanliness of buildings and lands, and mandates necessary actions to be undertaken if cleanliness is not maintained.

After the enforcement of this scheme, many examplery cases of improvement of vacant lots has been on the rise through such activities as growing of flowers or turning the vacant lot into a parking space.

Box. III-4 Preventing illegal dumping in Korea

In cases when designated Volume Based Waste Fee (VBWF) bags are not used and wastes are disposed indiscriminately in inappropriate places (i.e remote hill areas) or illegally incinerated, a maximum fine of 1 million won (USD 950) is imposed on the violator.

Rewards for reporting illegal waste dumping

Anyone found to throw away garbage without using VBWF bags or illegally burning waste is imposed with maximum of KRW 1 million (USD 950) of negligence fine, in accordance with the waste management law. Since imposition of fines for unlawful activities have its limitations in effectively preventing such behaviors, the reward system for reporting unlawful activities was introduced in 2000. Anyone who reports unlawful activities is paid as much as 80 percent of the fine charged to the violator. This system contributed to expanding the social awareness on preventing the indiscriminate dumping of wastes. Members of social groups and environmental NGOs are appointed as the voluntary monitoring group for unlawful dumping. Unlawful activities can be reported through environmental pollution report center or through the internet.

Village-level VBWF system for rural areas

In rural areas, houses are scatterly located and there is a long tradition of burning or disposing waste in an indiscriminate manner. Therefore, a different system from urban areas was introduced in July 2002 to effectively deal with waste problem in rural areas.

In village-level VBWF system, the head of local municipalities is required to install community waste collection bins and recyclable waste bins where residents bring their waste and the municipality conduct waste collection duties. The waste collection fee is levied on the whole community and the payment is made through the village fund. Later, each household is charged on an average rate.

In order to prevent illegal waste dumping, supervisors for waste collection is designated and voluntary monitoring group is formed. Agricultural waste vinyls, pesticide bottles, and recyclable items are separated from regular household waste, and agricultural machinery and waste oil are collected separately and transported to the nearest recycling centers.

7. Legislation of Punjab waste management act

In the long-run, it is crucial that waste management be supported by legal arrangements which provide a systematic guideline for waste management nationwide. While statements on sanitation are usually very positive in long-term plans and development strategies, generally, waste management as a priority is not as high as other development priorities(World Bank, 1997). Thus, Punjab should have a comprehensive municipal solid waste management act to minimize the generation of waste and to properly treat it. It should provide coherent direction to sanitation administrators of local governments through the municipal SWM bylaws specifying the provincial act. Core contents of the act are suggested as below.

Table. III-6 Suggestion of Punjab waste management act

Provisions	Contents
General Provision	§Purpose, definition of terms, scope of act
Waste classification	§Municipal solid waste §Industrial waste: general waste, hazardous& medical
Share of waste management Responsibility	§GoPunjab - technical, financial support to sub-governments §CDGs / TMAs -adjustment of waste management projects - technical, financial support to sub-governments §Town and union - waste collection / transportation / treatment §Citizens - proper discharging of waste - waste reduction and recovery; sweeping and cleaning
Waste management plan	§GoPunjab - establish comprehensive waste management plan §CDGs / TMAs - establish waste treatment action plan
Waste collection / transportation / treatment	§Responsibility to follow the waste collection/transportation/treatment guideline §Setting waste treatment standard §CDGs / TMAs - responsible for providing waste collection service and to maintain sanitary environment - authority to charge the waste collection and treatment fee - authority to mandate waste service - regionalization of waste treatment facility operation
Recycling	§GoPunjab and CDGs / TMAs - responsible for promoting recycling among Citizens -responsible for waste separation
Waste treatment facility	§Criteria of selecting waste treatment facility location §Environmental impact assessment on the installation of the facility §Conflict resolution channel
Inspection and supervision	§Inspection and supervision on waste treatment contractors, illegal behavior of waste disposal, collection, treatment, etc.

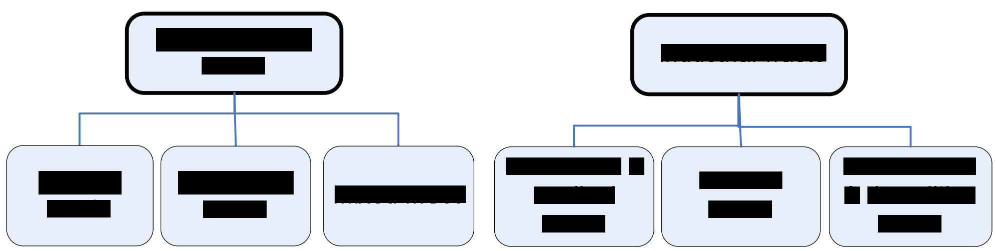
7.1 Purpose of the waste management act

The waste management act aims ‘to properly collect and transport waste generated in local governments in Punjab, treat it appropriately and making a pleasant province’ as the basis of all waste related measures. It adopts new concept to reduce the waste generation rather than just to treat waste properly. Thus, it wants to make sure all residents live in a clean and sanitary environment without negative health impact due to waste.

7.2 Classification of waste

Pakistan Environment Protection ACT 1997 (PEPA) defines municipal, hazardous, hospital, industrial, agricultural, organic/inorganic waste. But it needs classify waste by its sources and compositions. Although any number of solid waste source classifications can be developed, the following categories have been found useful.

Fig. III-4 Classification of waste



7.3 Responsibility of local governments and citizens

The act declares the responsibility of GoPunjab, local governments and its citizen. By the act, local governments should be obliged to investigate current status of waste generation and treatment within the jurisdiction, appropriately to treat and dispose waste. And it should try to induce proper waste generation at designated area incubating the public awareness on cleaning. GoPunjab should support the local government financially and technically to achieve its duty. The citizen should make an effort to dispose waste properly and sweep its community area and keep it clean.

7.4 Establishment of comprehensive waste management plan

GoPunjab should establish a long-term plan for the waste management every 10 years and obtain and provide guidance to local governments. Based on the comprehensive waste management plan by GoPunjab, CDGs/TMAs should establish the waste treatment action plan and then obtain approval of GoPunjab. Although CDGs/TMAs are responsible for the waste service within its jurisdiction, they cannot afford to forecast future amount of waste generated in the area. Thus it is desirable that GoPunjab establishes the comprehensive waste management plan. The comprehensive waste management plan should involve following contents: 1) evaluation of previous waste management policy, 2) current status and forecasts of waste management, 3) tenets of the policy, 4) waste management policy of each areas, 5) budget and financing plan.

7.5 Responsibility to obtain waste statistics

Survey on waste statistics is critical as it provides fundamental information to develop the waste management policy. Every level of government, GoPunjab, CDGs/TMAs, and towns/unions has duty to investigate waste related data. In principle, it should be conducted by CDGs/TMAs who are responsible for waste treatment. In practice, CDGs/TMAs are constrained to have budget or proper survey methods to do it. To collect coherent data, it is recommended for GoPunjab to collect waste with assistance of CDGs/TMAs (Kim, 2003: 74-80).

The Urban Unit can survey the data with cooperation with the statistics team in GoPunjab. It should conduct a province-wide sample survey every year. It must analyze the composition of waste from each source as it is critical to prevent the waste generation and establish recycling policy. For industrial waste, as waste generation reflects economic development, waste data should be collected and recorded by types of industry (Kim, 2003: 74-80).

7.6 Waste collection, transportation and treatment

By the act, everyone involving waste contractors in charge of waste collection, transportation and treatment should comply with appropriate criteria and procedures. It should be declared in the act that CDGs/TMAs are responsible for the collection, transportation, and treatment of solid waste within its jurisdiction, though the Punjab local government ordinance (Section 36 and 54).[17] The act should give authority to charge waste service fee.

[17] Punjab Local Government Ordinance, Section 36. [Integrated management of services in City District] on creation of a city district under Section 8, the organizations and authorities providing municipal services and facilities and the offices decentralized or set up in a tehsil or

And the act should allow CDGs/TMAs to cooperate waste treatment with other CDGs/TMAs. It could be inefficient that a CDG or TMA operate the treatment facility which has economy of scale. Thus, the provision allows CDGs/TMAs to operate the facility and treat the waste together. The act should be declared that CDGs/TMAs can mandate the waste service to a qualified agency. The agency operating waste treatment facility is obliged to hire qualified technicians maintaining and managing the facility.

An industrial waste generator has duty to reduce the amount of waste generated and improves the discharged waste to be treated properly. And it has to record the current status of waste generated, recycled, disposed and keep the record as the record is critical to forecast waste generation and to appropriately treat the waste.

7.7 Waste treatment facility

While Punjab Local Government Ordinance declares the duty of waste treatment and waste facilities, it does not deal with further issues related to the facilities. It need provide legal basis to set criteria for locating the waste facilities and implement the environmental impact assessment on the facilities. In case that conflict among stakeholders occurs, it should legally support conflict resolution channel to solve it. The upper government has the authority to arbitrate the conflict.

7.8 Recycling promotion

GoPunjab and its local governments should promote recycling in its jurisdiction and enterprise should comply with governmental measures to increase recycling. The citizen is responsible for separating the recyclables from other wastes.

7.9 Inspection and supervision

By the act, waste generators and waste service contractors should be monitored if they treat waste appropriately, charge the proper level of fee on the service, and implement administrational measures. Local governments have also responsibility to check if the service contractor has sufficient equipment and skills to do the job.

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tehsils or districts notified to be City district shall come under the administrative and financial control of the City District Government.
Sectioin 54. (1)-(h)- (ii), the functions and powers of the Tehsil Municipal Administration shall be to provide, manage, operate, maintain and improve the municipal infrastructure and services, including sewage and sewage treatment and disposal.

Table. III-7 Waste-relevant laws in Korea

Laws	Contents
Waste Control Act	Preliminary and general §Classification of waste: municipal / industrial /designated / medical waste §Range of the law: the law does not deal with radioactive waste, sewage, waste water, excretion, carcass, sea waste §Waste management framework plan: the city and province to establish a waste management framework plan every 10 years §Responsibility to survey statistics on waste Waste discharge and treatment §The service provider has the authority to charge a service charge §Waste management criteria §Mayor's responsibility on the waste management and charging Designated waste §Duty on the proving of designated waste treatment and inspection service of monitoring agency Waste treatment company §Types of service and what happens when the service provider withdraws and cancels its license §Auditing and supervision of service §Sequential management measures Inspection and supervision of waste treatment contractors §Qualification of technical managers and education and training on waste treatment managers §Measurement to prevent waste
Waste Control bylaw of Seoul	§Support for the waste management industry: facilities, manpower, equipment, cost, technology, etc. §Tipping fees §Service areas of solid waste collection and transportation §Inspection and supervision of waste treatment contractor §Rewards for reporting on illegal dumping §Civil participation §Civil conference §Waste statistics research §Process of charging penalty fee

Source: Waste Control Act, Waste Control bylaw of Korea

8. Formalization of informal waste pickers' activities

8.1 The need for formalization

While recycling activities are a valuable contribution to resource recovery and provide an important income for the waste pickers, it must also be borne in mind that these activities often disturb the collection and disposal process (IP: 16). Waste pickers or scavengers burn waste while looking for valuables, scatter waste collected in containers, delay and interfere with the work of equipment, especially in landfill sites. Also, waste picking poses substantial health and safety risks to scavengers. Therefore, there exists a strong need to formalize their activities and enhance their quality of life.

There are many ways for governments, planners, nongovernmental organizations, and others to address the needs of waste pickers, while also helping to meet the objective of operating a municipal waste management system efficiently and effectively. These may involve technical solutions to raise the productivity of waste pickers and improve the health and safety conditions under which they work, measures to improve waste pickers' housing and living conditions, training to enhance their employment options outside of waste picking, assistance to help them start and operate small recycling enterprises and assistance with organizing cooperatives.

8.2 Two approaches to formalization

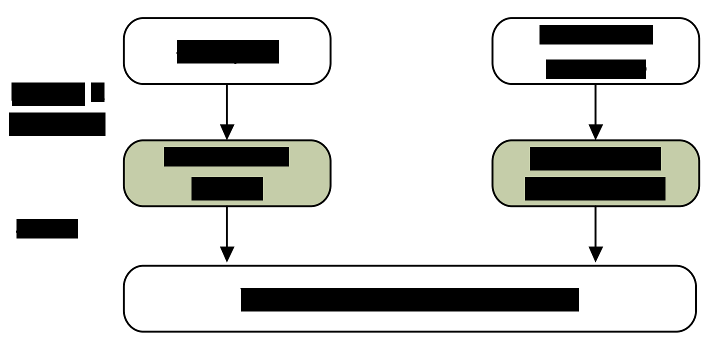
The best social program for waste pickers might be one that will provide them a stable opportunity to make their living. In this aspect, the local governments and companies in charge of waste collection and treatment take measures to organize waste pickers into formal work solving the lack of labor and providing the income.

The types of work waste pickers can participate in could vary according to their main locations of waste collection. Waste pickers could be categorized into two groups: street waste pickers and dumping site waste pickers. Street waste pickers collect waste from waste containers or waste receptacles in commercial or residential areas or garbage bags found on doorsteps. Most of them are not unorganized and move freely in and out of the occupation as their individual circumstances change. As they are the first to extract anything from the waste source, there is a greater chance of extracting valuables such as recyclable material compared to dumping site waste pickers. Dumping site waste pickers work in a landfill site. Waste coming into a landfill site contains comparatively less valuables as street waste pickers already took much of them while they don't need to hang around dumpsters and waste containers. They live in or near a landfill site. Waste picking in some landfill sites is carried out by cooperatives of waste pickers or controlled by organized groups of intermediaries to improve the efficiency of the work and incomes. Two groups' activity could be organized as seen in Fig. III-5.

Local governments encourage households and enterprises to separate their recyclables before discharging them on the street for pickup. Street waste pickers could be involved in collecting recyclables separated at their source. Sweepers should inspect and supervise if they scatter waste and make the street dirty. Instead of allowing them to collect recyclables, they could own and sell what they collect. As there is no incentive to attract waste pickers' participation, it could be considered that the local government or private company in charge of waste collection in the area provide a subsidy to them. When a private company hires waste pickers, the local government should also inspect not only their performance but also the possibility of whether or not the company is exploiting them.

In Lahore, the private contractor offered waste pickers the job of the waste collection. They collect the waste and take it to the collection point and sort it for recyclables. The contractor allowed them to take the sorted waste in lieu of the monthly salary that would otherwise be paying to the sanitary workers. The monthly salary would then become the income instead of the sale of recyclables. Waste pickers would complement the lack of manpower. In Cairo, the government integrated the wahis and zabbelin into the formal mechanized waste collection system by having them establish legal companies and comply with the municipality's requirements. Many cooperatives have also obtained the exclusive rights to carry out recycling activities. In Pune, India rag pickers cooperatives, recycle 25 percent of waste generated by the city's one million residents (Medina 1997a).

Fig. III-5 Incorporation of scavengers into formal SWM system



For waste pickers in landfill sites, it is suggested that local governments provide areas or infrastructure at landfill sites where waste pickers can safely sort waste before it is buried in the landfill. A conveyer belt or a table designed for sorting makes their work safer and more efficient in reducing the amount of waste which will have to be buried, and also makes supervising an easier task. In Rio de Janeiro, the landfill site includes a covered area with picking belts operated by a cooperative, which receives all the income from the operation (World Bank and SKAT 1998). The Bank-financed Mexico Northern Border Environment Project and Second Solid Waste Management Project both included covered sheds with slow-moving conveyor belts just outside the landfills for waste pickers to use. Providing such conveyor belts, however, raises the costs of the landfill operation. According to some analysts, a minimum 10 year life span for the landfill would be needed to justify the costs (Rushbrook and Pugh 1999). To make working areas and tables in a landfill would be reasonable in Pakistan at this point.

It is important to provide clean water and sanitation facilities at dumpsites where waste pickers can wash as dangerous waste items may pose risks of infection or injury. To ensure that these facilities continue to function after being built, program designers should establish rules of access and provide resources for their regular cleaning and maintenance. If a cooperative or a private recycling firm has been given exclusive access to the site for waste picking, planners should consider giving ownership of the facilities to the group.

Box. III-5 Wahis and Zabbelin as a part of the formal waste collection system of Cairo

When converting Cairo's waste collection system from one based on donkey carts to one based on mechanized trucks, the municipal government encouraged wahis and zabbelin to establish legal waste collection companies and obtain a license for garbage collection.

Informal collectors are now in charge of most of Cairo's municipal solid waste management collection. In cases when the municipality licensed companies that were not under the control of the informal collectors, the wahis and zabbelin have sometimes violently confronted such companies, forcing them to leave the area. This happened in Zamalek and on some routes in Nasser City. However, some private firms have made agreements to sell the household wastes they collect to the zabbelin. This has enabled them to operate in peaceful co-existence with the informal collectors.

Source: Volpi(1997)

Enhancing employment opportunities of them and their families the governments should encourage waste pickers to find a job in the formal sector instead of waste picking. They need vocational training, with literacy training as a top priority. Training in health, hygiene, child care and family planning is also critical, particularly where women and children constitute a large proportion of the waste picker population. The curriculum and the schedule of classes should be developed with the waste pickers themselves. In many cases it will be possible to take advantage of ongoing government programs offering vocational training and basic education (including adult education) to low-income families. Furthermore, such education and health programs could attract them to formalizing their waste picking and making it easier to monitor.

Moreover, the program could lead waste pickers to start and operate small recycling enterprises. This may include training in specific skills, such as bookkeeping and technical skills. It may also include providing credit to entrepreneurs interested in setting up small businesses (Haan, et. al. 1998).

IV. Case Study I: Solid Waste Management Master Plan for Lahore

1. Outline

1.1 Location

Lahore is the capital of Punjab, the largest city of Pakistan. It is situated in the north-eastern part of Pakistan along the river Ravi and borders India. It is found at between 31°15’ and 31°42’ North latitude, 74°01’ and 74°37’ East longitude. The total area is 1,772 .

Lahore is a center of not only finance and commerce but also transportation. It is connected to Western Asia and India. The main railway extends from North and South. It is famous for steel manufacturing, shoe-making, rubber products, and traditional metal craft. Wheat and cotton are the largest crops. Other crops include rice, sugarcane, and millet.

1.2 Population

The population of Lahore is 8,000,000 as of 2006 increased by 27% compared to 1998. As the urbanization is accelerated, people who live in cities increase. It comprises 80% or 6,400,000 in Urban Area, and 20% or 1,600,000 in Rural Area.

Table. IV-1 Population in City of Lahore, 1998-2006

(unit: person)

	1998*	**2001***	**2006****
Urban	5,209,088 (82.4%)	5,774,886(10.9%) (82.0%)	6,400,000(13.6%) (80.0%)
Rural	1,109,657 (17.6%)	1,266,953(14.2%) (18.0%)	1,600,000(26.2%) (20.0%)
Total	6,318,745 (100.0%)	7,041,839(11.4%) (100.0%)	8,000,000(13.6%) (100.0%)

Source: * Integrated Master Plan for Lahore - 2021, National Engineering Service Pakistan Ltd.
** Data from Lahore

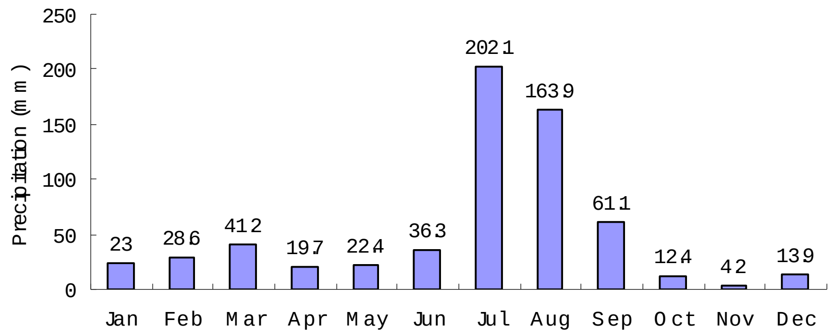
1.3 Housing

Generally, citizens live in individual houses or low buildings rather than apartments. 8 persons live in a house with one or two rooms. In Lahore, road infrastructure is relatively well-developed. Especially, commercial and residential areas recently built have wide roads, vehicles are able to access to the area while old towns have narrow streets. Most of buildings have 3 or 4 floors. There are a few high-rise buildings.

1.4 Precipitation

The annual average rainfall in Lahore is about 628.8mm with about 34 rainy days in a year. More than 50% of precipitation concentrates during the summer season , especially July and August. The rainfall in July accounts for 32.1% of the annual precipitation and 22.1% of yearly rainy days.

Fig. IV-1 Mean precipitation in Lahore, 1961-1990



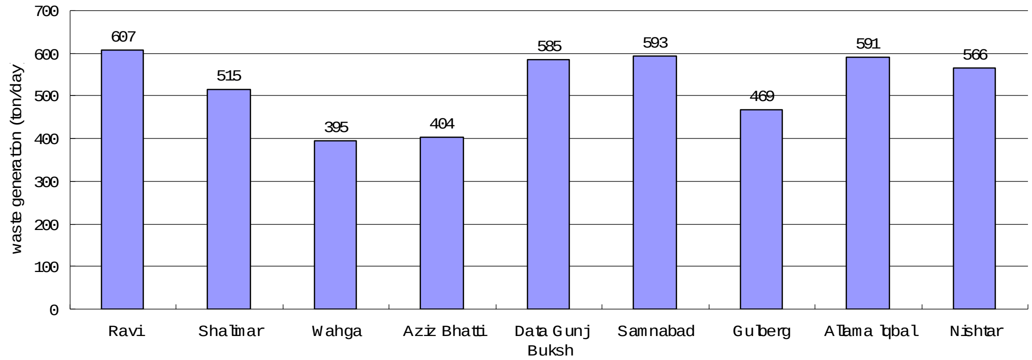
Source: Integrated Master Plan for Lahore - 2021, National Engineering Service Pakistan Ltd.

2. Solid waste management practices in Lahore

2.1 Waste generation and composition

It is 5,000 tons of waste per day to be generated in Lahore as of 2006. Waste generation per capita ranges 0.5~0.65 kg/day, higher than other cities except Multan and DG Khan. Ravi Town among 9 towns in Lahore has the highest rate of waste generation taking 12.8%. Only 76% of the total waste generated, 3,800 ton/day is collected. Remaining 24% of the waste generated is left on open space uncollected.

Fig. IV-2 Waste generation in Lahore

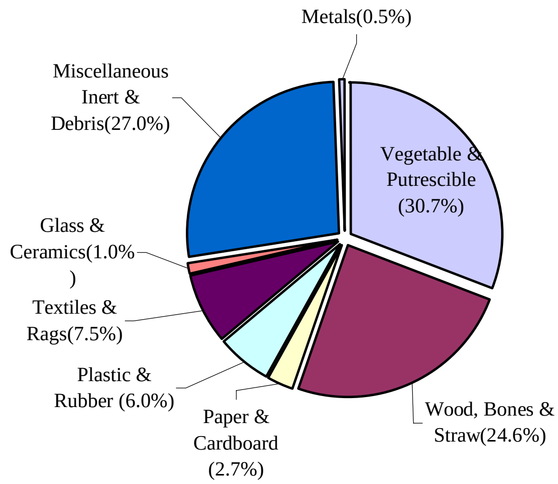


Source: KOICA (2006.6), p.46

They come from residential, commercial, hospital, and industrial area: about 1,000 thousand (urban) households, 44 hospitals, 500 clinics, food, vegetable markets, animal markets and shops, industrial factories from textile, engineering, steel, chemicals, power generations, pharmaceuticals, leather, consumer goods (Ernst Basler + Partner and ICEPAK, 2007).

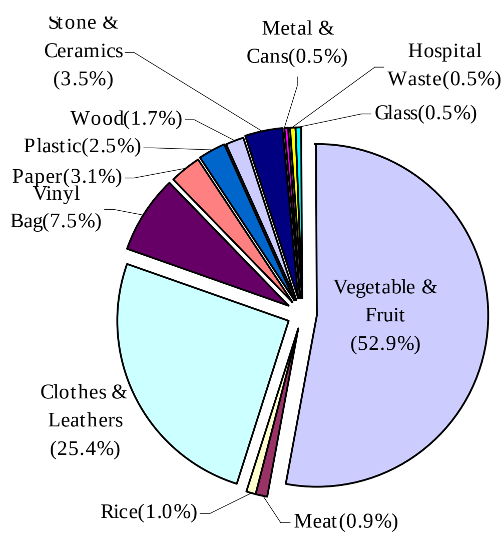
According to a survey by Ernst Basler + Partner, organic waste like vegetable, putrescible, wood, bones, straw occupies almost 55.3%, Mischellaneous Inert, Debris 27.0%, Inorganic waste (Paper, Cardboard, Plastic, Rubber, Textiles, Rags) 16.2% comparatively low. Korean team analyzed the composition of waste in Mehmood Booti, Jan. 2007. The figure reveals the result. Organic (Food Waste) is 54.8% as main element, Clothes & Leathers are 25.4%. The result can be compared to the result of Ernst Basler+Partner, which reported that materials such as the organic & inorganic (clothes& leathers, vinyl bag, paper, plasics, wood) account for 95.0% of total waste. A research by seasons or waste sources must be followed to design a detailed waste treatment facility.

Fig. IV-3 Waste composition in Lahore



Source: Punjab Solid Waste Management Reform(2007. 2), Ernst Basler + Partners Ltd., p71/193

Fig. IV-4 Waste composition in Mehmood Booti, Lahore



Source: The research of waste element incoming into Mehmood Booti dumping site, Field rearchers, 2007

2.2 Waste collection and transport system

Waste generated in Lahore is collected by the municipal government. About 70% of generated waste is collected and sent to dumping sites. Uncollected waste remains on street or road, open spaces. Waste dumped on streets is collected with hand carts or donkey carts. The municipality does not have collection equipments sufficiently. The equipment already they have is old and obsolete.

The waste management in Lahore takes through 3 steps as shown Fig.IV-5. In 1st step, sanitary workers and sweepers collect waste. In 2nd step, the waste is gathered from carts to vehicles, and lastly it is transported to the final treatment facility. During the process, waste pickers, namely scavengers, retrieve valuable materials from the waste dumpster and sell them to recycling shops.

Fig. IV-5 Flowchart of waste management in Lahore

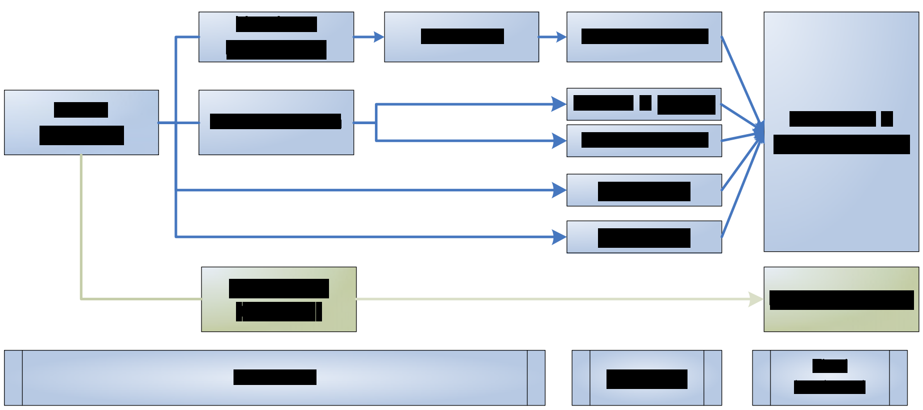


Fig. IV-6 Waste collecting and transportation in Lahore

Box. IV-1 Waste management by areas in Lahore

On January 17, 2007, Team 2 investigated waste management organization in an apartment complex, individual houses and commercial areas in Lahore.

Waste collection in an apartment complex (HBFC apt)

Middle or high income class residents lives in the four-story apartment. There are 260 residential units in the building; one household consists of 4~7 members. There are approximately 1,430 residents. Six sanitary workers collect garbage from 4-7AM under the door-to-door collection system. Waste is majorly composed of food or vegetables, vinyl bags and packing papers.

View of apartment

Dustbin in front of door

Collecting equipment

Waste from the apartment complex

Transfer point in residential area

Sanitary workers transport waste into a container on the road using a handcart. Waste is composed of food, vinyl bags, packing papers. (redundant.. already mentioned above in the last sentence)

Transfer point in residential area

Waste from residential area

Transfer point

Waste in transfer point

Transfer point and transfer station in commercial areas

There is a container in the central reserve on the road. Waste is allowed to be dumped into it only from 5-9AM daily. After 9AM, it is forced to close due to traffic. From here, it takes about 2 hours to reach the dumping site. The waste contains leathers and clothing as leather and fabric markets are concentrated in this area.

Transfer point in commercial area

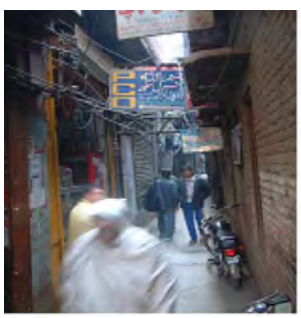
Waste in commercial area

Transfer station in commercial area

Waste in transfer station

Waste collection in back-lane, downtown

The back-lanes are connected with stores and individual houses. They are narrow and only handcarts can go through to collect waste. Sanitary workers take garbage that is left in front of doors.



Back-lane

Waste vinyl bag in front of a door

2.3 Waste treatment and disposal

There are 3 dumping sites and 1 composting facility in Lahore; 1 dumping site is official one and the others are illegal. However, there are not sanitary landfill sites. All dumping sites are operated without any pollution controlling facilities including leachate treatment.

2.3.1 Dumping sites

There are three dumping sites in Lahore: Mehmood Booti, Saggian, and Baggrian sites. Table.IV-2 below shows outline of them. Waste is just dumped without proper treatment facility in Lahore. Let alone offensive smell, there is not consideration about dust or noise from the dumping sites, critical impact to ground and underground water system and soil. Although one of them is operated by the municipality, it is not different in that all of them don't manage the environmental impact. Only the official one in Mehmood Booti site measures the amount of incoming waste.

A landowner of unofficial dumping site allowed the Lahore municipality to dump waste to his land. He intends to fill up the low land with waste instead of soil. The dumping practice severely contaminates the River Ravi with leachate and flowing down waste.

Table. IV-2 General information on the dumping sites in Lahore

dumping site	Location	Area (m^2)	Operation period	Waste amount (ton/day)	Current capacity (ton)
Mehmood Booti	Northern region	320,207	about 10 years (1997~Present)	600~ 700	2,800,000
	An official landfill run by the city government, operating by a simple dumping method without special quarantine or facilitations for leachate				
Saggian	Northwest region	252,929	about 12 years (1995~Present)	1,500	2,240,000
	Operating along River Ravi without special quarantine or facilitations for leachate				
Baggrian	Southern region	28,328	N/A	N/A	300,000 ton
	Operating on private land without special quarantine or facilitations for leachate				

N/A : not available

Mehmood Booti dumping Site

Surrounded by farmland, Mehmood Booti dumping site is 1km away from Ravi river in northern Lahore. It has been operated by the municipal government since 1997. About 600~700 tons of waste from adjacent towns – Data, Gullberg, Shalamar, Aziz Bahatti – comes in to the land (Fig.IV-7). Land area is 320, 207 m2 and 2.8 million tons of waste is dumped for 10 years along a road every day with 5~6m height. CDGL operate it year-round in all weather conditions.

Entry and inside road are unpaved and about 20m, 3.5m respectively.

Due to simple dumping method on flatland, waste is openly exposed. The dumping site does not have a leachate barrier, gas collection, treatment facility, rainwater drainage or any treatment facility except a weighing-bridge. It rainy season, leachate leakages and deteriorates soil and farmland. Also, there is high possibility that groundwater under and near the site have been seriously contaminated since the landfill site was open. The ground subsides is continuously subsiding and unstable due to rapid, steep slope. In order to build a facility on it, it needs to harden the waste.

Fig. IV-7 Catchment area of Mehmood Booti dumping site

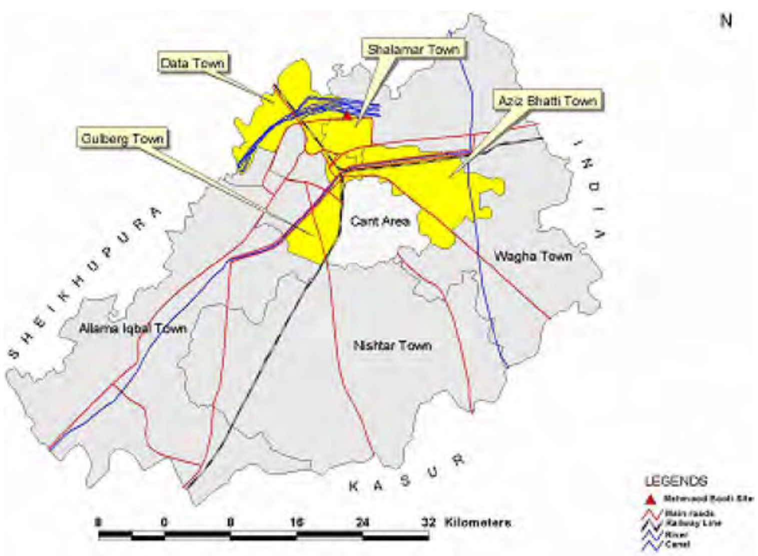


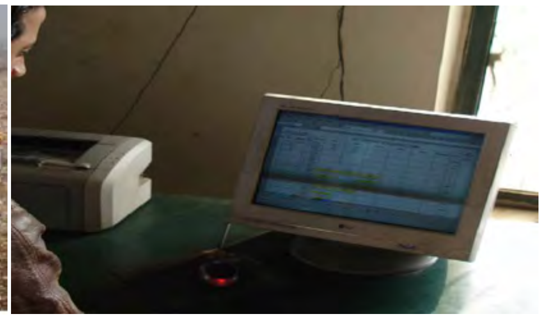
Fig. IV-8 View of Mehmood Booti dumping site

View of Mehmood Booti dumping site

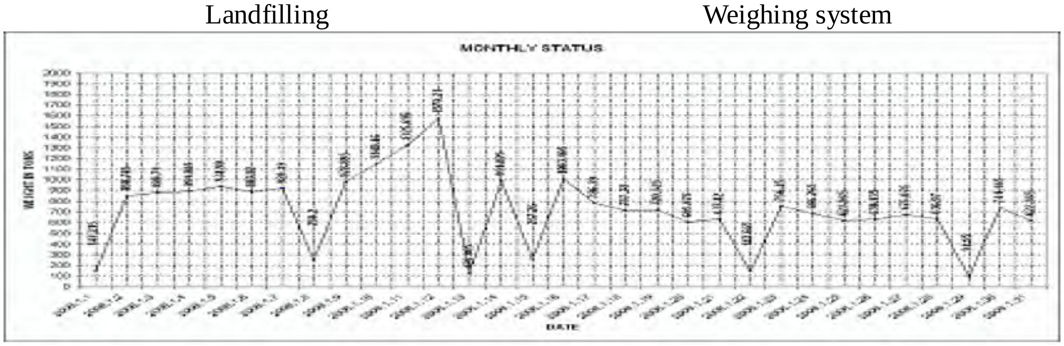
Entry road

Leachate leakage

Landfilling



Weighing system



Incoming waste records

Saggian dumping site

Saggian dumping located alongside the River Ravi. Although it is not an official one, municipal or private-owned trucks dump waste the private land. The land owner thinks the waste reclaims the subsided land and allowed to dump waste to his land after 1995. About 1,500 tons of waste from 3 towns – Dta, Ravi, Samanabad – comes in to the site every day (Fig.IV-9). Land area is 252,929 m^2 and 2,240 thousand tons of waste is dumped from 1995 to the present with 5m height.It is open year-round in all weather conditions like Mehmood Booti site but on Sunday, about 20% or 300 ton/day of usual waste is incoming. Entry road and inside road are about 5m and 3.5m, respectively and both of them are unpaved.

Waste is simply dumped on flatland and openly exposed. There is not any facility to protect environment. Furthermore, it is flooded every 10-20 years although it hasn't been inundated since 1998. It has harmful impacts upon agriculture and fishing, especially during the rainy season. Fortunately, the dumping site is far from residential areas.

Fig. IV-9 Catchment area of Saggian dumping site

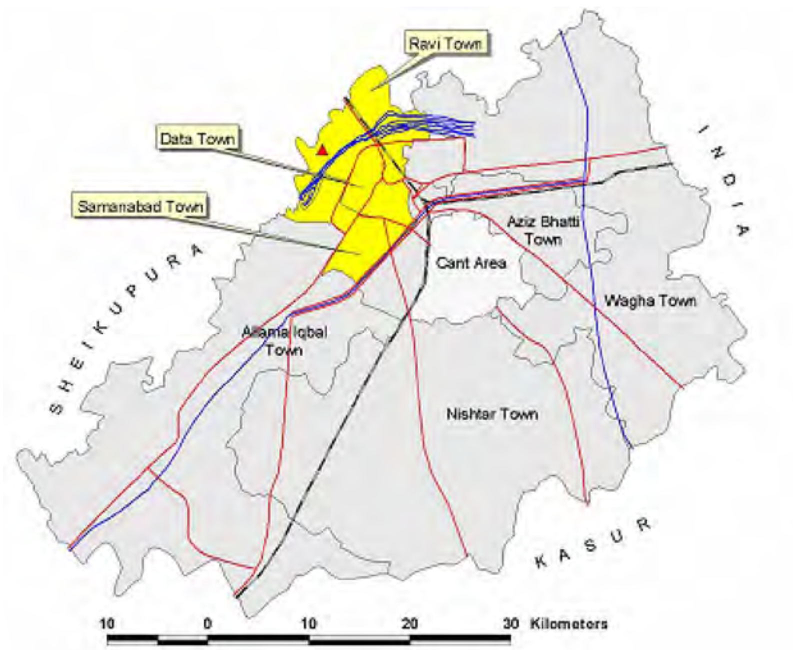


Fig. IV-10 View of Saggian dumping site

View of Saggian dumping site

Entry road

Inside road

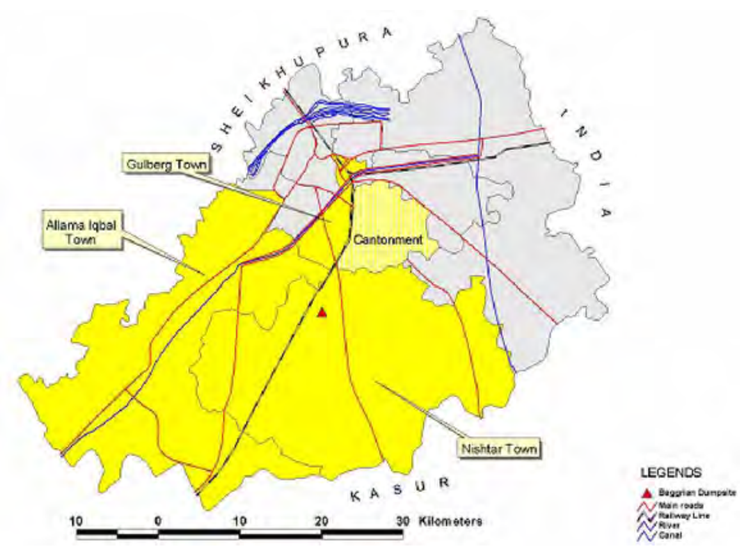
Landfilling 1

Landfilling 2

Baggrian dumping site

Baggrian dumping site is situated in South. Land area is 28,328 m^2 and current capacity is 300 thousand tons. It is also a private land and has similar conditions to other two dumping sites and waste is dumped without any covering. It is exposed to risks that leachate from waste causes serious contamination of groundwater and soils when they have rain.

Fig. IV-11 Catchment area of Baggrian dumping site



2.3.2 Composting facility

There is a composting facility built in March 2006 just beside the Mehmood Booti dumping site in Lahore. Area is about 151,757 . There are about 60 staffs involving 3 professional technicians. Organic waste comes from food market and gardens in Lahore. It adopts aerobic composting methods. Its potential capacity to compost waste is about 400ton/day (146,000ton/year) but it produces just 120 ton/day. Organic waste contains lots of vinyl and needs to be gotten rid of them. The quality of compost produced by the plant seems good. The plant can improve its efficiency through reorganizing the segregation and collection system. Sale price of compost is 225Rupi/50kg.

Fig. IV-12 View of compost facility in Lahore

Operative equipments

View of Windrow

Composting process takes steps of the 1st screening, mixing making windrow, the 2nd screening and packaging. Firstly, materials bigger than 2 inches is screened from the waste and sent to the landfill. But remaining organic materials still have lots of vinyl bags in it. After the 1st screening, vegetable, fruit, gardening waste or animal manure from nearby food markets are added to the remaining. Mixed wastes are moved to composting field as a form of windrow width 3~4.2m, height 1.8, length 210m. They are composted for more than 3 months at least. After composting is completed, the piles of windrows go through the 1/4 inch or 1/2 inch sieving machine. All compost produced from 1/4 inch sieve is sold to farmers with 225 rupi/50kg. One from 1/2 sieve is used for road divider. Any unorganic substance or order was not found in compost from1/4 inch sieve but in from 1/2 sieve. Compost contains 20% moisture or more, water holding capacity 250%, organic material 820%, nitrogen 2.5%, phosphorus 1%, Fe 60ppm, Mn 20ppm, Zn 50ppm in it.

Fig. IV-13 Screening of solid waste

Fig. IV-14 Compost packaging

2.4 Institutional arrangement and financial aspects

2.4.1 Solid Waste Management Bye-laws 2005

City District Government Lahore has the Solid Waste Management Bye-laws 2005 legislated in January, 2005. The Bye-laws defines solid waste as all sorts of wastes generated from human and animal activity which are normally solid and are discarded as useless or unwanted. It declares CDGL responsible for the sanitation of its jurisdiction. And it allows District Officers to inspect any building or land without any legal proceedings. CDGL can levy sanitation or environmental fee on the property situated within the area of the CDGL to cover the expenditure to be incurred under these by laws. Anyone who violates the bye-laws have to pay five hundred or less rupees. If the violation is continuing, the fine may extend fifty rupees for every day after the date of the first commission of offence.

2.4.2 Sanitary staffs and equipments

There are 23,544 sanitary workers in Lahore. Each staff is responsible for the waste generated by about 810 people in the city. The table reveals collection and transport equipment the CDG

Lahore has. Arm roll trucks, open trucks and tractors are mainly used. About 5% of them need to be repaired.

Table. IV-3 Status of workers in charge of managing waste in Lahore

Engineers	Inspectors & Supervisors	Drivers	Mechanics in workshop	Sanitary Workers	Scavengers	Total	Population/ Sanitary Workers
9 (0.04%)	238 (1.01%)	282 (1.20%)	118 (0.50%)	7,897 (33.54%)	15,000 (63.71%)	23,544 (100%)	810

Source: Ernst Basler + Partners Ltd.(2007), Punjab Solid Waste Management Reform, p90.

Table. IV-4 Status in equipment for waste collection & transportation of Lahore

Type	On-Road	Off-Road	Total	Operating ratio (%)
Arm Roll(10)	48	3	51	94
Arm Roll(5)	68	-	68	100
Open Truck (3ton)	90	5	95	95
Compactor (2.5ton)	21	17	4	81
Dumper (1ton)	33	28	5	85
Loader	11	8	3	73
Chain Bulldozer	2	1	1	50
Fiat Tractor 480	30	30	-	100
Fiat Tractor 640	5	5	-	100
Tractor MF-375	12	11	1	92
Tractor MF-240	40	38	2	95
Tractor MF-265	3	3	-	100
Tractor Loader MF-385	12	12	-	100
Mechanical Sweeper	33	33	-	100
Garbage Disposal Unit	30	30	-	100
Gully Sucker	2	2	-	100
Hand cart	4,500	4,500	-	100
Total	4,948	4,924	24	99.5

Source: Data from Lahore

Fig. IV-15 Equipment for waste collection and transportation in Lahore

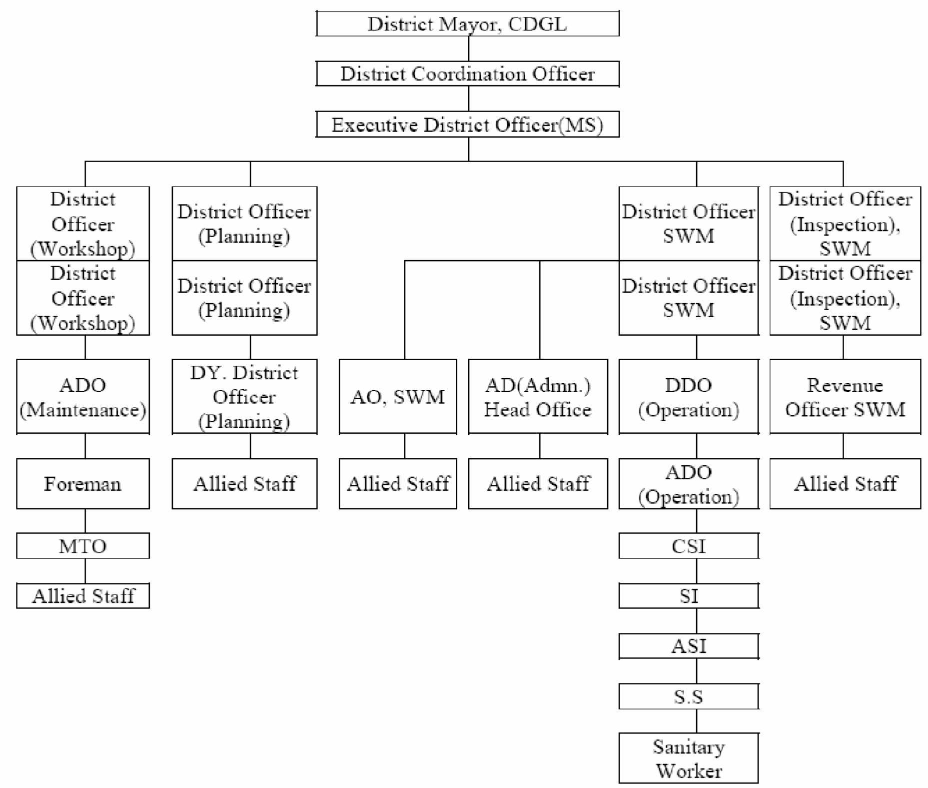
Hand cart | Compactor | Arm Roll truck

Mechanical Sweeper | Dumper | Loader

2.4.3 Organization of solid waste management

The following figure shows the administrative structure of solid waste service in CDGL. The District Nazim, mayor, CDGL heads the solid waste management department. The city areas are divided into 6 towns for the convenience of waste management. There is a workshop of the SWM Department, CDGL, is situated at the outfall road in Sant Nagar. The organization chart of the central workshop, City District Governmental Lahore is as follows:

Fig. IV-16 Status of waste operating system in Lahore

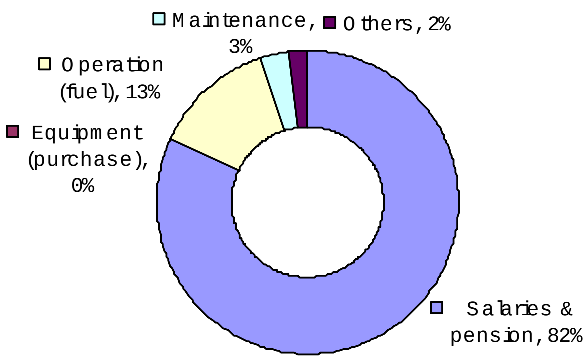


Source: Data from Lahore

2.4.4 Financial aspect of solid waste management

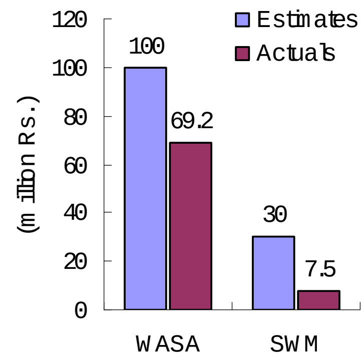
Expenditure for municipal waste services amounts to about 1,459 million Rs, or 16% of the total budget 9,206 million Rs. The CDGL is the one of the cities spend a large portion of the budget on SWM. The most (82%) of the SWM expenditure is allotted for labor costs while operation and maintenance costs represent about 16% of the total. It shows that municipal waste services in Lahore depend on manual work.

Fig. IV-17 Composition of SWM budget in Lahore, 2006-2007



Source: Ernst Basler+Partber, Icepak, 2007, p.93.

Fig. IV-18 Sanitation fee of Lahore, 2005-5006



Source: CDGL, District Budget 2005-2006

According to the City District Govt. Lahore Solid Waste Management Bye-laws 2005, households are obliged to pay sanitation fee for the municipal services.[18] It is collected through WASA (Water Sewerage Authority) billing. In areas beyond WASA jurisdiction, the local administration bills and collect but with very low collection efficiencies. In 2005-2006 estimates, CDGL expected to collect about 30 million Rs. as user fee on the solid waste services. But the actual receipt was 25% of the estimates (Fig.IV-18). Though in the 2006-2007 estimate of receipts CDGL plans to achieve the 8% cost recovery through imposing 120 million Rs. user fee, the extension of service area for SWM beyond WASA service area poses a challenge for collection the sanitation fee from all areas beneficiaries. Cost effective alternatives to sanitation fee should be considered.

2.5 Analysis of waste problem in Lahore

The major problem of SWM in Lahore occurs because of illegal dumping and littering. This is affected by several factors: an inefficient collecting and carrying system, the lack of sanitary workers and inefficient methods, the shortage of trained staffs with professional

[18] The bye-law states:
The City District Govt. Lahore may levy a Sanitation / Environmental fee on the property situated within the areas of the CDGL to meet with expenditures to be incurred under these by laws.

knowledge, obsolete or shortage of collecting and transport equipments, low awareness on the environment and pollution, the insufficient finance and resources allocated for SWM.

First, people do not use garbage can and stack the waste all around converting them into open dumps. This makes sanitary workers to avoid regular collection and allows waste remained on the streets for a long time. In addition to factors mentioned above, simple dumping method without any sanitary treatment in a landfill site causes significant contamination of groundwater and soil In light of public sanitation. Leachate from the dumping site can spread diseases through contaminated groundwater and rivers. River Ravi seems to be severely polluted.

Therefore, to improve the problems related to waste, first of all, comprehensive waste management system should be established securing the proper number of sweepers and building appropriate sanitary landfill site.

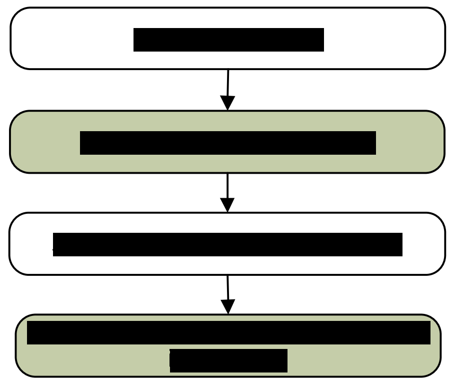
3. Recommendation for development of a solid waste management strategy and plan

3.1 Forecasting waste generation and composition

The amount of waste generation in future can be estimated based on the trends of population growth. Of course, it should reflect social and economic changes of the city as the quantity and composition are strongly linked to economic growth level. Generally, as the industrial development is accelerated, waste contains more plastic, vinyl, organic material and the volume also increases. But in a high techno-economic society waste generation can be decoupled from economic or population growth.

Generally, initial target year is 5 years after feasibility analysis for basic plan step, framework plan, construction, demonstration. In this study, middle and long term goals are set at an interval of five years.

Fig. IV-19 Process for estimating waste generation



The study refers to Integrated Master Plan for Lahore 2021. The prediction on per capita waste generation is based on the India's average increase of waste amount per capita (3.5%) which is similar to that of Pakistan. The amount of waste generation will increase to 5,788 ton/day in 2011, 7,479 ton/day in 2016 and 9,937 ton/day in 2021.

Table. IV-5 Waste generation in India

(unit: kg/capita/day)

Year	Waste Generation	Year	Waste Generation	Year	Waste Generation	Year	Waste Generation
2000	0.327	2010	0.471	2020	0.696	2030	1.032
2005	0.391	2015	0.571	2025	0.848		
			increasing rate(average)	: 3.5%			

Source: Improving Management of Municipal Solid Waste in India, Environment Unit South Asia Region

Table. IV-6 Estimate of future waste in Lahore

(unit:person, ton/day, kg/capita·day)

Year	Estimated population[1)]	Waste Generation (average)	Waste Generation per capita[2)] (average)
2006	6,400,000	5,000	0.5~0.65
2011	7,717,361	5,402~6,174 (5,788)	0.7~0.8 (0.75)
2016	8,798,459	7,039~7,919 (7,479)	0.8~0.9 (0.85)
2021	9,936,841	8,943~10,931 (9,937)	0.9~1.1 (1.0)

Source: Integrated Master Plan for Lahore - 2021, National Engineering Service Pakistan Ltd.; Improving Management of Municipal Solid Waste in India, Environment Unit South Asia Region
Note: The prediction on per capita waste generation is based on the India's average increase per capita (3.5%)

Fig. IV-20 Estimate of future waste in Lahore

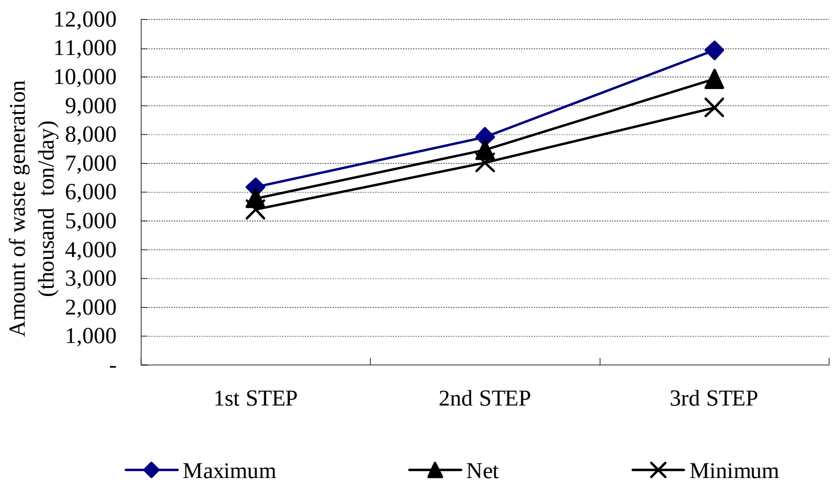


Table. IV-7 Estimate of waste composition generated in Lahore

(unit: ton/day)

Year	Combustible Waste		Incombustible Waste	Recyclable Waste	Total waste
	Organic	Inorganic			
2011	2,739~3,130 (average:2,935) (50.7%)	836~956 (average:896) (15.5%)	1,701~1,944 (average:1,823) (31.5%)	126~144 (average:135) (2.3%)	5,402~6,174 (average:5,788) (100.0%)
2016	3,569~4,015 (average:3,792) (50.7%)	1,090~1,226 (average:1,158) (15.5%)	2,217~2,494 (average:2,355) (31.5%)	164~184 (average:174) (2.3%)	7,039~7,919 (average:7,479) (100.0%)
2021	3,783~4,624 (average:4,203) (42.3%)	1,578~1,928 (average:1,753) (17.6%)	3,337~4,079 (average:3,708) (37.3%)	245~300 (average:272) (2.8%)	8,943~10,931 (average:9,937) (100.0%)

Table. IV-8 Estimate of future waste generation collection target in Lahore

(unit: ton/day, %)

Year	Waste Generation (average)	Waste collection (average)	Collection rate (%)
2006	5,000	3,800	76
2011	5,402~6,175+ (5,788)	4,592~5,248 (4,920)	85
2016	7,039~7,919 (7,479)	6,335~7,127 (6,731)	90
2021	8,943~10,931 (9,937)	8,943~10,931 (9,937)	100

3.2 Strategy for waste collection and transportation

The efficiency of waste collection and transportation systems in Lahore are ought to be improved further by shifting from manual labor to a more automated system. Adapting door-to-door collection can also increase the system's efficiency. Considering the geographical features of Lahore, where there are many areas with narrow alleys, different collection system is applicable to the main streets (where vehicles can easily access) and for the alleys (where vehicles have difficulty to access).

3.2.1 Door-to-door collection for vehicle accessible areas

As for the easily accessible main streets, each households and stores should be provided with garbage bins, bags or other waste storage containers to facilitate door-to-door collection. Vehicles will then collect and transport the wastes to the final disposal site. This process eliminates offensive odors, scavenging and wastes scattering, and helps maintain the environment clean. This might not be familiar to the citizens and sanitary workers so it may take some time before the door-to-door collection system gets fully implemented. Nevertheless, it is necessary to adapt this method to improve sanitary condition as well as to minimize problems. Collection should be conducted right after the residents put out their wastes in order to prevent odors, scavenging, and scattering of wastes.

3.2.2 Point-to-point collection for narrow areas

In Lahore, there are many areas with alleys, making it difficult for vehicles to approach house entrances. In this case, the door-to-door collection system will not be suitable. It is recommended, rather, to use the point-to-point collection system by utilizing the currently used method, which uses containers. In this method, sanitary workers (sweepers) collect and transport the wastes, using handcarts, to containers located at certain places. The containers are then transported for final disposal using arm-roll trucks. It is desirable that the containers are accessible both to the residents and collection vehicles. Each container should have sufficient capacity to contain the wastes in its corresponding area. Cautious management is required to prevent offensive odors and scattering of wastes by animals and scavengers.

Fig. IV-21 Door-to-door collection for the compactor accessible area (Zone I)

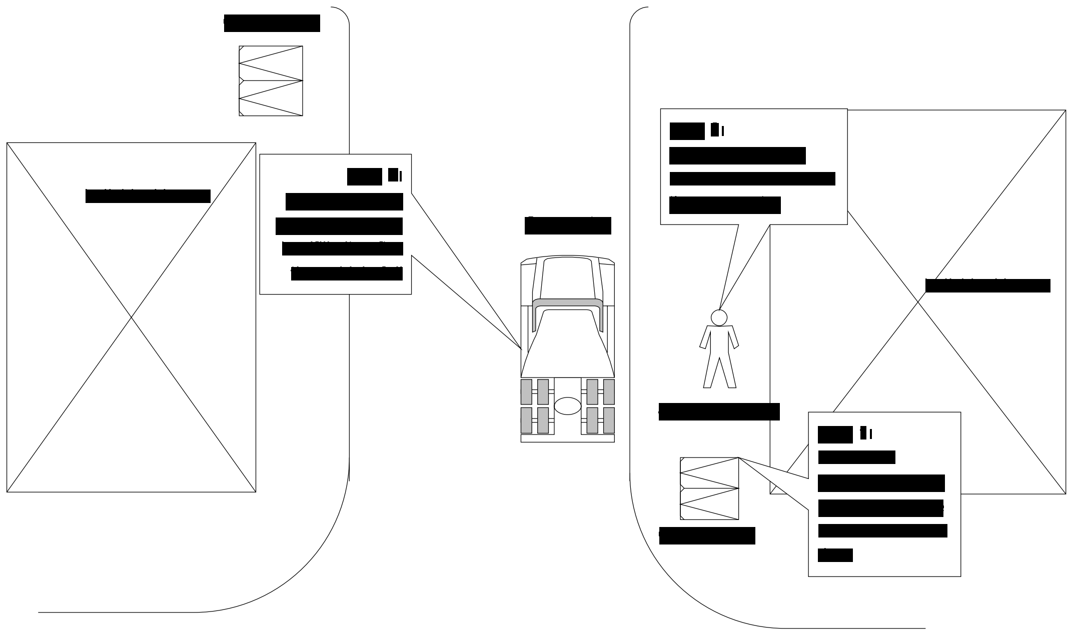


Fig. IV-22 Point-to-point collection for narrow areas (Zone III)

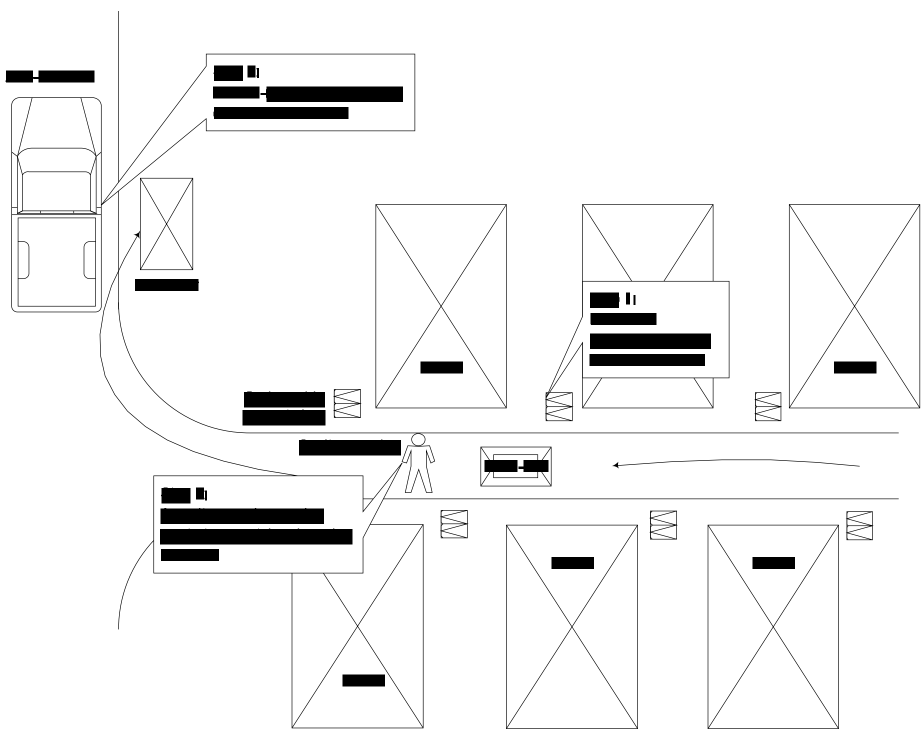
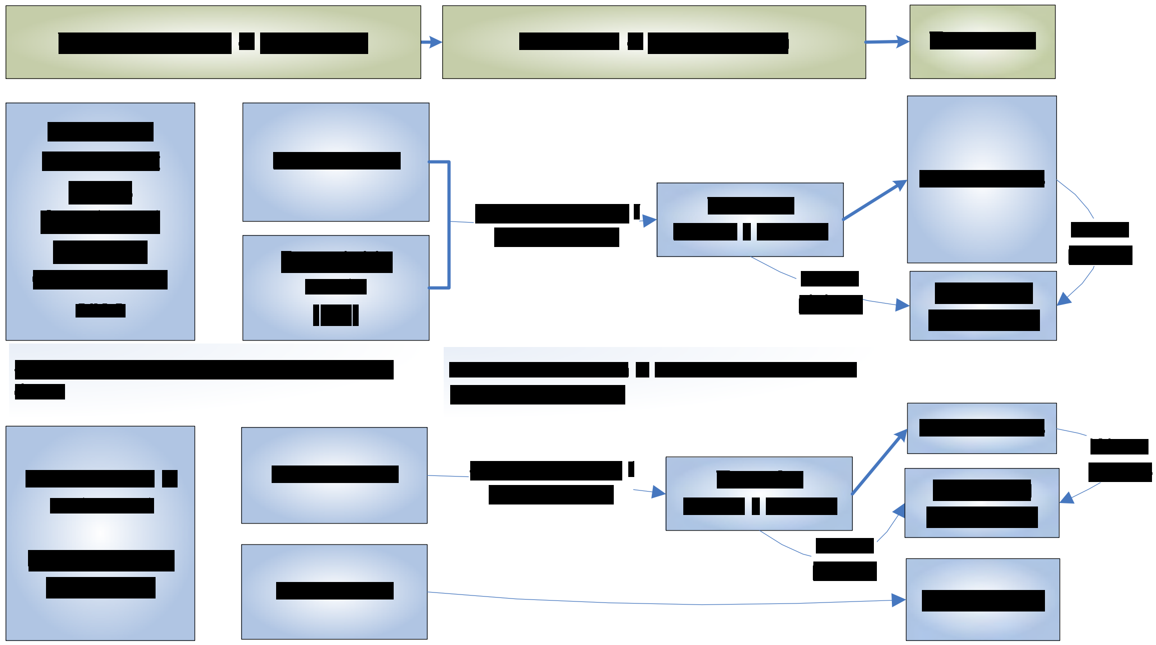


Fig. IV-23 Flowchart for improvement of waste collection & transportation system



*Transfer point is the point where collection vehicles bring wastes for larger vehicles in order to transport to landfill sites. An arm roll container could be used as a transfer point

3.2.3 Increasing the manpower for waste collection

Sufficient number of sanitary workers is a critical factor to provide the proper waste collection service. As shown in Box.IV-2, the present collection amount of a sanitary worker is about 0.4812 ton of waste a day. This means CDGL should employ 2,492 additional workers to provide full waste collection services to its citizens.

Box. IV-2 Estimating manpower requirements in current system of Lahore

- § Daily working hours: 8 hours
- § Total waste generated: 5,000 ton/day
- § Total waste collected: 3,800 ton/day (76% of waste generated)
- § Present number of sanitary workers: 7,897 persons

- § Collection efficiency of sanitary workers:
  - § 3,800ton/day÷7,897man = 0.4812 ton/man/day

- § Number of workers needed:
  - § 5,000 ton/day÷0.4812 ton/capita/day = 10,283

- § Deficit of sanitary workers:
  - § Number of necessary workers (A): 10,283
  - § Number of present workers (B): 7,897
  - § Number of deficit (C = A-B): 2,492

The collection efficiency depends on how to collect and the types of a waste container. If door to door collection through a bag type container is introduced instead of a moving or a fixed type, the collection efficiency can be dramatically increased. When a bag type container is adopted, it needs less workers than other types of containers. A bag container requires just 3,321 workers reduced to 58% as shown in the following table. At the same time it shortens working hours from present eight hours to four hours.

Table. IV-9 Collection efficiency by the types of garbage bin

(unit: MH/ton)

	Bag Type	Moving Type	Fixed Type
Pickup time	0.12	0.24~0.63	0.73~1.16
Others*	1.23	1.23	1.23
Total Collection	1.35	1.47~1.86	1.96~2.38

Source: Choi (1987.1), p. 344.
Note: *Others involve time for transport, round-trip, unloading.
Data presumes the waste is collected every 2 days
MH/ton: time to collect waste per ton per sanitary worker

Box. IV-3 Estimating manpower requirements in door to door collection

- § Calculation Method : applying the collection rate of bag container for the amount of waste (unclear)
- § Waste generation [1st Step(5,788ton/day), 2nd Step(7,479ton/day), 3rd Step(9,937ton/day)]
- § Waste collection [1st Step(4,920ton/day), 2nd Step(6,731ton/day), 3rd Step(9,937ton/day)]
- § Collection rate: 1.35MH/ton (Collection standard of 2-day intervals)
- § Amount of waste collection for 2 days:
  - § 4,920 ton/day×2 day = 9,840 ton
- § Total collection time per sanitary worker:
  - § 1.35 MH/ton × 9,840 ton = 13,284 MH
- § Collection standard per every 4 hours:
  - § 13,284 MH ÷ 4hr = 3,321capita
  - §
- § Shortened (Shortening?) the needed collection manpower and collection time by improving the collection system
  - § Collection manpower: 7,897capita → 3,321 capita (42% reduced)
  - § Collection time : 8 hours → 4 hours

In the next steps, the estimated manpower requirement is shown in table IV-9. When the bag-type container is used, 4,662 workers are needed for the 1st step (2011), 6,164 for the 2nd step (2016), and 8,757 in the 3rd step (2021). Regional condition and collection time should be considered later. As the collection system is improved, collection time and manpower requirement could be reduced. Other sanitary staff requirements are as shown in the table below.

Table. IV-10 Manpower requirement in each step, Lahore[19]

(unit:person)

Type	Present	2011	2016	2021
Superintending Engineer	-	1	1	1
Executive Engineer	3	8	9	10
Assistant Executive Engineer	6	15	18	20
Assistant Engineer	-	31	35	40
Qualified Diploma Sanitary Inspector	12	77	88	99
Qualified Sanitary Inspector	76	154	176	199
Qualified Sanitary Supervisor	150	514	587	662
Driver	282	541	707	1,019
Sanitary worker	7,897	3,321	4,543	6,707
Total	8,426	4,662	6,164	8,757

3.3 Improvement of solid waste management equipment

3.3.1 Collection and transport equipment

To increase the efficiency of collection and transportation, a large portion of current manual work should be replaced with mechanical collection system. The operation rate of the collection and transport equipment should be improved by rearranging the repairing system and by facilitating the supply of new parts. The more efficient equipments as shown in the following figure should be introduced and obsolete ones should be replaced with more efficient ones.

In order to estimate what kind and how many equipments are needed, this study refers to Seoul, one of the cities in Korea similar to Lahore in lights of population and waste composition etc. The compactor make collection and transportation easier, especially for door to door collection.

[19] Manpower requirement for SWM

Superintending Engineer	One per city
Executive Engineer	One per 1,000,000 people
Assistant Executive Engineer	One per 500,000 people
Assistant Engineer	One per 250,000 people
Qualified Diploma Sanitary Inspector	One per 100,000 people
Qualified Sanitary Inspector	One per 50,000 people
Qualified Sanitary Supervisor	One per 15,000 people
Driver	depends on the number of collection and transfer vehicles in each step

If the door-to-door collection system is settled, the hand carts, arm roll trucks and dumpers will no longer be needed as they are at present. Therefore, when door-to-door system is fully settled, the use of compactors and size of other equipments should be dramatically increased.

In the area of narrow alleys where the door-to-door system cannot be applied, the currently used containers and arm roll trucks should be maintained. Improvements should be adapted slowly by considering local conditions in the future.

In addition, tractor loaders can be used to recover and load back wastes scattered around a container. After improving the collection condition, tractor loaders will no longer be as needed as they currently are.

Fig. IV-24 Collection, transport equipment used in Korea

Handcart

Compactor

Food Waste Collection Vehicle

Mechanical Sweeper

Dumper

Arm Roll Truck

The requirement of waste collection vehicles and equipments in Lahore is estimated as in Table.

IV-11 and Table. IV-12. The use of 10m^3 arm roll truck maintained in current status. Instead, 2.5ton compactor and 5ton compactor are increased in order to increase collection of waste generated as much as 100% in 2021 year.

Table. IV-11 Collection & transport equipment requirements in Lahore

(unit: EA)

Type	Present	2011	2016	2021
Arm Roll Truck(10)	51	51	51	51
Arm Roll Truck(5)	68	68	68	68
Open Truck(3ton)	95	100	105	110
Compactor(2.5ton)	21	50	57	192
Compactor(5ton)	-	-	84	174
Dumper(1ton)	33	33	33	33
Tractor Loader	23	23	23	23
Tractor & Trolley	90	90	90	90
Mechanical Sweeper	33	43	59	87
Hand Cart	4,500	4,500	4,500	4,500
Total (Hand Cart excluded)	414	458	570	828

Note: *See the details in Annex-7.
**Bulk Density of Solid Waste in Arm Roll Truck : 400kg/ , Number of Trips of Collection Vehicles : 3 to 6 from Asif Iqbal (2006)

Table. IV-12 Equipment requirements of transfer station in Lahore

(Unit : EA)

Type	Present	2011	2016	2021
Arm Roll Truck (15ton)	-	29	37	53
Arm Roll Container (15ton)	-	44	56	80
Excavator	-	6	9	11
Total		79	102	144

Note: See the details in Annex-7.

3.3.2 Improvement of solid waste management equipment in landfill sites

Table. IV-13 Daily incoming waste in Lahore Landfill

	2011	2016	2021
Katorbund Road Site	4,447 ton/day	5,722 ton/day	3,708 ton/day

Table. IV-14 Equipment for landfills

Type	Dimension (/hr/EA)	Working hours (hr)	Capacity per day (/day/EA)
Transport and spreading equipment (Bulldozer)	102	8	816
Compacting equipment (Compactor)	120	8	960

Fig. IV-25 Equipment for landfills

transport and spreading (Bulldozer)

landfilling bulldozer (Compactor)

Table. IV-15 Proposed landfill management equipment in Lahore

(unit: EA)

Type		Dimension	2011	2016	2021
Landfill equipment	Bulldozer (exclusively for reclamation use)	32ton	6	6	5
	Compactor	32ton	5	5	4
Molding equipment	Bulldozer	32ton	2	2	2
	Excavator	1.0	2	2	2
	Loader	2.29	2	2	2
	Grader	3.6m	1	1	1
	Roller	32ton	1	1	1
Supporting equipment	Watering cart	5,500ℓ	1	1	1
	Disinfection cart		1	1	1
	Mechanical Sweeper	4.0	1	1	1
Total			22	24	20

3.4 Network design for waste collection and transportation

Large portion of expenditure on SWM is spent on waste transport to a final disposal site. Generally, landfill sites are far from waste sources in metropolitan cities like Lahore. Moreover, in Lahore, many of container collection and transfer points are in the middle of road and waste pickers take out and scatter waste out of containers to collect valuable materials. The waste on the roads and streets disrupt the traffic flow and walking. Therefore, Lahore needs transfer station located as near as possible to waste sources, with easy access to highway routes to reduce any disturbance the public and transport cost.

3.4.1 Collection and transfer network

There is no principle to adapt to all situations. Collection routs are established by transfer cost. In order for effective collection and transfer in Lahore, it is important to shorten the moving line of the collection vehicle, for which the followings should be considered:

- § To refer to established policies or regulations in determining the location and collection frequency,
- § To interrelate the conditions from established systems of the same collection personnel and vehicle form,
- § To arrange as far as possible for it to start and end around the highway by using typographical layout and hindrances like road border,
- § To collect dustbins on both sides of the alley simultaneously, as far as possible,
- § To avoid repeated running and to choose the route less subject to traffic signals,
- § To collect avoiding rush hours in lots of traffic,
- § To choose the downward route of collection from high-lying to low-lying areas,
- § To collect avoiding U-turns,
- § To arrange the starting point near the garage and to locate the last collected container nearest to the disposal site,
- § To collect beginning with the area with much generation of waste,
- § To set the collection route clockwise as far as possible.

It is understood that in selecting the route for collecting and transporting waste, the plan must be made in consideration of the characteristics of actual process of collecting and transferring waste. However, with difficulty of grasping the local characteristic of Lahore we established the collection and transfer network based on the result of cost analysis.

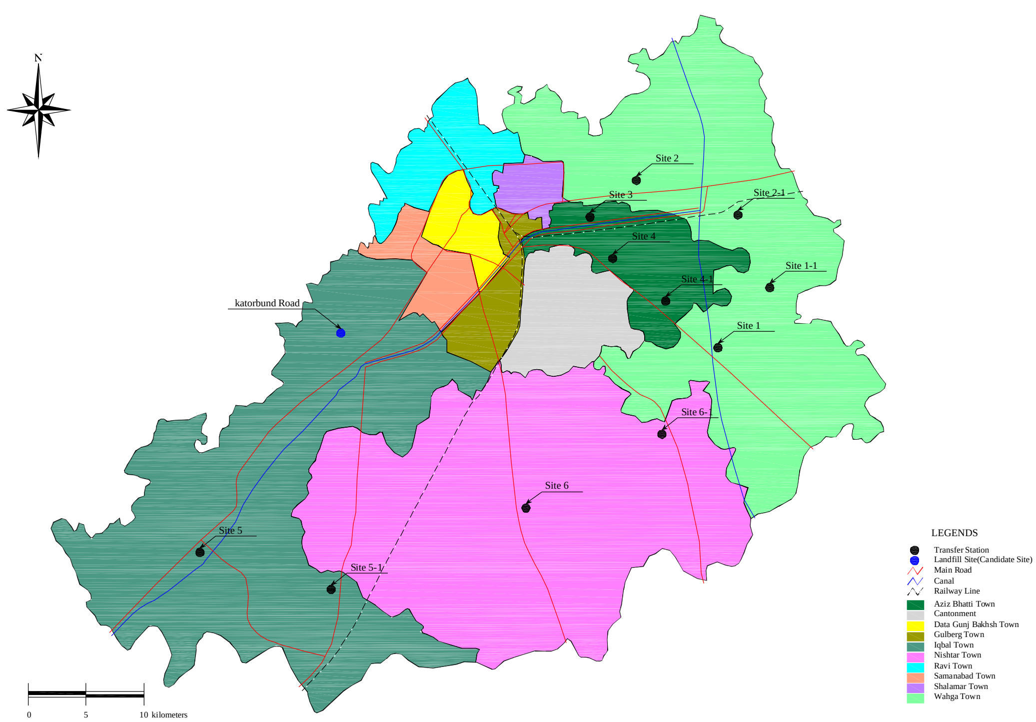
There are a total of 9 towns in Lahore, 6 of which are located near the (within 20km, Iqbal town, and part of Nishtar town) site of the proposed sanitary landfill. The plan for these 6 towns is to directly transport wastes to the sanitation landfill right after collection. For the remaining 4 towns, (Iqbal town, and part of Nishtar town) which are more than 20km from the planned sanitary landfill site, wastes will be collected in smaller vehicles and then transferred to a 15-ton Arm Roll Truck at a load-change point. The wastes will then be conveyed to the Katorbund Road Landfill Site.

Table. IV-16 The network systems of collection and transportation classified by towns of Lahore

Landfill	Towns	Route
Katorbund Road	Ravi, Shalimar, Data Gunk Bakhsh, Samanabad, Some areas of Iqbal , Some areas of Nishtar, Gulberg	Towns à Sanitary landfill (Katorbund Road)
	Wahga, Aziz, , Some areas of Iqbal, Some areas of Nishtar	Town à transfer station à Sanitary Landfill (Katorbund Road)

Note: *See the details in Annex-8(Transfer Station Plan).

Fig. IV-26 Map of waste transfer station



3.4.2 Metropolitanization

In terms of economy of scale, waste treatment facility is more efficient when managing by metropolitanization considering distances, amounts of generation, procedure circumstances, etc. than when managing independent treatment facilities by districts. If a consensus is made by districts regarding inter-district processing capacity, facility location, managing subject of facility and managing regulations, establishment and operating expenses, etc., establishing metropolitan waste treatment project will have synergy effect in cutting budget and minimizing environmental pollution (MOE, 2004: 29-30).

With a large facility scale, equipment unit price per ton lowers and the ratio of entire facility to total construction cost, too. With a large scale, the facility is maintained and managed more rationally and more effectively and also easier to make a regular checking plan.

Maintenance of mechanized facility entails high-degree technological knowledge and function and engineers possessed of state-set qualifications, but a lage-scale centralization of facility allows lowering the ratio of engineers to total operating personnel. Since in maintaining a mechanized facility managing personnel is not necessarily proportionate to the largeness or smallness of processing scale, local government community can take on the personnel needs without difficulty.

It can successively manage with handling amount in accordance with facility, exercise a full capability, and stabilize the operating situation. Operating waste treatment facility parallel allows grasping exactly the countermeasure on shifting handling amounts and also elastic operation. Technology advanced by increment of facility capacity makes handlings possible and recovery of resources or energy can also be expected.

In spite of its advantages, it also takes disadvantages. In case of different collection systems between local governments processing plan is somewhat hard to make and it needs a unified collection plan. Increase of carrying distance: Metropolitanization of processing facility is accompanied by increasing carrying distance, which can add to cost for collection and transfer, so conference on collection transfer is necessary. For residents of located near the treatment facility, relieving their rejection sensation and publicizing about incinerating the waste from other regions is necessary.

In Korea, waste treatment facility plan is generally established for basic policy with controlling city, county and Ku singly deciding on the processing area, but the Waste Control Act provides, considering finance, man power, site securement, facility maintenance, etc., for preferably pushing forward metropolitanization by communal planning with neighboring cities, counties or town, instead of establishing by individual city, county or town, and for positive conference and reconciliation in order to metropolitanize the facility from the very stage of establishing the plan.

In Lahore, insufficient administrative system and institutional building on waste management, lack of public awareness for executing efficient waste administration policy, financial difficulty in constructing waste processing facility, etc. are estimated to make drawing out the agreement between neighboring cities. Therefore, Lahore at this stage will be hard to apply the plan of metropolitanizing waste processing facility. However, in the future stage when some consensus is elicited between neighboring cities, waste policies and institutions are constructed and building and operating technique of waste processing facility is set up to allow exchanging facilities, establishment of a metropolitanized plan will be possible, and then, the metropolitanized processing areas should be established clearly following the course of sufficient consultation and reconcilation between neighboring cities.

3.5 Stepwise strategic plan for waste treatment

3.5.1 Waste collection and treatment targets

Lahore is currently operating a simple throwing-out method of dumping site, and thus, they should solidify and organize sanitary landfill method for the short-term. For a long-term, by recycling, composting and incineration, reducing the waste load of landfills, they should lengthen the usage years of landfill site to its maximum and prevent the secondary environmental pollution due to the landfill site as far as possible.

Fig. IV-27 Suggested waste collection and treatment process

Table. IV-17 Waste treatment target in Lahore

(unit: ton/day)

			2011 (average)	2016 (average)	2021 (average)
Combustible Waste	Organic	Landfilling	1,887~2,157 (2,022)	2,262~2,544 (2,403)	-
		Composting	441~504 (472)	950~1,069 (1,010)	1,678~2,050 (1,864)
		Incineration	-	-	2,105~2,573 (2,339)
	Inorganic	Landfilling	711~813 (762)	981~1,104 (1,042)	-
		Incineration	-	-	1,578~1,928 (1,753)
Incombustible Waste		Landfilling	1,446~1,653 (1,549)	1,995~2,244 (2,120)	3,337~4,079 (3,708)
Recyclable Waste		Landfilling	107~122 (114)	147~166 (157)	-
		Recycling	-	-	245~300 (272)

3.5.2 Waste treatment facility requirement

Table. IV-18 Waste treatment target in Lahore

(unit: %)

Years	Landfilling (average)	Composting (average)	Incineration (average)	Recycling (average)	Total (average)
2011	90	10	-	-	100
2016	85	15	-	-	100
2021	37	19	41	3	100

Table. IV-19 Plan of waste treatment facilities

Years	Landfill (ton/5years)	Composting Facility (ton/day)	Incinerator (ton/day)	Recycling Facility (ton/day)
2011	9,096,637	500	-	-
2016	11,701,326	1,000 (500)	-	-
2016	7,167,431	2,000 (1,000)	4,500	300

Note: Values in ( ) represent "The need for additional capacity."

4. Treatment facilities and redevelopment scheme

4.1 Best practice siting consideration

4.1.1 Procedure of selecting sanitary landfill sites

It is strongly required to build a waste landfill site which can minimize impact to environment and residential areas around it and treat waste sustainably. Screening the potential landfill sites takes following steps:

- Planning the research for site validity
- Setting a criteria for the site evaluation
- Field survey on each candidate sites
- Details for exclusion of landfill facility sites and the selection standards
- Evaluation of each site
- Selection of an optimal site for the sanitary landfill

Fig. IV-28 Steps for selecting the best landfill site

Candidate Sites		
↓	←	Applying the site exclusion criteria Techniques: visual research, map check, evaluation of relevant data
Selecting possible sites		
↓	←	Setting up the standards of selecting a site Carrying out a site feasibility study for a possible site Techniques: visual research, Map check, Check of relation data
Selecting the best sites		

As Punjab province do not have any guideline for selection of the best sanitary landfill site. The study will develop the guidelines for Punjab considering those of other countries.

4.1.2 Considerations for selection of the location for waste treatment facility

Generally, the location for waste landfill facility should be selected in comprehensive consideration of the following, under the basic principle of securing the planned landfill volume.

Efficiency at collection and transfer

Of the waste treatment cost, collection and transfer takes up a very high proportion, which tends to arise from metropolitan to metropolitan, though varying from diverse conditions of forms of collection work, areas of collection, location of processing facility, traffic circumstances, etc. Therefore, in selecting the location of landfill it is important to plan for efficient collection and transfer under the sufficient examination of these.

Peripheral conditions

Landfill facility includes the risk factors of generating environmental problems via the facility itself, traffic of collecting and transfer vehicle, etc. Therefore, in order for these not to cause environmental pollution to neighboring areas, it is desirable to seek the effect of district improvement fully considering each of the following items.

§ Points of releasing water for handling leachate
§ Routes of carrying-in road, road approaching landfill facility, etc.
§ In case of residential area around, divisions by green, road, etc. and circumstance of noise, vascillation, bad odor, etc.

§ Locational relation with residential zone or public facility like school, hospital, etc.
§ Circumstance of electric power, telephone, water-supply facility, etc.

Topography and geology

In selecting a place for landfill facility, one with geology full of sustaing power and preferably on impermeable foundation, not one in danger of ground subsidence, is desired in terms of construction cost and maintenance. However, in case of locating a place with weak foundation, etc. a sufficient measure is needed so that landfill and each facility may not subside from inequality. Also, an area with plenty of surface runoff or reservoir of ground water or an area with water gotten at direct downstream is to be avoided, and as to underwater, too, it is necessary to examine water vein, water level, water-utilization, etc.

Safety against disasters

In Korea, landfill facility is often built in mountain area due to the difficulty of securing the site from level land, which involoves a danger of increasing surface runoff caused by lumbering, root cutting, etc. Against it, it is necessary to carry out sufficient survey on the point of release and, if need arises, to arrange a place for controlling disaster. Landfill facility should also avoid ground collapse and danger zone and be safe from earthquake and flood disaster.

After using plan of landfill site and its relation to municipal development

It is desirable that landfill facility serve not only to preserve the environment of local community around the proposed site for the facility but also to improve the wellbeing of the community. Meanwhile, seeking the formation of consensus with the residents in materializing the construction of landfill facility has been recently rising up as an important task, and post-use of the landfill site as an important factor to expect the consensus of the local residents. In this regard, a post plan of use needs to be set to expect the district improvement effect considering the staus quo of neighboring area and the future image of municipal development.

Association with relational facilities

The principle of processing waste is that courses of collection, transfer, treatment and disposal should be carried out smoothly, rapidly and economically without harming the living cisrcumstances. Therefore, facilities related to it needs to be arranged functionally and the location of landfill facility should be in a short distance from such standard place of work as cleaning operation, mid-treatment facility, etc. and be near the site for gathering earth for cover soil.

4.1.3 Setting up site exclusion criteria

First of all, the landfill sites which are physically, socially, or economically improper cannot be the landfill. The study refers to Korean guideline which is about where a landfill is not provided for because Lahore does not have a guideline or regulation for best practice siting considerations.

Table. IV-20 Unsuitable areas for landfill sites in Korea

Category	Unsuitable areas for landfill sites
Preservation of Natural Ecosystem	§Ecosystem preservation areas and green zone VIII §Areas set aside for natural monuments, national/state parks or reserved forests §Areas within 1km of a wildlife sanctuary
Water protection	§Water preservation areas §Regulated areas to preserve water source: §Areas within 20km of a wide water preservation area toward the upper stream, §Areas within 10km from general water preservation area toward the upper stream, §Areas within 15km from a pumping point toward the upper stream and within 1km toward the downstream.
Environmental Protection	§Areas whose contamination could significantly affect agricultural or public water quality

Source: MOE, Guideline for establishment of waste treatment facility

Table. IV-21 The standard of EPA, US

Category	Unsuitable areas for landfill sites
Airport Security	§Turbo engine airplane: within a 1,000ft radius of landing strip §Conventional type engine airplane : within a 5,000ft radius of the landing strip → The buffer zone prevents bird-related accidents
floodplain	§Low-lying areas with flooding risk §Banks or coastal areas that have frequency flooded over the last 100 years
Wetland	§Areas which don't meet the water quality standard of the state §Areas which don't meet the water quality standard for discharged water as found in the Clean Water Act. §Threat of destruction to endangered species §Risk of destruction to valued ecological resources
Geography	§Areas within 200ft of single layer zone formed in 4th geological age. §Earthquake zone, unstable zone

Source: EPA

Table. IV-22 Setting up site exclusion criteria for Punjab

Category	Unavailable areas for landfill sites
Preservation of Natural Ecosystem	1. Ecosystem preservation areas 2. Areas set aside for natural monument, national/state parks or reserved forests 3. Areas within 1km of a wildlife sanctuary
Water protection	4. Water preservation areas and the areas within 10km of the upper stream
Airport Security	5. Turbo engine airplane: within a 1,000ft radius of the landing strip Conventional type engine airplane: within a 5,000ft radius of the landing strip
Other areas	6. National heritage protection zones 7. Fault zones 8. Wetlands
Ensuring the volume of landfill	9. Areas which do not provide sufficient landfill capacity

4.1.4 Ranking potential sites with sustainability scores

The appropriate siting of a landfill to treat waste sanitarily is the primary environmental control, so a preliminary investigation of all possible landfill sites should be conducted to identify those sites with the best potential to be developed for landfilling. The objective of the section is to establish the criteria for ranking those sites inspect of environment and social & economic lights.

Many developed countries involving Korea provide the guideline for selecting appropriate a landfill site. Generally, the guidelines contain following contents to be considered:

- Location inspect of distance from a landfill site
- Environmental impact from a waste landfill facility
- Social needs
- Economic conditions e.g. land cost.

Environmental impact is given much more weight and others are adjusted to be fit to characteristics of the subject city.

Fig. IV-29. Flowchart of ranking candidate sites

Table. IV-23 Criteria and score allotting of landfill selection checklist of Korea

City	Allotment of marks	Evaluation focus	Note
Busan	§Considering the importance of each factor, give more weight to it (3~16 point)	§Present condition of residence (16 points) §Land cost and construction cost (13 points)	Absolute evaluation
Namwon	§Considering the importance of each factor, give more weight to it (3~8 points)	§Landfill capacity (12 points) §Water quality, water system (10 points)	Absolute evaluation
Sangju	§Considering the importance of landfill size and capacity, give more weight to it (6~15 points) §Other provisions are equally evaluated on a scale of 105	§Landfill capacity (22 points) §Potential disaster (11 points)	Absolute evaluation
Daejeon	§Considering the importance of nuisance odor, give more weight to it (10 points) §Five points are equally allocated to other factors	§Landfill capacity, odor, potential disaster, land cost or construction cost (10 points)	Relative evaluation

Table. IV-24 Landfill selection checklist and scores of 4 cities in Korea

Category		Busan	Namwon	Sangju	Daejeon	Mean
Population (thousand persons)		3,660	97	111	1,462	
General condition	1. Potential capacity of a landfill	10	12	22	10	13.5
	2. Access to road	3	4	7	5	4.8
	3. Efficiency of waste collection & transportation	3	4	-	5	4.0
	4. Connection with a sewage disposal plant	2.5	4	-	5	3.8
	5. Feasibility of utility Installation	2.5	3	-	-	2.8
	Sub-total	21	27	29	25	25.5
Environmental impact	6. Visibility and scenery	-	5	5	5	5.0
	7. Ecosystem	4	5	5	5	4.8
	8. Air quality	2.5	5	5	5	4.4
	9. Water quality	12	10	5	5	8.0
	10. Noise and Vibration	3	5	5	5	4.5
	11. Odor	2.5	5	10	10	6.9
	12. Post environmental Management	-	3	5	-	4.0
	Sub-total	24	38	40	35	34.3
Technology	13. Convenience of development & construction	10	3		5	6.0
	14. Potential disaster	4	7	11	10	8.0
	15. Attainability of covering soil	4	3			3.5
	Sub-total	18	13	11	15	14.3
Social impact	16. General status of residence	16	8	5	5	8.5
	17. Obstacles around the landfill	-	4	5	-	4.5
	18. Status of cultural assets & public facility	5	-	-	5	5.0
	19. Status of land use and plan	3	4	5	5	4.3
	20. Plan of post-construction & land use	-	-	5	-	5.0
	Sub-total (8 factors)	24	16	20	15	18.8
Economic section	21.Land & construction cost	13	6	-	10	7.3
Total		100	100	100	100	100

Table. IV-25 Landfill selection standard of Japan

Category	Criteria of evaluation
Locational conditions	· Is the candidate site efficient for Landfilling (capacity/area)? · Is the excavated soil sufficient to cover the waste? · Is the road to extend to a final landfill site? · Is the land use plan (on flatland/landfilling site) optimal?
Environmental impact	· Natural conditions - Geography: presence of an earth fault, colluvium or subsided land - Flora and fauna protection: under what level of environmental protection does the area belongs to? · Social conditions - How much of the area is cultivated land? - Presence of culturally or historically significant sites, on or near the area · Environmental pollution - Do odor, noise & vibration from the landfill negatively affect nearby areas?
Economic efficiency	· Construction cost · Construction and operation cost

Considering regional features, status and referring to that of Korea, the study selected the evaluation criteria for the landfill location in Lahore. In case of Korea, the check list reflects the regional features. The evaluation checklist of Lahore contains 16 factors in 4 sections. Especially, some factors in locative section which influence to waste collection and transportation and efficiency of landfill operation are allotted 10 points.

Absolute evaluation can distort the different features of the candidate sites. Relative evaluation is adopted to secure objectivity. If the final score is above 100%, it would rank on the 1st, 90% ranks 2nd, 80% ranks 3rd. If the gap is within 10%, both of them will be given due considerations.

Table. IV-26 Site evaluation factors and scoring method for Punjab

Category	Factors	Marks	Standards for site selecting
Location	1. Size and capacity of the landfill	10.0	Is the capacity of the landfill sufficient?
	2. Size of water-collecting area	5.0	Is the capacity of the landfill's water collection facility sufficient?
	3. Transfer distance	10.0	Is the distance within the capacity of transport equipments?
	4. Accessibility to the landfill	10.0	Is it possible to extend and widen the road to the landfill site?
	5. Municipal facilities	5.0	Is it easy enough to construct municipal facilities like power or water supplies?
	6. Safety from disasters	5.0	Is it safe in the event of a disaster?
	7. Ease to construct the landfill	5.0	Is it easy enough to construct a landfill site when considering soil, groundwater level, etc?
	Sub-total	50.0	
Environment	8. Visibility	5.0	Does it ruin the scenery?
	9. Impact to water contamination	5.0	Is there a risk of polluting nearby water by soil outflow during construction? Is it far enough from the river?
	10. Impact to air pollution	5.0	Does the polluted air from the landfill spread and influence adjacent areas?
	11. Impact to odor	5.0	Does the odor spread and influence adjacent areas?
	12. Impact to noise & vibration	5.0	Does the noise and vibration from the landfill affect adjacent areas?
	13. Impact to ecosystem	5.0	Does it negatively affect the surrounding ecosystem?
	Sub-total	30.0	
Society	14. Residential areas and other facilities influenced by the landfill	5.0	Are there nearby residential areas or social facilities around it? If so, can they relocate to another area?
	15. Historical and cultural heritage	5.0	Does it affect nearby site(s) of cultural or historical significance?
	Sub-total	10.0	
Economy	16. Construction cost	10.0	Is the construction cost feasible?
	Total (16 factors)	100	

4.2 Feasibility assessment on the planned sanitary landfill sites

4.2.1 General description of the candidate sites

CDG Lahore is now looking for new sanitary landfill sites in order to improve the waste treatment practice. There are three candidates: Katorbund road, Sunder, and Kana sites. This study applies the landfill site selection criteria developed at the previous section to test the feasibility of the candidates.

Fig. IV-30 Location of candidate landfill sites in Lahore

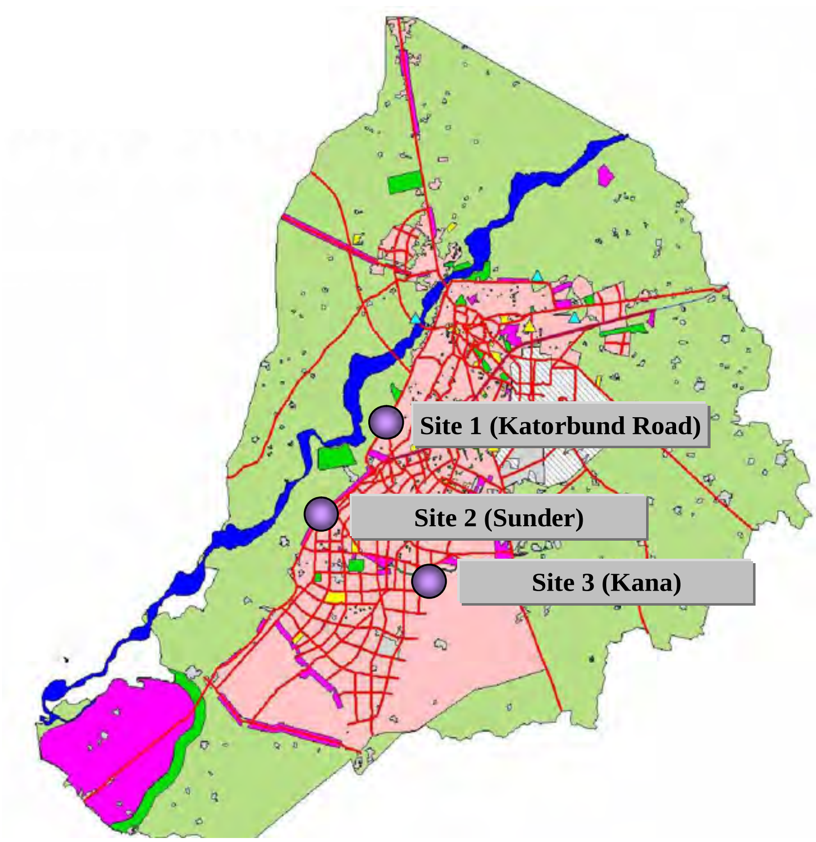


Table. IV-27 Outline of candidate sites in Lahore

	Site 1 (Katorbund Road)	Site 2 (Sunder)	Site 3 (Kana)
Location	31° 28′40N, 74° 13′13E	31° 21′35N, 74° 08′09E	31° 23′23N, 74° 20′33E
Altitude	198m	184.5m	196.5m
Site View Site 1			
Site View Site 2			
Site View Site 3			
Area	505,857	556,443	252,929
Distance from city center (Approx.)	10	31	22
Entering Road	Easy access because of well paved road (length is 2.5km, width is 10m)	Easy access because the main road extends to the entrance.	Access is difficult due to narrow road (width is 5m)
The spread of residential area (Approx.)	2~3 houses	2000 houses 1km away	Residential area 1km away
Geography	Excavated ground (eroded basin)	Flat ground	Flat ground
Groundwater Level (Approx.)	12 ~ 15m	9m	12 ~ 15m
Land use	Denuded Land	Grassland & Denuded Land	Farmland & Grassland
Water system (Approx.)	About 3km away from the Ravi River	About 5km away from the Ravi River	About 32km away from the Ravi River
Utility facilities	No sewage treatment or water supply facilities Power supply facilities	No sewage treatment or water supply facilities Power supply facilities	No sewage treatment or water supply facilities Power supply facilities

4.2.2 Application results of the site selection standards

Three candidate sites were evaluated based on the criteria mentioned above. The first procedure was the application of exclusion criteria and all of the candidates meet the requirement of exclusion criteria. No candidates seriously jeopardize natural ecosystem, water supply sources, airport security, etc. In landfill management, the actual reclamation period can be longer than the estimated period because the waste ground can sink by 30~40%.

Table. IV-28 The Outcomes of applying the exclusion criteria

Unsuitable areas for landfill sites			Site 1 (Katorbund Road)	Site 2 (Sunder)	Site 3 (Kana)
Preservation of Natural Ecosystem	1. Ecosystem preservation area		X	X	X
	2. National & state parks or and natural protection forests		X	X	X
	3. Natural monument & a wildlife sanctuary within 1km		X	X	X
Protection of a source of water supply	4. Water reservoir within 10km of the upper stream		X	X	X
Airport Security	5. Turbo engine airplane: within a 1,000ft radius of landing strip Conventional type engine airplane: within of a 5,000ft radius of landing strip		X	X	X
Other area	6. Protection zone for cultural and historical assets		X	X	X
	7. Fault zone		X	X	X
	8. Wetland		X	X	X
Ensuring the volume of landfill	9. Potential capacity	Landfill capacity ( )	13,155,000	15,016,000	5,117,000
		Landfill period* (years)	9	10	4

Note * : If Sites 1 ~ 3 are simultaneously built and operated, 10years of reclamation period would be secured for each site.- Site 1: 23 years, Site 2: 26y ears, Site 3 : 18 years

Table. IV-29 The outcomes of applying the selection criteria

Classification	Factors	Marks	Site 1 (Katorbund Road)	Site 2 (Sunder)	Site 3 (Kana)
Location	1. Size and capacity of the landfill	10	10	10	9
	2. Size of water-collecting area	5	5	5	5
	3. Transfer distance	10	10	8	9
	4. Access to the landfill	10	10	10	8

	5. Municipal facility	5	5	5	5
	6. Safety from disasters	5	5	5	5
	7. Ease of landfill construction	5	5	5	5
	Sub-total	50	50	48	46
Environment	8. Visibility	5	4	5	5
	9. Impact to water contamination	5	4	4	5
	10. Impact to air pollution	5	4	5	5
	11. Impact to odor	5	4	5	5
	12. Impact to noise & vibration	5	5	5	5
	13. Impact to ecosystem	5	5	4	4
	Sub-total	30	26	28	29
Society	14. Residential areas and other facilities influenced by the landfill	5	4	4	5
	15. Historical and cultural heritage	5	5	5	5
	Sub-total	10	9	9	10
Economy	16. Construction cost	10	10	10	9
Total		100	95	95	94

The result shows all three candidate sites are available as a landfill site getting more than 90 points. When reclamation facilities are established in stages at these 3 landfills, it is estimated that Site 1 (Katorbund Road) would be the most adventurous considering the cost of acquisition and its proximity to the towns. However, the evaluation is based on the visible test and interviews with officials in it. It requires more precise feasibility investigation.

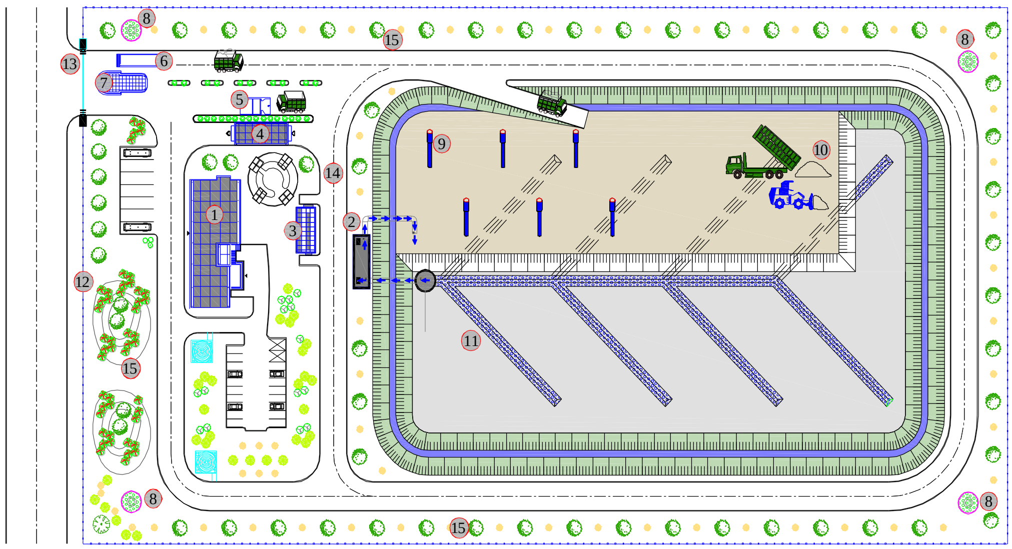
4.2.3 Scheme for sanitary landfill sites

Table. IV-30 Scale of two sanitary landfill sites in Lahore

Classification	Site 1 (Katorbund road)	Site 2 (Sunder)	Site 3 (Kana)
Landfill Area( )	354,100	389,510	177,050
Average Landfill Height (m)	37	39	29
Potential capacity ( )	13,155,000	15,016,000	5,117,000
(years) *	9	10	4

Note * : When Site 1 ~ 3 are simultaneously built and operated, 10years of reclamation period would be secured for each site.- Site 1: 23 years, Site 2: 26y ears, Site 3 : 18 years

Fig. IV-31 Layout plan of sanitary landfill in Lahore



REMARK

1	Administration Building	5	Washing Wheel Station	9	Landfill Gas Collection Facility	12	Boundary Fence
2	Leachate Collecting Well	6	Weigh-Bridge	10	Waste Landfilling	13	Entering Gate
3	Landfill Gas Treatment Facility	7	Guard House	11	Leachate Collecting & Drainage Facility	14	Paved Access Road
4	Vehicle Repairing Garage	8	Ground water inspection Well			15	Green Zone

Fig. IV-32 Standard cross section of sanitary landfill in Lahore

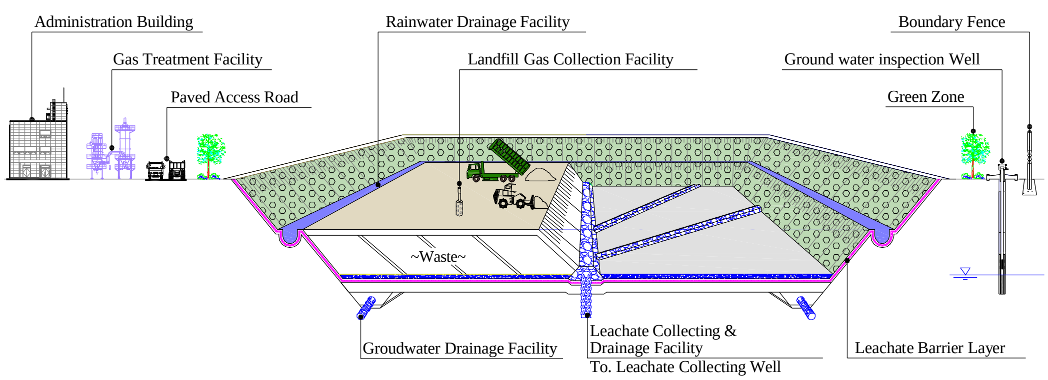


Fig. IV-33 Katorbund Road: In-between landfill

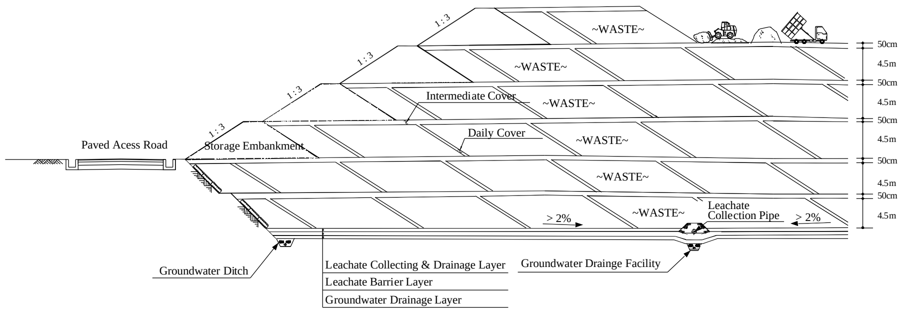
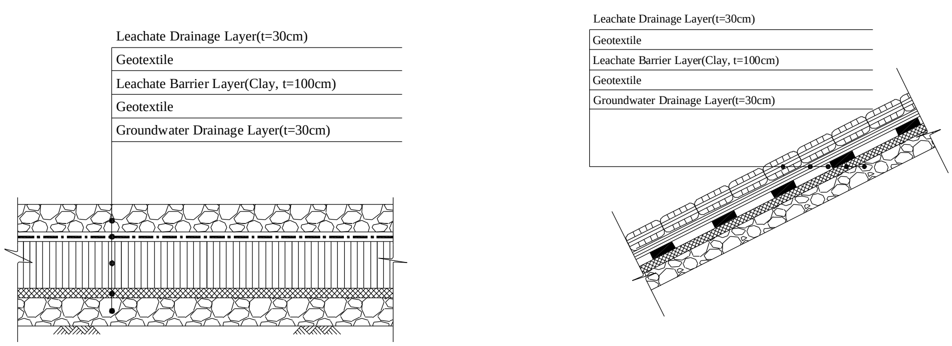
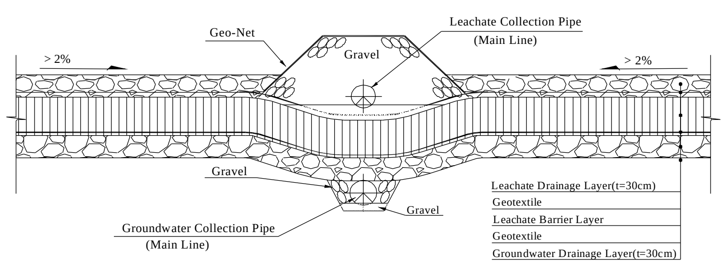


Fig. IV-34 Leachate Barrier, drainage layer of sanitary landfills in Lahore

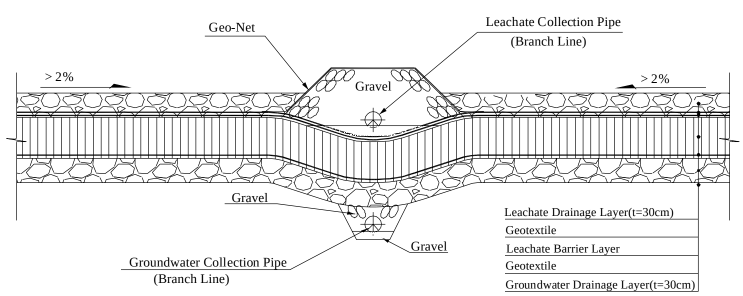


Bottom part slope part

Table. IV-31 Leachate and groundwater collection pipe of sanitary landfills in Lahore

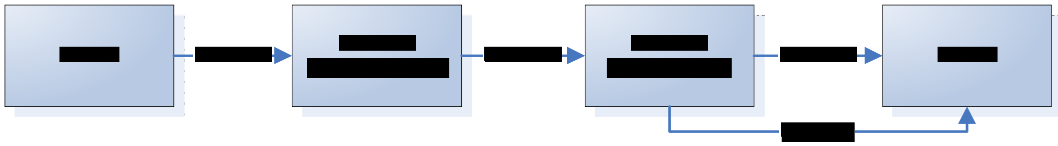


Main Line



Branch Line

Fig. IV-35 Leachate recirculation process of sanitary landfills in Lahore



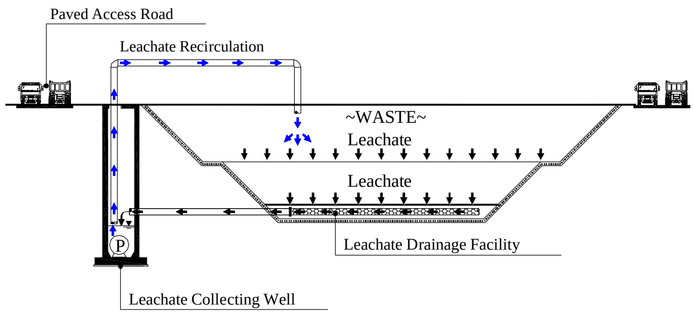
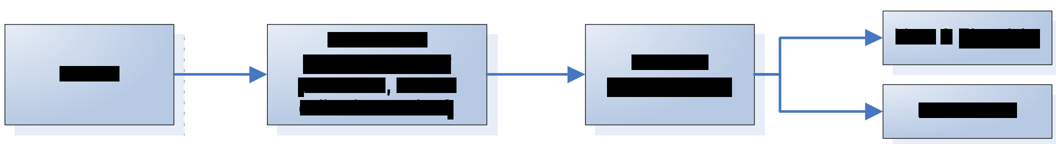
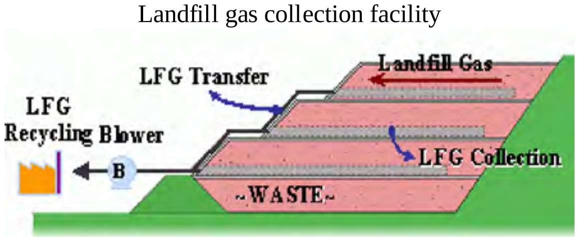


Fig. IV-36 Gas collection and treatment method



Landfill gas collection facility



Horizontal collection method

Landfill gas treatment facility

Generator

Vertical collection method

Incineration

4.2.4 Composting facility

For waste recovery technology at Lahore, composting method is the most suitable among foraging, landfill, incineration and carbonizing technology that can be adapted for food waste resource-recovery, and of all composing methods the introduction of respiratory composting method is estimated to be the most advantageous in consideration of Lahore's food waste characteristics, application incidents, economic aspects, resource saving effect and creation of economic revenue via recovering resources and energy, recycling, possibility of securing demanding places, etc.

Table. IV-32 Treatment capacity of composting facility in Lahore

(unit: ton/day)

Year	Treatment target	Facility capacity
2011	504	500
2016	1,069	1,000 (500)
2021	2,050	2,000 (1,000)

Note: Values in ( ) of represent "need for capacity extension"

And for the quality standard of compost as the final product, there is no explicit regulation despite existing data on the components of compost produced at Lahore's composting facility, so the optimal standard of quality suited for Lahore's reality should be established in referring to Korea's quality standard of compost. It should be appropriate to put forward in the direction of establishing the optimal standard of handling food waste suited for Lahore by putting together the emission form and nature of Lahore's food waste, required quality standard of compost, site conditions, installation, economy of operating cost, etc. through sufficient examination and review in the stage of future basic plan and design.

Aerobic composting can be done in 2 ways: windrow system, which is currently practiced in Lahore; and mechanical method. At the early stages of implementation of either of the 2 methods, it is expected that wastes will not be properly segregated. It is therefore recommended to use windrow system at this stage. When wastes segregation, collection and treatment facilities are settled and smoothly operated, the mechanical or in-vessel system may then be adapted.

System	Windrow system	Mechanical or In-vessel system
Overview	§Compost materials are piled in triangular rows with width of 4.5m and height of 1~2m. §Aeration is done by turning the pile every 3 days. For wet materials, turning should be done every day. §Covering the windrows is needed prevent water from flowing through the compost. §The composting period is 1month and stabilization period is approximately 20 days.	§All treatments in this method are run mechanically. §Treating the materials within a vessel provides high degree of control over the process. The composting condition is controlled by stirring, ventilating, and moisture addition if necessary. §Deodorization suppress offensive odors is required. Composting period is approximately 36 days.
		
Process flow	§Waste à Receiving à Trommel Screen & Sorting à Mixing à Windrow(using Wheel Loader) à Sorting à Compost à Wrapping	§Pre-treatment, Fermentation & Post-maturing process §Waste à Receiving à storage à Crushing à Grading à Draying à Fermentation(15 days) and After ripening (21 days) à Compost à Wrapping
Features	§Fast drying §Large amount of wastes can be treated. §Produces stable compost. §Requires relatively low investment. §Requires large space. §Possibilities of offensive odor. §Reacts sensitively to weather environment.	§High quality compost can be obtained in short period. §Can be installed in narrow space. §Not affected by weather. §Requires excessive initial investment for installation. §Requires advanced operating and maintenance. §Easy control of offensive odors.
Cost (Approx.)	§Investment cost : 600,000 Rupi/ton §Expenditures : 78,000 Rupi/ton.year	§Investment cost : 6,289,308 Rupi/ton §Expenditures : 826,360 Rupi/ton.year
Application	§For wastes that are not properly segregated, during the initial stages of waste management, when operations are not yet smooth.	§In the stage when separation collection and operation for the facility is smoothly run.

4.2.5 Incinerator

Of the Stocker Type, Fludized Bed Type, Rotary Kiln Type and Plylosis Type adaptable to incineration method, introduction of Stocker Type is estimated to be the most advantageous as Lahore's incineration technology considering the characteristics of incineration-targeted waste, suitability for handling large-volume waste, managing incidents, reliability/stability/economy aspects, operating manipulation, maintenance, securing technical manpower, etc. Currently some hospitals at Lahore are operating the incinerator but with no explicit standard of handling, no more than a level of burning waste, so the optimal standard of incinerating facility suited for Lahore's reality need be established by referring to Korea's standard for incinerating facility.

Table. IV-33 Incinerator capacity in Lahore

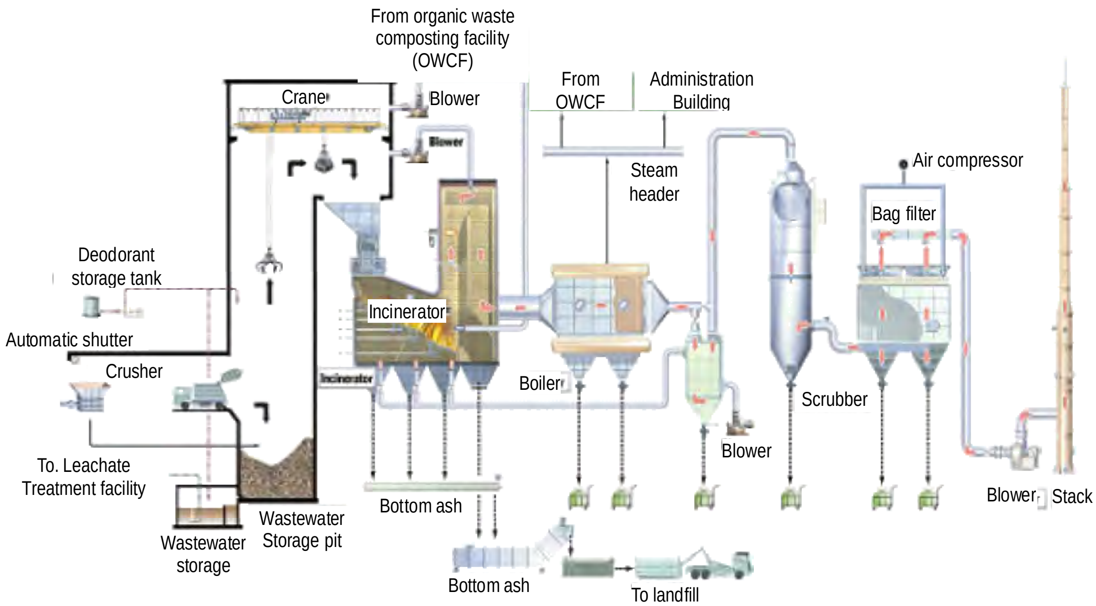
(unit: ton/day)

Year	Treatment target	Incinerator capacity
2021	4,501	4,500

It should be appropriate to push forward in the direction of establishing the optimal standard of incinerating facility suited for Lahore by synthesizing the nature of incineration-targeted waste, site conditions, facility scale, suitability of handling technology, installation, economy of operating cost, etc. through a sufficient examination and review in the future stage of basic plan and design.

The Stoker Type as proposed for incinerating method at Lahore's incinerating facility comprises the system capable of successive, stable waste incineration, minimized environmental pollution and maximized use of energy. The main process consists of incineration, usage of remaining heat, and facility for preventing environmental pollution; detailed facility consists of those for carrying-in supply, incineration, combustion gas cooling, emission gas handling, steam generation, ventilation, water supply, re-emission, filthy wastewater handling, utility, electric supply, chief control, etc. The following is the composition, process and standard of facility for Stoker-type incinerating facility generally applied in Korea.

Fig. IV-37 Process of Incinerator



4.2.6 Recycling facility

Table. IV-34 Treatment capacity of recycling facility in Lahore

(unit: ton/day)

Year	Recycling target	Recycling facility capacity
2021	300	300

For Lahore's sorting technology at recycling facility, introduction of the mixed sorting system of hand sorting by human combined with automatic sorting by machine is deemed to be the most advantageous. For standard of recycling facility, as there being currently no regulations on explicit standard for handling of recycle waste at Lahore, the optimal standard suited for Lahore's reality should be established by referring to Korea's standard of recycling facility.

It should be appropriate to push forward in the direction of establishing the optimal standard of recycling facility suited for Lahore by synthesizing the emission form and nature of recycle waste, required quality standard of recycled goods, site conditions, facility scale, suitability of handling technology, installation, economy of operating cost through a sufficient examination and review in the future stage of basic plan and design.

Generally, waste sorting is largely divided into manual sorting by human and automatic sorting by machine, but in the actual scene a mixed sorting system is being applied in combination of manual sorting, considering the limit of mechanical facility, and mechanical sorting. Of these, manual sorting by human is the oldest one, unsanitary and kind of dangerous, but by pre-education on sorting subject and visual sorting work, it has the strength of very high sorting efficiency and currently is the sorting method applied to most recycling facility.

Mechanical sorting is the sorting technology by using physical nature such as gravity, electromagnetic nature, color, etc. Automatic sorting technology on some subject items has been developed and is applied, and in considering manpower shunning tendency due to the poor environment of sorting work, aggravating economy caused by the burden of personnel expenses, etc. the ratio of mechanical sorting is on the rise. In addition to manual sorting, sorting method like this includes various kinds of mechanical sorting in consideration of the physical characteristics of the sorted subject, and the followings are the generally applied sorting methods.

Table. IV-35 Sorting methods of solid waste

Methods	Contents
Manual sorting	§ The oldest sorting method, unsanitary and somewhat dangerous, but able to attain a high rate of the recyclables. It manually sorts the recyclable waste discharged at each home and re-divides manually and recycle it.
Wind sorting	§ Method of separating chiefly combustible matter and incombustible inorganic matter with a strong air passage by using the difference in particle's surface area and density
Magnetic sorting	§ Method of separating heavy matters divided by wind sorting into metal and base metal. Sorted iron metal is compressed to about 1,200kg/m3 for recycling.
Inertia sorting	§ Method of separating the waste by using difference in inertia and elasticity. Used for the final compost sorting process.
Screen sorting	§ Method of sorting large waste, PET bottles, etc, by a screen using the difference in entry according to its dispersion (according to size by using screens)
Gravity sorting	§ Method of separating by principle of emission where, among the waste put in from the upper part of screen, light parts rise up and become separated, small particles of heavy matter sink through the screen, and large particles are emitted through the emission opening by the vascillating power of the screen.
False current sorting	§ Method of discerning conductors and non-conductors in waste in order for false current Flux to well surpass the magnetic field caused by coil. Used for separating non-polar conductors such as aluminum, copper, zinc, etc.
Optic sorting	§ Method of separating colored from ordinary glass. If an aberration between reflective characteristics of colored glass and standard color is perceived, compressed air is released to separate colored glass.

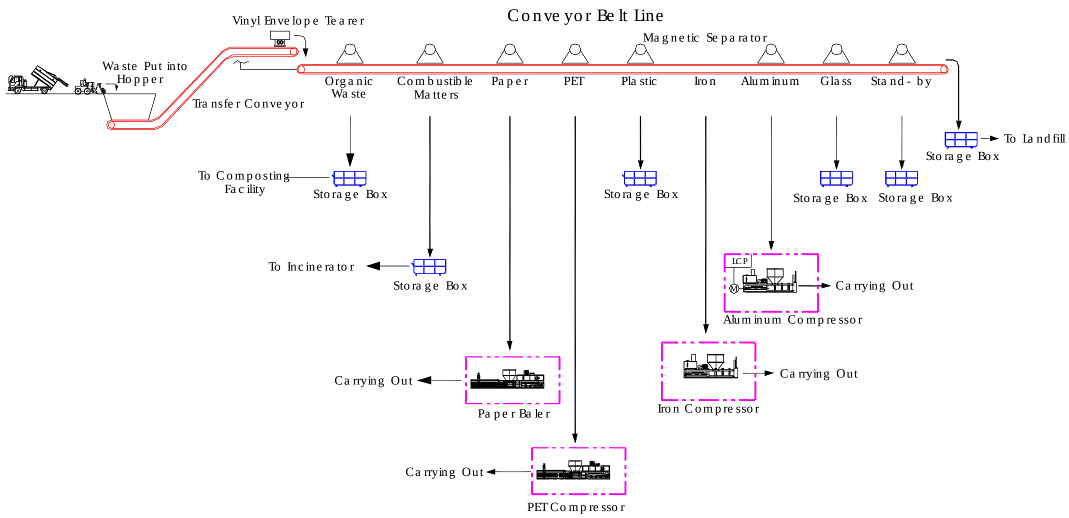
Table. IV-36 Function of recycling facilities (i)

Methods	Contents
Carrying-in/input facility	§Facility introducing recyclable waste into sorting facility §Facility standard: -To install it in PIT form in order for recyclable resources to easily reach the slanting conveyor. – Slanting conveyor must be installed with Flight on the bottom and Guide on both sides in order for recyclable resources not to be spilled or tipped.
Sorting facility	§Facility sorting and classifying recyclable waste §Facility standard: -The facility should be planned according to the characteristics of recycled able goods. These include forms of separated collection, anticipated amount of incoming waste, and number of items to be sorted. The main design factors include width of sorting line, speed, needed power, charge proportion, and thickness of sorting subject layer on the belt. - Several sorting lines can be installed instead of one according to the form and amount waste. Work efficiency, safety, quality of sorting subject, and economy could be improved by possible automation. The work time should also be given equal consideration, as automation can lead to 10-15% work reduction. -There should be a space allowance for the installation of a compression facility which may be deemed necessary depending on the materials that may come up after sorting. -The nature of the work should be given due consideration to prevent worker physical injuries.
Volume reduction facility	§Facility reducing the volume of recyclable waste by using heat §Facility standard: - Installed for the purpose of reducing bulky plastic materials. Fire preventing facility and deodorizing facility need to be installed.
Crushing facility	§Facility for reducing the volume of recyclable waste classified from item to item which serves to increase efficiency in terms of storage and transfer §Facility standard: -Installed for the purpose of crushing plastics (PE, PP, PS, etc.), bottles (white, blue, brown), etc. -Design considerations include type and structure of input materials. For plastics (shattering), chip size about 10-20mm.
Compression facility	§Facility for exerting a certain pressure on sorted, recyclable wastes of low density and for reducing volume to make storing, transfer and recycling possible. §Facility standard: -Installed for compressing paper, PET and cans (iron can, aluminum can, etc.) and in danger of coming apart after compression, a joining facility is installed as well. §- The facility must be stable and with sufficient space for sorting..
Undercurrent facility	§Facility for temporarily keeping sorted, handled recycling waste before carrying-out or move to keeping facility §Facility standard: - Undercurrent facility should be installed in consideration of amount by undercurrent items, seeming density, keeping period, etc.
Carrying-out facility	§These are equipments used to move recyclable wastes into transport vehicles, for instance, handcart, loader, etc. §Facility standard: - The equipments should be purchased at proper capacity depending on the amount of items to be carried or conveyed into the transport vehicle.
Keeping facility	§Facility for keeping sorted, handled recyclable waste §Facility standard: -This facility is installed to store materials that are harmful to the environment, except possibly those which are critically unstable.

Table. IV-37 Function of recycling facilities (ii)

Methods	Contents
Facility preventing environmental pollution	§Said of facilities preventing air pollution, water pollution, noise and vibration, bad odor, etc. §Facility standard: - Facility for aggregating and handling the dust generated from facilities for input, sorting, crushing (shattering), compression, etc. - Deodorizing facility: Facilities like activated charcoal, absorptive top, etc, for handling the bad odor generated from volume-reducing facility - Facility preventing noise: Facilities for lessening noise in order to meet law-regulated standards and to improve work environment
Accompanying facility	§Measuring facility: This facility is installed to quantify the amount of wastes brought into the facility. This facility is installed with a computerized management system. A similar facility is also installed to measure the materials that come in and out of the crushing facility. §Car wash facility: Facility for washing vehicles. This also includes wastewater handling facility.

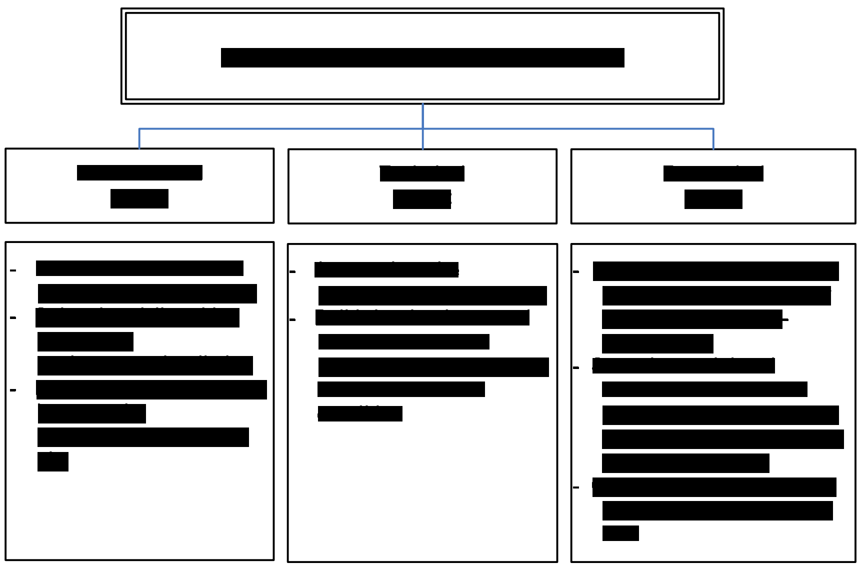
Fig. IV-38 Process of recycling facility



4.3 Restoration scheme for the currently operating dumping sites

Dumping site now under operation at Lahore is a landfill managed by simple landfill method without proper environmental pollution system. All kinds of pollutants are introduced into the near river, underwater, soil and atmosphere, which become origin of environmental pollution such as pollutions of water, soil, air and bad odor generation, therefore reconciliation project should be considered as soon as possible. So reconciliation project must consist of minimizing the environmental damage into neighboring areas, enforcing the quantitative analysis of location features by dumping sites and pollution liability effecting roundabout area for estimating environmental volume and establishing an improvement measure suited for the actual scene, rational and methodical. Hereby, we can prevent longtime environmental damage nearby caused by neglecting dumping site and increase the economic values like preserving local environment, securing usable land according to landfill stabilization.

Fig. IV-39 Benefits from restoration of dumping sites



4.3.1 Environmental impact assessment of dumping site

Leachate pollution

Leachate amount generated in a landfill is generally estimated with a following reasonable formula.

$$Q = (1/1000) * C * I * A$$

Q : quantity of leachate generation (/day)
I : average daily precipitation(/ day)

C : leachate constant

A : landfill area( )

Leachate constant means the rate how much precipitation penetrates into waste layer. It is affected by landfilling condition, precipitation, topography. Here, in mountainous area leachate constant (C) is 0.5 in plain area. Daily precipitation (I) is 1.72mm/day. Total quantity of leachate generation in two dumping sites in Lahore is estimated as in Table. IV-38.

Table. IV-38 Estimated leachate of dumping sites Lahore

Dumping sites	Leachate constant (C)	Average daily precipitation (I, /day)	Landfill area (A,)	Quantity of leachate generation (Q, /day)
Mehmood Booti	0.5	1.72	320,207	275
Saggian	0.5	1.72	252,929	218

The amount of pollution from leachate at the dumping site is assessed by calculating BOD, COD, T-N, and key items of leachate quality. In case of Korea's unsanitary landfill, the larger the landfill area, the larger is the amount of pollution caused by leachate.

Therefore, in the considerably large Lahore' dumping site, the pollution amount is also expected to be large. A project that can minimize the environmental impacts by leachate is needed in enforcing the improvement project.

Gas generation

Gas generation is the dumping sites is estimated using EPA model and its figures are given in Fig. IV-40 and IV-41.

Fig. IV-40 LFG generation in Mehmood Booti dumping site

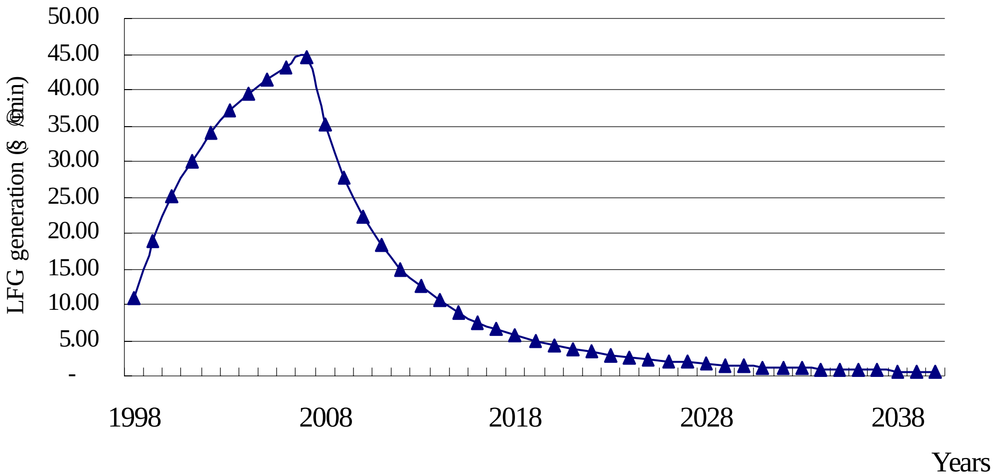
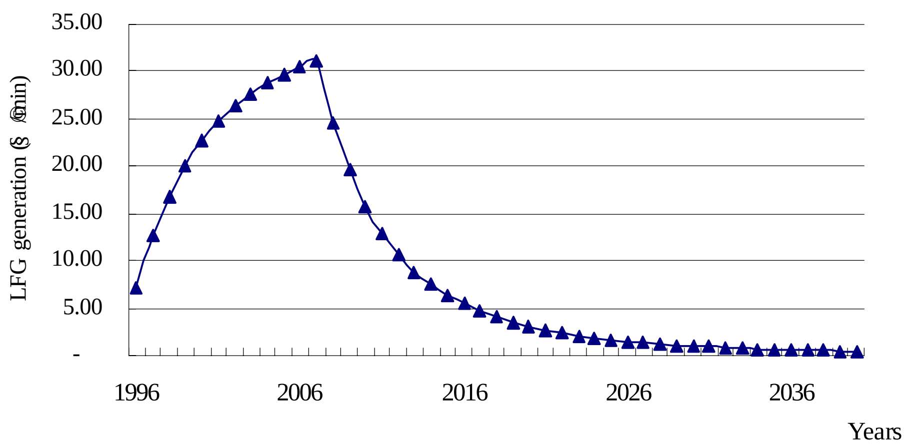


Fig. IV-41 LFC generation in Saggian dumping site



Environmental impact assessment of dumping site

Solid waste landfill causes major negative environmental impacts if not managed in proper method. Thus, environmental impact assessment should be carried out to prevent or minimize the potential negative impacts on the environment and enhance the positive ones by proposing proper mitigation measures. Now, there's no assessment method in Lahore, the assessment on the candidate landfills was carried out according to "Guideline for maintenance of landfill ate termination of usage" by Korean Ministry of Environment (2001. 12). The assessment results are given in the Table IV-39.

Table. IV-39 Environmental impact assessment on dumping sites in Lahore

	Factors	Scoring basis		Score	
				Site 1	Site 2
Pollution (15 points)	Liner system	§ No liner system § Low retaining wall or low quality liner system § Fully installed retaining wall and low barrier wall § High quality liner system	4 3 2 0	4	4
	Implementation of leachate treatment procedures	§ No treatment § No collection of leachate § Self-, simple, or septic tank treatment § Advection, connection, full-function service, or wastewater holding tank	4 4 2 0	4	4
	Height of the final cover	§ Less than 1m § 1m to 2m § more than 2m	3 2 0	3	3
	Stability of the reclaimed land (loss of four sides, subsidence of ground , leaking)	§ leakage § No leakage	2 0	2	2
	Collection and emission of landfill gas	§ not operated § operated	2 0	2	2
	Sub-Total		15	15	15
Features of landfill (36 points)	Time after the final landfilling	§ Less than 2 years § 2 to 5 years § 5 to 10 years § 10 to 15 year § 15 to 20 year § more than 20 years	15 12 10 6 3 1	15	15
	Quantity of landfilled waste	§ More than 50,000 § 20,000 to 50,000 § 5,000 to 20,000 § Less than 5	5 3 2 1	5	5
	Areas of landfilling	§ More than 10.000 § 5,000 to 10,000 § 1,000 to 5m000 § Less than 1,000	5 3 2 1	5	5
	Types of waste	§ Municipal industrial waste § Municipal, industrial, construction waste § Municipal, construction waste § Municipal waste	7 5 3 1	5	5
	Types of landfill	§ Valleys § Hills § Plains § Coast	4 3 2 0	2	2
	Sub-Total		36	32	32

Table. IV-40 Environmental impact assessment on dumping sites in Lahore (ii)

Factors		Scoring basis		Score	
				Site 1	Site 2
Impact to residence (25 points)	Present land use types	§ Farmland	5	4	4
		§ Grassland, forest and fields, s store house, floricultural complex	4		
		§ Park, resort, environmental, gymnastic, handicapped facilities, playground, golf courses	3		
		§ Buildings (factories, offices), agricultural or industrial complex	2		
		§ Transportation	1		
	Possession of land	§ Private land	4	4	0
		§ Public land	0		
	Distance from residential areas	§ Less than 500m	4	2	2
		§ 500m to 1km	2		
		§ more than 1km	0		
	Population of nearby residents (within 500m from the landfill; 4 persons/ household)	§ more than 1000	7	5	5
		§ 100 to 1000	5		
		§ 4 to 100	3		
		§ less than 4	1		
	Civil petition (pollution of ground water, bad odor, dust, using land related research)	§ Civil petition	5	0	0
		§ No civil petition	0		
Sub-Total			25	15	11
Potential pollution of rivers or ground water (24 points)	State of ground water use	§ Drinking water	8	5	5
		§ Municipal or agricultural water	5		
		§ Industrial water	3		
		§ Out of use	1		
	Water preservation zone	§ Water preservation zone I	8	1	1
		§ Water preservation zone II	4		
		§ Out of the zone	1		
	Distance to the nearest waterway from the landfill	§ within 200m	8	4	5
		§ 200m to 500m	5		
		§ 500m to 2km	4		
		§ more than 2km	2		
Sub-Total			24	10	11
Total			100	72	69

Note: In case there is no data available to estimate an item, a point higher than 50% of the highest points regarding diverse events of each item was applied (eg. If present usage of ground water is unknown, point 5, larger than the 4 points, 50% of the highest point was applied)

Source: Korean Ministry of Environment (2001.12), Guideline for maintenance of landfill at termination of usage.

As for facility for preventing leakage of pollutants (15 points each of the total 15 points), there is no leachate treatment facility which is most serious source of all pollutants penetrated at dumping site. As for concerning landfill characteristics (32 points each of the total 36 points), it is a dumping site under landfilling, and shows a state of very big volume of environmental pollution considering characteristics of waste's decomposition, underground water flow, landfill amounts and area, etc.

Regarding the pollution possibility of underground water and nearby rivers (10 and 11 points , respectively, out of total 24 points), there is a great potentiality of pollution leaking out pollution to nearby areas, which use underground water. Leachate outleak has a relatively great effect on living circumstances because of its possible pollution of underground water and rivers.

Redevelopment of landfill site in Lahore

At this point, as a result of analyzing the environment impact factors on Lahore's dumping sites, 72 and 69 points respectively imply a high validity of improving dumping site. Considering minimization of environmental damage to neighborhood area, stability of landfill and reliability on landfill control, improvement project is deemed necessary.

4.3.2 Suitable restoration scheme for the dumping site in Lahore

Currently, Lahore's dumping site in operation without the facility for preventing environemental pollution involves much possibility for acting as every kind of pollutants, so improvement project is in urgent need, we think. Therefore, by considering overall the location, waste landfill years, degrees of polluting neighboring environment, etc. and proposing the most suited improvement measures, we should not only attain the less environmental pollution nearby and improve living environment but also create economic values, lift up urban images and make a guidline for future improvement project in Pakistan's dumping site.

Mehmood Booti dumping site

At Mehmood Booti dumping site located to the north of Lahore, landfill began in 1997 and now continues. A certain closed area of dumping site have reached stabilization status to some degree, but those in current district of dumping site seem to actively generate landfill gas in their stage of decomposing waste. Also there's a rather unstable elements in landfill slanting and with a large scale of landfill, it must have a large amount of leachate generation. During a visit to Mehmood Booti dumping site, it was found that the local soil is composed of clay. This condition lessens the environmental effects due to wastewater flowing through the dumping site. To achieve similar effects, the following maintenance operation is recommended.

At this stage, the key points of on-site maintenance and control of Mehmeood Booti dumping site are suggested as installation of a final cover 1) for obstructing the penetration of water into landfill layers, a generator of leachate, site stabilization 2) for securing the structural stability of landfill layers, facility for drainage/collecting and treatment leachate 3) dealing with the leachate generated in the landfill layers, facility for Landfill gas(LFG) collecting & treatment 4), facility for rainwater drainage 5), boundary fence 6) , measuring facility 7), etc. Among these, Landfill gas collecting & treatment System will be linked with recycling system of landfill gas and this will enable CDM business. After maintenance is completed, regular monitoring of the surrounding environment. If environment (underground water, soil and etc.) is affected by the wastewater from the dumping site, the installation of Leachate barrier wall is strongly recommended.

Fig. IV-42 Restoration scheme of Mehmood Booti dumping site

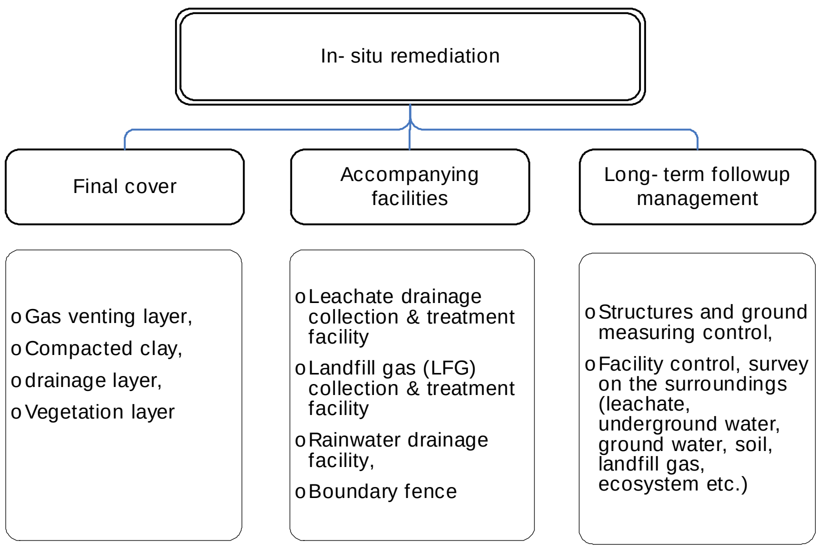
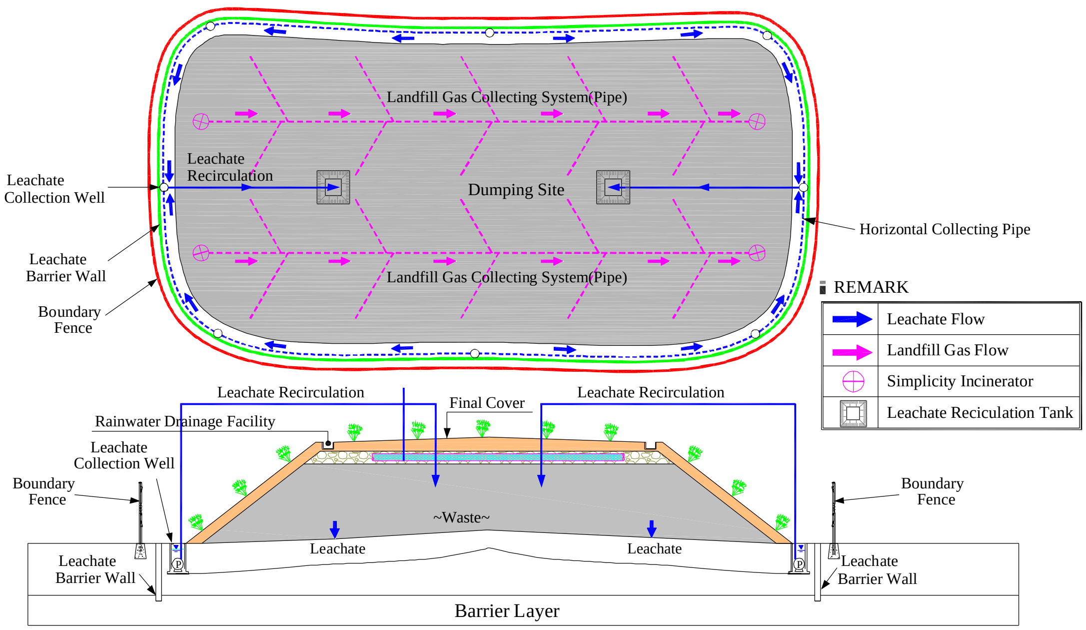


Fig. IV-43 Layout plan on Mehmood Booti dumping site



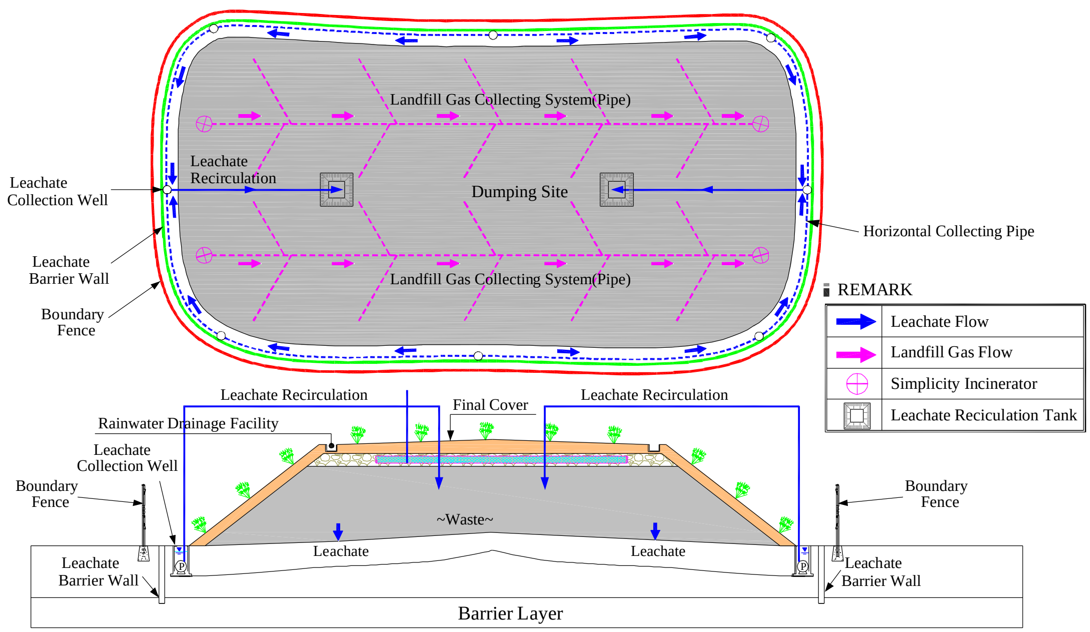
Saggian dumping site

At Saggian dumping site located to the north of Lahore, landfill began in 1997 and now continues. A certain closed area of the landfill site has reached a stabilization of waste to some degree, but those in current landfill seem to actively generate landfill gas in the stage of decomposing waste. Also there's a rather unstable elements in landfill slanting and with a large scale of landfill, it must have a large amount of leachate generation.

Saggian dumping site is closely located to Ravi river. The method of maintenance was therefore selected in consideration of the water level in the Ravi River as the most important element. Generally, in case dumping site located below the water level during the last 100 years, the field maintenance method (Case 1) is applicable and if it is located above the water level, reclamation method (Case 2) is applicable after excavating and transporting the landfill waste. Furthermore, in economical aspect, in case the landfill for the waste is not secured, the filed maintenance method (Case 1) is applicable. If landfill, which enables the transportation and treatment of waste is secured, reclamation method (Case 2), which eliminates the reclaimed waste, the potential cause of pollution, is applicable. This method is suggested to resolve the environmental problems although its construction is costly.

After conducting the field investigation and interviews, it was found that there was no overflow from Ravi River so it was concluded that the water level is not critically high. Given the consideration that after the excavation, there is no sanitary landfill, to which the waste can be transported, the field maintenance method (Case 1), which is same as Mehmood booti dumping site, should be implemented for the restoration scheme for Saggian dumping site(Fig. IV-44).

Fig. IV-44 Layout plan on Saggian dumping site



Excavation/ transfer/ sanitation landfilling is estimated to minimize the possible civil petition and environmental hazard by clearing out pollution origin and contribute to maximizing efficiency at land use too. As a prerequisite, however, they should secure a landfill to be operated sanitarily and to contain all amount of digged waste. Excavation/Transfer/Sanitation landfill plan suggested enforcing the digging of landfill waste, deodorization, and transfer. Site recovery of the landfill wastes are the key points.

Fig. IV-45 Restoration flow on Saggian dumping site

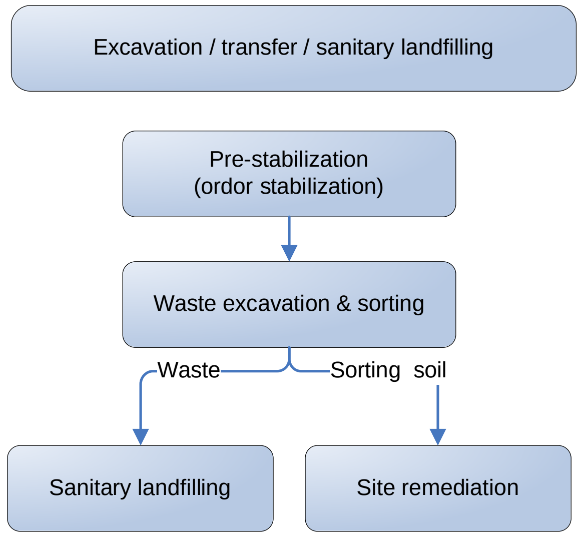
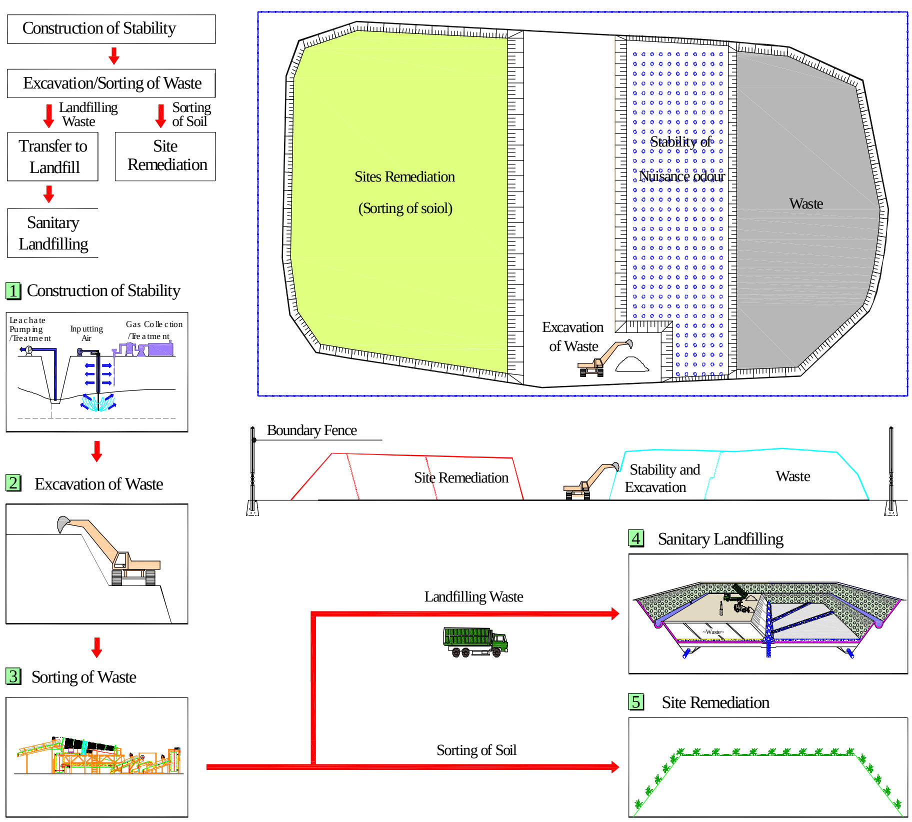


Fig. IV-46 Layout plan on Saggian dumping site



5. Cost benefit analysis from improvement of SWM

5.1 Investment and operating cost for improvement of waste collection and transportation

The following cost is based on the price of Korean and Pakistan vehicles.

Table. IV-41 Purchase cost of waste collection and transport equipment in Lahore

Type	Purchase price (Rupi/EA)	Equipment requirement (EA)				Purchase cost (Rupi)		
		Present	2011	2016	2021	2011	2016	2021
Open Truck (3ton)	900,000	95	100	105	110	4,500,000	4,500,000	4,500,000
Compactor (2.5ton)	1,800,000	21	50	57	192	52,200,000	12,600,000	243,000,000
Compactor (5ton)	3,170,000	-	-	84	174	-	266,280,000	285,300,000
Mechanical Sweeper	2,000,000	33	43	59	87	20,000,000	32,000,000	56,000,000
Total		149	193	305	563	76,700,000	315,380,000	588,800,000

Note : The estimated Purchase Cost includes the costs due to increased number of equipments.

Table. IV-42 Purchase cost of landfill equipment in Lahore

Type		Purchasing price (Rupi/EA)	Equipment requirement (EA)
Landfill equipment	Bulldozer (32ton)	25,600,000	6
	Compactor (32ton)	24,500,000	5
Covering equipment	Bulldozer (32ton)	11,860,000	2
	Excavator (1.0)	8,000,000	2
	Loader (2.29)	8,000,000	2
	Grader (3.6m)	9,228,000	1
	Roller (32ton)	3,971,000	1
Supporting equipment	Watering cart (5,500L)	2,000,000	1
	Disinfection cart	450,000	1
	Mechanical sweeper (4.0)	15,000,000	1
Total			14

Table. IV-43 Transfer station construction cost

Class	Collection amount (ton/day)			Capacity of the transfer station (ton/day)			Construction cost* (Rupi)		
	2011	2016	2021	2011	2016	2021	2011	2016	2021
Site1	202	276	408	250	300	450	8,112,500	1,622,500	4,867,500
Site2	209	286	423	250	300	450	8,112,500	1,622,500	4,867,500
Site3	116	158	234	150	200	250	4,867,500	1,622,500	1,622,500
Site4	305	417	616	350	450	700	11,357,500	3,245,000	8,112,500
Site5	297	406	599	300	450	600	9,735,000	4,867,500	4,867,500
Site6	389	533	787	400	550	800	12,980,000	4,867,500	8,112,500
Total	1,518	2,076	3,067	1,700	2,250	3,250	55,165,000	17,847,500	32,450,000

Note: * unit cost per ton is 32,450 rupi/ton.

Table. IV-44 Purchase cost of transfer and transport vehicle in the transfer station

Type	Cost (Rupi/EA)	No. of vehicles (EA)		
		2011	2016	2021
Arm Roll Truck (15ton)	4,541,000	29	37	53
Arm Roll Container (20)	333,000	44	56	80
Excavator.(1.0)	8,000,000	6	9	11
Total		79	102	144

Table. IV-45 Labor cost for sanitary workers in Lahore

Staff	Average wage (Rupi / month)	Number of workers (person)		
		2011	2016	2021
Superintending Engineer	35,000	1	1	1
Executive Engineer	30,000	8	9	10
Assistant Executive Engineer	20,000	15	18	20
Assistant Engineer	20,000	31	35	40
Qualified Diploma Sanitary Inspector	10,000	77	88	99
Qualified Sanitary Inspector	10,000	154	176	199
Qualified Sanitary Supervisor	8,000	514	587	662
Driver	8,000	541	707	1,019
Sanitary Worker	6,500	3,321	4,543	6,707
Total		4,662	6,164	8,757

Table. IV-46 Operating cost for waste collection and transport equipment

Type	Operation costs* (Rupi/ month)	No. of equipment (EA)		
		2011	2016	2021
Arm Roll Truck (10)	35,000	51	51	51
Arm Roll Truck (5)	35,000	68	68	68
Open Trucks (3ton)	25,000	100	105	110
Compactors (2.5ton)	25,000	50	57	192
Compactors (5ton)	25,000	-	84	174
Dumpers (1ton)	50,000	33	33	33
Tractor Loaders	34,000	23	23	23
Tractor & Trolley	30,000	90	90	90
Mechanical Sweepers	30,000	43	59	87
Total		458	570	828

Source: * Punjab Solid Waste Management Reform Second Draft Report, EBP-Iceppak, Fed, 2007, annex-3

Note: Assumption

Diesel: 37.25 Rupi, Collection vehicle: Arm Roll Truck(15ton)

Collection and transportation vehicle average driving speed: 50 /hr

Transporting distance: Apply transport distance of Main Road from waste storage to the final location

Loading and unloading time: 15 minutes each

Collection and transportation vehicle mileage : 10 /ℓ

Table. IV-47 Operating cost from transfer stations to the waste disposal facilities

(unit: ton/day, rupi/day)

Year	Transfer station	Maintaining cost [1]	Dstance [2] (km)	No. of trip	Transporting costs	Operating costs [3] (Rupi/day)	Operating costs [3] (Rupi/year)
2011	Site 1	5,250	82	13	4,112	9,362	3,417,155
	Site 2	5,250	68	14	3,535	8,785	3,206,606
	Site 3	3,150	54	8	1,552	4,702	1,716,267
	Site 4	7,350	58	20	4,392	11,742	4,285,748
	Site 5	6,300	50	20	3,684	9,984	3,644,303
	Site 6	8,400	70	26	6,769	15,169	5,536,695
	Total	35,700	-	-	24,045	59,745	21,806,774
2016	Site 1	6,300	82	18	5,626	11,926	4,352,986
	Site 2	6,300	68	19	4,837	11,137	4,064,921
	Site 3	4,200	54	11	2,124	6,324	2,308,089
	Site 4	9,450	58	28	6,009	15,459	5,642,416
	Site 5	9,450	50	27	5,041	14,491	5,289,163
	Site 6	11,550	70	36	9,261	20,811	7,596,069
	Total	47,250	-	-	32,897	80,147	29,253,645
2021	Site 1	9,450	82	27	8,306	17,756	6,480,774
	Site 2	9,450	68	28	7,140	16,590	6,055,508
	Site 3	5,250	54	16	3,135	8,385	3,060,500
	Site 4	14,700	58	41	8,870	23,570	8,603,231
	Site 5	12,600	50	40	7,442	20,042	7,315,231
	Site 6	16,800	70	52	13,672	30,472	11,122,303
	Total	68,250	-	-	48,565	116,815	42,637,547

Note: 1) Unit cost per ton is 21 rupi/ton

2) Distance from transfer station to final process location

3) Maintain and managing expense + transport costs

Table. IV-48 Investment and operating cost for waste collection and transportation in Lahore

Classification		Cost	Remark
Collection & Transport equipment	Purchasing cost (rupi/year)	65,392,000	§ Purchasing cost for collection/transportation equipment per year.
	Operation cost (rupi/year)	221,444,000	§ Operating cost per year
Landfill equipment	Purchasing cost (rupi)	362,469,000	§ Purchasing cost for operating equipment for the landfill.
Transfer station equipment	Purchasing cost (rupi/year)	23,676,433	§ Purchasing cost for operating equipment for transshipment facility per year.
Transfer station construction	Construction cost (rupi/ton)	32,450	§ Construction cost for transshipment field per ton
	Operation cost (rupi/ton)	21	§ Operating cost for transshipment per ton.
Sanitary worker	Labor cost (rupi/year)	555,906,000	§ Labor cost for managing wastes per year.

5.2 Construction and operating cost for the waste disposal facilities

The Construction and operating cost by waste disposal facilities was assessed in application of unit cost per ton or m^2 / m^3 to the facility scale of each facility. There is limit to estimate the precise cost due to lack of information. So, it adopted Korean price level and adjusted it fit for Pakistan's condition. For labor, around 10 % of Korea's labor was applied for Pakistan's; for cost, around 70% of Korea's was applied for Pakistan's.

Table. IV-49 Construction and operating unit cost of waste disposal facilities

Class	Facility	Cost (Approx.)
Investment cost	Landfill facility (Rupi/m2)	9,434 1)
	Compost facility (Rupi/ton)	600,000 2)
	Incinerator (Rupi/ton)	11,320,000 3)
	Recycle facility (Rupi/ton)	4,400,000
Operating cost	Landfill facility (Rupi/m3)	240 ~ 294
	Compost facility (Rupi/ton.year)	78,000
	Incinerator (Rupi/ton.year)	152,000
	Recycling facility (Rupi/ton.year)	124,100

Source:1) Approximately 70% of average cost of In-Beetween Landfill in Korea: 9,434 Rupi/m2
2) Composting data of Korea and other major countries
3) Korea incineration technology association(2000.7), study on a solid waste incinerator and database, p.27.
- 50 ton/day/facility : 3 hundred million KRW/ton (18,867,925 Rupi/ton)
- 100 ton/day/facility: 2.5 hundred million KRW/ton (15,723,270 Rupi/ton)
- 200 ton/day/facility ~300 ton/day /facility : 2 hundred million KRW/ton (12,578,616 Rupi/ton)

- 300 ton/day/facility ~400 ton/day/facility: 1.8 hundred million KRW/ton (11,320,755 Rupi/ton)

Table. IV-50 Construction cost of waste disposal facilities in Lahore

	Sanitary landfills			Compost Facility	Incinerator	Recycling Facility
	Site 1	Site 2	Site 3			
Areas Capacity	354,100m^2 13,155,000m^3	389,510 m^2 15,016,000 m^3	177,050 m^2 5,117,000 m^3	500ton/d (2011)	4,500 ton/d (2021)	300 ton/d (2021)
Unit cost	9,434Rupi/ m^2 254Rupi/ m^3	9,434Rupi/ m^2 245Rupi/ m^3	9,434Rupi/ m^2 326Rupi/m3	600,000 Rupi/ton	11,320,000 Rupi/ton	4,400,000 Rupi/ton
Total construction cost (thousand Rupi)	3,341,370	3,678,920	1,668,142	300,000	50,940,000	1,320,000

Note : tax, design & construction consulting fee is not included

Table. IV-51 Operating cost of waste disposal facilities in Lahore

	Sanitary landfills			Compost Facility	Incinerator	Recycling facility
	Site 1	Site 2	Site 3			
Total capacity	13,155,000 m^3	15,016,000 m^3	5,117,000 m^3	500ton/d (2011)	4,500 ton/d (2021)	300 ton/d (2021)
Unit Cost	24 0Rupi /m^3	240 Rupi m^3	240 Rupi m^3	78,000 Rupi/ton.yr	152,000 Rupi/ton.yr	124,100 Rupi/ton.yr
Total operating cost (thousands Rupi)	3,157,200	3,603,840	1,228,080	39,000/yr	684,000 /yr	37,230 /yr

Note: tax is not included

5.3 Cost analysis of each landfill

The location of landfill facility should be determined by the total analysis of construction cost, operating cost and transfer cost. The larger the size of the facility, the lower the construction cost but operating costs are the same. The closer the location of the facility to the city, the lower the transfer cost gets. By carrying out a total analysis, Site 1 (Katorbund Road) is determined to be the most adventurous for the new landfill for Lahore.

Table. IV-52 Cost analysis of sanitary Landfill in Lahore

	Capacity (m^3)	Construction cost (Rupi/ m^3)	Operation cost (Rupi/ m^3)	Transfer cost (Rupi/ m^3)	Total cost (Rupi/ m^3)
Site 1	13,155,000	254	240	30	524
Site 2	15,016,000	245	240	92	577

Site 3	5,117,000	326	240	66	632

Note: 1. Assumption: Transport vehicles - compactor(2.5ton), round trip, Gas filling cost is 37.25Rupi/L, in case 1L drives 10km

2. Tax, design & construction consulting fee is not included

5.4 Expected profit from operation of waste disposal facilities

Expected profit from electric sales and heat supply

Table. IV-53 Expected profit from landfill sites

Class	Lahore
Recyclable landfill gas	90 /min
Maximum energy generation	9
Expected profits	9 × 4Rupi/ H = 315,360,000 Rupi/year

Table. IV-54 Expected profits from incinerator in Lahore

	Korea	Lahore	Note
Capacity of Incineration Facility (ton/day)	11,468	4,500	
Amount of Waste Heat Generated (Gcal/Year)	4,951,000	1,943,000	Incineration Facility generates 1ton/day (431.7Gcal/year)
Amount of Waste Heat Used (Gcal/Year)	4,419,000	1,736,000	About 89.3% of amount of Waste Heat Generated
§Use of Heat	3,482,000	1,368,000	About 78.8% of amount of Waste Heat used
§Use of Energy Generated	937,000	368,000	about 21.2% of amount of Waste Heat used
Profit from Use of Waste Heat (Rupi/year)	7,853,000,000	3,078,376,000	About 39.2% of Korea
§Profit from Heat supply	6,014,000,000	2,357,488,000	
§Profit from Energy Generated	1,839,000,000	720,888,000	

Expected profits from compost sales

Table. IV-55 Expected profits from compost sales in Lahore

	2011	2016	2021
Capacity of composting facility (ton/day)	500	1,000	2,000
Compost sales (ton/day)*	100~150	200~300	400~600

Compost sales cost (Rupi/kg)		4.5	4.5	4.5
Profit from compost sales	Rupi/day	450,000 ~ 675,000	900,000 ~ 1,350,000	1,800,000 ~ 2,700,000
	Rupi/year	164,250,000 ~ 246,375,000	328,500,000 ~ 492,750,000	657,000,000 ~ 985,500,000

Note: * 20~30% of composting facility capacity

Expected profits from recyclable material sales

Table. IV-56 Expected profits from recycling facility in Lahore

	Korea	Lahore	Note
Capacity of recycling facility (ton/day)	143	300	
Total sale (/Year)	11,386,230	23,888,000	79,624 products from 1ton of facility capacity
Total sale (Rupi/year)	155,889,000	334,432,000	about 14 Rupi /kg

Box. IV-4 Recyclable material sales of a Korean recycling facility "S", 2005

"S" Recycling Facility Scale : Total 143Ton/Day

- § Recycling product sorting facility : 100Ton/Day
- § Major waste crushing facility : 4Ton/Day
- § Styrofoam reducing facility : 3Ton/Day

Incoming amount and sales of recyclables

(unit: kg)

	Quantity	Note
Total incoming recyclables ( )	17,727,210	
Total Recycle sales ( )	11,386,230	64.2% of Bring in products
Sales ( )	10,787,710	94.7% of total sales
Free sales ( )	598,520	5.3% of total sales
Total Sales Cost of Recycle Products (KRW)	2,478,627,980	

The sorted waste is separated into 34 different items. According to weight, major items are brown bottle 18.87%, PETE 12.77%, White bottle 14.34%, PP 6.88%, PE 6.77%, Film Type 5.32%, Metal Can 4.52%, Bed Spring (3.52%), Scrap iron (3.54%). All items are sold to

private companies. For Film types, a subsidy is granted.

Sales amount and price of each Categorized Recycled products

Item	Amount (/year)	Unit Cost (KRW)	Sales (KRW/year)	Item	Amount ( )	Unit Cost (KRW)	Sales (KRW/year)
Paper	47,950	65	3,116,750	Yoghurt Bottle	135,360	500	64,296,000
Copper (Wire)	770	2,500	1,925,000	Rubber Bottle	52,540	20	1,050,800
Nectar	5,230	1,400	7,322,000	PVC	4,010	40	160,400
Motor Waste	25,860	300	7,370,100	Plastic (Remnants)	98,470	20	1,969,400
Stainless	20,610	1,200	23,495,400	Plastic Wraps	194,510	51	9,920,010
Bed Spring	400,570	52	20,829,640	Banding String	31,790	35	1,112,650
Water Bottle	3,270	30	98,100	Adapter	8,070	52	419,640
Scrap Iron	403,230	173	59,294,870	Styrofoam (Heat)	142,440	677	96,431,880
Aluminum (Silver)	25,720	1,200	29,320,800	Styrofoam (Compressed)	119,170	677	80,678,090
Aluminum Can	57,440	1,180	64,390,240	Brown Bottle	2,148,310	47	95,921,950
Metal Can	514,680	231	112,946,370	Various Bottle	524,470	15	7,473,660
Electric Wire	20,110	652	12,456,100	Green Bottle	525,350	33	16,739,610
Oil Paper	7,640	67	486,260	White Bottle	1,632,250	74	114,747,050
PETE	1,453,680	600	741,376,800	Plate Glass	83,970	20	1,595,430
PE(Plastic)	771,360	625	409,784,930	Mechanics	258,740	4 Type	32,680,830
PP	783,280	550	366,183,340	Mobile Phone	210	1,000	210,000
Mixed Plastic	279,590	415	92,823,880	Film Type	605,580	-	-
Total: Sales Amount 11,386,230 , Sales Cost2,478,627,980 KRW/Year(155,889,000 Rupi/year)							

Expected profits from greenhouse gas reduction

The Clean Development Mechanism(CDM) is an arrangement under the Kyoto Protocol allowing industrialized countries with a greenhouse gas reduction commitment (so-called Annex 1 countries) to invest in emission reducing projects in developing countries as an alternative to what is generally considered more costly emission reductions in their own countries.

Recovery of landfill gas, reduction of greenhouse gas through substitute of fossil energy can make profit in Lahore landfills. The reduced amount of greenhouse gas is referred to greenhouse gas reduction estimates through CDM project, officially registered to UNGCC by Sudokwon Landfill Management Corp. Operation of Lahore landfills is expected to make 28,085,000~82,417,000 rupis annually.

Operating the incinerators Korea reduced 1,350,000 ton of greenhouse gas annually, 801,900,000 Rupi by sales of emission trade credit. It has been shown that operating incineration facility at Lahore leaves profit of 314,702,000 Rupi/year.

Table. IV-57 Expected profit from greenhouse gas reduction

		Korea	Lahore
Landfill sites	Reclaimed Facility capacity	131,000,000 ton (Sudokwon Landfill I & II)	Landfilling waste - Site 1 : 13,155,000 ton - Site 2 : 15,016,000 ton - Site 3 : 5,117,000 ton
	Greenhouse gas reduction (CO2) - about 9.24% of landfilling capacity	Greenhouse gas reduction for 10 years: 12,100,000 ton/10 year	Greenhouse gas reduction: -Site1: 1,215,522 ton/10 year -Site2: 1,387,478 ton/10 year -Site3: 472,811 ton/10 year
	Carbon finance	718,740,000 Rupi/year	Annual profit: -Site 1 : 72,202,000 Rupi/year -Site 2 : 82,417,000 Rupi/year -Site 3 : 28,085,000 Rupi/year
Incinerator	Incineration facility capacity	11,468 ton/day	4,500 ton/day
	Greenhouse gas discharge reduction (CO2)	1,350,000 ton/year	529,800 ton/year
	Carbon finance	801,900,000 Rupi/year	314,702,000 Rupi/year

Note: CO_2 discharge cost: $10 (594Rupi/ton) per 1 tCO_2
Source: Sudokwon Landfill Site Management Corps.(2007. 5), CDM Project data.

5.5 Economy analysis along dumping site restoration plan in Lahore

The unit cost of restoration plan for Lahore's dumping site for cost analysis was first by dividing Korea's standard construction unit prices into material, labor, and expenses, partitioning then in proportion and then about each item they were reckoned out in their adjustment to Pakistan's local circumstance. Analysis results are as shown below in Table IV-58.

Table. IV-58 Restoration cost for the dumping site in Lahore

Dumping site	Landfilling Area (m2)	Unit cost (Rupi/m2)	Restoration cost (Rupi)
Mehmood Booti	320,207	3,200	1,024,663,000
Saggian	252,929	3,200	809,373,000

5.6 Total cost for construction of waste disposal facilities in Lahore

Final cost to construct waste disposal facilities contain initial investment, consulting cost for facility designing and supervision. Total cost for the 1st step is as seen in a following table. Later, it needs to estimate the cost for 2nd and 3rd step, reflecting the circumstances in Lahore.

Table. IV-59 Total cost for construction of waste disposal facilities, Lahore

Contents		Cost (Rupi)
Construction cost	Landfill sites	3,341,370,000
	Composting facilities	300,000,000
	Sub-Total	3,641,370,000
Consulting Service Cost		442,545,000
Total		4,083,915,000

Note: See the details in Annex-11

V. Case Study II: Solid Waste Management Master Plan of Sialkot

1. Outline

1.1 Location

Sialkot is located in the north-eastern part of Pakistan and between 32°31´ North latitude and 74°32´ East longitude. The city is in the North of Ike River and in the South of Jammu hill area . The population of Sialkot is approximately 125million in 1998 and the total area is 1,010 .

Sialkot is a trading center for cereal as the capital of railway and is the center of industry. It was famous with the processed metal good, and produces a variety of industrial goods such as sport supplies, medical appliances, rubber, metal products, and plates.

1.2 Population

The population of the urban center area was 439,000 in 1998, 35% of the total population. The number of people living in the rural area is 811,000 that takes 65% of the total population.

Table. V-1 Population in city of Sialkot

(unit: person)

Area	Population (1998) (capita)
Urban	500,000 (%)
Rural	750,000 (%)
Both	1,250,000 (100%)

Source: Punjab Solid Waste Management Reform(2007. 2), Ernst Basler + Partners Ltd., p6/193

1.3 Road and buildings

Road condition is important factor of waste collection critically. In Sialkot, most roads are not paved and maintained. Streets are even narrow. Large sized waste collection vehicles are not easy to access to the door. Buildings are low and they were built on the flat ground. But some houses are on the slope.

1.4 Climate

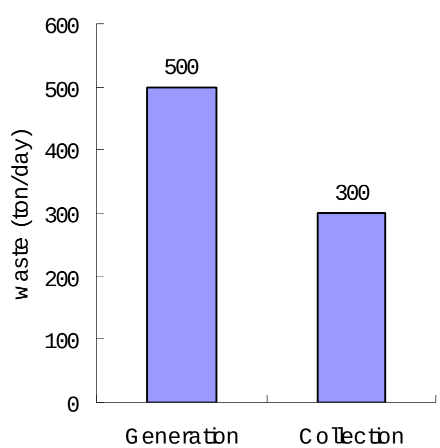
It is extremely hot and wet in summer and relatively cold in winterin Sialkot. June and July are the hottest season, the lowest temperature in winter is around 4 . Land is fertility and the annual average rainfall is about 1,000mm.

2. Solid waste management practices in Sialkot

2.1 Waste generation and composition

In 2006, 500 tons of waste was generated daily. Only 60% of the total waste generated or 300 tons is collected daily. Accordingly, about 30% of the total amount, that is 1,500 ton/day. Remaining waste has not been collected and dumped at the vacant lots.

Fig. V-1 Waste generated and collected

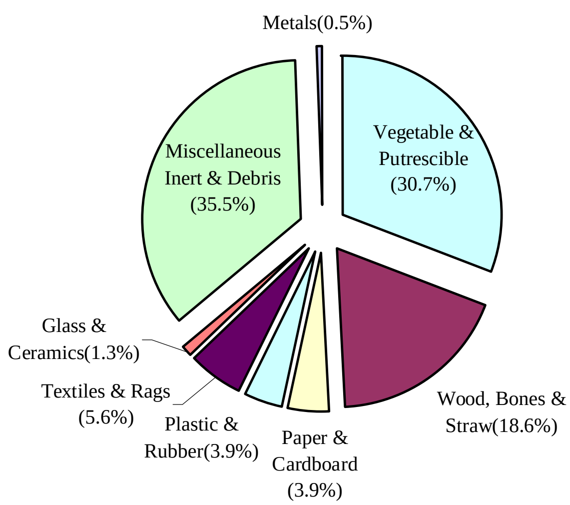


Source: Data from Silakot

Most waste comes from residential, commercial, hospital, and industrial areas: about 96,000 households, 11 hospitals, industrial factories (sports goods), and slaughter houses (Ernst Basler + Partner and ICEPAK).

Municipal waste from Sialkot is composed of vegetable, paper, cardboard, bones, textiles, rags, glass, ceramics and etc. Organic materials such as vegetable, bones, wood represent almost half of the waste or 49.3%. Paper/cardboard and glass/ceramics account for 3.9% and 1.3% respectively. Textiles and rages is 5.6% and metal is 0.5 % like Lahore. For the accurate information to design the waste treatment facility, it should be analyzed by seasons or waste sources.

Fig. V-2 Waste composition in Sialkot



Source: Ernst Basler + Partner and ICEPAK, 2007

2.2 Waste collection and transport system

Only 60% of waste generated in Sialkot is collected and then transported to dumping sites. In rainy season, the waste has been dumped alongside Eminabad Road, Kissanwali Road, Dhery Sandha, Langrianwali, Gunianwali, Adalat Garha Road. Remaining 40%, 200 ton/day has been dumped at such areas as road side, river banks and vacant lots. Some unprocessed organic food waste is removed by feeding livestock. As Fig.V-3, the waste generated is transported to dumping sites after being collected at 146 collection points using tractor trolleys or by sanitary workers.

Fig. V-3 Flowchart of waste management in Sialkot

2.3 Waste treatment and disposal

There is only one unsanitary landfill, Gohadpur road dumping site in Sialkot. It was open in 2005 and has been operated about 2 years. It takes about 2 hours to take waste to it from the center of city. It is a private land surrounded by farmland and close to fish farm. The land owner allows the waste dumping at his land to level up the subsided ground. Land area is 141,700m^2 and about 300 tons of waste comes in the site every day. There is 60,000 tons of waste in it. Insade road is unpaved and about 3.5m.

As in the Lahore, the dumping site is operated without any quarantine and facility for leachate. Nevertheless, relatively small leachate is expected to come out since the dumping site practices the soil covering every day unlike other dumping sites in Punjab. However, the groundwater or soil pollution could be happened as leachate barrier facilities aren't constructed and operated.

Table. V-2 Gohadpur road dumping site in Sialkot

Location	Area ( )	Operation period	Daily Amount (ton/day)
close to fish farm	141,700	about 2 years (2005~now)	300

Fig. V-4 Status of Gohadpur road dumping site

A view of the dumping site

Transport vehicle of cover soil

Waste landfilling & soil covering

2.4 Institutional arrangements and financial aspects

2.4.1 Sanitary staffs and equipments

The number of person sanitary staffs in Sialkot is 1,047people as shown in Table V-3. Thus, one sanitary staff has managed waste generated from 1,194 people.

To collect and transport waste, tractors and trolleys are main equipments. Aong the total equipment, about 11% are out of order.

Table. V-3 Sanitary staffs in Sialkot

Sanitary Staff							Population / Sanitary Worker
Chief Sanitary Inspector	Sanitary Inspector	Kora Lorry Drivers	Sanitary Supervisors	Sanitary Workers	Mashki	Total	
1	6	19	29	1,047	45	1,147	1,194

Source: Data from Sialkot

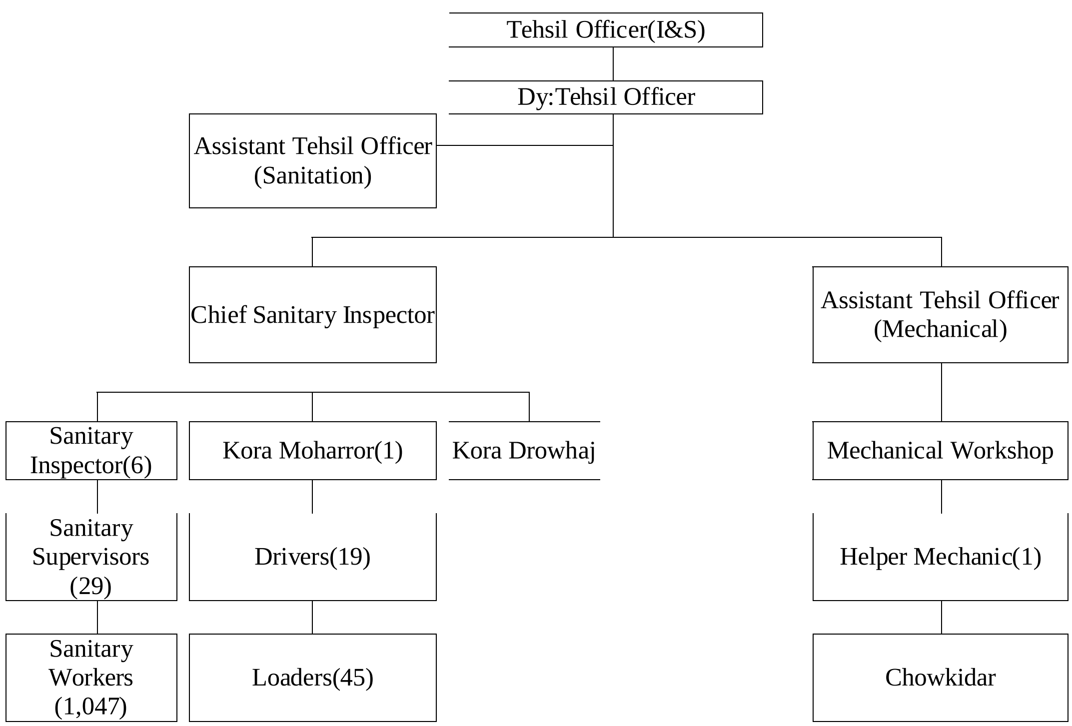
Table. V-4 Waste collection and transport equipments in Sialkot

Equipments	Total	On-Road	Off-Road	Working Ratio (%)
Tractors	42	39	3	93
Trolleys	46	38	8	83
Dewatering Sets	16	16	-	100
Mechanical Sweeper	3	3	-	100
Scraper(front Blade)	1	1	-	100
Front End Loader	2	2	-	100
Water Sprinkler	3	3	-	100
Total	113	102	11	90

Source: Data from Sialkot

2.4.2 Organization of solid waste management

Fig. V-5 Organization of solid waste management in Sialkot



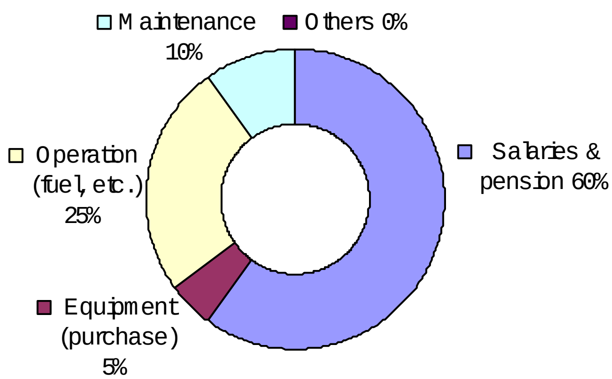
2.4.3 Financial aspects of solid waste management

Team 1 investigated the share and composition of the 2006-2007 expenditure for solid waste management in Sialkot.[20] Expenditure for municipal waste services amounts to about 30 million Rs, or 4% of the total budget of the TMA. It is the lowest among 9 cities in both of ratio and absolute amount, although the total budget, 811 million Rs is not small.

Of the total SWM expenditure, the bulk (60%) is spent on the labor costs. Operation costs represent 25% of the total. From the large portion of labor costs it could be inferred that the solid waste services depend on manual work though labor cost is relatively low. Operational and maintenance costs account for 25% and 10% respectively.

Households are not obliged to pay for the service and direct cost recovery through user fee isn't existent like other cities.

Fig. V-6 Composition of SWM budget in Sialkot, 2006-2007



Source: Ernst Basler+Partber, Icepak, 2007, p.93.

[20] Solid waste service cost is hard to extract precisely from financial records. As mentioned in Chapter II.3.2, Sialkot doesn't have exclusive account used only for solid waste services. The labor cost for the services is found in the detailed function code, 'health branch & sanitation' while other expenditure for it is in the function code, 'sanitation' separated with 'water supply' (annex-1). Combined records limit to see the share for SWM. Thus, the municipality need record the expenditure breakdowns in detail to recognize the cost for SWM and control it.

2.5 Problems in solid waste management

Main problem of waste management in Sialkot is illegal waste dumping on the street; This is caused by inefficient collecting and carrying system, the lack of waste collector and inefficient collecting work, the shortage of manpower with professional waste management, obsolete and shortage of waste collecting and transportation, equipments, poor awareness of residents on the environmental issues, the shortage of financial resources.

Furthermore, since there is no sanitary landfill site, reclaiming work has been progressing only by dumping. Pollution of underground water and the soil might be polluted for a long time without any leachate lining and disposal facility.

If these dumping sites are continuously utilized as now, it will influence negatively on the river, groundwater and soil.

In addition, there is insufficiency of road network and paved roads to prevent effective waste collect and transportation. The collection, transport equipment in Sialkot is relatively small like a tractor or trolley. The number of sanitary workers is insufficient.

3. Recommendations for development of a solid waste management strategy and plan

3.1 Forecasting waste generation & composition

Like the Lahore’s prediction, the future waste generation of Sialkot is estimated based on the change in the future population and waste generation per one person. We referenced the average increasing rate(1.95%) in future population and applied Indian data(3.5%) where has similar situation to Pakistan to mean increasing of waste generation per person.

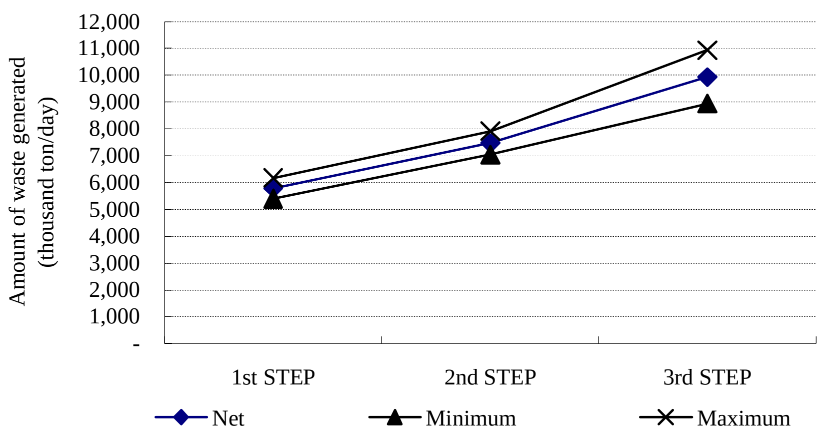
It is predicted that Sialkot’s population will continuously increase to about 1.7 million 15 years later. Then the waste amount will increase to 1.3 thousand tons in accordance with the increase in population. As the economy and standard of living grow, waste generation per capita will increase from present 0.47 kg/capita/day to 0.75 kg/capita/day in 2021. Furthermore, the composition of waste changes reflects the changes of the consumption and lifestyle.

Table. V-5 Estimate of future waste generation in Sialkot

(unit:person, ton/day, kg/capita·day)

Year	Estimated population	Waste Generation (average)	Waste Generation per capita (average)
2006	1,250,000	500	0.47
2011	1,376,722	688~826 (Average : 757)	0.5~0.6 (Average : 0.55)
2016	1,516,290	910~1,061 (Average : 986)	0.6~0.7 (Average : 0.65)
2021	1,670,008	1,169~1,336 (Average : 1,253)	0.7~0.8 (Average : 0.75)

Fig. V-7 Estimate of future waste generated in Sialkot



The future waste generation amount prediction according to each waste composition is predicted according to the same method by revising a proportion of Lahore's composition increase rate. According to the prediction results, from now 62.7% till the early and mid target year the inflammability wastes is predicted to decrease to 56.9%, and in 3rd step long term target year it will gradually decrease to 49.7% whereas the nonflammability wastes will increase from 37.3% to 43.1% by the 2nd step which is the early and mid target year and will increase up to 50.3% in the 3rd step, the long term target year. Organic materials will be reduced. The composition of waste generated in Sialkot is predicted as in Table.V-6.

According to Sialkot, from the generation of recycle possible waste, it is predicted with assuming that, with excluding organic wastes, 2% inorganic waste among inflammable waste, and 6% nonflammable waste is possible for recycle and hereafter it is appropriate to make accurate research for recycled wastes and the data must be accumulated and modified according to the actual condition. The generation of each composition according Sialkot's future plan of each target year is predicted with consideration to waste composition reclamation ratio as of stated below.

Table. V-6 Estimate of waste composition generated in Sialkot

(unit : ton/day)

Year	Combustible Waste		Incombustible Waste	Recyclable Waste	Total waste
	Organic	Inorganic			
2011	304~364 (Average:334) (44.1%)	86~104 (Average:95) (12.5%)	279~335 (Average:307) (40.5%)	20~23 (Average:22) (2.9%)	688~826 (Average:757) (100.0%)
2016	401~468 (Average:435) (44.1%)	114~133 (Average:124) (12.5%)	369~430 (Average:399) (40.5%)	26~30 (Average:28) (2.9%)	910~1,061 (Average:986) (100.0%)
2021	414~473 (Average:443) (35.4%)	164~187 (Average:176) (14.0%)	553~632 (Average:592) (47.3%)	39~44 (Average:41) (3.3%)	1,169~1,336 (Average:1,253) (100.0%)

3.2 Strategy for solid waste collection and transportation

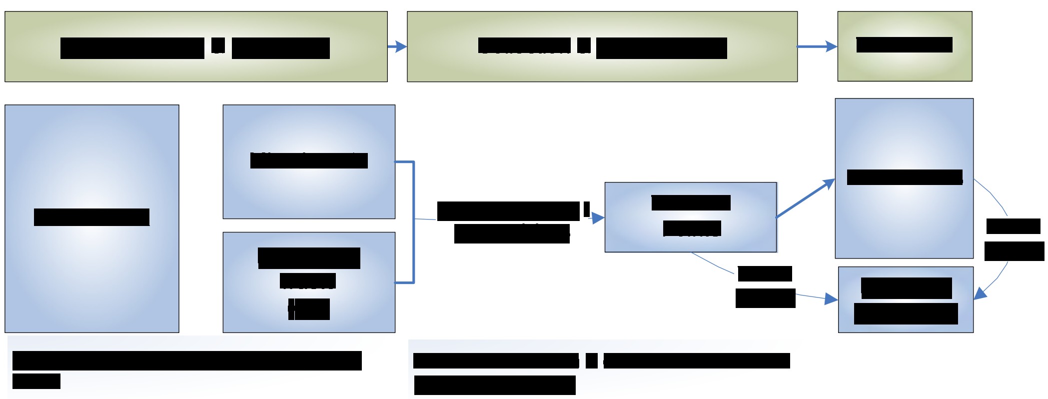
The biggest problem in current municipal waste collecting and carrying system in Sialkot is discharging waste at the undesignated place, dumping illegally along the roadside and empty lots, etc. Furthermore, a lot of narrow alleys prevent the efficient waste collection and transportation.

To improve waste collecting and carrying system, TMA Sialkot is recommended to adopt the door to door collection system which ensures where the waste comes from and can help to systemize waste discharge practice. Sialkot also needs to change the collection system which mainly depends on small equipment into new collection system depending on larger equipment to improve collection and transport efficiency.

3.2.1 Improvement method for waste collection and transportation system

The waste from Sialkot is collected from 146 collection points that are located at major occurrence areas. The collected waste is transported to dumping sites by tractors and trolleys for treatment. In order to improve the collection and transportation system of Sialkot, adaptation of door-to-door system is recommended. This will also make the residents responsible for their waste just like in Lahore region. However, it might be difficult for Sialkot to fully adapt the door-to-door system due to its narrow alleys. Therefore, like Lahore, for the main streets (Where waste collection vehicles have easy access), it is recommended to adapt door-to-door system and for the narrow alleys (Where such vehicles have difficult access), sanitary workers can move the waste to the areas where the vehicles can easily access using handcarts for loading the waste to collection vehicle. The flowchart for improvement of waste collection and transport system of Sialkot is as follows:

Fig. V-8 Flowchart for improvement of waste collection & transport system



3.2.2 Increasing the manpower for waste collection

Currently TMA Sialkot collects 300 tons daily, only 60% of total waste generated. 1,047 sanitary workers collect 300 ton/day, one worker in Sialkot collect 0.2865 tons of waste. This indicates that total 1,745 sanitary workers for are necessary. It shows that it is necessary that hiring 698 of sanitary workers for improving the efficiency of waste collection.

Box. V-1 Estimating manpower requirements in current system of Sialkot

§ Daily collecting duration : 8 hours

§ Total waste generated: 500ton/day

§ Total waste collected : 300ton/day

§ Present condition of sanitary workers: 1,047 persons

§ Collection efficiency of sanitary workers:

- § 300ton/day÷1,047man = 0.2865ton/capita·day

§ Number of workers needed:

- § 500 ton/day÷0.2865 ton/man·day = 1,745 men

§ Deficit of sanitary workers:

- § Number of necessary workers (A): 1,745
- § Number of present workers (B): 1,047
- § Number of deficit (C = A-B): 698

The collection efficiency depends on how to collect and the types of a waste container. If door to door collection through a bag type container is introduced instead of a moving or a fixed type, the collection efficiency can dramatically increase (Table.IV-9). When a bag type container is adopted, it needs less workers than other types of containers. It can reduce manpower and collection time from present 1,047 persons to 358 persons (66%), and from eight hours to four hours.

Box. V-2 Estimating manpower requirements in door to door collection

§Calculation Method : Using the collection rate of a garbage bag for the amount of waste

§ Waste generation

§ 1st Step(757ton/day), 2nd Step(986ton/day), 3rd Step(1,253ton/day)

§ Waste collection

§ 1st Step(530ton/day), 2nd Step(788ton/day), 3rd Step(1,127ton/day)

§Collection rate: 1.35MH/ton (Collection standard of 2 days interval)

§Amount of waste collection for 2days:

§ 530 ton/day × 2 day = 1,060 ton

§Total collection time per sanitary worker:

§ 1.35 MH/ton × 1,060 ton = 1,431 MH

§Collection standard per 4 hours:

§ 1,450MH ÷ 4hr = 358 capita

§ Shortening the required collection manpower and collection time by improving the collection system

§ Collection manpower: 1,047capita → 358 capita (66% reduced)

§ Collection time: 8hours → 4hours

Table. V-7 Manpower requirement in each step, Sialkot

(unit:person)

Sanitary Staffs	Present	2011	2016	2021
Superintending Engineer	-	1	1	1
Executive Engineer	-	2	2	2
Assistant Executive Engineer	-	3	4	4
Assistant Engineer	-	6	7	8
Qualified Diploma Sanitary Inspector	1	16	18	20
Qualified Sanitary Inspector	6	32	35	39
Qualified Sanitary Supervisor	29	107	118	130
Driver	25	81	112	155
Sanitary worker	1,047	358	532	761
Total	1,147	606	829	1,120

Note: manpower requirement refers to footnote no.15 in previous chapter, p.82.

3.3 Improvement of solid waste management equipment

3.3.1 Collection and transport equipment

Collection and transporting equipment requirement is calculated based on the same methods as in Lahore. However, Sialkot is not a large city as much as Lahore, road networks of Sialkot is not well-organized. Narrow streets also should be taken into consideration. Thus, comparatively smaller equipment is efficient to increase the accessibility and mobility in the city. The compactor and open truck make collection and transportation easier, especially in door to door collection. The number of future equipment reflects the high efficiency of the compactor and open truck.

Table. V-8 Collection & transport equipment requirements in Sialkot

(unit: EA)

Type	Present	2011	2016	2021
Tractors & Trolleys	42, 46	42, 46	42, 46	42, 46
Mechanical Sweepers	3	5	7	10
Front End Loaders	2	4	6	9
Open Truck(3ton)	-	6	9	13
Compactors(2.5ton)	-	24	40	66
Compactors(5.0ton)	-	-	8	15
Hand Cart	-	450	450	450
Total(Hand Cart excluded)	93	127	158	201

Note: See the details in Annex-8

3.3.2 Improvement of solid waste management equipment in landfill sites

Table. V-9 Daily incoming waste in Sialkot Landfill

Landfill	2011	2016	2021
Daska Road Site	530 ton/day	758 ton/day	533 ton/day

Table. V-10 Equipment for landfills

Type	Dimension (/hr/EA)	Working hours (hr)	Capacity per day (/day/EA)
Transport and spreading equipment (Buldozer)	102	8	816
Landfilling equipment (Compactor)	120	8	960

Table. V-11 Proposed step by step landfill management equipment of Sialkot

(unit: EA)

Type		Dimension	2011	2016	2021
Landfill equipment	Bulldozer (exclusively for reclamation use)	32ton	1	1	1
	Compactor	32ton	1	1	1
Molding equipment	Bulldozer	32ton	1	1	1
	Excavator	1.0	1	1	1
	Loader	2.29	1	1	1
	Grader	3.6m	1	1	1
	Roller	32ton	1	1	1
Supporting equipment	Watering cart	5,500ℓ	1	1	1
	Disinfection cart		1	1	1
	Mechanical Sweeper	4.0	1	1	1
Total			22	24	20

3.4 Stepwise strategic plan for waste treatment

With a proposition for management, to treat the waste that is generated from the future Sialkot effectively, safely and hygienically, a plan for each target year has been established to collect and transport to the designated management target. As assessment of waste composition is made and according to this, a proposition for appropriate scale of waste treatment facility is made.

Also, the proper location and scale for the waste treatment facility is pre-analyzed, with the proposition of a technical plan and operation guideline for the waste treatment facility, and will contribute to Sialkot's environmental policy as well as to the systematic and realizable waste management policy.

3.4.1 Waste collection and treatment targets

The estimate amount of waste generated is based on population growth of Sialkot. The result provides fundamental information to design a waste treatment facility. Reflecting the increasing amount of waste generation, the collection rate will be increase average 10% in each step from present 60% to 90% in 2021.

Table. V-12 Estimate of future waste generation and collection target in Sialkot

(unit: ton/day, %)

Years	Waste Generation (average)	Collected waste (average)	Collection rate (%)
2006	500	300	60
2011	688~826 (757)	482~578 (530)	70
2016	910~1,061 (986)	728~849 (788)	80
2021	1,169~1,336 (1,253)	1,052~1,202 (1,127)	90

It is recommended that the waste will be collected through 3 categories: i) combustible waste, ii) incombustible waste, and iii) recyclable waste. Until 2016, organic and inorganic waste will be buried in landfill sites. Reusable waste except what waste pickers took will be buried in landfill sites, too.

In related to recyclable materials, waste pickers take out them from sources and landfill sites. The measure in Table.V-12 doesn't involve what the waste pickers took. However, recycling policy should be prepared since waste pickers would disappear as the city develops. In the 3rd step, after 2016, combustible waste will be incinerated except some organic waste to be composted. Valuable waste will be recycled in the recycling plants.

Fig. V-9 Suggested waste collection and treatment process

Table. V-13 Waste treatment target in Sialkot

(Unit: ton/day)

			2011	2016	2021
Combustible Waste	Organic	Landfilling	212~255 (average:234)	321~374 (average:348)	-
		Composting	-	-	372~426 (average:399)
	Inorganic	Landfilling	60~73 (average:66)	91~107 (average:99)	-
		Incineration	-	-	147~169 (average:158)
Incombustible Waste		Landfilling	195~234 (average:215)	295~344 (average:319)	497~569 (average:533)
Recyclable Waste		Landfilling	14~16 (average:15)	21~24 (average:22)	-
		Recycling	-	-	35~40 (average:37)

Note: ( ) is the average of the treatment amount range

3.4.2 Waste treatment facility requirement

The capacity of future waste treatment facilities reflects the stepwise waste treatment plan. The facility capacity is based on the amount of waste collected in Sialkot not generated.

Table. V-14 Estimating the amount of waste treatment in Sialkot

(unit: ton/day)

Years	Landfilling (average)	Composting (average)	Incineration (average)	Recycling (average)	Total (average)
2011	482~578 (530)	-	-	-	482~578 (530)
2016	728~849 (788)	-	-	-	728~849 (788)
2021	497~569 (533)	372~426 (399)	147~169 (158)	35~40 (37)	1,052~1,202 (1,127)

Table. V-15 Plan of waste treatment facilities

Years	Landfill (/5years)	Composting Facility (ton/day)	Incinerator (ton/day)	Recycling Facility (ton/day)
2011	1,128,505	-	-	-
2016	1,657,213	-	-	-
2016	1,109,570	430	170	40

4. Treatment facilities and redevelopment scheme

The facilities in Sialkot include sanitary landfill, food waste resource facility, incineration facility, and recycle facility. Each facility should take into consideration waste discharging condition, location, circumferential and climatic condition, should be connected to make a more effective, rational, safe and pro-environmental plans.

4.1 Feasibility assessment on the planned sanitary landfill sites

4.1.1 General description of the candidate sites

No official landfill exists in Sialkot. Gohad Pur Road site is simply landfilling waste without any contamination preventing facilities. Accordingly, Sialkot must build sanitary landfill sites and choose the appropriate as soon as possible.

Currently, TMA Silakot suggested 2 candidates with long period landfill capacity. The candidates are Daska road and Eminabad road. The study applies the standard for sanitary landfill site selection to examine whether they are appropriate sanitary landfill sites.

Table. V-16 Landfill candidate sites in Sialkot

Classification	Site 1 (Daska Road)	Site 2 (Eminabad Road)
Site View Site 1		
Site View Site 2		
Area	60,702	40,468
Distance from city center (Approx.)	8.8	8.9
The spread of a residential area (Approx.)	§Many households relatively within 1km	§Few households relatively within 1km
Geography	§Denuded Land §Depression ground (eroded basin)	§Denuded Land §Depression ground (eroded basin)
Water system (Approx.)	§A long distance from Ravi River	§A long distance from Ravi River
Utility Facilities	§No sewage disposal or water supply facilities §Power supply facilities are located.	§No sewage disposal or water supply facilities §Power supply facilities are located.

4.1.2 Application results of the site selection standards

The application of the exclusion criteria suggests that Daska Road site and Eminabad Road site are suitable for waste landfill facilities as shown in Table.V-17. After the disintegration of the waste, the landfill can sink approximately 30~40% so the actual reclamation period can be longer than the estimated period.

To handle the wastes generated in Sialkot safely for a long term, the location, environmental, social and economical conditions of the 2 proposed sites must be examined. The evaluation result over 90 points shows two candidates meet the least criteria to be a landfill. In case the landfill facility is built by stages, between the two candidate sites, Site 1 (Daska Road) would be more adventurous in economical aspects due short transport distance of waste and for securing the space for landfill. However, the evaluation is based on the visible test and interviews with officials in it. It requires more precise feasibility investigation.

Table. V-17 Outcomes of applying the exclusion criteria

Unsuitable areas for landfill sites			Site 1 (Daska Road)	Site 2 (Eminabad Road)
Preservation of Natural Ecosystem	1. Ecosystem preservation area		X	X
	2. National & state park or and natural protection forest		X	X
	3. Natural monument & a wildlife sanctuary (involving areas within 1km)		X	X
Protection of a source of water supply	4. Water reservoir within 10km toward the upper stream		X	X
Airport Security	5. Turbo engine airplane : 1,000ft within areas from landing strip Conventional type engine airplane : 5,000ft within areas from landing strip		X	X
Other area	6. Protection zone for cultural and historical assets		X	X
	7. Fault zone		X	X
	8. Wetland		X	X
Ensuring the volume of landfill	9. Potential capacity [Landfill height 25m (standard)]	Landfill capacity( )	1,478,700	892,000
		Landfill period* (year)	7**	5**

Note: * Landfill capacity is calculated based on incoming waste amount.
** In case Site 1 ~2 are simultaneously established and operated, more than 10 years of reclamation period for each site will be secured. - Site 1:14 years, Site 2: 13 years

Table. V-18 Outcomes of applying selection criteria

Classification	Factors	Marks	Site 1	Site 2
Location	1. Size and capacity of the landfill	10	10	8
	2. Size of water-collecting area	5	5	5
	3. Transfer distance	10	10	10
	4. Access to the landfill	10	10	10
	5. Municipal facilities	5	5	5
	6. Safety from disasters	5	5	5
	7. Easy of landfill construction	5	5	5
	Sub-total	50	50	48
Environment	8. Visibility	5	4	5
	9. Impact to water contamination	5	5	5
	10. Impact to air pollution	5	4	5
	11. Impact to odor	5	4	5
	12. Impact to noise & vibration	5	4	5
	13. Impact to ecosystem	5	5	5
	Sub-total	30	26	30
Society	14. Residential areas and other facilities influenced by the landfill	5	4	5
	15. Historical and cultural heritage	5	5	5
	Sub-total	10	9	10
Economy	16. Construction cost	10	10	8
Total		100	95	96

However, the evaluation was conducted by the location viewing and interviews with officials related to the site. Thus it can be different from the actual conditions. Therefore, a more accurate and proper evaluation of the proposed site must be executed to select the appropriate location for the waste treatment facility.

4.1.3 Scheme for sanitary landfill facility

The new sanitary landfill must be available to contain the amount of municipal waste generated from all areas of Sialkot for long period. And it should consider leachate treatment at the site, protection of surrounding environment, waste moving line and landfilling structure.

Table. V-19 Scale of two sanitary landfill sites in Sialkot

Classification	Site 1 (Daska Road)	Site 2 (Eminabad Road)
Area( )	60,702	40,468
Height(m)	25	22
Potential capacity ( )	1,478,700	892,000
(years) *	7	5

Note : * In case Site 1 ~2 are simultaneously established and operated, more than 10 years of reclamation period for each site will be secured.- Site 1:14 years, Site 2: 13 years

The structure or method of landfilling will be semi-aerobic sanitary landfilling and cell method (refer to -5.1). The scale or plan of sanitary landfill facility is described in Table.V-19. Blueprint for construction of sanitary landfill refers to Fig.V-10.

Fig. V-10 Suggestion on sanitary landfill sites in Sialkot: In-between landfill

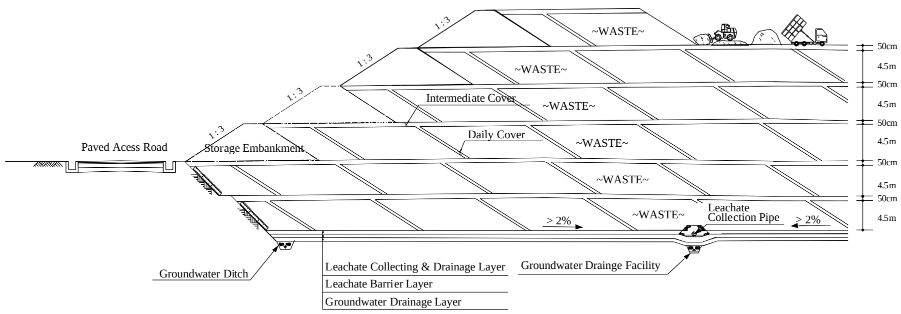
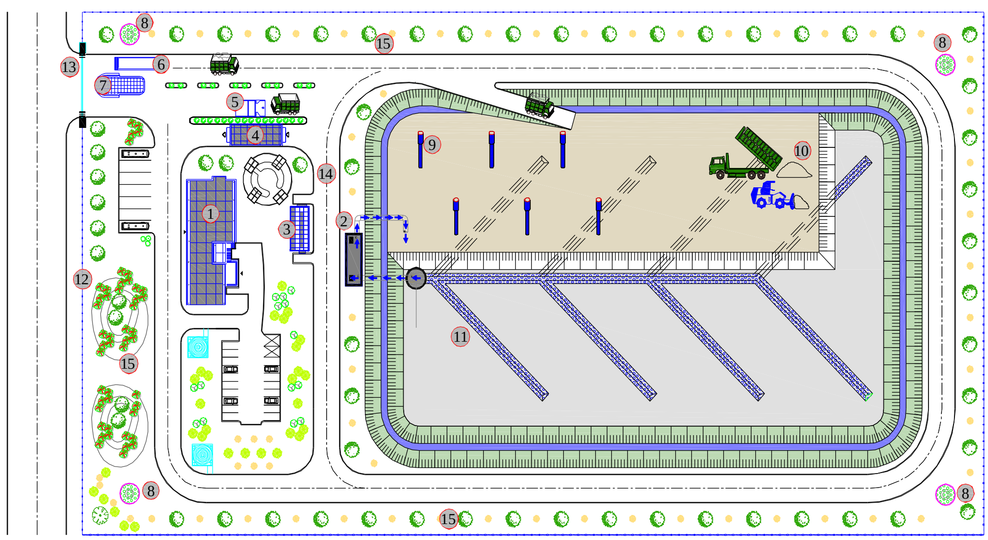


Fig. V-11 Layout plan of sanitary landfill in Sialkot

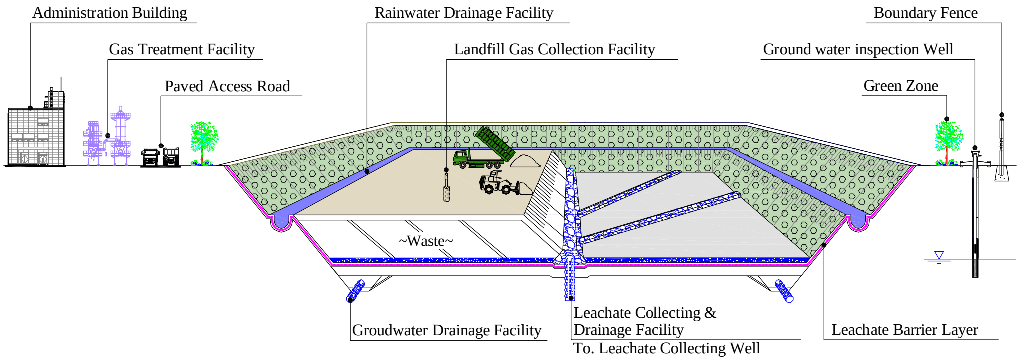


REMARK

1	Administration Building	5	Washing Wheel Station	9	Landfill Gas Collection Facility	12	Boundary Fence
2	Leachate Collecting Well	6	Weigh-Bridge	10	Waste Landfilling	13	Entering Gate
3	Landfill Gas Treatment Facility	7	Guard House	11	Leachate Collecting & Drainage Facility	14	Paved Access Road
4	Vehicle Repairing Garage	8	Ground water inspection Well			15	Green Zone

Fig. V-12 Standard cross section of sanitary landfill in Sialkot

Standard Cross Section



4.1.4 Composting facility

For waste recovery technology at Sialkot, composting method is the most suitable treatment method, respiratory composting is recommended for Sialkot.

Table. V-20 Treatment capacity of composting facility in Sialkot

(unit: ton/day)

Year	Treatment target	Facility capacity
2021	426	430

4.1.5 Incinerators

Sialkot Incineration technique can be applied with the incineration method where Sialkot's incineration target waste characteristic, large amount of waste treatment compatibility, operation cases, trustworthy/safe/economic condition, operation fabrication and maintenance conservativeness, technology secure must be taken into consideration with a conclusion that the Stoker Type introduction has the most advantage. Hereafter the basic plan and design step must go through enough research and examination and must select incineration target waste, ground condition, facility scale, treatment skill appropriateness, installation, and operation expenses to establish a standard incineration facility standard for Sialkot.

Table. V-21 Incinerator capacity in Sialkot

(unit: ton/day)

Year	Treatment target	Incinerator capacity
2021	169	170

4.1.6 Recycling facilities

Recycling facility is planed to operate in the 3rd step (year 2021). See the specified functions and types of the facilities for the recycling in 4.2.6 of Sialkot case.

Table. V-22 Treatment capacity of recycling facility in Sialkot

(unit: ton/day)

Year	Recycle target waste	Recycle facility scale
2021	40	40

4.2 Restoration scheme for the currently operating dumping sites

Currently operating dumping site in Sialkot doesn't have pollution prevention facilities for environment pollution so that it causes environment pollution such as waste, soil, nuisance odor pollution. Therefore, there should be required for restoration as quickly as it can. The dumping site in Sialkot was already described in the previous. Gohad Pur Road dumping site is the state that is not well equipped with environmental pollution prevention facilities during the current operation at Sialkot and dumping site that is under operation to simple reclamation methods is generating all kinds of pollutants flow to a surrounding river, underground water, the soil and an atmosphere, and includes a possibility to work with the water pollution, soil pollution, air pollution and foul odor. Therefore urgent repair business enforcement was analyzed.

Therefore to Minimize the environmental damage of the surrounding region for maximization of upper part land utilization, quantitative and apparent analysis must be made regarding pollution potential power to be made in a location characteristic of dumping site and a surrounding region to evaluate environmental volume that is most suitable for the field conditions and with this the repair plans must be reasonable and systematic.

The long term surrounding environmental damage from dumping site negligence is prevented to maintain local environment and the economic value is created to secure land possible to use along reclaimed land stabilization

As Gohad Pur Road dumping site is located along by the roadside, the In-situ Stability Method could be suitable for the site since there is a little environment impact to the surrounding areas. The concept scheme for Gohadpur site refers to Fig. IV-44 and Fig.IV-45.

4.2.1 Environmental impact assessment of dumping sites

Leachate pollution

Table. V-23 Estimated leachate in Gohad Pur dumping site

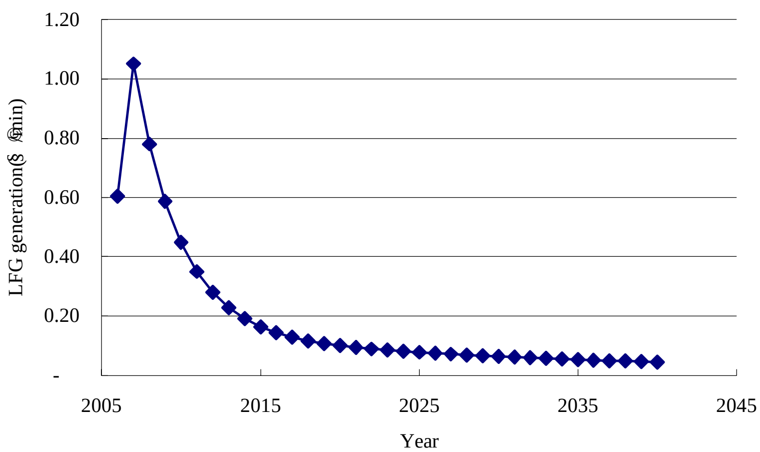
Leachate constant (C)	Average daily precipitation (I, /day)	Landfill area (A,)	Quantity of leachate generation (Q, /day)
0.5	2.74	141,700	194

Note: calculation formula is the same as in Lahore.

Gas generation

The gas generated amount from dumping site takes reclamation gas occurrence cause terminability waste and reclamation progress period into consideration for evaluation. The reclamation gas generated amount of Gohad Pur Road dumping site during the current operation at Sialkot uses the EPA Model and from the results, by 2007 the standard is 05 /minute but recycling of reclamation gas is considered to be difficult. On the other hand, this forecast results, there is hardly prediction data of dumping site and there may be a different in the actual reclaimed gas generated amount. Hereafter enough investigations at basic plan next and design steps will be judged so that correct evaluation shall be performed

Fig. V-13 Estimate of gas generated from Gohad Pur dumping site



Note: EPA Model LFG generation

An environmental impact factor examination of dumping Site

Sialkot dumping site environmental pollution potentiality is evaluated to be rational and in order to review feasibility of a repair business, tried to analyze environmental impact by the dumping site with the point adding system which was a method same as Lahore.

Examination of a redevelopment of landfill site in Sialkot

The results that analyzed environmental influence factor regarding Gohad Pur Road dumping site of Sialkot at current step repair feasibility of dumping site is 60 points which is considered high which must take Environmental damage minimization, a stability security of reclaimed land, a reliability security of reclaimed land management into consideration when processing repair business.

After forecasting accurate environmental influence benignancy at basic plan and design steps enforcement thoroughly field survey, should judge whether or not there is by repair business feasibility enforcement regarding the dumping site of Sialkot.

Table. V-24 Environmental impact assessment of a dumping site in Lahore (i)

	Factors	Scoring basis		Score
Pollution (15 points)	Liner system	§ No liner system	4	4
		§ Low retaining wall or low quality liner system	3	
		§ Fully installed retaining wall and low barrier wall	2	
		§ High quality liner system	0	
	Implementation of leachate treatment procedures	§ No treatment	4	4
		§ No collection of leachate	4	
		§ Self-, simple, or septic tank treatment	2	
		§ Advection, connection, full-function service, or wastewater holding tank	0	
	Height of the final cover	§ Less than 1m	3	3
		§ 1m to 2m	2	
		§ more than 2m	0	
	Stability of the reclaimed land	§ leakage	2	2
		§ No leakage	0	
	Collection and emission of landfill gas	§ not operated	2	2
		§ operated	0	
	Sub-Total		15	15
Features of landfill (36 points)	Time after the final landfilling	§ Less than 2 years	15	15
		§ 2 to 5 years	12	
		§ 5 to 10 years	10	
		§ 10 to 15 year	6	
		§ 15 to 20 year	3	
		§ more than 20 years	1	
	Quantity of landfilled waste	§ More than 50,000	5	5
		§ 20,000 to 50,000	3	
		§ 5,000 to 20,000	2	
		§ Less than 5	1	
	Areas of landfilling	§ More than 10.000	5	5
		§ 5,000 to 10,000	3	
		§ 1,000 to 5m000	2	
		§ Less than 1,000	1	
	Types of waste	§ Municipal industrial waste	7	5
		§ Municipal, industrial, construction waste	5	
		§ Municipal, construction waste	3	
		§ Municipal waste	1	
	Types of landfill	§ Valleys	4	2
		§ Hills	3	
		§ Plains	2	
		§ Coast	0	
	Sub-Total		36	32

Table. V-25 Environmental impact assessment of a dumping site in Lahore (ii)

Factors		Scoring basis		Score
Impact to residence (25 points)	Present land use types	§ Farmland	5	4
		§ Grassland, forest and fields, s store house, floricultural complex	4	
		§ Park, resort, environmental, gymnastic, handicapped facilities, playground, a golf courses	3	
		§ Buildings (factories, offices), agricultural or industrial complex	2	
		§ Transportation	1	
	Possession of land	§ Private land	4	0
		§ Public land	0	
	Distance from residential areas	§ Less than 500m	4	0
		§ 500m to 1km	2	
		§ more than 1km	0	
	Population of nearby residents (within 500m from the landfill; 4 persons/ household)	§ more than 1000	7	1
		§ 100 to 1000	5	
		§ 4 to 100	3	
		§ less than 4	1	
	Civil petition (pollution of underwater, a bad smell, a dust, using land related research	§ Civil petition	5	0
		§ No civil petition	0	
Sub-Total			25	5
Potential pollution of rivers or ground water (24 points)	State of underwater use	§ Drinking water	8	5
		§ Municipal or agricultural water etc.	5	
		§ Industrial water	3	
		§ Out of use	1	
	Water preservation zone	§ Water preservation zone I	8	1
		§ Water preservation zone II	4	
		§ Out of the zone	1	
	Distance to the nearest waterway from the landfill	§ within 200m	8	2
		§ 200m to 500m	5	
		§ 500m to 2km	4	
		§ more than 2km	2	
Sub-Total			24	8
Total			100	60

Note: In case there being no data to estimate on regarding each item, a larger point than 50% of the highest points regarding diverse events of each item was applied (Ex. If utility present about underground water is unknown, point 5 larger than the 4 points, 50% of the highest point was applied)

Source: Korean Ministry of Environment (2001.12), Guideline for maintenance of landfill at termination of usage.

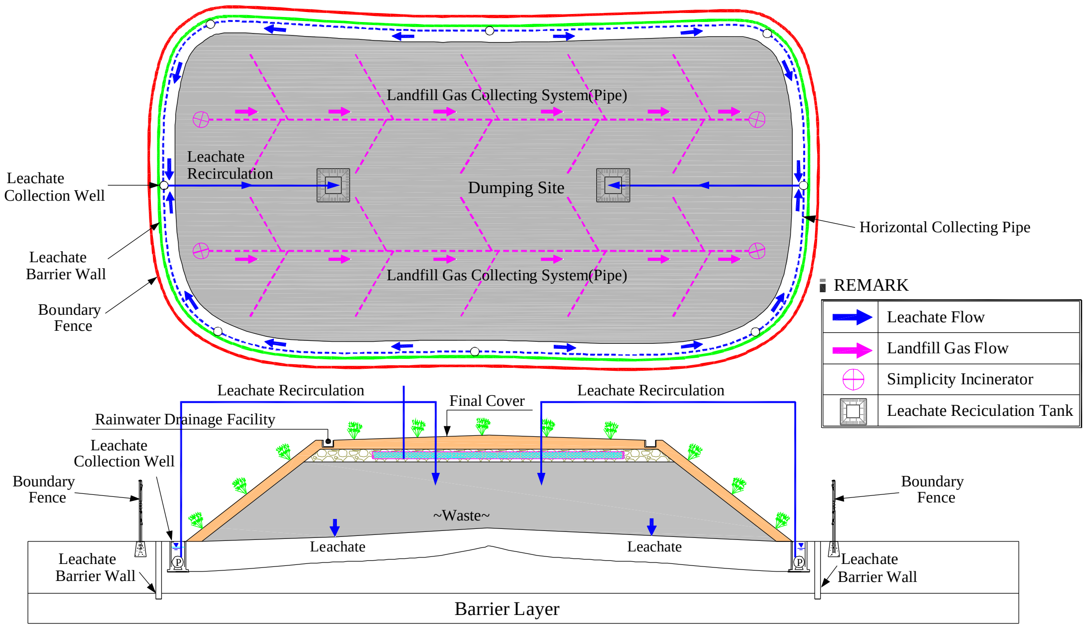
4.2.2 Most suitable restoration scheme for the dumping site in Sialkot

Gohad Pur Road dumping site has started reclamation since the year 2005 and is still under operation and the reclamation gas occurrence is performed actively to waste active decomposition. There is the element that a reclamation slope is a bit unstable but daily soil work process will reduce the leachate caused by precipitation penetration.

Therefore, a proposal of field repair and management plans (a local stabilization plan) is evaluated to things most reasonable under a repair plan as is judged so that an influence to the surrounding environmental influenced by leachate leaks which is not large much, but shall do so as this evaluation enforces field investigation and an examination more faithful at future basic plan and design steps by the results by naked eye investigations, and to select.

During a visit to Gohad Pur Road dumping site, it was found out that the local soil is mainly composed of clay. Due to this, it is determined that the environment would be less affected by the wastewater coming from the dumping site so the following maintenance implication is recommended. At this stage, the key points of actual scene maintenance and control of Mehmeood Booti dumping site suggested installing a final cover [1)] for preventing the penetration of rainwater into landfill layers, a generator of leachate, site stabilization [2)] for securing the structural stability of landfill layers, facility for drainage/collecting and treatment leachate [3)] dealing with the leachate generated in the landfill layers, facility for Landfill gas(LFG) collecting & treatment [4)], facility for rainwater drainage [5)], boundary fence [6)], measuring facility [7)], etc. Among these, Landfill gas collecting & treatment System will be linked with recycling system of landfill gas and this will enable CDM business. After maintenance is completed regular investigation for the environment around the dumpling site will be done. If case the environment (underground water, soil, etc.) is affected by the wastewater from the dumping site, a Leachate barrier wall is strongly recommended.

Fig. V-14 Layout plan on Gohad Pur dumping site



5. Cost benefit analysis from improvement of SWM

5.1 Investment and operating cost for improvement of waste collection and transportation

The following cost is based on the price of Korean and Pakistan vehicles.

Table. V-26 Purchase cost of waste collection and transport equipment in Sialkot

Type	Purchasing price (Rupi/EA)	Equipment requirement (EA)			
		Present	2011	2016	2021
Tractor & Trolley	640,000	42	42	42	42
Mechanical Sweeper	2,000,000	3	5	7	10
Front End Loader	1,750,000	2	4	6	9
Open Trucks(3ton)	900,000	-	6	9	13
Compactors(2.5ton)	1,800,000	-	24	40	66
Compactors(5ton)	3,170,000	-	-	8	15
Total		47	81	112	155

Table. V-27 Purchase cost of landfill equipment in Sialkot

Equipment		Purchasing price (Rupi/EA)	Equipment requirement* (EA)
Landfilling equipment	Bulldozer(32ton)	25,600,000	1
	Compactor(32ton)	24,500,000	1
Covering Equipment	Bulldozer(32ton)	11,860,000	1
	Excavator(1.0)	8,000,000	1
	Loader(2.29)	8,000,000	1
	Grader(3.6m)	9,228,000	1
	Roller(32ton)	3,971,000	1
Supporting equipment	Watering cart(5,500L)	2,000,000	1
	Disinfection cart	450,000	1
	Mechanical sweeper(4.0)	15,000,000	1
Total			10

Note: purchase equipment in the first step(2011)

Table. V-28 Labor cost for sanitary workers in Sialkot

Staff	Average wage (Rupi /month)	Number of workers (person)		
		2011	2016	2021
Superintending Engineer	35,000	1	1	1
Executive Engineer	30,000	2	2	2
Assistant Executive Engineer	20,000	3	4	4
Assistant Engineer	20,000	6	7	8
Qualified Diploma Sanitary Inspector	10,000	16	18	20
Qualified Sanitary Inspector	10,000	32	35	39
Qualified Sanitary Supervisor	8,000	107	118	130
Driver	8,000	81	112	155
Sanitary Worker	6,500	358	532	761
Total		606	829	1,120

Table. V-29 Operating cost for waste collection and transport equipment

Equipment	Operating cost* (Rupi/Month)	Collection and transport equipment(EA)		
		2011	2016	2021
Tractor & Trolley	30,000	42	42	42
Mechanical Sweeper	30,000	5	7	10
Front End Loader	34,000	4	6	9
Open Trucks(3ton)	25,000	6	9	13
Compactors(2.5ton)	25,000	24	40	66
Compactors(5ton)	25,000	-	8	15
Total		81	112	155

Note: Disturbance cost along an equipment improvement calculates additional purchasing costs regarding increase of equipment

Table. V-30 Investment and operating cost for waste collection and transportation in Sialkot

Classification		Cost	Remark
Collection & Transportation equipment	Purchasing cost(rupi/year)	13,620,000	§Purchasing cost for collection/transportation equipment per year.
	Operation cost (rupi/year)	38,444,000	§Operating cost per year
Landfill equipment	Purchasing cost (rupi)	108,609,000	§Purchasing cost for operating equipment for the landfill
Sanitary worker	Labor cost (rupi/year)	75,522,000	§Labor cost for managing wastes per year.

5.2 Construction and operating cost for the waste disposal facilities

Table. V-30 Construction cost for waste disposal facilities in Sialkot

	Sanitary landfills		Compost Facility	Incinerator	Recycling Facility
	Site 1	Site 2			
Capacity (Total)	60,702m2 1,478,700m3	40,468m2 892,000m3	430ton/d (3rd step)	170 ton/d (3rd step)	40 ton/d (3rd step)
Unit Cost	9,434Rupi/m2 387Rupi/m3	9,434Rupi/m2 428Rupi/m3	600,000 Rupi/ton	11,320,000 Rupi/ton	4,400,000 Rupi/ton
Total Construction Cost (thousands Rupi)	572,260	381,776	258,000	1,924,400	176,000

Note : tax, design & construction consulting fee are not included

Table. V-31 Operating cost for disposal facilities in Sialkot

	Sanitary landfills		Compost Facility	Incinerator	Recycling facility
	Site 1	Site 2			
Capacity (Total)	1,478,700m3	892,000 m3	430ton/d (2021)	170 ton/d (2021)	40 ton/d (2021)
Unit Cost	294Rupi/ m3	294Rupi/ m3	78,000 Rupi/ton.yr	152,000 Rupi/ton.yr	124,100 Rupi/ton.yr
Total Operating Cost	434,738 thousands Rupi	262,248 thousands Rupi	33,540thousands Rupi Rupi/yr	25,840 thousands Rupi/yr	4,964 thousands Rupi/yr

Note : tax, design & construction consulting fee are not included

5.3 Cost analysis of each landfill

The location of installation of landfill facility should be determined by the total analysis of construction cost, operating cost and transfer cost. The larger the size of the facility, the lower the construction cost but the operating cost is the same. The closer the location of the facility to the city, the lower the transfer cost gets. By carrying out a total analysis, Site 1 (Daska Road) is determined to be the most adventurous for the new landfill for Siaklot.

Table. V-32 Cost analysis of sanitary Landfill in Lahore

	Capacity (m^3)	Construction cost (Rupi/m^3)	Operation cost (Rupi/m^3)	Transfer cost (Rupi/m^3)	Total cost (Rupi/m^3)
Site 1	1,478,700	387	294	27	708
Site 2	892,000	428	294	27	749

5.4 Expected profit from operation of waste disposal facilities

Expected profit from electric sales and heat supply

Table. V-33 Expected profit from landfill sites

Class	Sialkot
Recyclable landfill gas	10 /min
Maximum energy generation	1
Expected profits	1 × 4Rupi/ H = 35,040,000Rupi/year

Table. V-34 Expected profits from incinerator in Sialkot

Class	Korea	Sialkot	Note
Capacity of Incineration Facility (ton/day)	11,468	170	
Amount of Waste Heat Generated (Gcal/Year)	4,951,000	74,000	Incineration Facility generates 1ton/day (431.7Gcal/year)
Amount of Waste Heat Used (Gcal/Year)	4,419,000	66,100	About 89.3% of Waste Heat Generated
Use of Heat	3,482,000	52,100	About 78.8% of Waste Heat used
Use of Energy Generated	937,000	14,000	about 21.2% of Waste Heat used
Profit from Use of Waste Heat (Rupi/year)	7,853,000,000	117,795,000	About 1.5% of Korea
Profit from Heat supply	6,014,000,000	90,210,000	
Profit from Energy Generated	1,839,000,000	27,585,000	

Table. V-35 Expected profits from compost sales in Sialkot

Class		2021
Capacity of composting facility (ton/day)		430
Compost sales (ton/day)		86~129
Compost sales cost (Rupi/kg)		4.5
Profit from compost sales	Rupi/day	387,000 ~ 580,500
	Rupi/year	141,255,000 ~ 211,882,500

Expected profits from recyclable material sales

Table. V-36 Expected profits from recycling facility in Sialkot

Class	Korea	Sialkot	Note
Capacity of recycling facility (ton/day)	143	40	
Total sale (/year)	11,386,230	3,184,960	79,624 products from 1ton of facility capacity
Total sale (Rupi/year)	155,889,000	44,589,440	about 14 Rupi /kg

Expected profits from greenhouse gas reduction

Appeared to things that appeared to things that suggested to a carbon discharge of 4,896,000~8,116,000 Rupi per year in case of waste reclamation facilities operation, and was effective against profit, and suggested to a carbon discharge of 11,891,880 a year Rupi in case of incineration facilities operation, and was effective against profit.

Table. V-37 Expected profit from greenhouse gas reduction

		Korea	Sialkot
Landfill sites	Reclaimed Facility capacity	131,000,000 ton (Sudokwon Landfill I & II)	§Landfilling waste - Site 1 : 1,478,700 ton - Site 2 : 892,000 ton
	Greenhouse gas reduction (CO_2) - about 9.24% of landfilling capacity	Greenhouse gas reduction for 10 years: 12,100,000 ton/10 year	§Greenhouse gas reduction: -Site1: 136,632ton/10 year -Site2: 82,421 ton/10 year
	Carbon finance	718,740,000 Rupi/year	§Annual profit: -Site 1 : 8,116,000 Rupi/year -Site 2 : 4,896,000 Rupi/year
Incinerator	Incineration facility capacity	11,468 ton/day	§170 ton/day
	Greenhouse gas discharge reduction	1,350,000 ton/year	§20,020 ton/year

	(CO2)		
	Carbon finance	801,900,000 Rupi/year	§11,891,880 Rupi/year

Note: CO_2 discharge cost: $10 (594Rupi/ton) per 1 tCO_2
Source: Sudokwon Landfill Site Management Corps.(2007. 5), CDM Project data.

5.5 Economy analysis along dumping site restoration plan in Sialkot

Table. V-38 Restoration cost for the dumping site in Sialkot

Dumping site	Landfilling Area (m2)	Unit cost (Rupi/m2)	Restoration cost (Rupi)
Gohad Pur	141,700	3,200	453,440,000

5.6 Total cost for construction of waste disposal facilities in Sialkot

Final cost to construct waste disposal facilities contains initial investment, consulting cost for facility designing and supervision. Total cost for the 1st step is as seen in a following table. Later, it needs to estimate the cost for 2nd and 3rd step, reflecting the circumstances in Sialkot.

Table. V-39 Total cost for construction of waste disposal facility, Sialkot

Contents		Cost(Rupi)
Construction cost	Landfill sites	572,260,000
Consulting Service Cost		78,750,000
Total		651,010,000

Note: See the details in Annex-11

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Glossary

Aerobic composting

A method of com-posting organic wastes using bacteria that need oxygen. This requires that the waste be exposed to air, either via turning or by forcing air through pipes that pass through the material.

Agricultural digestion

Waste from farm and agriculture activities including poultry, cattle farming, animal husbandry, residues from the use of fertilizers, pesticides and other farm chemicals.

Anaerobic digestion

Phenomenon by which organic matter is transformed into methane(or another reduced organic compound, e.g. ethanol or lactic acid) in the absence of air (oxygen).

Ash

The noncombustible solid by-products of incineration or other burning process.

Autoclaving

Sterilization via a pressurized, high-temperature steam process.

Bughouse

A combustion plant emission control device that consists of an array of fabric filters through which flue gases pass in an incinerator flue. Particles are trapped and thus prevented from passing into the atmosphere.

Basel Convention

An international agreement on the control of trans boundary movements of hazardous wastes and their disposal, drawn up in March 1989 in Basel, Switzerland, with over 100 countries as signatories.

Biodegradable material

Any organic material that can be broken down by microorganisms into simpler, more stable com-pounds. Most organic wastes (e.g., food, paper) are biodegradable.

Bottom ash

Relatively coarse, noncombustible, generally toxic residue of incin-eration that accumulates on the grate of a furnace.

Bulky waste

Large wastes such as appliances, furniture, and trees and branches, that cannot be handled by normal MSW processing methods.

Cell

The basic unit by which a landfill is developed. It is the general area where incoming waste is tipped, spread, compacted, and covered.

Chemocar

A special vehicle for the collection of toxic and hazardous wastes from residences, shops, and institutions.

Cleaner production

Processes designed to reduce the wastes generated by production.

Co-disposal

The disposal of different types of waste in one area of a landfill or dump. For instance, sewage sludges may be disposed of with regular solid wastes.

Cogeneration

Process by which a fuel is burnt to produce, simultaneously, electric power and useful heat.

Collection

The process of picking up wastes from residences, businesses, or a collection point, loading them into a vehicle, and transporting them to a processing, transfer, or disposal site.

Combustibles

Burnable materials in the waste stream, including paper, plastics, wood, and food and garden wastes.

Combustion

In municipal solid waste management the burning of materials in an incinerator.

Commingled

Mixed recyclables that are collected together after having been separated from mixed MSW.

Communal collection

A system of collection in which individuals bring their waste directly to a central point, from which it is collected.

Compactor vehicle

A collection vehicle using high-power mechanical or hydraulic equipment to reduce the volume of solid waste.

Composite liner

A liner system for a land-fill consisting of an engineered soil layer and a synthetic sheet of material.

Compost

Organic matter after microbial decomposition, composed of slow degradable matter(fibres), and mineral fertilising matter. Organic matter that has reached, after fermentation which is usually aerobic but also anaerobic, a relatively stable state of decomposition. Compost is often made from plant material (leaves or grass clippings) but can also be made from domestic or industrial solid waste, less frequently from agricultural waste. Compost, also called humus, is a soil conditioner and also used as a fertilizer. Composting is the process which produces compost.

Composting

Biological decomposition of solid organic materials by bacteria, fungi, and other organisms into a soil-like product.

Construction and demolition debris

Waste generated by construction and demolition of buildings, such as bricks, concrete, drywall, lumber, miscellaneous metal parts and sheets, packaging materials, etc.

Controlled dump

A planned landfill that incorporates to some extent some of the features of a sanitary landfill: sitting with respect to hydrogeological suitability, grading, compaction in some cases, leachate control, partial gas management, regular (not usually daily) cover, access control, basic record-keeping, and controlled waste picking.

Curbside collection

Collection of composables, recyclables, or trash at the edge of a sidewalk in front of a residence or shop.

Curing

Allowing partially composted materials to sit in a pile for a specified period of time as part of the maturing process in composting.

Disposal

The final handling of solid waste, following collection, processing, or incineration. Disposal most often means placement of wastes in a dump or a landfill.

Diversion rate

The proportion of waste material diverted for recycling, composting, or reuse and away from landfill or incineration.

Drop-off center

An area or facility for receiving composting or recyclables that are dropped off by waste generators.

Dump

See controlled dump and open dump.

Emissions

Gases released into the atmosphere.

Emission Standards

Permissible standards established by the Federal Agency or a Provincial Agency for emission of air pollutants and noise and for discharge of effluent and waste.

Energy recovery

The process of extracting useful energy from waste, typically from the heat produced by incineration or via methane gas from landfills.

Environmental impact assessment (EIA)

An evaluation designed to identify and predict the impact of an action or a project on the environment and human health and well-being. Can include risk assessment as a component, along with economic and land use assessment.

Environmental risk assessment (EnRA)

An evaluation of the interactions of agents, humans, and ecological resources. Comprised of human health risk assessment and ecological risk assessment, typically evaluating the probabilities and magnitudes of harm that could come from environmental contaminants.

Fabric filter

See baghouse.

Flaring

The burning of methane emitted from collection pipes at a landfill.

Fluidized-bed incinerator

A type of incinerator in which the stoker grate is replaced by a bed of limestone or sand that can withstand high temperatures. The heating of the bed and the high air velocities used cause the bed to bubble, which gives rise to the term fluidized.

Fly ash

The highly toxic particulate matter captured from the flue gas of an incinerator by the air pollution control system.

Garbage

In everyday usage, refuse in general. Some MSWM manuals use garbage to mean "food wastes," although this usage is not common.

Groundwater

Water beneath the earth's surface that fills underground pockets (known as aquifers), supplying wells and springs.

Hazardous waste

Waste that is reactive, toxic, corrosive, or otherwise dangerous to living things and/or the environment. Many industrial by-products are hazardous.

Heavy metals

Metals of high atomic weight and density, such as mercury, lead, and cadmium, that are toxic to living organisms.

Hospital

In the context of the Hospital Waste Management Rules 2005, hospital includes a clinic, laboratory, dispensary, pharmacy, nursing home, health unit, maternity centre, blood bank, autopsy centre, mortuary, research institute and veterinary institutions, including any other facility involved in health care and biomedical activities.

Hospital Waste

Includes waste material supplies and material of all kinds, and waste blood tissue and other parts of the human bodies from hospital, clinics and laboratories.

Household hazardous waste

Products used in residences, such as paints and some cleaning compounds, that are toxic to living organisms and/or the environment.

Humus

The end product of composting, also called compost.

Incineration

The process of burning solid waste under controlled conditions to reduce its weight and volume, and often to produce energy.

Industrial Waste

Waste resulting from an industrial activity.

Informal sector

The part of an economy that is characterized by private, usually small-scale, labor-intensive, largely unregulated, and unregistered manufacturing or provision of services.

Inorganic waste

Waste composed of material other than plant or animal matter, such as sand, dust, glass, and many synthetics.

Integrated solid waste management

Coordinated use of a set of waste management methods, each of which can play a role in an overall MSVVM plan.

International NGO

An organization that has an international headquarters and branches in major world regions, often with the purpose of undertaking development assistance.

In-vessel composting

Composting in an enclosed vessel or drum with a controlled internal environment, mechanical mixing, and aeration.

Itinerant waste buyer (Periwala)

A person who moves around the streets buying (or bartering for) reusable and recyclable materials.

Landfill gases

Gases arising from the decomposition of organic wastes; principally methane, carbon dioxide, and hydrogen sulfide. Such gases may cause explosions at landfills.

Landfilling

The final disposal of solid waste by placing it in a controlled fashion in a place intended to be permanent. The Source Book uses this term for both controlled dumps and sanitary landfill.

Leachate

Liquid (which may be partly produced by decomposition of organic matter) that has seeped through a landfill or a compost pile and has accumulated bacteria and other possibly harmful dissolved or suspended materials. If uncontrolled, leachate can contaminate both groundwater and surface water.

Leachate pond

A pond or tank constructed at a landfill to receive the leachate from the area. Usually the pond is designed to provide some treatment of the leachate, by allowing settlement of solids or by aeration to promote biological processes.

Lift

The completed layer of compacted waste in a cell at a landfill.

Liner

A protective layer, made of soil and/or synthetic materials, installed along the bottom and sides of a landfill to prevent or reduce the flow of leachate into the environment.

Manual landfill

A landfill in which most operations are carried out without the use of mechanized equipment.

Market waste

Primarily organic waste, such as leaves, skins, and unsold food, discarded at or near food markets.

Mass-burn incinerator

A type of incinerator in which solid waste is burned without prior sorting or processing.

Materials recovery

Obtaining materials that can be reused or recycled.

Materials recovery facility (MRF)

A facility for separating commingled recyclables by manual or mechanical means. Some MRFs are designed to separate recyclables from mixed MSW. MRFs then bale and market the recovered materials.

Methane

An odorless, colorless, flammable, explosive gas, CH, produced by anaerobically decomposing MSW at landfills.

Micro-Enterprise

A synonym for small-scale enterprise: a business, often family-based or a cooperative, that usually employs fewer than ten people and may operate "informally."

Mixed waste

Unsorted materials that have been discarded into the waste stream.

Modular incinerator

A relatively small type of prefabricated solid waste combustion unit.

Monofill

A landfill intended for one type of waste only.

MSW

Municipal solid waste.

MSWM

Municipal solid waste management.

Municipal solid waste

All solid waste generated in an area except industrial and agricultural wastes. Sometimes includes construction and demolition debris and other special wastes that may enter the municipal waste stream. Generally excludes hazardous wastes except to the extent that they enter the municipal waste stream. Sometimes defined to mean all solid wastes that a city authority accepts responsibility for managing in some way.

Municipal solid waste management

Planning and implementation of systems to handle MSW.

NGO

Nongovernmental organization. May be used to refer to a range of organizations from small community groups, through national organizations, to international ones. Frequently these are not-for-profit organizations.

Night soil

Human excreta.

NIMBY

"Not In My Back Yard." An expression of resident opposition to the siting of a solid waste facility based on the particular location proposed.

Nuclear Waste

Waste form any nuclear reactor or nuclear plant or other nuclear energy system, wheter or not such waste is radioactive.

Open dump

An unplanned "landfill" that incorporates few if any of the characteristics of a controlled landfill. There is typically no leachate control, no access control, no cover, no management, and many waste pickers.

Organic waste

Technically, waste containing carbon, including paper, plastics, wood, food wastes, and yard wastes. In practice in MSWM, the term is often used in a more restricted sense to mean material that is more directly derived from plant or animal sources, and which can generally be decomposed by microorganisms.

Pathogen

An organism capable of causing disease.

Picker

See waste picker.

Pollution

The contamination of soil, water, or the atmosphere by the discharge of waste or other offensive materials.

Post-consumer materials

Materials that a consumer has finished using, which the consumer may sell, give away, or discard as wastes.

Primary material

A commercial material produced from virgin materials used for manufacturing basic products. Examples include wood pulp, iron ore, and silica sand.

Privatization

A general term referring to a range of contracts and other agreements that transfer the provision of some services or production from the public sector to private firms or organizations.

Private Sector Participation

A partnership between the public and private sectors which allows the private sector to participate in service delivery. This term is preferred in the context of municipal solid waste management to "privatization" which implies that the public sector is no longer responsible for ensuring provision of the service.

Processing

Preparing MSW materials for subsequent use or management, using processes such as baling, magnetic separation, crushing, and shredding. The term is also sometimes used to mean separation of recyclables from mixed MSW.

Producer responsibility

A system in which a producer of products or services takes responsibility for the waste that results from the products or services marketed, by reducing materials used in production, making repairable or recyclable goods, and/ or reducing packaging.

Putrescible

Subject to decomposition or decay. Usually used in reference to food wastes and other organic wastes that decay quickly.

Pyrolysis

Chemical decomposition of a substance by heat in the absence of oxygen, resulting in various hydrocarbon gases and carbon-like residue.

Recyclables

Items that can be reprocessed into feedstock for new products. Common examples are paper, glass, aluminum, corrugated cardboard, and plastic containers.

Recycling

The process of transforming materials into raw materials for manufacturing new products, which may or may not be similar to the original product.

Refuse

A term often used interchangeably with solid waste.

Refuse-derived fuel (RDF)

Fuel produced from MSW that has undergone processing. Processing can include separation of recyclables and noncombustible materials, shredding, size reduction, and pelletization

Resource recovery

The extraction and utilization of materials and energy from wastes.

Reuse

The use of a product more than once in its original form, for the same or a new purpose.

Risk Waste

Infectious waste, pathological waste, sharps, pharmaceutical waste, genotoxic waste, chemical waste, and radioactive waste.

Rubbish

A general term for solid waste. Sometimes used to exclude food wastes and ashes.

Sanitary landfill

An engineered method of disposing of solid waste on land, in a manner that meets most of the standard specifications, including sound siting, extensive site preparation, proper leachate and gas management and monitoring, compaction, daily and final cover, complete access control, and record-keeping.

Scrubber

Emission control device in an incinerator, used primarily to control acid gases, but also to remove some heavy metals.

Secondary collection

The process of picking up waste at the collection points, loading them into a vehicle and take the waste to a treatment facility or final disposal site.

Secondary material

A material recovered from post-consumer wastes for use in place of a primary material in manufacturing a product.

Secure landfill

A disposal facility designed to permanently isolate wastes from the environment. This entails burial of the wastes in a landfill that includes clay and/ or synthetic liners, leachate collection, gas collection (in cases where gas is generated), and an impermeable cover.

Segregation rate

The proportion of waste material diverted for recycling, composting, or reuse and away from landfilling or incineration.

Septate

Sludge removed from a septic tank (a chamber that holds human excreta).

Set-out container

A box or bucket used for residential waste that is placed outside for collection.

Sewage sludge

A semi-liquid residue that settles to the bottom of canals and pipes carrying sewage or industrial wastewaters, or in the bottom of tanks used in treating wastewaters.

Site remediation

Treatment of a contaminated site by removing contaminated solids or liquids or treating them on-site.

Solid Waste

All sort of wastes generated from human and animal activity which are normally solid and are discarded as useless or unwanted.

Source reduction

The design, manufacture, acquisition, and reuse of materials so as to minimize the quantity and/or toxicity of waste produced.

Source separation

Setting aside of compostable and recyclable materials from the waste stream before they are collected with other MSW, to facilitate reuse, recycling, and composting.

Special wastes

Wastes that are ideally considered to be outside of the MSW stream, but which sometimes enter it and must often be dealt with by municipal authorities. These include household hazardous waste, medical waste, construction and demolition debris, war and earthquake debris, tires, oils, wet batteries, sewage sludge, human excreta, slaughterhouse waste, and industrial waste.

Subsidy

Direct or indirect payment from government to businesses, citizens, or institutions to encourage a desired activity.

Tipping fee

A fee for unloading or dumping waste at a landfill, transfer station, incinerator, or recycling facility.

Tipping floor

Unloading area for vehicles that are delivering MSW to a transfer station or incinerator.

Transfer

The act of moving waste by a large transport vehicle from a transfer station to the final disposal site.

Transfer point

A designated point, often at the edge of a neighborhood, where collection vehicles transfer waste to larger vehicles for transport to disposal sites.

Transfer station

A major facility at which MSW from collection vehicles is consolidated into loads that are transported by larger trucks or other means to more distant final disposal facilities, typically landfills.

Transition countries

The countries of Eastern Europe and the former Soviet Union that are in various steps of restructuring their economies. The changes involve a move away from being substantially state run toward a variety of new configurations, ranging from moderate economic liberalization to a significant dismantling of the state's role in the economy.

Vectors

Organisms that carry disease causing pathogens. At landfills rodents, flies, and birds are the main vectors that spread pathogens beyond the landfill site.

Vermiculture

See worrn culture.

Virgin materials

Any basic material for industrial processes that has not previously been used, for example, wood-pulp trees, iron ore, crude oil, bauxite.

Waste

Any substance or object which has been, is being or is intended to be, discarded or disposed of, and includes liquid waste, solid waste, waste gases, suspended waste, industrial waste, agricultural waste, nuclear waste, municipal waste, hospital waste, used polyethylene bags and residues from the incineration of all types of waste.

Waste characterization study

An analysis of samples from a waste stream to determine its composition.

Waste collector

A person employed by a local authority or a private firm to collect waste from residences, businesses, and community bins.

Waste dealer

A middleman who buys recyclable materials from waste generators and itinerant buyers and sells them, after sorting and some processing, to wholesale brokers or recycling industries.

Waste Management

Includes waste segregation, waste collection, waste transportation, waste storage, waste disposal and waste minimization and reuse.

Waste management hierarchy

A ranking of waste management operations according to their environmental or energy benefits. The purpose of the waste management hierarchy is to make waste management practices as environmentally sound as possible.

Waste picker

A person who picks out recyclables from mixed waste wherever it may be temporarily accessible or disposed of.

Waste reduction

All means of reducing the amount of waste that is produced initially and that must be collected by solid waste authorities. This ranges from legislation and product design to local programs designed to keep recyclables and compostables out of the final waste stream.

Waste stream

The total flow of waste from a community, region, or facility.

Waste-to-energy(WTE) plant

A facility that uses solid waste materials (processed or raw) to produce energy. WTE plants include incinerators that produce steam for district heating or industrial use, or that generate electric power; they also include facilities that convert landfill gas to electric power.

Water table

Level below the earth's surface at which the ground becomes saturated with water.

Wetland

An area that is regularly wet or flooded and has a water table that stands at or above the land surface for at least part of the year.

Windrow

An elongated pile of aerobically composting materials that are turned periodically to expose the materials to oxygen and to control the temperature to promote biodegradation.

Working face

The length and width of the row in which waste is being deposited at a landfill. Also known as the tipping face.

Worin castings

The material produced from the digestive tracts of worms as they live in earth or compost piles. The castings are rich in nitrates, potassium, phosphorous, calcium, and magnesium.

Worm culture

A relatively cool, aerobic composting process that uses worms and microorganisms. Also known as venniculture.

Yard waste

Leaves, grass clippings, prunings, and other natural organic matter discarded from yards and gardens.

Annex-1. Profiles of Nine Cities & Budget Estimates of Sialkot

1. Figures on the nine participating municipalities

Name	Form of administration	Total no. of towns /union councils	Number of towns /union councils	Areas (km²)	Population (million persons)
Lahore	CDG	9 / 150	8 / 130	1,772	6.4
Faisalabad	CDG	8 / 289	4 / 113	589	2.5
Rawalpindi	CDG	2 / 80	1 / 46	175	1.7
Multan	CDG	6 / 129	4 / 97	495	1.5
Gujranwala	CDG	11 / 150	4 / 64	368	1.4
Sargodha	TMA	1 / 45	1 / 27	268	0.6
Sialkot	TMA	1 / 50	1 / 29	276	0.5
Bahawalpur	TMA	1 / 44	1 / 35	184	0.5
DG Khan	TMA	1 / 38	1 / 30	170	0.3

Source: Ernst Basler + Partners and ICEPAK (2007), p4.

2. Labor cost for health and sanitation of Sialkot, 2006-2007

(unit: million Rs.,%)

Object	Budget estimates	(%)
Total **(Say)**	120,739,721 (107,800,000)	100.0 (89.3)
Establishment charges*	4,075,848	3.4
Pay	4,075,848	3.4
Pay of officer	157,485	0.1
Pay of other staff	3,918,363	3.2
Regulation allowances	46,833,758	38.8
Hose rent allowance	13,734,144	11.4
Conveyance allowance	4,889,520	4.0
Dress allowance	1,880,280	1.6
Washing allowance	-	0.0
Other regular allowance	4,418,116	3.7
Medical allowance	5,946,600	4.9
Special allowance	5,031,965	4.2
Ad hoc relief	5,031,965	4.2
Others	5,901,168	4.9
Other allowance (excluding TA)	34,563,846	28.6
Other allowance (excluding TA)	122,752	0.1
Honoraria	1,057,984	0.9
Medical charges /overtime	7,619,872	6.3
Leave salary	10,029,753	8.3
Tension contribution	15,733,485	13.0
Increase as per Gov. R.B.P.S	-	0.0

Note: * Establishment charge is not credible; as provided by the Budget Estimates, 2006-2007

3. Contingent expenditure on SWM of Sialkot, 2006-2007

(unit: million Rs.,%)

Object	Budget estimates	(%)
Total	14,750,000	100.0
(Say)	(15,000,000)	(98.3)
Purchases of durable goods	760,000	5.2
Transport	-	0.0
Machinery Equipment	700,000	4.7
Furniture & Fixtures	50,000	0.3
Other	10,000	0.1
Repairs & maintenance of durable goods	1,655,000	11.2
Transport	1,000,000	6.8
Machinery Equipment	645,000	4.4
Furniture & Fixtures	10,000	0.1
Other	-	0.0
Commodities & services	12,135,000	82.3
Transportation	12,030,000	81.6
Traveling allowance	10,000	0.1
POL charges, air plane, helicopter, staff cars, motorcycles, etc.	12,000,000	81.4
Others	20,000	0.1
Communications	-	0.0
Postep & telegrap	-	0.0
Telephone & trunk calls	-	0.0
Telex and tele printer	-	0.0
Courier & pilot services	-	0.0
Others	-	0.0
Utilities	-	0.0
Gas	-	0.0
Waster	-	0.0
Electricity	-	0.0
Hot & cold weather charges	-	0.0
Other	-	0.0
Office stationery	50,000	0.3
Printing & publications	50,000	0.3
Newspapers; periodicals & books	5,000	0.0
Other expenditures on commodities & services	-	0.0
Law charges	-	0.0
Fairs, exhibitions & other national celebrations	200,000	1.4
Unforeseen expenditures for disaster	50,000	0.3
Preparedness and relief	-	0.0
Purchase of drugs & medicines	-	0.0
Other (sports)	-	0.0
Transfer payment	200,000	1.4
Scholarship, bonuses & other awards	200,000	1.4
Bonuses	200,000	1.4
Cash reward for meritorious services	-	0.0
Loans & repayments	0	0.0
Loans to government servants	0	0.0
House building advances local government	-	0.0
Motor car advanced local government	-	0.0
Motorcycle/scooter advances local government	-	0.0
Cycle advances local government	-	0.0
Others	-	0.0
Miscellaneous expenditures	0	0.0
Conferences / seminars / workshops / symposia	-	0.0

Annex-2. Waste composition of dumping sites

n Mehmood Booti dumping site

1. Date of Examination :January 20, 2007

2. Place of Examination : Mehmood Booti dumping site

3. Method of Examination : Measurement of weight after classifying certain sample waste by composition

4. Contents of Examination

§ Weight of organic matters as the greatest part of the wastes, amounted to 214.5 kg, which is equivalent to 54.8% of the total weight, 391.5kg. This looks almost the same as the case of "Ernst Basler + Partners Ltd. Switzerland and ICEPAK(2006. 9)" with its organic matter content of 55.3%.

§ Proportion of Combustible waste was 95.0% while proportion of non-combustible waste was 5.0%. Food and clothes wastes occupied 80.2% of the total.

§ Food waste amounted to 54.8% of the total, where ratio of vegetable waste to meat waste was higher.

§ Clothes and leather together take 25.4%. More precisely, the proportion of leathers was much lower. The clothes were fully wet as they absorbed the moisture from food wastes, which had a significant effect on weight measurement. Meanwhile, presence of sanitary napkins and diapers was also considerable. For sanitary napkins, the majority was cloth products.

§ Vinyl had a proportion of 7.5%. Considering the low ratio in quantity, vinyl wastes make up a considerable part in number, and this would have a big impact on recycling.

§ Paper and plastic constitute 3.1% and 2.5% each. For paper, there were lots of packing papers for biscuits and for plastic, lots of film products and some plastic products. PET products were not really found, and we can presume the products were already collected before being brought in.

§ Wood made up only 1.7%.

§ Stone and Ceramics amounted to 3.5%. There were lots of broken parts of ceramic wares and some bricks.

§ Hospital wastes amounted to 0.5%, consisting of injection bottles, drugs, injectors, etc.

§ Metal and cans amounted to 0.5%. Presumably, such products were collected before being brought in, thus the ratio became lower. Therefore, it might be necessary to perform a composition examination at original sources of waste or transfer stations.

Table. Annex- 1 Composition of wastes in Lahore

Waste Composition			Weight ( )	Ratio (%)	Waste Composition		Weight ( )	Ratio (%)
Combustible Waste	Food Waste (Organic)	Vegetable & Fruit	207.0	52.9	Non-combustible Waste	Stone & Ceramics	13.5	3.5
		Meat	3.5	0.9		Metal & Cans	2.0	0.5
		Rice	4.0	1.0				
		Sub-Total	214.5	54.8		Hospital Waste	2.0	0.5
	Clothes & Leathers		99.5	25.4				
	Vinyl Bag		29.5	7.5		Glass	2.0	0.5
	Paper		12.0	3.1				
	Plastic		10.0	2.5		Total	19.5	5.0
	Wood		6.5	1.7				
	Total		372.0	95.0				
Total Weight 391.5 , Ratio 100%								

Fig. Annex-3-1 Mehmood Booti dumping site

Waste Composition Examination

The Measurement

n Gujranwala and Faisalabad dumping sites

In Gujranwala, inorganic matters had the greatest ratio, 53.2%, in the total waste and organic matters made up the next greatest proportion with 41.5%, while in Faisalabad the ratios were 47.6% for inorganic matters and 47.4% for inorganic matters. The result shows a bit of difference between the two areas.

Fig. Annex-4-1 Waste composition of Gujranwala

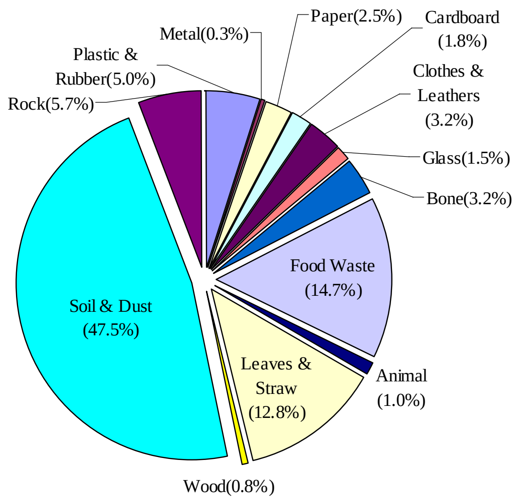
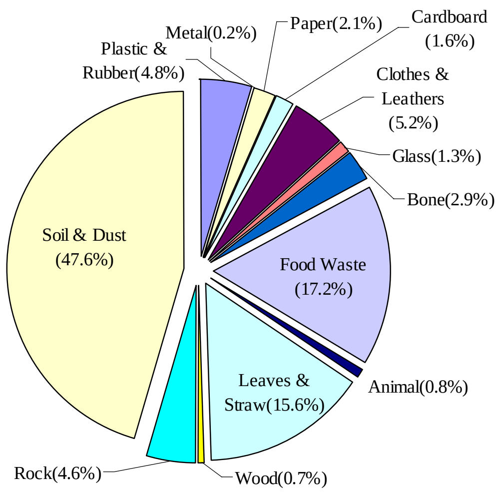


Fig. Annex-4-2 Waste composition of Faisalabad



Annex-3. Estimation of planned population through statistics in a mathematical way

Estimation of planned population through statistics in a mathematical way can be made by method of arithmetic series, method of geometric series, method of least squares, method of exponential function, method of logistic curve, etc. The scope and way of estimation for each method are as follows.

1. Method of arithmetic series

Based on an average population increase per year, a certain number of population of year shall be added to current population number. This is appropriate for estimating population of small towns, counties or districts having a low growth rate.

$$P_{o+n} = P_o + na$$

Therein, P_{o+n} : Estimated number of population after n years, P_o : Population of base year, n : number of year passing from base year, a : Average rate of annual population increase (=P_{o+n} - P_o/n)

2. Method of geometric series

This is also called Compound Interest Curve Method. The estimation can be made by supposing a population change within a given census zone as tendency of Geometric Curve or Compound Interest Curve and using geometric average with population increase rate. It is recommended for estimating population of rapidly developing cities such as new industrial cities rather than current cities with normal speed of development.

$$P_{o+n} = P_o(1 + r)^n$$

Therein, P_{o+n} : Estimated number of population after n years, P_o : Population of base year, n : number of year passing from base year, a : Average rate of annual population increase (= $P_{o+n}/P_o{}^{1/n}$ - 1)

3. Method of least squares

This estimates by applying method of least squares to some data, based on an average rate of annual population increase, and is appropriate for estimating a population change in a short period.

$$P_x = mx + b$$

Therein, P_x : Population of year x, x : Year of population estimation, m, b : invariable numbers

$$m = \frac{N\sum XY - \sum X \sum Y}{N\sum X^2 - \sum X \sum X} \quad , \quad b = \frac{\sum X^2 \sum Y - \sum X \sum XY}{N\sum X^2 - \sum X \sum X}$$

4. Method of exponential function

It takes a form of compound interest calculation and estimates for a certain period of time as the base, however, this method of exponential function has a principle that population continues to change.

$$P_x = bmx$$

Therein, P_x : Population of year x, x : Year of population estimation, m, b : invariable numbers

5. Method of logistic curve

This is an experience growth curve, making an assumption that population increases until a certain point of time before saturation, which also refers as to S Curve Method or Mathematical Method. It can be applicable to when a population increases as time goes by reaching its highest level of increase at the middle point, however, afterwards the rate of increase becomes reduced and the population reaches status of saturation after n years.

$$P_x = \frac{S}{1 + e^{b - mx}}$$

Therein, P_x : Population of year x, x : Year of population estimation, m, b : invariable numbers

Annex-4. Estimation of quantity of wastes through statistics in a mathematical way

Estimation of quantity of wastes through statistics in a mathematical way normally makes use of the following 4 techniques. In Korea, each city estimates it with different ways according to combination of statistical technique and political aspect, among which Dynamic Simulation Model is not used in practice.

1. Trend Model

Trend Model estimates the future with past tendency by substituting past waste treatment facility (at least 5 years before) for numerical model, which uses Correlation Analysis interpreting only correlation between time and quantity of the accompanying wastes.

2. Multiple Linear Regression Model

Quantity of wastes must reflect features of an area in many ways. There are plenty of factors representing the local area and the factors function in a complex correlation, therefore, it is not recommendable to consider only a simple correlation. A more simple and effective way is comprehensively understanding features of the entire factors rather than grasping features of each factor. Multiple Linear Regression Model can be used for complex system analysis as representing features of each factor in a comprehensive way.

3. Simple Regression Model

Simple Regression Model is a regression analysis whose independent variable describing dependant variable exists as a single variable. This can be used only for where it is assumed quantity of wastes and quantity of wastes by composition are affected by only one independent variable.

4. Dynamic Simulation Model

In the method of Dynamic Simulation Model, you can evaluate all factors with functions against time and then convert the correlation between factors expressed as functions into a numerical formula.

Annex-5. Waste collection and transport equipment estimates

n Lahore

1. Waste collection & transport equipment requirement in Lahore

The required number of waste collection and transport equipments to efficiently collect and transport the current and future wastes of Lahore is estimated as follows: (This is also shown in [Table. Annex 6-2].

§ The frequency of trips and amount of waste carried by each vehicle is estimated based on the analysis by "Solid waste management in Lahore metropolitan area"

§ Also the plan is made so the total amount of waste of Lahore region can be collected. (The plan is made to fully utilize the currently used vehicles and the estimation was made by adding the equipment composition currently used in Korea.)

§ As for the currently used Arm Roll Truck/Container, it is recommended to maintain the current number of vehicles assuming that these vehicles can be utilized for point-to-point collection at narrow alleys where it is difficult for the collection/transport vehicle to access.

§ Also, as practiced in Korea, the containers may also be located at apartments.

§ When door-to-door system is adapted for collecting waste in the future it is planned to increase the number of open trucks and compactors by stages. (In Korea, the treatment rate per equipment is 40% for open truck, 30% for compactor and 30% for others.)

Table. Annex- 2 Amount of waste generated and collected in Lahore

Year	Waste generation (ton/day)	Waste Collection Rate (%)	Waste Collection (ton/day)
Present	5,000	76	3,800
2011	5,788	85	4,920
2016	7,479	90	6,731
2021	9,937	100	9,937

Table. Annex- 3 Waste collection equipment requirement in Lahore

Type Name	No. of trips (trip/day)	Amount (ton/trip)	Current (EA)	Equipment requirement (EA)			Treatment Amount (ton/day)		
				2011	2016	2021	2011	2016	2021
Arm Roll Truck (L : 10)	6	5.0	51	51	51	51	1,530	1,530	1,530
Arm Roll Truck (M : 5)	6	2.5	68	68	68	68	1,020	1,020	1,020
Open Trucks (3ton)	4	3.0	95	100	105	110	1,200	1,260	1,320
Compactors (2.5ton)	4	2.5	21	50	57	192	498	566	1,917
Compactors (5.0ton)	4	5.0	-	-	84	174	-	1,683	3,478
Dumpers (1.0ton)	4	1.0	33	33	33	33	132	132	132
Tractor Loaders	-	-	23	23	23	23	-	-	-
Tractor & Trolley	6	1.0	90	90	90	90	540	540	540
Mechanical Sweepers	-	-	33	43	59	87	-	-	-
Hand Cart	-	-	4,500	4,500	4,500	4,500	-	-	-
Total			-	458	570	828	4,920	6,731	9,937

2. Equipment requirement of waste transfer stations in Lahore

Transfer equipment is determined to efficiently transfer wastes coming into the station. The assumptions are as follows:

- § Transport equipment capacity: 15ton
- § Average speed of collection vehicles: 50km/hr
- § Distance: it is presumed that the collection vehicles follow the Main Road from transfer stations to final disposal sites.
- § Time to load or unload : 15 minutes per truckload (total: a half hour)

Table. Annex- 4 Result for operation equipment of transfer station in Lahore

Class	Round-trip distance (km)	Amount of waste (ton/day)			Transfer Time (min.)	Time to load & unload (min)	Transfer Time per once (min)
		2011	2016	2021			
Site 1	82	202	276	408	98.4	30	128.4
Site 2	68	209	286	423	81.6	30	111.6
Site 3	54	116	158	234	64.8	30	94.8
Site 4	58	305	417	616	69.6	30	99.6
Site 5	50	297	406	599	60.0	30	91.0
Site 6	70	389	533	787	84.0	30	116.0

Table. Annex- 5 Equipment requirement in waste transfer station in Lahore

	Freq. of possible transfer	2011		2016		2021	
		Freq.	Equip. requirement(EA)	Freq.	Equipment requirement(EA)	Freq.	Equipment requirement(EA)
Site 1	4	13	5	18	6	27	8
Site 2	4	14	4	19	5	28	8
Site 3	5	8	3	11	3	16	4
Site 4	5	20	5	28	7	41	10
Site 5	5	20	5	27	6	40	9
Site 6	4	26	7	36	10	52	14
Total			29		37		53

Note: In case transport vehicle is absent due to its repair and etc, the estimation was done considering 1 EA of equipment for spare.

n Sialkot

3. Estimating of waste collection & transport equipment in Sialkot

In Sialkot, city areas have lots of narrow alleys so it would be difficult for the big waste collection vehicles to access the points where wastes are located. It is planned to fully utilize the tractor trolley, which is in use currently.

For areas which are accessible to collection and transport vehicles, open trucks and compactors will be added by stages.

Table. Annex- 6 Amount of generated & collected waste step by step in Sialkot

Year	Waste generation (ton/day)	Waste Collection Rate(%)	Waste Collection (ton/day)
Present	500	60	300
2011	757	70	530
2016	986	80	788
2021	1,253	90	1,127

Table. Annex- 7 Estimated rerult of collection & transport equipment in Sialkot

type	No. of trips (trip/day)	Amount (ton/trip)	Present (EA)	Equipment requirement (EA)			Treatment amount (ton/day)		
				2011	2016	2021	2011	2016	2021
Tractors	42	7.0	1.0	42	42	42	294	294	294
Trolleys	46	-	-	46	46	46	-	-	-
mechanical Sweepers	3	-	-	5	7	10	-	-	-
Front End Loader	2	-	-	4	6	9	-	-	-
Open Trucks(3ton)	-	3.0	3.0	6	9	13	53	79	113
Compactors(2.5ton)	-	3.0	2.5	24	40	66	183	297	495
Compactors(5.0ton)	-	3.0	5.0	-	8	15	-	118	225
Hand Cart	-	-	-	450	450	450	-	-	-
Total			-	127	158	201	530	788	1,127

Annex-6. Transfer Station Plan

1. Planning

The cost for collection and transportation to the to the landfill takes the greatest portion of the total waste management cost. This is especially true for big cities like Lahore, where landfill, or other waste disposal sites, are located at a considerable distance from the areas where wastes are generated. It is therefore recommended that the current transport system, which is based on the containers, should be improved.

Currently in Lahore, the containers serving as collection points are mostly located at the center of the city roads while transshipment and related facilities are located near the stores, where there are a lot of wastes. This situation causes inconvenience when it comes to waste collection and transportation. This ultimately gives a bad affect to collection and transport of waste. Also, scavengers scatter wastes around when they are collecting recyclable items from waste containers.

The installation of transshipment facility that makes the container (located at the certain areas of the city) a base (position) is required. In order to do this, we would like to suggest the size of transshipment installation by targeted year plan in 3 steps, which is for efficient collection and transport of waste from Lahore region.

2. Requirement for planning

§ Targeted year plan
Mid-Term(1st Step ~ 2nd Step) : 2011 ~ 2016
Long-Term(3rd Step) : 2021

§ Targeted waste: Municipal Solid Waste

§ Targeted areas

Among the 9 towns in Lahore, except 6 towns (Ravi Town, Shalimar Town, Data Gunk Bakhsh Town, Samanabad Town, Gulberg Town, part of Iqbal Town, and part of Nishtar Town) which are located in 20km from the sanitary landfill (to be constructed in the future), the other 4 towns (Wahga Town, Aziz Town, part of Iqbal Town, and part of Nishtar Town)

3. Matters to be considered when designing transshipment field

Generally, the details vary depending on the size of the transshipment field. However, the design considerations for a transshipment field are transshipment method, size, requirement of equipment and supplementary material, environment and sanitary requirements.

Transshipment type :

Transshipment type for waste can be classified into Direct-Load Type, Storage-Load Type and Combined Direct-Load Type. Also, depending on the treatment size, a transshipment can be classified into Small(100ton/day), Medium(100ton/day ~ 5000ton/day), and Large(more than 500ton/day).

The feature for each type is as follows and its three dimensional figure is shown in Fig III-40.

Direct-Load Type :

It is a type by which the waste is directly loaded to the big vehicle, and transported to the final destination for disposal. It is a relay type, which can be installed at the outskirts of the city that is far from the residential area. Depending on the size of transshipment field, it can be classified into Non-pressure type, Large size pressure treatment type, Small and medium size pressure type, small size pressure type (agricultural area) and small type (landfill).

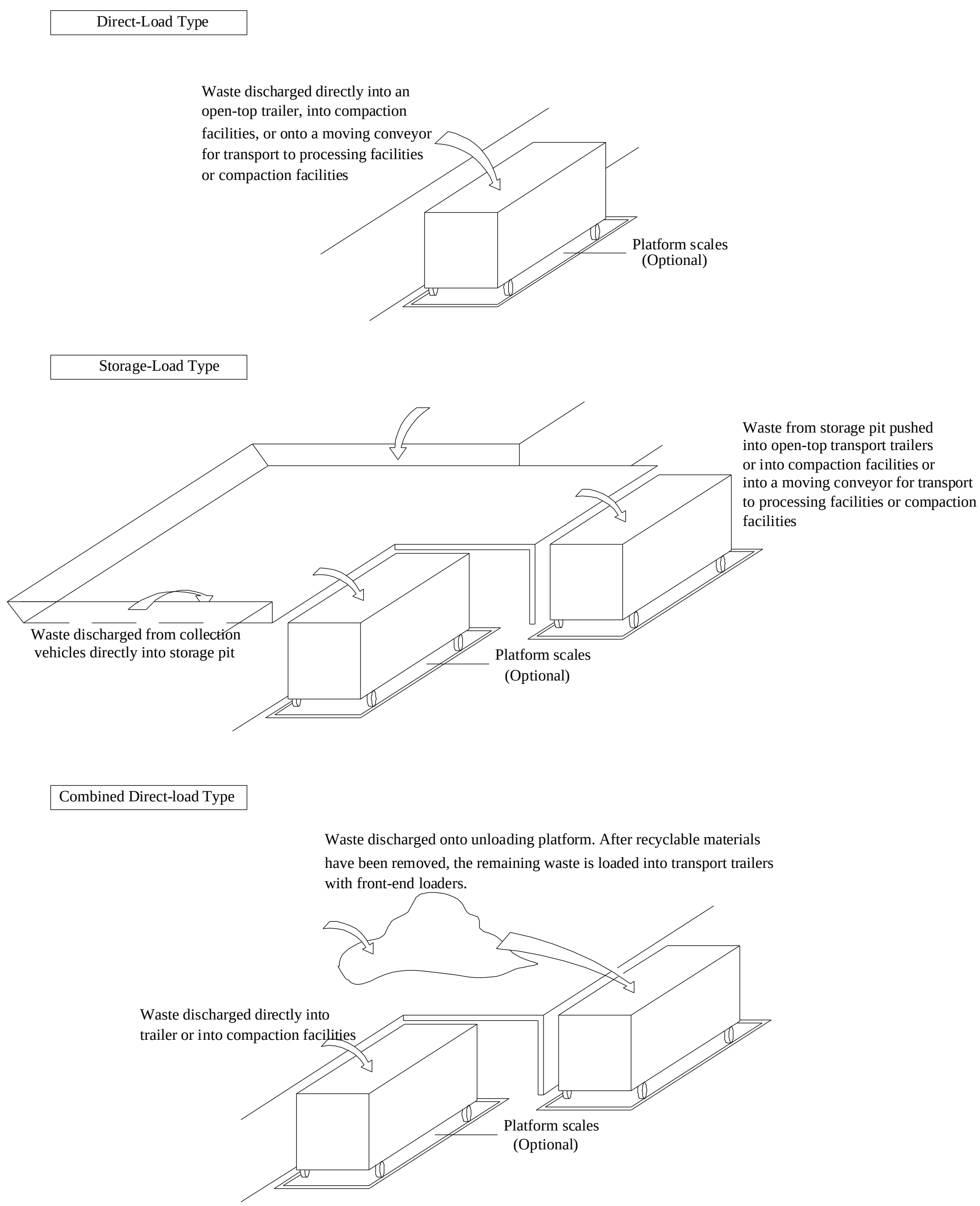
Storage-Load Type :

The waste in the collection vehicle is emptied into storage pit and it will be loaded into transport vehicle using various supplementary equipments (bulldozer, compressor, conveyor for transport and etc.) This type is suitable for treating large volumes of waste generated in big cities. Its difference from Direct-Load Type is that it stores waste for a certain period (1~3days). Storage-Load Type can be classified into big capacity storage-load type (Non-pressure treatment) and medium capacity storage-load type (pressure, crushing, and grading).

Combined Direct-Load Type :

It combines Direct-Load Type and Storage-Load Type. Generally, Combined Direct-Load Type is a Multipurpose Facility and it provides broader range of service than Single-purpose Facility. It also enables collection of materials (recycling materials) simultaneously.

Fig. Annex-9-1 Definition sketch for the types of Transfer Stations



4. Size of transshipment facility

When planning for transshipment facility, it is important to carefully estimate the required capacity of storage facility and transshipment treatment facility. When determining the treatment capability of transshipment, it is important that the unloading time for waste from the collection vehicle dos not take much time. The time for the collection vehicles entering to the transshipment field should be not overlapped with each other's time.

5. Requirement for equipment and supplementary device

The equipment and supplementary device required vary depending on the function of the transshipment field. For Direct-Load Type transshipment field, equipments for pushing the waste into the transport vehicle and equipments for spreading the waste evenly are required. However, the formation and number of equipment required vary depending on the treatment size.

For Storage-Load Type, Tractor Loader to push the waste into the hopper and equipment for spreading and refining the waste are required.

Because the weighing equipments provide important data for management, there should be a clear understanding of the status and technology development. These equipment should be installed at separate areas for the medium and large size transshipment filed.

In addition to the key facilities, there should also be auxiliary facilities such as main building, vehicle base, cafeteria, conference room, offices, locker rooms, shower booths, and rest rooms.

6. Required environment and public sanitary condition

When planning transshipment field, the offensive outlook can be minimized by adequate design and operation. The recently built large transshipment fields are surrounded with fence and made easier to clean and to maintain its cleanliness. In the sealed facility, there should be air adjuster which maintains lower air pressure inside the facility so odors and dusts would not be released to the outside. In addition, special care is required so paper pieces would not be blown off by wind so it is normal to install windscreen or net for protecting against scattering and dust.

To sum up, the best way to manage and maintain the transshipment field (minimizing problems with environment and sanitary problems) is continuous monitoring and cleaning.

The facility should be cleaned in a regular basis. For large simplified transshipment fields, it would be necessary to construct a complete sewage treatment facility especially when currently existing drainage systems are not accessible.

The scattering dust inside the working place is a threat to workers health. It is therefore necessary to install sprayers at certain locations in order to minimize dusts. Workers should always wear masks and air adjuster should be attached to the vehicles. Also, for safety matter, the waste coming directly from the private citizen should not be directly loaded into the pit.

7. Selecting the type of transshipment

The general type of transshipment has been briefly explained above. Areas such as Wahga Town and Aziz Town of Lahore are located at the outskirts from the city so the amount of their wastes is relatively small compared to the unit area. In this case, it is concluded that applying Direct-Load Type, which is simpler to build and economical, would be appropriate

8. Selecting a location for transshipment field

The following factors should be considered when selecting a location for transshipment field. a) Proximity to the locations where wastes are generated b) Accessibility to transport vehicles. c) Social acceptability and environmental security. d) Economics of collection, transportation, construction and maintenance., e) Other factors such as ground stability and reliability of electrical and water supply.

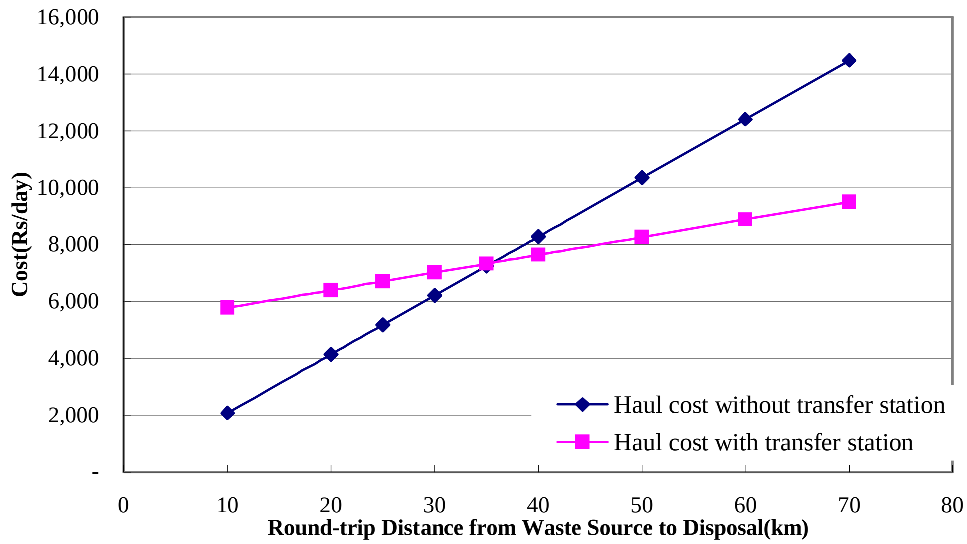
However, it is not possible satisfy all the above factor so usually, analysis between the elements are required and decision is made based on the transport cost which finally lead to selecting one out of several candidate sites.

For selecting the location of transshipment field of Lahore, economical analysis has been done based on the information suggested in "Waste Transfer Stations: A Manual for Decision-Making, June 2002, US EPA". As a result, as it is shown in Fig -41, for areas approx. 40km from the final destination of disposal, it is most economical to transport the wastes directly and without going through any transshipment fields. Thus, the towns located within 40km from the sanitary landfill are set up as areas for direct transport. For the towns that are located further than 40km (both ways) from the final destination, they are set up as areas in which transshipment fields should be built.

The selected location for the transshipment field is determined by considering the economical aspects. However, future installations of transshipment fields in Lahore will also be taking other matters into considerations aside from economic aspects.

The planned location of the transshipment based on economical analysis is shown in Fig -42. When planning the installation future transshipment fields, there should be a detailed analysis of the neighboring road conditions, economics, ground stability, location conditions and opinions of local citizens.

Box. Annex-9-1 Sample Comparison of Hauling Costs With and Without a Transfer Station



§ The Following assumptions were used to create this sample comparison :

- Operate transfer station : 21 Rs/ton
- Average payload of collection truck hauling directly to landfill : 4.5 ton
- Average payload of transfer truck hauling from transfer station to landfill : 15 ton
- Average trucking Cost(direct or transfer hauling) : 3.7 Rs/km

The comparison shows a break-even distance of about 40 kilometers(round-trip). In other words, for this example, using a transfer station is cost-effective when the round-trip distance exceeds 40 kilometers. When the round-trip distance is less than 40 kilometers, direct haul is more cost-effective. Although the same economic principles apply, break-even distances will vary in different situations based on the site-specific input data.

[Calculating Transfer Station Break-Even Point]

To Calculate the break-even point for a specific facility, the following inputs are required:

- § Transfer Station Cost : Operate transfer station, in Rs per ton
- § Direct Haul Payload : average payload of collection truck hauling directly to landfill, in tons
- § Transfer Haul Payload : average payload of transfer truck hauling from transfer station to landfill, in tons
- § Trucking Cost : average cost of direct or transfer hauling, in Rs per kilometer

Once these values are known, use the following formulas to calculate cost at different distances :

- § Cost of Direct Haul(without the use of a waste transfer station)

Distance(kilometers) multiplied by Trucking Cost(Rs per kilometer) divided by Direct Haul Payload(tons).

- § Cost of Transfer Haul
- § Transfer Station Cist(Rs per ton) plus Distance(kilometers) multiplied by Trucking Cist(won per kilometer) divided by Transfer Haul Payload(tons)

9. Estimating size of transshipment field facility

In order to transport the waste of Lahore to the final destination of disposal in a more economical, sanitary, and stable way, there is a need to install and run a transshipment field at Wahga, Aziz, Iqbal, and Nishtar town, which are located within reach from the future sanitary landfill. The plan for the size of the facility is as follows:

Wahga Town

§ 1st Step : Install transshipment field (250ton/day) at 2 locations (Site 1 and Site 2)

§ 2nd Step :Extend the existing Site1 and Site 2 (250ton/day) to 300ton/day by extending 50ton/day each.

§ 3rd Step : Other than Site 1 and Site 2, Site 1-1 and Site 2-1(150ton/day) will be added.

Aziz Town

§ 1st Step : Site 3 (150ton/day) and Site 4(350ton/day) will be installed.

§ 2nd Step : Existing Site 3 (150ton/day) will be extended to 200tons/day by extending 50tons/day and Site 4-1 (100ton/day) will be newly added.

§ 3rd Step : Site 3 (200ton/day) will be extended to 250ton/day and Site 4-1 (100ton/day) will be extended to 350ton/day.

Iqbal Town

§ 1st Step : Install transshipment field (300ton/day) at 1 location(Site 5)

§ 2nd Step : Install transshipment field (150ton/day) at 1 location(Site 5-1)

§ 3rd Step : Site 5-1 (150ton/day) will be extended to 300tons/day by extending 150ton/day

Nishtar Town

§ 1st Step : Install transshipment field (400ton/day) at 1 location(Site 6)

§ 2nd Step : Install transshipment filed (150ton/day) at 1 location(Site 6-1)

§ 3rd Step : Site 6-1 (150ton/day) will be extended to 400tons/day by extending 250ton/day

Size of transshipment field facility by stages

(Unit : ton/day)

		Capacity of facility				
		2011	2016		2021	
Wahga town	Site 1	250	300	(extended by 50ton)	300	
	Site 1-1	-	-		150	(Newly added)
	Site 2	250	300	(extended by 50ton)	300	
	Site 2-1	-	-		150	(Newly added)
Aziz town	Site 3	150	200	(extended by 50ton)	250	(extended by 50ton)
	Site 4	350	350		350	
	Site 4-1	-	100	(Newly added)	350	(extended by 250ton)
Iqbal town	Site 5	300	300		300	
	Site 5-1	-	150	(Newly added)	300	(Extended by 150ton)
Nishtar town	Site 6	400	400		400	
	Site 6-1	-	150	(Newly added)	400	(Extended by 250ton)

§

Annex-7. Candidate landfill evaluation: Lahore

n Location

1. Size and capacity of the landfill

Size and capacity of a landfill is a critical factor to decide period of landfill use. Areas for other facilities should be put into consideration, thus about 70% of the candidate site area would be the actual landfill size.

Candidate site	Mark	Area( )	Landfill size( )	Score
Site 1	10	505,857	354,100	10
Site 2		556,443	389,510	10
Site 3		252,929	177,050	9

2. Size of water-collecting area

If the basin area is wide, the rainfall drainage facility should be extended. If it comes into the landfill area, it increases leachate quantity.

Candidate site	Marks	Site area( )	Basin area( )	Basin area rate* (%)	Score**
Site 1	5	505,857	505,857	100	5
Site 2		556,443	556,443	100	5
Site 3		252,929	252,929	100	5

Note: * Basin area rate= basin area( ) ÷ site area( ))
**Lower basin area rate(%) gets higher marks.

3. Transport distance for waste

This section evaluates the economics of landfill operations by estimating the distances between the proposed sites and the locations where wastes are to be collected.

Candidate site	Marks	Amount of waste (ton/day)	Distance to the candidate (km)	Transport distance for waste (km.ton/day)	Score**
Site 1	10	4,447	10	44,470	10
Site 2		4,447	31	137,857	8
Site 3		4,447	22	97,834	9

Note: * Transport distance for waste= Waste amount(Ton/day) x distance to Candidate Landfill(km)
** Higher scores for shorter transport distance from collection location

4. Accessibility to the landfill

The current road to the landfill should be extended or newly made. The accessibility to the landfill by current roads is evaluated.

Candidate site	Marks	Accessibility to the landfill	Score
Site 1	10	good	10
Site 2		good	10
Site 3		bad	8

5. Municipal facilities

It evaluates accessibility of water supply and sewage system, and power supply to the landfill. As the pipeline is short, it gets higher marks.

Candidate site	Marks	Water supply	Sewage system	Power supply facility	Score
Site 1	5	unavailable	unavailable	available	5
Site 2		unavailable	unavailable	available	5
Site 3		unavailable	unavailable	available	5

6. Safety from disasters

If the facility stands on steep slope, impact from disasters increases.

Candidate site	Marks	Gradient	Score
Site 1	5	low	5
Site 2		low	5
Site 3		low	5

7. Ease of landfill construction

If the land slope is steep, it disturbs construction. This item considers the ease of construct the landfill.

Candidate site	Marks	Gradient	Score
Site 1	5	low	5
Site 2		low	5
Site 3		low	5

8. Visibility

This sees if the landfill site screens visibility from roads or villages.

Candidate site	Marks	Distance ( )	Score
Site 1	5	0.5	4
Site 2		1	5
Site 3		1	5

9. Water contamination

During construction, soils and leachate from the construction site could pollute a river. Thus, this item checks the distance from the site to the river.

Candidate site	Marks	Distance( )	Score
Site 1	5	3	4
Site 2		5	4
Site 3		32	5

10. Air pollution

It checks houses, schools or any facilities affected by air pollution from the landfill.

Candidate site	Marks	Distance ( )	Number of facilities	Score
Site 1	5	0.5	3	4
Site 2		1	2,000	5
Site 3		1	30	5

11. Odor

It checks houses, schools or any facilities affected by odor from the landfill.

Candidate site	Marks	Distance ( )	Number of facilities	Score
Site 1	5	0.5	3	4
Site 2		1	2,000	5
Site 3		1	30	5

12. Noise & vibration

The construction process causes noise and vibration which influence the area within 200m.

Candidate site	Marks	Distance ( )	Households	No. of households & facility within the impact area	Score
Site 1	5	0.5	3	n.a	5
Site 2		1	2,000	n.a	5
Site 3		1	30	n.a	5

13. Ecosystem

It evaluates the impact upon nearby ecosystem. The less green area there is, the higher the score is.

Candidate site	Marks	Current ecosystem	Score
Site 1	5	Bare ground	5
Site 2		Grassland and Bare ground	4
Site 3		Farmland and grassland	4

n Society

14. Residential areas and other facilities influenced by the landfill

Candidate site	Marks	Distance( )	Households	Score
Site 1	5	0.5	3	4
Site 2		1	2,000	4
Site 3		1	30	5

15. Historical and cultural heritage

It checks the distribution and historical and cultural heritage or any public facilities influenced by the landfill within 500 m.

Candidate site	Marks	Heritage	Multi-purpose facility	Score
Site 1	5	N/A	N/A	5
Site 2		N/A	N/A	5
Site 3		N/A	N/A	5

n Economy

16. Construction cost

Candidate site	Marks	Construction cost* (Rupi/m3)	Score
Site 1	10	254	10
Site 2	10	245	10
Site 3	10	326	9

Annex-8. Candidate landfill evaluation: Sialkot

n Location

1. Size and capacity of the landfill

Size and capacity of a landfill is a critical factor to decide period of landfill use.

Candidate site	Mark	Landfill size( )	Score
Site 1	10	60,702	10
Site 2		40,468	8

2. Size of water-collecting area

If the basin area is wide, the rainfall drainage facility should be extended. If it comes into landfill area, it increases leachate quantity.

Candidate site	Marks	Site area( )	Basin area( )	Basin area rate* (%)	Score**
Site 1	5	60,702	60,702	100	5
Site 2		40,468	40,468	100	5

Note: * Basin area rate= basin area( ) ÷ site area( ))
**Lower basin area rate(%) gets higher marks.

3. Transport distance for waste

This section evaluates the economics of landfill operation by estimating the distances between the sites and the locations where wastes are to be collected.

Candidate site	Marks	Amount of waste (ton/day)	Distance to the candidate landfill (km)	Transport distance for waste (km.ton/day)	Score**
Site 1	10	530	8.8	4,664	10
Site 2		530	8.9	4,717	10

Note:* Transport distance for waste= Waste amount(Ton/day) x distance to Candidate Landfill(km)
** Higher scores for shorter transport distance from collection location

4. Accessibility to the landfill

Current road to the landfill should be extended or newly made. This item evaluates the accessibility to the landfill by current roads.

Candidate site	Marks	Accessibility to the landfill	Score
Site 1	10	good	10
Site 2		good	10

5. Municipal facilities

It evaluates accessibility of water supply and sewage system, and power supply to the landfill. As the pipeline is short, it gets higher marks.

Candidate site	Marks	Water supply	Sewage system	Power supply facility	Score
Site 1	5	unavailable	unavailable	available	5
Site 2		unavailable	unavailable	available	5

6. Safety from disasters

If the facility stands on a steep slope, impact from the disasters increases.

Candidate site	Marks	Gradient	Score
Site 1	5	low	5
Site 2		low	5

7. Ease of landfill construction

If the land slope is steep, it disturbs construction. This item considers the ease of construct the landfill.

Candidate site	Marks	Gradient	Score
Site 1	5	low	5
Site 2		low	5

n Environment

8. Visibility

This sees if the landfill site screens visibility from roads or villages.

Candidate site	Marks	Distance ( )	Score
Site 1	5	0.5	4
Site 2		1	5

9. Water contamination

During the construction, soils and leachate from the construction site could pollute a river. Thus, this item checks the distance from the site to the river.

Candidate site	Marks	Distance( )	Score
Site 1	5	Very far	5
Site 2		Very far	5

10. Air pollution

It checks houses, schools or any facilities affected by air pollution from the landfill.

Candidate site	Marks	Distance ( )	Number of facilities	Score
Site 1	5	0.5	Many relatively to others	4
Site 2		1	Few relatively to others	5

11. Odor

It checks houses, schools or any facilities affected by odor from the landfill.

Candidate site	Marks	Distance ( )	Number of facilities	Score
Site 1	5	0.5	Many relatively to others	4
Site 2		1	Few relatively to others	5

12. Noise & vibration

Construction causes noise and vibration which influence the area within 200m.

Candidate site	Marks	Distance ( )	Households	No. of households & facility within the impact area	Score
Site 1	5	0.5	Many relatively to others	a	4
Site 2	5	1	Few relatively to others	n.a	5

13. Ecosystem

It evaluates the impact to nearby ecosystem. The less green area there is, the higher the score is.

Candidate site	Marks	Current ecosystem	Score
Site 1	5	Bare ground	5
Site 2		Bare ground	5

n Society

14. Residential areas and other facilities influenced by the landfill

Candidate site	Marks	Distance( )	Households	Score
Site 1	5	0.5	Many relatively to others	4
Site 2		1	Few relatively to others	5

15. Historical and cultural heritage

It checks the distribution and historical and cultural heritage or any public facilities influenced by the landfill within 500 m.

Candidate site	Marks	Heritage	Multi-purpose facility	Score
Site 1	5	n.a	n.a	5
Site 2		n.a	n.a	5

n Economy

16. Construction cost

Candidate site	Marks	Construction cost* (Rupi/m3)	Score
Site 1	10	387	10
Site 2	10	428	10

Annex-9. Consulting Service Cost for the "Solid Waste Treatment Facility Construction Project"

1. Consulting service cost for the "Solid Waste Treatment Facility Construction Project" in Lahore, Pakistan

(Exchange Rate : USD 1 = Rupi 59.43)

Description		Amount (US $)	Remark
Basic & Detail Design Cost		3,003,000	
Supervision Cost		3,554,000	
Direct expense for design	1) Abroad Business Trip Cost	51,700	
	2) Topographical Survey	394,569	
	3) Soil Investigation	272,000	
	4) Waste Component Investigation	12,000	
	5) Research & Analysis environment quality	42,300	
	6) Interpreter & Translator	31,850	
	7) Report Press	32,550	
	8) Bird eye View	24,000	
	9) Workshop (Local)	28,200	
	Sub Total	889,169	
Net Proposal Sum		7,446,169	
Devaluation		-169	
Total		7,446,000 (442,545,000Rupi)	

2. Breakdown of lump sum price

Item	Description	Quantity	Unit	Unit Rate (US $)	Amount (US $)
1. Basic & Detail Cost	4.9% of Construction cost				3,003,000
- Construction Cost					61,267,000
2. Supervision Cost	5.8% of Construction cost				3,554,000
- Construction Cost					61,267,000
3. Direct expense for design					889,169
1) Abroad Business Trip Cost					51,700
- Airplane cost	Project Manager(1 person) : 3 times Basis Design Engineer(4 person) : 2 times Basis	11	time	1,700	18,700
- Staying cost	1 week Basis (field stay cost, cars rental cost, field activity cost, etc)	11	time	3,000	33,000
2) Topographical Survey					394,569
- Topographical Survey	New Sanitary Landfill - Katorbund Road:505,857 - Sunder : 556,443 - Kana : 252,929	1,315,230		0.3	394,569

Item	Description	Quantity	Unit	Unit Rate (US $)	Amount (US $)
3) Soil Investigation					272,000
- Boring Test	40,000 per 1 spot - Katorbund Road : 13 spot - Sunder : 14 spot - Kana : 7 spot	34	Lot	4,000	136,000
- Field & Lab Experiment	40,000 per 1 spot - Katorbund Road : 13 spot - Sunder : 14 spot - Kana : 7 spot	34	Lot	4,000	136,000
4) Waste Component Survey					12,000
- Waste Component Survey		12	Lots	1,000	12,000
5) Research & Analysis Environment quality					42,300
- quality of air	Classified New Sanitary Landfill each 3 point executions	9	Lots	400	3,600
- quality of water		9	Lots	900	8,100
- quality of groundwater		9	Lots	800	7,200
- soil		9	Lots	800	7,200
- noise		9	Lots	400	3,600
- vibration		9	Lots	300	2,700
- odor		9	Lots	1,100	9,900
6) Interpreter & Translator					31,850
- Interpreter & Translator	field survey 5 times, 1 time per 7days(1day 7hr)	245	hr	130	31,850
7) Report Press					32,550
- Consulting Report		500	Page	25	12,500
- Soil Investigation Report		200	Page	25	5,000
- Translation Cost		700	Page	20	14,000
- Carrying charge		3	Lots	350	1,050
8) Bird eye View		3	Lots	8,000	24,000
9) Workshop (Local)	The 2 person standard total 3 times enforcement which include the reporter 1st person				28,200
- Airplane cost		6	time	1,700	10,200
- Staying cost		6	time	3,000	18,000

3. Consulting service cost for the "Solid Waste Treatment Facility Construction Project" in Sialkot, Pakistan

(Exchange Rate : USD 1 = Rupi 59.43)

Description		Amount (US $)	Remark
Basic & Detail Design Cost		491,100	
Supervision Cost		558,000	
Direct expense for design	1) Abroad Business Trip Cost	51,700	
	2) Topographical Survey	30,351	
	3) Soil Investigation	48,000	
	4) Waste component investigation	10,000	
	5) Research & Analysis environment quality	28,200	
	6) Interpreter & translator	31,850	
	7) Report Press	32,550	
	8) Bird eye view	16,000	
	9) Workshop (Local)	28,200	
	Sub Total	276,851	
Net Proposal Sum		1,325,951	
Devaluation		-951	
Total		1,325,000 (78,750,000Rupi)	

4. Breakdown of lump sum price

Item	Description	Quantity	Unit	Unit Rate (US $)	Amount (US $)
1. Basic & Detail Cost	5.1% of Construction cost				491,100
- Construction Cost					9,629,000
2. Supervision Cost	5.8% of Construction cost				558,000
- Construction Cost					9,629,000
3. Direct expense for design					276,851
1) Abroad business trip cost					51,700
- Airplane cost	§Project Manager(1 person) : 3 times Basis §Design Engineer(4 person) : 2 times Basis	11	time	1,700	18,700
- Staying cost	§1 week Basis (field stay cost, cars rental cost, field activity cost, etc)	11	time	3,000	33,000
2) Topographical Survey	§				30,351
- Topographical Survey	§Daska Road : 60,702 §Eminabad Road Site : § 40,468	101,170		0.3	30,351
3) Soil Investigation					48,000
- Boring Test	§40,000 per 1 spot - Daska Road : 3 spot - Eminabad Road Site : 3 spot	6	Lot	4,000	24,000
- Field & Lab Experiment	§40,000 per 1 spot - Daska Road : 3 spot - Eminabad Road Site : 3 spot	6	Lot	4,000	24,000
4) Waste Component Survey					10,000
- Waste Component Survey		10	Lots	1,000	10,000
5) Research & analysis environment quality					28,200
- quality of air	Classified New Sanitary Landfill each 3 point executions	6	Lots	400	2,400
- quality of water		6	Lots	900	5,400
- quality of groundwater		6	Lots	800	4,800
- soil		6	Lots	800	4,800
- noise		6	Lots	400	2,400
- vibration		6	Lots	300	1,800
- odor		6	Lots	1,100	6,600
6) Interpreter & Translator					31,850
- Interpreter & Translator	field survey 5 times, 1 time per 7days(1day 7hr)	245	hr	130	31,850
7) Report Press					32,550
- Consulting Report		500	Page	25	12,500
- Soil Investigation Report		200	Page	25	5,000
- Translation Cost		700	Page	20	14,000
- Carrying charge		3	Lots	350	1,050
8) Bird eye View		2	Lots	8,000	16,000

Item	Description	Quantity	Unit	Unit Rate (US $)	Amount (US $)
9) Workshop (Local)	The 2 person standard total 3 times enforcement which include the reporter 1st person				28,200
- Airplane cost		6	time	1,700	10,200
- Staying cost		6	time	3,000	18,000

Annex-10. Solid Waste Training Workshops

1. The Training Workshop in Pakistan

Forty SWM staffs from Punjab took a take a training workshop in Lahore for 4 days from Jan. 15, 2007 to Jan. 18, 2007. The workshop was to address institutional deficiency or urban service delivery at the local level. The workshop was to focus on general and theoretical concepts and knowledge transfer about SWM with lecturers from Korean experts and presentation/participation of SWM officers in Punjab. Participants were very interested in recycling, user charge, especially regarding vinyl shopping bags to reduce disposal of plastic.

Date	Theme	Lecturer
Jan.15	Understanding of solid waste management	Jang Min CHU, KEI
	Generation and properties of municipal solid waste	Byung Tae KIM, Daejin Univ.
	Public education and participation for solid waste management	Hong-Shup CHO, The Hankyoreh Daily Newspaper
Jan.16	Solid waste transformation technology	Byung Tae KIM, Daejin Univ.
	Public education and participation for solid waste management	Hong-Shup CHO, The Hankyoreh Daily Newspaper
	Participation Session	-
Jan.17	Waste treatment technology: landfill	Kyung-Ho LEE, SLC
	Economic Approach to solid waste management	Chang Hoon LEE, KEI
	A review on the development of SWM policy in Korea	Hoi-Seong JEONG, KEI
Jan.18	Waste management status and improvement schemes in Punjab	Jae Kyu CHOI, SLC
	Participation Session	-
	Participation Session	-

2. The Training Workshop in Korea

The SWM staffs (about 35 people) from Punjab were invited to participate in a training workshop in Korea. The workshop was focused on transferring knowledge and technology on SWM developed during recent decades in Korea. The training workshop involved lectures and field studies, including visits to SWM facilities, collection and other relevant sites constructed and operated by SLC. The schedule of the program was as follows:

Date	Theme	Lecturer
Apr. 9	Lecture 1: Technology and policies of Industrial & Hospital Waste Management	Seungdo KIM, Hanlim Univ.
	Lecture 2: PR on the SWM Policies Focusing on the Introduction of Volume-based Waste Fee System	Myongsoo Yoo, Ministry of Environment)
Apr.10	Lecture 3: Economics of Waste Collection Fee & Waste Management Budget	Junwoo Park, Sangmyung Univ.
	Lecture 4: Privatization of Waste Collection & Treatment Services	Hyunjoo Moon, KEI
	Field trip: Waste Gathering and Collecting Site at an Apartment in KyungSeo-dong, Incheon	Collection System
	Field trip: Gangseo Sewage Treatment Plant	Sewage Treatment
Apr.11	Lecture 5: Environmental Impact Assessment Methods of Waste Management Projects	Seunghoon Lee, KEI
	Lecture 6: Solid Waste and Recycle Policy in Korea	Sanghun LEE, ENVICO(Korea Environment & Resources Corporation)
	Field trip: Wasted Plastic Treatment Plant in Hwasung (Jeongwoo Recycle)	Recycling Plant
	Field trip: Environmental Management Office in Ansan	Industrial & Domestic Sewage
Apr.11	Lecture 7: Solid Waste Management in Seoul Metropolitan City (Local Government)	Ki Young YOO, Seoul Development Institute
	Lecture 8: Technical Method of Waste Landfill Site Selection	Byung Tae KIM, Daejin Univ.
	Field trip: Sudokwon Landfill Site Operation Practice	Landfill
Apr.12	Field trip: Mapo Resource Recovery Facility (Incineration, Recycling Exhibition)	Recycling of Waste
	Field trip: the Restored Landfill sites: Noel Park & Haneul Park	Transition of Nanji

Annex-11. Participant List of the Training Workshop in Pakistan (Jan. 15-18, 2007)

No.	Name	Age	Designation	Qualification	Experience in SWM	District / Organization
1	Dr. Rai Qamar-uz-zaman	44	Dy. District Officer (SWM)	MBBS	13	CDG Fasialbad
2	Dr. Aslam Pervaiz	50	Dy. District Officer (SWM)	B.A	21	CDG Fasialbad
3	Muhammad Arif	39	Sanitary Inspector	B.A	16	CDG Fasialbad
4	Zakaullah	35	Sanitary Inspector	B.A	13	CDG Fasialbad
5	Muhammad Abid Hussain	36	Sanitary Inspector	B.A	10	CDG Fasialbad
6	Tahir Hehmood	26	Sanitary Inspector	B.A	8	CDG Fasialbad
7	Muhammad Sajjad	38	Sanitary Inspector	B.A	16	CDG Multan
8	Waris Ali	36	Sanitary Inspector	B.A	14	CDG Multan
9	Mukhtar Ahmed	40	Sanitary Inspector	Intermediate	16	CDG Multan
10	Shahid Bashir	38	Sanitary Inspector	B.A	16	CDG Multan
11	Faheem Ahmed Khan	39	Motor Transport Officer	B.A	12	CDG Multan
12	Dr. Mazhar Azim Ch.		District Officer (SWM)	MBBS	12	CDG Rawalpindi
13	Kamran Khan		Tehsil Officer ®	Master Econm		CDG Rawalpindi
14	Sarfraz Khan Shahis		C.O Muree			CDG Rawalpindi
15	Tuaqeer Naseer Khan		Sanitary Inspector	B.A		CDG Rawalpindi
16	Abdul Hakim Anjum	43	Tehsil Officer (finance)	MBA		TMA Bhawalpur
17	Naeem Hassan	43	Chief Officer	D.Com	16	TMA Bhawalpur
18	Saeed Ahmed	42	Tehsil Officer (regulation)	B.A	16	TMA Bhawalpur
19	Muhammad Sonhara	33	Sanitary Inspector	Under BA	2	TMA DG Khan
20	Riaz Ahmed	44	Inspector Regulation	LLB	21	TMA DG Khan
21	Muhammad Asif Sheikh	40	Administration Officer	BA. LLB	28	TMA Sargodha
22	Malik Khurram Lftikhar	25	Tehsil Officer (regulation)	BA. LLB	1	TMA Sargodha
23	Muhammad Ajmal		PS to Tehsil Nazim	MA (LLB)	10	TMA Sargodha
24	Abid Hussain		Su	B.A	11	TMA Sargodha
25	Shafqat Javaid Cheema	43		B.A	18	TMA Sialkot

No.	Name	Age	Designation	Qualification	Experience in SWM	District / Organization
26	Rafaqat Ali Bhalli	43		M.A	23	TMA Pasrur
27	Syed Muhammd Azhar Ali	34	Sanitary Inspector	B.A	11	Cantt. Board, Gujranwala
28	Raja Muhammad Nadir Ali	49	Cantt. Executive Officer	BA. LLB	22	Cantonment Board Lahore
29	Sheikh Shahid Bashir	51	Cantt. Executive Officer		22	Cantt. Board Rawalpindi
30	Rana Manzoor Ahmed		Cantt. Executive Officer			Cantt. Board Sargodha
31	Faheem Zafar		Cantt. Executive Officer			Cantt. Board Multan

Annex-12. SWM Focus Group Discussion

(June 26, 2007)

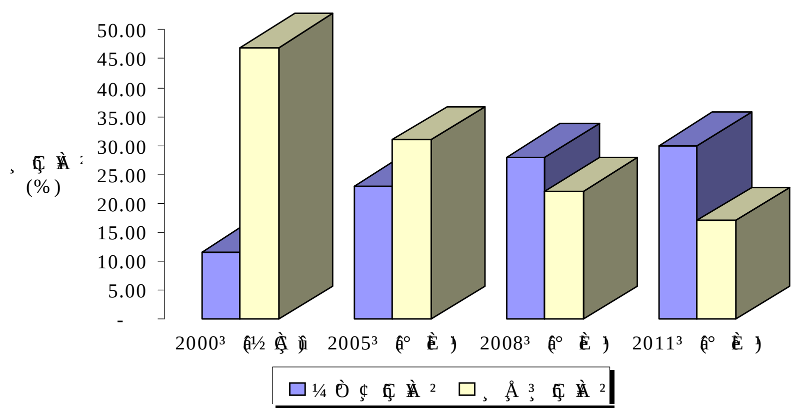
The Urban Unit, Planning & Development Department, GOP organized a focus group discussion to speak and discuss the final reforms and proposals for the solid waste management by the two consultants i.e., Korea Environment Institute (KEI) and Ernst Basler & Partners. The workshop was arranged by the Urban Unit at Management Professional Development Department (MPDD), Lahore on June 26, 2007.

Participants were key sanitation staff from various cities, experts from the private sector, World Bank specialists, NGOs, academia and donors. The objective of this workshop was to discuss the proposed reforms in solid waste management with the stakeholders and to incorporate their relevant suggestions and recommendations.

No.	Name	Designation	District / Organization
1	Dr. Aslam	Deputy District Officer, Solid Waste Management	Faisalabad.
2	Ch. Saeed Ahmad	District Officer, Solid Waste Management,	Gujranwala.
3	A. Shakoor Bhutta	District Officer, Solid Waste Management,	Multan.
4	Mr. Rafiq Jatoi	District Officer (Planning), Solid Waste Management,	Lahore.
5	Dr. Mazhar	District Officer, Solid Waste Management,	Rawalapindi.
6	Mr. Bashir Bhatti	Tehsil Officer (I&S)	Chiniot.
7	Mr. Qammar Abbas	Tehsil Officer (I&S)	Mailsi.
8	Mr. Mirza Yaqoob	Tehsil Officer (I&S)	Daska
9	htaq Niazi	Assistant District Officer (Aziz Bhatti Town)	Lahore

Annex-13. Waste Disposal Method in Korea & Major Advanced Countries

Korea treated waste and depended on unhygienic reclamation treatment such as dumping on a hilly country or idle land as what Lahore did in 1970 to -early 1980s., The effects of this practice, such as water, air, and soil pollution, have risen tremendously. The waste Management law of 1986 enforces the technologies of hygienic reclamation, incineration, composting, middle treatment and recycling. In the early implementation of this law, waste management policy has been focused on landfill. However, due to difficulties brought out by limited space and location suitability, it diverted its focus on reducing waste material weight thereby raising up the issue of burning up.



The waste management policy, having been based on landfill disposal and incineration has reached the limit of these practices. With increasing heat generation and exhaustion of available spaces for landfills, added with the pollution brought out by burning of combustible materials. Land fill treatment, the final step of waste disposal also converts materials into leachate and landfill gases. Recently, generation of heat brought by burning of combustible waste has increased rapidly and waste gas has been produced at a rate beyond the control of management capabilities. This has been the main reason of lifting the expenses of operation management.

After that, the volume-rate waste disposal system, EPR (Extended Producer Responsibility) provision, which sprohibition direct dumping of food wastes on landfill has been enacted. The new practice includes avoiding disposal supon landfill, using wastes sa precious energy resource, and maximizing the use of technologies to further reduce the need for disposal. ,MBT (Mechanical Biological Treatment), a type of resource circulation treatment technology, uses thermal-depolymerization process technology upgrade existing material degradation and recycling methods. It also includes waste heat recovery. Other diversified technologies were also introduced such as the use of Bio Reactor, waste disposal landfill technology. Advanced countries changed their target policy focus from mass dumping and burning to reduction of garbage generation, reuse, recycling, and using the materials for energy generation.

Fig. Annex- 1 The movement of waste treatment technology of Korea

Waste generation	ð	unhygienic landfill the open air and a small sized destruction by fire.	ð	a former treatment and middle treatment (destruction by fire, composting, feeding) the final treatment (hygienic landfill) landfill	ð	MBT Thermal-depolymerization process applied technology treatment of waste heat recovery Bio-Reactor landfill

England
Presently, England dumps 75% of its wastes into landfill, the highest so far, only a small portion of wastes are being disposed off by burning and composting. is the country is gradually reducing landfill and burning by introducing recycling, RDF and composting. Unprocessed BWM and flammable waste materials are prohibited from land fill. BWM undergoes anaerobic and aerobic treatment and converted into as compost, which is used as soil conditioner, molding soil. Other material goes through MBT for energy generation. Recycling should be done after MRF treatment. Landfill tax is at present, 3P per ton, but is going to be raised to 35 P per ton by 2011.

Japan
Japan, being a country that is low on usage practicality, needs to reduce its volume of waste generation. In a location where temperature and humidity is high, waste materials decay rapidly, thus, immediate treatment is necessary. Burning and fragmentation covers 95.8% of wastes processing and the rest is treated in landfills. According to 2002 standards, 78.4% burning ratio is already the highest in the world. There are 1,490 burning facilities and the handling capacity is 198,874ton/day. Disposal treatments and intermittent burning is decreasing while generation of flammable waste is increasing. Burning is guaranteed as a solution to decreasing landfill space in addition to waste reduction. Thermal-depolymerization on commercial scale are being developed using RDF.

America
America is depending highlty on landfill and focusing on treatment of landfill gases. Leachate is recirculated into landfills to generate landfill gases as well as revitalize non-degradable materials. BLM (Bioreactor Landfill Method) stabilizes landfills early. In 2002, the total amount of wastes recycled and composted reaches 30%, 55% is disposed in landfills and 4% disposed by burning.

Italy

In 1995, 85% of Italy's wastes were dumped into landfills unprocessed. Dumping in landfills has been decreased gradually and is now separately collected since 2002. Further treatment is also being applied such as MBT treatment or by incinerating. For disposal of saprophytic wastes, the capacity of composting is extended from 28,000,000 at present to 50,000,000, and incinerator capacity is also increased.

France

France has allowed the final waste to be dumped into landfills per law enacted on June 1, 2002. This allows recyclable or recollectable material are 100% reused. After collecting green waste, it produces biogas and low-level polluted compost. This can be used for agricultural purposes but the amount is very limited. Burning is very highly practiced. At present, incinerators are being operated with total capacity expected to be increased by about 1-2% in 2006.

Netherlands

Netherlands dump only 10% of its wastes containing organic matters into landfills, the rest are dipsosed of by burning. Waste segregation should allow biodegradable materials to be composted.

Spain

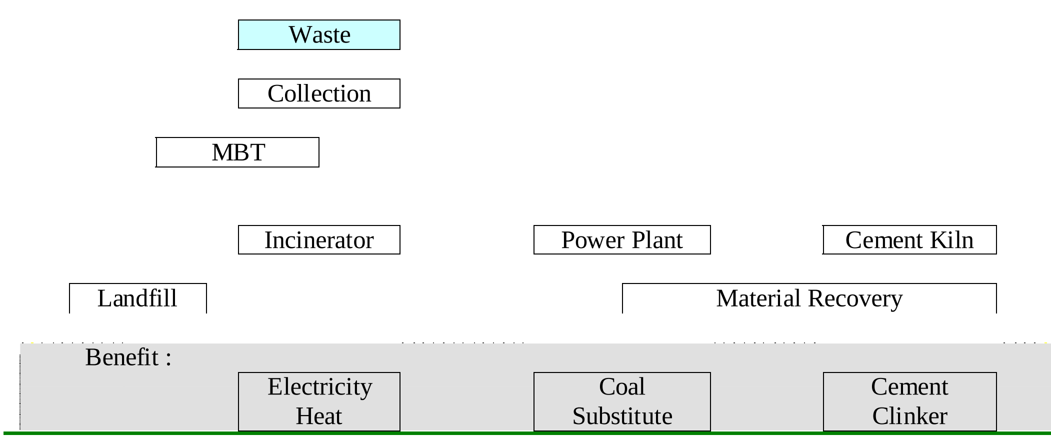
Since waste of Spain has high percentage of organic matter, the potential of reducing landfill requirement is very high, 20% in every year. By installing MBT, the country produced biologically treated compost and is able to reduce landfill area.

Germany

In the early, Germany has been dependent on landfill. After enacting the waste law in 1972, landfill has been reduced and incinerators and other waste establishments have been increased rapidly. In the middle of 1980, waste materials has been used as resource recollection and second fuel through separate collection and segregation. Presently, waste generation has been restrained and policies have been enacted to recover energy from wastes. Landfill is going to be removed gradually by 2020 and recycling facilities and heat treatment related to MBT will be established to destroy harmful materials. A stable disposal plan was also suggested.

- From 2005, organic wastes discharged from home and commercial areas have to be treated by heat (MBT), or by biological processing (composting) for landfill.
- Plastics, Paper, and Wood collected from MBT must be separated from other organic wastes (RMSW) and should be kept in allowable amounts to be used as fuel for development plants.
- Sewage of city is used as compost or soil conditioner. Other materials should be burned before disposing into landfills.

Flow of waste disposal in Germany.



Annex-14. Waste Treatment Technology for Lahore: Landfill

The review contained herein are sanitary landfills, recycling and treatment of food waste, burning, recycling technology, advanced disposal transport by pipeline, MBT system, recycling waste, both solid and gas, resource circulation systems, and the general quality of bio energy technology. This will serve as a guide line for creating an appropriate plan to be made available to Lahore.

Sanitary landfill is the most general and universal technology for the final waste disposal together with burning. The cost is low and the construction is simple. Ninety percent (90%) of wastes in the world is dumped into landfills to prevent environment pollution brought out by industrial development and increase in waste generation. Due to challenges regarding the availability of space for landfill, other methods and equipments of disposal are being developed. Landfill technology is so far the most developed. The development of landfill technology has gone through the following stages.

Fig. Annex- 2 The development steps of waste landfill technology

Stage 1	Stage 2	Stage 3	Stage 4
[simple abandonment]	[managed abandonment]	[sanitary landfill]	[resource circulation landfill]
wastes are simply dumped into rivers and valleys; this disposal is conducted only by residents	restricted landfills to a particular area; gradually developed as a mass size; brought in the understanding of control but without special landfill technology.	Intended for environmental preservation; proper handling of leachate and waste gas; perfect covering; strengthen environmental awareness; proper landfill management, tightened control on wastes	strengthen the role as a high function landfill locals recover resources). avoid instant dumping into landfill. diversed landfill technology (extend life cycle, promote early stability of waste materialsall)application.

Sanitary landfill is the most used method to dispose waste effectively and stably. It is pro-environment. When building up the plan for establishing or selecting a location, it is advised to consider the following characteristics.

Table. Annex- 8 The strength & weakness of sanitary landfill

Strength	Weakness
§ cheaper compared to other waste technology. § mass disposal of waste is possible at one time. § At the end of landfill life, the place can be available as a park, car park, or as an idle land. § generated gases can be collected and recycled § is not easily affected by changes in the amount of wastes to be disposed	§ considerable land area is needed and maybe difficult to source out especially in places where prices are high § landfills produce arsenic acid; are habitats to insects and rodents; landfill gas, bad smell, and leachate threatens to pollute the areas around. § at the end landfill life, ground subsidence cause difficulty in reusing the land.

A waste sanitary landfill must have available undercurrent of waste that is safe for the living and natural environment. A santitary landfill must prevent its leachate, arsenic acid, bad smell, and inhabiting insects from degrading the surrounding area. The technology of waste must have diverse functions to adhere to social trend. In the past, a landfill is just a pile of "abandoned stuff" or simply "disposal place". Nowadays, a waste landfill must have the following functions and characteristics:

- § Must have the capacity to absorb the disposal requirement of service area and must have both "preservation" and "disposal" functions;
- § Must not allow harmful materials to be dumped into it;
- § Must preserve the environment;
- § Reach the function as "region returning" to the people of around the landfill area.
- § It must have the potential to be a resource stock for the coming generations.

1. Classification of Waste Landfill

Waste landfills are classified by the presence of covers that reduce pollution around the area, disposal method, structure, construction, and formation.

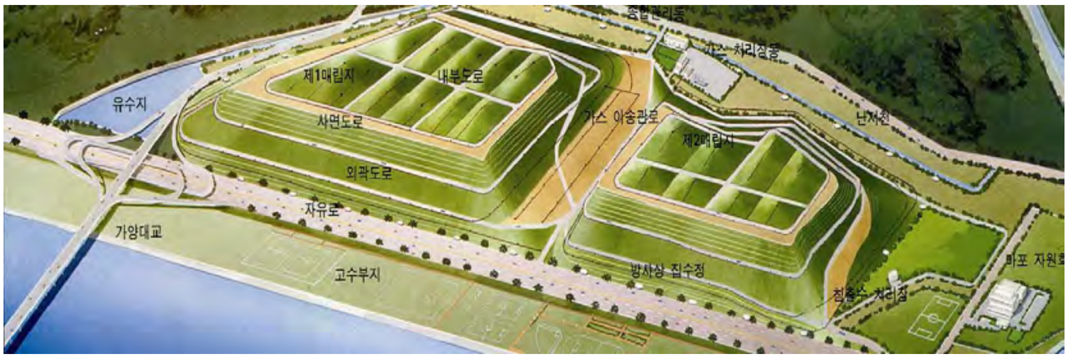
1.1 Classification by Presence of Cover

Based on the presence of cover, a landfill can be classified into open dumping and hygienic landfill.

Open Dumping

This is the kind of landfill being operated in Lahore. Without certain covering, waste is simply dumped into a low swampy place or a puddle. There was a landfill in Nanjido, Korea that was opened in 1978 and was closed 1992. The Nanjido landfill (Fig -27) was operated with covering on the Han river side. The final landfill height reached 90m.

Fig. Annex- 3 Landfill of Nanjido in Korea



Sanitary Landfill

To prevent pollution of the surrounding ground, the sanitary landfill is designed with covering. It prevents fire due to production of methane gas, habitation of flies, rats, insects, and bad smell. It also prevents leachate pollution by hardening the waste placed in the landfill. A landfill pile is then covered after reaching a certain height.

As the representative sanitary landfill of Korea, Nanjido, was closed, the metropolitan landfill was opened in the same year and is still being operated up to now.

Table. Annex- 9 Landfill location of Seoul Metro Politan area

Location		58 Baeksuk-Dong Seo-Ku, Incheon City, Republic of Korea			Longitude·Latitude	
					North Latitude	East Longitude
					37 33 ~37 37	126 36 ~ 126 40
Area ( )	Total	Site 1	Site 2	Site 3	Site 4	Others
	19.9million	4.1 million	3.7 million	3.3 million	3.9 million	4.9 million
Period of Landfill		1992.2 ~ 2000.10	2000.10 ~ 2010.9	After 2010		-
Capacity(ton)		64 million	67 million (in progress)	-		-

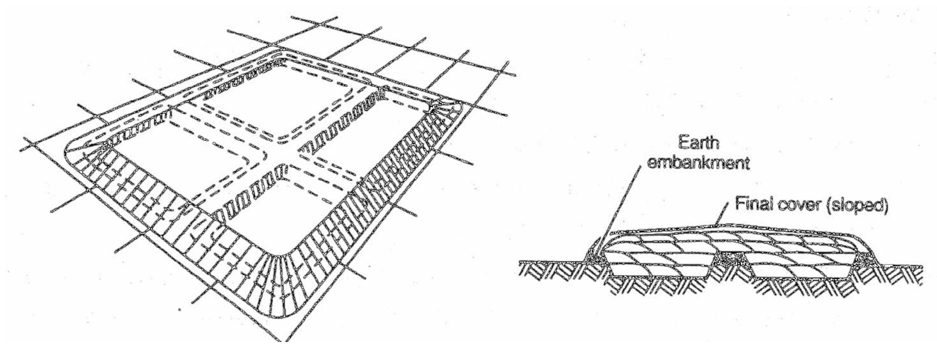
1.2 Classification by landfill method

The method to be employed in a landfill should be chosen appropriately based on the quality of land. Based on the condition of land where the landfill is located, landfills can be further classified into excavated cell/trench method, area Method, or canyon/depression method,.

Excavated Cell/Trench Method

Excavated Cell/Trench Method applies to inclined areas, where it is operated from the lower to the upper part of inclined sides. First, the trench is dug out where waste is later dumped and hardened. The hardened materials are then covered with soil from the next upper ditch. The widely used length of trench ranges from 60 to 300 meters. The depth is from 1 to 3m, width is 5 to 15m, and the gradient of excavation is 1:2-3.

Fig. Annex- 4 Structure of excavated cell/trench method

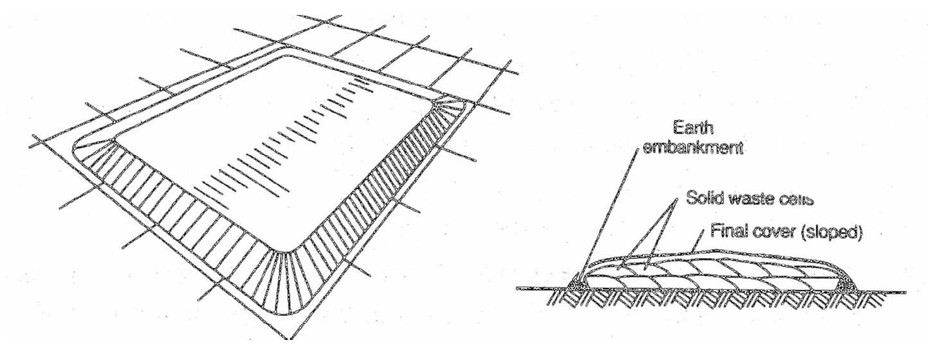


Area Method

Area Method does not require excavation. It could be established on a flat, even or gently inclined areas. It is applicable to places where ground water level is very high. Wastes are dumped on the surface and then covered after being hardened.

In case where the surrounding ground is low, the soil to be used for covering must be brought in from other areas because the landfill will gradually gain height over its surrounding grounds.

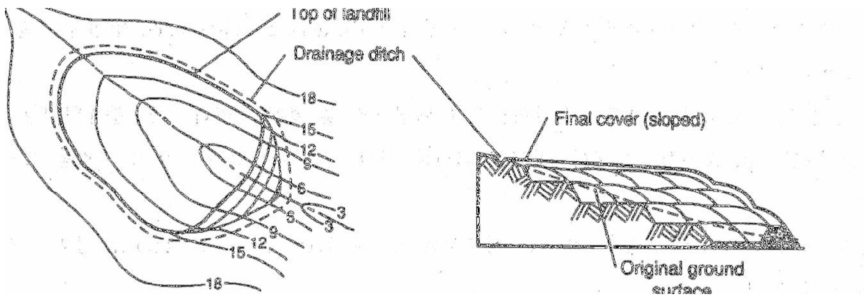
Fig. Annex- 5 Structure of area method



Canyon/Depression Method

As the name implies, the canyon/depression method applies to areas which are depressed geographically. The type of hardening depends upon the quality of the land, soil for covering, and proximity of covering materials.

Fig. Annex- 6 Concept for canyon / depression method



1.3 Classification by landfill structure

According to structure, hygienic and stable landfill is classified into five: anaerobe hygienic landfill, improved anaerobe model landfill, semi-aerobic hygienic landfill, improved semi-aerobic hygienic landfill, and aerobic hygienic landfill. The selection criteria are as follows:

§ Geography and quality of land, bad odor during the operation, insect infestation, and prevention of waste scattering. Wastes must be stabilized early to prevent leaking of leachate that could contaminate both ground and surface water. The possibility of a landfill gas explosion should be taken into consideration.

Anaerobe hygienic landfil:

This is the early type of landfill. This a general anaerobe landfill added with molding function.

Improved anaerobe model landfill

Leachate pipes are installed at the bottom of the landfill intended to collect water and prevent leachate from leaking.

Semi-aerobic hygienic landfill

In addition to leachate pipes, ventilation pipes are inserted down to the bottom of the landfill to provide air. This type is good for landfills on level land.

Improved semi- aerobic hygienic landfill

This includes all the leachate and ventilation pipes plus those installed on the sides of the landfill. This type quickly prohibits leachate and water settling at the bottom. The extended degree of being aerobic reduces bad smell. The structural designs also promotes pile stability making it suitable for both mountain and valley areas.

Aerobic hygienic landfill

Air induction pipe is installed where air is then forced into the landfill further increasing its aerobic degree.

Fig. Annex- 7 Classification by the structure of landfill

anaerobe hygienic landfill

improved anaerobe model landfill

semi-aerobic hygienic Landfill

(improved semi- aerobic hygienic landfill

aerobic hygienic landfill

1.4 Classification by Landfill Construction

Construction of landfill is classified as Sandwitch, Cel, or Bailing System. It can be chosen based on location, geography, volume rate of disposal, and the size of exposure.

Sandwich

In this type, waste materials are evenly spread, pressed and then covered with molding soil. This composes one layer of the sandwich over which another layer will be added on to. The size of exposure of waste as well as the daily capacity of the landfill is less. This can be applied to the narrow landfill areas, which could among mountains. There is, however, a possibility of bad effect to surrounding environment due to perimeter exposure though it is comparatively economical.

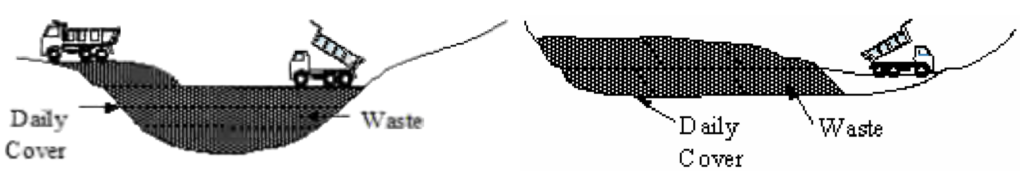
Cell

After completing a day's landfill work, molding is then applied at the point where waste is exposed. It is a method of daily molding on each cell. This is mostly applicable to hygienic landfill establishments. The size of cell is based upon the capacity of the landfill. A layer of waste is completed in every cell. This prevents fire from occurring, minimize points of exposure, scattering of waste, bad smell, and insect infestation.

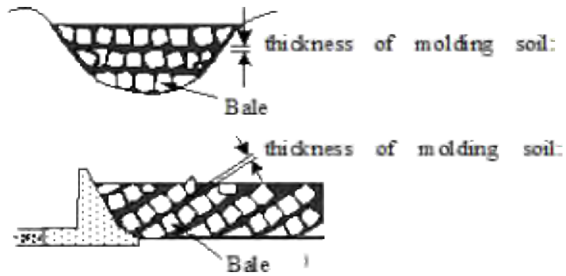
Bailing System

Before the waste is disposed into the landfill, it is first compressed into a certain mass and reduced volume. This way, the waste materials are easy to transport and more stable. It also takes advantage of expensive lands because of reduced material volume. The bales are then piled in layers, with 5-10 cm. of molding in between layers. The final molding layer should have thickness of 1.5 to 2 meters depending on the foreseen use of the land in the times to come.

Fig. Annex- 8 Landfill classification by construction methods



Sandwitch construction **Cell construction**



Compress and landfill construction

1.5 Classification by formation

Formation of landfill establishment is classified as Above Ground Landfill, Below Ground Landfill, or In-Between Landfill. In choosing which formation is most appropriate for a landfill the things that must be considered are the soil quality, stableness and construction.

Above Ground Landfill

Above Ground Landfill is implemented without touching natural foundation, thus, costs less. The location can be found after finishing the construction. However, the landfill capacity is less than that of excavating the ground and can spoil the location scenery during the landfill. When the pipeline of leachate is damaged or loses function, leachate flows off the ground. Also there is possibility of exposure of waste along the perimeter.

Below Ground Landfill

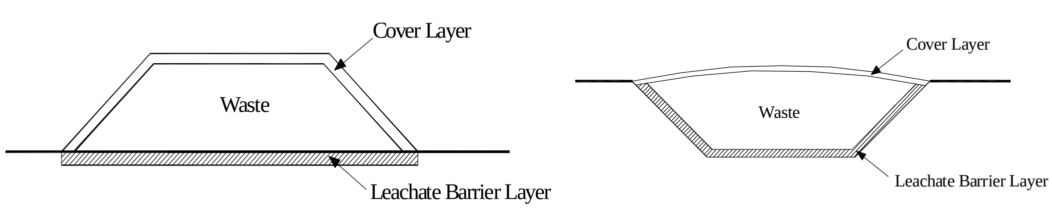
Below Ground Landfill is the opposite of the above ground landfill. The cost of landfill formation and excavation is big but the capacity of landfill is also bigger. The landfill is made below the ground. The height of the landfill is low and therefore, more stable.

However, the collecting basin of leachate is lowered. In case the leachate protection layer is destroyed, the leachate can pollute the soil and underground water. Counter measures for such incident increases the cost.

In-Between Landfill

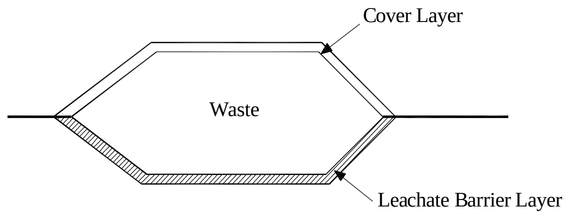
In-Between Landfill is paralleling both below ground landfill and above ground landfill. It must be chosen after consideration of expenses, capacity of landfill, location and geography.

Fig. Annex- 9 Landfill classifications by formation



Above Ground Landfill

Below Ground Landfill



In-Between Landfill

2. Size of landfill site

Choosing the size of landfill should be made after reviewing the details concerning guarantees on the landfill location, and the efficiency of investment on the landfill plant construction, construction cycling, waste accessibility, accuracy of prediction and local circumstance. The landfill is sized based on the quantity of annual waste material to be disposed and on the availability of molding soil up to the end of the landfill's service years. The annual capacity of the landfill is computed as the annual volume of waste materials to be disposed minus the annual subsidence rate of the landfill.

* Capacity of disposal establishment plan( ) =
[annual plan quantity for landfill( ) (1 - subsidence rate of layer of waste + amount of soil for molding( )

Planning the target years of utilization of the landfill location is a significant matter in deciding how much space will be needed for treating waste stably. There must be a consideration on the generation of wastes in the time to come. There might also be changes in disposal circumstance, may it be local, social, or economical. Generally, landfills are planned to last 10-15 years in service. In the case of Lahore, the location is guaranteed for 15 years.

Predicting the quantity of annual landfill treatment (/year) is used to size the plant so that it lasts up to the targeted number of years. Annual landfill treatment quantity is divided into weight of molding soil and waste generated.

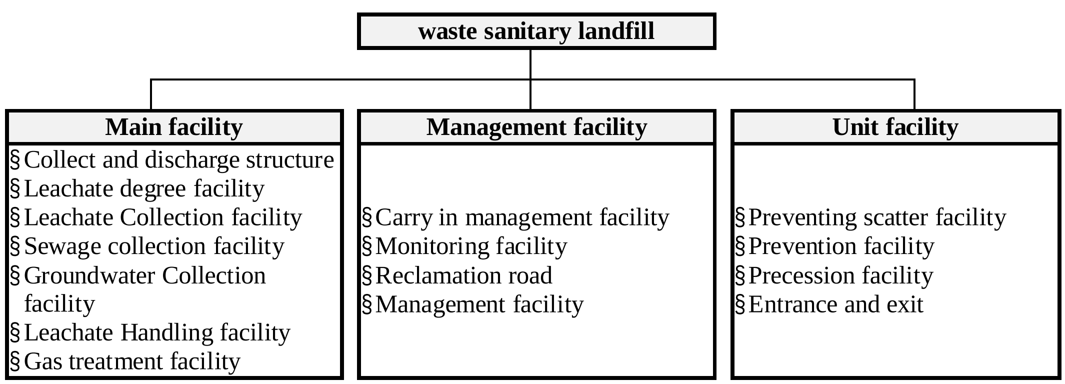
*** The quantity for annual plan landfill treatment (/year) =**
The quantity for annual plan landfill treatment (ton/year) the weight of scrapped

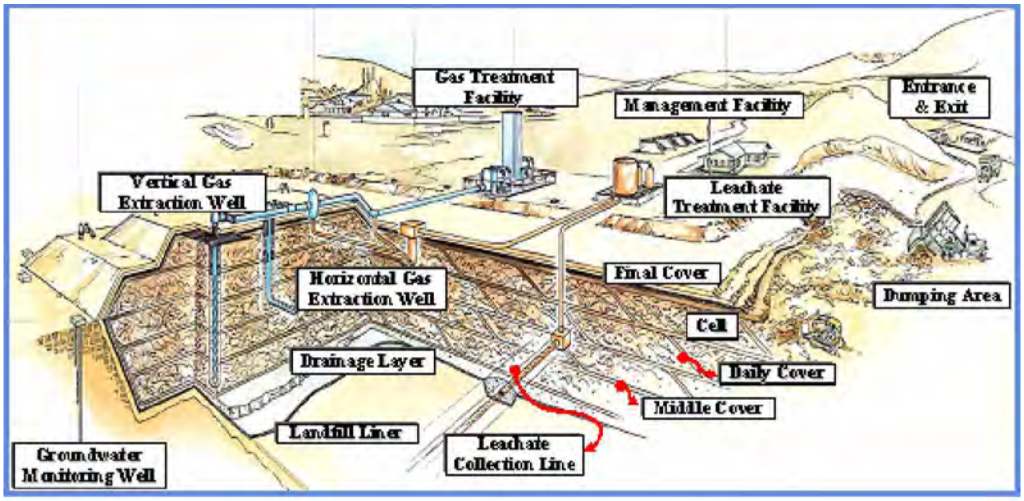
3. Facilities and the standard of waste landfill

The waste landfill must facilitate the safety of the wastes, prevent environmental pollution and at the same time must be planned to preserve the life environment. To do so, there must be collection and discharge functions that prevents the outflow and the breakdown of wastes; balancing functions that prevents circumference ground pollution due to outflow, outflow water distribution function that quickly discharges the outflow generated in the landfill to the outflow discharge facility; sewage removal function to smoothly remove remnants from sewage; outflow discharge function that prevents negative effects on the surrounding environment; removal of ground water moving towards the landfill; ground water collection and delivery function that can quickly discharge the water from the waste reclamation area; soil and gas handling function that can minimize the effects of scattered waste and harmful insects; and reduction of methane gas and offensive odor.

To have a smooth execution, the facilities and functions mentioned above must be installed and operated with all facilities having an independent role that at has an organic complementary relation with other facilities.

Fig. Annex- 10 Waste sanitary landfill construction





The standard feature of the main facility that constructs a waste sanitary landfill can be the guideline in installing optimum sanitary reclamation facility that can be implemented in Lahore.

3.1 Collection and discharge infrastructure

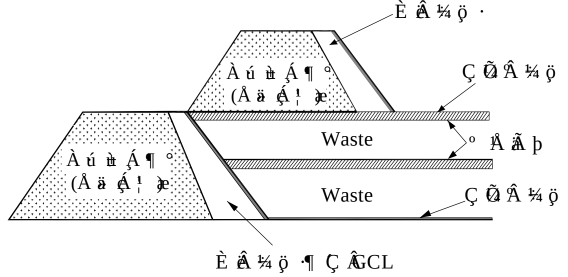
The infrastructure prevents the outflow and collapse of wastes and to handle the wastes safely. It is necessary to install the facilities and to predict temporary collapse of ground. To safely and systematically install the infrastructure, the geographic condition of the landfill and the waste level height that will be reclaimed must be taken into consideration. There must also be an overall display of the following functions:

§ Able to control planned capacity of waste reclamation
§ Prevent waste outflow and collapse.
§ Safely collect and discharge against earthquake and other disaster.
§ Prevent sewage inflow and exposure of land
§ The leachate that can be accumulated from precipitation must be stored safely
§ Must secure systematic safety after reclamation
§ Must not affect circumference landscape or the use of sand

Storage Structure Formation

The storage structure form that is generally used is classified as soil levee. Retention of wall structures, concrete structures and the topography and geological condition along with the environmental, economic, and constructional condition must be taken into consideration for a selection of suitable formation. Among these, the soil level does not have any obstacles and is economical, easy to carry out and is environment friendly. Its weak point is that it has reduced reclamation capacity.

Fig. Annex- 11 Soil levee conception



The retaining wall and concrete structure has a small facility scale that can secure a relatively large reclamation facility volume. It must be solid enough to handle the bearing limit of the ground foundation and must be able to operate the obstacles of reclamation work. However, it has an economic disadvantage.

Fig. Annex- 12 Retaining wall structure

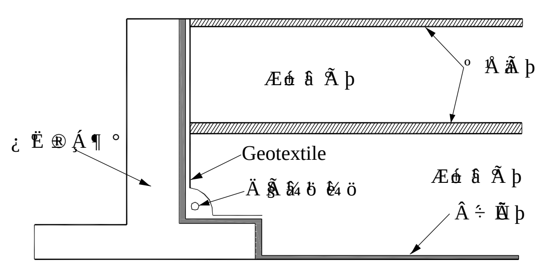
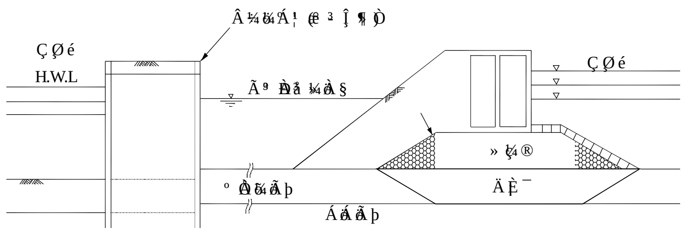


Fig. Annex- 13 Concrete structure



Normally the Korean waste reclamation landfill has the disadvantage of reduced reclamation capacity but does not have any obstacles when it comes to the reclamation works. It is also economical, easy to construct, friendly to the environment and adheres to the soil levee method

Guidelines in constructing the storage structure according to facility standard

Currently there is no clear regulation in constructing a waste landfill storage structure in Lahore and they only refer to Korea's general waste landfill standards (Waste management method). Lahore must establish its standards according to prevailing conditions.

- § The retaining wall and levee must be safely installed considering the reclaimed waste load, reclaimed section and leachate. In this case the retaining wall's activity must have a safety ratio of above 1.5, a complete map safety ratio of above 2.0, bearing power safety ratio of above 3.0 and the levee's surface activity safety ratio of above 1.3.
- § The reclamation facility retaining wall and levee must not be exposed to leachate and maintain structural safety.

3.2 Leachate Facility

The leachate facility is the most important facility in an established landfill. This prevents exposure of leachate, which is hazardous to the environment. Leachate is generated from retained wastes, decomposition and the inflow of groundwater at reclamation level. Thus, one of the objectives of waste landfill is to prevent contaminants from leaking into public areas. Leachate Facility Function is as followings:

- § The leachate facility must be able to the following functions:
- § Must be able to fixate pollutants that the reclaimed waste level possess
- § Must be able to prevent possible leaking of leachate and confine the outflow within landfill areas in case of precipitation

§ Must be able to block contact between the groundwater and leachate from the landfill

§ Must be able to suppress the spread of pollutants into the lower grounds, where landfill maintenance facilities are located.

Leachate Facility Construction

Leachate liner and used ingredients are generally separated as exterior liner system and vertical liner system. This is the suitable method selected after considering the topography and quality conditions, economic, environmental and construction.

When the exterior liner system's ground permeability is large, there will also be a need for a large amount of soil grounds that will be used to cover the landfill. The material is clay substitute liner material and geomembrane. This method has minimum manufacturing requirements and already been applied to sanitary landfill. Most sanitary landfills employ the liner sheet method of construction.

Normally, the liner materials used in the exterior liner system includes clay liner, liner sheet, mixed liner, spray liner, soil stability (lithification) liner, and chemical absorbent liner. The material selection must be according to the actual condition considering economic and construction status.

Clay Liner : Natural clay liner, compaction clay liner

liner sheet :

- Geomembrane : Thermoplastics(PVC), Crystalline Thermoplastics(HDPE, MDPE, LDPE), Thermoplastics Elastomers(CPE, CSPE), Elastomers(EPDM, IIR)
- GCL(Geosynthetic Clay Liner) :
  Synthetic fiber and Bentomat combination - Bentomat, Claymax, Geobent
  Geomembrane and Bentomat combination - Paraseal, Gundseal

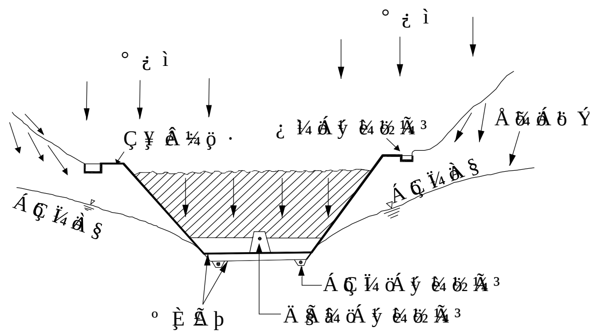
Admired Liner : Mud-Bentomat, Flyash combination, Mud Cement, Asphalt Concrete, Mud-Sand Asphalt, Concrete

Spray-on Liner : Asphalt and shortcrete

Soil Stabilized Liner : Bee Star, EMC(Earth Materials Catalyst)

Chemical Absorptive Liner : Active carbon and disposed tire

Fig. Annex- 14 Exterior liner system



As for the vertical liner system, when solid ground foundation or the permeable layer of the soil is widely distributed, a vertical or an inclined liner must be installed to enhance prevention of leachate or groundwater penetration.

+. Installing a liner wall up to the impermeable layer prevents water movements in both direction, that is, inflow and outflow.

Generally the vertical liner system prevents the spread of leachate from the used or expired landfill that does not have a standard shelter facility rather than forming a new waste landfill. An exterior liner system, blocks the leachate from being exposed due to poor construction of liner system.

The liner materials used in the vertical liner system includes core, Sheet Pile, Slurry Wall, Soil Mixed Wall, and Grout Curtain. Material selection must be made according to the actual condition while keeping economic and construction status into consideration.

Core

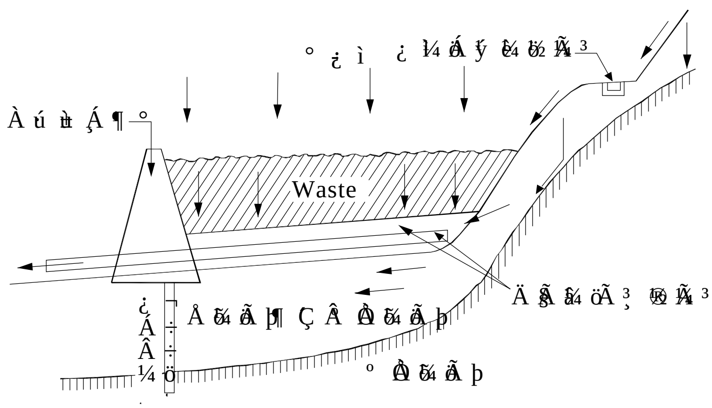
Sheet Pile

Slurry Wall : Mud Bentonite, Cement Bentonite, Plastic Concrete, Vibrated Beam, Diaphragm Wall

Soil Mixed Wall

Grout Curtain

Fig. Annex- 15 Vertical liner system concept



Leachate liner system facility standard establishment Guideline

Currently, there is no clear regulation on construction of waste landfill storage in Lahore. They use Korea's waste landfills for reference. There is a need to establish Lahore's condition must be established to adhere to standards. Leachate liner design applied in Korea is as following:

- § Leachate exposure in reclamation facility must be prevented by considering the following factors: landfill floor and sides must be designed according to the waste characteristics; reclamation height; and geographic conditions. Clay liner (clay:clay mineral mixation) must be used together with large scale polyethylene and other engineered liners corresponding to the above to install the liner system.
- § When using engineered liners, the thickness must be more than 2.0 and there should be more than 1 layer. On the lower part of the engineered liner, the clay must be hardened to below 1 10^{-7} /sec and the thickness must be above 50
- § If the slope of the sides and the entrance road are too steep, it will be impossible to install a clay liner to the lower part of the engineered liner. Therefore must be layering with engineered clay liner.
- § When using clay liner, the calculation must be below 1 10^{-7} /sec and the thickness of the installed liner above 1m.

3.3 Leachate Storage Facility

The leachate storage facility aids in the collection of leachate and polluted precipitation and move them to a leachate treatment facility. The other purpose of the leachate storage facility is to decrease the burden of the storage structure, the liner level in particular, from leachate pressure.

The leachate storage facility must have the following overall functions:

- § Must store the leachate quickly within the reclamation level.
- § Must drain the stored leachate quickly from the reclamation area.
- § Must have the supplementary function to treat generated gas.
- § Must have a supplementary function of the liner system that can prevent leaking of leachate into the surrounding environment.

Leachate is a polluted liquid mixed with many dissolved substances and suspended solids. Water penetration into a pile of wastes places an important role in generating leachate. Even though the water does not readily penetrate into the landfill, small quantity of leachate produced by biological and chemical reactions eventually accumulate. The leachate's quantity and quality is an important factor in the design of landfills.

Table. Annex- 10 Life waste decomposition stage

2011	Aerobic decomposition is rapid and continues for 1 month
2016	The microorganism that can live in an averted or other environment can,with may other effect, hydrolyze cellulose and other substances that can be easily decomposed. The process has high biological oxygen demand and may produce ammonia.
2021	Methane generating bacteria will begin to consume simple organic compounds. Carbon dioxide and methane (with additional various substances) combination are then generated and compose the reclaimed gas.

The factors that influence leachate generation are the following:

- § Reclaimed waste construction
- § Landfill
- § Age of Landfill (Reclamation elapsed time)
- § Final Soil Status
- § Landfill Operation (for example, moisture addition, recirculation of leachate, waste compression, and thickness of molding)

§ Climate change (for example the annual amount and degree of precipitation level)
§ Water ecological condition according to the landfill circumference
§ Landfill condition (for example, chemical, biological activity, groundwater, temperature, pH, stability)

Factor that affect the amount of leachate generated

The factors that influence the amount of leachate generated are precipitation, reclaimed waste condition; final soil condition. These factors have the following features:

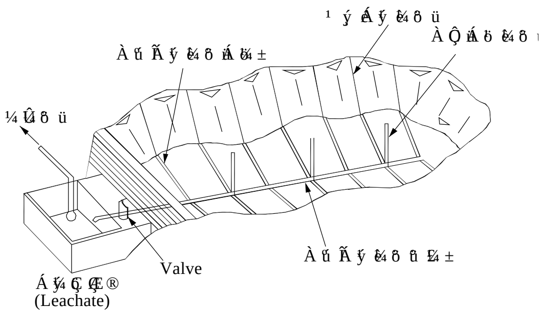
Table. Annex- 11 Factors that affects the amount of leachate generated

Precipitation	§ Precipitation makes the most contribution to the generation of leachate. § The longer the duration of precipitation the higher is the rate of water penetration into pile of wastes, thereby, creating more leachate. Short term heavy rains quickly saturate the rate of infiltration through the surface making the penetration amount is quite small. Amount of precipitation is greatly affected by geographic location.
reclaimed waste condition	§ When waste is compressed, more of its mass can be piled up at the same volume, increasing its density. Waste moisture flows through gaps and increases the amount of leachate. The unsaturated waste continues to absorb moisture until it reaches its moisture holding capacity. Therefore, the waste that has a lower water holding will absorb more moisture to decrease the amount of generated leachate.
final soil condition	§ After the landfill's final soil condition is placed, the generated leachate will decrease due to the following 2 reasons. The top soil will grows plants decreasing the amount of moisture penetrating into the stock pile. Another reason is that the low permeability layer decreases the penetrating amount of moisture. The final soil layer along with mixture of soil, resin liner and clay mold layer will decrease the penetration.

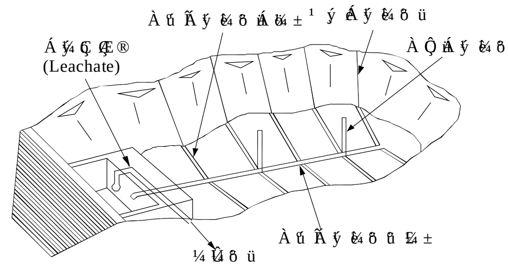
Leachate Storage Structure

The leachate storage pipe installed in the lower part of the landfill is composed of line and wire. Drainage is made possible by installing it at a certain slope. At the location where the line and wire are connected, is supplied and removed to facilitate aerobic decomposition. The capacity of the leachate storage facility is determined according to climate condition and location. It is designed to fit the landfill geographical condition and liner structure to store more efficiently. At the same time, it must not be clogged. The leachate storage facility follows the reclamation formation and structure but generally it is constructed with leachate blockage system, leachate drainage layer, storage pit, and leachate transfer pipe. The drainage layer that includes the leachate drainage system uses highly water permeable aggregates. The drainpipe that is installed within the leachate drainage layer (meritorious pipe) is constructed to prevent blockage. The drainage pit location is as shown below.

Fig. Annex- 16 Leachate storage facility location



Sample of Leachate installed outside landfill



Sample of Leachate installed inside landfill

Guidelines to establish facility standard for leachate storage facility

Currently, there is no clear regulation in constructing a waste landfill leachate storage structure in Lahore. Referring to Korea's general waste landfill, Lahore's condition must be established according to the suitable facility standard.

Table -54. Leachate storage facility standard plan applied in Korea

Name of document :	Waste management
Leachate storage facility standard plan	
Above the liner facility, a leachate storage layer (Permeability calculation of above 1 10^{-2} /s and thickness above 30) and drainage facility such as drainpipes and perpendicular catchments system must be installed.	
With the reclamation facility, when the liner system is installed through engineering composition resin liner, the engineering composition resin drainage layer which is permeable calculation that is above 3.3 10-5 /sec (geocomposite, geonet, geotextile) must be installed.	
When the liner system is installed with clay liner the permeable calculation must be above 1 10^{-2} /s and must layer with sand that has a thickness more than 30 , the drainpipes must not have any blockage and must install aggregate with enough air gap.	
The leachate storage facility must have a slope of more than 2% from the floor	
The liner system of the reclamation facility must be protected and to keep it exclusion, put a	

3.4 Groundwater Storage Facility

The groundwater or spring-water that in the grounds lower than the landfill must be drained properly. If the water is not properly drained, it will create an uplift pressure that could damage the liner or the landfill floor. This will also cause increase in gap pressure at the circumference ground and impair the safety of the landfill structure. Leachate will then leak and cause groundwater pollution.

To prevent such incident, the groundwater storage facility places an important role and must have a structure that can block the groundwater and spring-water effectively.

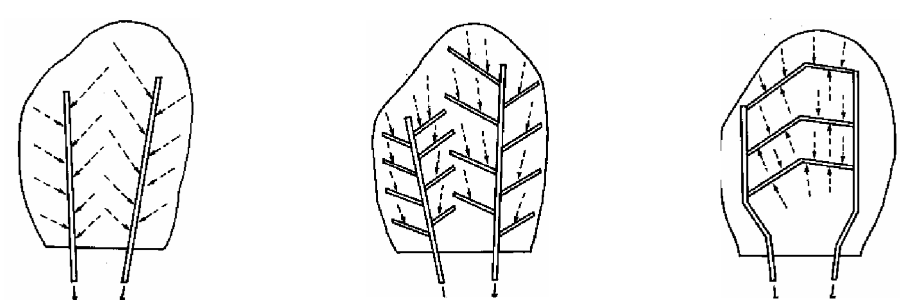
The necessity of groundwater storage facility is decided based on the landfill installation, district repair, geological data.

Groundwater Storage Facility Structure and Formation

The groundwater storage facility generally composed of opened pipe with filter materials such as gravel and debris using the culvert structure. The groundwater main flow direction lays in the main line that is constructed to connect to the branch line.

The groundwater storage facility formation follows the installation method where it is divided into the straight line type, branch type, and ladder type. Method selection is based on geographic condition, leachate generation feature, economics, and overall conditions.

Fig. Annex- 17 Groundwater storage system installation



Straight line type | Branch Type | Ladder Type

Guideline for construction facility standard for Groundwater storage facility

Currently there is no clear regulation in constructing a waste landfill's groundwater storage in

Lahore. Referring to Korea's general waste landfill, Lahore's condition must be established according to the suitable facility standard.

Table. Annex- 12 Groundwater storage facility standard, Korea

Name of document :	Waste management method
Groundwater storage facility standard plan Must install a facility that will prevent the groundwater or rainwater from having contact with the	

3.5 Precipitation Storage Facility

Precipitation Storage facility must prevent precipitation from penetrating into the landfill. Precipitation that fall into the landfill must not infiltrate into the reclaimed waste area by quickly discharging the precipitation and reducing the its penetration rate. This functionalities must be installed in order to properly manage the landfill.

Heavy rainfall brings large amount of water into contact with the wastes. This could generate various polluted substances. It is a lot cheaper to reduce leachate generation than to handle and treat the generated leachate. It is, therefore, important to reduce the amount of generated leachate.

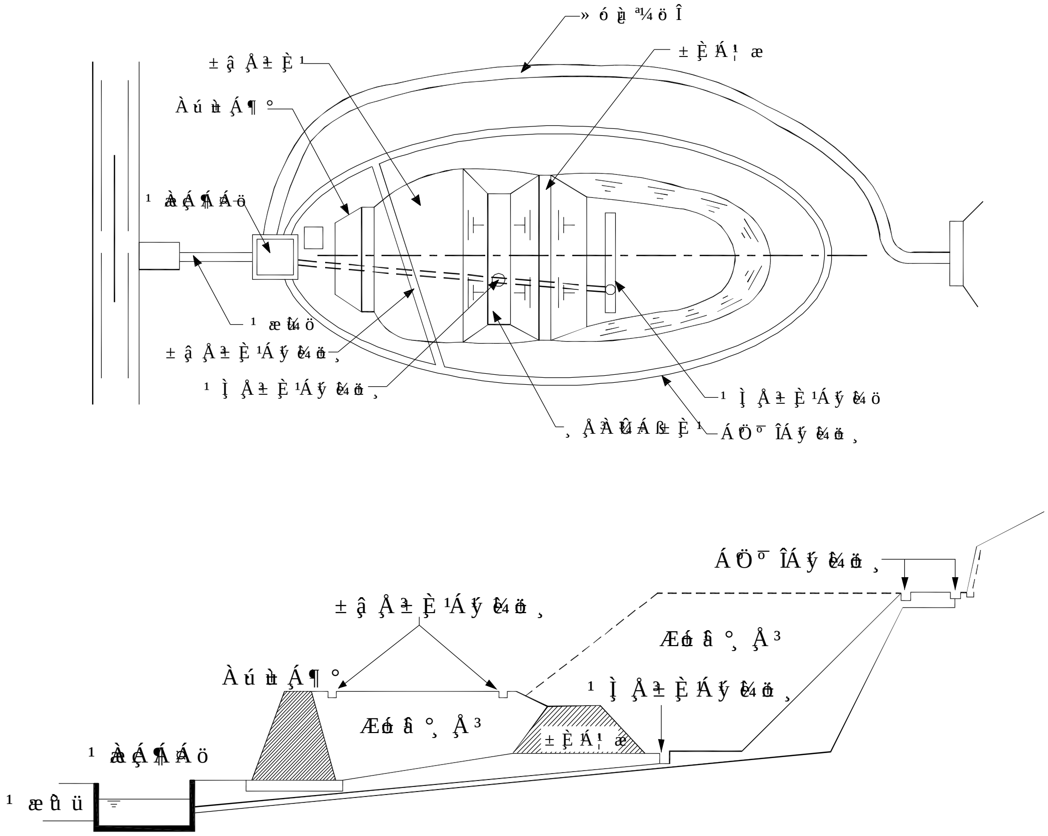
Precipitation Storage Facility function

Precipitation Storage Facility must have the following functions and must operate overall at a maximum.

§ Able to store and discharge precipitation along the landfill circumference drainage system
§ Have a over flow prevention division embankment
§ Have a function that stores the surface exposure from the final soil
§ Precipitation Storage Facility Formation

The Precipitation Storage must reduce the amount of leachate by precipitation removal . precipitation storage must be equipped with a total precipitation drainage system as shown below.

Fig. Annex- 18 Precipitation storage facility structure



A Precipitation storage must have a culvert, open channel, precipitation pipe, small levee and storage that have the following features.

Table. Annex- 13 Precipitation storage facility feature

Type	Feature
culvert	The watercourse is used to intersect the lower Waste landfill road and this generally uses the closed conduit's pattern and square type
open channel	The open channel is the facility to economically remove the precipitation, and the established location changes according to the waste landfill operation plan. Therefore, for the operation of waste landfill, it must be temporarily installed and sometimes installed for the long term
precipitation pipe	When the waste landfill underground pipe system must store the percipitation, it must be installed even when it is not possible for installation
small levee	It must be installed in places where overflow is possible and prevent waste loss. The removal facility is sometimes deliberately installed to prevent precipitation from inflow but the temporary storage and the grit chamber is sometimes also deliberately installed
storage	The facility can control surface exposure outflow and for the waste landfill circumference exposed roundabout, the waste landfill upper course must be installed or installed on the lower course to regulate the outflow from the landfill

The storage is divided into temporary and long term storage

- The temporary storage is the temporary facility to control exposed amount below the peaking outflow and is installed to control the outflow of surface exposure
- The long term storage reduces the peaking outflow and the total discharge of outflow and as a long term facility, it is installed to store portions of or all of the outflows

Precipitation storage facility scale establishment

The Precipitation storage facility plan must consider the floodgate data of euro extension, euro average slope, water collection dimension, exposed calculation, soil moisture content, plantation condition, drainage material, section and inclined geography, geography data and precipitation intensity (generated frequency and duration) and Peak run-off flow rate.

* The basic article for precipitation storage facility scale establishment

Precipitation removal facility capacity is small which is an important factor in minimizing the damage caused by overflowing accident. In Korea, the reclamation district frequency is 10 years within the area and 25 years for the outer reclamation district. In Japan, reclamation district frequency is 10~15 years. In America, a strict application of 25 years is implemented.

It is very important to plan the precipitation storage facility to make accurate prediction of Run-off from and into the waste landfill. In America, a rational Curve Number, US Geological Survey Model is used while in Korea, logic is mostly applied.

Guideline for the precipitation storage facility establishment standard

Currently there is no clear regulation in constructing a waste landfill precipitation in Lahore. Referring to Korea's general waste landfill, Lahore's condition must be established according to the suitable facility standard.

Table. Annex- 14 Precipitation storage facility standard plan, Korea

Name of document : Waste management method
Precipitation storage facility standard plan The Rainwater removal facility must be able to block the rainwater that fall outside the landfill area from flowing into the Landfill or Land filling facility. On the other hand, rainwater that fall inside the Landfill or Land filling facility must not flow into the waste reclaimed district

3.6 Leachate Treatment Facility

The Leachate Treatment Facility should be designed appropriately so that the generated leachate is treated within the landfill facility before being discharge into nature or undergoing further treatment. The design should minimize negative effects to the surrounding environment.

There are various factors that influence the amount of leachate generated in a landfill. These include precipitation, site status, surface water penetration, type of construction, moisture content, waste thickness, climate, amount of soil penetration inside the landfill, landfill surface evaporation loss, exposure of the outermost layer, and capacity of water collection system.

Therefore, the leachate treatment facility must be selected after taking the following into consideration: volume and characteristics of leachate, standards of effluent level , and treatment facility location standard. The leachate treatment system is selected after taking the location condition, environmental, safety, and economic conditions into consideration.

Leachate Characteristics

The characteristic of differs based on many factors such as landfill operation, landfill condition (for example, chemical, biological activity, percentage of water content, temperature, pH, stability), soil thickness, soil mold, heavy rain penetration ratio, hydrogeology condition in landfill circumference, climate change (for example, the amount of annual heavy rain and atmospheric temperature), years of reclamation, reclamation method, landfill structure and reclamation waste formation. Each landfill has different set of these factors. The burden treating polluted ground water is greater than the burden of preventing from happening.

It has been shown that leachate concentration gradually decreases through years of reclamation.

Table. Annex- 15 Quality characteristics of leachate according to the landfill reclamation

Class	5 years after reclamation		Landfill that is older than 10 years
	Range	typical value	
BOD	2,000~30,000	10,000	100~200
TOC	1,500~20,000	6,000	80~160
COD	3,000~60,000	18,000	100~500
TSS	200~2,000	500	100~400
Organic nitrogen	10~800	200	80~120
Ammonia nitrogen	10~800	200	20~40
Nitrate	5~40	25	5~10
T-P	5~100	30	5~10
Alkalinity	1,000~10,000	3,000	200~1,000
Total Hardness	300~10,000	3,500	200~500
pH	4.5~7.5	6	6.6~7.5
Ca	200~3,000	1,000	100~400

Mg	50~1,500	250	50~200
K	200~1,000	300	50~400
Na	200~2,500	500	100~200
Cl	200~3,000	500	100~400
Sulfate	50~1,000	300	20~50
Total Iron	50~1,200	60	20~200

Methods of Estimating the Volume of Leachate Generation

To estimate the capacity of leachate management facility, the daily and hourly rate of leachate generation must be understood. There are 3 models used to quantify the amount of leachate generation: the HELP Model, Water Balance Method Model, and the rational Water Flow Balance Model. The decision on which model to use must be based on actual conditions on the landfill.

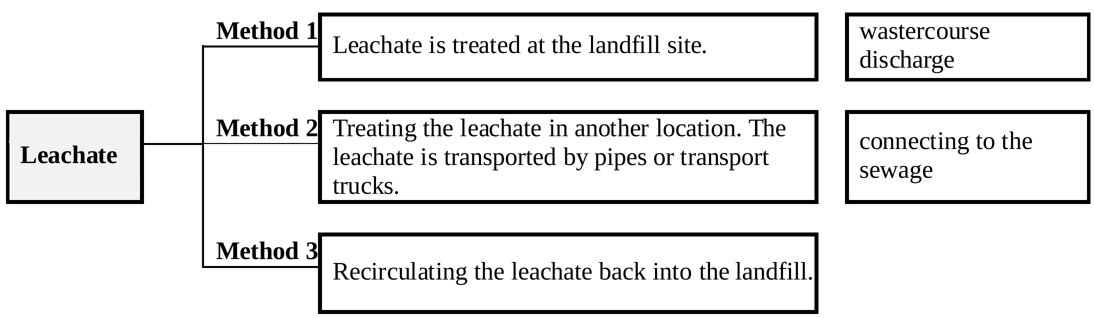
Method of Determining Leachate Characteristics

Basically the leachate quality is determined by the characteristics of the wastes from which it is generated. However, the reclamation status and method of drainage also affects the leachate quality. However, it is not clear whether these factors have quantitative effects or none.

Values can be estimated by referring to reseaches that has been conducted on a landfill district that has similar kind of wastes.

Leachate Treatment Methods

There are 3 Leachate Treatment Methods which can be applied based on geographic condition, environment, safety, and economic considerations. Method 1 is the most commonly used. As an alternative for the standard leachate treatment plan, Case 3 is the most economical and promotes landfill stability.



[Method 1]: Treating the leachate at the landfill site

Leachates contain high and low concentration of organic matter. It contains large amount of insoluble substances making it difficult to be complete treated with only a single process. A complete treatment would require biological, physical, and chemical processes.

The basic leachate treatment includes biological process in the early stages and then a series of physical and chemical processes.

*** Leachate→ Handling and Control → Biological Treatment → Physical and Chemical treatments → Disposal**

Handling and Control: Use of one-sided screen and a grit chamber

Biological treatment: Is the process of removing COD, BOD, and Nitrogen from the waste materials. The major processes involved include Aerated Lagoon Process, Activated Sludge Process, Contact Aeration Process, Rotating Biological Contactor, and Trickling Filter Process. The appropriate process must be selected after reviewing the costs, efficiency and maintenance capability.

Physical and chemical treatment: COD, chromaticity, SS, heavy metal, and Coliform is removed through coagulation and precipitation methods. Other methods include ozone oxidation, sand filtration, activated carbon absorption and chelate method.

Generally the leachate treatment must be able to treat and remove 6 specific items. The are BOD, COD, chromaticity, heavy metal, nitrogen compound, and SS.

Table. Annex- 16 methods of treating and removing specific item

Items	Treatment and Removal Method
BOD	Biological treatment, active carbon, coagulation
COD, chromaticity	Precipitation, active carbon, biological treatment, ozone oxidation
Heavy metals	Precipitation(alkali method), Chelate absorption(alkali method), Precipitation(dopes mixed)
Nitrogen compound	Biological treatment, Air Stripping, absorption, chorine treatment method
SS	Precipitation, filtration

Leachate treatment methods applied to Korean landfill has been found to be varying and complicated because Korean landfill practitioners follow the standards of treatment methods. The Leachate Treatment Process Flow Diagram below shows the processes practiced in Korea's representative landfills, the Metropolitan Landfill and Daejun GeumGoDong Landfill.

- Metropolitan Landfill Leachate Treatment Process Flow Diagram (Korea)

Fig. Annex- 19 Leachate treatment process folw diagram as practiced in Korea's major landfills

Leachate	ð	**Collection**	ð	Anaerobe Absorption	ð	Denitrification	Oxidation	ð	**1st Coagulation**	ð	Oxidation **Coagulation**	ð	**Final Discharge**

- Daejun GeumGoDong Landfill Leachate Treatment Process Flow Diagram(Korea)

Leachate	ð	**Flux Collection**	ð	Anaerobic Absorption	ð	Abandonment Oxidation	ð	**1st Precipitation**	ð	**Rotating Biological Contactor**
Confusion	ð	**Coagulation**	ð	**2nd Coagulation**	ð	**Filtration Facility**	ð	**Inverse Osmotic Facility**	ð	**Discharge**

[Method 3]: Leachate Recirculation System

Leachate Recirculation System is alternative to existing Leachate treatments as it is already practiced in more advanced countries. The Leachate Recirculation System includes spreading the leachate on surface of the landfill. This is done by installing pipe systems that collects leachates from the bottom of the landfill and raise it to the surface. Solid Waste Association of

North America (SWANA, 2002) states that the purpose of Landfill Leachate Recirculation System is "To accelerate the biological safety of wastes, by regulating into the waste landfill layer the leachate and reclaimed gas condensation will infuse moisture and air to a new type waste landfill". Thus, the Leachate Recirculation System improves biological process and requires deliberate control. In 5~10 years after the end of recirculation, the soluble organic waste component is transformed and stabilized

Leachate Recirculation System has the technique to recirculate the leachate into the reclamation layer. It supplies the necessary moisture to sustain inorganic organism activity and increases the solubility of Biodegradable Municipal Solid Waste.

Leachate Recirculation System Flow and Concept

Fig. Annex- 20 Leachate recirculation system flow

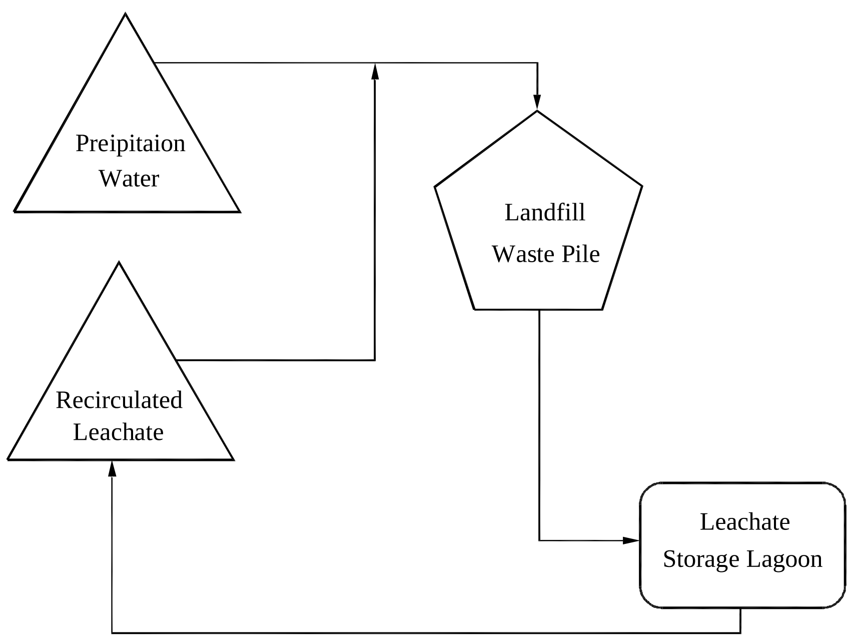


Fig. Annex- 21 Leachate recirculation system

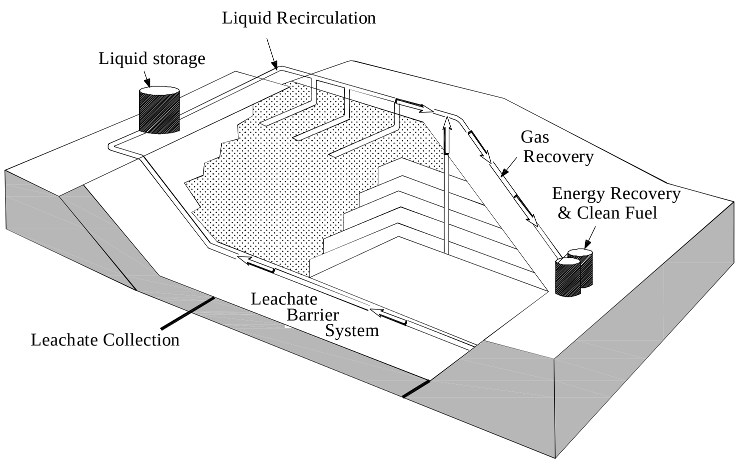


Table. Annex- 17 Strength and weakness of leachate re-circulation system

Streangth
* Early stability of waste: Easily biodegradable waste can be biologically stabilized within 5~10 years. With the early sinkage of the reclaimed waste, the long term sinkage problem is lowered. Further, during the ex-post management period of leachate improvement, the waste retained grounds for ex-post management period can be reduced
* Additional reclaimed space secured to extend landfill life: While early stability of waste reclaimed takes place, the waste sinkage and density enhance the reclaimed volume thereby increasing the life span of the landfill making it possible to bring in additional wastes
* Short gas production period according to the reclaimed gas retrieval ration increases: Leachate recirculation in waste landfill produces reclaimed gas in a short period of time; when compared to the current waste landfill, the economic side of the retained gas production and usage can be strengthened
* Leachate treatment reduces expenses: Through leachate recirculation, the leachate treatment cost is reduced, and it can be used to supply moisture and therefore effectively reducing the following expenditures: (1) waste landfill maintenance expenditure and (2) amount spent on the waste decomposition through reasonable amount of moisture supply.
* Waste landfill ex-post management expenses and long term danger reduction: Waste landfill is stabilized early and will eventually reduce environmental danger in the long term

Weakness
* Reclaimed gas generation volume increase and the related matter: Leachate recirculation in waste landfill creates more reclaimed gas in a shorter period of time than normal waste landfill. Therefore the reclaimed gas storage system must be relatively bigger and must be installed faster.
* Moisture supply/Leachate recirculation and related additional early investment and operational costs: Leachate recirculation and moisture supply relate to pipe, pump and other apparatus, which is equivalent

to additional expenses. According to the economic data analysis of the US Waste Management Inc, 1,150 tons/day of waste landfill uses about 208,018,900Rupi (US$3,500,000) for their Leachate recirculation system and moisture supply installation
* Offensive Odor: Leachate recirculation waste landfill has a tendency to cause offensive odor during dispersion of waste
* Possibility of exposure: Leachate recirculation and other moisture supply can increase the possibility of exposing leachate to the surface. When the leachate is exposed, it is unpleasant and does not only cause foul odor but also instigates pollution.
* Instability: Leachate and other moisture supply can increase about 30% of reclaimed waste degree. This waste degree increase can be a source of damage on the waste landfill's surface
* Waste Landfill fire: The discharge of a large amount of organic matter in a short period of time can produce reclaimed gas and residual products that produce heat can be a potential danger in causing fire in the waste landfill
* Excess moisture supply on wastes: Poor operation could supply excessive moisture which can inhibit anaerobic discharge where the waste layer can have either liquid or semi-liquid characteristic

Review of Cases where Leachate Recirculation is Practiced

Japan:

In the city of Sen-Dai, Japan, leachate is recirculated back into the landfill through a sloping molder layer of the reclaimed land. This promotes evaporation of leachate as well as excluding the surface effectively.

In an Internal landfill next to the central breakwater in Tokyo. Irrigation method is employed. Leachate is irrigated into the landfill to promote evaporation and improve water quality.

America

Florida Bioreactor Demonstration Project:

About 800 tons of waste from the city is brought daily into 10 acres of the 46 acres of land that is used for demonstration purposes. Perpendicular pipes are for air, leachate, and water.

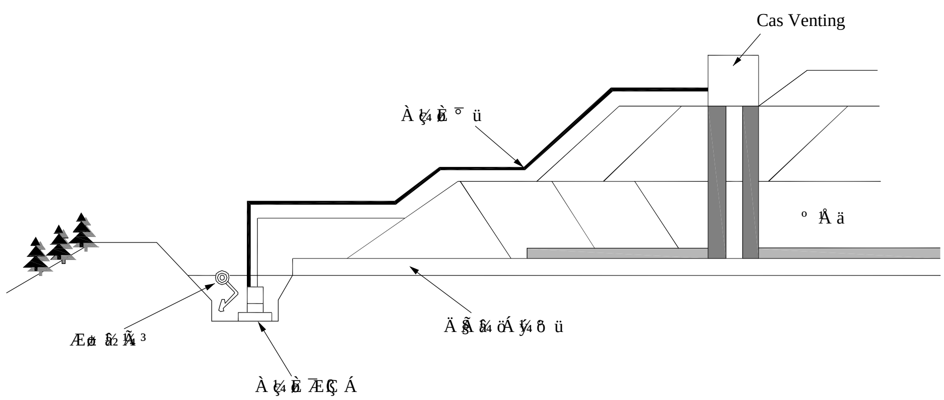
Outer loop Landfill (Louisville, Kentucky):

Vertical trench is used to inject leachate into the landfill by gravitation. The trench is also used to extract gases. This method increased the amount of the generated gases by 30 to 40 percent. It also generated profit by selling the produced methane gas. This also shortened the managing period afterwards.

Williamson County Landfill (Tennessee):

The landfill costs about 14,858,500Rupi(250,000$) every year with the whole amount attributed to the recirculation system. The perpendicular burin installed is PVC. It was then ruined by the sinking ground so the large HDPE pipe is recommended instead.

Fig. Annex- 22 Re-circulating system: aerotropic and ventilation subsystem



Standards of Leachate Treatment

There is no specific standard regarding leachate treatments in landfill. It is therefore recommended to follow the standards used in the process of planning to establish a proper standard suitable for the conditions of Lahore.

Table. Annex- 18 Leachate treatment facility standard, Korea

Name of document :	The law about management of the waste
Standards For Leachate Treatment Facilities A flowmeter should be installed to monitor the changes in the amount of leachate. The flowmeter should be able to withstand more than 7 times of the most frequent rainfall for the past 10 years.	

The facilities should be established to treat the leachate under the required level.

Leachate treatment can be entrusted to a nearby treatment facility, is case that facility is available. This would reduce the facility requirement of the landfill.

Leachate should be treated under following levels:.

Area	(BOD) (/ℓ)	(COD) (/ℓ) cases by the permanganate: the amount of emission of the leachate above 2,000 daily	(COD) (/ℓ) cases by the permanganate: the amount of emission of the leachate below 2,000 daily	(COD) (/ℓ) cases by the potassium bichromate	amount of suspended particles (SS) (/ℓ)
Clean area	30	50	50	400(90%)	30
A section	50	80	100	600(85%)	50
B section	70	100	150	800(80%)	70

Name of document :	The law about management of the waste

items area	[H+]	normal hexane extricated amount: mineral oil (/ℓ)	normal hexane extricated amount: animals & plants (/ℓ)	amount of phenol (/ℓ)	amount of cyanide (/ℓ)	amount of chrome (/ℓ)	amount of soluble iron (/ℓ)	amount of zinc (/ℓ)	amount of copper (/ℓ)	amount of cadmium (/ℓ)	amount of mercury (/ℓ)	amount of organic phosphorus (/ℓ)
Clean area	5.8 ~ 8.0	under 1	under 5	under 1	under 0.2	under 0.5	under 2	under 1	under 0.5	under 0.02	not found	under 0.2
A section	5.8 ~ 8.0	under 5	under 30	under 3	under 1	under 2	under 10	under 5	under 3	under 0.1	under 0.005	under 1
B section	5.8 ~ 8.0	under 5	under 30	under 3	under 1	under 2	under 10	under 5	under 3	under 0.1	under 0.005	under 1

amount of arsenic (/ℓ)	amount of lead (/ℓ)	amount of chrome (6+) (/ℓ)	amount of soluble manganese (/ℓ)	amount of fluorine (/ℓ)	amount of PCB (/ℓ)	No. of bacterium (unit/ℓ)	chromaticity	ammoniac nitrogen (/ℓ)	inorganic nitrogen (/ℓ)	total phosphorus (/ℓ)	trichloroethylene (/ℓ)	tetrachloroethylene (/ℓ)
under 0.1	under 0.2	under 0.1	under 2	under 3	not found	under 100	under 200	under 50 (95%)	under 150 (85%)	under 4	under 0.06	under 0.02
under 0.5	under 1	under 0.5	under 10	under 15	under 0.005	under 3,000	under 300	under 100 (90%)	under 200 (80%)	under 8	under 0.3	under 0.1
under 0.5	under 1	under 0.5	under 10	under 15	under 0.005	under 3,000	under 300	under 100 (90%)	under 300 (70%)	under 8	under 0.3	under 0.1

As additional information, the following is the standards used in major countries.

Nation	distinguishing the waters where discharged	BOD (/)	COD_{Mn} (/)	COD_{Cr} (/)	SS (/)	pH	Total nitrogen (/)	Total phosphorus (/)	other toxic matters (number of categories)
Japan	stream	160 (daily average 120)	-	-	200 (daily average 150)	5.8~ 8.6	120 (daily average 60)	16 (daily average 8)	14
	ocean	-	160 (daily average 120)	-		5.0~ 9.0			
Germany	-	20	-	200	-	-	70 (100)	3	4
Switzerland	-	20	-	-	20	-	-	-	5
Italy	-	40	-	160	80	-	12	-	8
Holland	-	7~20	-	-	-	-	4~8	-	5
Austria	-	20~25	-	75~90	30~50	-	-	-	2

3.7 Gas Collection Facilities

The purpose of these facilities is to prevent disasters caused by landfill gases. Unorganized waste processing could cause fire or explosions. Theses incidents hamperis plant development and could cause bad effects to the residents in the vicinity. The other purpose is to collect the energy from these gases.

Functions of Gas Collection Facilities

The Gas Collection Facilities must have the following functions all together:

- § The density of the gases in the surface layer should be prevented from reaching disastrous level and prevent negative effects to the surrounding environments.
- § The structure should be built without disrupting landfill operations
- § It could be easily built even if landfill operation is ongoing.
- § It should contribute to the stabilization of the layer of the wastes.
- § It should have the complementary function of the pump system for the leachate.

The mechanism of generation and movement ofreclaimed gases

Landfill gas is generally a product of decomposition of wastes. Others include physical and chemical processes such as volatilization and evaporation as part of the main mechanism. The following are factors affecting the generation of landfill gases:

- § Increase in temperature and vapor pressure due to heat produced by the decomposition of wastes.
- § Erosion of the materials (ex: hydrogen is produced because of erosion)
- § The generation of gases caused by changes in water pH. (Ex: hydrogen cyanide or hydrogen sulfide is produced due to increased acidity)
- § The reaction between organic compound (ex: esther)

Landfill is a great anaerobic reactor. Chemical reaction occurring in a landfill is shown as

$$\text{Organic Matter} + H_2O \text{ ----}\rightarrow \text{ Biodegraded Organic Matter} + CH_4 + CO_2 + \text{Other Gases}$$

The gases produced in the equation above are those that are produced in great amounts and the "other gases" are those that are produced in small amounts. The main gases are generated by anaerobic decomposition. Some of the small quantity gases can be very toxic and can be a bad factor for public sanitation.

The amount of the gas generated may differ according to the characteristics of the wastes. These characteristics include compounds present in the waste, moisture content, oxygen availability, temperature, hydrogen, pH (the degree of alkalinity and acidity), compound of sulfide, nutrition, and time of reclamation.

The gas produced is composed of 45~60% methane, 40~60% carbon dioxide, non-methane organic compounds, and tiny amounts of different kinds of gases. The percentage and the characteristics are similar to the followings.

Fig. Annex- 23 Portion of compounds and characteristics of the reclaimed gases

compounds	volume percentage(%)	characteristics
methane	45~60	no color, no odor, flammable, explosive, choking, lighter than the air.
carbon dioxide	40~60	no color, no odor, weak acid, heavier than the air.
nitrogen	2~5	no color, no odor, no taste
oxygen	0.1~1	no color, no odor, no taste
ammonia	0.1~1	no color, pungent odor.
non-methane organic matters	0.01~0.6	low density, various compounds, toxic, pungent odor (ex : acrylonitrile, benzene, 1,1-dichloroethane, 1,2-cis dichloroethylene, dichloromethane, carbonyl sulfide, ethyl-benzene, hexane, methyl ethyl ketone, tetrachloroethylene, toluene, trichloroethylene, vinyl chloride, and xylenes)
sulfur	0~1	pungent odor(smell of rotten egg)
hydrogen	0~0.2	no color, no odor
carbon monoxide	0~0.2	no color, no odor

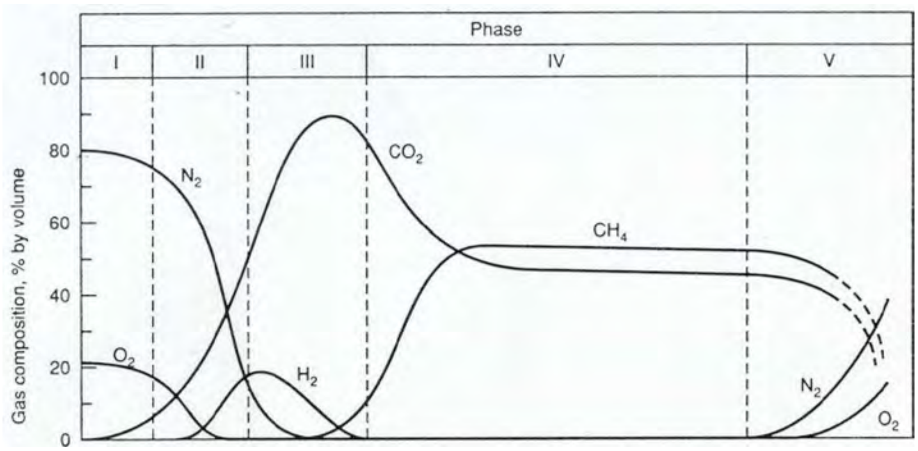
Source : Tchobanoglous, Theisen, and Vigil 1993; EPA 1995

The general changes in gas composition due to the time of decomposition varies in five steps as the following.

Phase 1	Phase 2	Phase 3	Phase 4	Phase 5
Initial Adjustment Phase	**Transition Phase**	**Acid Phase**	**Methane Fermentation Phase**	**Maturation Phase**
Easily decomposed matter produce CO_2 and consumes	Acid-making bacteria produce fatty acids, CO_2,	Organic acid increase and gradually	Acetic Acid and H_2 formed from phase 2 are converted into	Organic matters that can be decomposed

oxygen from air. -- Organic decomposition phase	and H_2 under inorganic conditions. -- Initial acid making phase.	decrease the production of CO_2 & H_2	CH_4 & CO_2 by bacteria	biologically and slow decomposing matters are all converted into CH_4 & CO_2

Fig. Annex- 24 Changes in gas composition from Phase I to V.



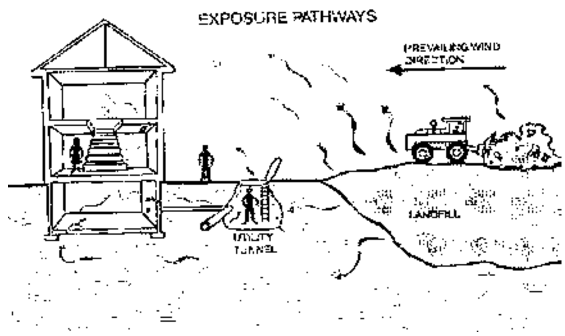
As gas is produced, the internal pressure increases forcing gases to move outside through the utility tunnel. For example, methane, which is lighter than oxygen, tends to move upwards, while carbon dioxide, which is heavier than the oxygen, tends to move downwards.

Gas movement can be horizontal or vertical but, generally, towards the region where there is less resistance. The horizontal movement is more likely to occur more than the vertical movement. This is due to the presence molding layers in relatively well-reclaimed waste landfills. Gas movement takes place by diffusion which is dictated by the differences in pressure, density, and by the convection current caused by the differences in the internal pressure which is influenced greatly by how well water penetrates through the layers.

The gas has negative effects on the surround environment and threatens men's health as well as the safety of landfill operation. It is therefore necessary to understand the pathway of the gas and its characteristics to lower the its chances of contact with mankind.

The following picture shows various ways on how humans are exposed to the gas.

Fig. Annex- 25 The pathway of the gas in the landfill



Predicting the amount of gas emissions.

The emissions should be evaluated based on the information about the amount of the organic waste which is the main cause of gas production aside from the time of burial.

The gas produced by the reaction of anaerobe can be represented through the analysis of the general compound of organic matter which is, in chemical form, $C_aH_bO_cN_{d.,}$ The volume of gas that can be produced can be solved using the following equation:

$$C_a H_b O_c N_d + \left(\frac{4a-b-2c+3d}{4}\right)H_2O \rightarrow \left(\frac{4a+b-2c-3d}{8}\right)CH_4 + \left(\frac{4a-b+2c+3d}{8}\right)CO_2 + dNH_3$$

In addition, the organic matter which is the main cause of the gas production can be divided into acute decomposing matter, subacute decomposing matter, steady decomposing matter as in the following table:

Table. Annex- 19 The waste division by decomposition rate

Division	Materials	Period of Decomposition
Acute decomposing matter	food, newspapers, leaves etc.	3months ~ 5years
Subacute decomposing matter	papers, trees, textiles etc.	5years ~ 50years
Steady decomposing matter	rubbers, leathers etc.	over 50years

There are many models that can be used to predict the amount of generation of gas. These models include EPA Landfill Air Emission Estimation Model (EPA Model), Palos Verdes Model, Scoll Sheldon Arleta Model, PG&E Model, Scholl Canyon Model, LFGER Model, and zero reaction models. These models have the following characteristics. Generally, the models used to predict the amount of gas produced are based on the primary models. The mostly used and widely trusted EPA model is used to predict the amount of gas generation in the sanitary landfill to be established in Lahore.

Table. Annex- 20 Models used in the predicting the amount of gas generation

Model	Equation of model	Features of model
EPA Model	primary reaction model dL over dt = -kL	§ This model reflects each of the landfill in the U.S. The first Lag Time is not considered and various results can be extracted by changing $L_{0\,\&}$ t.
Palos Verdes Model	2nd stage primary reaction model dG over dt = -k_1 L dL over dt = -k_2 L	§ Contrary to the EPA model, this model takes the first Lag Time into consideration. The k_1 and k_2 are considered from the half-life period, based on decomposition period for 99% decompostion and measured data
Sheldon Arleta Model	2nd stage primary reaction model dG over dt = -k_1 L dL over dt = -k_2 L	§ Based on Fair, Moore curve of treatment of foul water by inorganic reaction theory, similar to Palos Verdes Model. The waste is calculated by its shape, by decomposing speed and by year.
PG&E Model	Graph fitting model. assumption of hyperbolic equation or exponential function	§ It uses a statistical method such as the Monte Carlo Method. It needs data gathering to be applied.
Scholl Canyon Model	primary reaction model dL over dt = -kL	§ This is the model using the experience of Scholl Canyon landfill in the U.S., similar to EPA Model but given default number is different
LFGER Model	2nd stage linear model assumption of triangular shape of gas generating function	§ The model considers the basic chemical shape of the waste. Triangular Gas Production Method developed into MS Excel Program.
0 stage reaction model	primary reaction model dL over dt = -k	§ This was widely used in the past but is no longer used these days because the data generated by this model differs from the actual data.

The EPA model which is used here has the following characteristics.

The decomposition rate of organic matters is presented as proportional to the density of the organic matter. In special cases it can follow non-related 0 stage reaction but in most cases it follows the primary reactions under the natural circumstances.

The equation is as follows.

SCALE 90 dL over dt = -kL

Where

L - the amount of gas that can be possibly generated after a certain time t

t - time passed,

k - constant of gas generation

The equation can be converted to

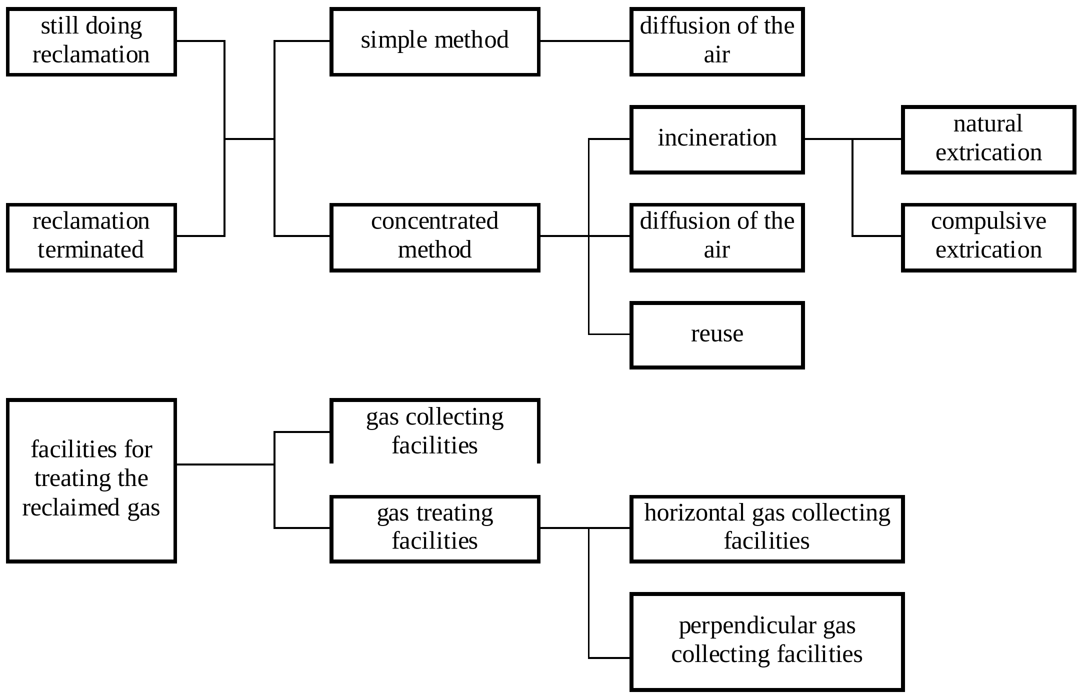
The amount of gas generated as well as the rate are influenced by the many factors such as the diversity and the composition of the waste. The amount and rate of gas generation can vary according to the to the amount of the leachate generated.

To calculate the exact amount and rate, it is necessary to evaluate the different types of models related and compare the resulting numbers to deal with uncertainty. The given L_0 and the number for the constant 'k' in the EPA model are representative values. Also, the percentage reflects the American type of wastes. For this reason, it is not proper to adapt this numbers since Lahore waste is quite different.

Since there are no references on the type of wastes in Lahore, we adapted the data acquired from investigating a somewhat different type of landfill in Korea. It seems that the accurate analysis should take place in the future basic plan phase to the design phase.

Gathering and treating system of the reclaimed gas

Fig. Annex- 26 Classification of gas collection and treatment sytem



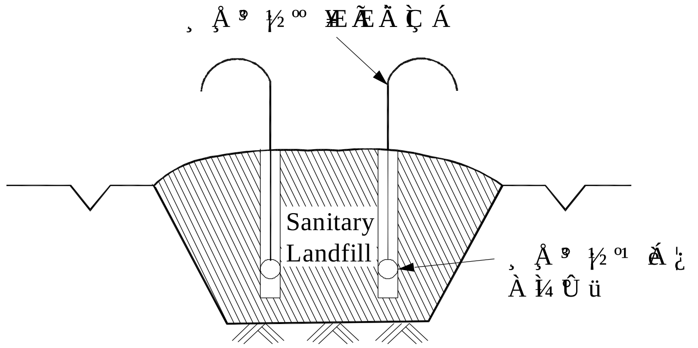
Classification of gas collection system

The collection system for landfill gas can be generally classified into three. These are natural discharge system, compulsive emission system, and hybrid system. To decide which system to choose, one must consider how deep into the ground the gas is located, depth of groundwater, type of soil, condition of the land, the current use of the surrounding area (whether residencial or commercial), fee for establishment, money for maintenance, and energy value of the gas.

The natural discharge system is installed by inserting pipes through the layers and down into the zone where the gas is located. Gas is then driven out by the difference in pressure. This system can be employed in relatively shallow landfills.

It has the advantage of being economical, however, it has the disadvantage of being less effective in odor reduction. Also it is only adaptable where underground conditions allows.

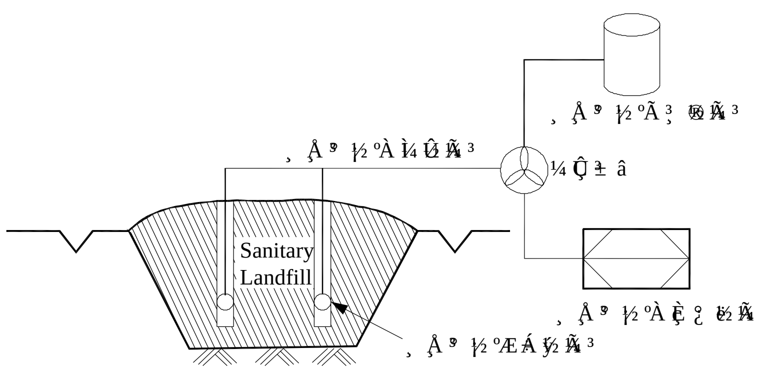
Fig. Annex- 27 Natural discharge system



In a compulsive emission system, horizontal pipes are inserted into the layers of reclamation. The gas is then extracted compulsively through transferring pipes connected to the gathering pipes. This system is preferred in areas where the landfill is deep or when the landfill is intended to be developed into a residencial area in the future.

This method is flexible and can be adjusted to suit the surrounding conditions. It is also effective in lessening odor and the system can be reused. However, the system is complicated and has high maintenance cost.

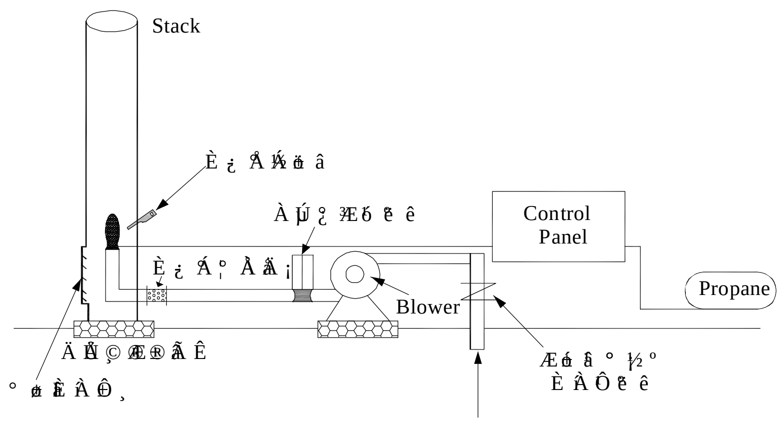
Fig. Annex- 28 Compulsive emission system



Hybrid system is a result of a natural discharge system upgraded into a compulsive emission system.

This system is only used when the amount of gas produced and transferred increases to a level in which natural discharge system could no longer work well. It is used only when compulsive emission system is found to be economically viable.

Fig. Annex- 29 Hybrid system



Classification of gas treatment systems

Gas treatment systems can be classified into incineration system, diffusion and dilution system and recycling system. The features for each system are as follows:

The incineration system uses a method in which the collected gas is burned in an incinerating equipment, There are simple incinerating system, water pipe incinerating system and burner incinerating system. Simple incinerating system is widely used in small landfills.

The diffusion and dilution system just let the gas diffuse naturally into the atmosphere. This is suitable for landfills where there is only little amount of gas produced.

The recycling system makes productive uses of the recovered gas. The gas can be sold to industrial institution after increasing its purity by dehydration, or fed into a system where vapor is produced in the process of incineration, used as fuel to generate electricity or stored as a compressed gas.

Evaluation of the methods of recycling recovered Gas

Generally the reclaimed gas contains about 45~60% of CH_4 which has caloric value of about 4,500~5,000kcal/ . A recycling system must be very effective in utilizing this resource.

Moreover, in an area like Lahore, the land is full of a great amount of recyclable gas that can make a commercial establishment viable.

There following are 3 methods of gas recycling currently used:

- Electric Power Generation: Reciprocating Engine, Combustion Turbine, Combined Turbine, and Steam Cycle Power Plants
- Medium Energy Content Gas: This system is the alternative of selling the gas that is only separated from the water to the customer.
- High Energy Content Gas: It is a method of removing CO_2 and other tiny materials to increase CH_4 concentration up to 95%, making it an alternative for LNG. is the system can connected to the LNG pipes and sold. There are types of method such as Membrane Process, Solvent Absorption, Molecular Sieve and etc.

Currently, the type of equipments used in American landfills is mostly the Reciprocating Engine. This engine is used to create power from landfill gases, mostly under the level of 3MW.

Table. Annex- 21 Current equipment for the resources of reclaimed gas (USA)

types of energy		running	constructing	planned	total
Generation of electric power	gas engine	147	55	46	248
	gas turbine	35	4	1	40
	steam turbine	5	-	1	6
	complex fire power	3	-	1	4
	cogeneration	1	-	1	2
	others	14	7	10	31
production of gas	medium quality gas	70	13	29	112
	high quality gas	7	9	8	24
others	evaporation of leachate	9	2	2	13
	fuel cell	2	-	1	3
	greenhouse	1	-	2	3
	composition of methanol	-	-	1	1

Source : feasibility study and basic plan on the business of making energy in the landfill in the National Capital region (2000), the ministry of environment(Korea)

On the other hand, examining the practices in developed countries, Reciprocating Engine is used in the middle and small scales while Steam Cycle Power Plants are used on the big scale power plants. Reciprocating Engine is used in places where is power requirement is under 6.4 . Places where power is about 6 mostly depend on combination of small scale producers ranging from 2~3 .

Table. Annex- 22 The examples of recycling the reclaimed gas in the developed countries and their scales

Division	Types	Landfill (countries)	Gathered gas (/min)	Scale of the facilities
Generation of electric power	gas engine	Santa Rosa (America)	65	6.4
		Newby Island (America)	62	5.3
		Neumunster (Germany)	-	200 2unit
		Ihlenberg (Germany)	-	100 6unit & 750 4unit 260 5unit
		Rastorf (Germany)	-	307 2unit
		Neu Wulmsdorf(Germany)	350(emission)	
	steam turbine	Peunte Hill (America)	623	50
		Gazmont (Canada)	447	25
		Edgeborough (America)	170	10.75
	gas turbine	Altamont (America)	32	6.4
	internal heat	Shakespeare Farm (U.K.)	7.5	200
production of gas	high quality gas	Fresh Kill (America)	-	196 /min
	medium quality gas	Scholl Canyon (America)	140 /min	140 /min

The examination is based on the way of producing gas and the method of development recycling the gas in the sanitary landfill of Lahore.

For producing the gas (medium quality gas, high quality gas), the investment and maintenance cost is cheaper than that of conventional power generation. Constant market is required though. For high quality gas, it is required to guarantee the quality. The technology used must be reliable. These make it hard to apply these systems to the sanitary landfills in Lahore.

Steam turbine, particularly the complex turbine type, produce lesser pollution and at superior thermal efficiency. However, it is only effective in large scale power production, above the level of 10 MW, making this system unapplicable to Lahore landfills, where the level is only 1-5 MW.

On the other hand, Reciprocating Engine and Combustion Turbine type requires a considerable amount of money to install and maintain. This system is, however, mostly modulated making it very suitable for the small scale places and flexible in terms of management. Therefore, Reciprocating Engine and Combustion Turbine type is the most appropriate system for the sanitary landfill of Lahore.

Guidelines for establishing the standards for the facilities of treating the reclaimed gas

There is no significant regulation for the landfill in Lahore. The regulation should be set up by referring to the general standards used in Korea for the typical landfill.

Table. Annex- 23 Standard for gas treatment facilities, Korea

Name of document :	Law of managing the waste

Standards for gas treatment facilities

There is a need to install power generating facilities or a facility that could both collect and incinerate landfill gas in case gas is produced after the reclamation of organic wastes.

Lowering the threat caused by the reclaimed gas

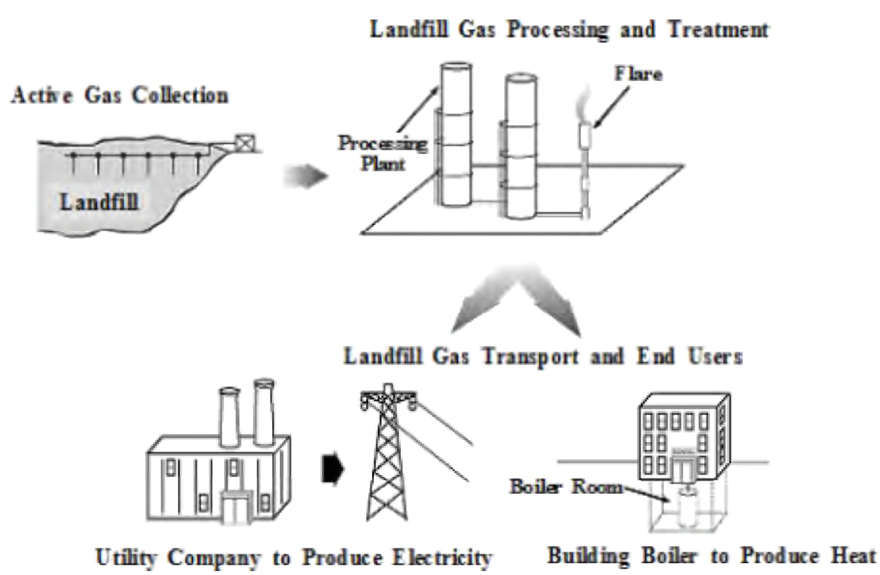
Gaining the safety of the facility
(Reducing the effusion of the leachate and preventing damage to the final molding layer)

Incinerating the gas generated or recycling the gas for a source of power or energy and establishing a horizontal or a perpendicular pipes to make collecting gas easier

The density of emission is regulated under the systematic monitoring to minimize threatening in Korea and other major developed countries. Also, after the economical efficiency is confirmed, the gas is managed by the concept of "recycling the resources", which produces energy from the reclaimed gas.

The gas generated in most of landfills is gathered and collectively handled under the concept of recovering the energy. If the method of using the reclaimed gas has an economic efficiency, the gas will be used to produce heat and electricity, or as fuel.

Table. Annex- 24 The figure of using the gas as a resource



In the landfill located in the national capital region of Korea, the power plantat with scale of 6.5 is operated December 2001 and produced 53N /min for power and 16N /min for heating and air conditioning. It produced a total of 45,314MWh. Of this amount, 32,854MWh was used for its own power while 12,460MWh was sold in the market, generating profit.

Other businesses related to heat and power production in large scale landfill are also taking places.

Table. Annex- 25 The current usage of reclaimed gas in Korea

Division	scale and method of generating power
landfill in the National Capital region	9.83MW(gas engine) or 50MW(steam turbine)
landfill in Geum-go dong, Daejon	3.2MW(gas engine)
Landfill in Sang-gok, Busan	3MW(gas engine)
landfill in Hee-cheon, Jeju Island	2MW(gas engine)
landfill in Nae-cho dong, Gunsan	1MW(gas engine)
landfill in Kwangju	2MW(gas engine)

Three landfills in major developed countries are also examined. These landfills are the Palos Verdous Landfill and Fresh Kills Landfill, both in the, U.S., and the Breakwater Landfill in Japan.

System of recovering gas in Palos vs. landfill, located inF the U.S.

The landfill is located in Rolling Hill Estates City, L.A.. It is the first landfill that recovers the methane gas and was able to make use of it. About 20 million tons of wastes, including organic solids and liquids, were buried in this landfill until the 1980s. Out of the 20 million tons of wastes, 3.8 million tons was decomposed organically. Gas recovery at the rate of 1.3 x 10^8 /day is expected so it is considered to recover the gas at the rate of 5.6 x 10^4 /day.

LFG recovering system in the Fresh Kills landfill, U.S.:

The landfill is located in New York City. It recovered 1 billion ft^3 of gas until 1988. The gas acquired here was sold to Brooklyn Union Gas Co. The amount sold was estimated to be equivalent to 2.5 million barrels of raw materials.

The recovering facilities in the central breakwater landfill in Japan.

The central breakwater is located in the Gulf of Tokyo. 61,240 thousand tons of waste was buried in this landfill. The amount of methane gas emission is expected to be 57,000~110,000 /day and the plant to recover the gas is built with a capacity of 6,200 /day. To run the facility, only 3,940 /day will be used.

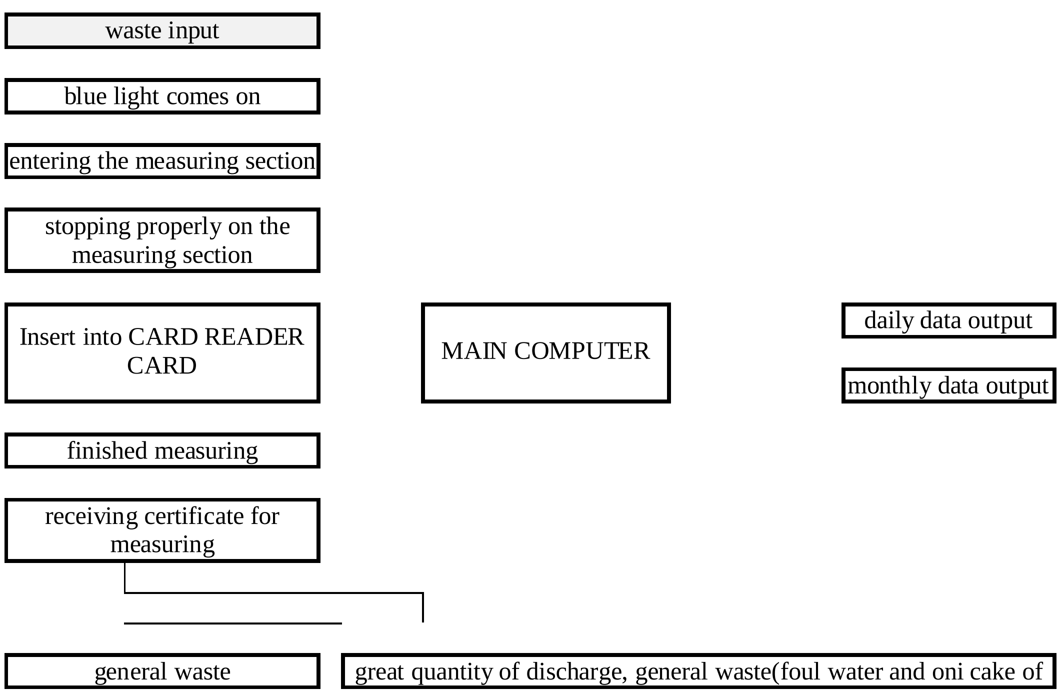
3.8 Waste Receiving Facilities

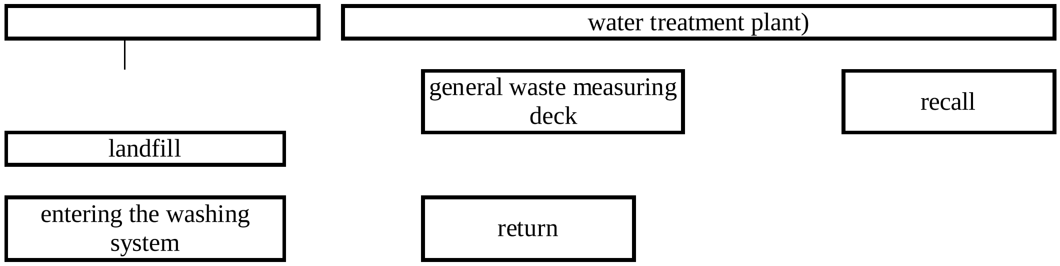
The purpose of these facilities is to minimize environmental pollution as well as to keep the operations economical and safe. These facilities should waste measuring function and be able to block materials that are not supposed to be buried in the landfill. The facilities are composed of measuring section, examination section, and conducting information section.

Measuring section

Measuring section is needed to check the amount of the waste received. The amount of waste is exactly checked for cost analysis and proper treatment. The following flowchart shows the general steps in measuring wastes received.

Fig. Annex- 30 Flow of measuring and carrying waste in the landfill site





Generally the location of these measuring facilities is found along the access road towards the landfill. To get the weight of waste materials received, a waste transport truck is measure twice, that is, before and after unloading the wastes. The general management of the system is similar to the following:

Fig. Annex- 31 Measuring system in the landfill site

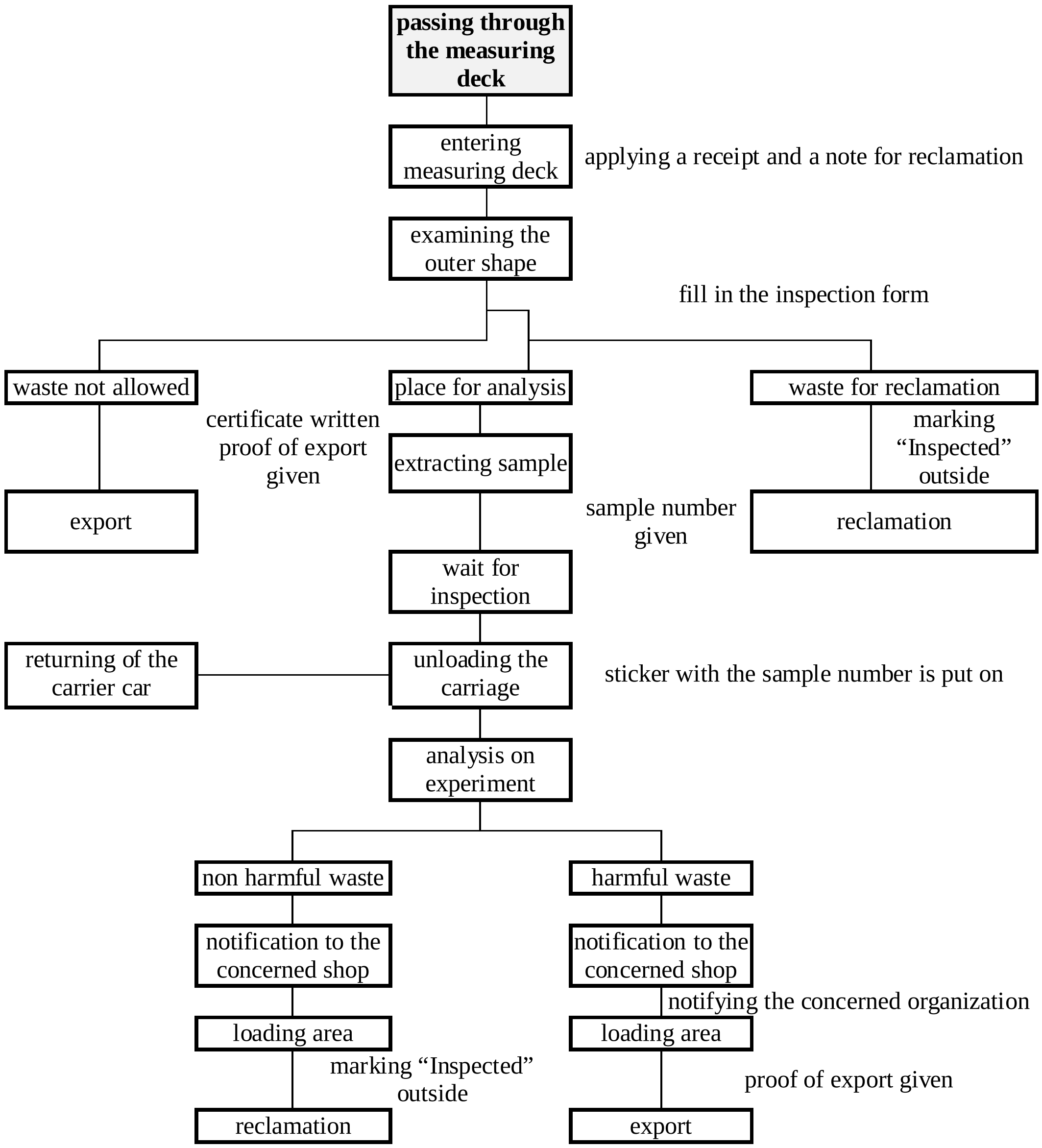
truck filled with the waste that needs to be measured | saving and outputting the result of the measurement | screen shot before measuring | screen shot after measuring

Wastes Examination facilities

Unexamined wastes can pollute the environment as well as hamper the systemic burial and molding. Therefore, it is important to set up the receving parameters such waste type, size, etc. before establishing the waste receving procedures.

The basic procedures of wate examinations are similar to the following.

Fig. Annex- 32 Examination facility flow



Conducting information section

This section analyzes the results of waste examinations every certain period of time. The wastes can be grouped by type. The specific burial location is also recorded.

3.9 The monitoring facility

This facility is used to check if there are changes in wastes, degree of subsidence in they reclaimed layer, changes in the leachate, underground water, gas generated and odor during burial and after the terminal date of burial. These data give information for the future planning of other landfills.

Monitoring procedure can be classified into regular monitoring and post-monitoring. Monitoring is conducted for the following 20 years after the terminal date. The list of monitoring is similar to the following:

Regular monitoring: subsidence of the burial layer, leachate, underground water, occurring gas, odor, noise and vibration

Post-monitoring: exclusion on rainfall, management of leachate, examination on quality of underground water, gas that occurs, stability of the layer or the structures and etc.

Currently, there is no specific standard for monitoring in Lahore, so it is likely to refer to the standards used in Korea to establish its facilities.

Table. Annex- 26 The monitoring system standard, Korea

Name of document :	Law of managing the waste
Standards for the monitoring system When the leachate occurs due to the reclamation, the inspection must take place more than 1 place at the upstream and more than 2 places at the downstream to figure out the contamination of underground water. The inspection on the quality of the water near the landfill should be done more than an one time per month in the period before two months from the reporting date and every once in a quarter after the	

3.10 Access Road

Introduction

Access roads should be established for the transport of wastes and molding materials, equipments, and personnel into the landfill.

Function of the road

The road should have the following functions:.

It must be able to give access to all areas in the landfill.

It should give easy access to all facilities in the landfill.

Types of roads

The roads can be classified by its purpose. These include roads for waste transport from far places, internal roads that lead to the unloading area, and the roads for managing the internal landfill area. Their features are similar to the following.

Roads for receiving wastes:

The roads to the landfill should not interfere with the vehicles carrying wastes or molding materials. The road include sections for public use and the internal road leadinf to the landfill.

Internal roads :

Internal roads starts from the point where it diverts from the public road towards the landfill facility. It should be constructed according to the procedures of the burial, the frequency of the burial and the time of the burial.

Management roads:

Managemetn roads should be contructed to cater to the needs of daily management, examination, safety management, and in & out of the materials.

Things to consider when planning the roads

The roads to the landfill are likely to cause an accident because it has a short distance and has lots of curves. So it is recommended to make the roads one-way and to and sturdy enough to withstand the weight of loaded trucks.

In addition, the road can also be used as access for the supplies of electricity, water and prevention of disasters. It is therefore recommended to plan the roads properly

The roads should be safe and the cars on the roads should be able to pass through it without any resistance. There are many factors to be determined in building the roads. These are the geometrical structure of the road (the number of lanes, the width of the road, the plane of the road), the structure of the covering for the road (thickness, types) and other arrangements (safety arrangement, information arrangement, distribution of water). The following should be considered before building the roads:

Number of cars passing through, the size of the car, the speed limit, the conditions of the service and the topography.

Guidelines for the standards of road facility

Currently there is no specific standards in Lahore The standards used in Korea can be referred to establish the standards applicable to the conditions of Lahore.

Table. Annex- 27 Road standard for the landfill, Korea

Name of document :	Law of managing the waste
The standards for planning the road in the landfill The road should be established to prevent any damages done to the drainage system during the process of carrying in the waste.	

3.11 Building Maintenance

This is for the general management of the system effectively. It should have the following functions:

- § It should have an office, a laboratory and equipment to manage the landfill.
- § It should have enough manpower to manage the facilities and it should provide a good condition for the tour of the residence in the vicinity.
- § It should be in harmony with the surroundings during the period needed to manage the landfill.

The composition of the main building

Generally, the main building is composed of management and other buildings.

Management building:

Facilities for office work: office for management, office for control, conference room, laboratory, and staff room.

Restroom, shower room, cafeteria, room for tourists, exhibition room

Facility for the clean water, air conditioning system, electric facilities, telecommunicating system.

Other buildings:

It is composed of storehouse, storage for the dangerous goods, service center, car wash, garage, parking lots and the water supply.

3.12 Facilities to prevent scattering

The molding should take place right after the burial to prevent the scattering and to get rid of the odor. If molding is postponed the wind can scatter the waste and pollute the environment. Therefore, the facilities are required to be established according to the prevailing weather and surrounding landmarks to prevent contamination.

The scattering dust is caused by the carriage cars, during unloading and before and after burying the wastes. The scattering dust of the uncovered road should be decreased using sprinkling vehicles and the molding should take place after the burial. Movable or fixed type of facilities should be established to prevent a disaster brought by scattering of dusts.

Fig. Annex- 33 Facilities to prevent scattering

3.13 Facilities to prevent the landfill from overflowing

The disaster can occur in the downstream of the landfill during overflow caused by heavy rains. To prevent this disaster, certain facilities should be established.

The form of facilities to prevent overflowing

Generally, it can be classified as a settlement area and preventing system of outflow of the soil.

Settlement area:

The area where the landfill takes place becomes like a dam or bank and the outflow of the soil or the features of the outflow differs from before the establishment. The landfill can withstand only up to a certain degree of rainfall and may give in during heavy rains. Settlement area and other facilities should be designed to prevent these kind of cases.

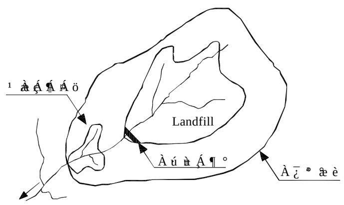
The establishment should consider the soil, type of layers, the shape of the land after the terminal period of reclamation, and the amount of undercurrent facilities and etc.

The method can be divided into 3 types as in the following:

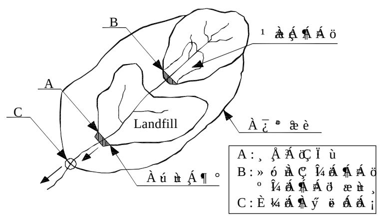
Table. Annex- 28 The method of establishing settlement area

Establishing in the downstream	This is the mostly used method and the settlement area controls the outflow of the soil from the landfill

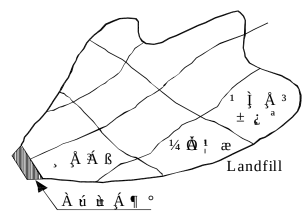
of the landfill	
Establishing in the upstream of the landfill	When the area including the landfill is big, the settlement area can be located in the upstream to prevent the outflow.
Establishing in the landfill	The internal area of the landfill is divided into sections with a small bank to be built with and it can be used as a temporary settlement area. After the final burial, when the area is capable of holding the rainfall, the area can be used to control the flood stream.



Establishing in the downstream of the landfill



Establishing in the upstream of the landfill



Establishing in the landfill

Facilities to prevent the outflow of the soil:

To prevent flood or the landslides, breast wall, rock sandbag or the undercurrent for the soil should be established in or near the landfill.

To prevent the disaster of landslide, the unstable layers should be left out before the establishment.

3.14 Washing system, front door, external stockade

Washing system

Washing system is needed to wash out the remaining dusts on the cars especially the wheels for sanitary reasons.

There are two types of washing system. One is to wash the wheels by sprinkling pressurized water and the other is to sink the wheel to wash it.

The former type is efficient in washing, but it is expensive to establish and maintain, The latter is cost-effective but takes time to wash and the efficiency is low.

Large scale landfills should follow the former type while the latter is preferred for smaller ones.

Fig. Annex- 34 Automatic washing system

One of the most typical types of automatic washing system is the use of a roller to wash the car. The car first enters, then the front wheels and the lower part of the truck is washed. This is then followed by washing of the hind wheels. Finally, the car goes out after the washing, then precipitated soil is discharged.

			
Vehicle enters	Front wheels & lower part of the front of the car are washed	Hind wheels & lower part of the hind of the car are washed	Vehicle goes out

Front door

To regulate the vehicles and people from coming in freely, there must be a front door needed.

External stockade

To manage the landfill effectively, people and animals as well as vehicle should be restricted from entering the place freely. Also, to prevent the surroundings from the outflow of the waste, there must be an external stockade.

3.15 Fireproof facilities

The fire can start from the gas generated in the landfill, so there must be a way to get rid of the causes of the fire to minimize the disaster. In case of fire, extinguishing procedure should take place as quickly as possible.

Causes of fire

The causes of fire could be artificial, self-starting due to fas emissions and neglect of the staffs.

Artificial fire by the gas: The gas located in the crack of the molding layer is sparked by the various types of equipment used to reclaim.

Self starting fire by the gas: When the gas composed of 40-60% percent of mainly methane gas, it does not have any problem. However, when oxygen comes in, the composition of methane gas lowers to 5~15% and it can be explosive.

Fire caused by the negligence of the staffs: These are fires caused by staffs smoking cigarettes, lighting a match or other kind of flame starting materials.

Fire Control

The principles to control the fire in the landfill includes avoidance of maximum fire occurrence, to put out fire promptly and to prevent from burning.

Fist steps to eliminate the factors that can cause fire similar to the following:

Staffs should not carry flammable materials such as matches or lighters and should obey the rule of non-smoking in the landfill.

When the molding layer cracks, direct gas effusion should be avoided by promptly filling in the cracks and make sure the gas does not develop.

Also, to prevent oxygen coming into the layer, which cause fire, a blocking membrane on the side of the reclamation layer should be installed and all necessary steps to maintain it should to be done. Also, the compound of the soil might change so persistent examination should be taken.

Second steps to eliminate the factors that can cause fire are similar to the following:

For small fires, use a fire extinguisher to put out fire quickly.

For big fires, mold properly on the top layer and establish pipes to diffuse as much gas as possible. Also, equipment to diffuse gas into the air can be another way of actively putting out fire.

Third steps to eliminate the factors that can cause fire are similar to the following:

The counter plan should be set up for the surroundings of the landfill as well as that of in the landfill. That may include storing water, soil, fire extinguishers, fire truck, or a water sprinkling car.

When fire occurs, prompt reaction is very important so there should be a regular equipment inspections and fire drills. In case of fire, treating the flammable materials properly is as important as putting out the fire itself. Also, notifying the fire station is necessary.

Fig. Annex- 35 Examples of materials for extinguishing fire in the landfill area

We have looked into the purpose of the landfill, its functions, types of landfill and the guidelines. All these are related to what will take place in Lahore. From this point we will look into the management and post-management after starting the reclamation.

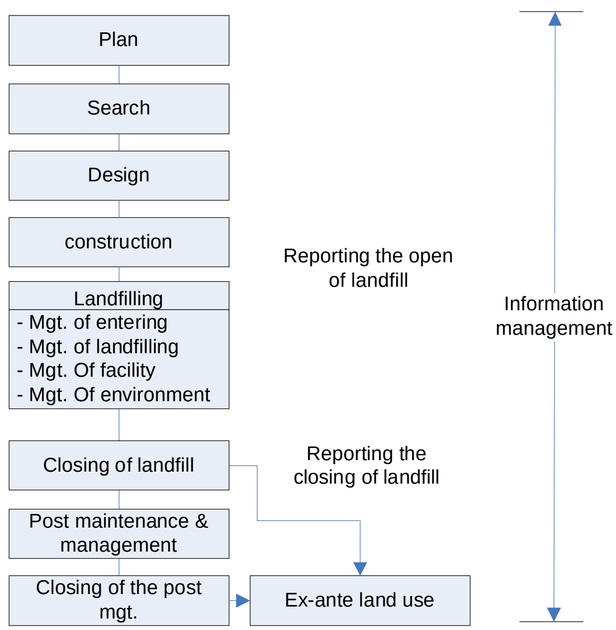
4. Wastes reclamation operating guidelines

Once waste reclamation is polluting the environment, the necessary steps to counteract these problems is complicated and requires a lot of expenses. In the u.s. 75% of reclamation systems (5,500 reclamation) polluted water and was taken care as a national problem. According to CERCLA(Comprehensive Environmental Response, Compensation, and Liability Act), the government budgeted 670 billion dollars to maintain and take care of the purification works and was included in the National Priorities List. Therefore, it is most important to have proper management from the beginning for both reducing cost and future management. Currently, to reduce the main problem, environmental pollution, it has to be pro-environmental to Lahore, and shouldn't cost too much fee. In order to make it possible, we consider the best plant for reclamation, need to have perfect plan, less costing reclamation.

Managing reclamation should accept stable conditioned wastes to minimize environmental problems. Integrated Waste Management includes reducing waste generation, recycling, burning, and current techniques to minimize environmental problems. In order to fulfill above factors, we have to manage firmly from beginning to the very last process. Also, this Integrated Waste

Management has to be managed considering the situation of the community and should be based on resources, economics, and environmental factors. Once reclamation starts, maintenance and management is essential for environment, and to the results could show up the future.

Fig. Annex- 36 Reclamation management flow



4.1 Acceptance management

Needs of wastes acceptance

To prevent pollution and maintain the facility, and for simplicity of the reclamation process, there is a need need to manage the amount of wastes coming in.

It is essential to know the type and exact amount of wastes.

Main objectives in managing waste acceptance are 1. pollution (water pollution, offensive odor, procreation of animals) 2. Facilities and 3. Reclamation process.

Knowing wastes can be compared to previous and future plans, for better management and environmental reasons.

Wastes acceptance parameters

It is important to know the types and amount of wastes. Information like acceptance date, car number, weight of empty vehicle, and name of the person should be recorded upon acceptance. Firm management of this process is one of the most important factors, directly and indirectly.

Standards

To prevent 2nd pollution, it is important to establish standards.

The standards consist of current situation, techniques, cost, etc., considering the factors below:

There are two types of handling ways: one type are those in the middle process, which includes dehydration, drying, crushing, burning, and solidification; and the other type is handling itself.

Right way of handling wastes and weight loss are based on a simple process.

As managing risks is getting important in reclamation, the standard of reclamation is getting tougher and more strict in terms of the types of wastes.

Best case is Germany, where waste reclamation is divided into 5 stages.

Table. Annex- 29 Classification of waste reclamation in Germany

Class	Statement
0	approve to inorganic wastes Approve little amount of organic wastes, and should be minimized

pre-handled wastes below the standard can be reclaimed in class I or in class II
Standard over stage II which contains more polluted factors than class II
Under ground reclamation surrounded by mountains and rocks

In Japan, acceptance standard is less than 10% of ash, sludge rate of less than 60~80%, no longer than 1m, needs to have appropriate wire and bags, plastics tire no longer than 15cm and without air.

In Korea, classify to managing reclamation and isolated reclamation. The existing laws are not as serious as those of Japan and Germany. However it's getting tighter since 2001 in terms of foods reclamation and sludge standard.

4.2 Process Management

Place of reclamation, security of reclamation plant, stability ground and safety, quality of water, gas and gas management are essential in managing wastes. Also, it is important as a basic source for future management

List of reclamation management

Each list of reclamation process should be go all together as a whole. Non-polluting, safe, efficient, properly managed plant, weather, condition of nature, and future plans should be determined before selecting the reclamation plants.

During the reclamation process, management is not the only focus needed. Efforts should also be exerted to take care of workers' health and safety, anti-pollution, efficiency and firmness of the plant.

Fig. Annex- 37 Landfilling management

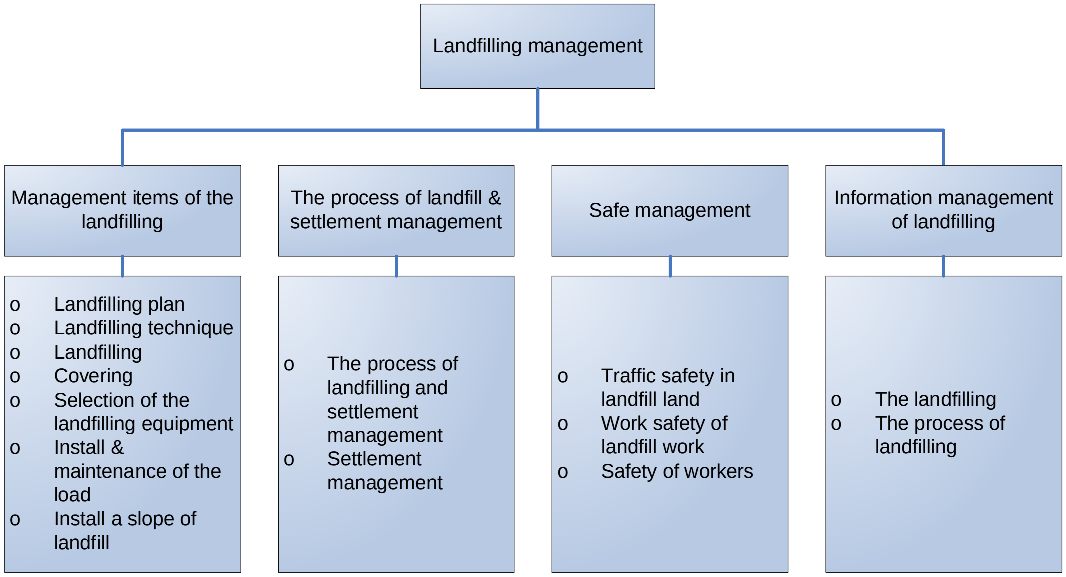


Fig -89. Lists of Managing reclamation

Characteristics of reclamation process

Contrary to the usual process of construction, reclamation is a manual process which can be controlled during waste acceptance. Minimizing the reclamation is an important factor in the process.

Also, to make the reclamation cost effective and clean, there is a need to classify orders by importance, taking care of water through the reclamation, collecting and reducing gas, and proper management of the plants.

Reclamation process includes wastes holding, shipping, and stopping. These factors should be connected closely.

The following statement shows the process of operation.

Loading and unloading:

Clear loading and unloading plans are required daily to make sure that proper procedure is observed.

Tips of choosing loading and unloading plants

Make sure the tires of transport vehicle are not flat.

Do not allow the driver to drive into the operating plants

Spreading, crushing, and pledge process:

Unloaded wastes on reclamation plate should be spread by bulldozer or or crunched and pledged by a compactor. In order to be safe and efficient, the following factors should be considered.

Compactor is more useful than the bulldozer, since compacter has higher compression ability.

For efficiency, and safety matters, the leaning rate should be 1 :3 ~1 : 10

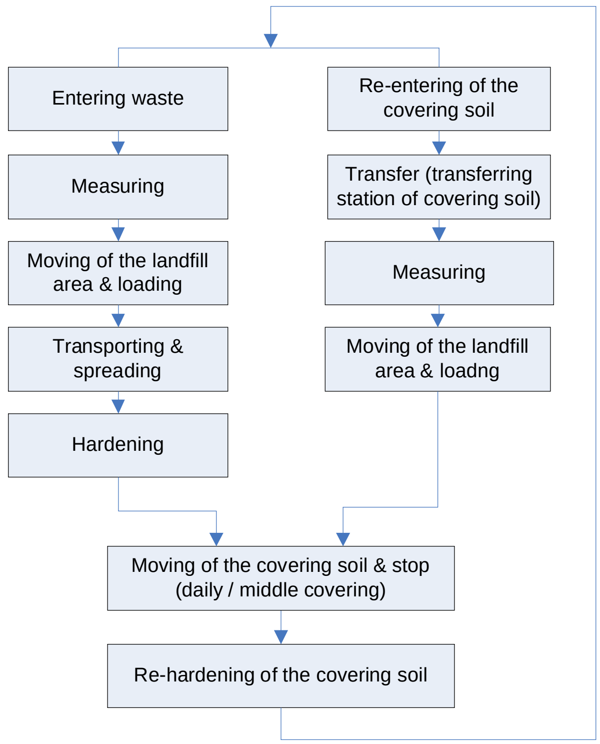
The thickness of waste layer is most suitable at 30~50cm. Running the equipment back and forth 5-6 times is enough to compact the waste layer.

Reclamation process should consider time, and environmental factors.

There should be a plan regarding peak times of receiving wastes, appropriate operating schedule, minimum pollution to the surrounding area, and efficient management.

Workers are exposed to dust and odor from vehicles in the reclamation plant. Therefore, improvement of weak condition should be arranged.

Fig. Annex- 38 Process of reclamation



4.3 Molding

Summary

The purpose of molding is to reduce exposure of wastes and prevent the spread of bacteria.

Forms and function of Molding

Forms and functions may vary depending on the allowed period of exposure daily. Molding should be planned carefully to maximize its functions. The middle and final molding are as follows:

Molding: Molding must be done right after piling the wastes to reduce exposure time as much as possible. Proper molding should reduce offensive odor.

Middle Molding

This is a continuous prevention of waste exposure, also intended to reduce offensive smell.

Final Molding

The final molding should be able to prevent the effects of heavy rains, keep gas from leaking, and secure plant pressure.

Selecting materials for molding

Sand soil is the most efficient for molding the first layer. This type of soil has high air and water permeability.

Soils with low permeability, such as gum soil, is the most efficient for middle molding

Final molding soil requires high-resistance and low permeability.

A guideline to establish the standard of molding

Currently, since there are no clear rules for molding in reclamation plants, it would be necessary to refer to the standards of Korea and find out the best option for Lahore.

Table -76. The standard of the covering installation plan applied to Korea.

<table>
<tr><td>Name of document :</td><td>Law of managing the waste</td></tr>
<tr><td colspan="2">Molding and management standard

First folding :

Sand soil is the most efficient for safety of wastes layer in first molding

The layer needs to be more than 15cm.

Middle Molding :

Layer needs to be higher than 30cm when the operation stops for more than 7 days

Degrees of slope larger than 2%

Final Molding :

Degrees of slope need to be higher than 2% when the operation stops. place gas layer

When closed the using of the landfill establishment, the inclination of the layer of the final covering should be constructed more than 2%. And for this case, the final covering layer should be installed gas elimination, interception, supply of water, natural vegetation layers in order.

The layer of gas elimination: install more than 30cm.

The layer of interception : It should be installed more than 45cm of thickness, less than 1 10^{-6} /sec of hydraulic conductivity clay with clay and saponite mixed or should be installed more than 30cm of</td></tr>
</table>

4.4 Equipment Operations

Reclamation operations are performed by mechanized equipment. Therefore, when choosing reclamation equipments, considerations must be given to amount of wastes, conditions of location, resolvability of wastes layer, stability of ground, and intended plan after useful life of the equipments.

Different types of equipment will do different functions such spreading the waste pile to desired layer thickness, digging, transport and placement of molding materials, and support functions that may be deemed necessary to conduct the entire operation.

The shape and the number of the equipment is influenced by many factors such as the shape and the amount of the waste, type of materials used for molding, method of burial, reliability and the cost of managing the equipments. All these factors should be considered to perform reclamation effectively.

Spreading, and hardening equipment

The equipment used to spread the unloaded soil should be used on the right purpose.

Table. Annex- 30 Basic direction of selecting reclamation equipment

Division		Basic Condition
Capacity of reclamation	Small amount	Using equipment for multiple purposes will be economical.
	Middle amount	Economic efficiency can be achieved if the equipments are used exclusively for its purpose.
	Large amount	Differing shipping of hardening equipment is economical
Condition of useable plant	When usable plant is poor	When the size of usable plant is small (to minimize expenses), improved hardness is economical
	When usable plant is good	For large plants, reducing hardness cost is economical.

Table. Annex- 31 Transport and spreading equipments

Division	Characteristics	Shape of equip.
Dogger for dried ground	Fixed up (power, improved orbit, centroid, and shovel edge) equipment in order to supplement problems during reclamation.	
Dogger for wet ground	For improved sludge reclaiming operation, its wide shovel makes it easier to operate in mixed reclamation	

Table. Annex- 32 Hardening equipment

division	Characteristics	Shape of equip
Compactor	Used in hardening operation to maximize density of reclamation Wheels are shaped to have a crushing effect when it is moving. It's better to use wheels with teeth (Sheep foot type)	
Dogger for dried ground	Can be used when the size of plant is small . The equipment can be used for both movement and hardening of materials.	
Dogger for wet ground	For improved sludge reclaiming operation, its wide shovel makes it easier to operate in mixed reclamation	

Molding equipment

A normal form of equipment used to dig, ship, stop, and harden.

Usually, a bulldozzer is used for digging and bulldogging and dump trucks is for shipping. Bulldogger and grader are widely used in stopping operation. A roller is used to harden the soil.

Supply equipment

The supply equipments are composed of watering cart in case of fire, disinfector, and a cleaning-up wagon to clean up local areas.

4.5 Measuring Management

Summary

One of the most important functions of plant management is to have a quick response field management and constant plant maintenance.

Objectives and methods of measuring management.

Objects and ways of monitoring

Monitoring the sinking layers of wastes is necessary to attain safety. Operation method is as follows:

Safety management of reclamation slope.

- § Measure the rate of plant sinking, amount of ratio, change, and changing period
- § Determine the safety of reclamation slopes
- § Check the safety of foundation facilities, and structures.

§ Analyze the sinking rate

§ Check reclamation silo and volume in real time

§ Managing sinking Wastes layer

§ Provide multiple sources for operating final reclamation silo and other structures

§ Measure volume change of wastes layer and each layer as well

§ Offer data for future plans.

The flow of measuring management is as shown in Fir III-67. The flow is grouped into setting up, managing workers and analyzing workers. For head workers measure and analysis, let measuring manager manage the workers.

4.6 Safety management

Safety management is a list of safety and public health. Specific examples are traffic conditions in plant and health management for workers.

Fig. Annex- 39 Safety management

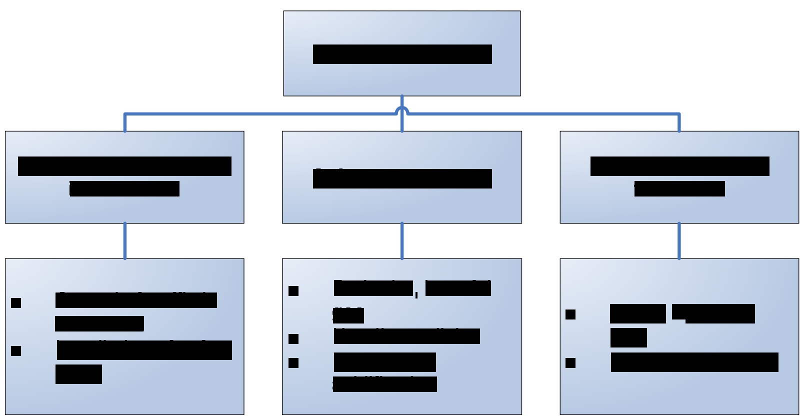
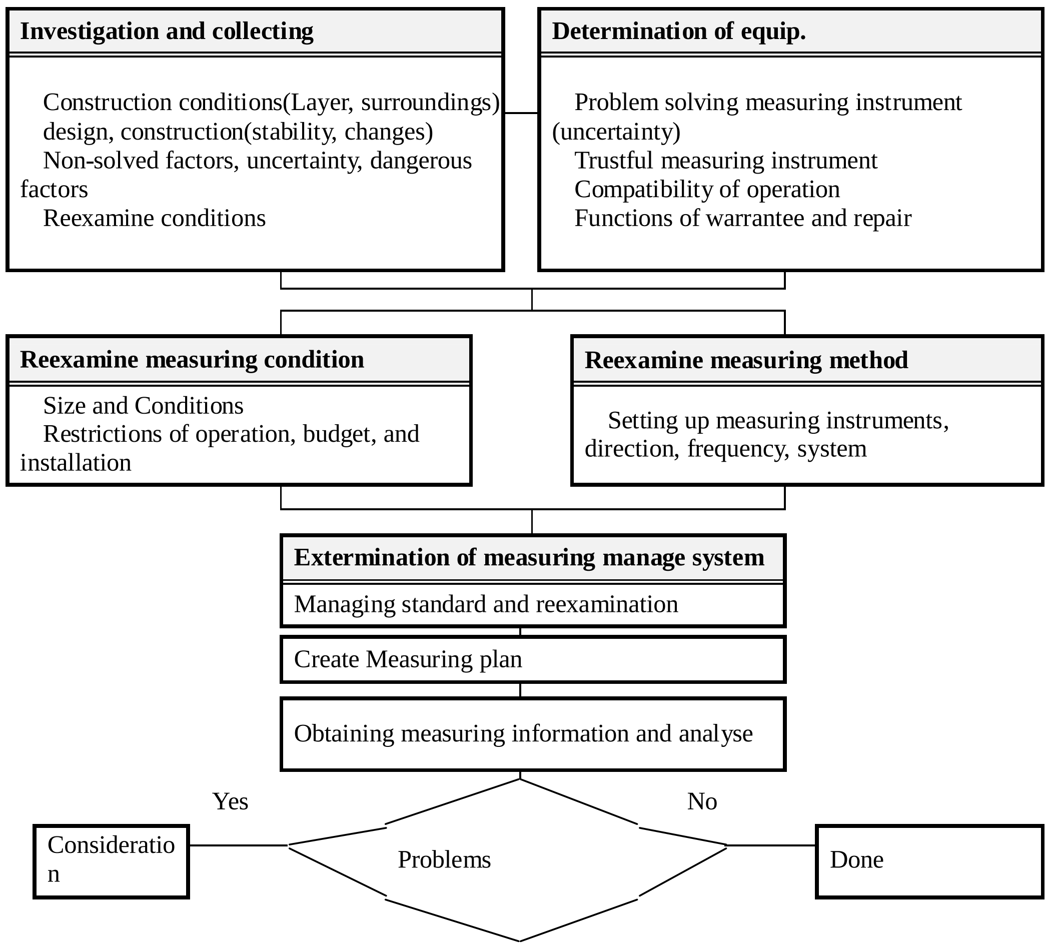


Fig. Annex- 40 Measuring management flow



4.7 *Environmental management*

Regular measurement is required not to be affected by wastes, water, gas, and to have prior counter plan.

Currently the running dumping site in Lahore is a simple dumping ground, which has the threats of water pollution, air pollution and land pollution since there's no appropriate anti-pollution facilities.

However, as residents became aware on environmental issues, especially on the effects of simple dumping, the need for environmental protection also became an issue. Also, management and monitoring of pollutants became more important.

Factors of wastes reclamation affect environment

Water pollution from leachate, fire from gas, offensive odor, and death of plants

Offensive odor from wastes reclamation

Noise, and a quake from reclamation facilities and vehicles

Infestation of harmful insects and animals

Pollution of reclamation area with arsenic acid

Therefore, Lahore needs to have projects concerning leachate, water, gas, odor, noise and quake control.

5. Operating guidelines after waste reclamation is completed

Even after reclamation, leachates and gases are continually produced under ground.

Leachate contains not only pollutants but also heavy metallic substances. The gas mostly consists of methane and Co2 or harmful chemical compounds, making it highly flammable.

In order to protect the environment, even if after all the processes, constant monitoring and management is required to prevent future problems.

Like Lahore, Korea also used to dump wastes into small mountains and ground. This caused the second environmental (offensive order, polluted leachate) problem to become a serious issue. This issue brought huge protests by people near the area.

The standards of building reclamation facility should be tightened and must be enforced by law to maintain and take a good care of reclamation areas and that noone will suffer any disadvantages.

Basic way of taking care of a completed reclamation

After finishing all the process of reclamation constant monitoring is until the time of stability.

Use of upper ground for practical uses (safety of structures, managing sinking)

Check neighbors regularly after reclamation (Quality of surface water, quality of under ground water, ground, air)

Monitoring, maintaining and managing can create high efficiency of using facilities, understanding future problems.

A goal of post-management

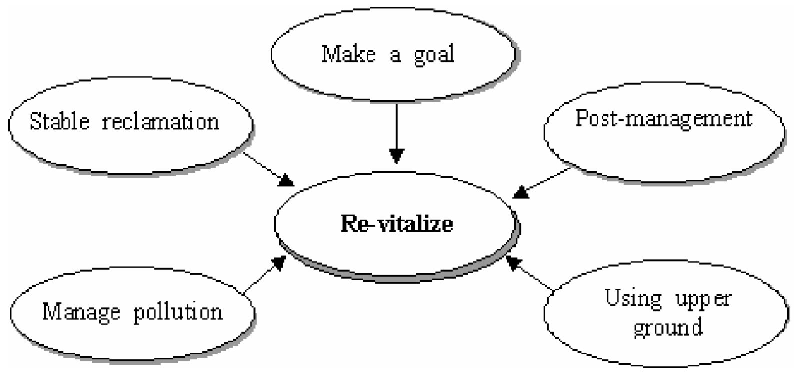
Since Korea rules these listed post-management skills, let's take a look and try to establish post-management skills to Lahore.

Time Limits: Within 20 years after reclamation

Area Limits: Indoor facilities of reclamation, within 2km radius

Post-Management factors: Elimination management, structures and layer, manage the top layer, leachate, gas, neighbor environment. (Quality of stream, quality of underground water, ground, air, etc)

Fig. Annex- 41 Goals of post-management



Process of Post-Management

In order to have successful Post-Management, it is recommneded to follow steps below. By re-constructing post-management goals, creating efficient and economic post-management is necessary, (5 years each after reclamation).

Fig. Annex- 42 Step of post management flow

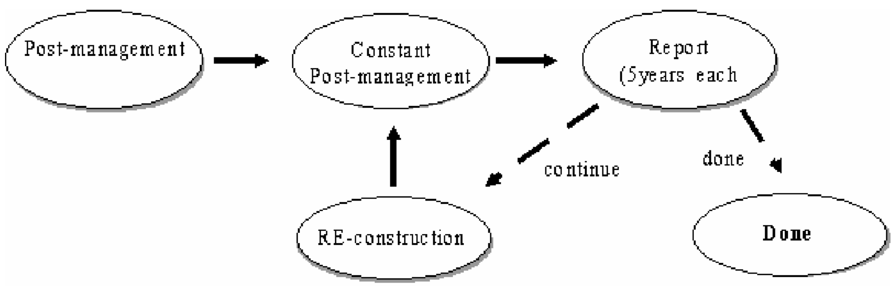


Table. Annex- 33 Environmental problem

division	Explanations
Effect of the gas	explosion may occur. compulsive injection system should be established. ventilation system should be built.
The instability caused by the structures underground	sinking might occur, influencing the structure above. It cab be serious. The final molding layer might have a crack which can be an opening for the gas to let out
Drainage facilities	drainage facilities might get polluted with the gas extricated.
Safety of the slope	The slope can be a factor threatening the stability of the soil
Interference with the underground structures	The soil bearing decreases and it can cause damage to facilities

Table -81. Standard of judgement by period

Year		0~5yrs	5~10yrs	10~15yrs	15~20yrs	More than 20 yrs
Standard of using	Sinking					
	Leaking Gas					
	Leachate					
	Dusting metal					
	Living					
	Change of Factor					
	Necessity of managing reclamation					
Possibility		Green field, Play ground				Houses, Bulding, Factoried

Note: : Occurs quick. : occurs a little. : No problem.

Fig. Annex- 43 Examples of using upper ground (Korea)

Annex-15. Making resources from the food waste

Food waste includes agricultural goods, sea goods and farm products out of date. In Lahore, the food waste is about 30.7%(about 1,535tons/day) of the total wastes. 500 tons of food waste is taken care of in fertilizing systems but it is not enough. Therefore, the technology in Korea and other major developed countries should be considered as reference for the system in Lahore.

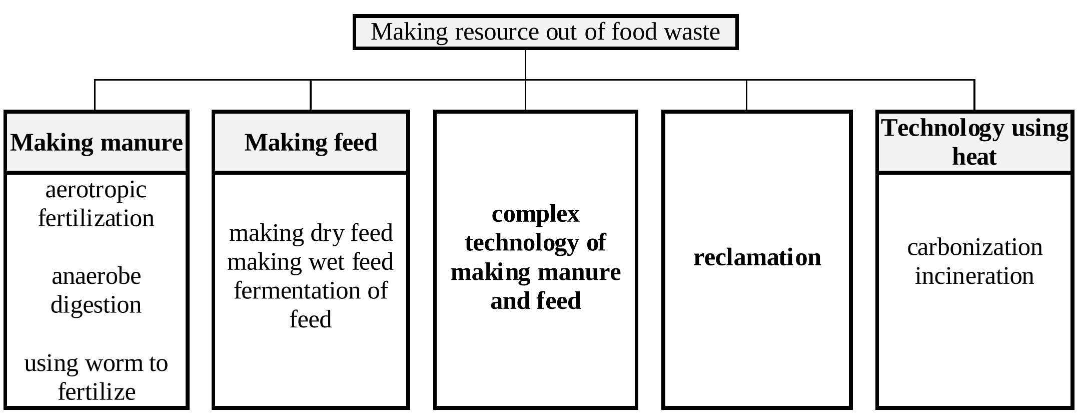
The following is the tendency in Korea.

[Tendency of dealing food waste in Korea]

The waste in Korea has increased significantly with the industrialization and the food waste, which forms most of the waste from life hood is becoming a problem. Korea first dealt with reclamation but this has caused environmental problems. They then minimized all the economic cost by recycling. Feed production of out a food wastes became a main part of dealing with waste problem but the demand for feeds has been decreasing. The country then sorted to using the wastes as a source of energy, where the demand is increasing and the related technologies has been improving.

Making resources out of the waste is another way of recollecting energy from wastes. The most suitable model for Lahore can be chosen by looking through these processes.

There are many methods and their features are similar to the following:



technology of making **manure by absorbing foul waste**				

1. Composting Technology

Introduction

Composting is lessens the weight of the wastes or converts the wastes into soil conditioner by using aerobic bacteria to decompose the organic. This technique is used widely throughout the world because of its effectiveness in terms of time as well as convenience in mixing up with other materials.

The technology can be classified as aerobic composting and aerotropic digestion, according to the need of oxygen.

Another way of making manure is Earthworn or Vermin composting where food wastes and foul water are decomposed in a digestive pipe.

The largest variable of making compost is to get a persistent supply because of salt. There is, however, a negative effect of this method, increase in soil acidity.

The basic principles of making compost and the index of compost

The basic principle of making compost is like the following.

aerobic waste **(food waste)**	fermentation· decomposition ð (bacteria)	decomposition reaction (weight loss, becoming harmless) stabilization (secondary decomposition and eliminating the odor) restoring to the soil(improving the structure of soil)

Making compost is a way of stabilizing organic wastes by the actions of bacteria. Maintaining proper conditions to support the activities of these bacteria is there a very important matter. The final quality of compost and safety is determined by the percentage of waste being decomposed based on the index of compost.

C/N ratio:

This shows the proper nutrients bacteria use and shows the features of the organic matter, showing information of how much food is being supplied per each organism.

Bacteria consumers one carbon per 15-30 units of nitrogen during the process of decomposition. Ideal C/N ratio should be initially about 20~30. A gradual decrease in this ratio is a very sensitive index in the progress.

When the C/N ratio is low, the nitrogen is oversupplied in the form of ammoniac acid and deters the action of bacteria. When the C/N ratio is high, there is not enough to get the progress done. In this case, chemical fertilizers (uric acid, ammonium sulfate) or excreta can be added.

Generally, the proper C/N ratio is about 5~20 and when the ratio is high the nitrogen might catch fire; also when the ratio is low, the nitrogen goes through the robbing phenomenon which harms the plants.

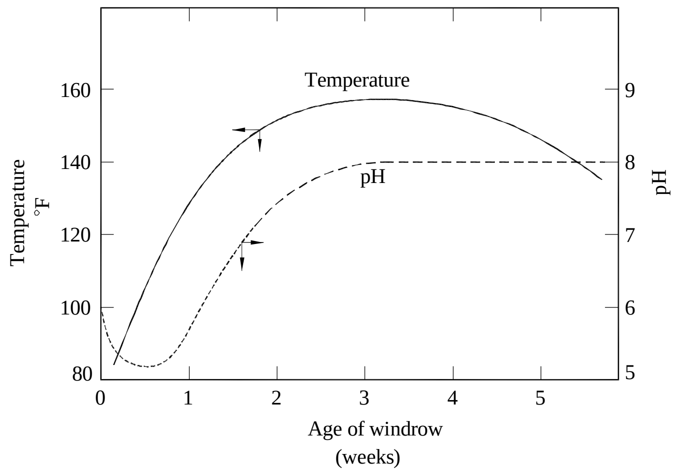
pH :

Bacteria is active in the range of pH 6~8, so it is recommended to keep the pH neutral during the process. Adding calcium hydroxide might help to keep the wastes from becoming acidic.

Temperature:

Temperature is a good measure of showing the progress of compost production. When temperature goes down slowly to about 40~45, it can be a sign that the process has finally ended. However, temperature may also decrease even when the material is not yet fully decomposed. This happens when the waste has become too wet and inhibits the supply of air.

Fig. Annex- 44 The change of temperature and pH in the composting technology



Moisture content:

For anaerobe method, the percentage of water should be 80~90% while for aerotropic method the percentage of water should be about 50~60%. When the percentage of water goes up, the supply of oxygen is hampered and bad odor develops. The rate of decompostion slows down as well as temperature. When the percentage of water is under 40~50%, decomposition becomes hampered with fungi growth.

To maintain proper moisture content, the waste materials should either be covered or sprinkled with water from time to time. Also, briquette can be used to solve this problem.

Volatility :

It is indicating the percentage when the dry sample is ignited at 550. When the organic carbon is converted into CO_2 and CH_4 by bacteria, the density decreases to show the rate of decomposition.

Color and odor :

The waste is white at first then turns green and it finally becomes dark grey or brown after turning into compost. Foul odor will be observed but becomes more like that of the soil towards the end of the process. The odor is caused by actinomyces and Fungi. When the odor increases because high moisture content, turning should be done frequently to enhance oxygen supply.

Oxygen intake:

The rate of oxygen intake can not be estimated exactly. However, by mechanical means, oxygen output can be estimated to the progress of the process. A good level of oxygen in gas output is in the range of 14-17%. When gas output is below 10% oxygen, the aerobic decomposition stops. If the concentration of CO_2 is the index, it should be about 3~6%.

The index of completed manure

In the long term, when the temperature goes down, the composting has been completed. Other ways to check the progress are looking through the material to be decomposed in the waste or checking oxygen used.

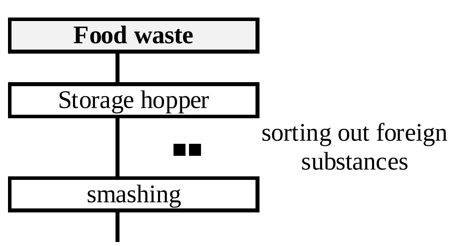
Controlling the composting process

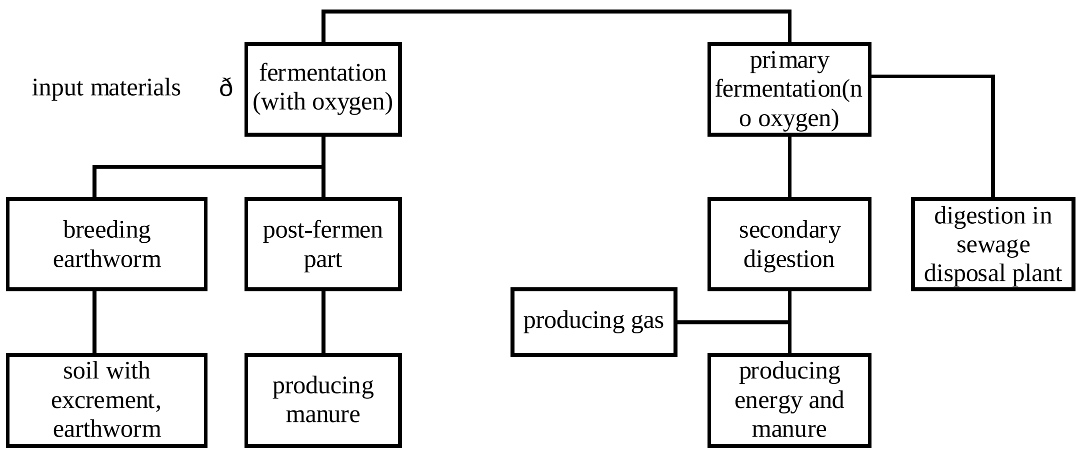
Controlling the composting process could include selection, crushing, storage, and wrapping. Crushing may take place after the process of selection and after composting has been completed.

Selection process excludes materials that can not be ecomposed. The bigger the surface of the materials for the manure, the lower the heat resolution rate. This makes crushing important. The size of the particle should be about 2.5~5 .

There are technology of making aerotropic manure, technology of making anaerobic manure, Earthworm Conversion or Vermin Composting and technology of making manure by absorbing foul water. We can find the most suitable guideline for Lahore by looking through each method.

Fig. Annex- 45 Flowchart for technology of making manure




input materials ð
fermentation (with oxygen)
primary fermentation(no oxygen)
breeding earthworm
post-fermen part
secondary digestion
digestion in sewage disposal plant
producing gas
soil with excrement, earthworm
producing manure
producing energy and manure

Composting technologies:

The process includes oxidizing and decomposing the organic matter with oxygen using aerotropic bacteria to reduce the weight, stabilize the remains, and produce compost for land improvement.

The ordinary method is an open system such as making compost on top of a platform while the closed system uses mechanical equipments. The former method prefers bigger particle to allow enough space for oxygen, while the latter uses a smaller particle to hasten the progress.

Composting on a platform (Windrow system):

The waste is packed in platforms where equipments get easy access. The platform should not be permeable to leachate.

The area needed is about 4 /100,000people in the U.S. The platform should be covered by a roof and there should be facilities that prevents water overflow in case of heavy rains.

The platform is needed to provide oxygen and to kill viruses by heating. When only solid waste is used, turning every 3 days should be enough to supply the required oxygen. When the material is mixed with sludge turning should be done every day.

There are two types of method to supply enough oxygen to the waste. These are Turned Pile System (turning over the ground) and the Aerated or Static Pile System (injecting oxygen compulsively).

In the Turned Pile System, turning allows the materials to dry faster. Large amounts of organic waste can be treated and a stable compost can be produced at a relatively low initial cost. However, the process needs large space and odor is more likely to be a problem. Moreover, the cost of management is high.

In the static pile system, the primary cost for establishment is also low. This system is effective in dealing with viruses and odor problem could easily be resolved. Similar to the Turned Pile System, this method is also sensitive to weather and requires greater space as compared to the the mechanical method.

Equipments that can turn the platform over is needed. When the platform is small bulldozer or a Front-end Loader can be used. For large platforms, the machine shown in Fig -73. can be used, which is capable of turning a windrow with a height of over 1.5m and width of 4.2m.

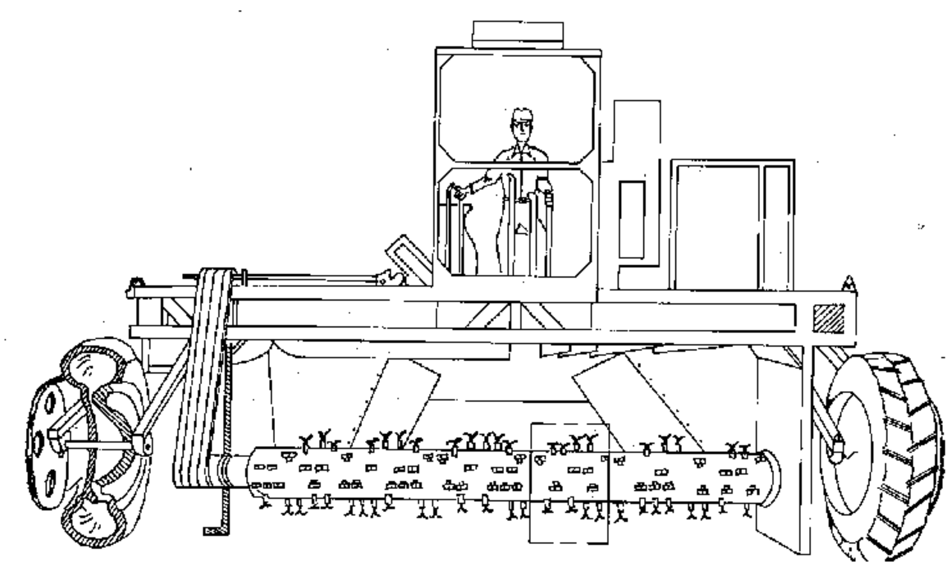


Fig -98. Special Equipment to turn over the manure (The Scrap, Windrow Turning Machine)

In the static pile method, air is both injected and sucked through metal boards placed under the platform. When taking out the water, air should be injected into the materials to decrease odor. In the U.S., the amount of air is known to be about 5 /min for a platform of 12m 6m 2.5m in height. To inject air effectively, the particle of the waste should be uniform in size and moisture should be limited. Also, papers are a cause of problem. The process controlled composting is similar to Fig -74. The time needed is at least 2 weeks. Also, the magnetic force and manpower are needed to remove metals and plastics from the compost materials.

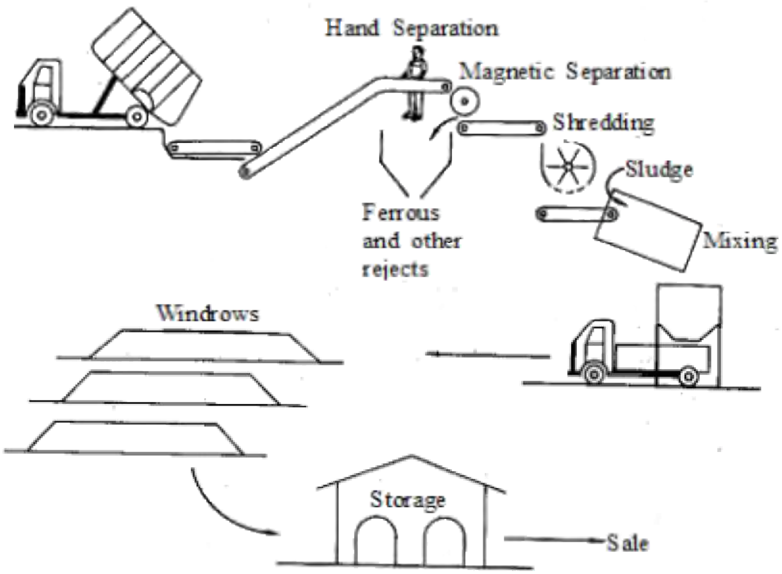


Fig -99. Example for technology of making manure out of waste

Mechanical or In-vessel system:

This method uses mechanical system from the beginning to the end. There are vertical and horizontal reactors. This method makes it possible to get the fertilizer in a short period of time. Also, it needs small space, not influenced by the weather, mechanically safe, and the materials can be effectively recovered to make many goods. However, the cost for establishment is expensive.

Anaerobic digestion:

This method stabilizes the organic matter from food wastes by using the anaerobic bacteria, which are active without oxygen.

In this process, the bacteria produce CH_2, CO_2, and N_2. (organic matter → manure + CH_2 + CO_2 + N_2)

The process undergoes 2 stages. Acid-producing bacteria convert organic matter organic acid. Secondly, methane producing bacteria converts the this product into methane, carbon dioxide, hydrogen sulfide and ammonia. Biologically stable remains can be obtained as well as all kinds of gas. The gas obtained from fermenting methane needs to be refined separately to make it suitable as an energy source. The remaining sludge should be dehydrated to and turned into compost.

Earthworm Conversion or Vermin Composting:

Oligochate annelids can eat food equivalent to its weight daily. This method is using this characteristics to make compost out of sawdust and rice hulls with the use of fermentation starter and certain portion of sludge. This mixture is then fed to the worms and the excrement is used as a fertilizer. The grown worm can be sold too.

The appropriate humidity (65~75%) and temperature(15~25) should be well maintained and the dehydration system should be taken care of to prevent foul odors.

Composting by foul water absorption:

This method is similar to aerotropic digestion. Food waste undergoes pre-treatment of acid fermentation stage before being fed into digestive stage in sewage disposal plant. This is fermenting with acid to supply the plant with a source of carbon.

Table. Annex- 34 Features of technology of making manure

Classification	Advantage	Disadvantage
Aerotropic Composting	§Compost recovery is high. §Easy maintenance due to simplified technology. §Easy to store, easy to handle §Large quantity of organic waste can be treated	§Generates foul smell. §When the chloride is oversupplied in the food waste, a good quality of manure cannot be produced. §aterials such as sawdust might be needed §requires a large space
Anaerobic Composting	§Produce biogas which contains 65% of CH_4 that can be used to produce heat and electricity §cost for management is cheap useful heat can be recovered §needs a small space and volume reduction effect is high(80~90%) . §sealed structure prevents odor from spreading	§needs to assure certain amount of organic compounds to be decomposed §needs professionals to operate §the cost for the establishment is high and the facilities are complicated §when the digestive system is damaged, long time is needed for repair
Earthworm/Vermin Composting	§Effective in reducing weight §not much odor problem	§primary breeding is difficult, needs a large space §
Composting by foul water absorption	§when integrated with sewage sludge ,CH_4 gas can be collected back §market for by-product can be easily found. §maximum use of facilities in sewage disposal plant is possible §when connected with sewage disposal plant, by-product can be easily consumed §cost for equipment and management is cheap	§only adaptable near sewage disposal plant §surplus of sludge in sewage disposal plant increases §load on sewage disposal plant increases §not effective compared to manure technique or feed technique §

Table. Annex- 35 Products by different types of technology,

	Product	Percentage decreased	examples of technology applied to
technology of making aerotropic manure	manure	70~80%	§ Seoul Gangdong, Busan Busan Jin-Gu, Daejon, Ulsan Joon-Gu, Suwon, Incheon NamDong-Gu, Ansan, Umsung, Jincheon, Chunan, Chilgok, Jeju Island
technology of making anaerobic manure	manure, methane gas	80~90%	§ Daejon Yoosung-Gu, Euiwang, Paju
Earthworm Conversion or Vermin Composting	manure	-	§ Ulsan Joong-Gu, Yeoju, Kweisan
technology of making manure by absorbing foul water	fermente d product of acid	-	§ Seoul Seonam sewage disposal plant, Busan Dongrae sewage disposal plant, Daegu Shinchun sewage disposal plant, Ulsan Nam-Gu sewage disposal plant, Kyungki Guri sewage disposal plant

2. Feeds production

This technology produces animal feeds from the sterilized food wastes. The methods are classified into drying and fermentation. The percentage of water in the feed detyermines whether it is dry feeds, wet feeds or fermentation feeds.

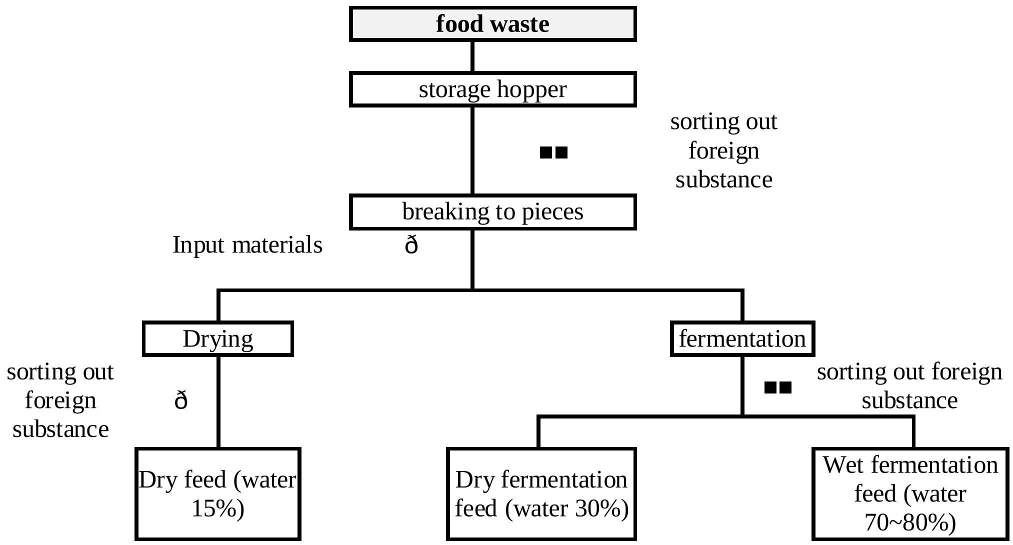
Animal remains and food wastes are broken into pieces, heated with steam, and checked for foreign substances in the process. However, quality and safety is an issue when it comes to long storage.

Feeds should not have any toxic materials or virus. Also, feed should be nutritionally balanced, good for digestion, not likely to decompose and good provider of high quality meat for animals.

Feeds production facility is effective when established near farmhouses. The initial and operation cost is also low. Quality and safety of the feeds are important so it is necessary to keep its sanitation as secondary wastes can be generated when sorting out foreign substances. It needs quick collection, transportation and process. It needs sterilization to get rid of harmful microorganisms. The problem is it is hard to store for a long time and is easily spoiled during summer time. For these reason, a suitable market is not easy to find.

Feeds can be produced using dry feed technique, wet feed technique, and fermentation feed technique. Thorough examination of these methods may help select the method most appropriate for Lahore.

Fig. Annex- 46 Flowchart of technology of feed



Dry feed technique

In this method, moisture content is reduce down levels below 15% using the heat and energy. The drying could be accomplished using hot air, vacuum drying, infrared rays or by dehydrating with heat and oil. This technique reduces the volume to 1/5 making transportation and storage easier. Dry materials also make mixing with other feed easier. Furthermore, sanitation is also improved because of sterilization effect during the process.

Hydrometallurgy feeding method:

Food trash containing moisture is sterilized by heating up to 80-140C and then fed to cattle. This method is used in farmhouses because it is both practical and economical.

Fermentation feeding method:

Mixture of many different kinds of microbes and enzymes use as cattle's feed. Differed to dryness fermentation, to hydrometallurgy fermentation.

Table. Annex- 36 Feature of feeding technology

	Advantage	Disadvantage
Dry feeding system	Ease of shipping and handling Low-cost of facility and sanitary Can produce High-protein feed Only small area is required Takes little time Efficient Feeds can be stored for a long time and doesn't spoil easily.	Limited control on nutritional value. Offensive odor. Not sanitary Hard to find suppliers
Hydrometallurgy feeding system	Low-cost of facility Good for cattles and pigs Low possibility of secondary pollution Simple setup and can be run in normal farmhouse Requires only a small area. Easy to operate and requires less time	Hard to differ excision Need to sort out badly decayed food Hard to ship due to lots of hydrogen Offensive odor Needs supplier near the area Hard to find suppliers

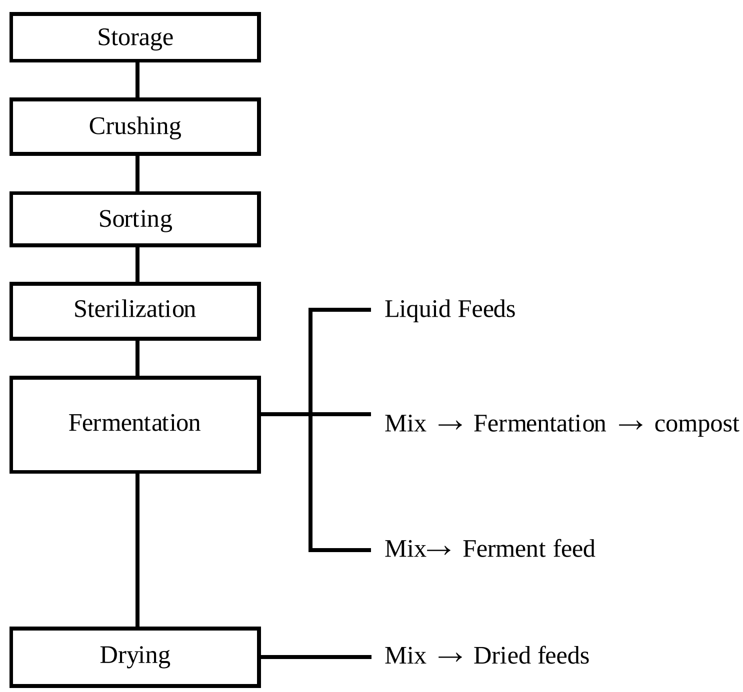
Table. Annex- 37 Product of feeding technology, reduction rate, and application examples

Class	product	Reduction Rate	Examples
Dry	Feeds	80~90%	Gang-dong, Do-bong, ul-jin, gwang-ju Ha-nam ,Asan, haewoondae Busan
Hydrometallurgy	Feeds	Less than30%	Go-ryung, won-ju, dong/seoGu Inchon, sugwipo-Jeju, pyung-taek, An-sung

3. Feeds and compost compound technology.

The complex method has its advantages of being able to produce both feeds and compost at the same time. The disadvantages, on the other hand are the high cost and complexity of the facility, the need for professional skills, the need for a wider area, and the technologies should be well tested and proven. The rate of material reduction ranges from 80 to 90%. An existing facility is currently operated in Go-Yang-si Korea. The following diagram shows the complex way of producing feeds and composts from wastes.

Fig. Annex- 47Diagram of feeds and composts progress



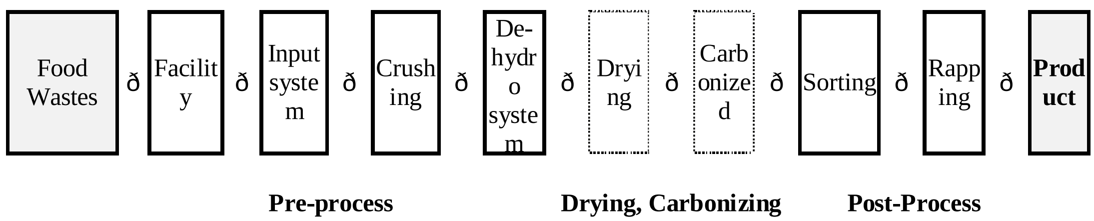
4. 4. Reclamation

Reclamation is the final destination of mixed food trashes which can no longer be recycled. This does not produce secondary wastes and relatively inexpensive. However, this method produces methane gas and offensive odor.

5. Carbonization

Carbonization is the process transforming waste materials into dry carbon granules with the use of heat. Without the presence of air, the dried wastes are converted into solid fuel. The carbonization process heat food wastes to 400~500 C at a low or zero oxygen condition. Fuel costs can also be reduce because gases can be collected during carbonization. Carbonized products can be stored for a long time, It uses simple principle, needs less time to set up and cheaper. However, chlorine is a problem during the burning process. The technology is not yet proven having no pre-examined examples yet. The process requires lots of fuel drying dry and reducing offensive odor during the process. In addition, the efficient of handling the materials is low. The final product is charcoal which is over 90% lighter. An existing facility is currently running in Kyung-san prefecture in Korea. The following is a process diagram of carbonization.

Fig. Annex- 48 The Procedure of cabonization

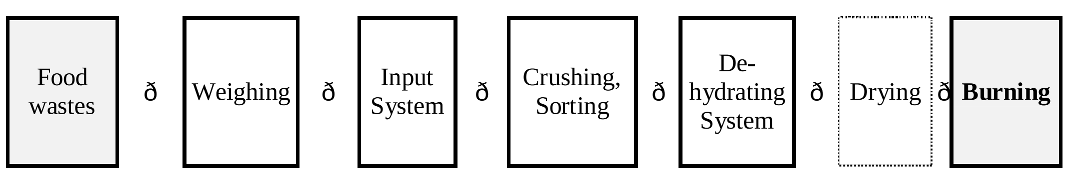


6. Incineration

This method reduces wastes into ashes by burning. Due to the amount of heat produced, the process can be used to run boilers. Waste can also be burned with fossil fuels such as coal to provide the necessary heat in power plants. Incineration has very high reduction rate, requires less energy input, does not need wide area, and can generate useful energy in the form of heat.

However, chlorine in food is transformed into dioxin during the process. In addition, lots of fuel is required when burning wet wastes. Reduction rate of burning is about 75%. An existing facility is currently running in Gwang-myung si, Korea. The following is a process flow diagram of incineration.

Fig. Annex- 49 Procedure of incineration



7. Standard guidelines for handling of food wastes.

Currently there is no clear rule regarding disposal of wastes in Lahore, hence, the need to create standards in this aspects.

Developed countries, including Korea, desire to establish a standard in handling food wastes to efficiently dispose wastes and avoid negative effects to the environment.

Korea

Food wastes are put into separate bags or containers.

Waste problem is addressed by reduce, recycle, and burn.

Waste moisture is reduced to levels below 25% by drying or fermentation.

Recycle

Food wastes from overseas are burned. (Air, Ship)

Food wastes from the communities are not disposed off directly. Recyclable materials, if there are any, should first be recovered.

By using bionic disposal facility, or worm breeding system, quality of lands can be improved. The following table shows a standard of land quality.

Table. Annex- 38 Standards of material sources and end products, Korea

List		Grade	
		Ga Grade	Na Grade
Harm Factors (/)	As	Less than 50	Less than 50
	Cd	Less than 5	Less than 8
	Cr	Less than 300	Less than 370
	Cu	Less than 500	Less than 750
	Pb	Less than 150	Less than 225
	Hg	Less than 2	Less than 3
Orgarnic Factors,		over 25% , Less than 50	over 25% , Less than 50
NaCl		Less than 1%	Less than 1%
Option		No higher than 20 room-temperature	

Table. Annex- 39 Composting standard of Japan

List	Grade

	Superior	1st Grade	2nd Grade
T-C (%)	40 ~ 45	45 ~ 50	15 ~ 50
T-N (%)	over 1.7	1.2 ~ 1.7	Less than 1.2
C/N Ratio	20 ~ 25	Around 30	Less than 35
T-P (P_2O_5)	over 0.8	0.5 ~ 0.8	Less than 0.5
T-K (K_2O)	0.3 ~ 0.5	0.3 ~ 0.5	Less than 0.3
T-Ca (CaO)	over 5	4 ~ 5	Less than 4
T-Mg (MgO)	over 0.3	0.2 ~ 0.3	Less than 0.2
pH	7.5 ~ 8.0	6.0 ~ 7.5	6.0 ~ 7.0
CEC	over 80	70 ~ 80	Less than 70
Hydrogen	Around 60	Around 60	Around60
Experiment of small plant	Not Harmful	Not Harmful	Not Harmful

Table. Annex- 40 Restriction of the best quality compost (MSW) in U.S.A

Elements	Restrict density (/ dry weight)			
	New York	Minnesota	Florida	Maine
Pb	250	500	500	700
Cu	1,000	500	400	1,000
Cd	10	10	15	10
Zn	2,500	1,000	900	2,000
Ni	200	10	50	200

Table. Annex- 41 Quality of compost by grade, Florida, USA

Contaminant	Florida State						
	MO(Mixed Organics)					Y(Yard waste)	Y and MO
	Type A	Type B	Type C	Type D	Type E	Type Y	Type YM
Cd(ppm)	15	20	100	100	100	15	15
Cu(ppm)	450	900	3,000	3,000	3,000	450	450
Ni(ppm)	50	100	500	500	500	50	50
Pb(ppm)	500	1,000	1,500	1,500	1,500	500	500
Zn(ppm)	900	1,800	10,000	10,000	10,000	500	500
Inerts(%)	2	4	10	10	-	2	2
Organic Matter (min %)	>25	>30	>35	>35	-	2	2
ROM(%)	>60	>40	>40	>20	-	>40	>40
Particle Size( )	10	15	25	25	-	25	25
Maturity	Mature	Mature or Semi	Mature or Semi	Can be fresh		Mature or Semi	Mature or Semi

Note: Type A, Y, YM : No limit

Type B : Uses in commerce, agriculture, and public institutions.

Type C : Limits where have chance to meet people.

Type D, E : Used in reclamation or recovery.

Table. Annex- 42 Limits for sludge EPA and standard of NYDEC

Contaminant	NYS DEC Sludge & Class II Compost limit1 (ppm)	NYS DEC Class Compost limit2 (ppm)	EPA503 EQ limit (ppm)	NYS DEC Cumulative limit (lb/ac~ /ha)	EPA 503 Cumulative limit (/ha)
As	None	none	41	none	41
Cd	25	10	39	3/4	39
Cr	1000	100	none	300/446	none
Cu	1000	1000	1500	75/112	1500
Pb	1000	250	300	300/446	300
Hg	10	10	17	none	17
Mo	None	none	none4	none	none
Ni	200	200	420	30/45	420
Se	None	none	36	none	100
Ti	None	none	none	none	none
Zn	2500	2500	2800	150/223	2800
PCBs	10	1	none	none	

Note:

(1) Part 360-4.4 limits for sludge and seepage which can be applied to field crops. Also applicable to Class II composts and sludge products may not be applied to food chain crops.

(2) Part 360-5.3 standards for Class I composts and sludge products, which may be applied to crops except those for direct human consumption.

(3) Part 360-4.4 (g) Amount that may be added over time. Lower number applies to Ag Soil groups 1-3, higher number to groups 4-10. Does not apply sludge products.

(4) Limits for molybdenum were deleted from U.S. EPA rules pending reconsideration.

Table. Annex- 43 Composts level by quality standard in Canada

		Density Code				Restricted Density (/ha)
		Code 1	Code 2	Code 3	Code 4	
Restrict elements (ppm)	As	< or = 13	> 13-30	> 30-50	>50	15
	Cd	< or = 2.6	> 2.6-5	> 5-20	>20	4
	Cr	< or = 210	> 210-250	> 250-800	>800	
	Co	< or = 26	> 26-50	> 50-300	>300	30
	Cu	< or = 100	> or = 100	> 100-500	>500	
	Pb	< or = 150	> 150-500	> 500-1000	>1000	100
	Hg	< or = 0.8	> 0.8-2	> 2-10	>10	1
	Mo	< or = 5	> 5-10	> 10-40	>40	4
	Ni	< or = 50	> 50-100	> 100-500	>500	
	Se	< or = 2	> 2.6-3	> 3-10	>10	
	Zn	< or = 315	> 315-500	> 500-1500	>1500	
Grade		A Type	B Type	C Type	D Type	
Ratio of mixture		Less than 1%	Less than 2%	Less than 10%	Less Than 10%	
Purpose of the use		Suitable to create high Quality products such as home garden	Suitable for land develop work such as woods or park	Suitable to restricted areas such as business plant, factories	Dump to permitted Area	

Table. Annex- 44 Compost level by quality standard in Europe

Items	The Netherlands			Belgium			France	
	Compost	Clean Compost	Very Clean Compost	Agriland	Parkland	SSMO	Class A	Class B
As ppm)	25	15	5	-	-	-	-	-
Cd(ppm)	2	1	0.7	5	1	8	8	3
Cr(ppm)	200	70	50	150	200	70	-	-
Co(ppm)	-	-	-	10	20	-	-	-
Cu(ppm)	300	90	25	100	500	90	-	-
Hg(ppm)	2	0.7	0.2	5	5	0.7	8	8
Mo(ppm)	5	-	-	-	-	-	-	-
Ni(ppm)	50	20	10	50	100	20	200	200
Pb(ppm)	200	120	65	600	1,000	20	200	200
Zn(ppm)	900	280	250	1,000	1,500	280	-	-
Inerts(%)	-	-	-	-	-	-	20	35
Glass	-	-	-	-	-	-	6	12
Plastic	-	-	-	-	-	-	0.5	1.2
ROM(%)	20	20	20	40	40	-	-	-
Particle size( )	-	-	-	-	-	-	11.2	-

Note: SSMO - Source Separated Mixed Organic, ROM - Reduction in Organic Matter

Table. Annex- 45 Standard of organic composts in Europe and U.S.A

Elements	The Netherlands	Belgium	France	Australia	U.S.A	Canada
As		-	-		-	
Cd, Ni, Pb						
Cr			-		-	
Co	-		-	-	-	
Cu			-			
Hg					-	
Mo		-	-	-	-	
Zn			-			
Se	-	-	-		-	
Inert Matter	-	-		-		-
Glass, Plastic	-	-		-	-	-
Organic Matter(min %)	-	-	-	-		-
ROM(%)			-	-		-
particle size( )	-	-	-	-		-
Maturitity	-	-	-	-		
DDT/DDD/DDE	-	-	-		-	-
Aldrin, Dieldrin, Chlordane	-	-	-		-	-
Heptachlor, HCB, Lindane,						

BHC						
PCBs	-	-	-			-

8. Operation example of food wastes in Korea and developed countries

For the purpose of determining which food wastes treatment is most applicable to Lahore, this paper will look into food wastes practices in Korea and other developed countries.

8.1 Korea

The facility of food wastes in Korea is getting larger. Turning wastes into feeds and composts were equally accepted in the past. Currenly, composting has become more widely accepted than turning the wastes into feeds. For large facilities with over 100 tons/day capacity, wastes are used as fuel.

Table. Annex- 46 Running facility examples of food wastes in Korea

Method		Name	Capacity (ton/day)	Cost (Million$)
composts	Aerobic composts	Seoul Nanji-do compost facility of food wastes	15	1.8
		Seoul Gang-dong compost facility of food wastes	30	5.9
		Inchon Namdong industrial complex	60	1.1
		An-san Food wastes dealing facility	70	-
		Dae-jeon Food wastes dealing facility	24	1.2
	Anaerobe burning	Ei wang Food wastes dealing facility	15	2.5
		Dong-hae Food wastes dealing facility	10	1.6
	Heating dry	Busan Food wastes dealing facility	30	1.4
	Vacuum dry	Nam-gu compost facility of food wastes	15	0.6
Feeds		gwang-ju feeds facility of food wastes	10	0.5
		Bu-chon feeds facility of food wastes	50	-
		gwang-ju buk-gu feeds facility of food wastes	150	3.1
		In-chon feeds facility of food wastes	20	-
Complex Composts/feeds		Ulsan feeds,and compost complex facility of food wastes	50	2.4
Merge		Dae-gu	98	6.0
		Ulsan namgu	40	3.3
		Seoul gang dong	20	1.0
		Busan	120	5.0
Breeding worms		Yeo-ju breeding worm facility	100	1.9
Carbonized		gyung-san	60	3.2

8.2 France: OTVD & Siloda

An initial process reduce the sizes of compost materials. These materials are then fed into a stable horizontal vessel which conveys the materials into a mixing chamber/vessel. The final products are produced in the last container.

-Used in Minnesota U.S.A.

Siloda pedals are added into IPA. Crushed compost materials move to Bay conveyor.

-Used in Europe, Middle East Asia, and Minnesota in U.S.A.

8.3 Denmark: DANO

A European system developed in 1933 and is most widely used as a composting technique.

-Used in Rome in Italy, and U.S.A

8.4 Switzerland: Buhler

This a conventional method which adds crushing and feeding before the main processing

Crushed compost materials are screened using a spinning drum. The screened materials then undergo fermentation in the ground, which has an aeration system.

-Used in About 100 countries,

8.5 Germany:

D.U.T

This is a quick anaerobic composting method which includes gas collection in the process. Microorganisms produce biogas, an alternative source of energy. Waste water is also reused after filtering.

-Using in Singen Germany

Weiss Bioreacter

Sludge compost materials are fed into a vacuumed cylindersilo, where controlled fermentation is conducted until maturity. Aeration is provided from the bottom to deal with bad odor.

-Used in U.S.A, Japan, and more than 35 countires in Europe.

8.6 U.S.A

Earp Thomas

Composts and microbes are fed into 8-10 pipes from the top, and remains inside for 1-3 days. This setup facilitates the supply of oxygen. After fermentation, maturity is achieved using the typical composting technique.

-Used in Heidelberg, Germany.

Eweson Digester

This method makes use of a long horizontal drum with 3 chambers. The materials are moved through the chambers after staying for a week in each. Inoculation is applied at the rate of 15%.

-Using in Sevier Tennessee, U.S.A.

Farifield Hardy

Materials are mixed and aerated within a ferroconcrete vessel which has a spinning screw at the center and aeration components at the bottom.

-Used in Wilmington Delaware, U.S.A.

International Process

The materials are fed into a Bay, about 60~70m, and mixed or turned once a day. after the process is completed in 3 weeks.

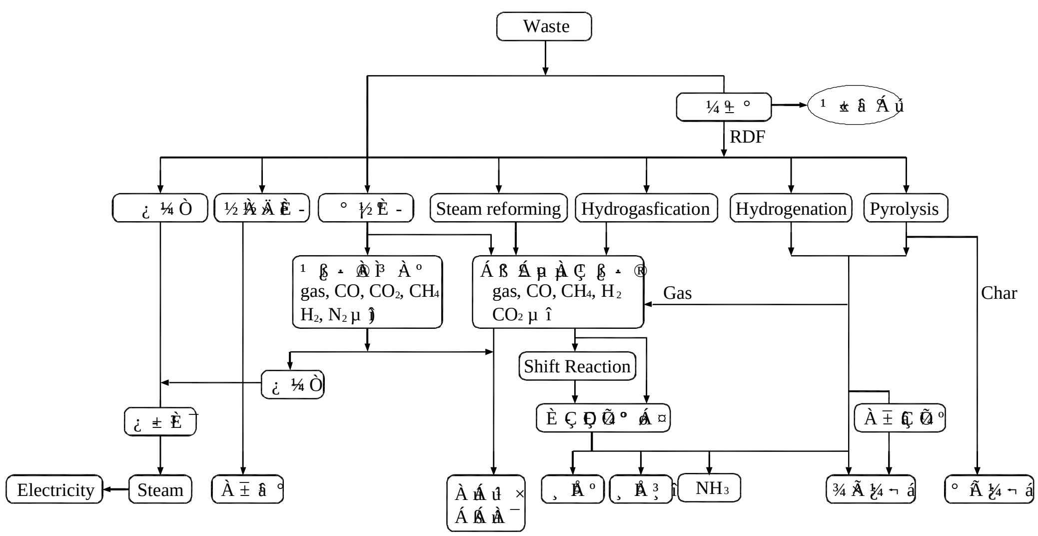
-Using in Anheuser Busch Brewery NY, U.S.A

Annex-16. Combustion and Pyrolysis

1. Combustion

Combustion is a technique which can produce energy from burning wastes. Heated oxidation and combustion is achieved with the supply of compressed air. The whole process involves drying, gasification, and heated oxidation. The products of combustion are CO_2 and H_2O, provided there is sufficient supply of oxygen and the temperature reaches up to 850 to 1200 degree Centigrade. It is important to supply the process with compressed inorder to avoid the production of tar and other undesired products. Also, heat energy from exhaust gas can be recovered using a steam boiler system.

Fig. Annex- 50 Techniques of combustion and pyrolysis



Combustible materials are first crushed and burned before being burned. Non-combustible materials are recovered from the burner. The gaseous products are released into the atmosphere.

Condition of combustion

Combustion is a high temperature combustion with the following chemical equation:

$$Combustible\ Materials + Oxygen \rightarrow CO_2 + H_20 + SOx + Cl + Heat$$

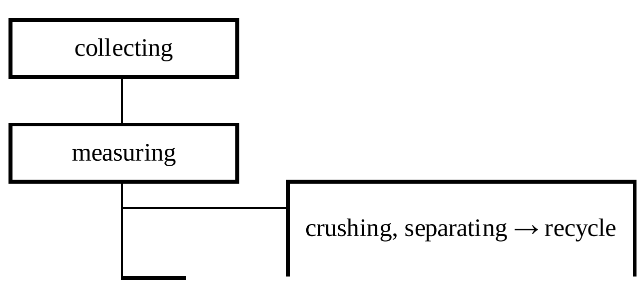
In order to attain a perfect combustion, temperature, time, turbulence (3T), and oxygen supply should be taken into consideration.

- § Oxygen: Amount of oxygen needed for perfect combustion can be estimated using the formula C + O_2 → CO_2 + H_2O. Oxygen is present in the air at 21% by volume and 23.15 % by weight. Shortage of oxygen will result to an incomplete combustion.
- § Temperature and time: Combustion temperature is affected by surrounding temperature, moisture content of the materials, supply of air, and shape of combustion turbine. If the temperature is too high, more air is required to cool down the process in order to prevent the formation of NOx. On the other hand, low combustion temperature will result to offensive odor due to HC, CO.

Energy can be recovered from the process by producing steam, which is more efficient at about 870C. The steam boiler capacity can be reduced when the system is efficient. When there's too much moisture in wastes, the temperature will be lower. If the temperature is high, usually takes short time so the burning time would not be important.

- § Turbulence: Created by air passing through a turbine. Gas leak problems can be resolved by installing baffles.

Combustion system is subdivided into heating facilities, pollution prevention facilities, and heat recovery facilities. The following is the process flow diagram of combustion. Collected energy can be used in processes that require heat. The metallic materials can be sold.



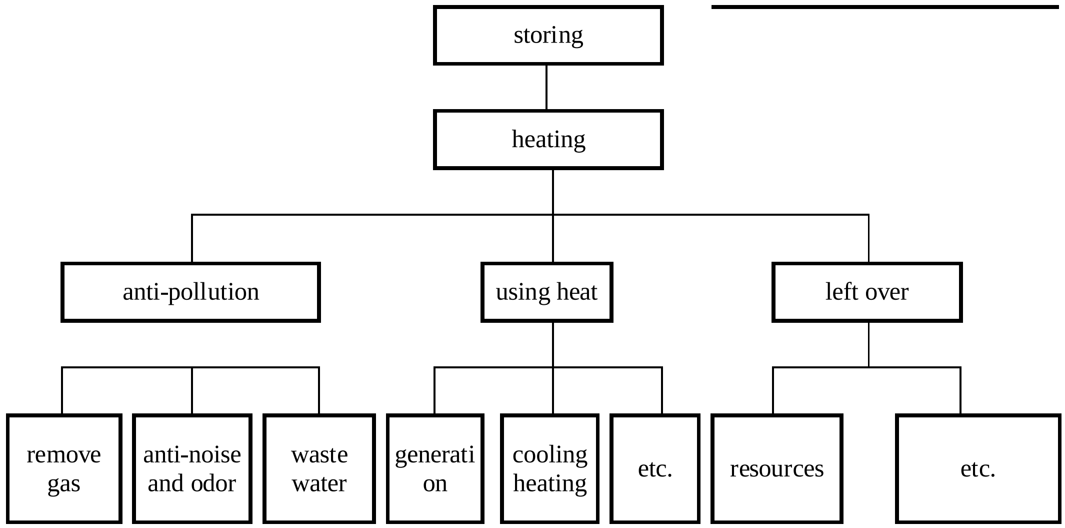
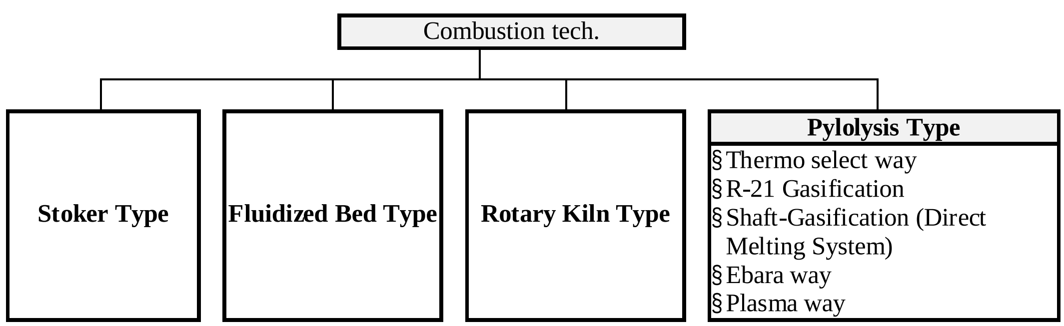


Fig -105. Process of combustion

In the early days, combustion was a simple burning method conducted by batch. Nowadays, as quality, and quantity of wastes are higher, stoker type, fluidized bed type, and rotary kiln types are created. Among those techniques, Stoker type is most widely used all over the world.

Combustion has the advantages of reduced transportation cost, less wastes, metallic matters recovery, and not affected by weather. However, the operating cost is high and there is great pollution potential. Its implementation is determined by social and environmental factors.

The different combustion techniques are the Stoker Type, Fluidized Bed Type, and Rotary Kiln Type. The following diagram shows the characteristics of each technique.



Strength and weakness of combustion

Combustion is the most widely used method. It is more hygienic than reclamation. The wastes can be reduced to about 13-20% by weight or 5-6% by volume, This is more reduction compared to reclamation Transportation cost can be reduced since the materials are much lighter. Also, metallic materials can be collected and reused after burning. It is not affected by weather and can be operated 24 hours a day. On the other hand, the operating cost is high, plants are hard to find and the process could create pollution.

The facility should be located away from populated areas and there should be a very effective system in preventing potentially harmful materials from being fed into the process. Professional workers are needed to operate a combustion system.

2. Pyrolysis

Pyrolysis uses gasification process in low oxygen system. It needs 250~800°C. Pyrolysis is a heating operation. Indirect heat is needed to consume and produce energy.

Oragnic wastes could produce gases like H_2, CH_4, CO; solids such as carbon; and liquid such as tar. Pyrolysis can be affected by these substances depending on concentration, temperature, pressure, and other factors.

This natural gas is called SNG (Substitute Natural Gas). The elements of the gas product always differ depending on the waste materials and temperature. More SNG can be produced when the temperature is high. In the US, 12 kg of gas is produced at 470°C but only 24 kg is produced at 910°C.

Table. Annex- 47 Products and by-products of pyrlysis

Temperature	Total weight( )	Gas( )	Liquid Tar( )	Solid left over ( )	eg.
470	100	12.3	61.1	24.7	U.S.A.
635	100	18.6	18.6	59.2	Wastes
800	100	23.7	59.7	17.2	
910	100	24.4	58.7	17.7	

Source: Drobny, N. L., H.E Hull and R.F. Testiu, Recovery and Utilization of Municipal Solid Waste, U. S. EPA, SW-10C, Washington, D. C., 1971)

When temperature is high, H_2, CH_4, CO of SNG is higher, but there's no improvement over 800

Table. Annex- 48 Elements of SNG

Temp. Elements	470	635	800	910
H_2	5.56	16.58	28.55	32.48
CH_4	12.43	15.91	13.73	10.45
CO	33.50	30.49	34.12	35.25
CO_2	44.77	31.78	20.59	18.31
C_2H_4	0.45	2.18	2.24	2.43
C_2H_6	3.03	3.06	0.77	1.07

Source: Drobny, N. L., H.E Hull and R.F. Testiu, Recovery and Utilization of Municipal Solid Waste, U. S. EPA, SW-10C, Washington, D. C., 1971)

SNG created from pyrolysis can be supplie to households or factories. SNG can transported and stored easier. For long distance transportation, SNG can be converted into liquid.

Since the fuel from pyrolysis has high energy value, it provides relatively clean burning. The SNG facilities and equipment are, however, expensive. In Korea, this technique is not widely accepted because the wastes are mostly composed of food leftovers, which has low caloric value compared to papers and plastics.

3. Gasification

Gasification is first used in the production of charcoal. The process reaches up 800~1600 degrees and 45bar pressure. This process requires less oxygen than perfect combustion. This process creates an inert gas by using pure oxygen during burning. In this process, the energy from wastes is transformed to chemical energy gas (syngas), which can be used for operation itself. Usually, the difference between combustion and gasification is that the products of combustion are $CO_{2,}$ and H_2O while gasification is produce high-energy fuel..

4. Guideline to Establish the Standard of Burning Facility

Currently, some hospitals in Lahore have burning facilities. However, these facilities are simply operates burning since there are no clear rules.

In order to make these facilities safe and clean, there is a need to look into the standards of Korea's facilities and find out which type of facility is the most suitable for Lahore.

Temperature of exit, remaining time and bottom ash (Korea)

Classification	Pyrolysis Facilities	High-temp.	High-temp. Melt.
Temperature( )	over 850	over 1,100	over 1,200
Remaining Time(sec)	over 2	over 2	over 1
Bottom Ash (%)	below 10	below 5	below 1

Table. Annex- 49 Air-polluting factors exhausting permission standard in Korea

Factors		Unit	Permission	Factors		Unit	Permission
Gas	SO_x	ppm	Below 30(12)	Gas	Br	ppm	Below 5
	HCl	ppm	Below 30(12)		C_6H_6	ppm	Below 30
	NO_x	ppm	Below 80(12)		C_6H_5OH	ppm	Below 10
	CO	ppm	Below 50(12)	Particle	Dust	/S	Below 30(12)
	F	ppm	Below 2		Cr	/S	Below 0.5
	CS_2	ppm	Below 30		Cu	/S	Below 10
	HCHO	ppm	Below 10		Zn	/S	Below 10
	NH_3	ppm	Below 100		Ni	/S	Below 20
	H_2S	ppm	Below 2		Pb	/S	Below 0.2
	Hg	/S	Below 0.1		Cd	/S	Below 0.02
	As	ppm	Below 0.5		Smoke		Below 2
	CN	ppm	Below 10		Micro Dust	/S	Below 0.5

Note: ( )is Standard of Oxygen (O_2 %)

Table. Annex- 50 Dioxin exhaust permission standard in Korea

(Unit: ng-TEQ/N)

Dioxin Handling capacity/h	New Facility	Current Facility	
		2001. 1. 1 ~ 2005. 12. 31	2006. 1. 1 ~
Over 4 tons	0.1	20	1
2 ~ 4 tons	1	40	5
25 ~ 2 tons	5	40	10

6.5.4 Factors to Consider When Planning Burning Facility

When planning to have a burning facility, it's important to consider the type of facility, size of the plant and number of facilities.

Since there's no standard regarding waste burning in Lahore, it would be necessary to look into the standards of Korea and consider establishing burning facilities in Lahore.

Choosing Burning Facility

A type which can completely burn waste materials.

Reliable and durable to last for a long time.

Easy to operate and maintain.

Safe Facility with anti-polluting system

Inexpensive.

Choosing the Size

Fig. Annex- 51 Location

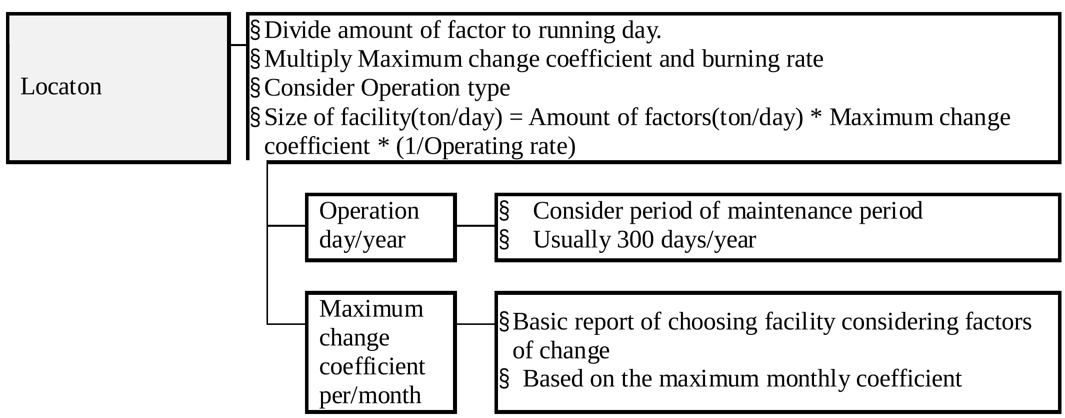


Table. Annex- 51

Classification		Area	Remark
Burning Facility	100ton/day	40 /ton	Below 4,000 /1 facility
	100~300ton/day	30 /ton	Below 3,000 ~ 9,000 /2 facilities
	300~500ton/day	20 /ton	Below 6,000 ~ 10,000 /2 facilities
	Over 500ton/day	10 ~ 15 /ton	Below 7,500 ~ 15,000 /2-4 facilities
Management	Below 500ton/day	330	35 ~ 50 workers
	over 500ton/day	500	50 ~ 70 workers
Etc.	below 500ton/day	330	

Over 500ton/day	500	
Building to land ratio	Below 40%	Standard of community

Annex-17. Waste recycling

To make recycling efficient and economical, it is important to be familiar with the basic waste treatment such as crushing, sorting, and compressing. Choosing the most suitable facility for Lahore can be based on these basic processes.

1. Crushing

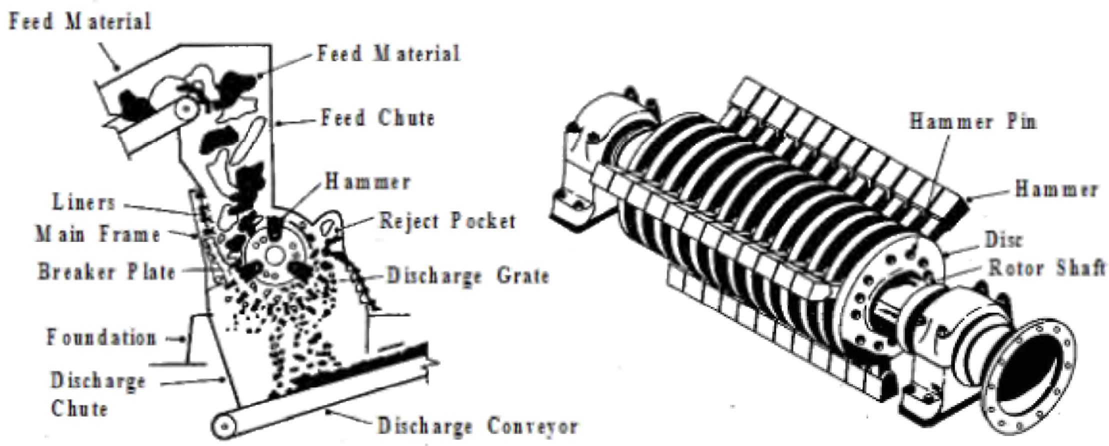
Crushing is used in order to attain uniform size of wastes and make handling easier. This help in reducing the capacity requirements of reclamation or burning facilities. Also it can be used in handling recyclable materials, composts, and mulch. Crushing takes place at the beginning or end of most processes, by applying tension, compression, and shearing to materials. Crushing is efficient in each process, and makes materials stable. It can reduce the size of the plant by 10~20%, stabilize the plate, extend useful life, and shorten process time. Moisture content is then considered after crushing. Robert Ham from the University of Wisconsin said properly crushed materials can be used as architecture materials in 5 years. It doesn't have offensive odor because of good aeration, no rats because there's no food, and no flies because of dryness. There's no chance of fire, and materials are not shattered by wind. When creating composts, aeration is improved when material sizes are uniform. Crushing also increases the capacity of transport trucks because increased material density.

1.1 Types of Crushers

Dry Crusher

Dry crusher includes cutting crusher which is good for wood, rubber, and plastics (Son Roll, Lindemann, Tollemacshe) Another crusher uses spinning motion to crush stone, cement, glass, and dried wood (Hammer Mill, Hazemag, B. J. D). And the last crusher is the compression crusher which uses two rollers rotating in opposite direction to crush glass, aluminum, and cans. The most widely using crusher, the Hammer Mill, can be vertical or horizontal type, both consists of a central rotor and a set of pins. Materials are fed into the hammer mill by the use of conveyors or by free fall.

Fig. Annex- 52 Structure of vertical and horizontal hammer mill



Wet Crusher

A wet crusher is composed of a spinning blade located at the bottom of the crusher. With the aid of water, materials are then crushed into small particles. A rotary drum is used for fibrous materials while a wet crusher is used for mixtures of sludge and solid wastes.

Mixed Crusher

Mixed crusher is used for size reduction of mixtures of metals and plastics and also for crushing typical waste materials. Mixed crusher is specialized in crushing rubber tires easily. Some materials may not be crushed at room temperature. This crusher can only be used after cooling the materials down. Mixed Crushers can crush thick metals such as the metal strings in tires and thick electric wires. Examples of mixed crushers are Small Grinders, Grinder, chippers, jaw crushers, Shredders, Rasp Mills, Hammermills, and hydropulpers.

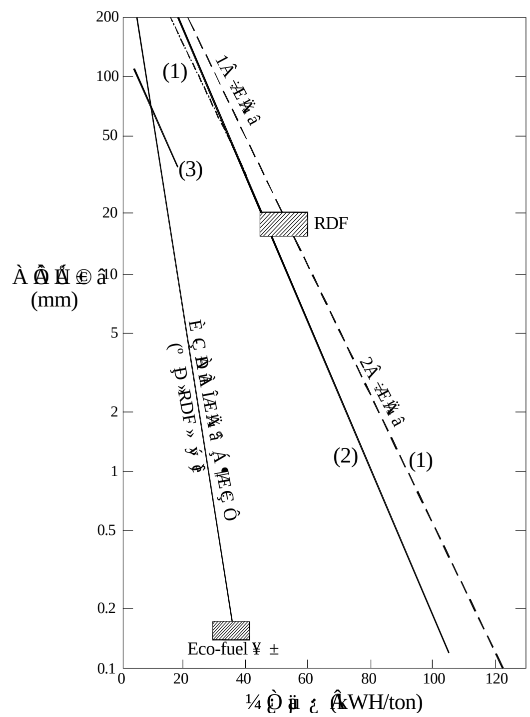
When you select a crusher, you should put the followings into considerations:

§ Characteristics materials to be crushed.
§ Required size of materials.
§ Keep out of bridging.
§ Appropriate conveyor, clearance between crushers.
§ Energy requirement, ease of using, reliability, and noise.
§ Machine dimensions such as footing size and height.

1.2 Characteristics of Crusher

Energy efficient of crusher is very slow. It is because there is more energy used in moving and changing the shape of materials than crushing. Fig III-90 is a good visualization of the above reasons.

Fig. Annex- 53 Required energy by size of material

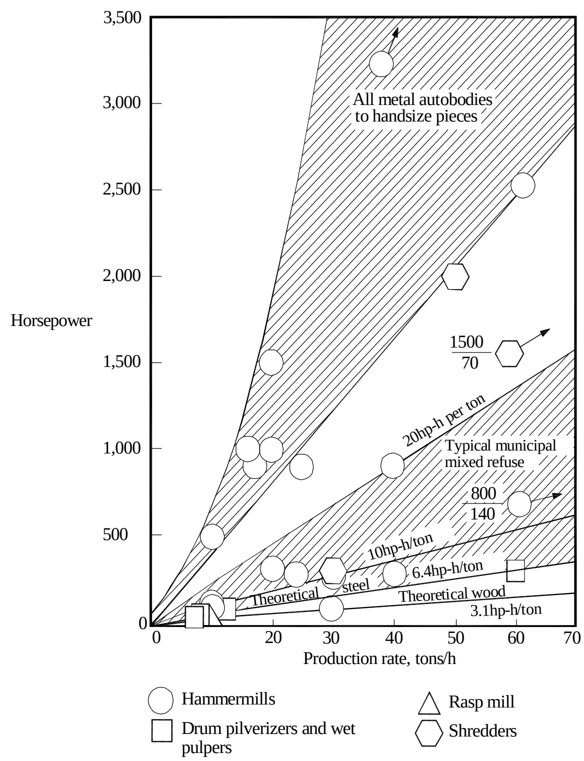


Source: Beningson, et al(1975), Preston (1976) and Savage, et al.(1979)

[Fig. Annex-29] shows the size of different kinds of crushers. Usually, crushing wastes at the rate of 1 ton/hr requires 15   H.

Normally, the size of materials is smaller when the spinning speed of rotor is faster. Energy consumption depends on amount of hydrogen and on the size of the materials.

Fig. Annex- 54 Required motoring in crushers



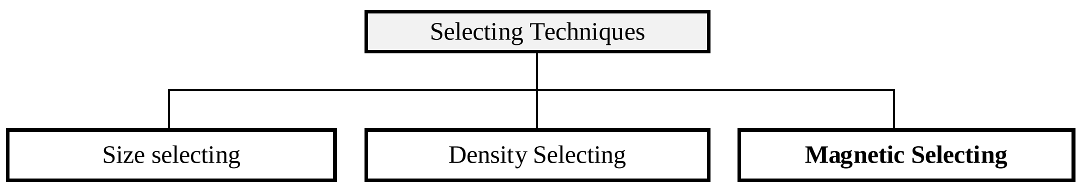
2. Sorting

Selection technique is to separate certain factors to recycle collected wastes. There are two ways of sorting out mixed wastes: manual and automatic. In the field, because of the limitations of automatic sorting, manual and automatic sorting are used together. Manual (hand) technique is the oldest and less efficient technique. It is, however, very accurate and is currently used in most facilities in Korea. Automatic sorting is based on weight, characterisitics, and color. New technique is being developed. Due to the high cost of rage, this technique will be getting larger and larger.

Sorting according to material properties

Waste materials can be sorted out according to size, density, and metal content. The following diagram show the types of selecting techniques.

Table. Annex- 52 Classification of selecting techniques

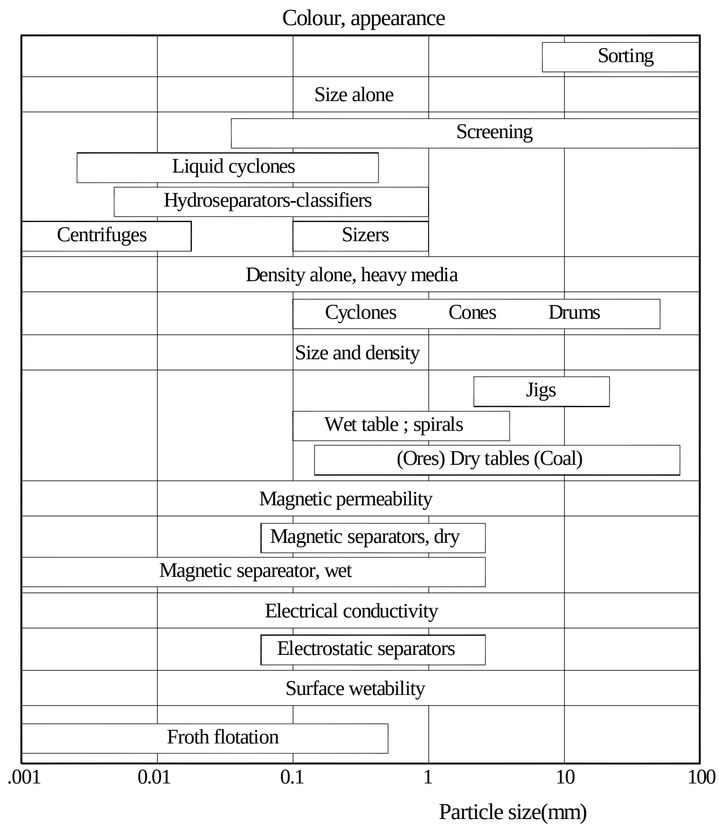


Size sorting is accomplished by using screen, which is also used in the process of creating fuel, composts, and mulch. The screen used can be vibrating screen, trommel screen or a disk screen. Density sorting makes use of the aerodynamic principles. This method can sort out light materials such as paper and plastics from heavy materials such as metals. Density sorting can be classified into inertial, floatation, and ballistic sorting. Magnetic sorting is separated metallic from non-metallic elements. And sorting can also be classified into dry and wet.

Table. Annex- 53 Comparison between dry and wet separation

Dry Separation	Manual: Hand Picking, Hand Sorting Using Screen :Air Classifier, Ballistic Separation Stoner, Fluidized Bed Separator, Secators, Magnetic Separator, Electrostatic Separator, Optical Sortor, Eddy Current Separator
Wet Separation	Sink/Float Separation, Wet Classifier, Jig, Table, Flotation

Fig. Annex- 55 Acceptable technique by size of elements



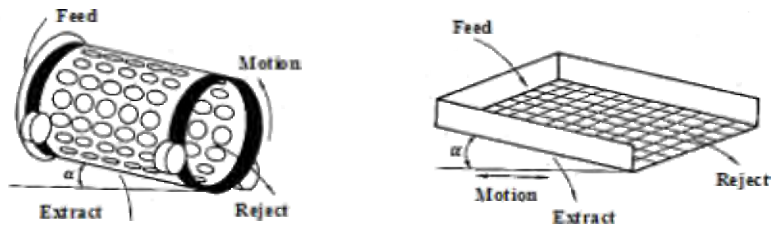
2.1 Hand picking

It is the oldest way of sorting out different materials. It's a method of separating recyclable trash with hands. This method is considered as non-sanitary and quite dangerous, though most accurate.

2.2 Screen or Sieve

By using screen, wastes are sorted out according to size. The screen or sieve is also used in the fuel production, handling of composts, and mulch. The types of screens are Vibrating screen, Trommel screen and Disk screen. There are two kinds of screens: Trommel, Reciprocating.

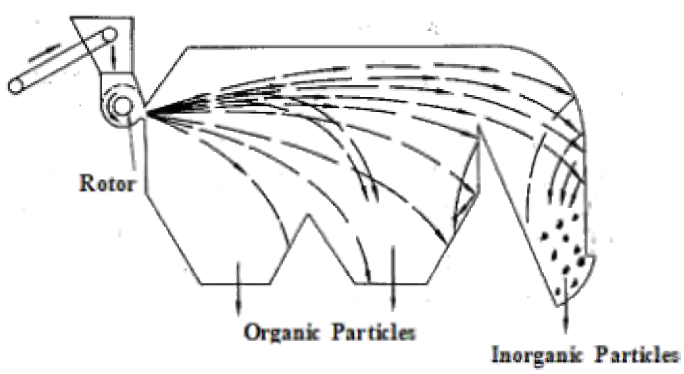
Fig. Annex- 56 Structure of trammel screen and plane vibrating screen



2.3 Ballistic Separator

Using inertia and elasticity, each element is separated by weight and used to separate organic factors. Heavy elements moves further away while light elements moves only at a relatively shorter distance .

Fig. Annex- 57 Waste separation by inertia

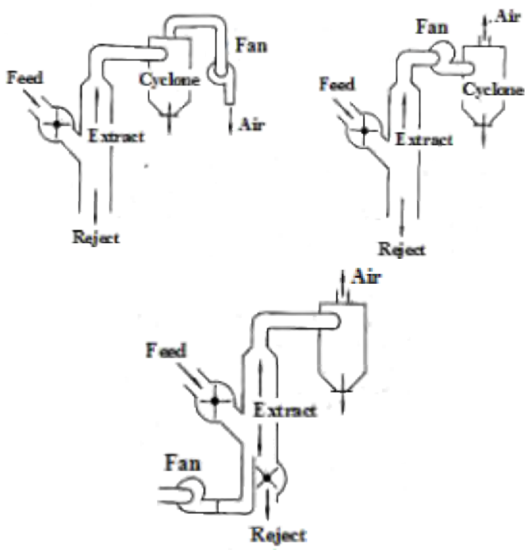


2.4 Air Sorter

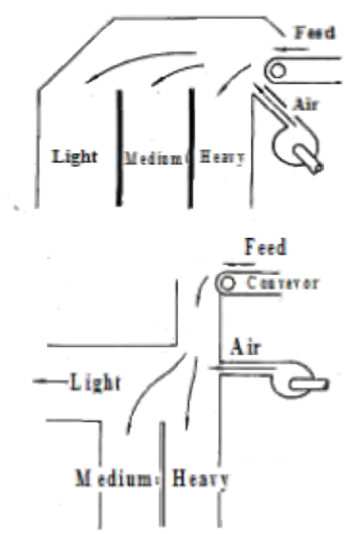
Air is blown into falling waste materials. The falling materials move along the direction of air but lighter materials move further than the heavier ones. Fig III-96 shows the mechanism of air sorter. Heavy materials are collected at the bottom while light elements are collected in a cyclone. Fig III-97 shows Air Knife Sorter using this mechanism. Air sorter vibrates to sort out the waste. Vibrating sorter, Utah sorter, and the zigzag sorter blow lighter elements further. There is also a rotating air sorter which uses inertia principle as shown in Fig III 98~101.

Air sorter should have air speed of at least 100ft/min. The upper limit of air speed is 2,000ft/min, at which efficiency starts to go down. Fig III-102 shows the efficiency of air sorting at different air speeds.

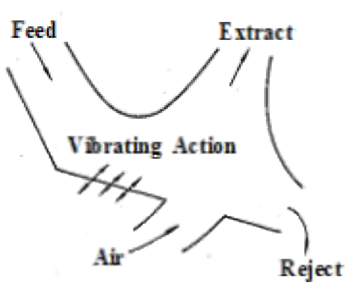
Fig. Annex- 58 Structure of air classifier



Air classifier

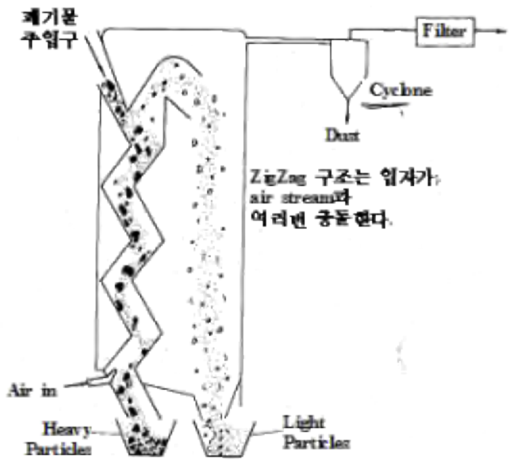


Air knife classifier

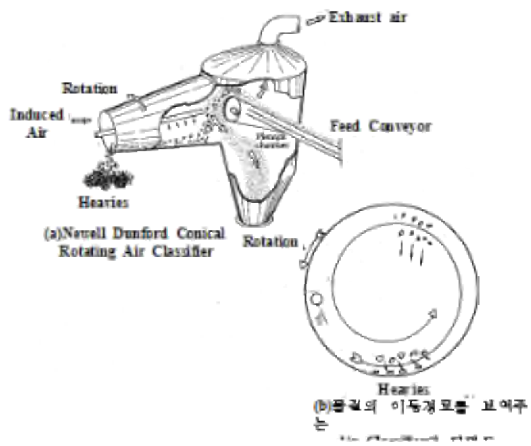


Vibrating air classifier

Utah air classifier

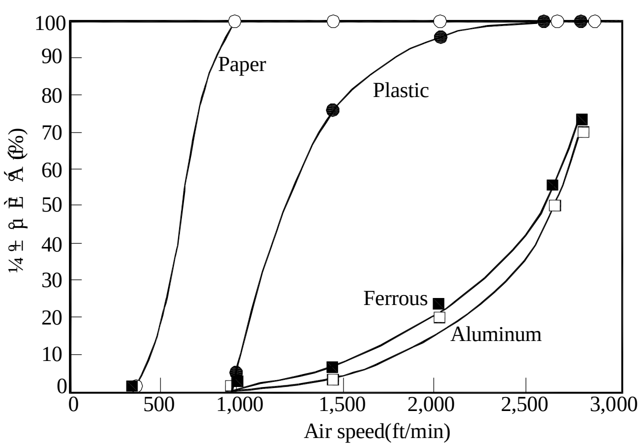


Zig-zag air classifier



Rotating air classifier

Fig. Annex- 59 Selecting efficiency by air speed



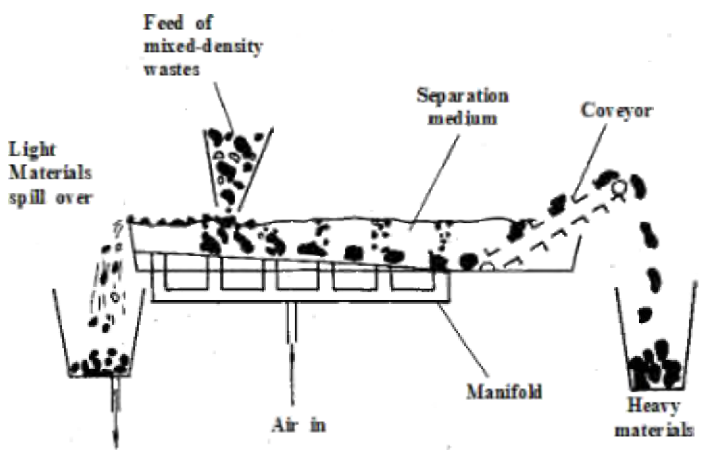
2.5 Stoner

Stoner, also called Pneumatic Table, is similar to Jig selecting heavy elements from water solution. This equipment works on the principle that heavier elements move upward over the lighter ones on a leaned vibrating plate. This technique is used when collecting aluminum and pieces of glass from composts.

2.6 Fluidized Bed Separator

Fluidized bed separator is used to collect metallic materials from crushed wire, which could be aluminum or bronze, from ash or crushed vehicles. The wastes are place in Ferrosilicon or iron powder. Air is then blown from the bottom upwards moving the light elements upwards and on top of the heavier ones. To use this technique, particle sizes should be 0.2~10cm, and at least variable of 0.2 cm.

Fig. Annex- 60 Structure of fluidized bed separator



2.7 Sector

Sector is used to sort out flexible and light materials. Materials are dropped into a slow rolling drum by a leaned conveyor. Light and inelastic particles move with the rotation of the drum and fall on one side while the heavy and resilient particles fall on the opposite side upon hitting the bouncing plate above the drum. This method is partially effective when separating glasses and stones from compost.

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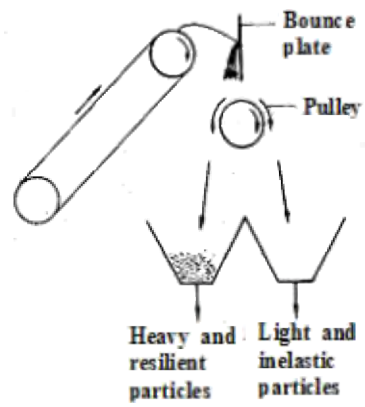
Fig. Annex- 61 Structure of sector



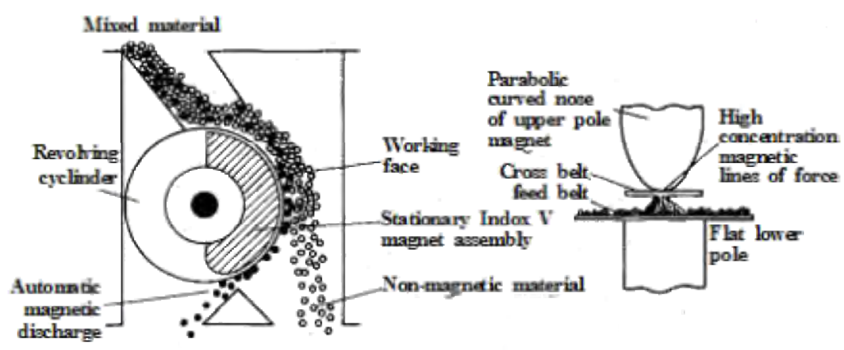
2.8 Magnetic Separator

This is the most commonly used method when separating metallic materials from wastes, whether crushed or not. A Permanent Magnet or an Electro Magnet is used.

No power is required when we using a permanent magnet, but capacity is relatively small. Also, wastes on the conveyor belt should not be thick to achieve high efficiency.

The efficiency of collecting metallic elements from wastes can vary according to the power of magnet, size of the belt, and thickness of wastes on the conveyor. This method is more efficient when used to collect metallic materials from crushed than non-crushed wastes.

Fig. Annex- 62 Structure of magnetic separator



(a) Pulley Separator (b) Cross-Belt High Intensity Separator

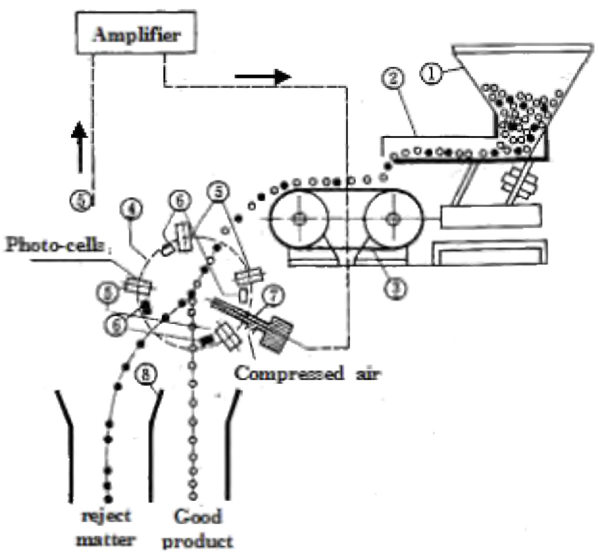
2.9 Electrostatic Separator

Materials which can be classified as conductors can be separated from non-conductors by supplying high-voltage electricity.

2.10 Optical Sorter

This technique is used to separate colored and non-colored glass. When glass powder goes into the vibrating plate through a conveyor, the glass powder automatically shattered on the ground, then move to optical sorter by conveyor.

Fig. Annex- 63 Structure of optical sorter



Vibrating supplier
Glasses place on the cracked bottom
Separator conveyor
, , Sensors light
Separate colored glass by seeing amount of light came through the colored glass

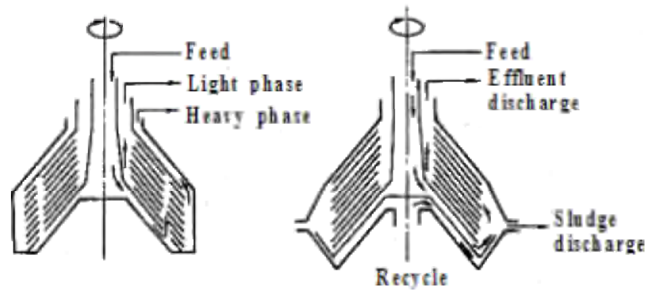
2.11 Sorting by Sinking/Floatation

Materials with different buoyancies are sorted out by putting them in a liquid such as water. Buoyant materials will float while the non-buoyant materials will sink.

2.12 Wet Classifier

Different materials immersed in a liquid settles down to the bottom at different speed. The materials are collected by a screw conveyor at the bottom. [Fig III-107] shows inertia separating system by using different timing of settling.

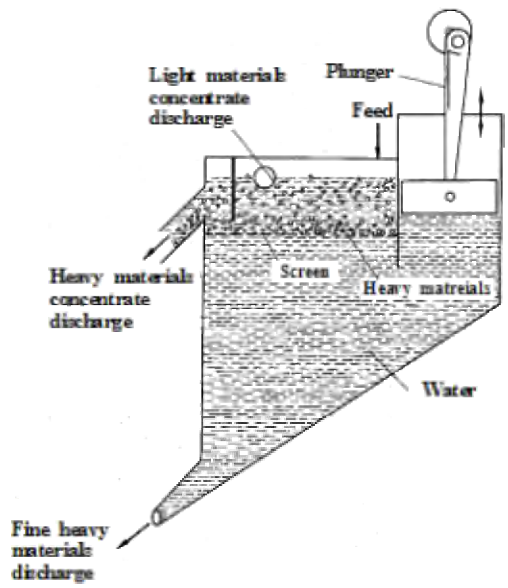
Fig. Annex- 64 Structure of nozzle-bowl centrifuge



2.13 Jig

This method was used in the olden days way of separate gold from other materials. The wastes are placed on a screen and shaken 2.5 times per second to separate heavy from light materials. This method has been upgraded to vibrating table or Jig and Stoner.

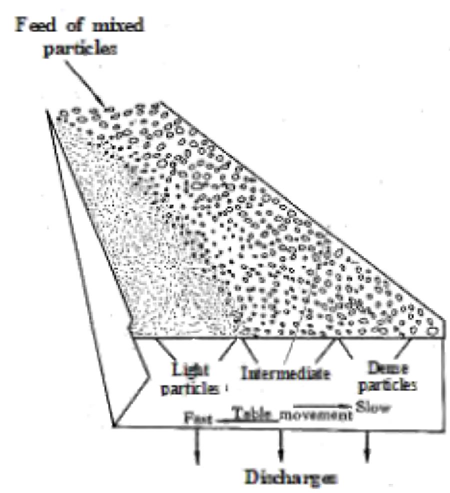
Fig. Annex- 65 Structure of jig



2.14 Table

Using weight difference, light materials are separated to the left hand side while heavy materials to the other side. The flow of materials is made possible by vibrating plate.

Fig. Annex- 66 Structure of table



2.15 Flotation

Heavy materials are separated by supplying air. This method is used to collect Cellulose fibers from white water in a paper Factory.

Guidelines in choosing the most suitable separator

Separator should be chosen correctly based on the type of wastes.

The operation process can be affected by rapping materials, thus, it is also necessary to consider the trends of rapping materials.

Also, organic wastes decompose more rapidly when hydrogen concentration is high.

When there is high concentration of organic matters, dusts and ashes must be removed from coal. When the container is plastic, the container should be opened by a bag splitter or bag opener, or specially produced vehicle that has screw compaction system.

During sorting, spinning hammer mill, frail mill or slow spinning disk mill are used for crushing. However, these machines have efficiency and safety problems. It is therefore necessary to properly select which type of equipment is most suitable for the operation.

Air classification in being operated by zigzag or rotary drum, it is expected that the amount of supply is equal. Magnetic Separation is commonly used in all cases. The following diagram Fig III-110~111 shows an acceptable process of sorting out different wastes.

Fig. Annex- 67 Basic separation

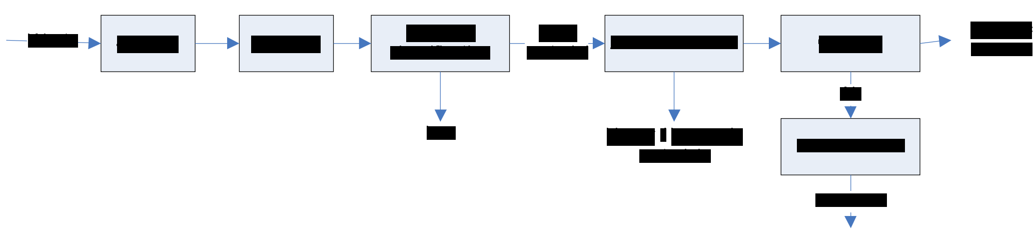


Fig. Annex- 68 Choosing organic matters with screen

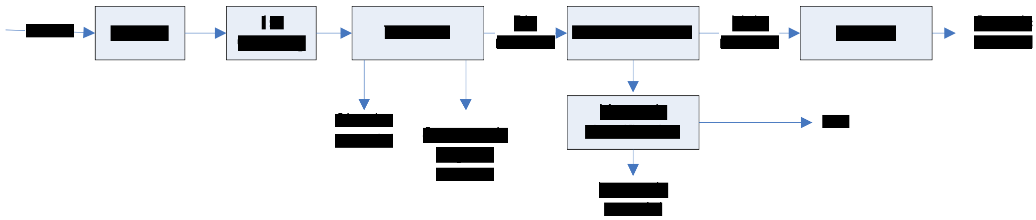


Fig. Annex- 69 Example of better choice of organic matters

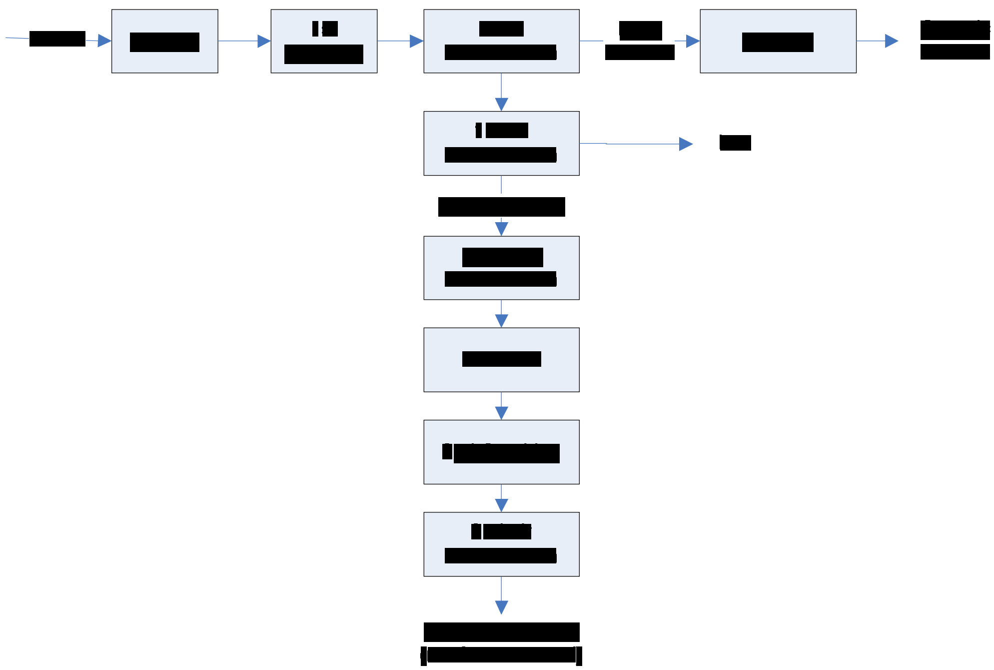


Fig. Annex- 70 Used screen to reduce over heated

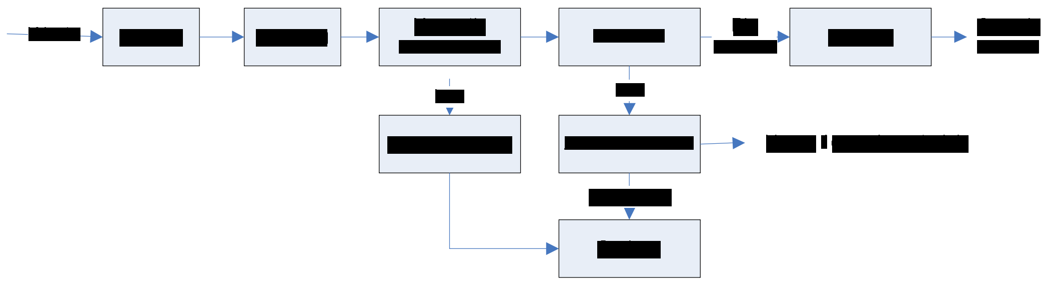


Fig. Annex- 71 Example of using ballistic separator rather than sir separator

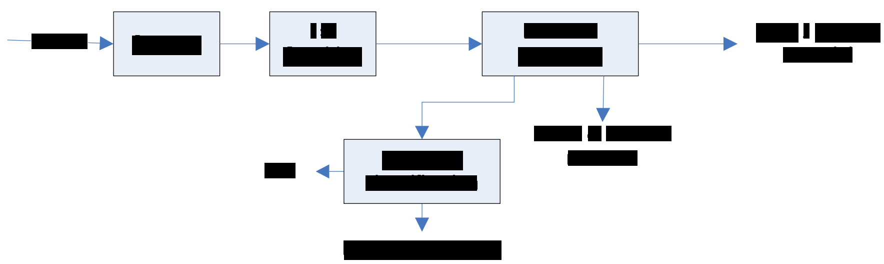


Fig. Annex- 72 Replacement of the 1st crush to screen

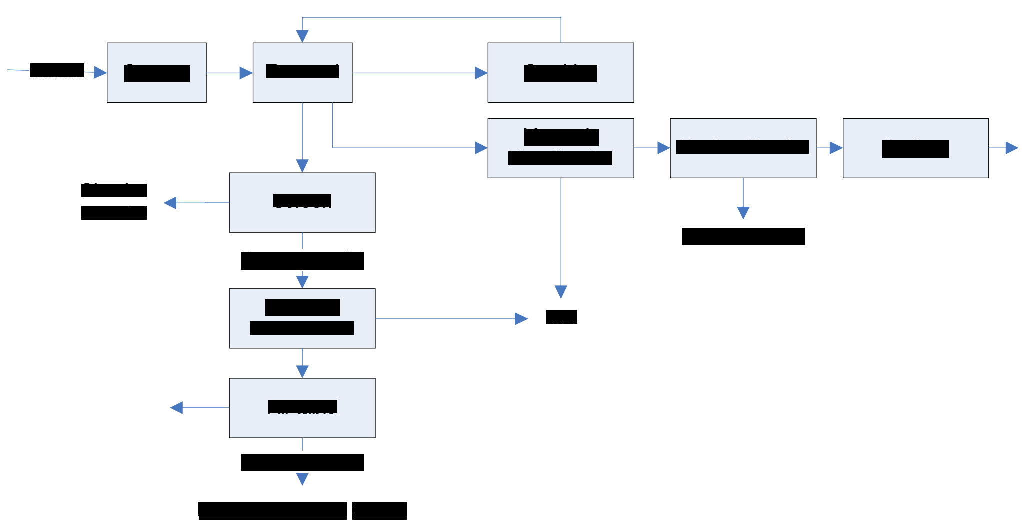
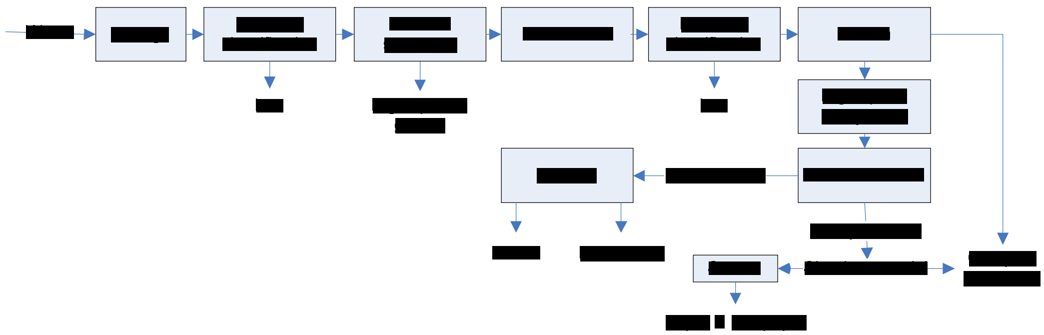
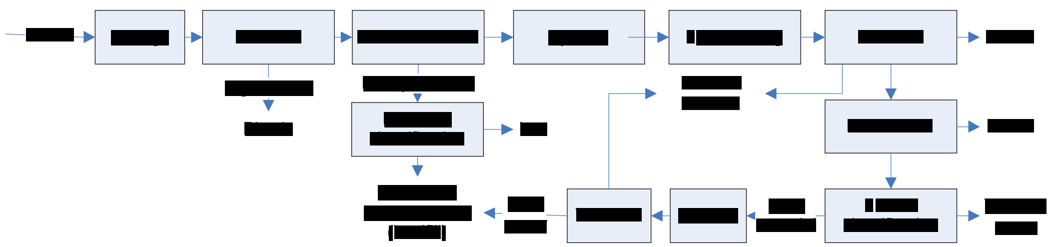


Fig. Annex- 73 Examples of basic separation



(a) Babcock Krauss-maffei separation system



(b) Flakt System

Fig -136. Example of separating papers

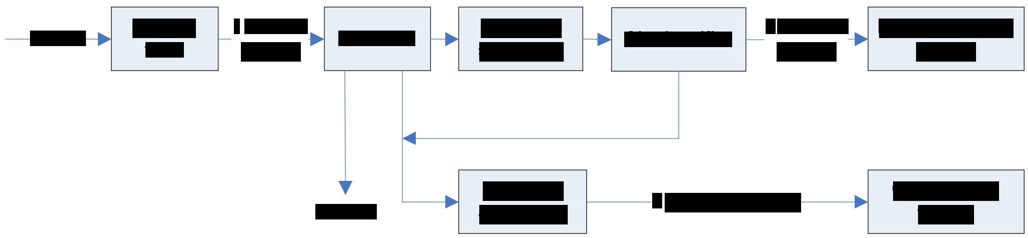
3. Currently Existing Sorting Systems in Korea and other Developed Countries.

This section covers a review of existing sorting systems in Korea and other developed countries for the purpose of determining which facility is best for Lahore.

3.1 Korea

The country recycled 1500 tons of wastes (22,000tons/day) in 1986. The following diagram shows the sorting process which incorporates manual picking.

Fig. Annex- 74 Example of separation in Korae



Each process is explained in the following:

Storage

Wastes delivered by vehicles are placed into the conveyor with the used of equipments such as a pay loader. Capacity of the storage facility is 1,500tons per day and has a flexible break time for 1 day. The floor is made of concrete with aeration facility.

Sorting

Sorting makes it possible to recover recyclable and reusable materials. This is done either manually, with the use of machines, or by a combination of both. Recyclable materials such as papers, plastics, wood, clothings, and glass are sorted manually while metallic materials are collected by magnet. When we a permanent magnet is used, no power is needed but the capacity is small. Also, wastes on the conveyor should not be thick to achieve high efficiency. The efficiency of collecting metallic elements from wastes can can vary according to the power of magnet, size of conveyor, and thickness of wastes on the conveyor. In addition, it is also more efficient to collect from crushed wastes than non-crushed wastes.

Fuel production

Flammable solid materials can be collected manually from reusable materials. The collected materials are then made as durable as possible by drying, crushing, heating and compressing to create pellets.

Compost

If dioxin and heavy metallic materials are recovered from wastes, reclamation plants can be reduced by 20%. Aluminum and iron can be processed in melting facilities and the slugs can be used as construction materials.

Bailing machines facilitate handling during transportation by compressing the wastes into regular sizes. The bails are and tied up with the iron band to prevent disintegration. Produced fuel should be commercialized and wrapped in certain quantities. Boxes and other containers such a pallets may be used. Also, the treatment system is a sequential process. To preserve the quality of collected materials, a warehouse is required.

3.2 Other countries

In Europe, recollected papers are recycled. In the US, paper is made RDF or WDF with other flammable organic matters and plastics.

The system in Europe has a limitation when it comes to purity of the paper. Recollected paper materials are passed through air sorter and supplied with water to separate vinyl materials. During the collection of separated paper materials, impurities such as plastic films, plastic bottles and fabrics can be included. In addition, wastes papers also contain wax, oil, cement, and plastic coatings. These impurities can be resolved by passing the collected papers in a wet pulp and Hydro Cyclone (Buekens, 1981).

With the exception papers, light materials recovered by air classifier are composted or used as fuel in Europe. An example this kind of fuel is Eco fuel. The iron collected from waste is mainly from cans. These cans are usually colored by lacquer and the lid is made of aluminum. This makes it difficult to recover pure iron economically.

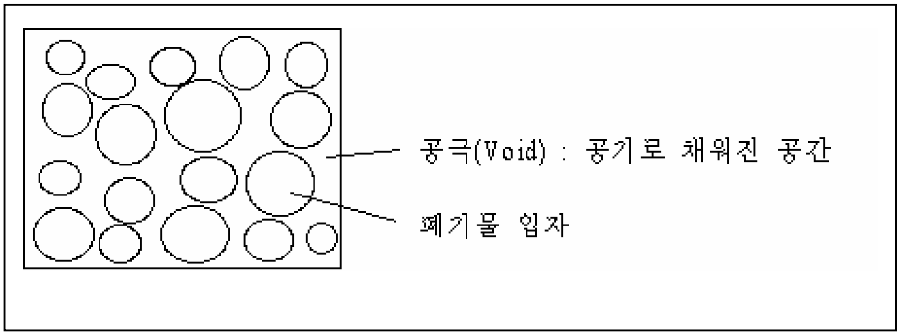
On the other hand, collecting aluminum cans is comparatively economical than collecting iron cans. Aluminum and iron are sorted out by Eddy Current Separator. Collected glass is sorted according to color (brown and green) and by transparency and sent to the glass factory.

Compressor Techniques

With the variety of waste contents, uneven size of particles, turning them into valuable resources has limitations. Compressing the materials is still the most efficient. Compressor technique reduces the volume of materials to facilitate handling. Vehicles with compressors are used to collect solid wastes in the most metropolitan cities in Korea. To increase landfill life, reusable papers are tied up and sent to treatment centers. High pressure compressor system is being developed. Compressor techniques can usually reduce the volume of wastes by 75~80%. This reduces the expenses on transportation and treatment. It also facilitates handling and storage with relative high level of cleanliness. Also, leachates and bad odor is usually reduced when the material is compressed.

Basic theory of pressing

A bulk of waste contains considerable volume of air space, which can be a major avenue of hydrogen absorption.



Volume filled with air.

Particle of waste

- Total Volume(V_m) = Volume(V_s) + space(V_v)

- Void ratio(e) = $\frac{V_v}{V_s}$

- Porosity(n) = $\frac{V_v}{V_m}$ 100

- Total weight(W_m) = solid(W_s) + hydrogen(W_w)

- Wet density(ρ_w) = $\frac{W_m}{V_m}$

- Dry density(ρ_d) = $$\frac{W_s}{V_m}$$ → bulk density

Generally, volume (Bulk density) is expressed to dried volume.

Volume reduction

Volume is reduced when the material is pressed. Percentage of volume reduction is used to determine the final volume.

$$Volume\ reduction(VR) = \frac{V_i - V_f}{V_i} \quad 100$$

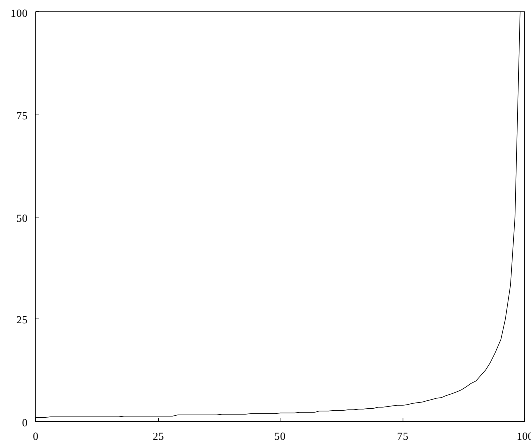
V_i : First volume, V_f : Final volume

§ Rate of press and volume loss

$$VR = \frac{V_i - V_f}{V_i} \quad 100 = \left(1 - \frac{V_f}{V_i}\right) \quad 100 = \quad \left(1 - \frac{1}{CR}\right) 100$$

$$\frac{VR}{100} = 1 - \frac{1}{CR} \qquad \frac{1}{CR} = \frac{100 - VR}{100} \qquad CR = \frac{100}{100 - VR} = \frac{100}{VR - 100}$$

Compaction ratio(%)



Volume reduction (%)

Characteristics and types of pressing

Currently existing techniques of pressing and rapping are Bailing and Cubing. These are explained below.

Bailing (Pressing/Rapping)

Bailing technique uses both pressure and vacuum to reduce wastes volume by 80%. This is a highly efficient technique and can make storage possible for a long time without odor and leaching. Cleanliness is an advantage of this technique. Bailing System vary according to the intended handling and degree of stability. It is mainly used in reclamation and burning silo to reduce volume. Characteristics of current bailing systems are as follows:

§ Bale size: Φ1.2m   1.2m (volume: 1.3 /Bale)

§ Bale capacity: maximum 25 Bale/hr (time: 3~4min/Bale)

Bailing First combined (PE Net) then rapped (LLDPE + UV Stabilizer Film) Process is as followed.

Fig. Annex- 75 Bailing process

insert wastes and press

⇓

Press and add (Netting)
use PE Net

⇓

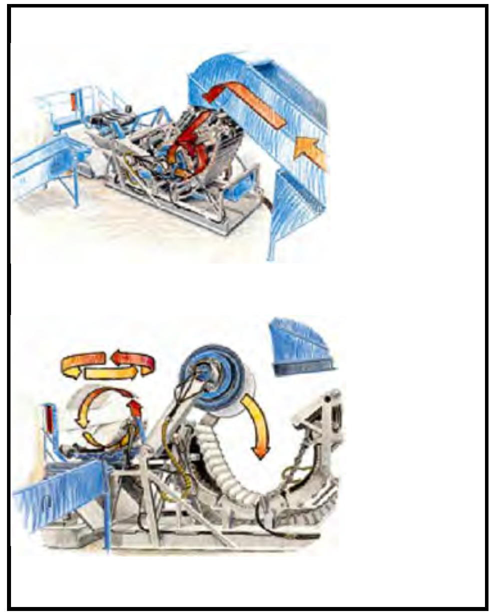
take out

⇓

Wrapping
LLDPE + UV Stabilizer Film

⇓

complete



Cubing technique

Cubing techniques uses pressure to turn bulks of wastes into cubes. The process can either be done using horizontal or vertical method. Usually, vertical is smaller while horizontal is used in middle to big industries. Flammable wastes are pressed into certain sizes which can be varied by a counter. Stable cubes are produced in 5 stages:

Fig. Annex- 76 Process of cubing

Conveyor	ð	store	ð	compress	ð	combine	ð	release

Fig. Annex- 77 Cubing facility