KEMENTERIAN PERUMAHAN
DAN KERAJAAN TEMPATAN

DAN

AGENSI KERJASAMA
ANTARABANGSA JEPUN

Dengan ini mengesahkan
bahawa

Telah menghadiri Bengkel Pengambasan
Tanah Sanitari
pada 1hb — 6hb Ogos 1988

Dato' Kamaruddin Mahmood
DPCM, JSM & KMN.
Ketua Setiausaha, Kementerian Perumahan dan
Kerajaan Tempatan

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wakil, Agensi
Kerjasama Antarabangsa
Jepun Di Malaysia

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WORKSHOP ON THE SANITARY LANDFILLING

OF

MUNICIPAL SOLID WASTES

BUTTERWORTH

1 - 6 AUGUST 1988

TECHNICAL SECTION

LOCAL GOVERNMENT DIVISION

MINISTRY OF HOUSING AND LOCAL GOVERNMENT

1. Rationale

1.1 Disposal is the final functional element in the solid waste management system and is the ultimate fate of all solid waste. Experience all over the world has shown that land disposal of solid wastes in sanitary landfills is the most economical and acceptable disposal method. This is true even in Malaysia although sanitary landfilling method has been scarcely practiced in Malaysia.

1.2 There are approximately 230 official municipal dumping sites in Peninsular Malaysia. In most of them crude open dumping is practiced creating a lot of environmental as well as social problems such as air pollution and scavengers. It is also responsible for the proliferation of NIMBY (Not In My Back-Yard) syndrome which makes future acquisition of dumping sites extremely difficult.

1.3 Without making due efforts to introduce sanitary landfilling method into their final disposal practice, many Local Authorities in Peninsular Malaysia are caught by the thought that incinerators may solve the never ending problem of finding new dumping sites. This mood looks to be hardly affected even after hearing about the troublesome operation of a modern incinerator in Kuala Terengganu. To overcome this situation, appropriate training on sanitary landfill should be given as soon as possible to the key personnel of at least major Local Authorities.

1.4 Environmental Quality (Prescribed Activities) (Environmental Impact Assessment) Order 1987 has come into force on the 1st April 1988, and now it is mandatory for any Local Authorities to carry out the EIA of their municipal solid waste landfill facility construction projects. Therefore, they should be given an appropriate orientation about the EIA of landfill facility construction projects. Correct use of sanitary landfilling method will reduce remarkably the possible negative environmental impacts to be caused by the final disposal of municipal solid wastes.

1.5 This workshop, which is designed to give a practical orientation about sanitary landfilling method to the people who are responsible for solid waste management in major Local Authorities, will mark an important step towards the improvement of final disposal of municipal solid wastes in Malaysia.

2. Objectives

2.1 To get the necessity and possibility of the use of sanitary landfilling method understood by the key personnel of major Local Authorities.

2.2 To give a practical orientation about sanitary landfilling method as well as the EIA of landfill facility construction projects.

2.3 To prepare the participants for the immediate action in respective Local Authorities for the improvement of final disposal practice. For this effect, participants from the same Local Authority will be requested to work as a team and prepare an action plan for their Local Authority entitled "Action Plan for the Improvement of Final Disposal"

3. Contents

3.1 This workshop will touch all the relevant issues of sanitary landfilling method. They are as follows :-

3.1.1 Necessity and possibility of the use of sanitary landfilling method.

3.1.2 Possible alternatives of processing and final disposal : Their advantages and disadvantages.

3.1.3 Actual situation of processing and final disposal in Malaysia.

3.1.4 Site selection of sanitary landfills.

3.1.5 Design of sanitary landfills.

3.1.6 Construction, operation and maintenance of sanitary landfills.

3.1.7 Selection and maintenance of equipment for sanitary landfills.

3.1.8 Control of sanitary landfills.

3.1.9 EIA of landfill facility construction projects.

3.1.10 Privatization of landfill facility construction and/or operation projects.

3.1.11 Costing of landfill facility construction and operation projects.

3.2 This workshop will also include the sessions to study the existing landfilling practices in Peninsular Malaysia. They are as follows :

3.2.1 Case study reports on landfills in Majlis Perbandaran Kota Bharu, Majlis Perbandaran Kuantan and Majlis Perbandaran Kota Setar. Terms of Reference of these case study reports are shown in Appendix 1.

3.2.2 Field surveys of existing landfills in Majlis Perbandaran Seberang Perai and Majlis Daerah Kulim.

4. Methodology

4.1 This workshop will be carried out using the following methods :

4.1.1 Lectures

4.1.2 Case studies

4.1.3 Field visits

4.1.4 Exercises

4.1.5 Group dynamics (K-J Method)

4.1.6 Presentations and discussions

4.1.7 Movie shows

4.1.8 Home works (Action Plans mentioned in 2.3 shall be prepared through home works and submitted to the Workshop organizers by the end of the Workshop).

4.2 The tentative programme of the workshop is given in Appendix 2.

5. Paper Presenters

5.1 In this workshop, papers will be presented by the following :

5.1.1 Mr. Yasushi Matsufuji, Associate Professor of Fukuoka University.

5.1.2 Dr. Kunitoshi Sakurai, JICA Expert attached to the Technical Section.

5.1.3 Mr. Tan Hoo, Director of the Technical Section.

5.1.4 Mr. Peter Ho Yuen Chuen, Principal Assistant Director, Department of Environment.

5.1.5 Mr. Susumu Shimura, JICA Penang Study Team.

5.1.6 Dr. M. Haroon, Director of Health Department, Municipal Council of Seberang Perai.

5.1.7 Mr. Raju, Municipal Council of Seberang Perai.

5.1.8 Municipal Council of Kota Bharu.

5.1.9 Municipal Council of Kuantan.

5.1.10 Municipal Council of Kota Setar.

6. Participants

6.1 All municipal councils and the City Hall of Kuala Lumpur are invited to send two officers each to this workshop, one from Health Department or Urban Services Department and the other from Engineering Department.

6.2 Total number of the participating Local Authorities should not exceed sixteen (16) to ensure effectiveness under the limited resources available and methodology proposed. This means that total number of participants should not exceed thirty two (32). However, the workshop can be repeated in future on a regional basis for other small Local Authorities with necessary modifications.

7. Time and Place

7.1 This workshop will be held from 1 to 6 August 1988 in the Convention Room of Butterworth Travel Lodge (Tel : - 04 - 348899.

Appendix 1

TERMS OF REFERENCE FOR

CASE STUDY REPORTS

1. The report should include, among others, the following informations :

   - Location of the landfill
   - Distance from the city centre and condition of the access road
   - Size and ownership of the site
   - Topography of the site
   - Surrounding land use and water use
   - Year of opening
   - Estimated remaining life
   - Estimated waste amount (daily)
   - Basic design
   - Description of basic operational procedures (excavation, unloading of wastes, compaction of wastes, covering, spraying, etc.)
   - Pollution control measures (gas and leachate)
   - Existence of animal and human scavengers
   - Type and number of equipment, their conditions and their ownership
   - Use of contractors
   - Auxiliary facilities such as gates and fences
   - Landscaping
   - Expected future use of the site

2. The report should explain about the problems encountered and the measures taken to overcome them including the evaluation. Examples of problems are shown in the following :

   - Lack of cover material
   - Operation in monsoon season
   - Difficulty in detecting the inflow of toxic and hazardous industrial wastes
   - Frequent breakdown of equipment

3. The report should propose a future improvement plan based on the evaluation made in item 2.

4. The report should be prepared using A4 size papers. To make the presentation visually attractive, the presentation should be made using color slides.

APPENDIX 2

WORKSHOP ON THE SANITARY LANDFILLING OF
MUNICIPAL SOLID WASTES
1 - 6 AUGUST 1988

	Morning		Afternoon	
Monday (1 Aug. 88)	08:00 - 09:00 09:00 - 09:30 09:30 - 10:00 10:00 - 10:15 10:15 - 10:45 10:45 - 11:15 11:15 - 11:45 11:45 - 12:15 12:15 - 12:45	Registration Inauguration Coffee Break Workshop Mechanism ABC (TH) Actual Situation (KS) Alternatives (KS) Alternatives (JICA S.T) Movie Show I	14:00 - 14:30 14:30 - 15:00 15:00 - 15:30 15:30 - 16:00 16:00 - 16:30 16:30 -	Case Study A (KB) Case Study B (K) Case Study C (AS) Group Dynamics (Explanation of KJ Method) Movie Show II High Tea
Tuesday (2 Aug. 88)	08:30 - 09:00 09:00 - 09:30 09:30 - 10:30 10:30 - 10:45 10:45 - 11:45 11:45 - 12:30	Site Selection (KS) Site Selection (JICA S.T) Design I (YM) Coffee Break Design II (YM) Kulim Project (KS)	14:00 - 17:00	Field visit to Kulim Land-fill site
Wednesday (3 Aug. 88)	08:30 - 10:00 10:00 - 10:30 10:30 - 10:45 10:45 - 11:15 11:15 - 12:45	Construction and O & M (YM) Equipment Selection (KS) Coffee Break Equipment Maintenance (KS) Control/ Privatization/ Cost (KS)	14:00 - 15:15 15:15 - 16:15 16:15 -	Exercise I Presentation & Discussion High Tea
Thursday (4 Aug. 88)	08:30 - 09:45 09:45 - 10:45 10:45 - 11:00 11:00 - 11:30 11:30 - 12:30	EIA (DOE) Pollution Control (YM) Coffee Break Briefing about actual and future sites (MPSP) Weighbridge (MPSP)	14:00 - 16:30	Field visit to the actual and future dumping sites in MPSP

Friday (5 Aug. 88)	08:30 - 09:30 Exercise II 09:30 - 10:30 Presentation & Discussion 10:30 - 10:45 Coffee Break 10:45 - 12:15 Group Dynamics II	14:45 - 16:30 Group Dynamics III 16:30 - High Tea
Saturday (6 Aug. 88)	08:30 - 10:30 Group Dynamics IV 10:30 - 10:45 Coffee Break 10:45 - 11:45 Presentation & Discussion 11:45 - 12;15 Evaluation 12:15 - 12:45 Closing	

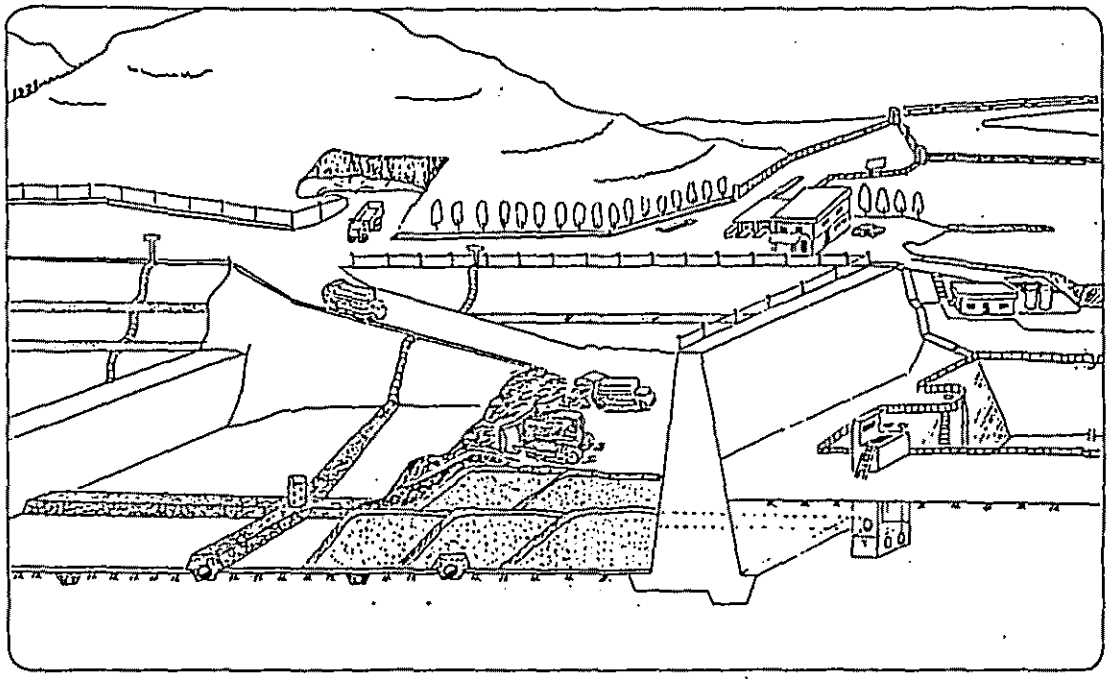
Notes : TH = Tan Hoo, KS = Kunitoshi Sakurai,
YM = Yasushi Matsufuji, DOE = Department of
Environment, MPSP = Majlis Perbandaran
Seberang Perai, KB = Kota Bharu,
K = Kuantan, AS = Alor Setar

Movie Show I = Sanitary Landfill - You're the Operator
Movie Show I = Hamura Gravel Pit SLF Project

Exercise I = Evaluation of Kulim Landfill Project
Exercise II = Evaluation of Seberang Perai Landfill Project

Group Dynamics I, II, III & IV = Problem Solution
by KJ Method

Sanitary Landfill Design and Operation



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FUKUOKA UNIVERSITY

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1. BACKGROUND

1.1. Land and Population

Japan`s territory encompasses an area of 378,000 km². With 119 million people, it registers a population density of 320 people/km². Japan`s population density is higher than that of major Western countries, including the United States with 25 people/km²; France, 99; Britain ,229; and West Germany, 248.

Moreover, 70% of Japan`s land is mountainous and timbered. The habitable area is only 80,000 km², or only 21% of the total land. In terms of population per square kilometer of the habitable area, while the United States has the lowest figure with 50 people ;France 158; Britain 358 and West Garmany 386, in Japan, this figure is 1,452. Thus,Japan has one of the highest population densities in the world.

1.2. High Economic Growth and Changes in Industrial Structure

Japan`s population, having marked gradual increases from 83 million in 1950, exceeded 100 million in 1970 and reached 119 million in 1983. However,with the year by year declining population growth rate, the 1983 population represents a slight increase of 0.66% over the previous year and indicates a stabilized population growth.

The Japanese economy started showing high growth in the 1960s and had successfully maintained remarkable growth untill 1973 when

Table 1-1 Population per Square Kilometer of Habitable Area in Major Countries

	Japan	W. Germany	France	Britain	U.S.A.
Habitable area (10km²)	805	1,594	3,389	1,564	45,814
Total area (10km²)	3,777	2,486	5,470	2,441	93,718
Ratio of habitable area to total (%)	21	64	62	64	49
Population in the habitable area (persons/km²)	1,452	386	158	358	50

Note: The figures for the habitable area were obtained in 1980 for Japan, 1975 for West Germany, 1979 for France, 1977 for Britain and 1974 for the United States. The figures for population were as of October 1, 1980 for Japan and mid-1980 for the remaining countries.

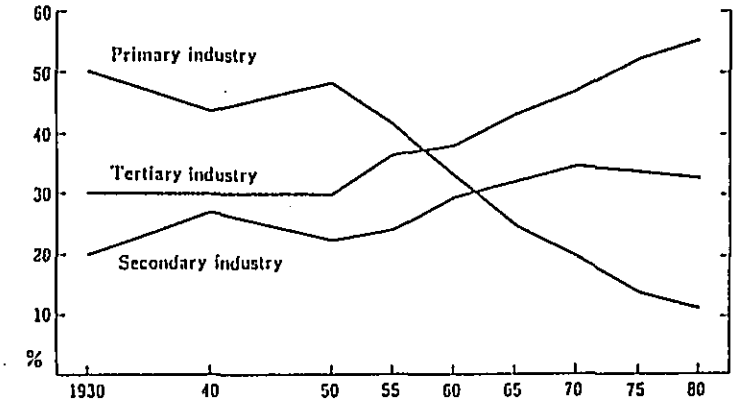


Fig. 1-1 Japan's Structure Employment

skyrocketing oil prices halted the high growth rate. Between 1960 and 1965,real GNP growth rates averaged 10% a year. Average annual growth rate reached a record high of 11.6% during the 1965-70 period. Economic recession, triggered by increasing oil prices, however, slowedthe growth rate, with average GNP growth rates standing at 5.4% during the 1970-75 period and 6.0% during the years between 1975 and 1980.

On the other hand, resulting from economic development, dramatic changes have been in the employment structure since 1950. The number of persons employed in primary industry, the largest at that time, started diminishing rapidly and become the smallest, while the number of persons in secondary and tertiary industries has continued to grow. In particular,the tertiary industry marked sharp increases in the number of persons employed and this upward trend is continuing.

1.3. Graviation of Population toward Cities and Changing Environment

The changes in employment structure are synonymous with shifts of population from the agricultural sector to the commercial / industrial sectors. In other words, population shifts from rural to urban areas become marked. Particularly population gravitation was made to the major urban areas of Tokyo, Osaka and Nagoya. Of Japan's total population, 22.5% is currently concentrated in the Tokyo metropolitan area, 13.0% in the Kinki district around Osaka and 6.7% in the Chukyo district around Nagoya. These figures show that as much as 42.2 % of the total population is concentrated in

Table 1-2 Population in Japan's Three Major Urban Areas (1983)

	50-km radius around Tokyo		50-km radius around Osaka		50-km radius around Nagoya	
	Population (1,000 persons)	Growth rate over the previous year (%)	Population (1,000 persons)	Growth rate over the previous year (%)	Population (1,000 persons)	Growth rate over the previous year (%)
0～10km	3,639	△0.1	4,233	△0.2	2,118	0.1
10～20km	7,808	0.7	3,670	1.0	1,848	0.9
20～30km	5,518	1.7	2,380	1.2	1,435	1.6
30～40km	5,979	1.7	2,831	1.2	1,865	0.8
40～50km	3,788	2.0	2,263	0.8	640	0.6
Total	26,732	1.2	15,377	0.7	7,907	0.8
Density of population (persons/km²)	3,491		2,076		1,080	

the three major urban areas, resulting in an incredibly high population density of 3,491 people /km² in the Tokyo metropolitan area,2,076 in the Kinki district and 1,080 in the Chukyo district.

Apart from these specific areas, the population gravitation toward other major urban areas has been noted nationwide.

The gravitation of both population and industries to major urban areas during the high economic growth period created massive housing demand in major cities as well as the suburbs. Such a highly concentrated population also caused sharp increases in the cost of land within these areas. Subsequently, conventional independently-constructed housing was replaced by collectively-constructed housing. Indeed,the large number of public and private apartment houses constructed in major cities and the suburbs dramatically changed the Japanese lifestyle.

Concurrently with the start of modernization of the distribution system, an increasing number of supermarkets opened primarily in newly-developed residential areas. These supermarkets facilitated large-quantity sales of pre-packed goods.

The high economic growth brought about an improved income level which spurred individual consumerism, thus creating an age of massproduction, mass distribution and mass consumption. At the same time, housing standards remained low, particularly in major cities and the suburbs where a growing number of people were forced to live in cramped housing. The living environment was changed by this trend.

Without storage space for even a temporary period, people began discarding used products and consumer durables as soon as such

products become redundant.

Under such circumstances, the amount of wastes has grown rapidly, associated with significant changes in quality of the wastes.

1.4. Waste Disposal and Public Cleansing Law

The Waste Disposal and Public Cleansing Law (Waste Disposal Law) is designed to preserve the living environment and improve public health through the promotion of adequate waste disposal to keep the environment clean.

1) Definition of wastes

The Waste Disposal Law defines wastes as "filthy and/or unnecessary things in a solid and/or liquid state, which include refuse, bulky wastes, cinders, sludge, excrement, waste oil, waste acid, waste alkali and animal corpses (though excluding radiocative substances andanything contaminated with radiocativity)."
Even if filthy or unnecessary, gaseous substances and those contaminated with radiocativity are excluded from the waste category specified by the Law. Others not subject to the Law are : (1) Earth and sand aswell as the like resulting from dredging activities conducted at ports,rivers, etc. (2) Aquatic animals and plants, etc. netted during fishingactivities and diacharged near the fishing site. (3) Earth and sand as well as the like which can be used in land reclamation.

2) Municipal and industrial wastes

Under the Waste Disposal law, wastes are roughly classified into two categories;
① municipal wastes generated mainly from living activities, and
② industrial wastes resulting from industrial activities.

Industrial wastes are further divided into 19 groups, including cinders, sludge, waste oil, waste acid, waste alkali and waste plastics. Figure 1.2 shows the 19 groups and examples from each group.

Municipal wastes are defined as wastes other than industrial ones. The greater part of municipal wastes results from living activities among citizens, i.e. munuicipal solid wastes, which include a wide variety of wastes, such as garbage (kitchen wastes), paper including newspapers and magazines, glass and metal in such

forms as bottles and cans, plastics and fabrics. Munucipal solid wastes also include bulky wastes, such as furniture and household appliances.

In the meantime, of the wastes resulting from business activities, those which can be disposed of by municipalities without difficulty in terms of quality and quantity are designated separately from other industrial wastes as "municipal wastes from the business sector."

3) Obligations of the government, municipalities and business operators

The Waste Disposal Law specifies that business operators, the government and municipalities are required to fulfill their obligations as outlined below.

① Business operators are responsible for disposing of wastes resulting from their business activities. They are also required to make efforts for volume reduction of their wastes and take necessary actions to prevent the products, containers and others involved in their manufacturing, processing, sales and other business activities from becoming a waste difficult to be disposed of.

② Municipalities are required to promote the concept of public cleasing, while endeavouring to carry out efficient management of waste disposal operations.

③ Prefectural governments are required to provide municipalities with necessary technological aids, if any, and endeavour to take necessary measures for adequate disposal by monitoring progressing status of industrial wastes.

④ The central government is required to promote technological development related to waste disposal and endeavour to provide municipalities as well as prefectural governments with technological and financial aids.

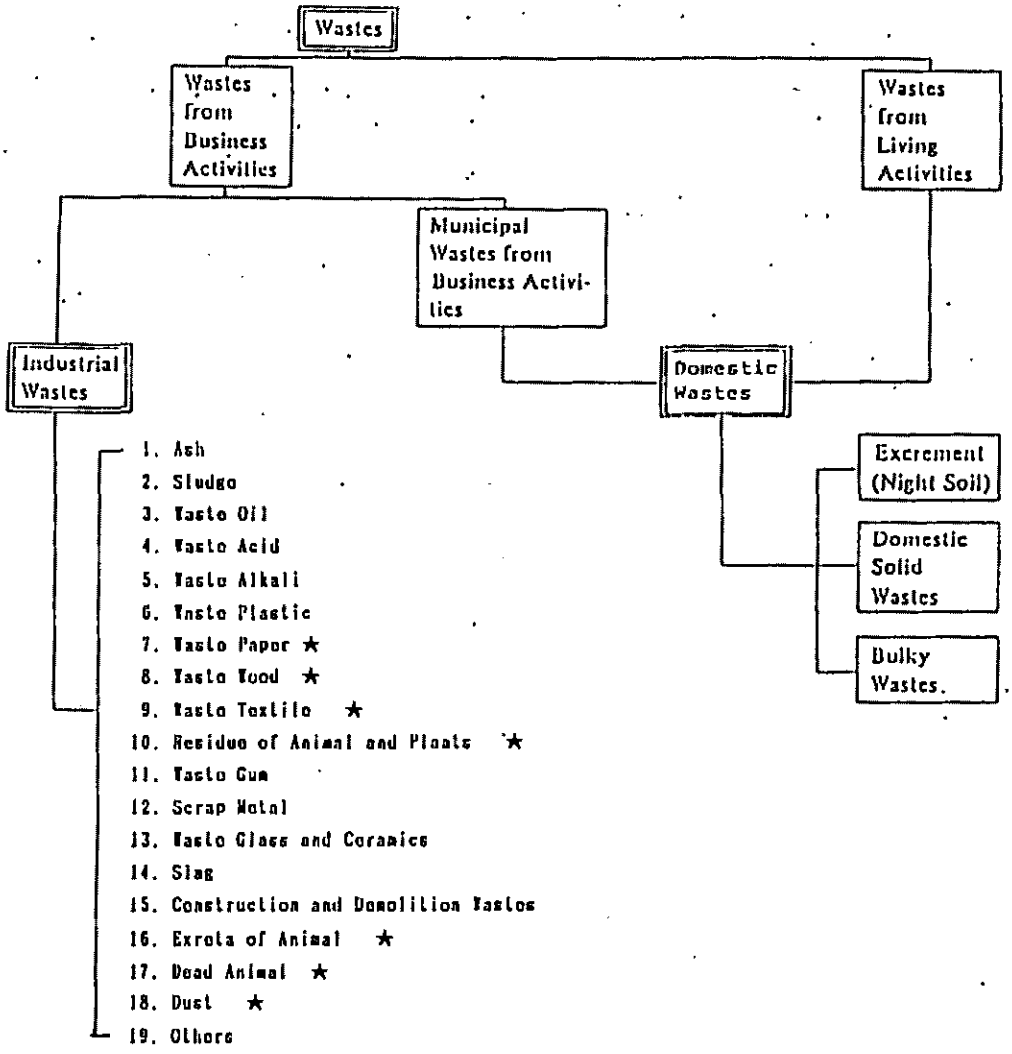


Fig. 1.2 Classification of Wastes

1.5. Municipal Solid Waste Management in Japan

Municipal Solid Waste Discharge

The change of municipal solid waste dischange is illustrated in Fig. 1.3

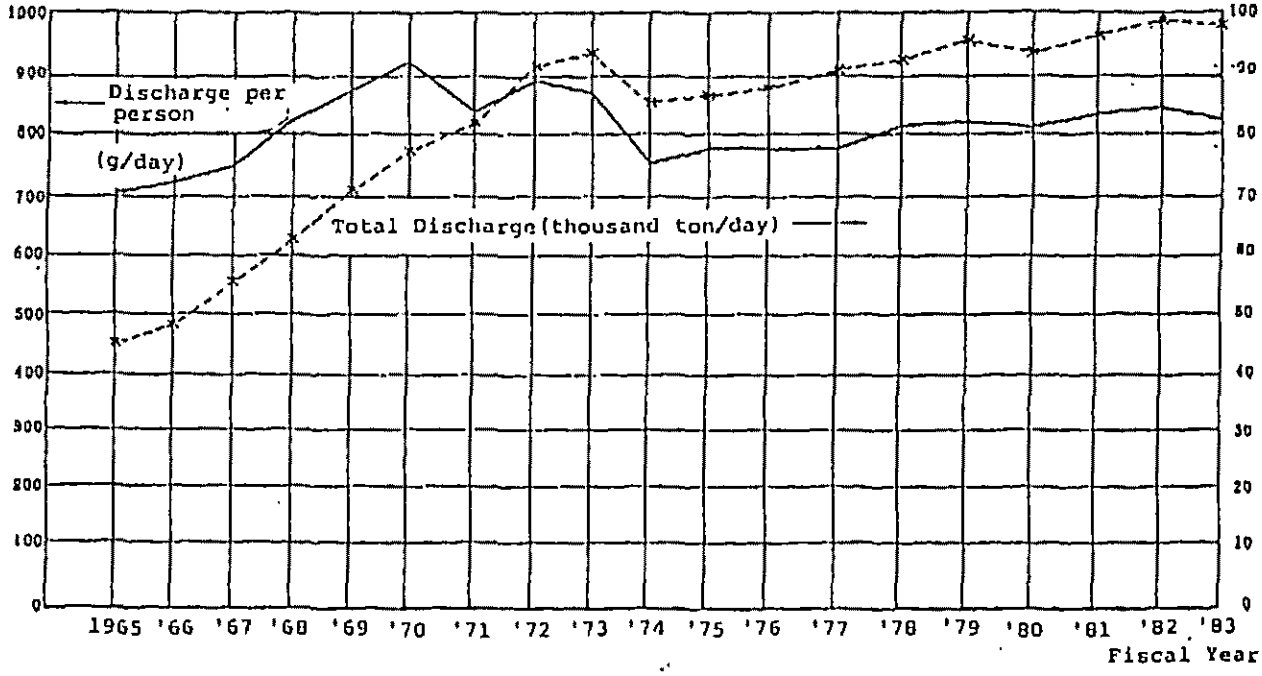


Fig. 1.3 The Change of Municipal Solid Waste Discharge

The discharged quantity of waste is said closely correlated with the GNP(gross national product). In other words, from 1955 until 1970, in accompany with activation of economic activity, the discharged quantity of waste has just increased uphill, and with the oil crisis in 1973 as the borderline, its growth has become blunt.

However, the daily discharge per person differs among various cities, as is shown in Table 1.3. Generally, the people in large cities generate more solid waste than those in small cities.

Table 1.3 Daily Discharge per Person in Various Cities (FY 1982)

City	Population (thousand)	Discharge (g/day·person)
Sapporo	1,470	1,773
Tokyo	8,334	1,710
Kawasaki	1,097	1,288
Kyoto	1,473	1,021
Osaka	2,623	1,806
Fukuoka	1,118	1,300

2) Quality of Municipal Waste

Examples of physical composition in municipal solid wastes are shown in Table 1.4. The proportion of combustibles is around 70% in typical municipal waste in Japan. Water content of municipal waste is about 40-50% ,though it is coming to decrease recently.

Typical lower calorific values of municipal wastes in Japan is of a range between 1,300-2,000 kcal/kg, while the values varies with the change of physical composition and water content. The lower calorific value is rising recently, according to decrease of water content and increase of plastics content. Specific gravity of municapal solid waste varies along with waste composition, etc. The one in Tokyo in FY 1974 is estimated to be 0.253. Collection-to-disposal Flow Diagram of MSW is shown Fig. 1.4.

Table 1.4 Physical Composition of Domestic Solid Waste

(FY 1983) (Weight %)

	Tokyo *1	Yokohama *2	Osaka *3
Papers	38.7	37.1	31.1
Feed Residuals	37.3	10.4	16.0
Textiles	3.4	3.7	3.8
Wood Splits, Straws, Grass	5.2		6.2
Plastics	8.4	14.0	15.9
Leathers, Rubbers	0.1		0.3
Metals	1.2	5.5	6.4
Glass	1.3	15.7	13.8
Ceramics	1.3	15.7	13.8
Sands, Stones	1.3	6.9	6.5
Others	0.1	6.8	6.5
Total	100.0	100.0	100.0

*1 Combustible waste only, wet-base

*2 Dry base, water content: 40.95%

*3 Dry base, water content: 45.9%

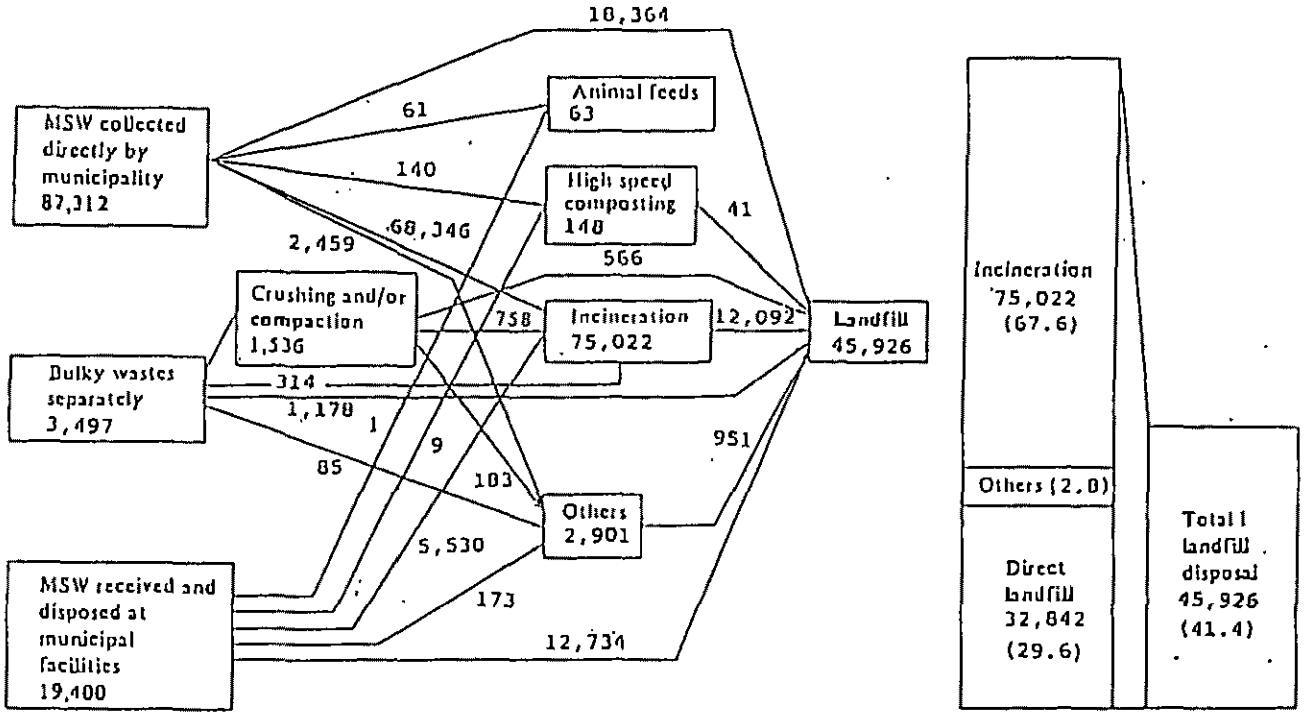


Fig.1.4 Collection-to-disposal Flow Diagram of MSW in Japan

2. GENERAL (Outline of landfill sites Today)

In Japan, landfill of wastes is subject to the standard for landfill of wastes and the standards for construction, operation and maintenance of landfill site of wastes. Both standards are based on the Waste Disposal and Public Cleansing Law .

The standard for landfill of wastes (Article 6 of the Cabinet Order) gives standards for advanced treatment for different kinds of waste, a standard for covering with soil to prevent hygienic problems due to rotten substances and standards for prevention of pollution of surface and ground waters and other matters .

Statutory formalities for official nortification and others must be followed in respect of the landfill sites specified in Table 2.1, and they should conform to the standards for their construction ,operation and maintenance .

The Type Ⅰ landfill site complete cut-off from the outside, and a specific strength is therefor required of concrete structure.

For TypeⅢ landfill site ,retaining walls ,dams ,etc. are needed as shown in Table 2.1, and there are little technical difficulties.

For TypeⅡ landfill site where waste water is treated, lining system ,leachate collection facilities, leachate treatment facilities,etc. are needed (Fig.2-1 show the typical sanitary landfill site (TypeⅡ) in Japan.)

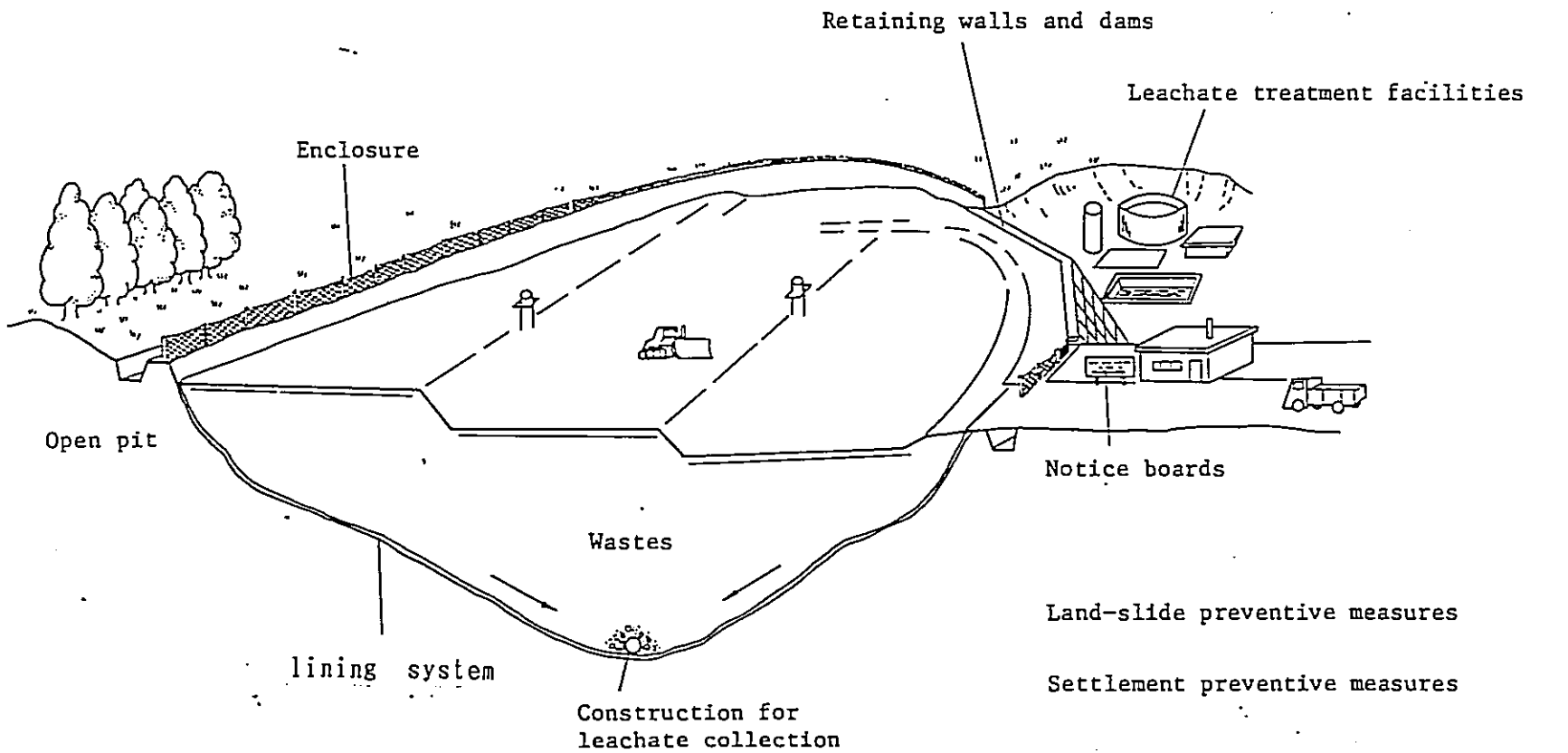
Also measures should be taken against rats and hygienic insects which feed on rotten matters or the like.

This report will describe the sanitary landfill technique for the TypeⅡ landfill site, which has been subjected to the most thorough examinations and studies.

Table 2.1 Waste Disposal Facilities (Landfill Sites)

Type of landfill site	Filling substances	Site to be notified to authorities	Outline of facilities
Type I	Industrial wastes including hazardous substances	All sites of this type	Notice boards, enclosure, structure for excluding outside rainwater, structure for preventing rainwater inflow, land-slide preventive measures, settlement preventive measures, external periphery separating facilities (15 cm or more thick concrete), internal separating facilities (10 cm or more thick concrete), corrosion preventive measures and covers.
Type II	General wastes Industrial wastes not specified for type I and type III.	Site with a landfill area of 1,000 m^2 or more	Notice boards, enclosure, structure for excluding outside rainwater, land-slide preventive measures, settlement preventive measures, water interrupting measures, structure for leachate collection, leachate treatment facilities, retaining walls and dams.
Type III	Waste plastics, rubber scrap, metal scrap, glass and porcelain chips and construction waste materials.	Site with a landfill area of 3,000 m^2 or more	Notice boards, enclosure, rataining walls and dams.

Fig. 2.1 The Outline of Type II Landfill Site



3 .HISTORY OF THE LANDFILL SITE IN JAPAN

Historically, the disposal of solid waste began with the mere elimination of waste from the living areas, but to appropriately answer the need for preserving the environment and for preventing environmental pollution, it has developed into the efficent disposal processes and now even the resource recovery in the final disposal stage is developing.

Similarly, as indicated in Fig.3.1, the landfill by wastes has experienced a transition of concept from just a dumping site to a treating site for final disposal and finally to a space for recovering usable land . Before in 1960`s many landfill site are open dumping area. But because of our affluence and increasing population, amount of solid waste are expected to increase.

Many of solid waste have been directlly disposed of on land, the vast majority of it in an unsatisfactory technique.

Open and burning dumps, which were all too common, have contributed to water and air pollution and provide food , harborage ,and breeding grounds for insects.

In addition ,these dumps are unsightly and very often lessen the value of nearby land and residences.

In 1960`s, in response to an aroused public, legislation has been passed on the goverment to aid the development of satisfactory disposal practices and to plan for all aspect of solid waste management. In the former half of 1970`s, the development and implementation of such plans has, however, required the combined support of all citizens, university, industry ,and goverment.

An acceptable alternative to the present poor practies of land disposal has been the sanitary landfill .

This alternative has involved the planning and applying of engineering and construction techniques.

Sanitary landfill is an engineered method of disposing of solid waste on land by spreading them in thin layers, compacting them to the smallest practical volume, and covering them with

soil each working day in manner that protects the environment.

By definition, no burning of solid waste occurs at a sanitary landfill.

Sanitary landfill is not only an acceptable and economic method of solid waste disposal ,it is also an excellent way to make otherwise unsuitable or marginal land valuable.

Thorough planning and the application of engineering principles to all stages of site selection, design, operation and completed use will result in successful and effecient sanitary landfill.

In order to meet this objective, it is also essential to have an understanding of solid waste decomposition processes-how the many variable may affect the decompsition rate, decomposition products, and how these factors may influence the environment.
In essence, these relationships determine the physical stability of the fill and its potential to produce such environmental problems as uncontrolled gas generation and movement and water pollution.

Although these relationships are not fully understood , sufficient knowledge is available to enable us to recognize potential problems and to plan and design sanitary landfill that will not harm the environment.

The final selection of a sanitary landfill site, its design, and its operation should be based on a systematic , integrated study and an evalution of all physical conditions, enconomics, and social political restraints.

In the latter half of 1970`s, sanitary landfill techniques have improved in Japan because of the finding of a new landfilling concept. It should be essential for a country like Japan where land space is limited that recovery system as indicated in (D) of Figure 3.1. be established in order to deal with waste problems in the 1980`s.
In the first part of this Report, sanitary landfill techniques will be introduced. And in the second part, the new concept of sanitary landfill site and a few of recent studies in Fukuoka University will be introduced.

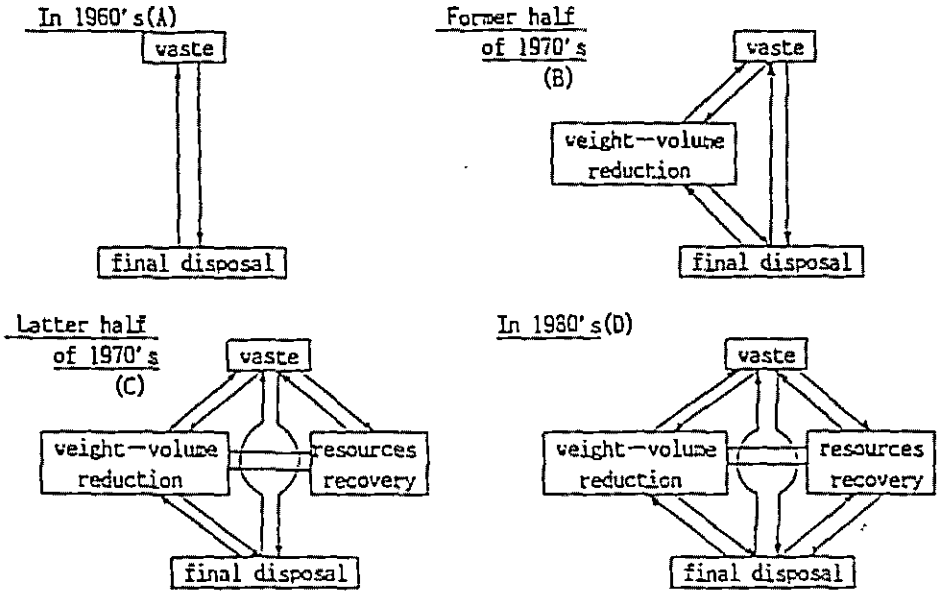


Fig. 3.1 Changing of Waste Disposal and Management

4. SANITARY LANDFILL DESIGN

The designing of a sanitary landfill calls for developing a detailed description and plans that outline the steps to be taken to provide for the safe ,efficient disposal of the quantities and types of solid wastes that are expected to be recieved .

The designer outlines volume requirements, site improvements (clearing of the land, construction of roadways and buildings, fencing,utilities ,etc), and all equipment necessary for day-to-day operations of the specific landfilling methods involved.

He also provides for controlling water pollution and the movement of decomposition gas. It describes the physical and chemical properties of bedrock, particularly as it may relate to the movement of water and gas (See Fig4.1)

The sanitary landfill designer should also recommend a specific use of the site after landfilling is completed. Finally ,he should determine capital costs and projected operating expenditures for the estimated life of the project.

The important items for sanitary landfill design are as follows;

1. Solid Waste Composition
2. Hydrology, Climatology and Geology
3. Volume Requirements
4. Control of Surface Water (Fig.4.2 ~ 4.4)
5. Groundwater Protection
6. Sanitary Landfilling Method (Table 4.1, Fig.4.5~ 4.9)
   - 6-1 cell construction and cover material
   - 6-2 trench methods
   - 6-3 area methods
   - 6-4 combination methods (bank method, wetland method etc.)
7. Gas Movement Control (Fig.4.10~ 4.12)
   - 7-1 permeable methods
   - 7-2 impermeable methods
8. Site Improvements

8-1 clearing and grubbing

8-2 roads

8-3 scales

8-4 buildings

8-5 utilities

8-6 fencing (Fig. 4.13～4.15)

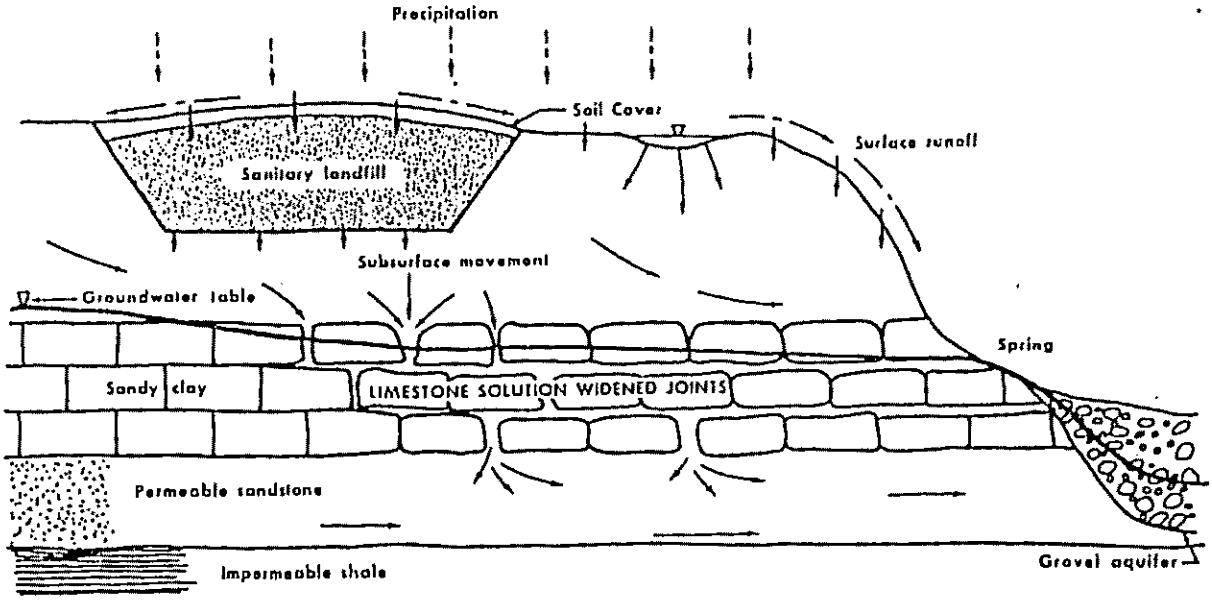


Fig. 4.1 Leachate and infiltration movements are affected by the characteristics of the soil and bedrock.

Objective of rainwater drainage facility

When rainwater permeates in landfill wastes, it dissolves or suspends contaminants which have been contained and decomposed by biochemical action,thus resulting in leachate .

Leachate has to be collected and treated at an leachate treatment facility to prevent it from contaminating the ground around a landfill where the wastes are reclaimed. Yet, the cost for leachate treatment is very expensive. Therefor, rainwater drainage facilities are established to:

1) prevent rainwater from permeating into a landfill(shown Fig.4.2)
2) prevent ground and spring water from permeating through base or sideface of a landfill to reduce the quantity of leachate. It is important to drain water from rainwater drainage facilities in such a way that would avoid all possibilities of disaster.

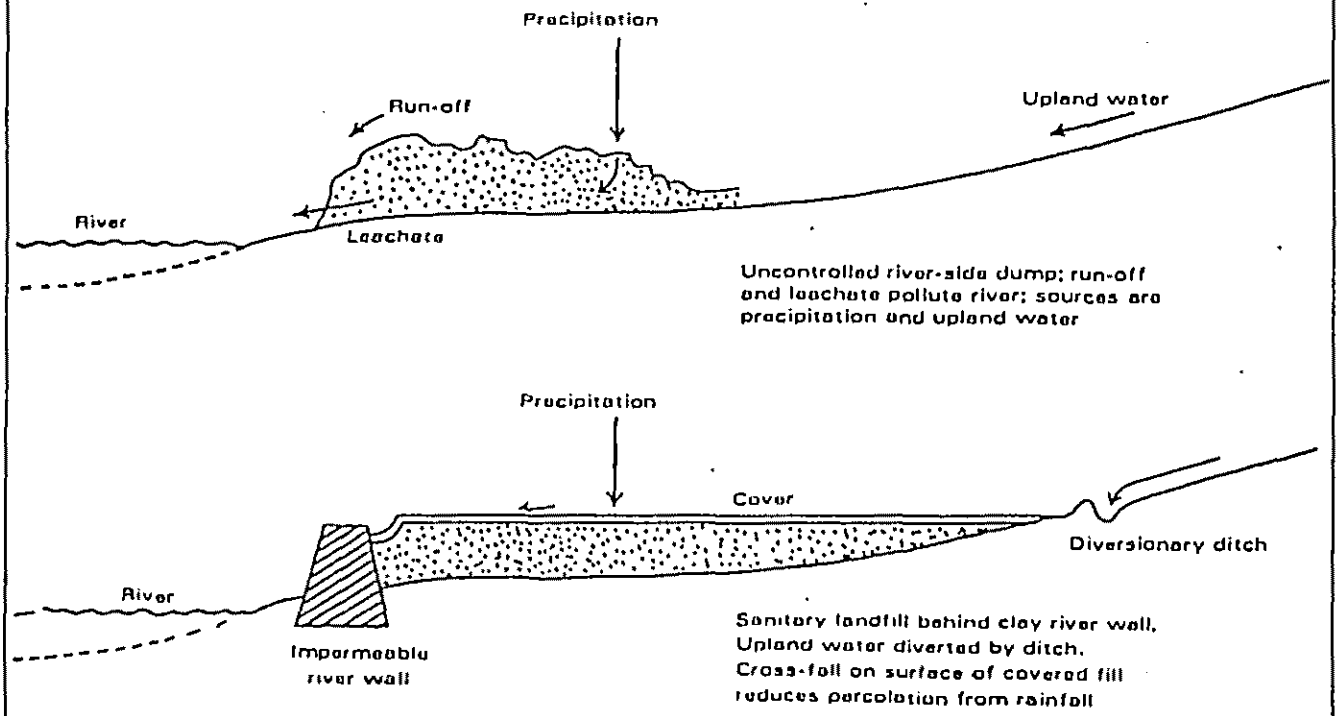
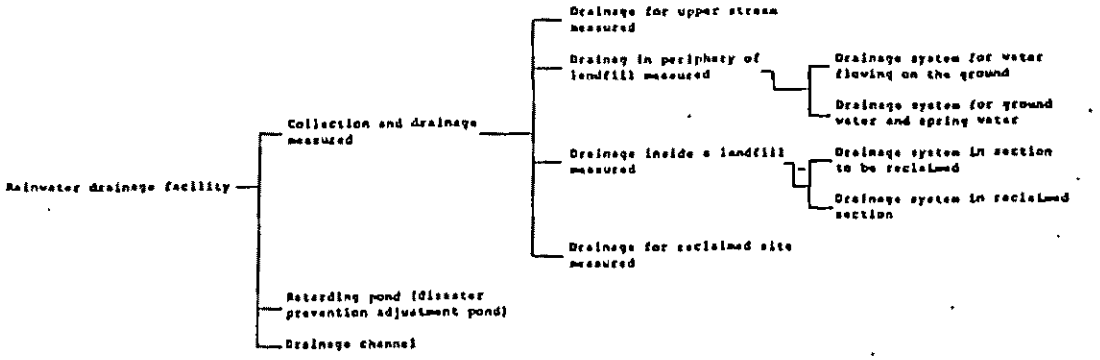


Fig. 4.2 CONTROL OF SURFACE WATER POLLUTION

Structure of rainwater drainage facility

Draining rainwater in a rainwater drainage facility is as follows:



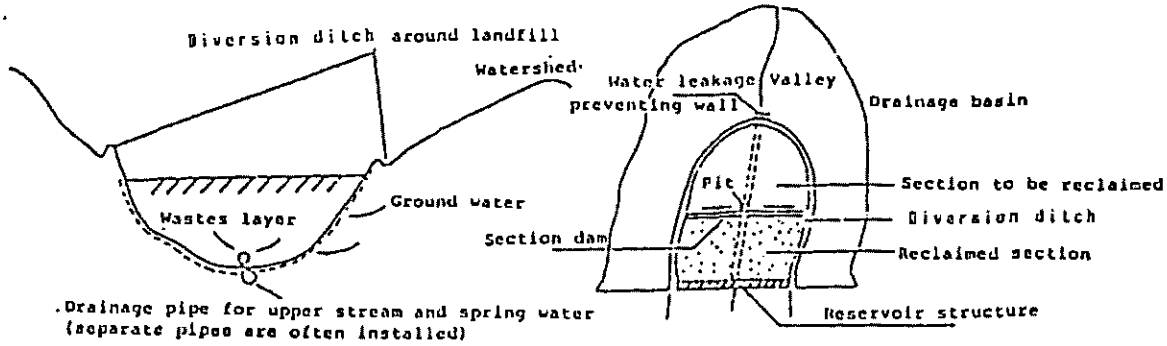


Fig. 4.3 Concept illustration of rainwater collection and drainage measure

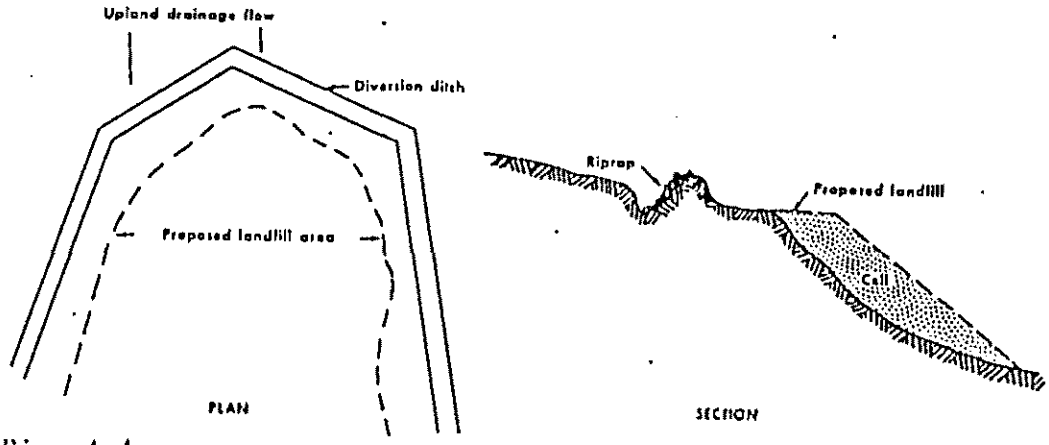


Fig. 4.4 Plan and section views of the use of a diversion ditch to transmit upland drainage around a sanitary landfill.

Sanitary Landfilling Method .

1 . Trench method (Fig. 4.5)

The trench method can be used where a high water table is not a problem.

In this method, the loose waste is dumped and then spread and compacted, following the cell concept of sanitary landfill construction.

The waste is covered with soil and graded to prevent ponding of surface water .

2 . Area method (Fig. 4.6)

The area method is used where high water table may prohibit the excavation of trenches. The loose waste which generally is spreadover a large area ,is first stockpiled and then compacted against an earth berm using the cell concept for sanitary landfill construction. Soil cover material may be hauled in form adjacent areas or secured at the toe of the working face as shown in Fig.4.7.

The site should be graded periodically to avoid ponding of surface runoff .

3 . Bank method

The bank method is a modification of the area method and merely takes advantage of the original sloping nature of the waste. When the waste has been set to a 3 : 1 slope, it is compacted and covered ,thus forming the berms for the adjacent cell.

4 . Wetland method

This method is used where the dump is in a marshland or in a river or other water course. The open dumped waste is first removed and then separated from the water by placement of mat of impervious material that reaches above high water level .

Another means of separation between the soil waste and the water can be achieved by diverting the flow of water or if necessary, by lowering the the ground water level.

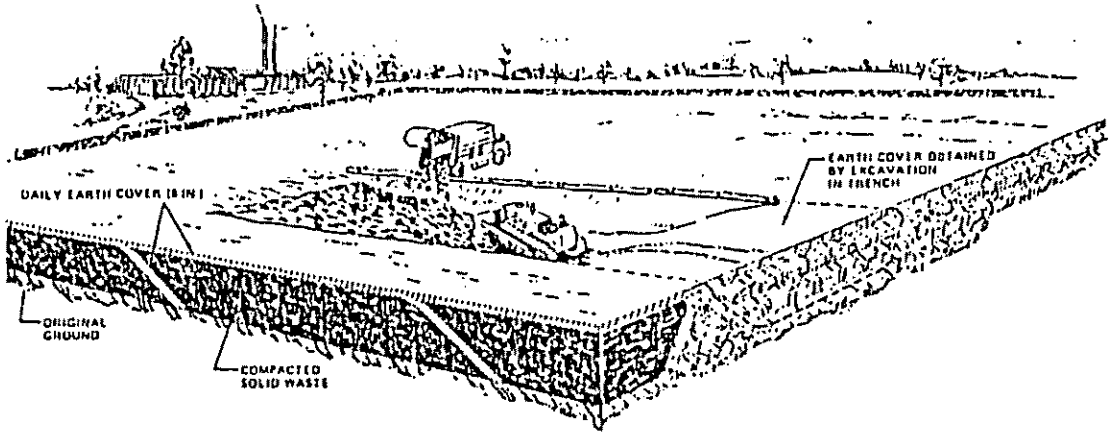


Fig. 4.5 In the trench method of sanitary landfilling, the collection truck deposits its load into a trench where a bulldozer spreads and compacts it. At the end of the day, the trench is extended, and the excavated soil is used as daily cover material.

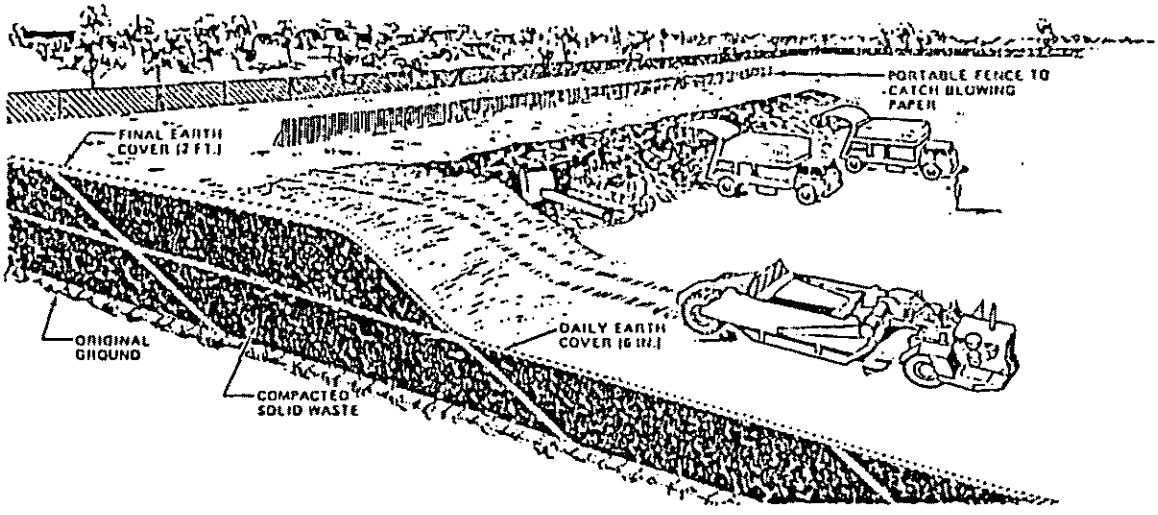


Fig. 4.6 In the area method of sanitary landfilling, a bulldozer spreads and compacts the waste on the natural surface of the ground, and a scraper is used to haul the cover material at the end of the day's operations.

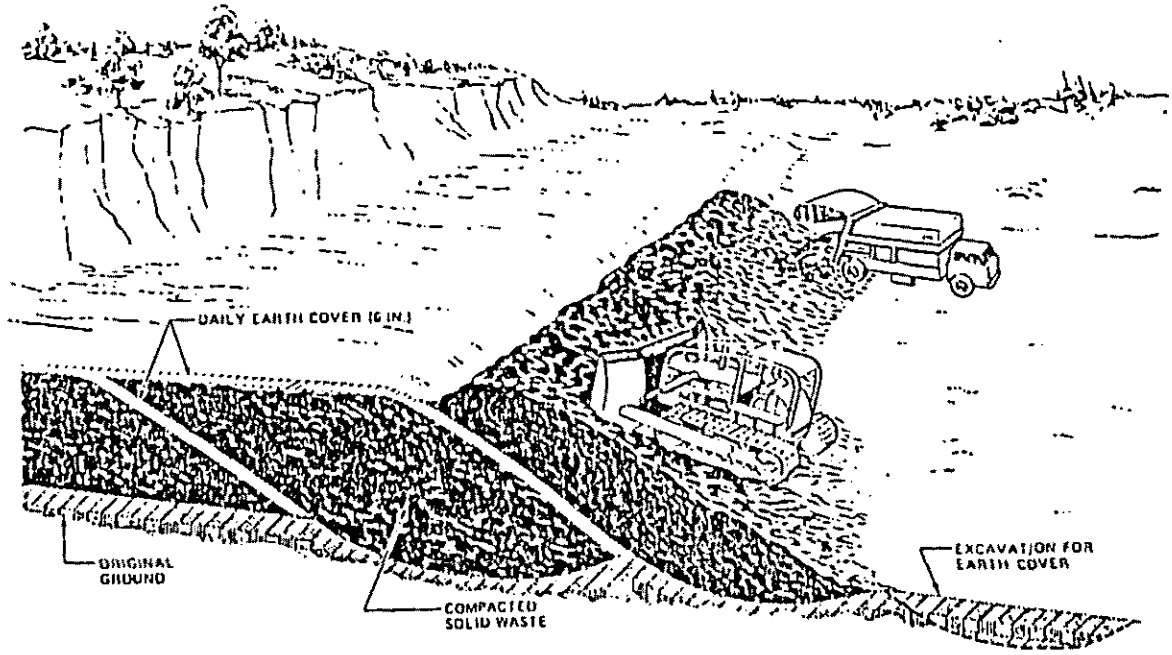


Fig. 4.7 In the progressive slope or ramp method of sanitary landfilling, solid waste is spread and compacted on a slope. Cover material is obtained directly in front of the working face and compacted on the waste.

The landfill method is determined by geographical features on the site and the amount of waste. Methods can be classified in three groups:the trench construction method (Fig. 4.8), the area method (Fig. 4.9), and the ramp method which mixes the trench and area methods (See Fig 4.7)

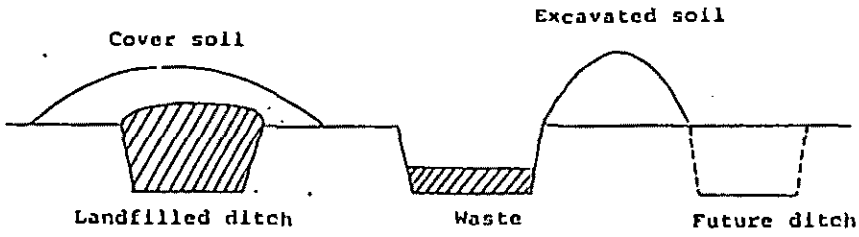


Fig. 4.8 Trench construction method

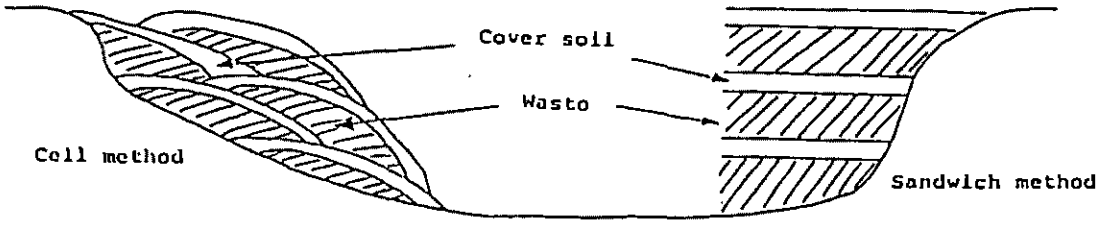


Fig. 4.9 Area method

In trench method, waste is disposed in the ditch and covered with earth and sand. Ditches are dug usually by heavy equipment. This method is popular at smaller final disposal sites. The area method is usually used for natural or artificial depression sites. This is the most basic method.

Area method can be further divided into the sandwhich, cell, and throwing methods. Fig. 4.9 illustrates the sandwich method and the cell method. Small scale final disposal sites use cell method. The cell method covers waste of one day with soil making one cell per every operational day. Currently, this remains the most popular method.

Gas Movement Control

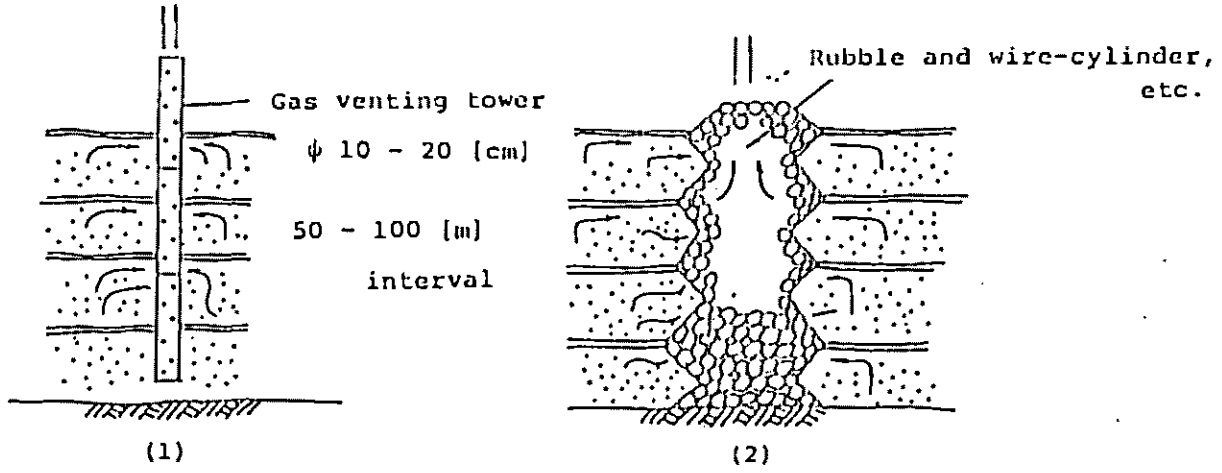


Fig. 4.10 Individual gas venting facility within landfill site

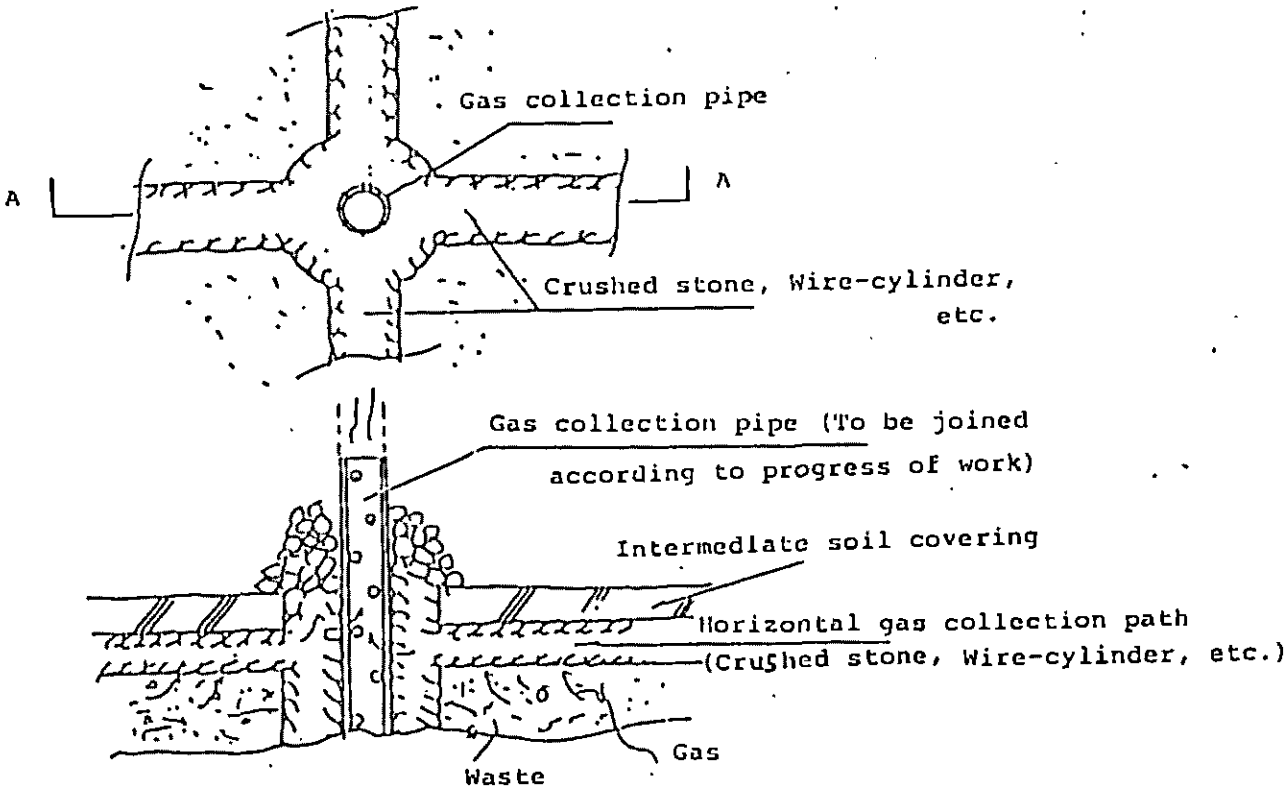


Fig. 4.11 Centralized gas venting facility within landfill site

Centralized diffusion method

This method is much more preferable considering that coordination with the gas venting facility is maintained even after the landfill completion and its gas collection effect is generally high and trouble some landfill work is not involved. The centralized gas system, which is composed of horizontal porous pipes, rubble and wire-cylinder, etc. is provided in the waste layer as shown in Fig. 4.10 ~ 4.12.

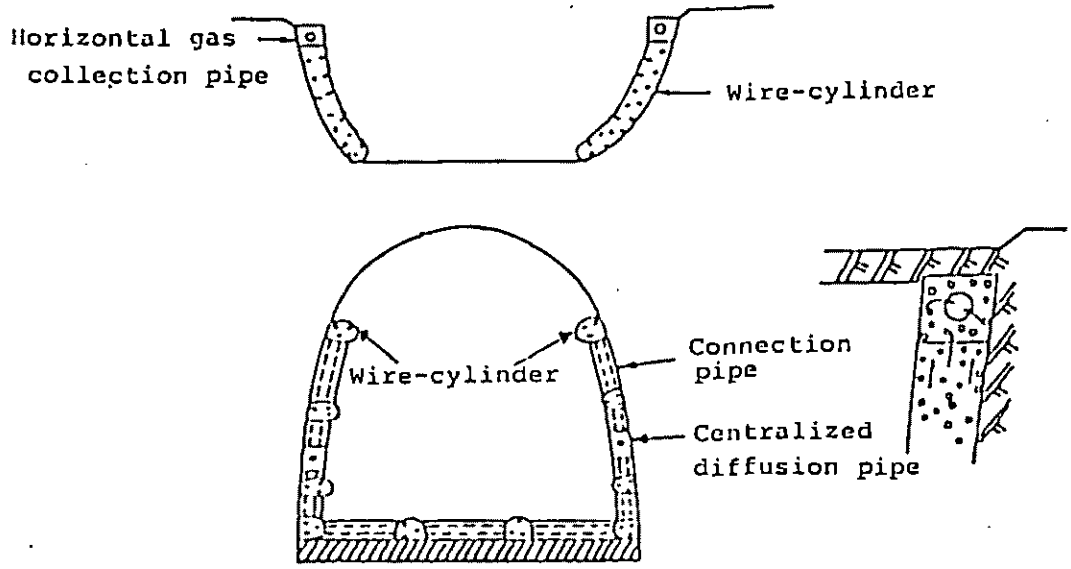


Fig.4.12 Centralized gas venting facility within landfill site

Arrangement of gas venting facility

Arrangement of the gas venting facility during works should be coordinated from the beginning with the centralized gas system since amount of gas generated is not known in advace. However, it is normally determined empirically refering to the similar circumstances of landfill works and work examples. As for ordinary installation, wire-cylinders are provided with 30-50 m interval at the slope and 50-100 m interval within the landfill site.

Fencing Idea of design

Although the height of the fence is most important, standard heights have yet to be established.

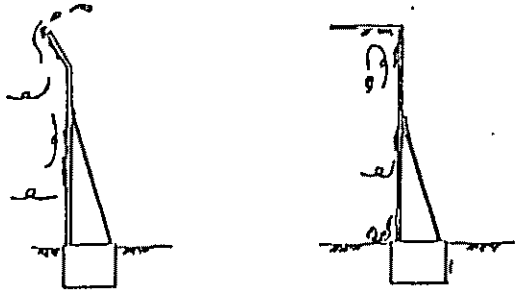


Fig. 4 13, Scattering of waste and an example of prevention

In most cases, however, waste usually doesn't scatter. Therefor, a fence (covered with chicken wire,20mm-40mm mesh) of 3 to 4 m in height will serve this purpose unless waste is piled to a height.

However, if waste gets caught on the fence, it may be blown over the fence by wind as shown in Fig.4.13, therefor, the spike shall need to be long enough with right angles.

Another case is shown Fig.4.14, 4.15.

Enough screens are necessary to form an arc sufficiently long to catch everything blown from the working area. They must be cleaned regularly if they are to remain effective, and in very high winds they must require to be temporarily supported by guy ropes secured to pegs driven into the ground.

FENCE OF AIRBORNE LITTER

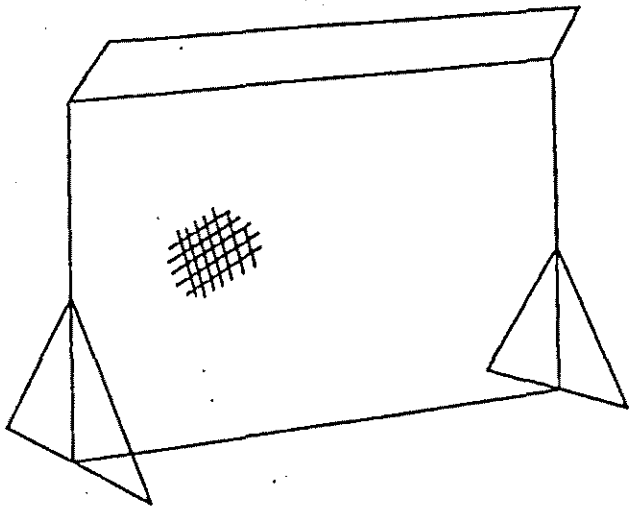


Fig. 4.14 Portable litter screen about 2½ metres high, 2½-3 metres long, covered with chicken wire, 20mm - 40mm mesh

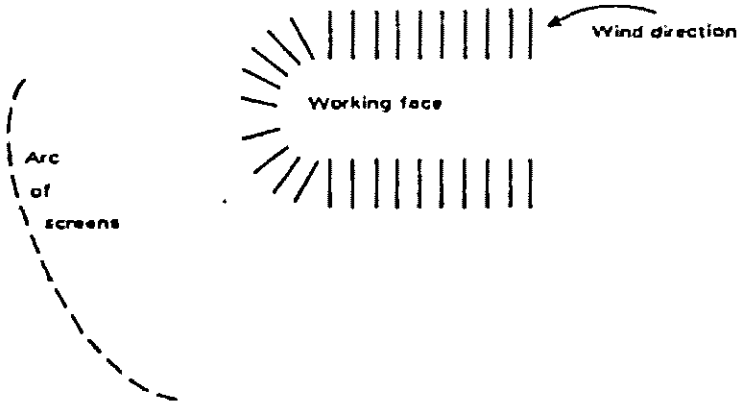


Fig. 4.15 A number of screens are used to form an arc the position of which is changed in accordance with wind direction

5 .SUMMARY OF DESIGNCONSIDERATIONS

The final design of a sanitary landfill should describe in detail:

(1) all employee and operational facilities

(2) operational procedures and their sequence, equipment, and manpower requirments.

(3) the pollution potential and methods of controling it ;

(4) the final grade and planned use of the completed fill;

(5) cost estimates for acquiring, developing, and operating the proposed site.

The designer should also provide a map that shows the location of the site and the area to be served and a topographic map covering the area out to 1000ft from the site .

Additonal maps and cross-sections should also be included that show the planned stages of filling (startup ,intermediate life ,and completion).

They should present the details of :

1. Roads on and off the site;
2. Buildings ;
3. Utilities above and below ground ;
4. Scales;
5. Fire protection facilities ;
6. Surface drainage (natural and constructed) and groundwater;
7. Profiles of soil and bedrock ;
8. Leachate collection and treatment facilities ;
9. Gas control devices;
10. Buildings within 1,000ft of property (residental,commercial, agricultural) ;
11. Streams ,lakes ,springs ,and wells within 1,000 ft;
12. Borrow areas and volume of material available ;
13. Direction of prevailing wind ;
14. Areas to be landfilled, including special waste area ,and limitations on types of waste that may be disposal of;
15. Sequence of filling ;
16. Entrance to facility ;

17. Peripheral fencing
18. Landscaping
19. Use of completed landfill

Fig. 5.1, 5.2 show the concept illustration of the typical sanitary landfill site in Japan .

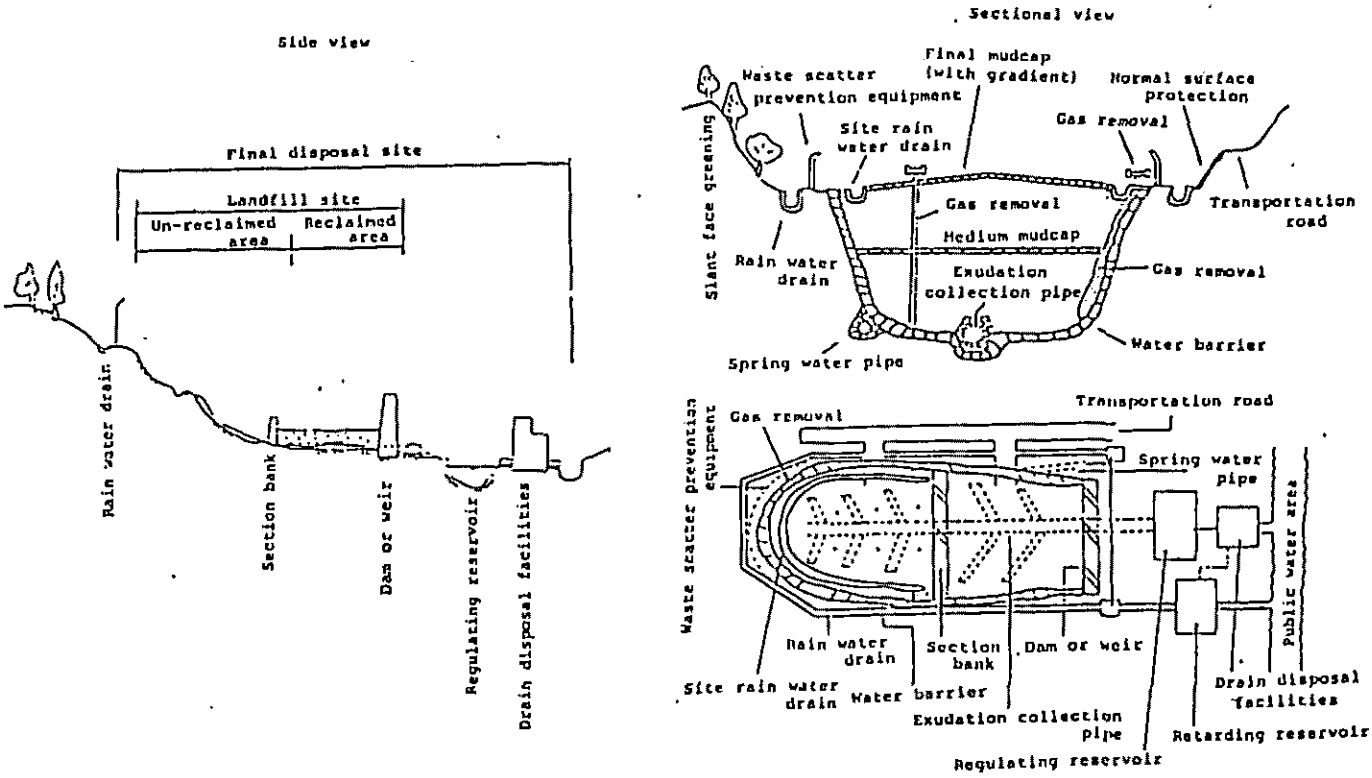


Fig.5.1 Landfill site concept illustration

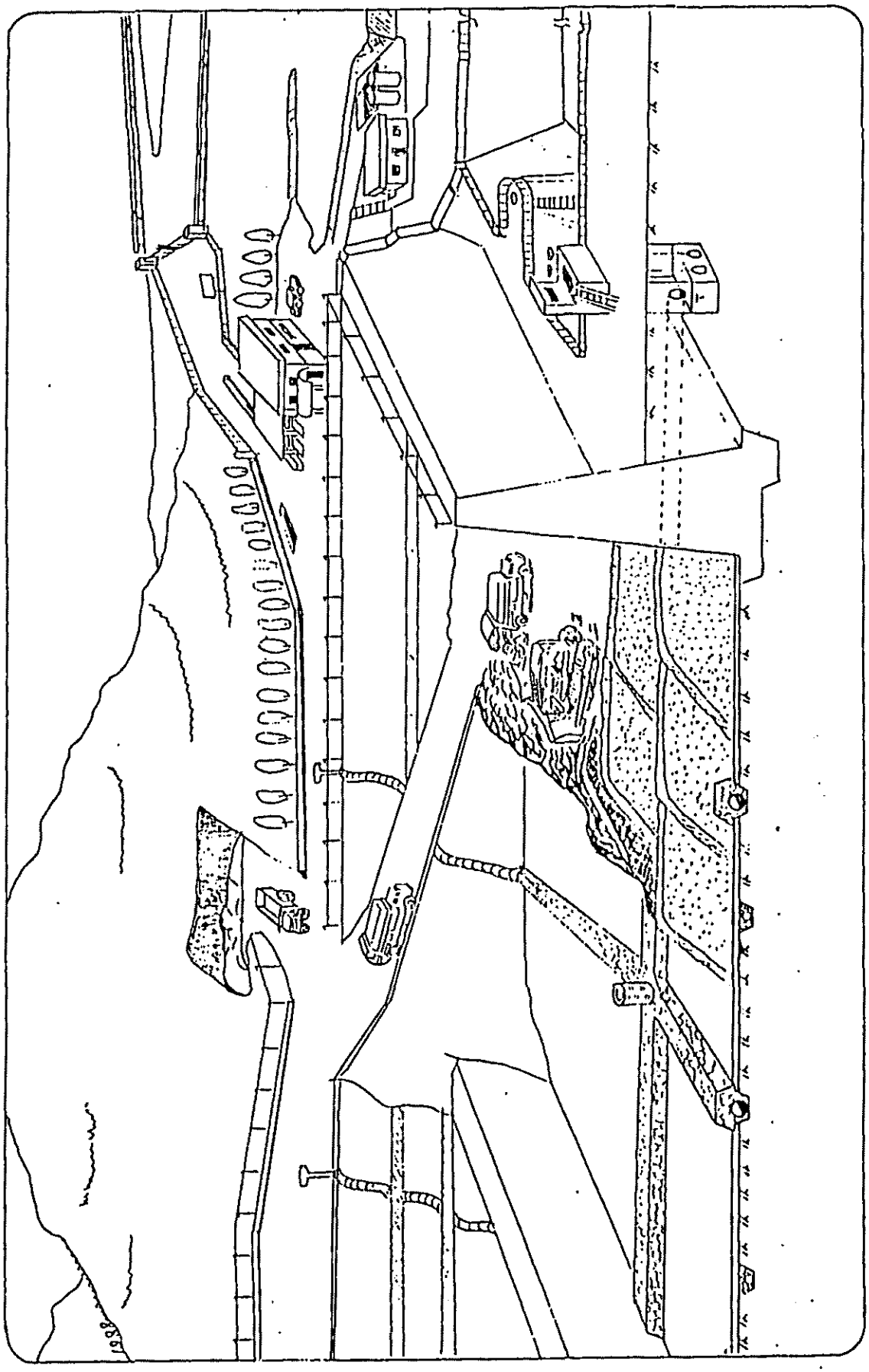


Fig.5.2 Concept illustration of a typical sanitary landfill site

6. CONSTRUCTION, OPERATION AND MAINTENANCE

The best designed disposal facility will be of little value unless it is constructed and operated as prescribed. This is especially true of a sanitary landfill because it is under construction up to the day the last particle of solid waste is disposed of .

Constructing the sanitary landfill on a daily basis in accordance with the design should be unequivocally required in an operational plan .

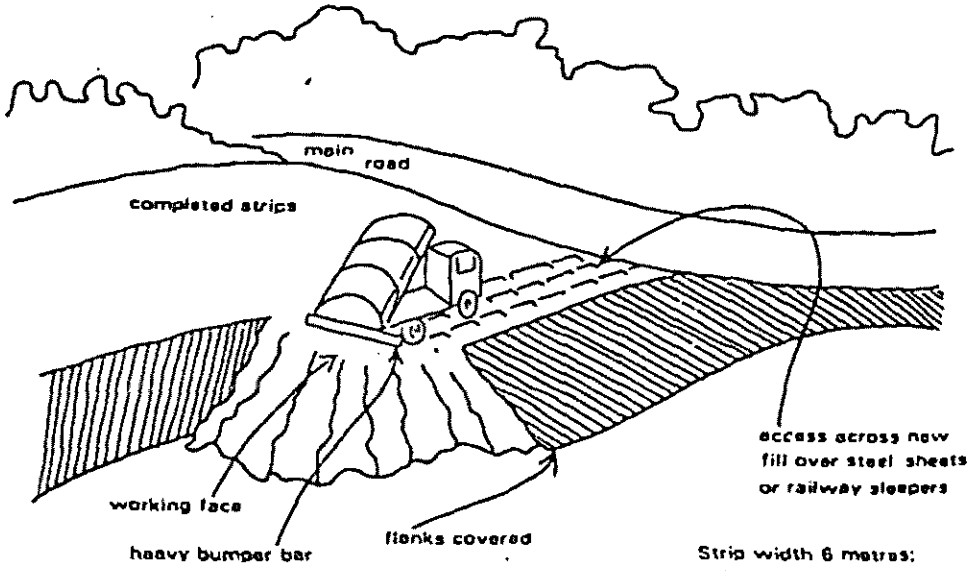
An operational plan is essentially the specification for construction and it should contain all items required to construct the sanitary landfill .

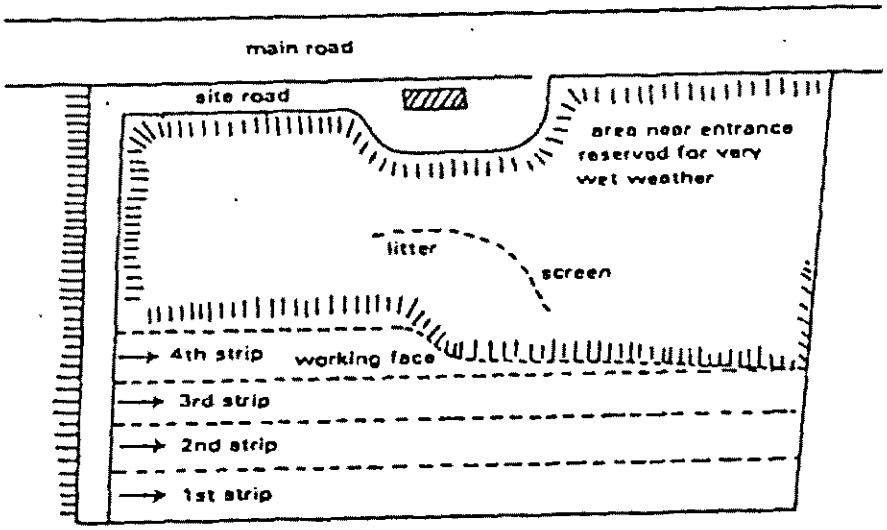
It should describe :

1) hours of operation
2) weighting the solid waste
3) traffic flow and unloading procedures (Fig.6.1)
4) designation of specific disposal areas and of handling and compacting various solid waste (Fig.6.2～6.5) (Table6.1)
5) placement of cover material (Table6.2,6.3)
6) maintenance procedures
7) adverse weather operations
8) fire control
9) litter control
10) salvaging operations if permitted .

Proper operation calls for drawing up a comprehensive plan that spells out routine procedures and anticipates abnormal situations. It must also provide continuity of activities even when personnel changes occur. New supervisors and personnel responsible for solid waste disposal must know what is being done at the landfill and why. The plan must, however, remain open for revision when necessary. Changes should be noted, and the rationale behind them explained. New personnel will benefit from the experience of others, and continuity of operations will be preserved. The plan

should also be used as a tool in training employees, defining their jobs, and giving them an insight into the work of others. In this manner, the employee will more fully understand the overall operation, and he may be able to perform other duties in an emergency.





STAGES 1. Entrance area and site of building filled with inert wastes
2. Site road formed from wastes, covered 25 cms soil plus 30 cms hardcore; waterproofed after 1 year.
3. First strip; wastes covered 25 cms
4. Subsequent strips formed
5. Cultivate strips 1 and 2 when work commences on 4th strip

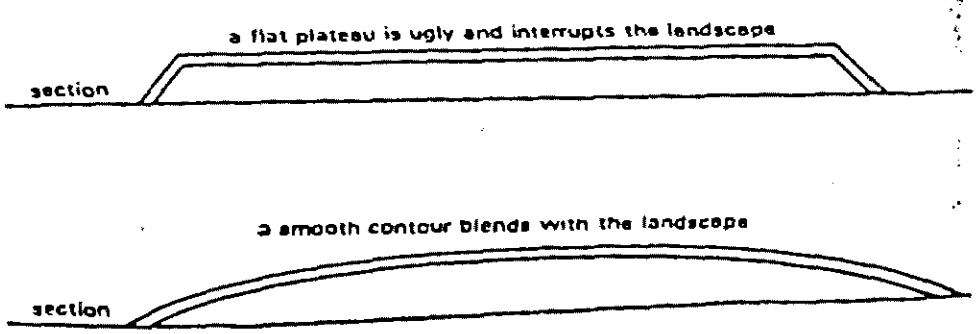


Fig. 6.1 SMALL MANUALLY OPERATED SANITARY LANDFILL

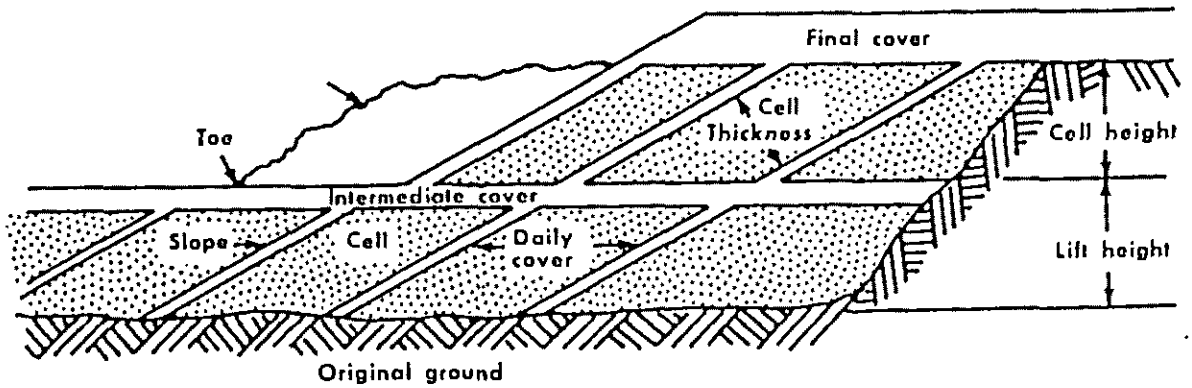


Fig. 6.2 The cell is the common building block in sanitary landfilling. Solid waste is spread and compacted in layers within a confined area. At the end of each working day, or more frequently, it is covered completely with a thin, continuous layer of soil, which is then also compacted. The compacted waste and soil constitute a cell. A series of adjoining cells makes up a lift. The completed fill consists of one or more lifts.

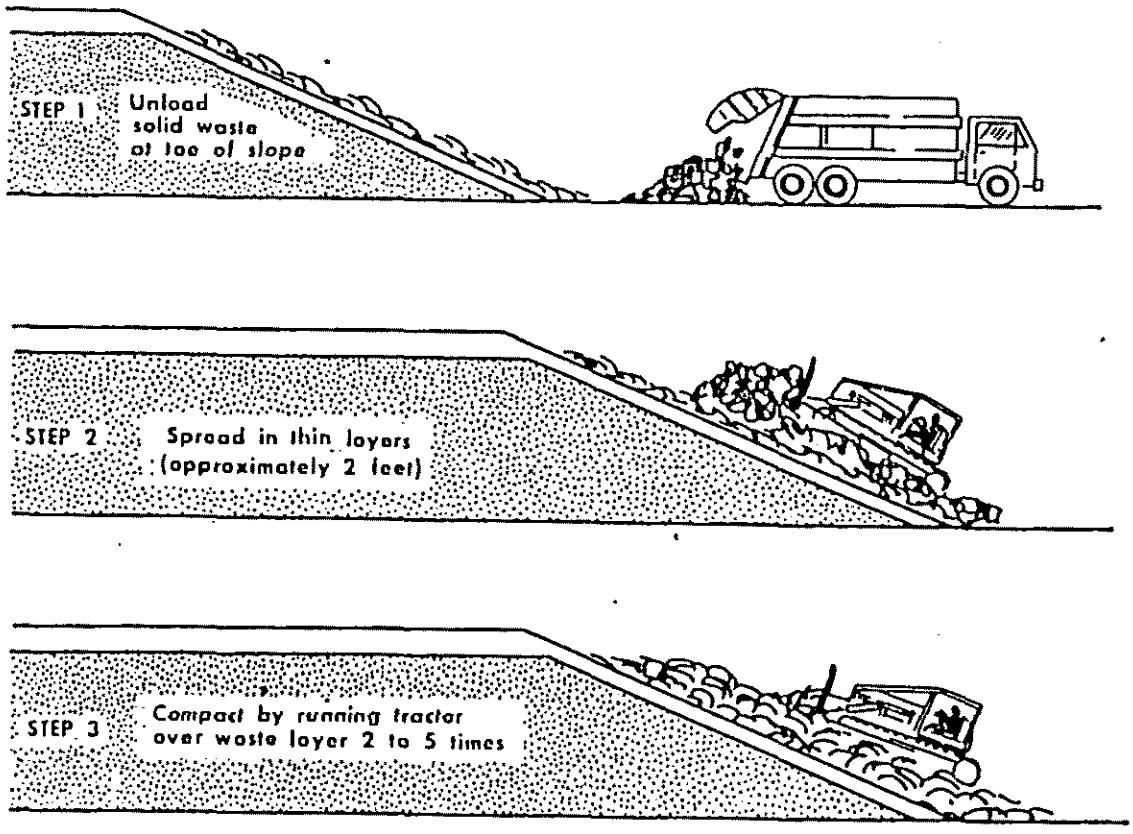
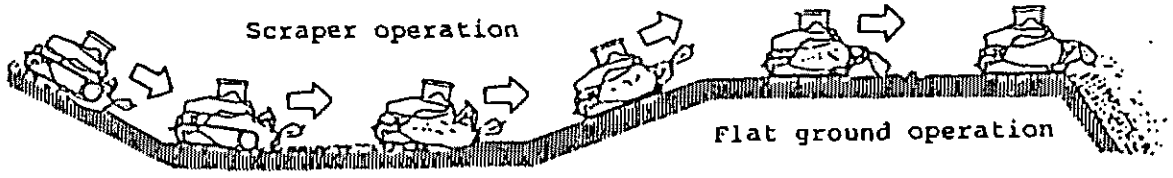


Fig. 6.3 Cushioning and bridging can be reduced and greater volume reduction achieved if the waste is spread in layers less than 2 ft deep and is then compacted by a tracked, rubber-tired, or steel-wheeled vehicle that passes over it 2 to 5 times. The equipment operator should try to develop the working face on a slope between 20 and 30 degrees.

Scrape dozers, outstandingly effective at housing site, flat small hills, slopes, or projected sediment by chipping, pick the cover soil, hold it and then cover somewhere else. Thus they are good at covering and leveling because of their rolling ability. Fig. 6.4, 6.5 shows sprape operations of scrape dozers.

Forward movement



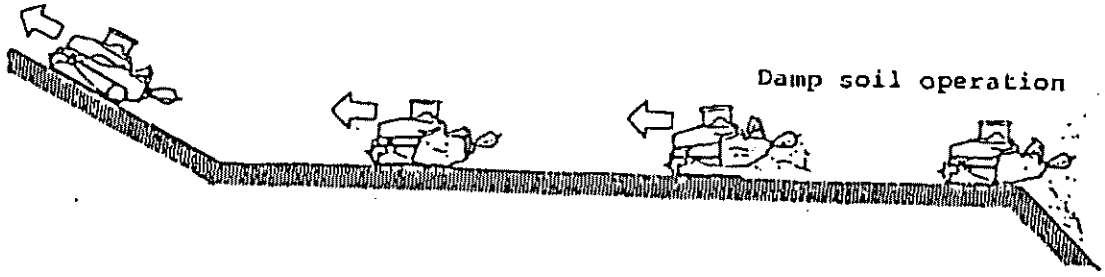
The equipment lifts the apron and lowers the bowl. The bowl blade digs about 50cm into the ground. Moving forward for about 30 sec. (approx. 15m) sill the bowl which begins to rise.

The dozer will climb a 20[°] slope with a full bowl.

It simultaneously levels the ground with a dozer blade. The end result -- a straight, flat, and compacted covering soil surface.

Fig. 6.4 Scraping operation by a scraper dozer

Reverse movement



Climbing a 30[°] slope is possible when the bowl is empty. The equipment lifts the apron and pushes earth and sand with an ejector. It spreads soil in both modes.

Fig. 6.5 (Continued) Scraping operation by a scraper dozer

Earthmovers dig and scrape and cover waste with earth and sand. They repair land surfaces, mostly used at large scale facilities. They have capacities that range from 1.5m^3 to 30m^3.

Table 6.1 is a comparison of sanitary landfill equipment.

Table 6.1 Comparison of sanitary landfill equipment

Operation / Type	Wastes		Cover Soil			
	Level	Press	Dig scrape	Level	Press	Drag
Crawladozer (Bulldozer)	A	B	C	A	B	D
Crawlaloader (Tractor shovel)	B	B	A	B	B	D
Wheeldozer	A	B	C	B	B	D
Wheeloader	B	B	C	B	B	D
Scrapedozer Scraper earthmover	D	D	B	A	B D	D A
Power shovel Dragline	D	D	A	C	D	D
Compactor	A	A	D	B	A	D

Sanitary landfill machines are expensive. It is, therefore, important to consider the scale of a final disposal site and the type of waste it will accommodate before determining what equipment to purchase. Additionally important may be the limitation of purchasing only one machine because of economic reasons. In this case, one machine must perform all the functions necessary for smooth landfill operation (leveling and rolling of waste disposal, collection of cover soil, covering and leveling of ground). This suggests that a crawl-type dozer is most suitable for work in limited areas and wheel-type loaders are, because of their excellent mobility, better suited for operation in larger sites spread over a wider area.

Table 6.2

Application of Cover Material

Cover material	Minimum thickness	Exposure time*
Daily	6 in.	0-7 days
Intermediate	1 ft	7-365 days
Final	2 ft	>365 days

* The length of time cover material will be exposed to erosion by wind and rain.

Table 6.3 Suitability of General Soil Types as Cover Material*

Function	Clean gravel	Clayey-silty gravel	Clean sand	Clayey-silty sand	Silt	Clay
Prevent rodents from burrowing or tunneling	G	F-G	G	P	P	P
Keep flies from emerging	P	F	P	G	G	E†
Minimize moisture entering fill	P	F-G	P	G-E	G-E	E†
Minimize landfill gas venting through cover	P	F-G	P	G-E	G-E	E†
Provide pleasing appearance and control blowing paper	E	E	E	E	E	E
Grow vegetation	P	G	P-F	E	G-E	F-G
Be permeable for venting decomposition gas‡	E	P	G	P	P	P

* E, excellent; G, good; F, fair; P, poor.
† Except when cracks extend through the entire cover.
‡ Only if well drained.

7. POLLUTION CONTROL AND MEASURES

A knowledge of solid waste decomposition processes and the many influences they exert is essential to proper sanitary landfill site selection and design .

Solid wastes deposited in a landfill degrade chemically and biologically to produce solid ,liquid and gaseous products .

Ferrous and other metals are oxidized ,organic and inorganic wastes are utilized by microorganisms through aerobic and anaerobic synthesis.

Liquid waste products of microbial degradation, such as organic acids ,increase chemical activity within the fill. Food wastes degrade quite readily ,while other material ,such as plastics , rubber ,glass and some demolition wastes ,are highly resistant to decomposition. Some factors that affect degradation are the heterogeneous character of the wastes, their physical, chemical , and biological properties,the availability of oxygen and moisture within the fill, temperature, microbial population ,and type of synthesis.

Since the solid wastes usually form a very heterogeneous mass of nonuniform size and variable composition, and other factors are complex,variable ,and difficult to control , it is not possible to accurately predict contaminant quantities and production rates .

7. 1 Waste Decomposition Within a Landfill

Organic substances in landfilled waste are transformed into variety of simpler organic substances and biogases by the action of microorganisms that are abundant in waste. In general, a waste within a landfill goes through three different stages with different types of bacteria predominating in each stage.

Shortly after of fillings, air is entrained within a pore of waste layer and aerobic condition will exist, however, the oxygen is consumed rapidly by the action of aerobic bacteria and then facultative anaerobic bacteria will dominate at next stage.

These produce large amount of fatty acids and carbon dioxide. Fatty acids as well as water soluble organic substances which are originally contained in waste should be a source of high BOD and /or COD of leachate and decrease pH of leachate to around 4 or 5, which in turn dissolve some inorganic substances in waste.

With time, methanogenic bacteria will dominate and anaerobic decomposition will proceed. These bacteria decompose the fatty acids to methane and carbon dioxide, which results in an increae of pH to 7or 8 and a fall of BOD and /or COD. A simple scheme of anaerobic biodegradation of organic substances is described in Figure7.1. Actual landfill site, however, receives different type of organic substances, some of which are readily degradable and others are not. Additionally, one landfill may have different parts of filled waste with a different stage of degradation which reflects leachate and gas compositions.

Figure 7.2 shows an example of material balance of organic carbon in landfill which was located at Tokyo Bay. This site was operated durning 1965 and 1974 and received mainly unprocessed municipal waste. Tokyo Metroporitan Goverment estimated 2.25×10^8 tons of organic carbon were contained in tipped waste. About 49.3% of them would be released from site in the form of gas such as methane and carbon dioxide, only 0.9% of organic carbon would dissolve in leachate and others would remaine in tipped waste as a humus by the year of 1984. This estimation shows half of organic carbon initially contained in waste is transformed into gaseous phase and another half will remain in landfill site for a long time.

Therefore, it takes several years for organic substance in waste to be degraded and stabilize through biological transformation.

7. 2 Leachate Generation and Environmental Effects

The rainfall infiltration, surface water which comes in

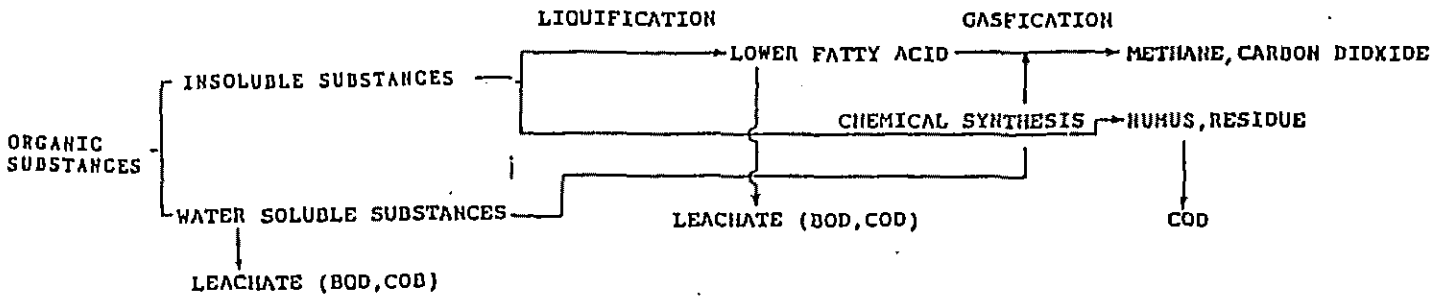
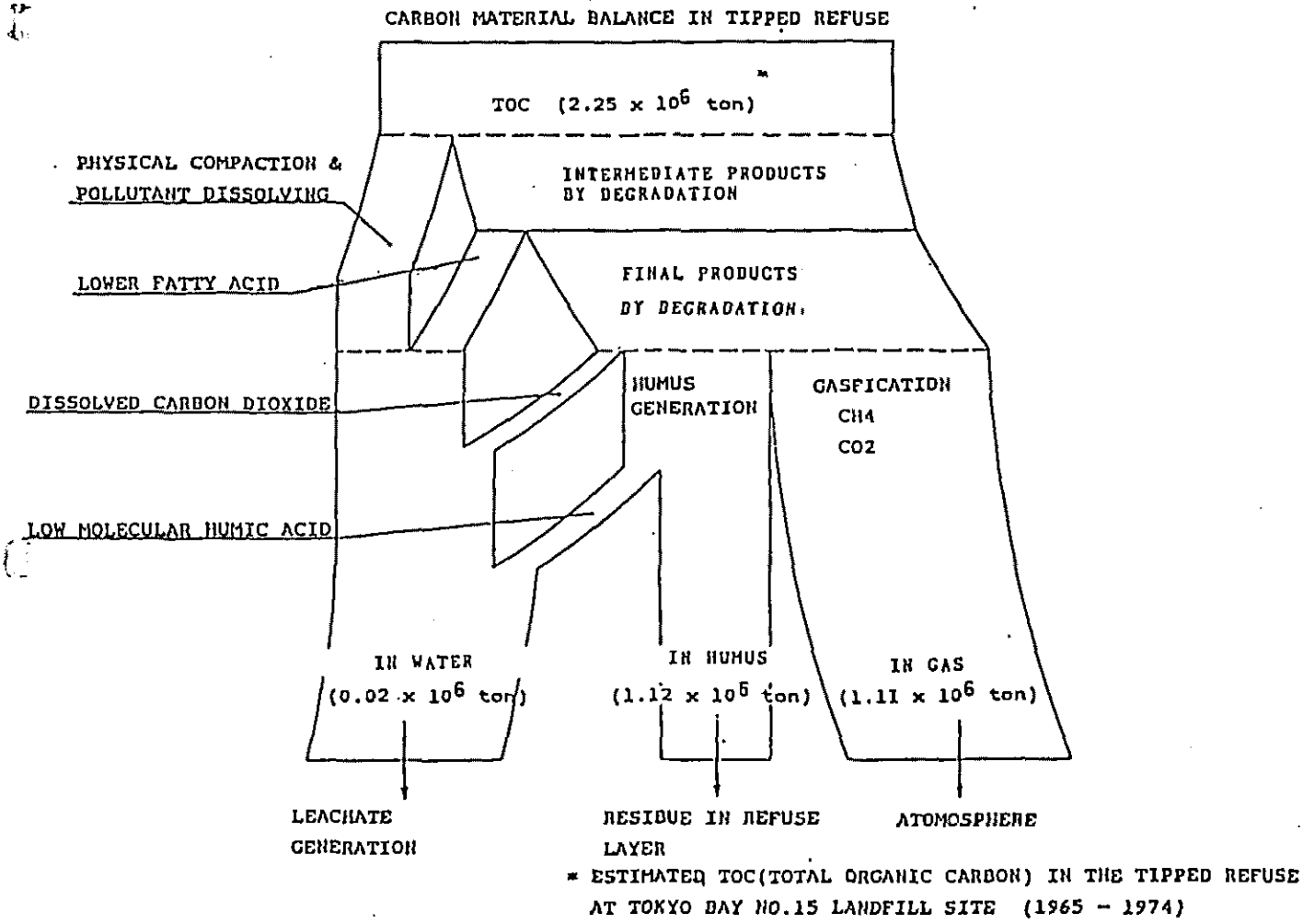


Fig. 7.1 Anaerobic Decomposition of Organic Waste



Source: Tokyo Metropolitan Government (1975)

Fig. 7.2 Material Balance of Total Organic Carbon in Tipped Waste

from out of the landfill arera, and groundwater when the landfill is constructed below the groundwater table and no lining systems are equipped, are major sources of leachate. These water percolating through waste produce highly contaminated leachate that will cause water pollution if this leachate enters into surface and groundwater unless sufficient natural attenuation or control has occurred. Figure7.6 shows an example of evidence of groudwater pollution caused by waste landfill . Constituents increase considerably to a maximum in the area underlying the landfill and then decrease gradually in both upstream and downstream of groundwater flow.

Landfill site must be selected and constructed to ensure the protection of water resources. Good design and maintenace can also ensure the prevention of water pollution . The substantial effects of surface water and groundwater pollution by leachate and associated problems are summarized in Table 7.1 and Table 7.2 respectively .

High BOD leachate and soluble metals in a reduced form will deplete the oxygen content in water resources, which results in a killing of oxygen-dependent species and bad taste and smell as well. Nitrogen,metals, organic and pH change increase toxicity of water and make unsuitable for agricultural and domestic use .

Non-biodegradable constituents will accumulate through food chains. Nitrogen, phosphorus will promote eutrophication in a closed region of surface water. Some constituents in leachate such as chlorinated organic compounds are chemically stable, hence once groundwater has become polluted by these substances it may be impossible to be restored naturally and diffi-cult and expensive to clean it up.

Fundamentals of leachate generation control is to understand water balance of the landfill site, that is, amount of input and output of water, water storage capacity of landfill. Input sources are rainwater infiltration , surface run-in, and groundwater if

sealing of landfill is insufficient and grounwater table is above the bottom of landfill, while outputs are leachate,surface run-off and evapotranspiration from landfill surface. Water balance study provides basic informations to estimate quantity and timing of leachate generation so that leachate control can be done.

It is also important to note that there exists natural attenuation capacity for some constituents in soil environment and waste itself toreduce polluting potential of leachate. Attenuation mechanisms include absorption, adsorption, filtration,dilution, dispersion, precipitation,oxidation-reduction, co-precipitation, ion exchange, and biodegradation,etc. Depending on constituents, geochemistry of the soil, and hydrogeological conditions, the effectiveness of attenuation processes are different from site to site.

Table 7.1 Potential Leachate Problems in Surface Waters

Parameter	Effect	Associated Problems
BOD	oxygen depletion	septic condition, discoloration, taste and odor problems
Iron	rust-colored stains	discoloration, slime growths on stream bottom, taste and odor problems
pH reduction	increased toxicity	potential problems for domestic use, irrigation, and stock watering downstream
Nitrogen	ditto.	ditto.
Metals	ditto.	ditto.
Organics	ditto.	ditto.
pH increase	metal precipitation	blanking of stream bottom, long term toxity
Calcium	increased hardness	interference with domestic use
Magnesium	ditto.	ditto.
Nitrogen	algal blooms	interference with domestic and recreational use
Phosphorus	ditto.	ditto.
Color	discoloration	reduced photosynthesis and oxygen depletion, esthetically unpleasant

Source: R.D.Cameron (1978)

Table 7.2 Potential Leachate Problems in Groundwaters

Parameter	Effect	Associated Problems
BOD	oxygen depletion	discoloration, taste and odor problems
Iron	rust-colored stains	staining of cloths and fixture, taste and odor problems
pH change	increased toxicity	possible problems for domestic use, irrigation, and stock watering
Nitrogen	ditto.	ditto.
Metals	ditto.	ditto.
Organics	ditto.	ditto.
Increase pH	metal precipitation	possible aquifierclogging
Total solids	attenuation and build-up	aquifier clogging, possible later desorption
Fluoride	high fluoride levels	mottled teeth
Selenium	toxicity	possible toxicity to human
Color	discoloration	esthetically unpleasant

Source: R.D.Cameron (1978)

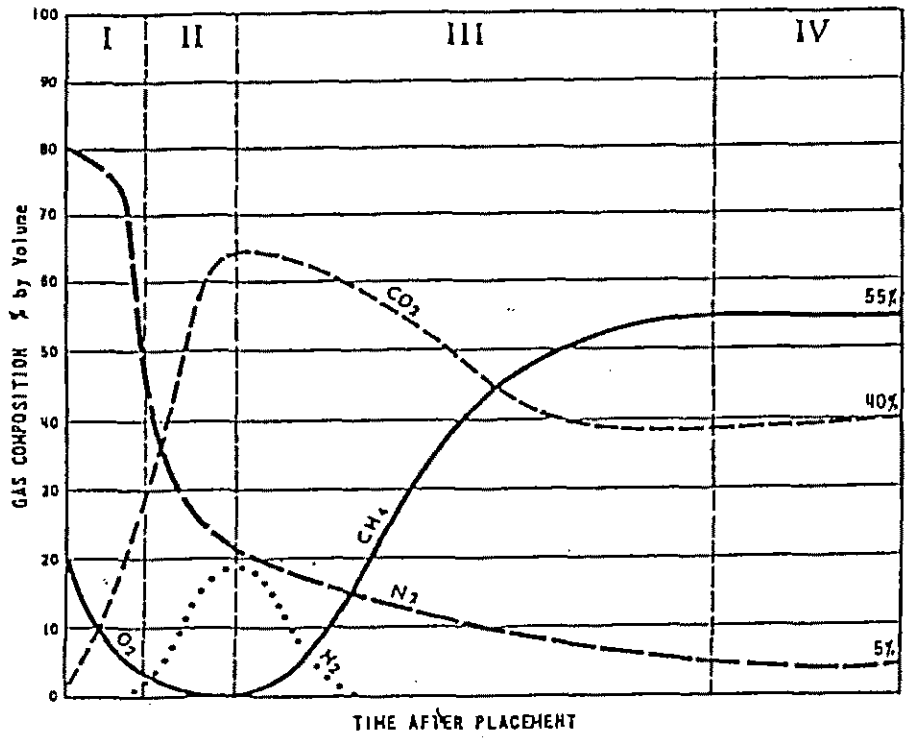
7.3 Gas Production Pattern

Gas production pattern of a typical sanitary landfill is shown in Figure 7.3. In this Figure four distinct phases are identified: phase 1, aerobic; phase 2, anaerobic ; nonmethanogenic ; phase 3, anaerobic methanogenic, unsteady; and phase4, anaerobic methanogenic, steady.

The nonmethanogenic stage is initiated by hydrolysis processes with converging complex organic matter to soluble components by means of cellulase. Within a short time, anaerobic conditions prevail, and there after only two gases are produced in appreciable quantity: methane (about 55% by volume)and carbon dioxide (about 40% by volume).

The rate of gas production and the duration of each phase are site specific. The bench scale landfill experiment of shredded municipal waste showed that it took about 300 days to reach stable methane production as shown in Figure 7.4. Most sanitary landfills are said to reach steady state methane production in 180 to 500 days. The first stage may complete only in a few days to weeks. It is quite difficult to estimate overall gas production period, however, as a common sence, a couple of decades will be needed for degradation of organic substances in municipal waste landfill.

Methane production is controlled by many factors such as waste composition, moisture content, temperature, alkalinity, redox potential and pH. Among them moisture is critical to gas generation. Gas production increases with moisture content up to saturation and optimum moisture content is said to be above 40 percent. Methanogenic bacteria can survive only within a narrow range of pH between 6.4 and7.4. Optimum temperature for anaerobic decomposition lies between 29 ℃ and 37 ℃. Some waste may inhibit activities of methanogenic bacteria, while onthe other hand, co-disposal of waste with high putrescible materials such as organic sludge may enhance gas production.



I. Aerobic
II. Anaerobic, Non-Methanogenic
III. Anaerobic, Methanogenic, Unsteady
IV. Anaerobic, Methanogenic, Steady

Source: G.J.Farquhar, F.A.Rovers (1973)

Fig. 7.3 Evolution of Typical Landfill Gas Composition

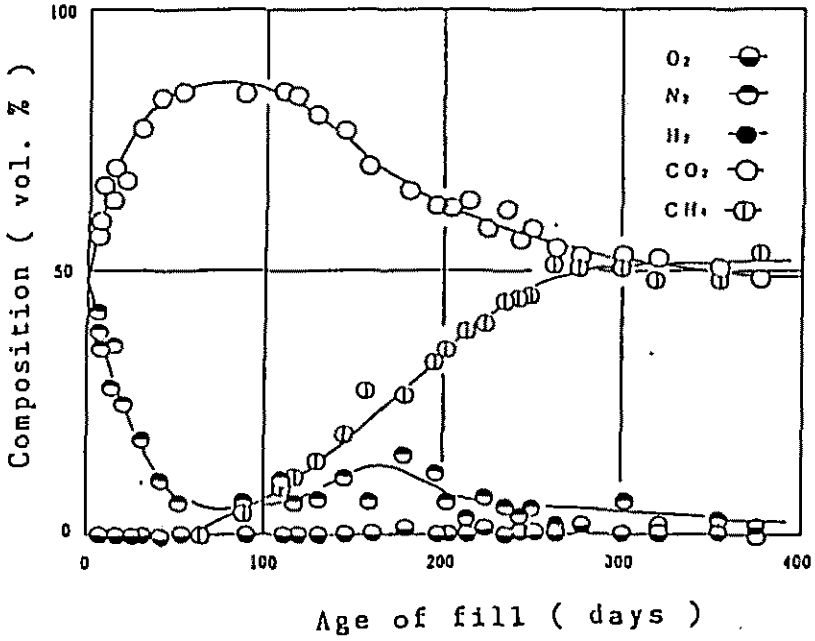


Fig 7.4 Gas Production in Bench Scale Landfill Experiment

7 . 4 Gas Migration and Control

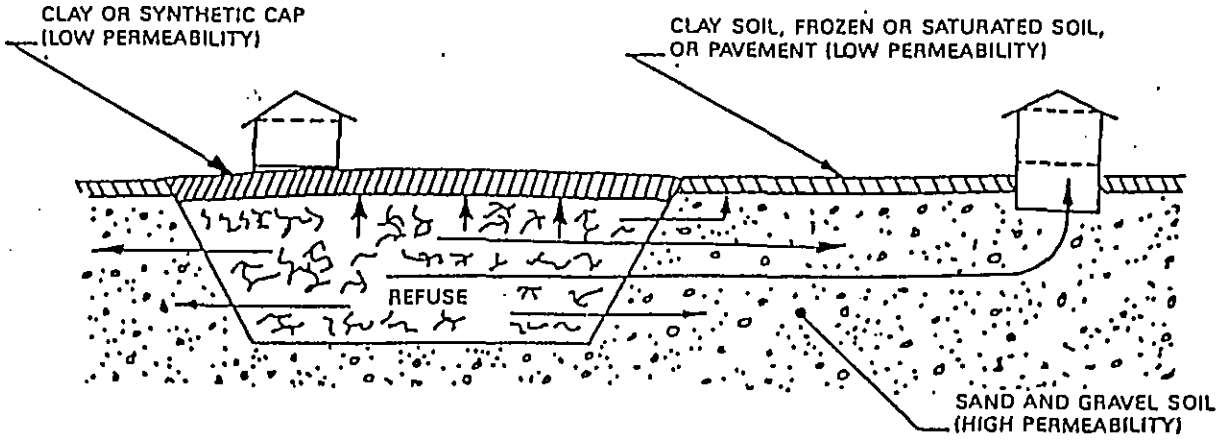
(1) Gas Migration

Landfill gases migrate quite easily to significant distances through soil. Movement will be greatest through highly permeable soil such as sand or gravel and least in silty and clayey soils. The gases generated inside landfills will vent to the atmosphere by upward migration and/or horizontal migration. If landfill surfaces are covered by low permeable soil, asphalt or capped with a clay or synthetic liner,there is greater tendency toward lateral migration. In general, a landfill constructed in a sand-gravel environment experiences greater lateral movement of gases than one in a clay environment(see Figure 7.5). Experiments at gravel pit landfill site in California, U.S,A. showed that rate of CO_2 movement in vertically downward and in horizontal direction was 27 tons/ha/yr and 25tons/ha/yr respectively, while upward movement through 41cm silt cover was $2\text{-}3\times10^5$tons/ha/yr.

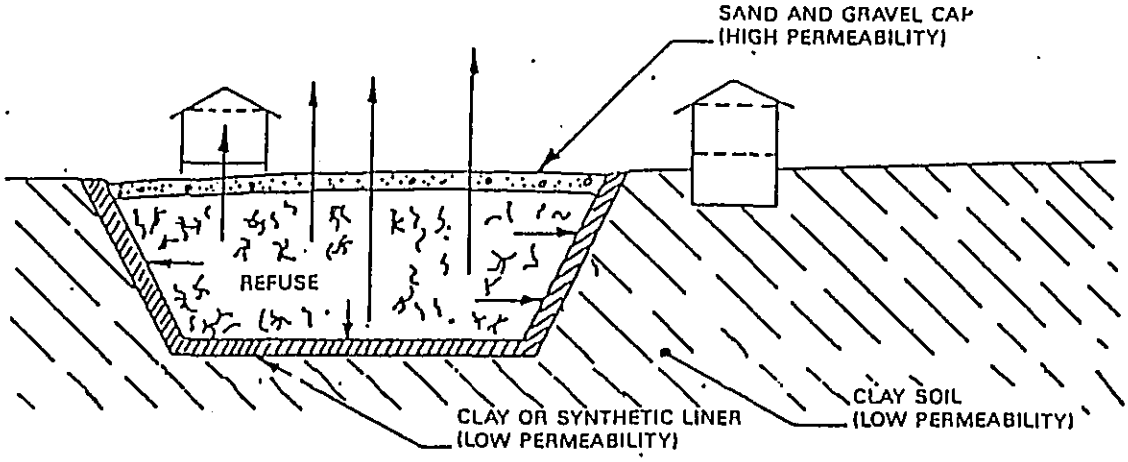
The most serious problem caused by landfill gases is explosion and/or fire hazard. Methane and some of trace gas as such as hydrogen are combustible, and in concentrations between 5 and 15 percent by volume in air, methane is ignitable at atomospheric pressure and temperature. An explosion hazard is enhanced when methane migrates from landfill site and is mixed with air in a confined space. Several tragic accidets caused by methane explosion have been reported in U.S.A.and Japan. Other actual or potential threats associated with landfill gases include acidification of groundwater by carbon dioxide, vegetation damage, odor problems, property value detorioration, and toxic emissions.

Excessive acidification of groundwater accelerates corrosion of iron, steel and dissolution of carbonate compounds from soil and rock formation. Presence of carbonates, bicarbonate, and hydroxides causes increase of alkalinity of water. Alkalinity is detrimental to many industry such as food production as well as

EXTENSIVE LATERAL MIGRATION



EXTENSIVE VERTICAL



Source: U.S.EPA (1985)

Fig. 7.5 Pathways of Gas Migration

objectionable to drinking water. Water containing carbonates and bicarbonates of calcium and magnesium increases hardness. Hardness profile of groundwater beneath the waste landfill site which was definitely identified as a source of groundwater pollution, is depicted in Figure 7.6.

(2) Gas Control Systems

Since uncontrolled gas migration can result in significant hazards, special control systems are required to alleniate these problems. Gas control systems make use of natural barriers when possible and of artificial barriers such as gas venting trenches and wells. Natural barriers include fine-grained soils such as glacial till or clay and water-saturated coarse-grained soils. Lateral gas migration can be naturally controlled at a landfill boundary where these kinds of soil formations exist.

Artificial control systems include permeable trenches with or without impermeable membranes, induced exhaust or gas-extraction systems,and vertical venting. These are summarized in Figure 7.7. Permeable trenches are constructed by digging down to the bottom of landfill or grounwater table and backfilling the trenches with coarse aggregate or builders`rubble. The gas can be vented to the atomosphere through this trench, or the trench can be equipped with gas collection or exhaust systems when sole trench does not work effectively to vent gas.

A permeable trench (see Figure7.7A) may be an effective lateral migration control system at an landfill site situated in less permeable soil having a deep water table. The trench should be constructed to a depth at least equal to the depth of the landfill .

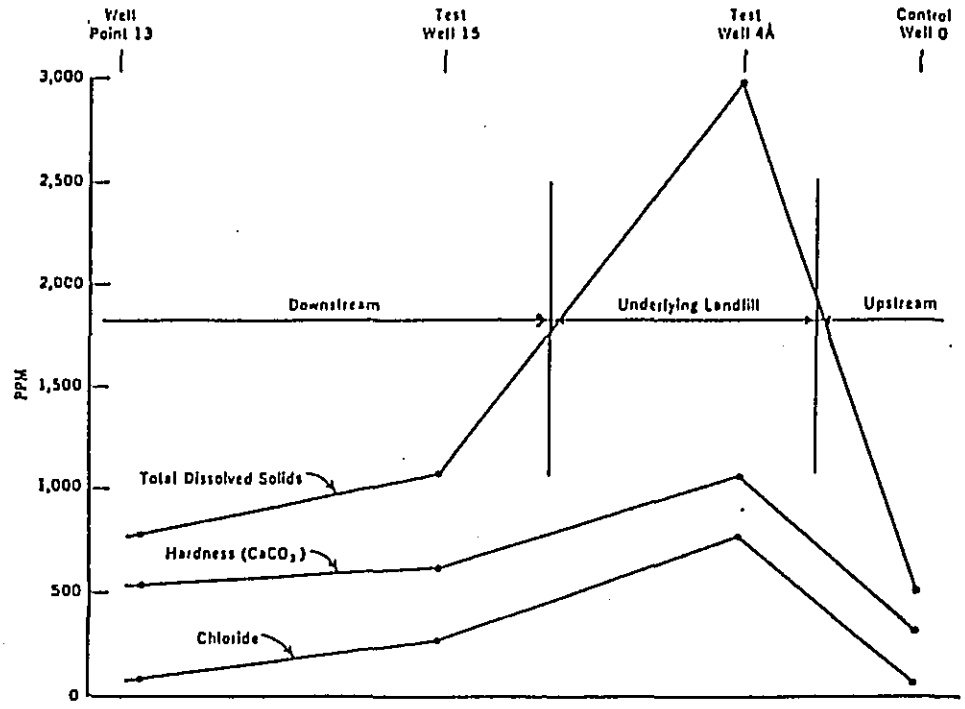
In permeable soils, a trench should be provided with an impermeable barrier such as plastic sheet or clay along the outer wall of trench (see Figure 7.7B). Pipe venting (see Figure7.7C) should be provided between the landfill and the impermeable

barrier in areas where top covering of trench may occur.

An induced exhaust system (see Figure 7.7D), consisting of a permeable trench equipped with gas vents or separately installed gas wells connected by a header to an exhaust blower is a most effective gas control method. Vertical vents, or gas wells, installed around the landfill at 30 to 60ft centers and down to the base of or to the water table are effective if connected to a header and exhaust blower.

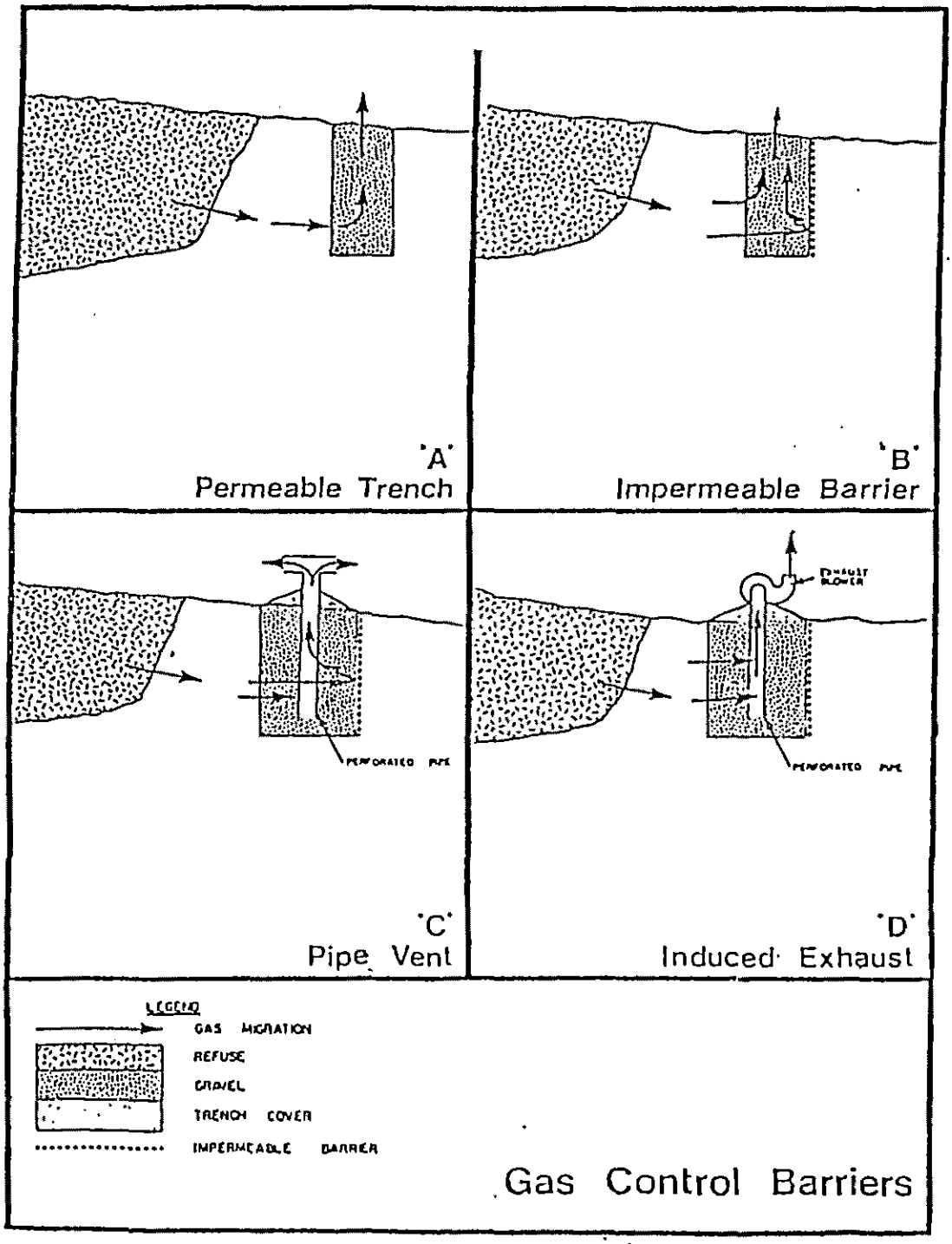
In landfills where soil conditions or site conditions make it difficult to construct deep trench, gas venting pipes can be installed either around the perimeter of the site or within the landfill itself. In these alternatives, unless a sufficiant number of such pipes are installed, pumping systems with an appropriate header will be required to ensure an adequate ventilation. In Japan, perforated pipes with a diameter of 10-20 cm are commonly used at an interval of 50-100m within a landfill. (see Figure7.8)

There are two methods of handling landfill gas that is collected from landfill. The first is to vent it directly to the atmosphere. The second one is to burn the gas, transforming it into odorless gases. The former method is not necessarily applicable to all landfill site because this method sometimes poses environmental problems due to hazardous or odorous gas constituents. The latter is effective whenever high concentration of methane is present and can be burned continuously. Special care must be done, however, to prevent flame from extinguishing by fitting a wind cowl to the pipe or wind shelter around the pipe.



Source: J.J.Coe (1970)

Fig. 7.6 Profiles of Certain Constituent Concentration in Groundwater near Landfill Site



Source: U.S.EPA (1985)

Fig.7.7 Gas Control Barriers

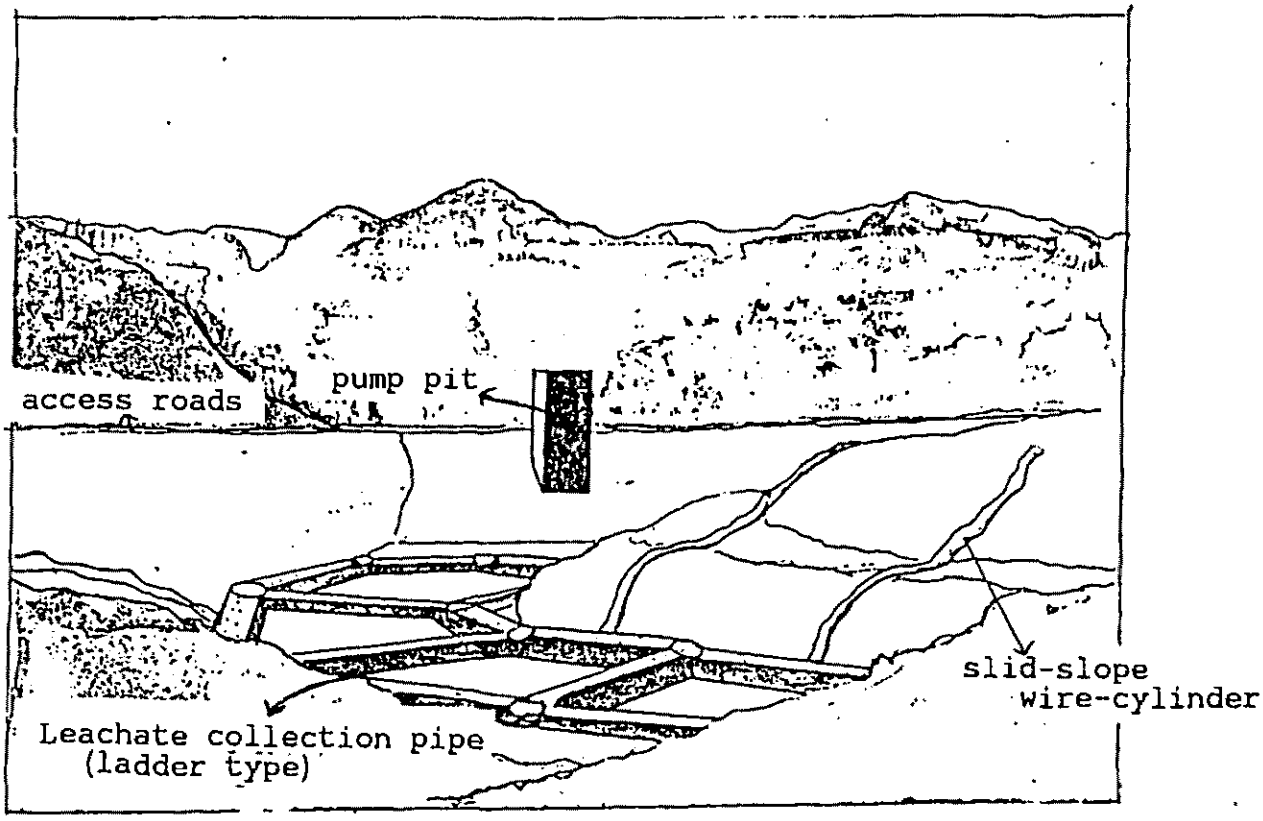


Fig.7.8 Typical sanitary landfill site with wire-cyclinder for gas control

8. LEACHATE CONTROL AND TREATMENT

8. 1 Leachate Characteristics

The chemical characteristics of leachate will depend on waste composition and conditions within the landfill such as temperature moisture, stage of decomposition, landfill depth and so forth. Among them, brief outline of leachate characteristics with a stage of decomposition are described in 7.1. As a whole, COD, BOD, and NH_3-N of leachate of typical sanitary landfill will change with time as shown in Figure 8.1. BOD decreases more rapidly than COD because BOD is attributed to more easily biodegradable substances in waste andthese are attacked by variety of bacteria at early stage of filling.

Landfill structures or landfilling techniques prescribe some conditions within landfill mentioned above and therefore rate of waste decomposition and stabilization. Considering a difference of metabolic function of microorganism within landfill, landfill structure is classified into five categories. Concept of these technologies are shown in Table 8.1 and Figure 8.2 and leachate characteristics generated from these landfills are compared in Table 8.2a,b, Fig.8.3. Aerobic type landfill structure can attain rapid decomposition of waste and quick stabilization, however, its construction and maintenance cost is the highest and proper operation is rather impractical.

Contrary to aerobic landfill, semi-aerobic type landfill is easy to construct with less maintenance care and early stabilization and quick decomposition of waste can be expected

So the semiaerobic landfill will be discussed first.

In Japan, after Dr.Hanasima et.al introduced a new method of stabilizing solid wastes by landfill, 「SEMIAEROBIC LANDFILL」 was defined as a sanitary landfill with perforated leachate collection pipes, which not only drains the leachate but also supplies the waste with air by natural convection.

Fig8.4 shows an example of the structure of semiaerobic landfills. Perforated pipes are enclosed by packed gravels overlaid by the solid waste and the waste is overlaid by the porous soil cover. These pipes are led to open air so that the influx of air is induced naturally. Since oxygen is supplied to micro-organisms by the natural convection of air, the waste can be stabilized biochemically through aerobic fermentation.

Some of the advantages in semiaerobic landfilling are that : (1) The leachate is less problematic than in aerobic landfilling; (2) the production of hazardous gases can be reduced; (3) the soild waste is more quickly stabilized than it is in anaerobic landfilling; (4) the groundwater pollution of leachate can be reduced; and (5) operations can be maintained at a low cost. For these reasons, this type is recommended for the landfill site which accepts organic waste in Japan.

8.2 Selection of Leachate Treatment Process

Composition of leachate changes with time and, although there are many low-molecular-weight organic compounds at early stage of filling, the fraction of high-molecular-weight compounds from less-decomposing organic substances becomes more not able as time goes on. Thus, for younger landfills of less than 5 years, biological treatment is effective but, as it gets older, leachate quality becomes more suitable forphysical and chemical treatments. Therefore biological treatment and coagulation precipitation are the minimum requirement for a treatment of landfill leachate during a life of landfill and higher level of treatment should be applied depending on the target of effluent quality. General flow diagram for leachate treatment is shown in Figure 8.5 and unit processes and their removal efficiency for each target contaminants are summarized in Table 8.3.

The fundamental processes of the leachate treatment are shown in Fig.8.6～8.11. and Table 8.4.

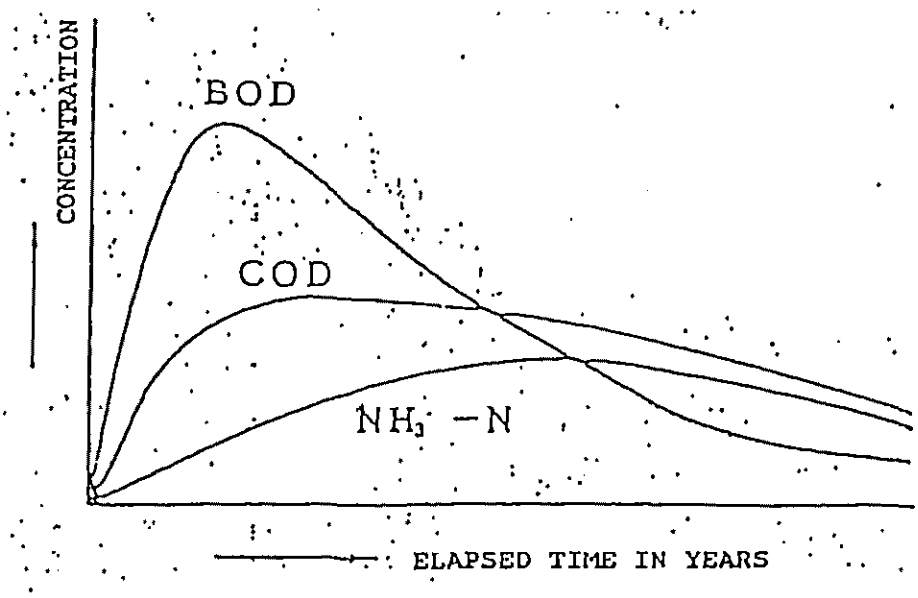
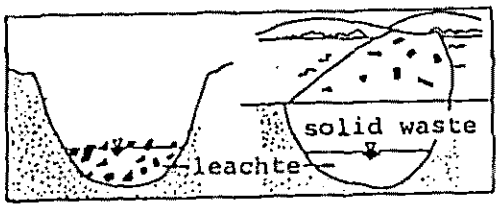


Fig. 8.1 Change of Leachate Concentration with Time

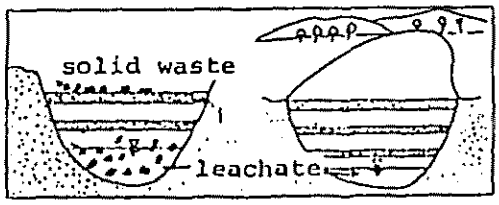
Table 8.1 Classification of Landfill Structure

Anaerobic landfill	Solid wastes are filled ;in digged area of plane field or valley. Westes are filled with water and in anaerobic condition.
Anaerobic sanitary landfill	Anaerobic landfill with cover like sandwich shape. Condition in solid waste is same as anaerobic landfill.
Improved anaerobic sanitary landfill (Improved sanitary landfill)	This has leachate collection system in the bottom of the landfill site. Others are same as anaerobic sanitary landfill. The conditions is still anaerobic and moisture content is much less than anaerobic sanitary landfill.
Semi-aerobic landfill	Leachate collection duct is bigger than the one of improved sanitary landfill. The opening of the duct is surrounded by air and the duct is covered with small crushed stones. Moisture content in solid waste is small. Oxygen is supplied to solid waste from leachate collection duct.
Aerobic landfill	In addition to the leachate collection pipe, air supply pipes are attached and air is enforced to enter the solid waste of which condition becomes more aerobic than semi-aerobic landfill.

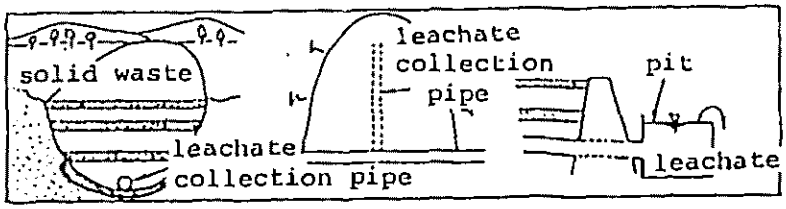
ANAEROBIC LANDFILL



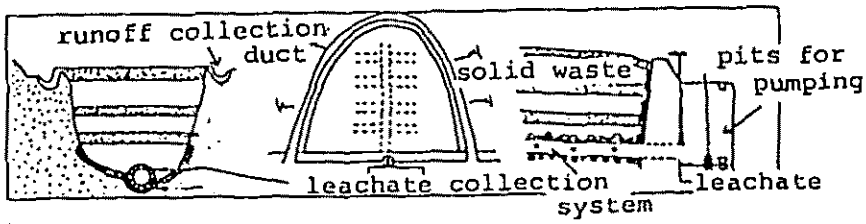
ANAEROBIC SANITARY LANDFILL



IMPROVED ANAEROBIC SANITARY LANDFILL
(IMPROVED SANITARY LANDFILL)



SEMI-AEROBIC LANDFILL



AEROBIC LANDFILL

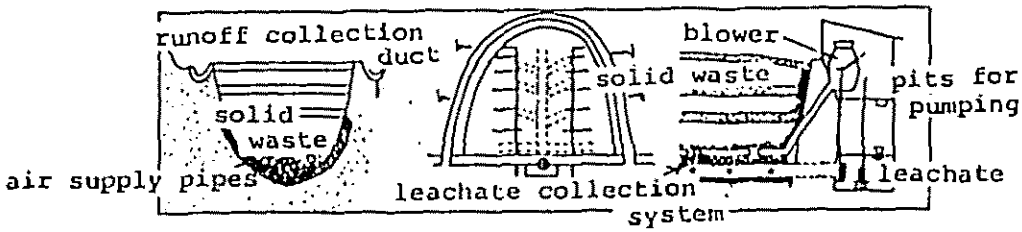


Fig. 8.2 Classification of landfill structures

Table 8.2(a) Landfill Structure and Leachate Quality

	Item	During landfill	6 months after landfill closed	1 year after landfill closed	2 years after landfill closed
Anaerobic landfill	BOD	40,000 - 50,000	40,000 - 50,000	30,000 - 40,000	10,000 - 20,000
	COD*	40,000 - 50,000	40,000 - 50,000	30,000 - 40,000	20,000 - 30,000
	NH^3-N	800 - 1,000	1,000	800	600
	pH	approx. 6.0	approx. 6.0	approx. 6.0	approx. 6.0
	Transparency (visibility) clarity	0.9 - 1.0	1 - 2	2 - 3	2 - 3
Anaerobic sanitary landfill	BOD	40,000 - 50,000	7,000 - 8,000	300	200 - 300
	COD*	40,000 - 50,000	10,000 - 20,000	1,000 - 2,000	1,000 - 2,000
	NH^3-N	800 - 1,000	800	500 - 600	500 - 600
	pH	approx. 6.0	approx. 7.0	7.0 - 7.5	7.0 - 7.5
	Transparency (visibility) clarity	0.9 - 1.0	1 - 2	1.5 - 2	1 - 2
Semi-Aerobic landfill	BOD	40,000 - 50,000	5,000 - 6,000	100 - 200	50
	COD*	40,000 - 50,000	10,000	1,000 - 2,000	1,000
	NH^3-N	800 - 1,000	500	100 - 200	100
	pH	approx. 6.0	approx. 8.0	approx. 7.5	7.0 - 8.0
	Transparency (visibility) clarity	0.9 - 1.0	1 - 2	3 - 4	5 - 6

Table 8.2(b) Composition of Initial Leachate* from Municipal Solid Waste

Component	Study A†		Study B†	
	Low	High	Low	High
pH	6.0	6.5	3.7	8.5
Hardness, $CaCO_3$	890	7,600	200	550
Alkalinity, $CaCO_3$	730	9,500		
Ca	240	2,330		
Mg	64	410		
Na	85	1,700	127	3,800
K	28	1,700		
Fe (total)	6.5	220	0.12	1,640
Ferrous iron	8.7‡	8.7‡		
Chloride	96	2,350	47	2,340
Sulfate	84	730	20	375
Phosphate	0.3	29	2.0	130
Organic-N	2.4	465	8.0	482
NH_4-N	0.22	480	2.1	177
BOD	21,700	30,300		
COD			809	50,715
Zn			0.03	129
Ni			0.15	0.81
Suspended solids			13	26,500

* Average composition, mg per liter of first 1.3 liters of leachate per cubic foot of a compacted, representative, municipal solid waste.
‡ One determination.

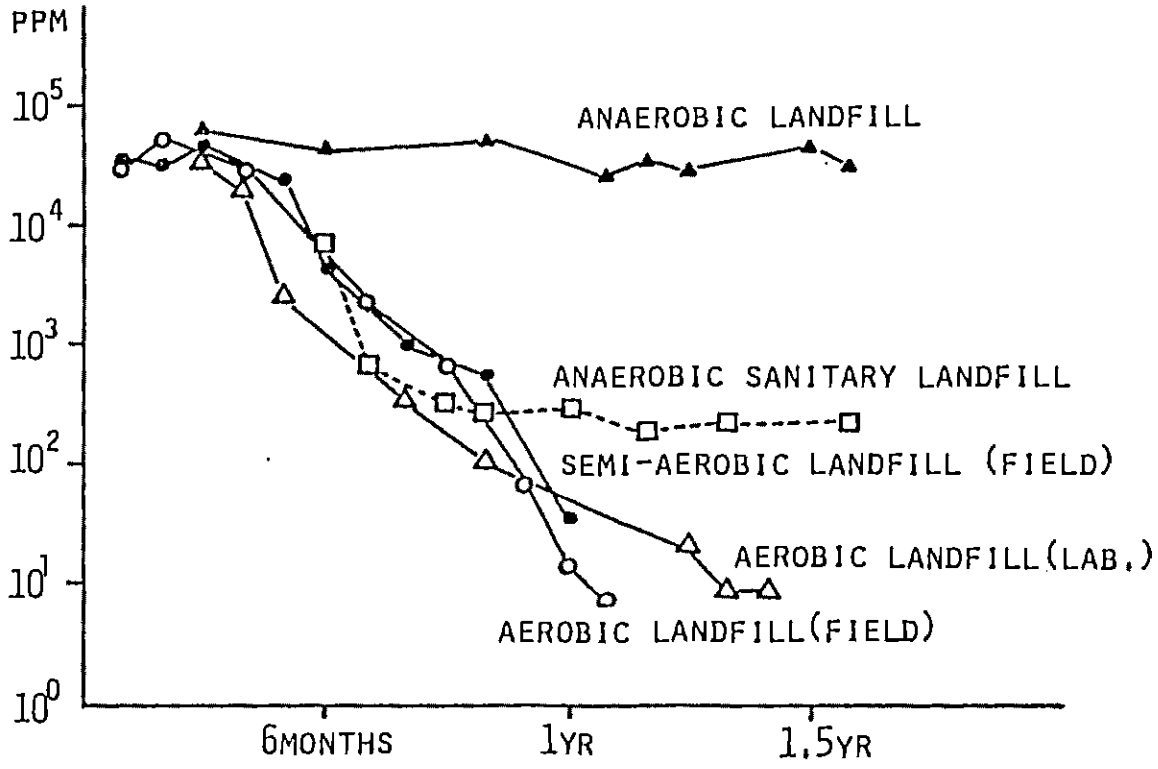
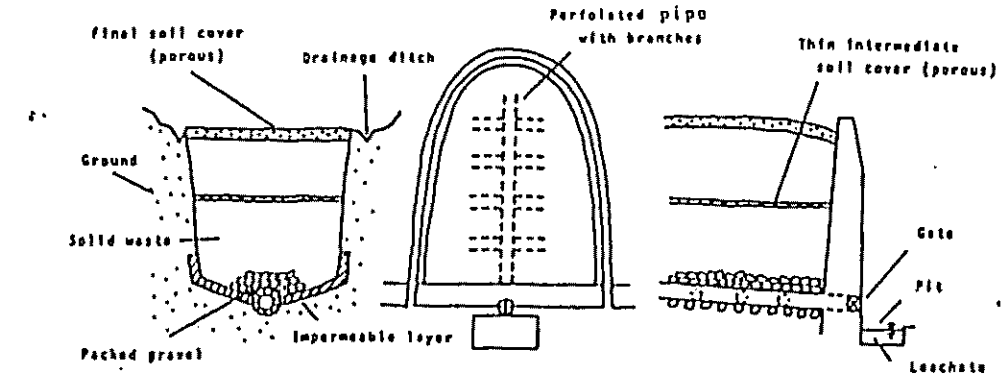


Fig. 8.3 Landfill structure and leachate quality (BOD_5) of the domestic solid waste



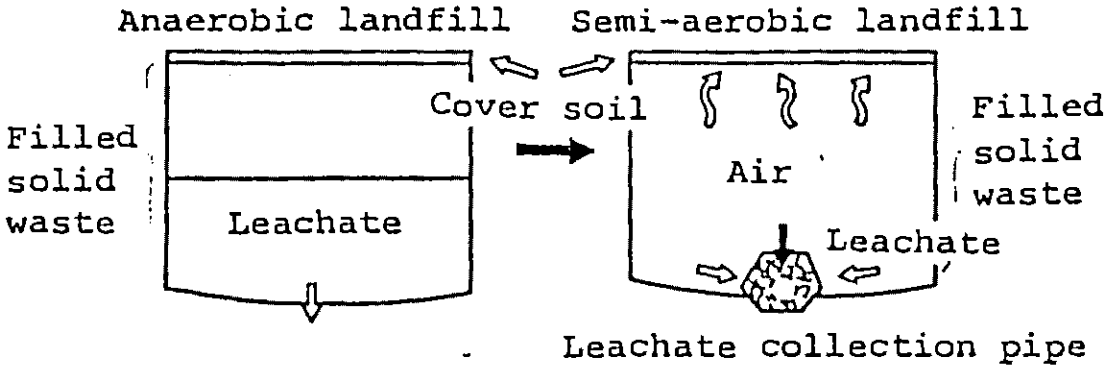


Fig. 8.4 Schematic Diagram of Semiaerobic Landfill

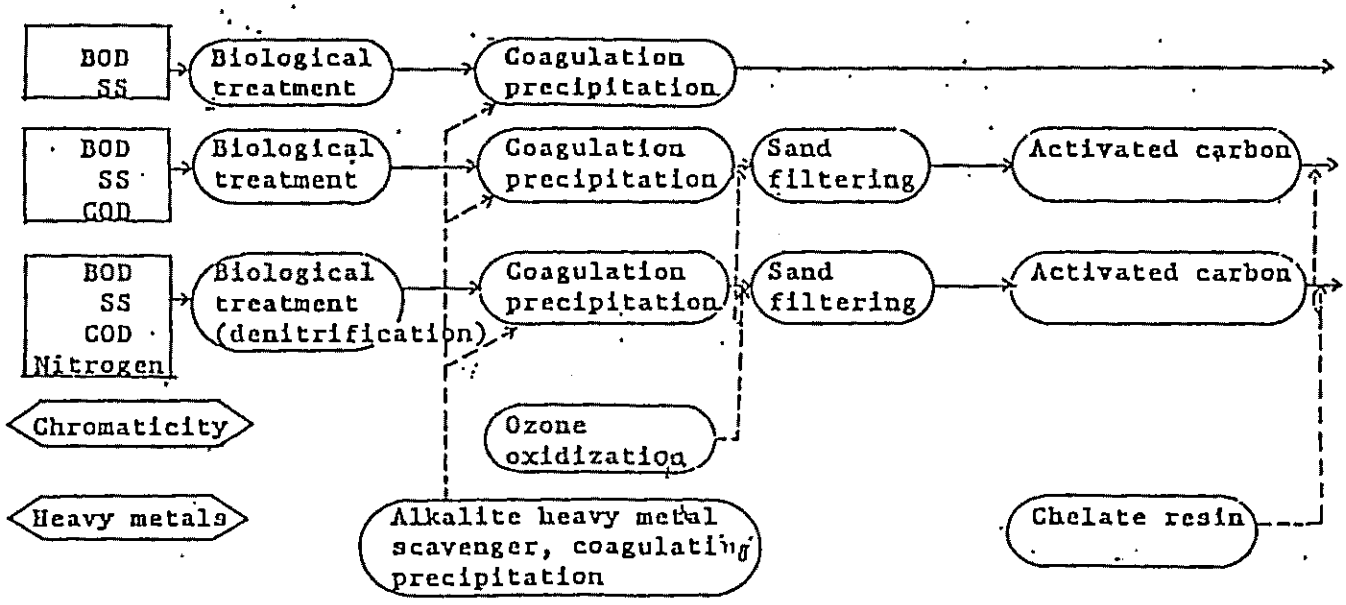


Fig. 8.5 Schematic Diagram of Leachate Treatment

Table 8.3 Leachate Treatment Technology

Treatment Technology	Target Pollutants						Remarks
	BOD	COD	SS	T-N	Color	Heavy Metals	
Rotating Biological Contactor	G	F	P	P	P	P	Applied at comparatively low concentration
Contact oxidation process.	G	F	P	P	P	P	Applied at comparatively low concentration
Activated sludge process (conventional, extended, non-continuous types	G	F	P	P	P	P	Rate of COD removal varies from 10 to 80% depending on the properties of water. NH_3-N may change NO_3-N.
Lagoon	F	F	P	F	P	P	When BOD in raw water is high, the rate of removal drops. The running cost is low.
Biological Medium filtration process	G	F	G	P	P	P	Since BOD load is as high as 3 - 5 kg (m^2-day), the site area can be small.
Biological denitrification	G	F	P	G	P	P	NH_3-N changes to N_2 gas.
Coagulating sedimentation process	F	G	G	P	G	F	Effective in removing SS, COD, and chromaticity.
Sand filtration	P	P	G	P	P	P	Required as pretreatment of activated carbon adsorption method.
Activated carbon adsorption	G	G	F	P	G	F	Effective in removing COD, and chromaticity; removal of toxic substances and organic nitrogen can be expected.
Ozonization	P	F	P	P	G	P	Especially effective in removing chromaticity.
Chelate resin	P	P	P	P	P	G	Effective in removing heavy metals.

Removal Efficiency: G=good, F=fair, P=poor

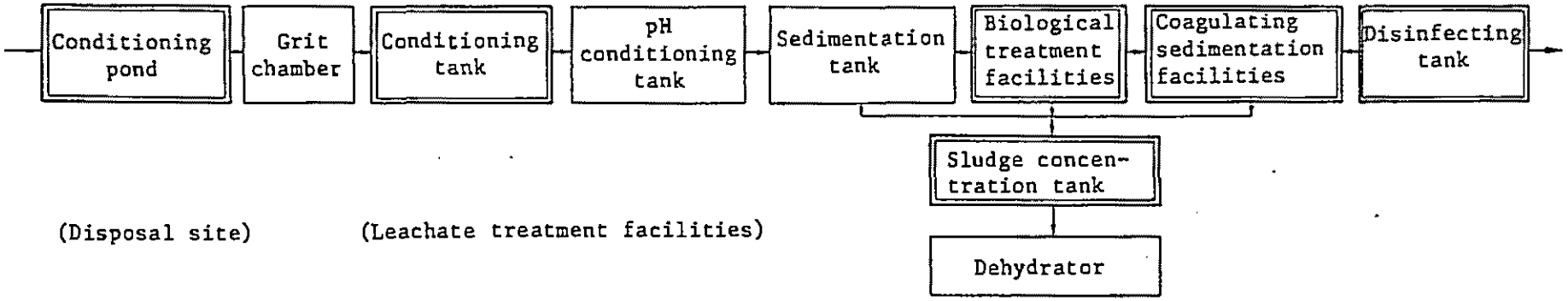


Fig. 8.6 Standard Treatment Flow Sheet

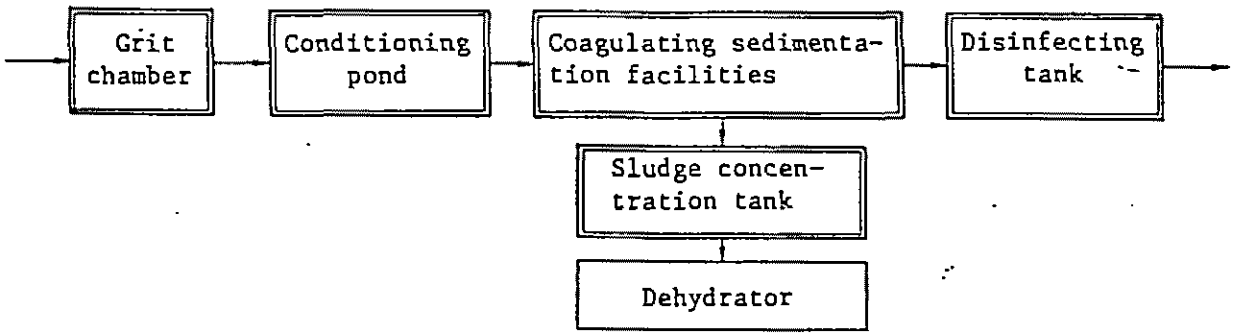


Fig.8.7 Treatment Flow Fundamentally Using Coagulating Sedimentation Facilities

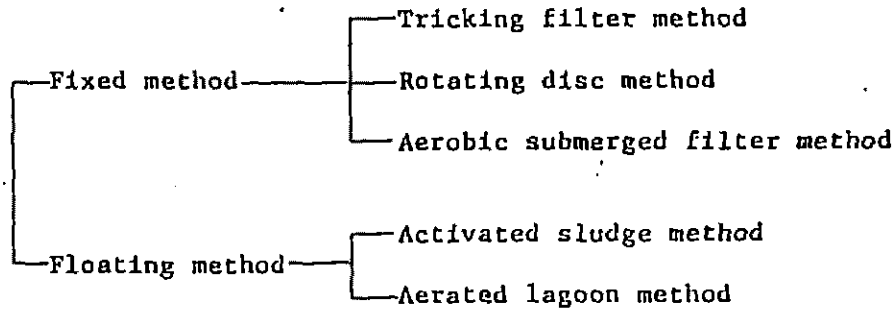


Fig. 8.8 Biological Treatment Method Used for Effluent Treatment

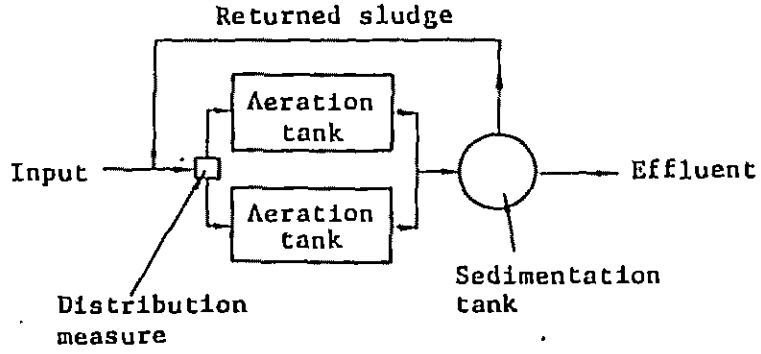


Fig. 8.9 Typical Case Where Two Aeration Tanks Are Used Under Activated Sludge Method

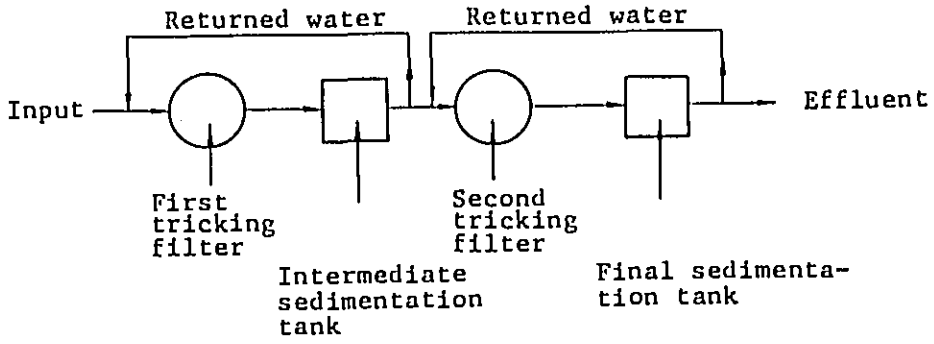


Fig.8.10 Example of Two-stage Tricking Filter Method

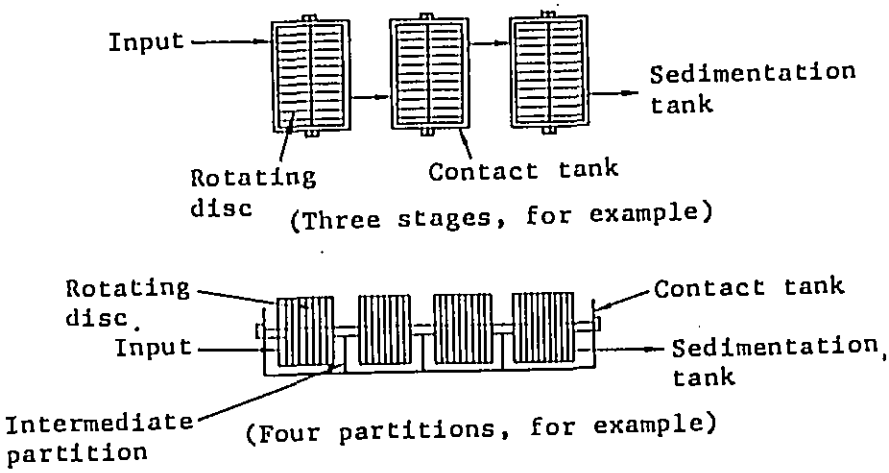


Fig. 8.11 Example of Treatment with Rotating Discs

Table 8.4 Comparison of Operation and Maintenance Items Under Biological Treatment Method

Biological treatment method	Activated sludge method	Fixed method		
		Tricking filter method	Aerobic submerged filter method	Rotating disc method
Control items	. Control of the quantity of sludge . Adjustment of the quantity of aeration	. Control of divagation and blocking of filling materials . Adjustment of the volume of circulating water . Adjustment of the quantity of aeration (tower system only)	. Control of divagation and blocking of filling materials . Adjustment of the volume of circulating water . Adjustment of the quantity of aeration	. Control of exfoliative sludge . Adjustment of the rotation speed

Construction cost of leachate treatment facility calculated by per volume of effluent decreases as the capacity of treatment facility increases and vice versa. As an example in Japan, construction cost of leachate treatment facility with a capacity of 200-300 m^3/day, which is equipped with a rotating biological contactor for biological treatment including denitrification process, coagulation precipitation,sand filtration, and activated carbon adsorption is 2.5-3 million yen per m^3.

8.3 Lining Systems of Waste landfill

Sanitary landfill in Japan is requested by technical standards set by the goverment to have lining systems at bottom and side of the landfill to prevent both leachate seepage into surrounding soil systems and grounwater intrusion into the landfill when constructed in the soil formations that is unsuiatable for pollutants attenuation or retardation of water movement which is the general case in Japan.

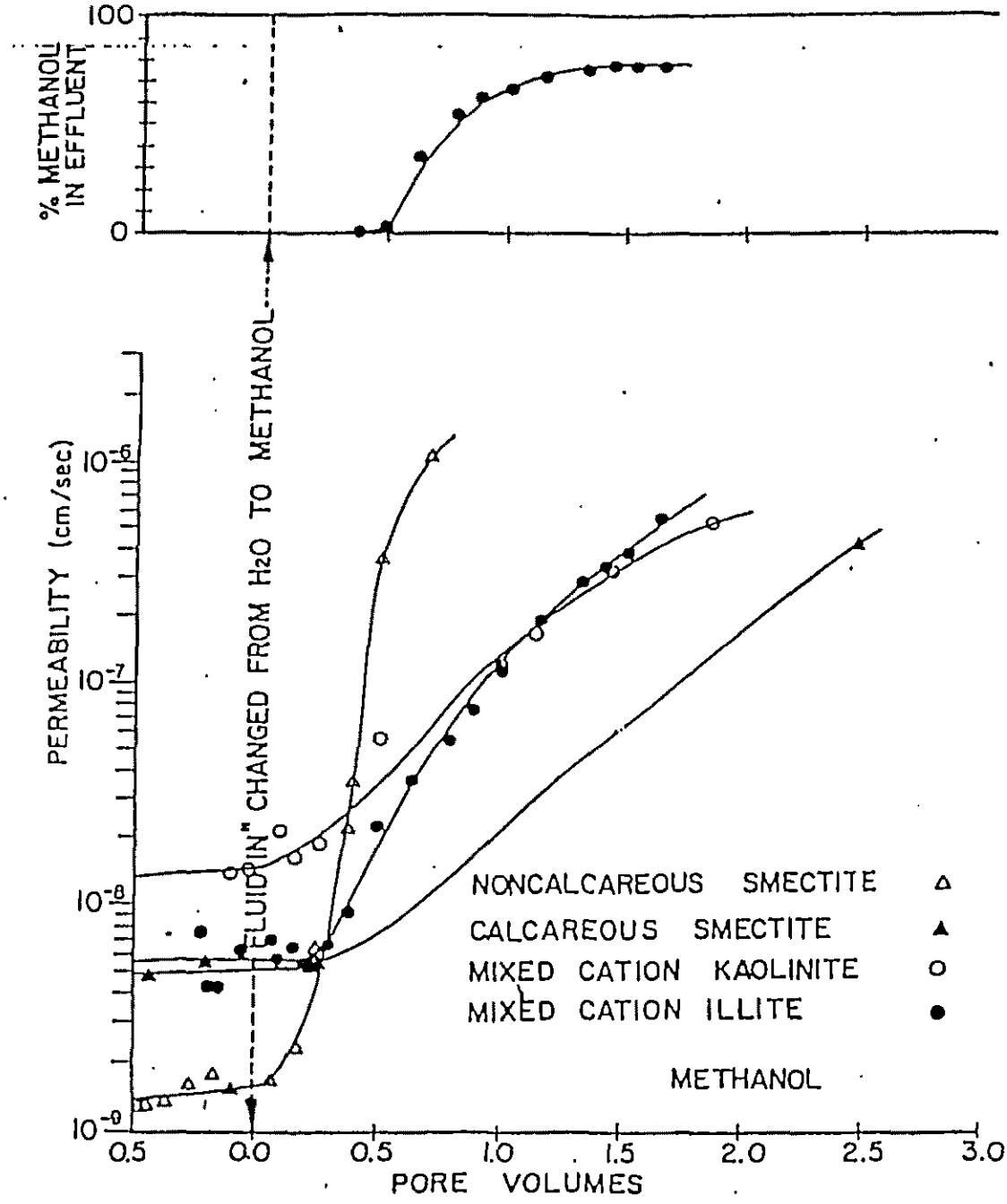
Hydraulic conductivity of lining material is required to be below 10^{-5}cm/sec. Lining materials that satisfy such condition are compacted clay, bentonite, asphalt, or synthetic menbranes such as PVC, HDPE(High Density Polyethylene), vulcanized rubber, etc. Rubber sheetis most commonly used in Japan, however, rather expensive. The cost of rubber sheet with a thickness of 1.5 mm is about 3-4,000 yen/m^2. Clay liner may be the cheepest if clay exists in sufficient amount in the vicinity of the landfill site.

A prime consideration when installing a liner is its effectiveness to prevent leachate movement during a whole life of landfill. Even the impermeable liner can not prevent leachate leakage if the liner has holes or cracks. Thus, the utmost care and QA/QC programs are needed not to destroy the liner in all aspects of design, construction, and operation. Another concern is an interference of chemicals in leachate with lining materials. Some organic chemicals are pointed out to react with some

synthethic liner and deteriorate physical and chemical property of lining materials. Even clay liner is damaged by some chemicals and its hydraulic conductivity for that chemical solution increases higher than that of water. Such example is shown in Figure 8.12 for methanol as a solution flowing through various clays .

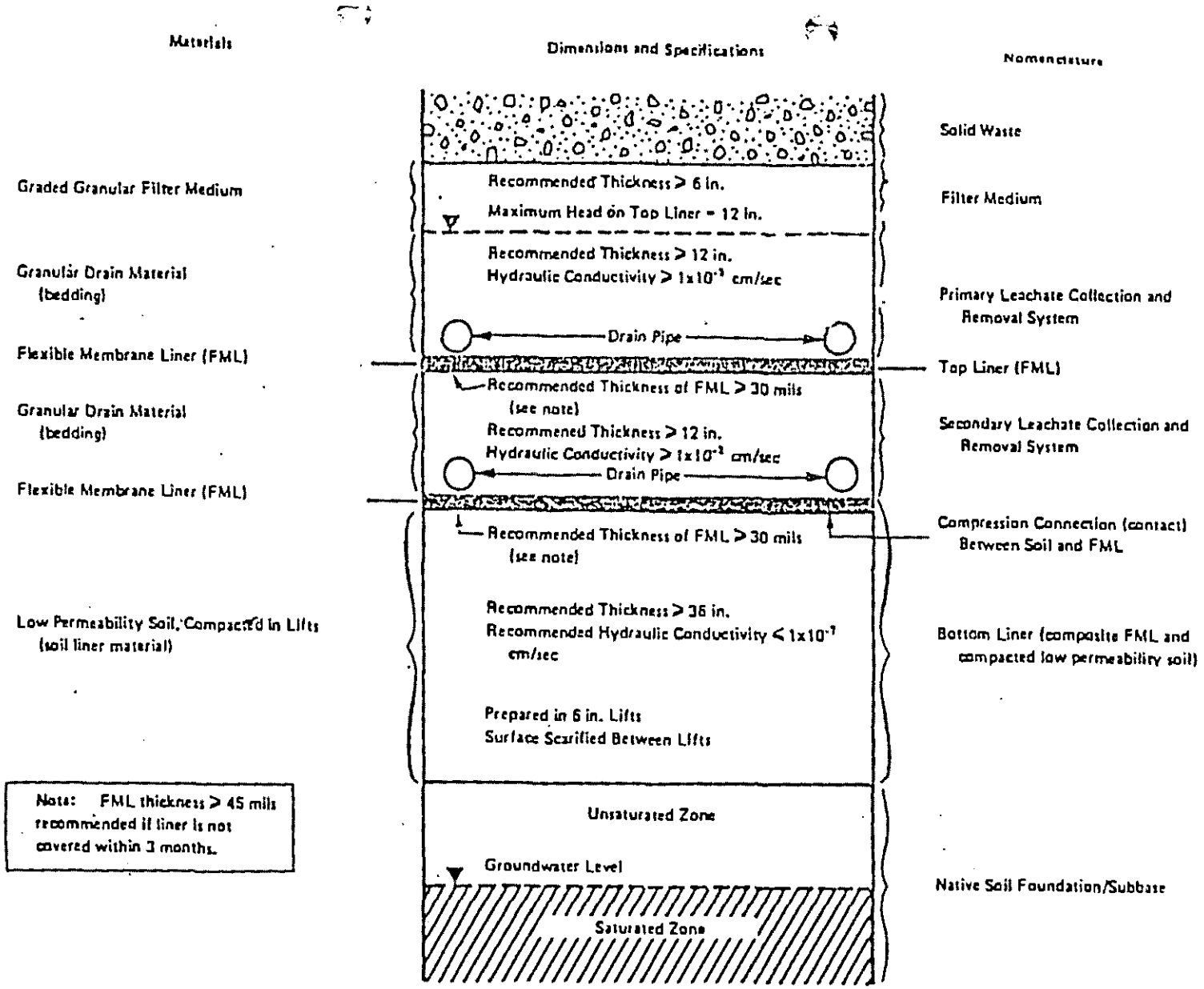
In Japan newly designed landfill sites have a semiaerobic landfill structure. In the case of semiaerobic landfills, leachate is quickly collected using the leachate collection system to let down the leachated water table to bottomn of landfill so that semiaerobic condition will be achieved. By this method the groundwater pollution and pollution load of lining can be reducted. Linner system is very important to collect leachate quickly at the bottom of landfill.

U.S.EPA has proposed double liner systems for hazardous waste landfills to assure perfectness of sealing as well as effective leachate drainage. They provide two types of double lining system. The first one is consisted of two flexible membrane liners for both primary (top) and secondary (bottom) liner. Another type consists of flexible membrane liner for primary liner and compacted soil for secondary liner. Both types have two leachate collection and removal systems above primary liner and between two liners. Details of these systems is sketched in Figure8.13. Secondary leachate collection and removal system is established so that corrective action or some countermeasures can be considered before serious environmental pollutions occure.



Source: U.S.EPA (1983)

Fig. 8.12 Permeability of the Four Clay Soils to Methanol



Source: U.S.EPA (1985)

Fig.8.13 Schematic Profile of an FML Double Lining System

8.4 Site Selection for Land Disposal

In the process of selection of suitable site for a landfill, many factors must be considerd. The major factors to be considered include environmental, engineering/economics, planning, and acceptability factors. Careful selection of sites is critical because, once the landfill is in operation, most of the natural phenomena such as water table fluctuation, floods can not be controlled easily. There is rarely an ideal site for a landfill and therefore a particular location must be developed and engineered to be suitable. From the view points to control and prevent surface water and groundwater contamination major considerations are environmental characteristics of the site, especially hydrology, geology, and soil properties.

Hydrological characteristics of the site are required to evaluate the site. These characteristics are the parameters governing the movement of water through the soils, surface runoff, and evapotran spiration. Hence, to a large extent, hydrology of the site will determine whether leachate will result in water pollution or not. The important site characteristics are the following: (1) depth to bedrockor gravel, (2) depth of the seasonal water table, (3) thickness of soil (4) soil texture, (5) soil permeability, (6) available water-holding capacity of the site, (7) soil pH, (8) soil salinity, (9) the shrink-swell potential of soil. The depth of soil to bedrock, gravel is an important factor to judge the possibility for grounwater contamination. Permeability is another indicator of potential for groundwater contamination.

Un suitable hydrogeologic conditions for landfill include flood prone area such as delta and tidal flats, low-lying sites of drainage basins, sites neerby well used for drinking water. These sites contain hydrogeologic conditions that have the potential of water pollution by leachate and should be restricted from selection for landfill site.

An evalution of the geologic and soil conditions underlying a landfill site is essential for proper design and management to prevent water contamination. Particular attention should be given to: (1) depth to subsurface soil, (2) characteristics of subsurface soil in relation to stability and water transmission, (3) degree of weathering with depth, (4) outcrops of bedrock, (5) type of bedrock, (6) fissures, faults, fractures, joints, limestome cavities, or other irregularities in the bedrock. If leachate generates and enters the rock strata with fractures and joints, contaminant will travel more easily than in silty and clay soils which usually have a very low permeability unless they have been subjected to jointing and form open fractures.

When man-made pits such as strip mines, stone quarries, sand and gravel pits are intended to be used as a sanitary landfill, some of them require extensive site improvement to meet geologic requirement for landfill. Because these formations have high permeability, pollution potentials are very high.

Soils that exist in or near the landfill site are often used as cover material of sanitary landfill. Cover of sanitary landfill perform great functions to control water pollution by reducing rainwater infiltration into underlying waste. To reduce infiltration surface vegetation must be considered.
Vegetation planted on final cover is also important to reduce infiltration. The plants can draw water out of the ground and reduce the amount of percolating water.

Site charactristics that are unacceptable for hazardous waste landdisposal are summarized in Table 8.5 , which include geology, hydrology, climate, topography, soils, land use as an environmental factor to be considered. These criteria is applicable also for the selection of a landfill site for municipal solid waste.

Table 8.5 Unacceptable sites for waste landfill

Environmental Factors	Restrictions
Geology	-Bedrock outcrop -Irregularities such as fissures or faults overlying groundwater
Hydrology	-Aquifer recharge zones -Flood prone areas such as river flood plains, delta, tidal flats -Wetlands -Seasonally high water tables (<4-6 ft) -Nearby private or community water supply wells and reservoirs
Climate	-Upwind of large populations -Extremely wet or cold conditions
Topography	-Overly steep slopes -Broken terrain
Soils	-Thin soil above groundwater -Saline soils -Highly permeable soils above shallow groundwater -Soils with extreme erosion potential
Land use	-Areas formerly used for landfills -Areas contaminated with persistent residues from past chemical spills or waste treatment processing

Source: U.S.EPA (1980)

9. COMPLETED SANITARY LANDFILL

Reclaiming land by filling and raising the ground surface is one of the great benefits of sanitary landfilling. The completed sanitary landfill can be used for many purposes, but all of them must be planned before operations begin.

9.1 Charactristics

The designer should know the future use of the completed sanitary landfill before he begins design work.

Unlike an earthfill, a sanitary landfill consists of cells containing a great variety of materials having different physical, chemical and biological properties. The decomposion solid wastes imparts characteristics to the fill that are peculiar to sanitary landfills. These characteristics require that the designer plan for gas and water controls, cell configuration, cover material specifications (as determined by the planned use),and the periodic maintenance needed at the completed sanitary landfill.

The examples of characteristics are as follows.

1. decomposition
2. density
3. settlement
4. bearing capacity
5. landfill gases
6. corrosion

9.2 Uses

There are many ways in which a completed sanitary landfill can be used; it can, for example, be converted into a green area or be designed for recreational, agricultural, or light construction purposes. The landfill designer should evaluate each proposal from a technical and economic viewpoint. More suitable land is often avaiable elsewhere that would not require the expensive construction techniques required at a sanitary labdfill.

The examples of uses are as follows;

1. green area
2. agriculture
3. construction (See Fig 9.1.)
4. recreation

9.3 Registration

The completed landfill should be inspected by the government agency responsible for ensuring its proper operation. Following final acceptance of the site, a detailed description, including a plat, should be recorded with the proper authority in the country where the site is located. This provides future owners or users with adequate information regarding the previous use of site. The description shoud,therfore,include type and general location of wastes, number and type of lifts, and details about the original terrain.

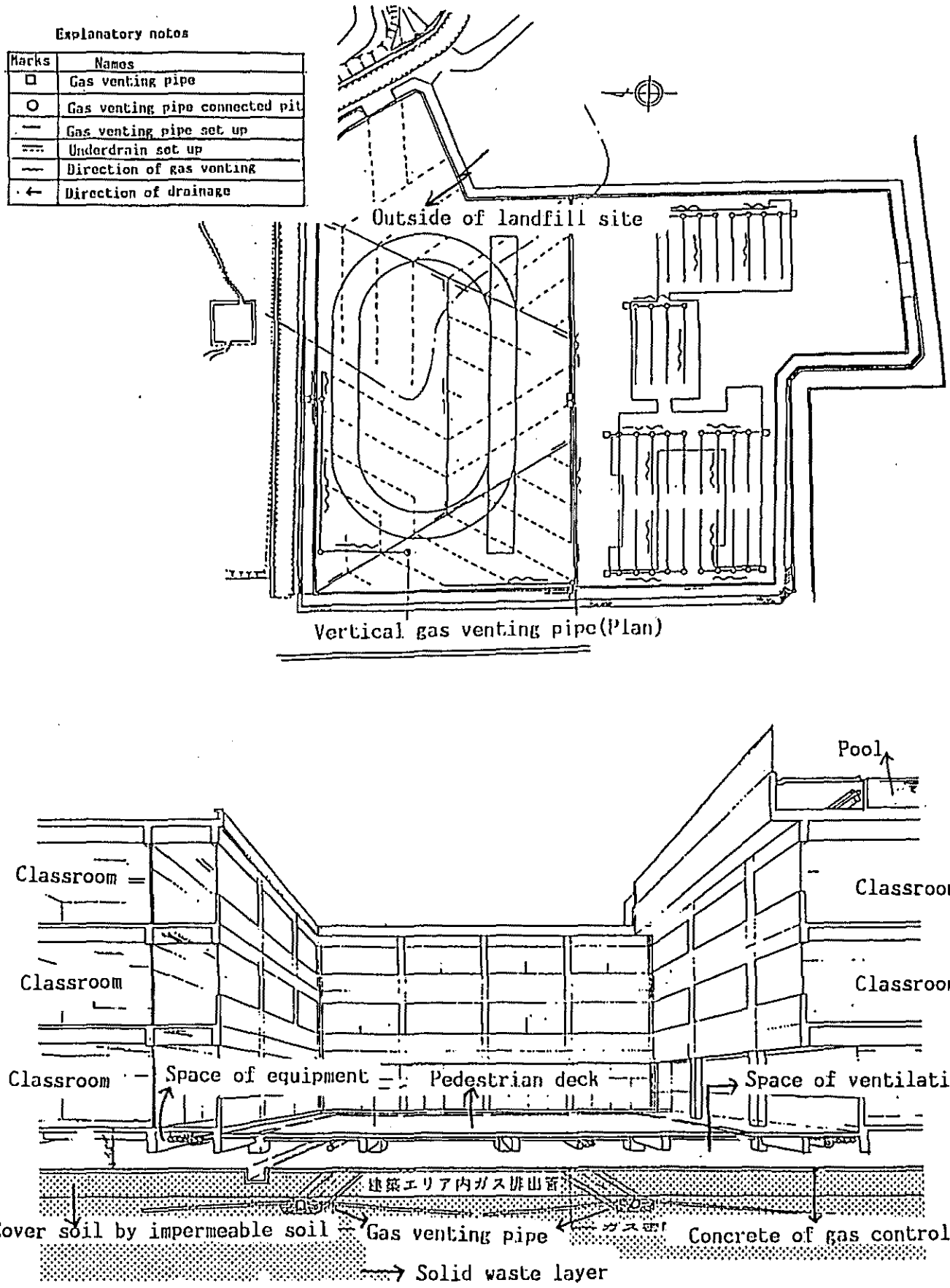


Fig.9.1 Example of gas control measure
(Reuse of completed landfill)

10. PROSPECT FOR FUTURE

The quantities of waste discharge have been increasing year by year, and efforts to reduce the volume of wastes are being made by intermediate treatment and resource recovery
The quantities to be finally disposed of, however, will stay unchanged or increase in future.
Since most of the areas suitable for landfill sites which are located near the sources of wastes are earmarked for other purposes, getting a landfill site is becoming very difficult.
In view of this, large-scale reclamation on seacoast technology, should be developed in the future.
Also development of a method for excavating the completed landfill site and reutilizing the excavated materials is under study as a measure to secure landfill site.

10.1 Development of Large-scale Reclamation on Seacoast Technology

Wastes has been persued in some cities; thus it is not a new development. Since it involves large scale and extensive operations, this undertaking gives great and extensive impact to the environment. To prevent pollution ofnear-by waters, secure water cut-off is needed, and there is a need to study a construction method that can lower the water level inside theshore protection wall artificially below the sea level and prevent outflow of stored water and others to near-by waters. As various wastes are gathered from a wide range of places, it is essential to perform research and development related to a system and a method for inspection of wastes at the time of operation, a control system to prevent congestion with transport vehicles and alternative means of transportation. (Fig. 10.1)
In addition to considerations related to environment preservation, studies should be made regarding development of methods for geting reclamation and control plans based on the character of wastes and from the standpoint of utilization of reclaimed land.

10.2 Development of Efficient Landfill Technology

Studies of measures for early stabilization of landfill site have to be made to develop an efficient landfill technology. For that purpose, circulatory semi-aerobic landfill method (Fig.10.2) is being developed as means for utilizing processing functions at landfill site.

10.3 Development of a Method for Excavating the landfill site and Reutilizing the Excavated Materials.

The purpose of the method is to reduce the cost of facilities at landfill site and reuse the site by excavating the compleated site, and reutilize organic materials turning them into compost, and soil, sand, rubbish, etc. into filling materials respectivily. (Fig.10.3, 10.4)

The technology and methods to be developed for this purpose include the following;

(1) Technology for excavating an existing landfill site.
(2) Technology for picking out and crushing excavated wastes.
(3) Method of reusing the materials picked out.
(4) Method of temporarily storing the materials picked out.
(5) Method of finally disposing of the materials picked out.
(6) Method of transferring the materials picked out.

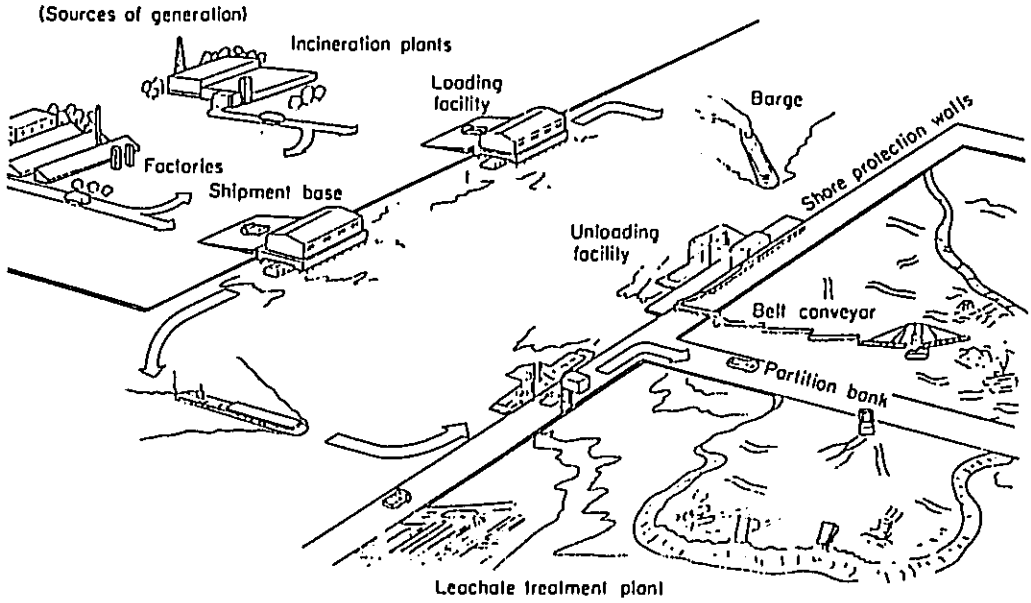
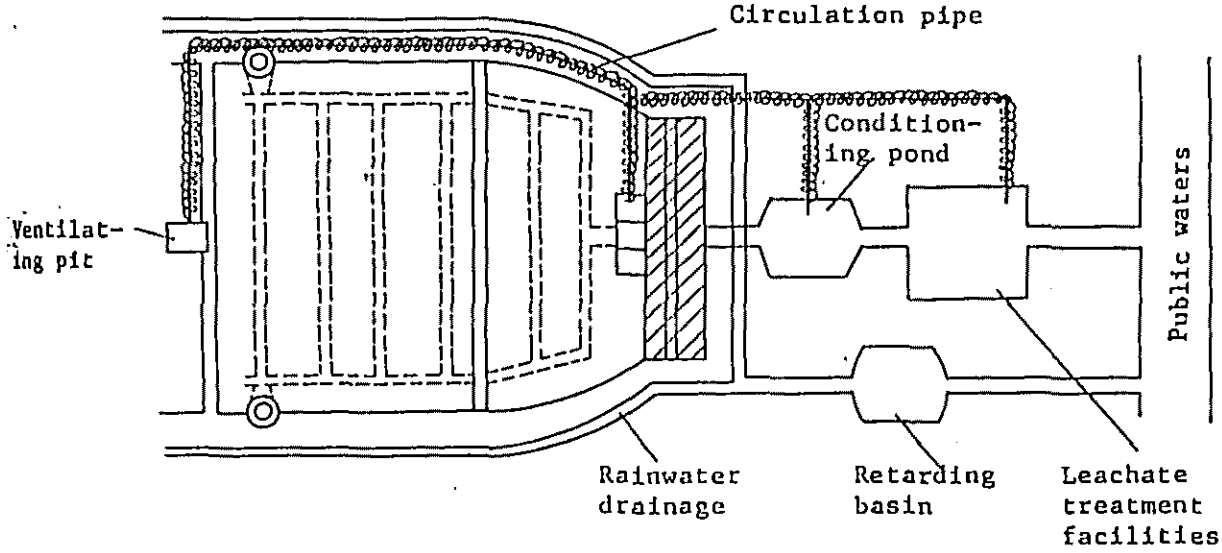
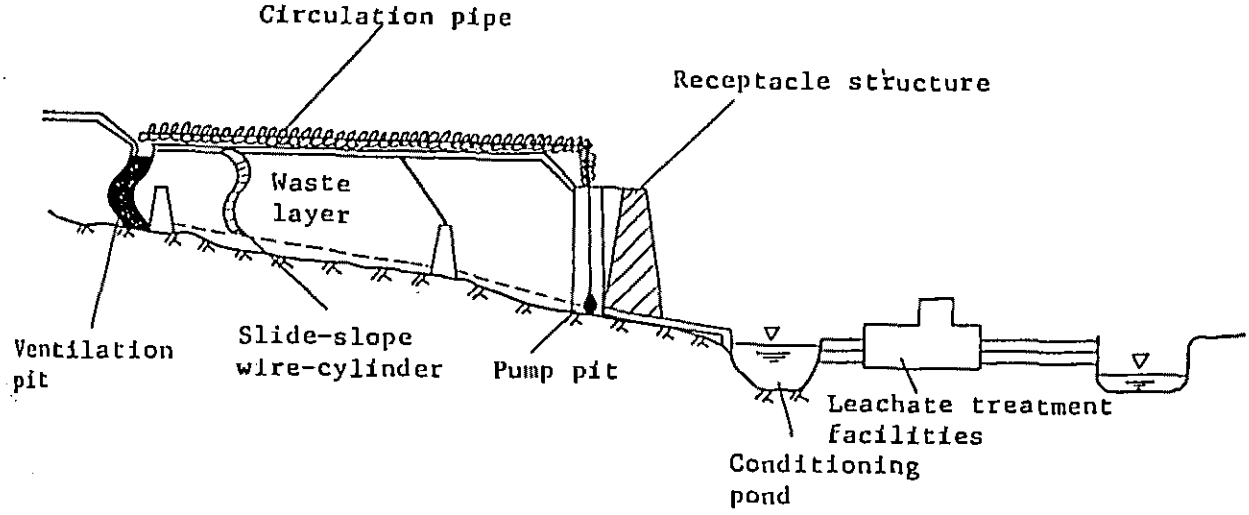
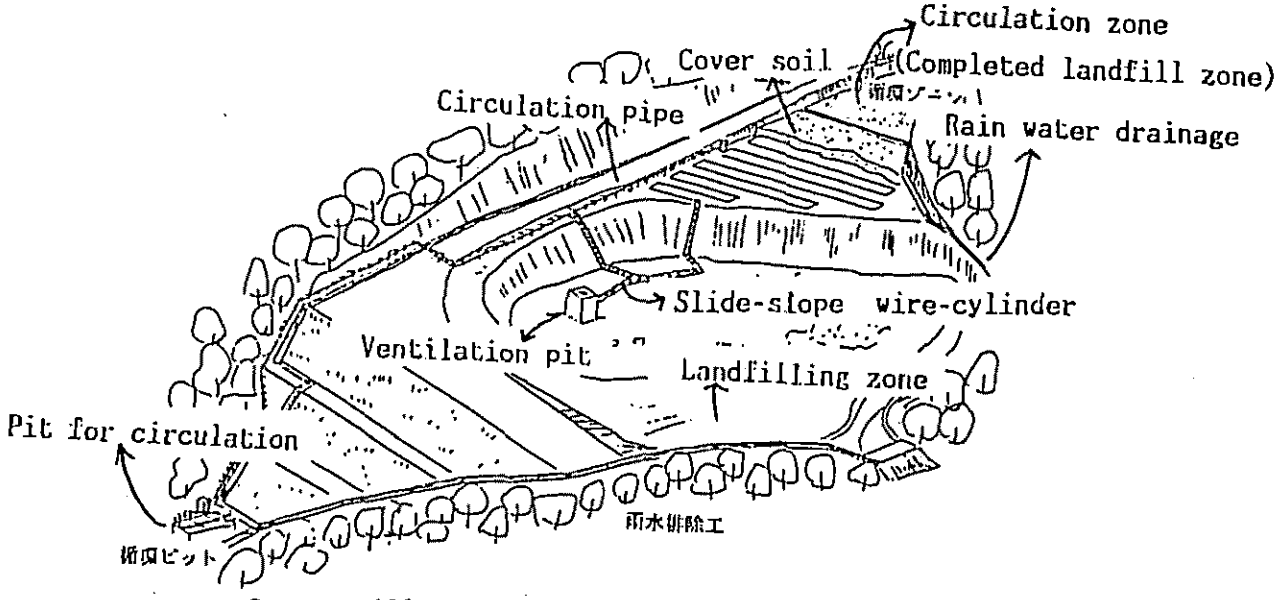


Fig. 10.1 Artist's concept of an offshore land reclamation site in the bay area.

Fig.10.2 Structure of Circulatory Semi-aerobic Landfill Site







Concept illustration of a circulatory semi-aerobic landfill site
(Combination type)

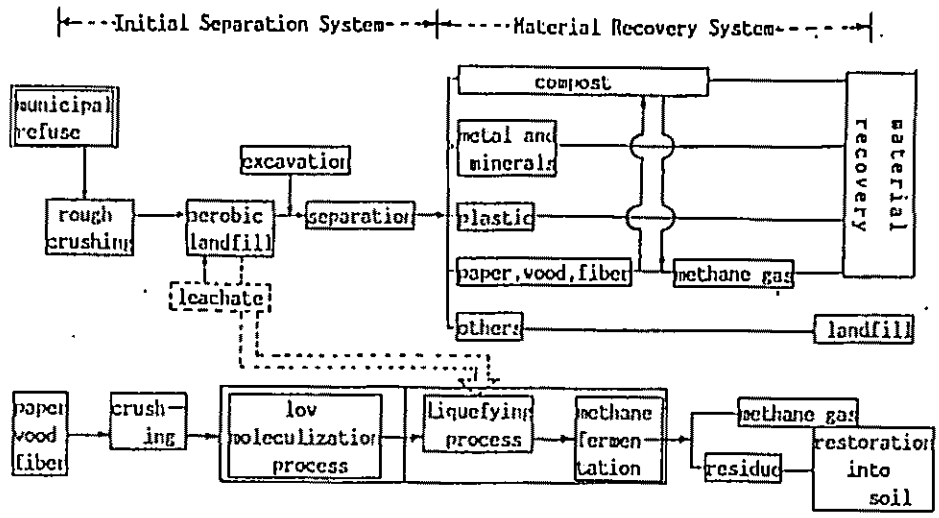


Fig. 10.3 Flow of Resource Reclamation Aerobic Landfill System

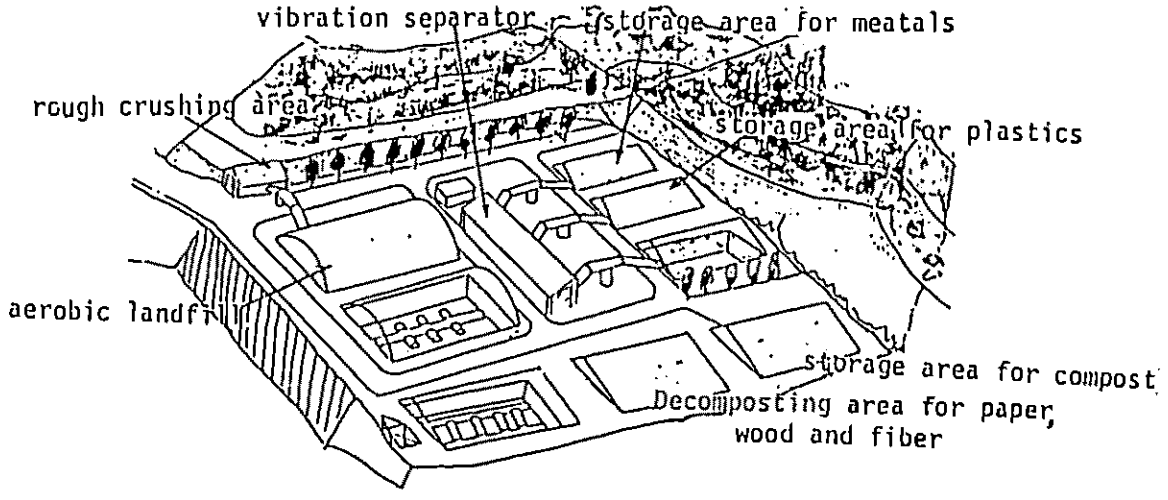


Fig. 10.4 Illustration of Resource Recovery Aerobic Landfill System

REFERENCES

1. Plastic Waste Management Institute,"PLASTIC WASTE-Resource Recovery and Recycling in Japan"

2. M.Hanashima,et al."Tecnology Progress of Inland Reclamation in Japan",Proc. of International Land Reclamation Conference and Exibition, April 26-29, 1983, Essex, England.

3. U.S.EDA, "Sanitary Landfill Design and Operation", 1972.

4. JICA, "Solid Waste Management and Night Soil Treatment",1978.

5. U.S. Department of Health, Education, and Welfare, "Open Dump Closing-Sanitary Landfill Operation ", 1970.

6. T.Ikeguti, S.Kondo, "Landfill Technology to Control Groundwater and Surface Water Pollution "Presented at the First Seminar for the Safe Disposal of Solid Wastes, Jan. 28-29, 1988, Bangkok, Thailand.

7. Frank. Flintoff, "management of solid wastes in developing countries" WHO Regional Office for South-East Asia, 1984.

SANITARY LANDFILL

Workshop on the Sanitary Landfilling of
Municipal Solid Wastes, 1-6 August 1988

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1. DEFINITION OF SANITARY LANDFILL

1.1 The SANITARY LANDFILL is defined by the American Society of Civil Engineers as :

> A method of disposing of refuse on land without creating nuisances or hazards to public health or safety, by utilizing the principles of engineering to confine the refuse to the smallest practical area, to reduce it to the smallest practical volume, and to cover it with a layer of earth at the conclusion of each day's operation, or at such more frequent intervals as may be necessary.

1.2 Such a landfill is a well-controlled and truly sanitary method of disposal of solid wastes upon land. It consists of four basic operations :

(1) the solid wastes are deposited in a controlled manner in a prepared portion of the site;

(2) the solid wastes are spread and compacted in thin layers;

(3) the solid wastes are covered daily or more frequently, if necessary, with a layer of earth;

(4) the cover material is compacted daily.

1.3 The final result can be a golf course, tennis court, playfield, botanical garden, municipal riding ring, or whatever not-too-heavy activity the community wants.

2. ACTUAL SITUATION OF PROCESSING AND FINAL DISPOSAL IN MALAYSIA

2.1 Solid wastes in Malaysia do not go through any processing activities except in the case of Kuala Terengganu. Those brought to the disposal sites are salvaged by scavengers and the rest left to mother nature for disposal. The market for compost is very low thus making composting not viable here in Malaysia although the City Hall of Kuala Lumpur is making use of the dried sludge from its central sewage treatment facilities as soil conditioner for its beautification programme of planting new trees and flowers.

2.2 Based on the sampling results carried out in 1978 paper constitutes the second highest percentage after putrescible materials in the average composition of domestic refuse. Coupled with favourable price of recycled paper, the paper recycling activities have been reestablished recently. This had ceased for a while possibly due to a much lower price of recycle paper. The country is importing large amount of paper and cardboard to cater for the needs of the information and paper-based industries. The Association of Paper Manufacturers of Malaysia is currently carrying out a supply and demand study towards paper production in general and the recycling paper industries in particular. This shall provide the necessary information and foresee the move towards paper recycling at a much larger scale. Simultaneously, efforts are being made to persuade the Government to relax the tax regulations which are prohibiting the export of waste paper. All these would conclude that the recycling of paper could look forward to better times. Other recycle items are hard to predict. The ongoing practices give little indication that systematic growth would occur. The returnable drinking bottles system had long stopped because most manufacturers are adopting the throwaway plastic bottles and other forms of containers for their products.

2.3 In recent years, DBKL has been studying the feasibility of energy recovery type incinerators to be constructed and operated by the private sector with no charge to DBKL. It has proved, however, that the continuous supply of "burnable" wastes to the plants, one of the conditions set by prospective contractors, cannot be achieved by DBKL especially in the wet season. This shows that incinerators can be introduced only by paying tipping fees whose level will be very high compared with that of sanitary landfills.

2.4 However, many Local Authorities are not informed correctly of the conclusion of the DBKL study and they are caught by the thought that incinerators may solve the never ending problem of finding new dumping sites. This mood has intensified after the construction of a modern incinerator in Kuala Terengganu. This incinerator with a capacity of 100 ton per day is the first plant of this nature in Malaysia and it has been in operation since September 1987. The operation so far in this plant shows, however, that Local Authorities are very likely to

suffer from the lack of appropriate personnel to operate these sophisticated plants.

FINAL DISPOSAL

2.5 Disposal is the final functional element in the solid waste management system and is the ultimate fate of all solid waste. In most of the Local Authorities in Malaysia, crude open dumping is practiced but in a few Local Authorities controlled tipping is practiced. Many of these dump sites are poorly located, in some cases too close to nearby housing units and in other cases too far from the town centre. In these crude open dump sites scavengers can be seen recovering recyclable materials. Animals feeding on refuse and open burning can also be observed. Table 1 shows scavengers recovering recyclable materials, animals feeding on waste and open burning taking place.

TABLE 1 : EXISTENCE OF SCAVENGERS, ANIMALS AND OPEN BURNING IN DUMPING SITES

	Number of Dumping Sites in Municipal Councils	Number of Dumping Sites in District Councils
With Scavengers	15 (79%)	68 (65%)
Without Scavengers	4 (21%)	37 (35%)
With Animals	15 (79%)	63 (56%)
Without Animals	4 (21%)	49 (44%)
With Open Burning	6 (32%)	86 (75%)
Without Open Burning	13 (68%)	28 (25%)

Source : Questionnaire on Solid Waste Management, May 1987
Note : This table covers all the relevant answers but not all the dumping sites.

2.6 There are approximately 230 official municipal dumping sites in Peninsular Malaysia. In the case of Municipal Councils, they have 1.8 dumping sites on average while District Councils have 2.7 on average as shown in Table 2. In the case of District Councils, more than one fourth have from 4 to 6 dumping sites. The size of these sites is small making the use of conventional sanitary landfilling method technically and economically difficult. On the other hand the reduction in the number of dumping sites will increase the transportation cost because of the existence of many small towns. By this reason, it is necessary to develop unconventional sanitary landfilling

methods for small landfills to improve the final disposal in District Councils.

TABLE 2 : DISTRIBUTION OF THE NUMBER OF FINAL DISPOSAL SITES

Number	Municipal Councils	District Councils
1 site/council	11 (24%)	6 (55%)
2 sites/council	14 (30%)	1 (9%)
3 sites/council	9 (20%)	4 (36%)
4 sites/council	5 (11%)	0 (0%)
5 sites/council	4 (9%)	0 (0%)
6 sites/council	3 (6%)	0 (0%)

Source : Questionnaire on Solid Waste Management, May 1987
Average : MCs = 1.8 sites/council, DCs = 2.7 sites/council.
Note : This table covers all the relevant answers but not all Local Authorities.

2.7 Through the field visits to 28 Local Authorities, the landfills in Kuantan and Alor Setar have been classified as possible candidates for model landfills in Peninsular Malaysia. Kuantan's tipping site located at a by-pass is about 7 km from the town centre and receives about 120 ton of wastes daily. The access to the site is very good and the site is fenced to avoid the entrance of strangers. The wastes are compacted by a bulldozer and sprayed and covered daily. The cover material is excavated on site. Alor Setar's tipping site at Jabi is about 16 km from the town centre and receives about 140 ton of wastes daily. Final access from the main road to the site is not so good needing improvement, but the wastes are compacted by a bulldozer and covered daily using the materials excavated on site. The operation in Alor Setar site is carried out by a private contractor.

2.8 One more good example is Lebuh Bakau dumping site in Pulau Pinang. Although the operation of the site is typical open dumping, it is the only one site in Peninsular Malaysia equipped with a weighbridge. The Municipal Council of Penang uses this weighbridge to measure the waste amount collected by private contractors and the payment is made on weight basis. Even in the case of Local Authorities which do not use private contractors for the collection of the wastes, the use of weighbridge is highly recommendable to monitor and improve the collection work productivity.

3. FINAL DISPOSAL IN DEVELOPING COUNTRIES

3.1 Open dumping remains the most prevalent form of disposal witnessed in developing countries. Very little of available budget for waste management is typically allocated to disposal. Since no monies are available for disposal, proposals for sophisticated resource recovery systems that "turn garbage into gold" are very attractive to local politicians. In most cases, reality would not bear out the promises and yet another "white elephant" would quietly stand as a tribute to poor planning analysis.

3.2 Landfill with special design to render the disposal site sanitary and neat, and to minimize the potential for gas and leachate generation and migration, is still the most cost-effective means of disposal available to most cities, both in developing and in industrialized countries. Only where there is either a potentially strong economic demand or intrinsic need for the by-products of resource recovery should such waste processing be considered.

3.3 The resource recovery options which are probably most appropriate in developing countries are based on biological decomposition of the organic fraction of the waste. Because of climate conditions which generally allow year-round outdoor treatment by biological systems, and because of the organic moist nature of the wastes, developing countries may find composting, biogas conversion, and methane recovery from landfills technologically feasible. Careful market evaluation, which includes a pilot/demonstration step for validation of market demand and acceptance, is essential.

3.4 The number of publications presenting an array of resource recovery options is extensive. Basically all these references promote highly mechanized systems and are directed toward audiences in industrialized countries. Only incineration with energy generation is truly proven among the non-biological techniques. Other systems using techniques such as pyrolysis and refuse-derived fuel, remain to be adequately established in industrialized countries- much less in developing countries.

3.5 The United Nations Development Programme, in concert with the World Bank as executing agency, is sponsoring a global research and development project starting in 1981 : to develop the state of the art of appropriate technology for resource recovery in developing countries. Particular attention will be given to systems that integrate more than one type of waste stream, and that integrate more than one type of technology.

3.6 Typically the main argument for resource in a city is lack of landfill space. Local government officials may be willing to consider spending heavily for resource recovery, but are often unwilling to spend a lesser amount for equipment that reduce the amount of waste requiring disposal, or transfer systems that allow more distant sites to be utilized. It should be remembered that some amount of landfill capacity would be needed for any common mode of disposal available.

4. NECESSARY DECISIONS FOR DISPOSAL PROCESS DESIGN

4.1 SELECTION OF FINAL DISPOSAL METHOD

- DIRECT DISPOSAL WITHOUT PROCESSING
  - SANITARY LANDFILL
  - DUMPING IN RIVER OR SEA
  - ANIMAL FEEDING
  - OPEN DUMPING
  - OPEN BURNING

) NOT ACCEPTABLE FROM THE VIEWPOINT OF ENVIRONMENTAL HEALTH

- PROCESSING FOLLOWED BY SANITARY LANDFILLING
  - SHREDDING
  - BAILING

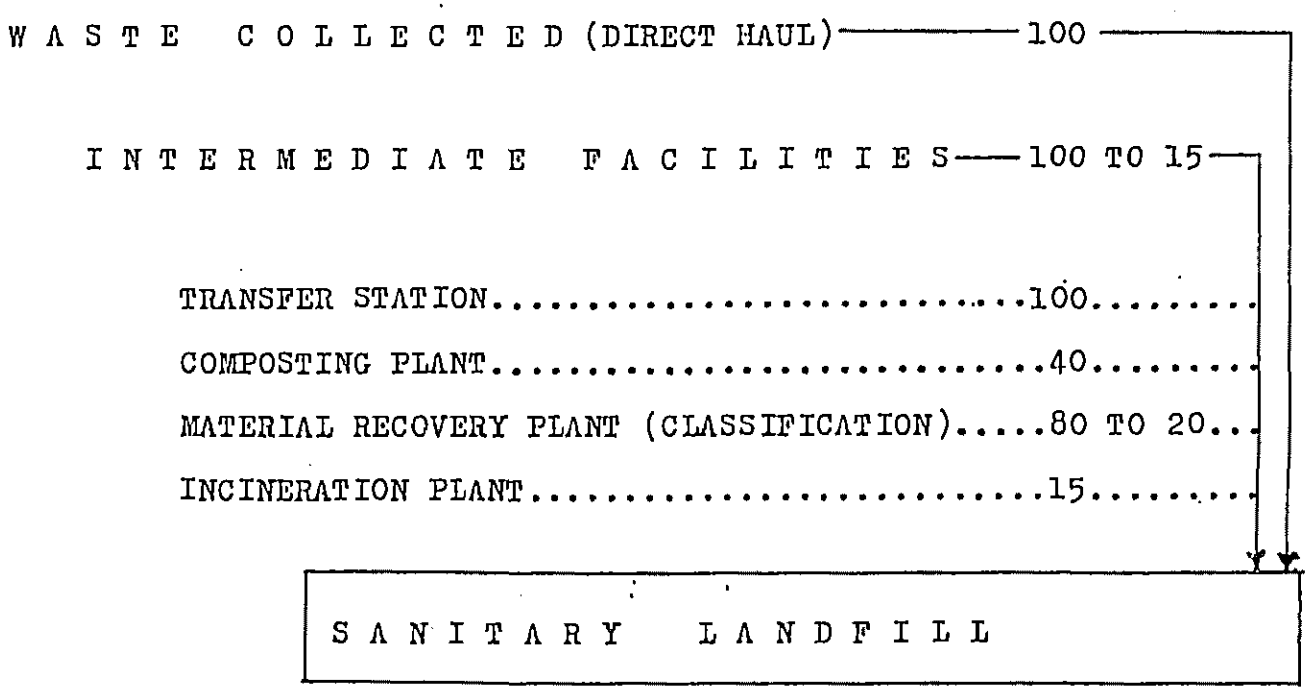
- PROCESSING FOR MATERIAL/ENERGY RECOVERY FOLLOWED BY SANITARY LANDFILLING
  - MECHANIC OR SEMIMECHANIC RECOVERY OF PAPER, METAL, GLASS, ETC.
  - COMPOSTING
  - INCINERATION
  - PYROLYSIS

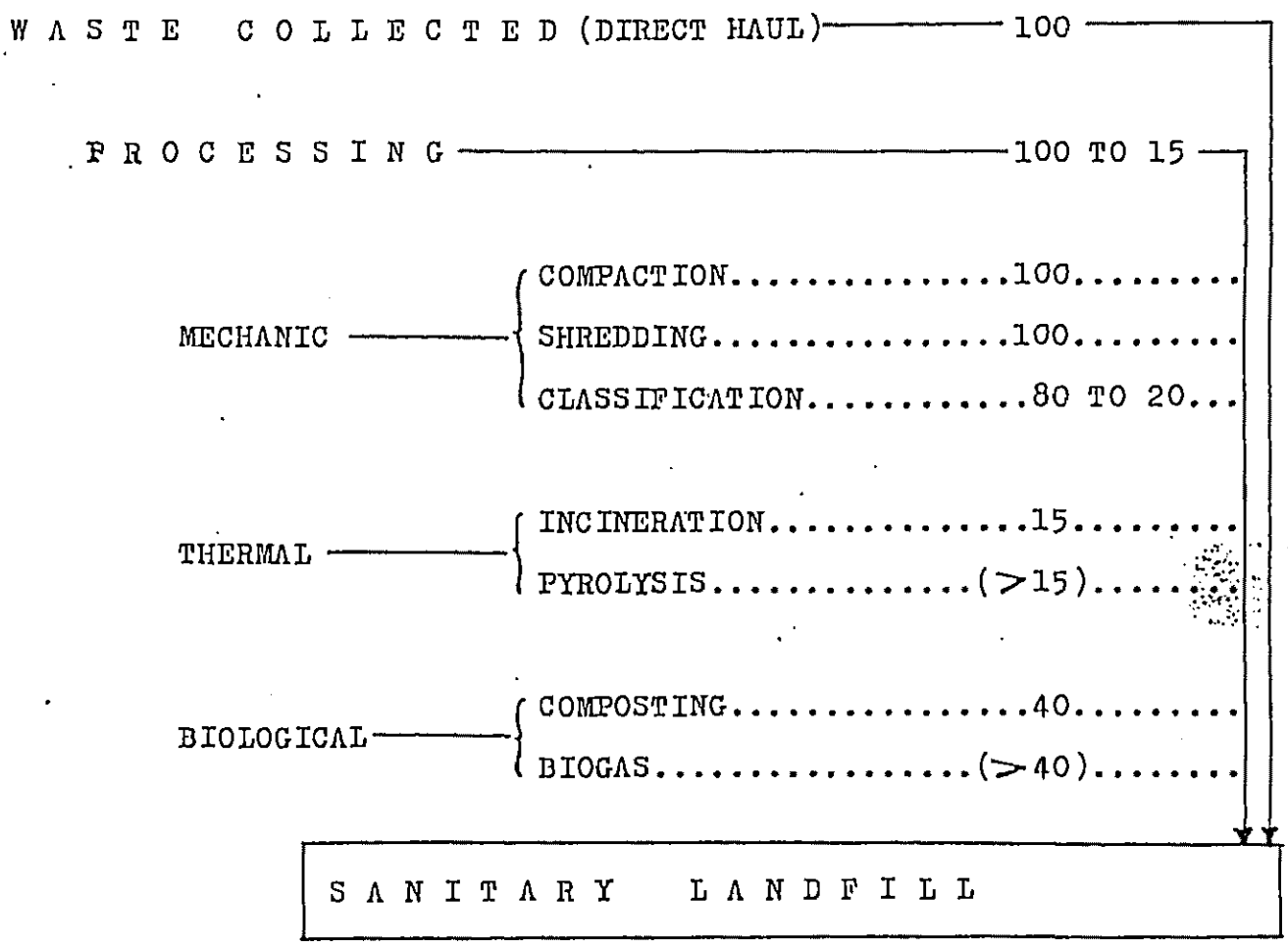
4.2 SELECTION OF THE SANITARY LANDFILL SITE

- CONFORMITY WITH THE LAND USE PLAN
- OWNER OF THE PROPERTY
- ACCESS TO THE SITE
- SIZE OF THE SITE
- PUBLIC SERVICE AVAILABILITY
- COVER MATERIAL AVAILABILITY
- WATER RESOURCE CONSERVATION
- DISTANCE FROM HOUSES AND FROM AIRPORT
- TOPOGRAPHIC AND CLIMATIC CONDITIONS

4.3 SELECTION OF THE AGENCY FOR THE FINAL DISPOSAL OPERATION

- DIRECT MUNICIPAL OPERATION
- MULTIMUNICIPAL OPERATION (SCALE ECONOMY)
- OPERATION BY PRIVATE CONTRACTORS


WASTE COLLECTED (DIRECT HAUL)
100
INTERMEDIATE FACILITIES
100 TO 15
TRANSFER STATION.....100.....
COMPOSTING PLANT.....40.....
MATERIAL RECOVERY PLANT (CLASSIFICATION).....80 TO 20...
INCINERATION PLANT.....15.....
SANITARY LANDFILL


WASTE COLLECTED (DIRECT HAUL)
100
PROCESSING
100 TO 15
MECHANIC
COMPACTION.....100.....
SHREDDING.....100.....
CLASSIFICATION.....80 TO 20...
THERMAL
INCINERATION.....15.....
PYROLYSIS.....(>15).....
BIOLOGICAL
COMPOSTING.....40.....
BIOGAS.....(>40).....
SANITARY LANDFILL

INVESTMENTS, COSTS AND INCOMES

PROCESSING AND FINAL DISPOSAL	INVESTMENT US$/TON	OPERATION US$/TON	INCOME US$/TON
COMPOSTING IN WINDROWS	3,000/ 5,000	4.00/ 6.00	3.00/ 6.00
MECHANICAL COMPOSTING	12,000/20,000	7.00/10.00	4.00/ 8.00
INCIN. WITHOUT HEAT USE	15,000/20,000	5.00/ 7.00	1.00/ 1.50
INCIN. WITH HEAT USE	25,000/35,000	10.00/15.00	25.00/35.00
SANITARY LANDFILL	1,500/ 3,000	1.50/ 2.50	-----
SLF WITH TRANSFER STA.	3,500/ 5,500	4.00/ 6.00	-----

(*) US DOLLARS OF 1976.

THE TABLE WAS PREPARED FOR THE CASE OF 300 TON/DAY.

5. POSSIBLE ALTERNATIVES OF PROCESSING AND FINAL DISPOSAL : THEIR ADVANTAGES AND DISADVANTAGES

MANAGEMENT OF SOLID WASTES IN DEVELOPING COUNTRIES (BY FRANK FLINTOFF)
CHAPTER 13 TREATMENT AND DISPOSAL

Over 90% of the world's solid wastes are disposed of in landfills. Sanitary landfilling is the main method used in the West: crude dumping is very common in the developing countries.

There is no form of treatment that can entirely avoid the need for land for final deposit. Treatment often enables a proportion of the wastes to be utilized in some way, but there are residues from all forms of treatment and the need for land space is rarely reduced by more than 70% (See Figure 16). Thus sanitary landfilling is usually necessary, although on a reduced scale, whatever form of treatment may be adopted. The most common forms of treatment are:

— size-reduction of the wastes by shredding or pulverization, in order to improve the land-filling qualities of the wastes, or as a stage in a composting process;
— composting, a system for controlling the natural decomposition process to produce an organic fertilizer:
— incineration, the primary purpose of which is to render the wastes inert, but which also reduces volume, and may sometimes provide a source of energy.

All these forms of treatment provide opportunities for recycling, because facilities for the extraction of saleable materials can be incorporated in the plants.

13.1 Recycling

The constituents which are commonly extracted from domestic-trade wastes for industrial use are:

— paper, for re-pulping;
— textiles for paper-making, machinery wipers, etc.;
— metals for re-melting;
— glass for re-melting or abrasives manufacture, etc.;
— rubber for a downgraded use;
— plastics for the production of an inferior grade.

Extreme poverty may lead to the extraction of some kinds of wastes for personal use:

— cinders, fragments of coal, coconut shells, etc., for use as fuel;
— metal cans for use as domestic vessels;
— vegetable wastes for animal feed.

The paradox of recycling is that in the wealthy nations, where saleable constituents may comprise 50% of the collected wastes, wages are often too high to permit the recovery, sorting and processing of these materials to be carried out profitably, whereas in the poorer countries the proportion of saleable materials may be negligible. This is partly because of low consumption of paper, metal, glass and plastic, packaging materials, and also because scavengers and refuse-handling workers extract almost everything which is of use before the wastes reach the disposal site.

In most developing countries, therefore, there is very little scope for recycling to be embodied as a planned stage of wastes disposal, because of intensive private scavenging. This can be a serious problem at landfill sites, which are often invaded, and sometimes permanently inhabited, by families of scavengers who support themselves in this way.

Planned recycling may, however, be profitable in countries where the high value of recovered materials and the low wage cost of recovery and recycling compensate for the relatively small proportions present in the wastes. This appears to be the case in India at present. Ways in which recycling can be operated in association with sanitary landfilling and composting will be discussed later.

13.2 Pulverization

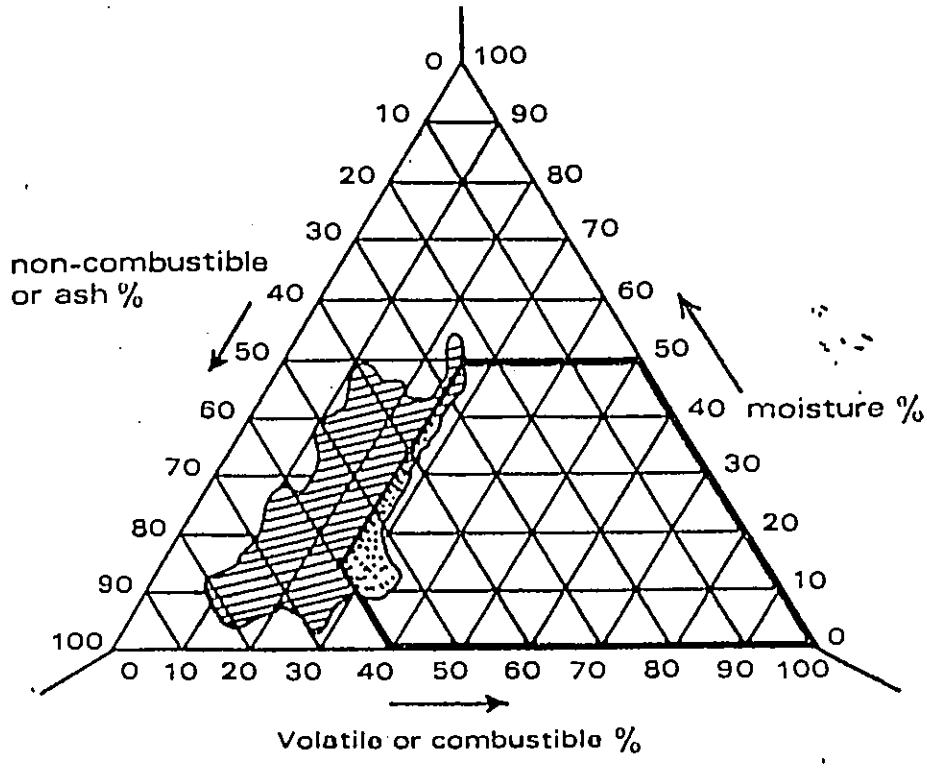
Because the wastes of the industrialized countries contain many bulky and hollow articles, even pieces of furniture, pulverization is sometimes used as a preliminary treatment before landfilling. By shredding cartons, breaking bottles and crushing cans in a hammermill, a fairly homogeneous mixture of wastes, of reduced particle size, is produced; this occupies less space at the time of deposit and ultimately decomposes to form a consolidated fill without voids, which could cause a protracted period of settlement.

The wastes of most developing countries, however, do not require this form of treatment for landfill purposes: they contain few hollow articles and in some countries up to 80 per cent of the crude wastes, as collected, would pass a 50 mm screen; this is almost as good as the average product of a hammermill in Europe. The most common bulky article in the wastes of the intermediate countries is the fibreboard carton; these can usually be extracted and sold. In tropical countries there may be bulky items of vegetable wastes, but these will ultimately decompose without pretreatment.

Figure 15

THREE COMPONENT DIAGRAM ILLUSTRATING THE UNSUITABILITY OF INDIAN WASTES FOR INCINERATION

(Adapted from "Solid Wastes Management in India", W.H.O., SEA/Env San/167, 1976; p. 34, Mr. A.D. Bhide, NEERI.)



Zone in which self-sustaining combustion reaction can be obtained

Zone in which values from 33 Indian cities lie

Zone in which values from some Indian cities lie giving self-sustaining combustion reaction

13.3 Composting

The wastes of S.E. Asian countries are often ideal for conversion into organic fertilizer because of their high vegetable/putrescible content. Economic forces also favour composting in those countries where high food production is of great importance, while fertilizer imports are limited by foreign exchange constraints.
There are five pre-conditions for successful composting:

— suitability of the wastes;
— a market for the product within 25 km of the city;
— the support of the agricultural authorities, particularly the ministry of agriculture;
— a price for the product which is acceptable to most farmers;
— a net disposal cost (plant costs minus income from sales) which can be sustained by the local authority.

When these conditions can be met, a developing country should closely study the possibility of composting because town wastes are a significant potential source of nitrogen, phosphate and potash as well as an organic soil supplement.

13.4 Incineration

Modern incineration plants have the following features:

— automatic feeding of the wastes through a vertical chute which is always full of refuse;
— automatic stoking of the burning wastes by mechanical grates;
— ash discharge into a water-sealed pit.

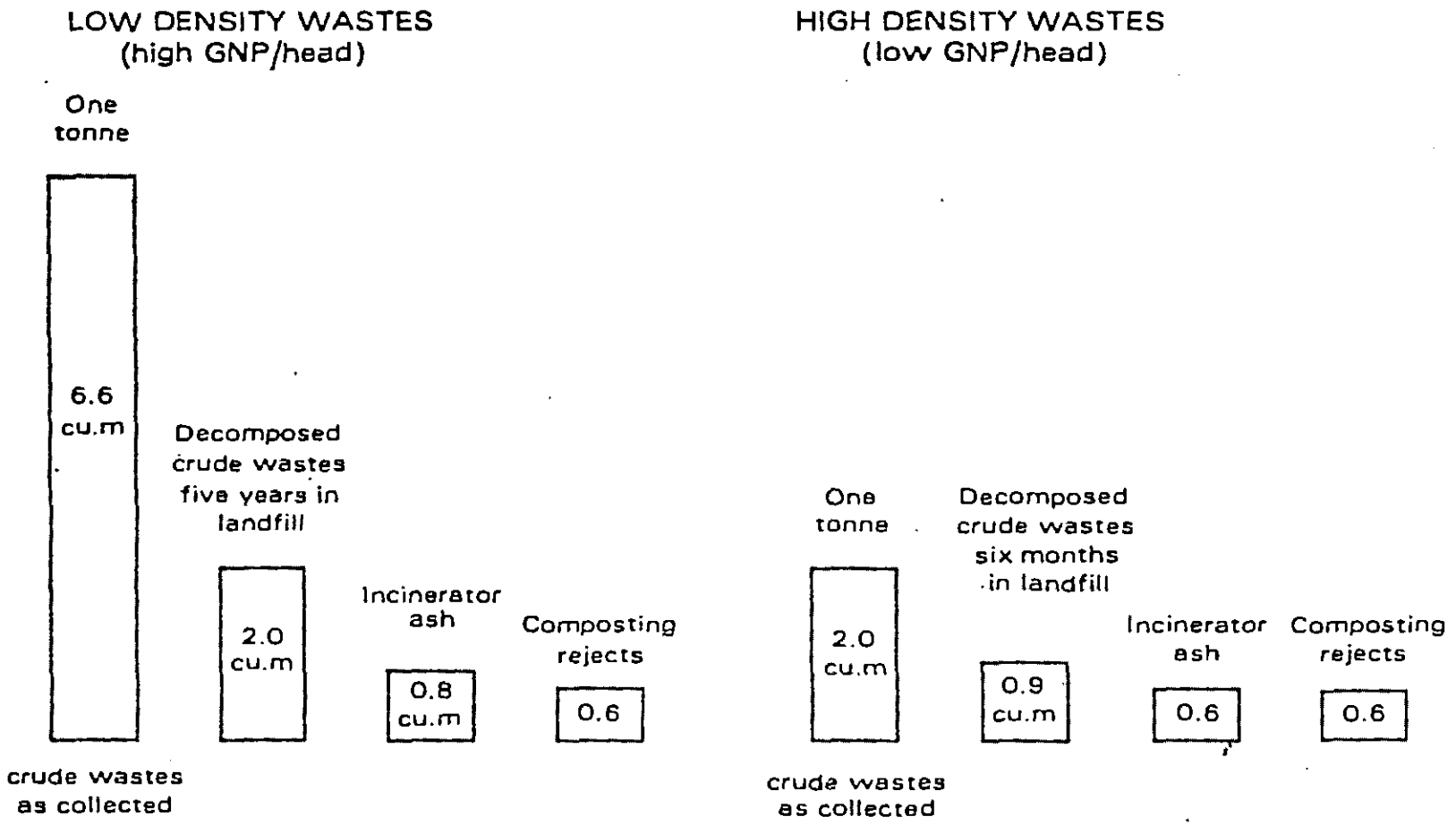
The furnace is never opened for feeding, stoking or ashing, and thus smoke emission is avoided by this total control over combustion air. The gaseous effluent of these plants is usually treated by an electrostatic precipitator in order to extract dust and grit.

The weight of ash is between 25% and 40% of the incoming wastes and the volume between 10% and 15%. The high density of the ash makes it an economical material to transport and it can sometimes be used for landfilling at sites where crude wastes would be unacceptable; however, it does contain soluble inorganic salts which could cause water pollution.

In many European incinerators boilers are installed and the steam is used for the generation of electricity, district heating, and sewage pumping, or sold to industry. This is possible because the wastes are of high calorific value, often one-third that of coal, and fairly low moisture content. As an energy source, however, solid wastes are of little significance. It has been calculated that if all British wastes were utilized for this purpose (which is impracticable), total energy production would be less than two per cent of current national consumption. Furthermore, it has rarely been demonstrated that heat recuperation is profitable; in many cases the value of the

Figure 16

PROBABLE LAND SPACE REQUIRED FOR SANITARY LANDFILLING OF UNTREATED WASTES COMPARED WITH SPACE REQUIRED FOR RESIDUES OF TREATMENT



steam is offset by a large increase in the capital cost of the plant and in maintenance costs.

For most developing countries incineration can be dismissed firmly as a rational solution to the problems of wastes disposal on the following grounds:

— wastes are too low in calorific value;
— they are probably high in moisture content;
— capital and operating costs are likely to be beyond the means of most cities.

In many countries calorific value is so low that, far from there being any possibility of recovering energy by burning wastes, supplementary fuel may be necessary for at least part of the incineration process. This is demonstrated in the three-component diagram, which shows that most Indian wastes are unable to sustain their own combustion.

An argument which is used in Europe to justify the high cost of incineration is that it reduces land space requirements and thus conserves land in the vicinity of the city, thereby deferring the time when the wastes, or the residues of treatment, have to be transported to much more distant landfill sites. It is true that space required for final deposit is reduced by a factor of about three, compared with the decomposed volume of crude wastes in sanitary landfill. However, it is likely that countries having wastes of high density would not benefit to the same extent and that this factor may be two or less. This is shown graphically in the bar chart, which tries to compare land space needs for low and high densities and for the main disposal methods.

13.5 Cost

Given satisfactory standards for the protection of health and the environment, cost will always be the criterion of choice of a waste disposal method. It is necessary, therefore, to consider the probable comparative costs of the main systems. There are dangers in suggesting comparative costs except for a specific city because of wide variations in labour cost and other influences such as site conditions, economy of scale, and the standards of buildings used to house treatment plant.

When it is considered that current total expenditure on solid wastes management, including collection of wastes and street cleansing, ranges between Rs 5 and Rs 15/person/year in many developing countries, incineration is ruled out simply on the ground that it would more than double annual budget requirements.

Thus the following table cannot pretend to do more than indicate the likely differences in scale of cost as between one method and another. It is assumed that all transport operations take place within a radius of 8 km.

Sanitary landfill	1 unit of cost
Pulverization/landfill	5 "
Incineration	15 "

Composting:				
minimum mechanization	5	" minus income,	say 2	net
full mechanization	10	" " "	say 7	net

At the time of writing, the cost unit for much of Asia could be taken to be about Rs 10. This assumption makes it possible to measure the cost impact of a disposal method in the following way.

At a low rate of wastes generation, 400 g/person/day, the weight to be disposed of/person/year would be 150 kg. The comparative costs per person/year, at 1975 price level, are, therefore:

Sanitary landfill	Rs 1.5
Manual composting	3.0
Incineration	22.5

13.6 Environmental aspects

(a) *Landfill.* Every crude dump is an environmental disaster causing health risks from flies and rats, air pollution from deliberate or accidental burning and water pollution through leaching by rainfall.

At a sanitary landfill vectors are controlled by the operating method. Groundwater pollution is avoided by careful site selection and surface water pollution is avoided by preliminary site engineering. Thus a well-managed site involves no risks of pollution transfer to water or atmosphere. Some short-term environmental degradation may be unavoidable in the form of traffic to and from the site, a scarred landscape caused by earthmoving operations, some visible refuse at most times, wind-borne litter during gales, and the noise of tractors.

If a sanitary landfill site provides restoration of a former surface mineral excavation, or improves a natural feature by creating a park on estuarial mud, then it confers long-term environmental benefits which heavily outweigh the short-term problems.

(b) *Composting.* Composting systems, both manual and mechanized, can be designed and operated so as to provide effective control over disease vectors, but it is rarely possible entirely to avoid occasional offensive odours. The solution to this lies in careful site selection. The possible economic importance of composting to certain developing countries has already been stressed. There may also be significant advantages to public health because it is often the custom for farmers to collect crude wastes and to use them as fertilizers without any proper treatment or control, thus causing risks which would be avoided if the wastes were processed into a hygienic product by the local authority.

(c) *Incineration.* Incineration has no obvious environmental advantages; in fact, it sometimes presents environmental problems. A very tall chimney is necessary to ensure that the effluent gases do not descend over the surrounding area; water consumption for gas cooling and clinker quenching may be very high; particle emission can seldom be controlled to

better than 99%, and even this is inadequate; large plants generate a very high level of traffic.

13.7 Conclusions

In terms of both cost and environmental protection; sanitary landfill and composting emerge as the most suitable methods of solid wastes disposal for developing countries. In the case of sanitary landfill, this conclusion is the same as that reached by the great majority of cities in the industrialized countries. Composting, however, has been rejected in most of Europe and USA because of high production cost, due to high wages; high cost of application on the farm, again due to high wages; but primarily because of the ready availability, at acceptable cost, of artificial fertilizers of guaranteed analysis. None of these factors apply at present in many of the developing countries. Thus, in most cases both sanitary landfill and composting may be equally worthy of consideration. In the succeeding chapters these two disposal methods are described in much greater detail.

6. ADVANTAGES AND DISADVANTAGES OF SANITARY LANDFILL

6.1 ADVANTAGES

1. Where land is available, a sanitary landfill is usually the most economical method of solid waste disposal.
2. The initial investment is low compared with other disposal methods.
3. A sanitary landfill is a complete or final disposal method as compared to incineration and composting which require additional treatment or disposal operations for residue, quenching water, unusable materials, etc.
4. A sanitary landfill can be put into operation within a short period of time.
5. A sanitary landfill can receive all types of solid wastes, eliminating the necessity of separate collections.
6. A sanitary landfill is flexible; increased quantities of solid wastes can be disposed of with little additional personnel and equipment.
7. Submarginal land may be reclaimed for use as parking lots, playgrounds, golf courses, airports, etc.

6.2 DISADVANTAGES

1. In highly populated areas, suitable land may not be available within economical hauling distance.
2. Proper sanitary landfill standards must be adhered to daily or the operation may result in an open dump.
3. Sanitary landfills located in residential areas can result in extreme public opposition.
4. A completed landfill will settle and require periodic maintenance.
5. Special design and construction must be utilized for buildings constructed on completed landfill because of the settlement factor.
6. Methane, an explosive gas, and the other gases produced from the decomposition of the wastes may become a hazard or nuisance problem and interfere with the use of the completed landfill.

7. SANITARY LANDFILL SITE SELECTION

S E L E C T I O N O F T H E S I T E

- I S T H E K E Y T O T H E S U C C E S S -

U R B A N I S T I C
E C O N O M I C
S A N I T A R Y
} B A S E S

THE SELECTION OF THE SITE IS AS MUCH OR MORE IMPORTANT FOR SMALL CITIES !!!

ATTENTION !!!!

S E L E C T I O N O F T H E S I T E

URBANISTIC BASES:

—— MAKE COMPATIBLE WITH THE URBAN DEVELOPMENT

- COMPATIBILITY WITH LAND USE PLAN
- FUTURE USE COMPATIBLE WITH THE URBANIZATION
- DIRECTION OF URBANIZATION TOWARDS THE SITE
- EXISTING OR PLANED PAVED ROADS

—— MAKE COMPATIBLE WITH OTHER URBAN SYSTEMS

- THERE SHOULD BE NO POSSIBILITY OF POLLUTING DRINKING WATERS
- AVAILABILITY OF ELECTRICITY AND TELEPHONE SERVICE
- AVAILABILITY OF SEWAGE SERVICE

S E L E C T I O N O F T H E S I T E

ECONOMIC BASES:

— INTERNAL ECONOMY OF THE SANITARY LANDFILL

- AVAILABILITY OF COVER MATERIAL IN THE SITE OR IN ITS VICINITY
- LIFE OF THE SITE COMPATIBLE WITH THE INFRASTRUCTURE

— GLOBAL ECONOMY OF THE SOLID WASTES MANAGEMENT SYSTEM

- RAPID AND SECURE ACCESS FOR THE VEHICLES

— COST OF THE LAND

- COST OF ACQUISITION OR COST OF RENTING

— RESULTING SOCIAL COSTS AND BENEFITS

- UP-VALUATION OR DEVALUATION OF THE VICINITIES
- COST/BENEFIT DURING THE WORK AND WITH THE UTILIZATION OF LANDFILLED AREA

S E L E C T I O N O F T H E S I T E

SANITARY BASES:

CLIMATIC CONDITIONS

- PLUVIAL PRECIPITATION
- EVAPORATION
- DOMINANT WIND

SOIL

- CHARACTERIZATION AND CLASSIFICATION
- PROBABLE PERMIABILITY
- GROUND WATER LEVEL

SUPERFICIAL WATERCOURSES

- FLOW DIRECTION
- WATER USE AND REQUIRED WATER QUALITY

TOPOGRAPHY

- AVAILABILITY OF COVER MATERIAL
- CAPACITY AND LIFE

8. SANITARY LANDFILL DESIGN PRINCIPLES

SLF Designers should always ask themselves the following three basic questions which will make it possible for them to work out operationable designs:

1) How to give refuse collection trucks reliable access to the working face throughout the life of SLF ?

2) How to get support for refuse compaction throughout the life of SLF ?

3) How to get cover material at reasonable cost throughout the life of SLF ?

ADDITIONAL CONSIDERATIONS

1) Water management (Drainage, leachate collection and treatment)

2) Landfill gas management

3) Structural stability

4) Landscaping

5) Special areas for bad weather period and/or special wastes

6) Final land use of finished SLF

IMPORTANT FACTORS THAT MUST BE CONSIDERED IN THE DESIGN AND OPERATION OF SANITARY LANDFILLS

Factor	Remarks
Design	
Access	*Paved all-weather access roads to landfill site; temporary roads to unloading areas.*
Cell design and construction	Will vary depending on whether gas is to be recovered; each day's wastes should form one cell; maximum depth of 10 ft; cover at end of day with 6 in of earth; gravel gas vent should be installed every 60 to 200 ft.
Cover material	Maximize use of onsite earth materials; approximately 1 yd^3 of cover material will be required for every 4 to 6 yd^3 of solid wastes; mix with sealants to control surface infiltration.
Drainage	Install drainage ditches to divert surface water runoff; maintain 1 to 2 percent grade on finished fill to prevent ponding.
Equipment requirements	Vary with size of landfill (see Table 10-15).
Fire prevention	Water onsite; if nonpotable, outlets must be marked clearly; proper cell separation prevents continuous burn-through if combustion occurs.
Groundwater protection	Divert any underground springs; if required, install sealants for leachate control; install wells for gas and groundwater monitoring.
Land area	Area should be large enough to hold all community wastes for a minimum of 1 yr but preferably 5 to 10 yr.
Landfilling method	Selection of method will vary with terrain and available cover.
Litter control	Use movable fences at unloading areas; crews should pick up litter at least once per month or as required.
Operation plan	With or without the codisposal of treatment plant sludges and the recovery of gas.
Spread and compaction	Spread and compact waste in layers less than 2 ft thick.
Unloading area	Keep small, generally under 100 ft on a side; operate separate unloading areas for automobiles and commercial trucks.
Operation	
Communications	Telephone for emergencies.
Days and hours of operation	Usual practice is 5 to 6 days/wk and 8 to 10 h/day.
Employee facilities	Restrooms and drinking water should be provided.
Equipment maintenance	A covered shed should be provided for field maintenance of equipment.
Operational records	Tonnage, transactions, and billing if a disposal fee is charged.
Salvage	No scavenging; salvage should occur away from the unloading area; no salvage storage onsite.
Scales	Essential for record keeping if collection trucks deliver wastes; capacity to 100,000 lb.

9. EQUIPMENT SELECTION

EQUIPMENT

A wide variety of equipment is on the market today from which to select the proper type and size needed for an efficient operation. The size, the type, and the amount of equipment required at a sanitary landfill depend on the size and method of operation and to some degree on the experience and preference of the designer and equipment operators.

Types. The most common equipment used on sanitary landfills is the crawler or rubber-tired tractor. The tractor can be used with a dozer blade, trash blade, or a front-end loader. A tractor is versatile and can normally perform all the operations: spreading, compacting, covering, trenching, and even hauling the cover material. The decision on whether to select a rubber-tired or a crawler-type tractor, and a dozer blade, trash blade, or front-end loader, must be based on the conditions at each individual site.

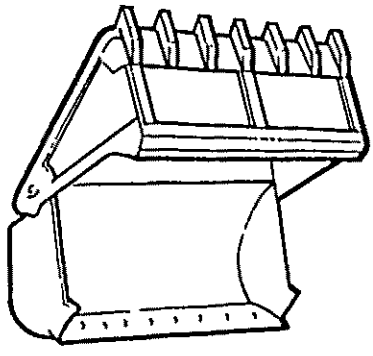
Other equipment used at sanitary landfills are scrapers, compactors, draglines, and graders. This type of equipment is normally found only at large sanitary landfills where specialized equipment increases the overall efficiency.

Size. The size of the equipment is dependent primarily on the size of the operation. Small sanitary landfills for communities of 15,000 or fewer, or sanitary landfills handling 46 tons of solid wastes per day or less, can operate successfully with one tractor of the 5- to 15-ton range.

Heavier equipment in the 15- to 30-ton range or larger can handle more waste and achieve better compaction. Heavy equipment is recommended for sanitary landfill sites serving more than 15,000 people or handling more than 46 tons per day.

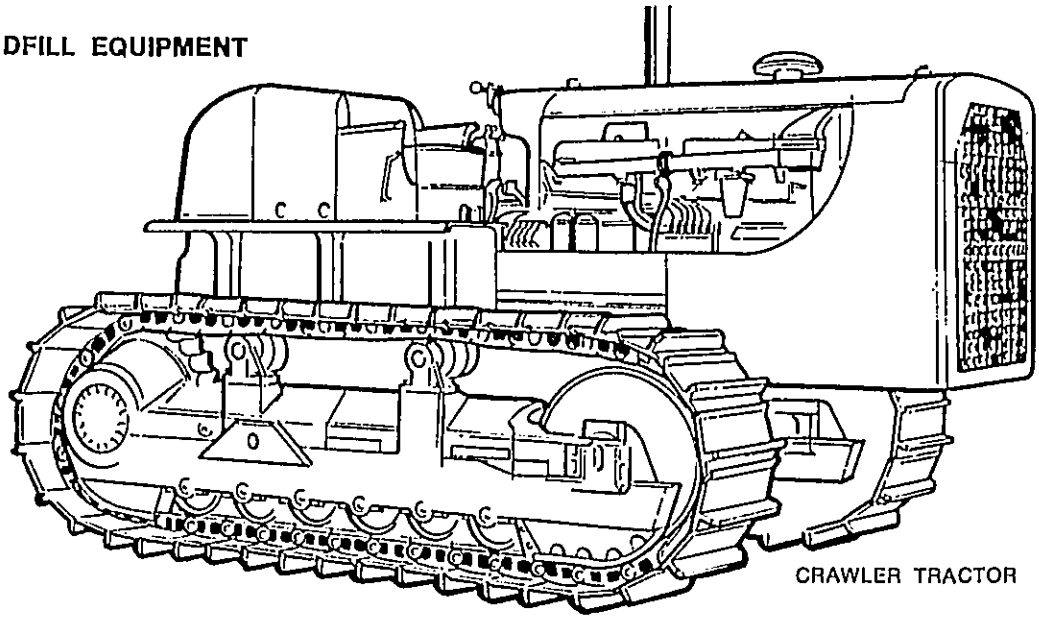
Amount. Sanitary landfills servicing 50,000 people or fewer, or handling about 155 tons of solid wastes per day or less, normally can manage well with one piece of equipment, but provisions must be made for standby equipment. It is preferable that a second piece of equipment be purchased and used for replacement during breakdown and routine maintenance periods of the regular equipment. Arrangements can normally be made, however, with another public agency or private concern for the use or rental of replacement equipment on short notice in case of a breakdown of the regular equipment.

At large sanitary landfills serving more than 100,000 people, or handling more than 310 tons of solid wastes per day, more than one piece of equipment will be required. At these sites, specialized equipment can be utilized to increase efficiency and minimize costs. In Table 1 a general guide is given for the selection of the type, size, and amount of equipment for various sizes of sanitary landfills.

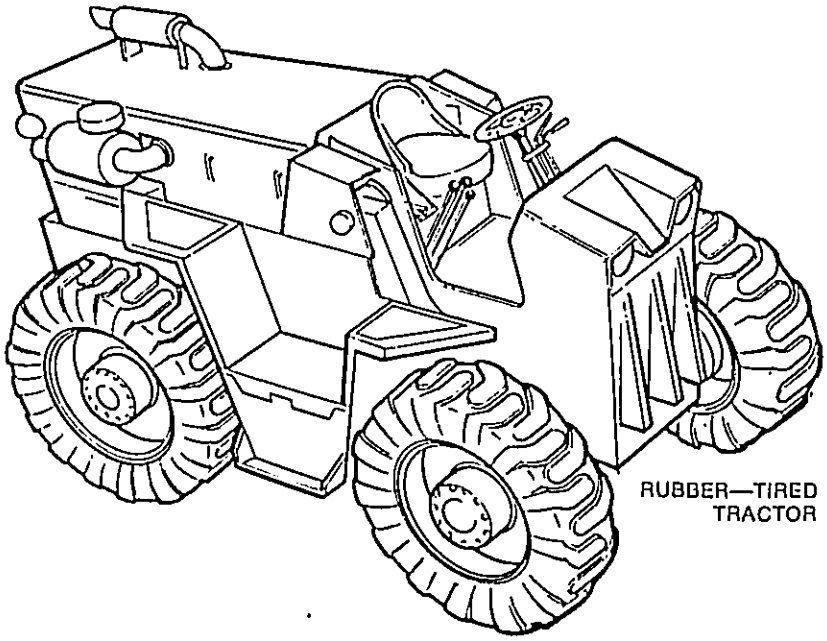


MULTIPURPOSE BUCKET

STANDARD LANDFILL EQUIPMENT

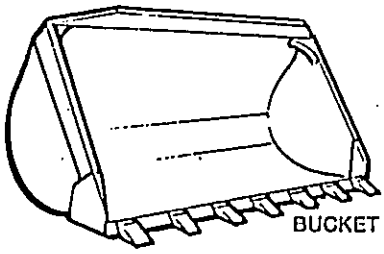


CRAWLER TRACTOR

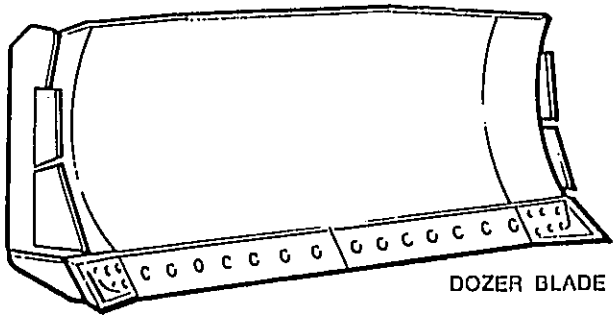


RUBBER—TIRED TRACTOR

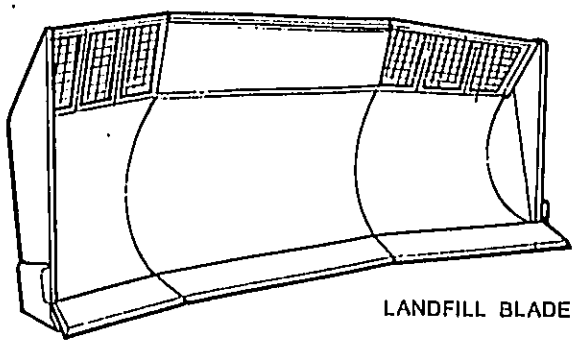
FRONT-END ACCESSORIES



BUCKET

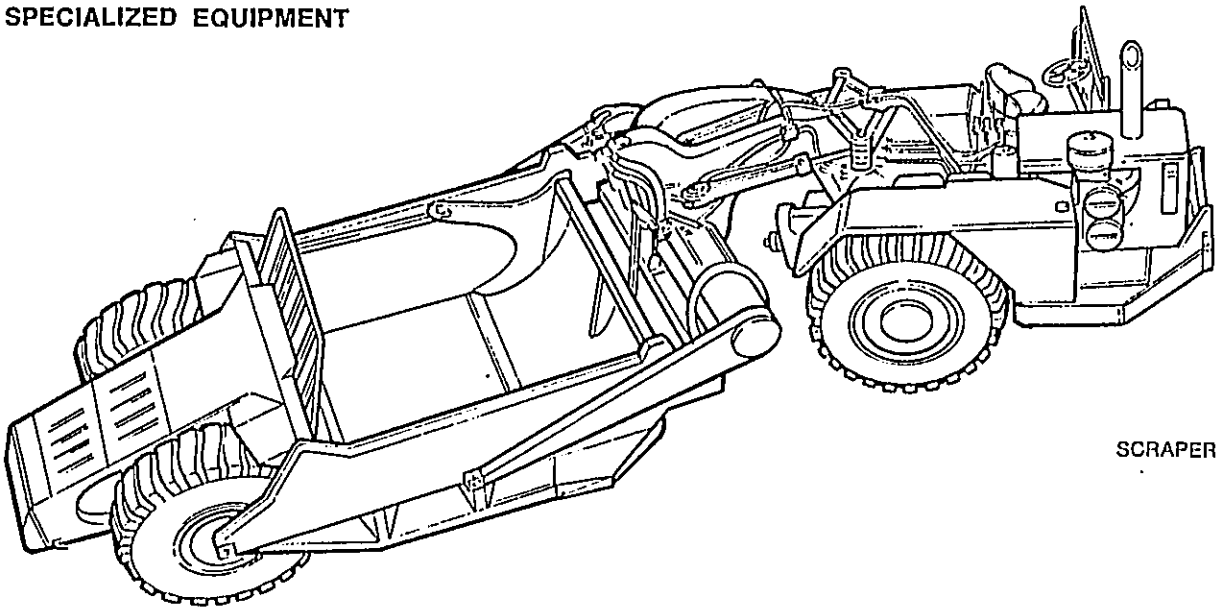


DOZER BLADE

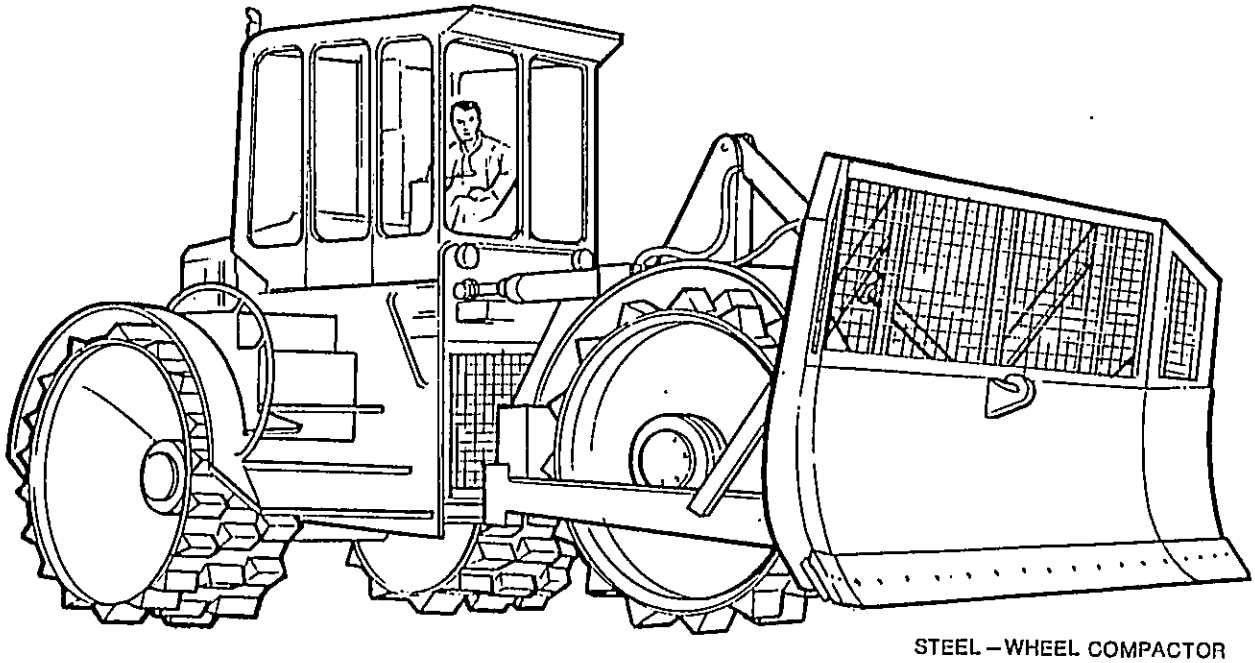


LANDFILL BLADE

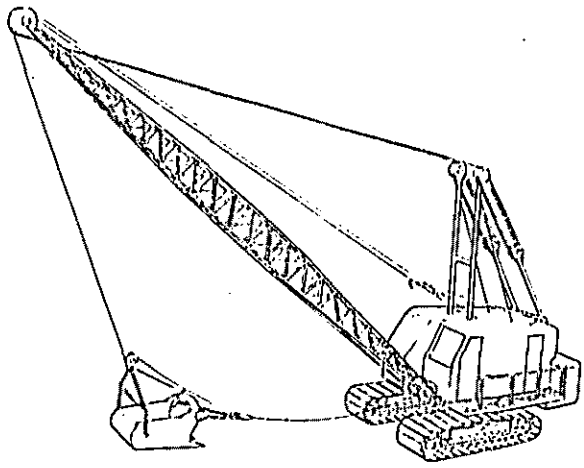
SPECIALIZED EQUIPMENT



SCRAPER



STEEL – WHEEL COMPACTOR



DRAGLINE

FACILITIES

A small sanitary landfill operation will usually require only a small building for storing hand tools, equipment parts, etc., and a shelter with sanitary facilities for the employees. A single building may serve both purposes.

A large sanitary landfill operation should have a maintenance and storage garage for equipment and an administration building. If the scales are not adjacent to the administration building, a scale house may also be needed. Sanitary facilities should be available for both employees and the public. In addition, it is recommended that locker rooms and showers be provided for the employees.

Table 1. AVERAGE EQUIPMENT REQUIREMENTS

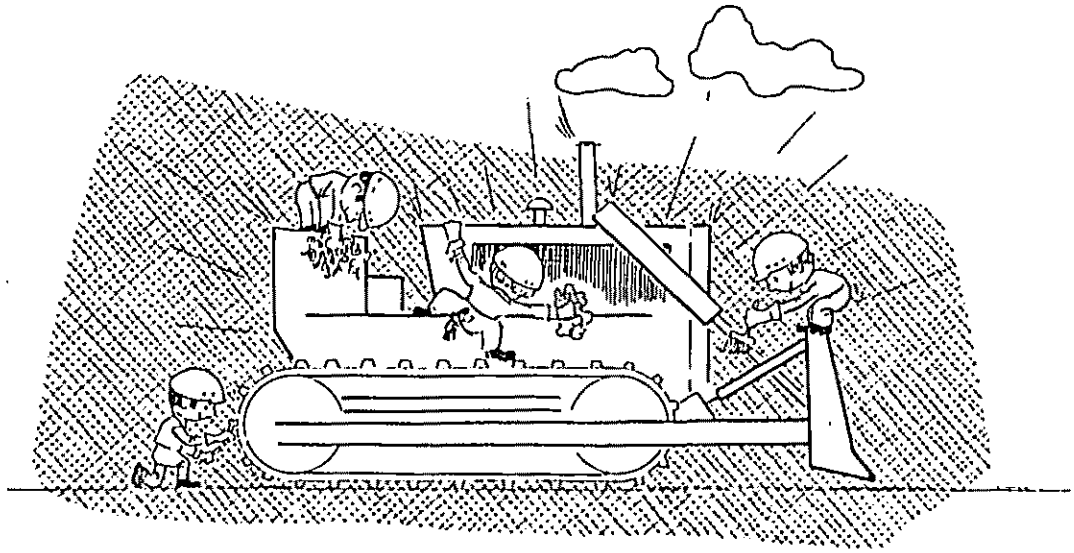
Population	Daily tonnage	No.	Equipment		
			Type	Size in lbs	Accessory *
0 to 15,000	0 to 46	1	Tractor crawler or rubber-tired	10,000 to 30,000	Dozer blade Landfill blade Front-end loader (1- to 2-yd)
15,000 to 50,000	46 to 155	1	Tractor crawler or rubber-tired	30,000 to 60,000	Dozer blade Landfill blade Front-end loader (2- to 4-yd) Multipurpose bucket
		*	Scraper Dragline Water truck		
50,000 to 100,000	155 to 310	1 to 2	Tractor crawler or rubber-tired	30,000 or more	Dozer blade Landfill blade Front-end loader (2- to 5-yd) Multipurpose bucket
		*	Scraper Dragline Water truck		
100,000 or more	310 or more	2 or more	Tractor crawler or rubber-tired	45,000 or more	Dozer blade Landfill blade Front-end loader Multipurpose bucket
		*	Scraper Dragline Steel-wheel compactor Road grader Water truck		

* Optional. Dependent on individual need.

10. EQUIPMENT CARE AND MAINTENANCE

Often we only see extra work when we think of equipment maintenance. But proper maintenance can prevent costly delays and repairs, make your job safer, and is the most important insurance for successful operation of a sanitary landfill.

PROPER MAINTENANCE PREVENTS EXTRA WORK



Your rig is an important and expensive machine. Without it, the landfill would become a dump--and complaints would soon roll in from the public.

If maintenance is neglected the machine will not do its best work, and you, the operator, will have to do extra work. On some landfills, all maintenance is done by others. Even so, you should have a basic knowledge of maintenance requirements.

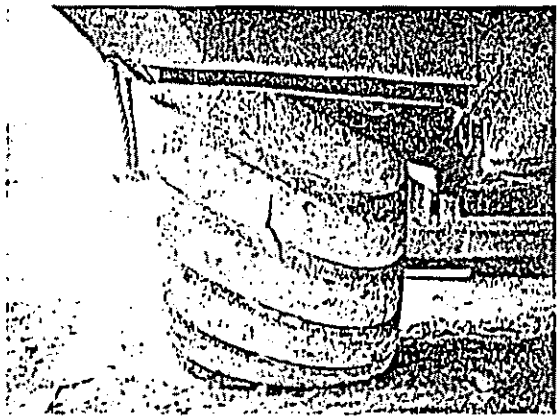
Taking care of your equipment will help:

1. Reduce accidents

2. Reduce costs by preventing breakdowns
3. Make your equipment last longer
4. Improve public relations

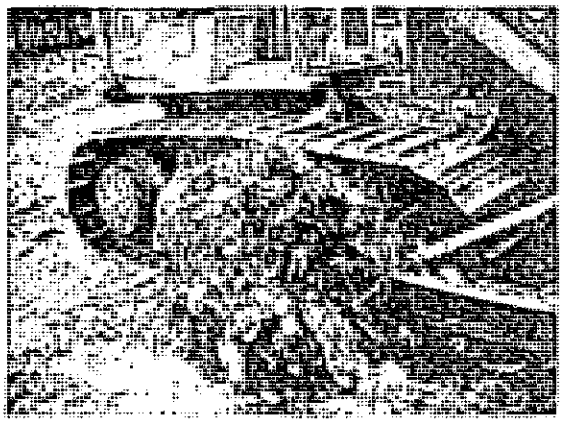
MAINTENANCE PROBLEMS

Heavy equipment working in earth always needs regular maintenance. The severe working conditions at a sanitary landfill are especially hard on the equipment, thus proper maintenance is even more important. The waste can affect both track and wheeled rigs:



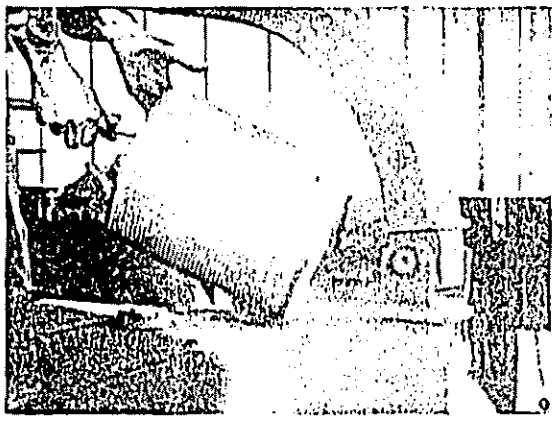
Tires

- Cutting or puncture by sharp objects
- Contact with corrosive liquids



Tracks

- Wrapping with wire, steel strapping or similar material
- Jamming with brush and debris
- Grouser wear from slippage on waste

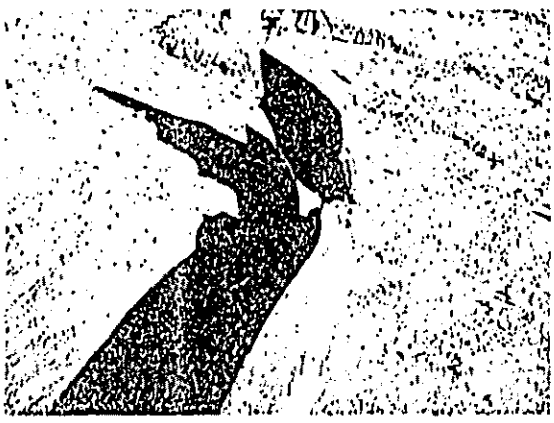


Air filter

- Clogging with dust

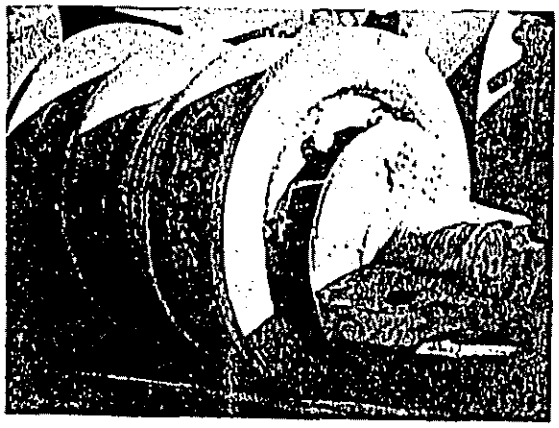
Radiator

- Clogging with dust, paper, plastic film, and debris
- Punctures
- Overheating of coolant



Undercarriage

- Damage by bulky wastes
- Excessive wear



Bearings and sprockets

- Excessive wear

Accessories can help protect most equipment parts from damage. These include steel-guarded tires, guards for the sides and undercarriage of dozers and loaders, and screens for the radiator.

What Do You Know? (Read each of the following statements. Mark them true or false and compare your answers with the correct ones shown below).

1. The saying "an ounce of prevention is worth a pound of cure" summarizes the importance of maintenance.
2. Equipment operating problems on sanitary landfills are more severe than on many other construction projects.
3. Accessories do not help to protect equipment from damage.

Answers: 1. True 2. True 3. False

PREVENTION OF PROBLEMS

As the operator, you should know three aspects of proper equipment care:

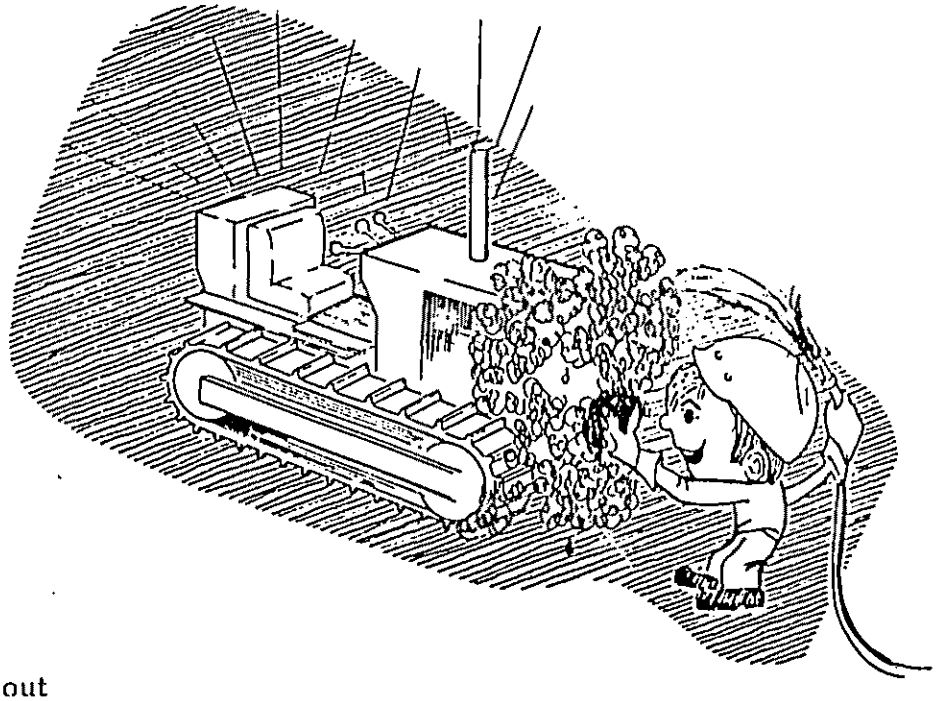
1. Cleanup and shutdown
2. Checkout
3. Record keeping

Cleanup and Shutdown

At the end of the day, after all waste has been covered by soil and no litter is visible, follow a proper shutdown procedure for the landfill equipment. In addition to the manufacturer's recommendations, you should:

1. Fill the fuel tank to prevent condensation
2. Clean debris out of tracks and off the equipment
3. Ground the blade, bucket, and other accessories
4. Set all brakes and transmission locks
5. Lock up the instrument panel if equipment has this protection
6. Guard against vandalism. Lock vehicles inside shelters

CLEANUP AND SHUTDOWN



Checkout

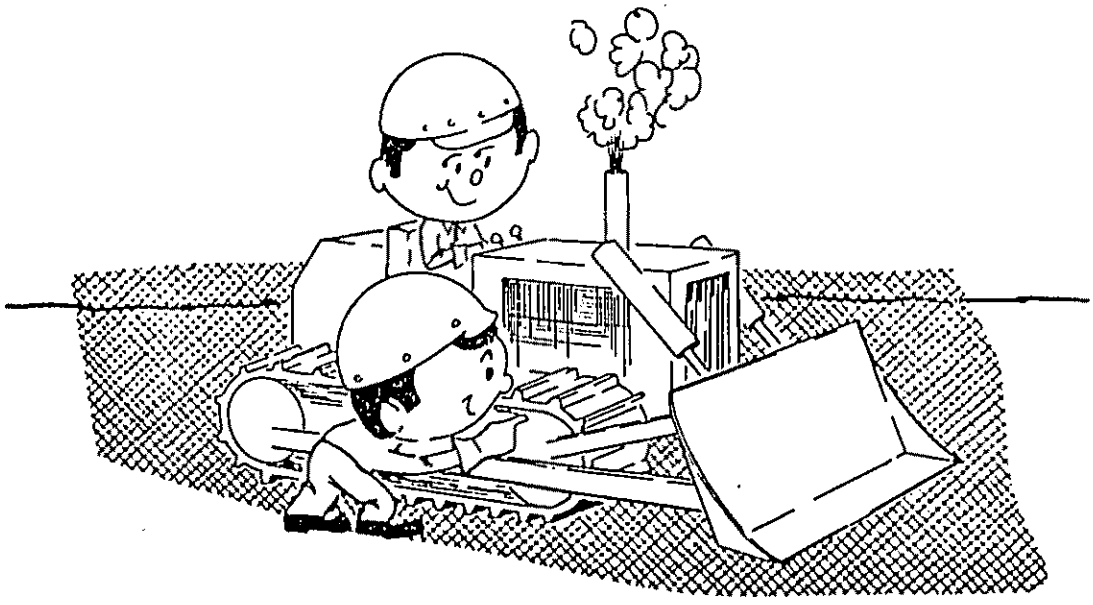
A walk-around inspection is needed to spot any damage or sign of problems and to prepare the equipment for use on the following morning. One problem encountered in northern climates is crawler tracks frozen to ground which can lead to stripped gears when vehicle is moved. This can be prevented by placing boards under tracks or simply parking vehicles overnight inside a shelter.

Check out the following items before leaving for the day:

1. Check tires, sidewalls, and tread for breaks and cuts
2. Clean radiator and air cleaner screens
3. Check all hydraulic fluid levels
4. Check undercarriage for damage
5. Check crankcase and transmission oil levels
6. Check level of coolant in radiator (after cooldown)
7. Check for worn hoses and belts

A written checklist containing these items helps to make sure you don't miss something. Be particularly careful in lubrication and greasing. Follow the manufacturer's guide to make sure you don't miss any grease points.

CHECKOUT



Record Keeping

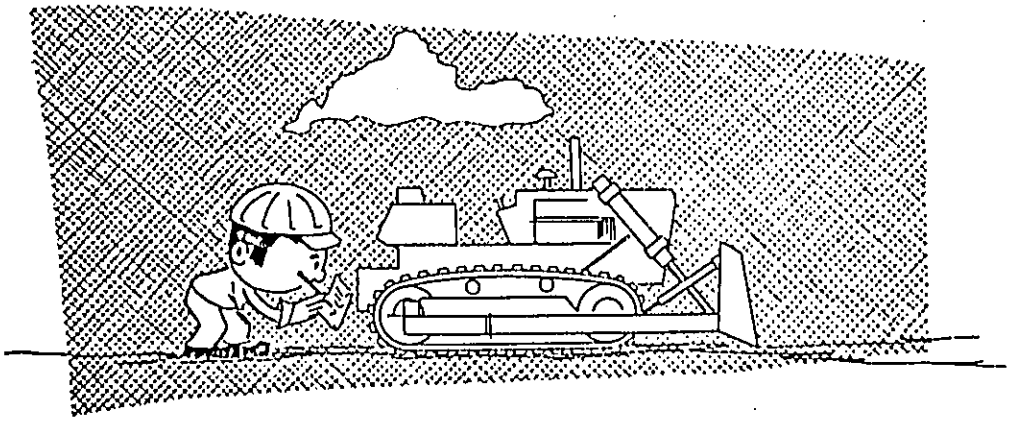
The operator can be sure his rig has received proper maintenance if he keeps careful records on:

1. Lubrication performed
2. Oil additions and changes

3. Filter changes
4. Fuel usage
5. Repairs
6. Operating hours

Take a reading of the equipment hour meter when oil and filter changes are made. Increasing use of fuel and oil can warn of possible breakdowns. Records can also be used to determine operating costs of equipment. This leads to better planning of the landfill operating budget.

EQUIPMENT CHECKS =
SAFETY + LESS MAINTENANCE



What Do You Know? (Read each of the following statements. Mark them true or false and compare your answers with the correct ones shown below).

1. Equipment should be carefully checked before leaving for the day.
2. Records have little practical value and usually are kept only to make the boss happy.
3. All waste should be covered before shutting down the equipment and closing the landfill.

Answers: 1. True 2. False 3. True

11. CONTROL OF SANITARY LANDFILL

11.1 Control of sanitary landfill should be carried out on the following four (4) aspects :

- Operation
- Construction
- Cost
- Environmental Pollution

The control process should be carried out through the following four (4) steps :

- Data collection
- Data processing and report making
- Information analysis and evaluation
- Action (preventive and/or corrective measures)

OPERATIONAL CONTROL

11.2 For the purpose of operational control, the following data should be collected and analyzed :

- Inflow of materials (solid waste and cover material) :
  transportor, origin, quality (type of wastes), quantity, time etc.
- Flow of vehicles and visitors at the landfill gate
- Workers time record
- Equipment time record (working time and idle time)

- Maintenance works carried out for each equipment
- Extraordinary happenings

Appropriate data collection forms should be developed and used to collect the above mentioned data.

CONTROLS OF SLF CONSTRUCTION

11.3 The progress of SLF construction should be checked periodically refering to the original design. For this purpose, the reference levels established at the time of topographic survey can be used. The surface of the filled area should be surveyed periodically (every six months, for example) and the deviation from the original design should be detected, evaluated and corrected if necessary.

CONTROLS OF COSTS

11.4 Analysis of SLF costs should be carried out in the central office using various informations acquired at SLF. This analysis can be done using the following guideline:

Guideline for the Analysis of SLF Costs

(When the unit cost is higher than the pre-established level, the factors shown in this table should be analyzed.)

Cost Item (C)	Unit	Factors for Analysis
Manpower	$/ton of waste	Efficiency Extra hours Total hours
Cover Material	$/ton of waste	Type and origin of cover material Cost of cover material
Equipment	$/ton of waste	Type of equipment Efficiency of equipment
Indirect Costs	$/ton of waste	Quantity of received waste Unforeseen costs

11.5 Usually the final disposal of municipal solid wastes in sanitary landfills needs from 5 to 10% of the total cost of public cleansing services. If this figure is applied, 5 - 10 M$/ton is necessary to carry out sanitary landfill in Malaysia. This cost depends very much on the size of SLF, availability of on-site cover material and the life of SLF.

CONTROL OF ENVIRONMENTAL POLLUTION

11.6 Monitoring of groundwater and surface water pollution should be carried out monthly at the first stage. However, monitoring frequency can be reduced later after confirming that no pollution is caused by SLF. Sampling of groundwater should be done in both upstream and downstream with different distances from SLF until 200m. This sampling should be carried out before, during and after the construction of SLF. Parameters to be analyzed should be the ones required by DOE.

11.7 Monitoring of influent and effluent of leachate treatment facility should be done more frequently (daily, for example) to check the conformity with effluent standard.

11.8 It will be convenient to measure the pluvial precipitation in SLF and the amount of leachate produced. The correlation observed in these two factors will be useful for future SLF design in Malaysia.

11.9 Effective gas emission by landfill gas vents should be confirmed at least in areas where building projects are foreseen.

12. PUBLIC OR PRIVATE OWNERSHIP AND OPERATION OF PROCESSING FACILITIES

In planning for new solid waste processing facilities, whether they are shredders, balers, or resource recovery plants, communities will be considering not only which types of facilities to choose but who should own and operate them.

ALTERNATIVES

The institutional alternatives available range from totally public to totally private ownership and operation with variations in between.

- *Public Ownership and Operation.* A publicly owned and operated facility can be operated either by an established city department or by a public authority which is financially self-supporting and administered separately from other agencies of city government.
- *Public Ownership and Private Operation.* A publicly owned facility could be operated privately either by the system contractor who built the facility for the city, or by an independent service contractor who had nothing to do with plant design or construction.
- *Private Ownership and Public Operation.* This is a rare option but can take place under what financiers call a leveraged lease. Therein the city could lease a plant from investors who help the city finance the facility in exchange for formal ownership of it and the tax advantages such ownership brings (see chapter on Capital Financing).
- *Private Ownership and Private Operation.* Under this approach a system contractor has full responsibility for financing, design, implementation, continued operation, and ownership of the facility. In reality, this full-service contractor is offering the city a service instead of a facility. He will usually charge the city a dump fee for delivered solid waste.

ADVANTAGES AND DISADVANTAGES

While solid waste processing may be carried out by either the public or private sector, it is the responsibility of the government (usually at the local level) to ensure that needed facilities are available, that they are environmentally acceptable, and that future needs are planned for. As processing technologies become more sophisticated, cities must take into consideration such things as technological risk and the degree of management expertise required for a given project, as well as availability and cost of capital. Cities must examine these factors in deciding whether to own and operate their own facilities or have a private firm provide these services. The following discussion presents the advantages and disadvantages to a city

of involving private firms in waste processing.

One advantage associated with private ownership and operation is that the local community does not have to finance the system. This is important if the city's borrowing power is limited. The involvement of a private firm also ensures that a community does not bear the entire risk associated with implementing new kinds of technology. A certain degree of risk to the city will always be present, however, since implementing a particular process, through private or public means, usually implies forgoing some other approach. Thus, if a system owned and operated by a private firm fails, the city may not lose any money directly but may find itself in a position of not having adequate disposal facilities.

A potential advantage of private operation lies in the fact that there are private firms which have greater expertise in management of capital-intensive processing facilities than most public agencies. Also, private management tends to be more adaptable to the needs of new systems. In some cities, the operation of such facilities by public employees has been unsatisfactory for a number of reasons, including: union and civil service rules and pay scales that make it difficult to hire and promote only motivated and competent employees, the city's lack of necessary technical and marketing sophistication, and the lack of profit incentives to run an efficient operation. Also, restricted budgetary policies often affect equipment replacement and maintenance.

The primary disadvantage of private ownership and operation is the limited control the city has over the facility. There is the danger that private interests may pursue profits in lieu of service, and that substandard disposal practices or possible plant shutdowns may result.

Other Considerations

Conditions favoring public ownership and operation would include:

- An economic study shows this to be more cost-effective.
- The creation of public jobs is desirable.
- Implementation may be easier because government ownership fits in with existing policy.
- Government employees are available for operating the facility.

Conditions favoring private ownership and operation would include:

- Commercial markets are available for recovered products.
- Private financing is preferred and can be obtained more efficiently.
- An economic study shows it to be the most cost-effective.
- Local policy favors private operation.
- A proprietary technology is involved.
- There is a desire to bypass civil service regulations.
- The operation requires people with experience in that particular type of facility.

Conclusions

It is the responsibility of the public sector to ensure that needed processing facilities are provided and are operated in an environmentally acceptable manner, whether or not they are actually owned and operated by a unit of government. In deciding between private and public operation and ownership of a given facility, a city must evaluate factors such as ability to raise capital, the degree of technological risk involved, the management expertise required, and the expected operating cost.

Bibliography

Practical guidelines for acquisition of resource recovery systems. Bedford, Mass., MITRE Corporation, Mar. 1975. 148 p., app. (Unpublished report.)

Shilersky, A. Resource recovery implementation; an interim report. Environmental Protection Publication SW-152. Washington, U.S. Environmental Protection Agency, 1975. (In preparation.)

13. COSTS

The cost of a sanitary landfill consists of the initial investment for land, equipment, and construction features, and the operating costs.

Initial Investment. The magnitude of the initial investment depends on the size and sophistication of the landfill. A typical breakdown of the major items that normally constitute the initial investment is as follows:

1. Land
2. Planning and designing
   a. Consultant
   b. Solid wastes survey
   c. Site investigation
   d. Design, plans, specifications
3. Site development
   a. Land development— clearing, landscaping, drainage features, etc.
   b. Access roads
   c. Utilities— water, electricity, telephone
   d. Fencing, signs
4. Facilities
   a. Administration
   b. Equipment maintenance
   c. Sanitation
   d. Weight scales
5. Equipment— tractor, scraper, etc.

Generally, the major portion of the initial investment is for the purchase of the land and equipment. Often a sizable part of the initial investment for land and equipment can be recovered through the development or use of the land and the salvage value of the equipment.

If funds are not available for the proposed investment, consideration should be given to leasing land or equipment, or both, to spread the cost over the life of operation.

Operating Cost. The operating cost of a sanitary landfill depends on the cost of labor and equipment, the method of operation, and the efficiency of the operation. The principal items in operating cost are:

1. Personnel
2. Equipment
   a. Operating expenses— gas, oil, etc.
   b. Maintenance and repair
   c. Rental, depreciation, or amortization
3. Cover material— material and haul costs
4. Administration and overhead
5. Miscellaneous tools, utilities, insurance, maintenance to roads, fences, facilities, drainage features, etc.

Wages ordinarily make up about 40 to 50 percent of the total operating cost. Equipment equals 30 to 40 percent; cover material, administration, overhead, and miscellaneous amount to about 20 percent.

The operating costs per ton versus the amount of solid wastes handled in tons and the population equivalent may be charted (Figure 4).

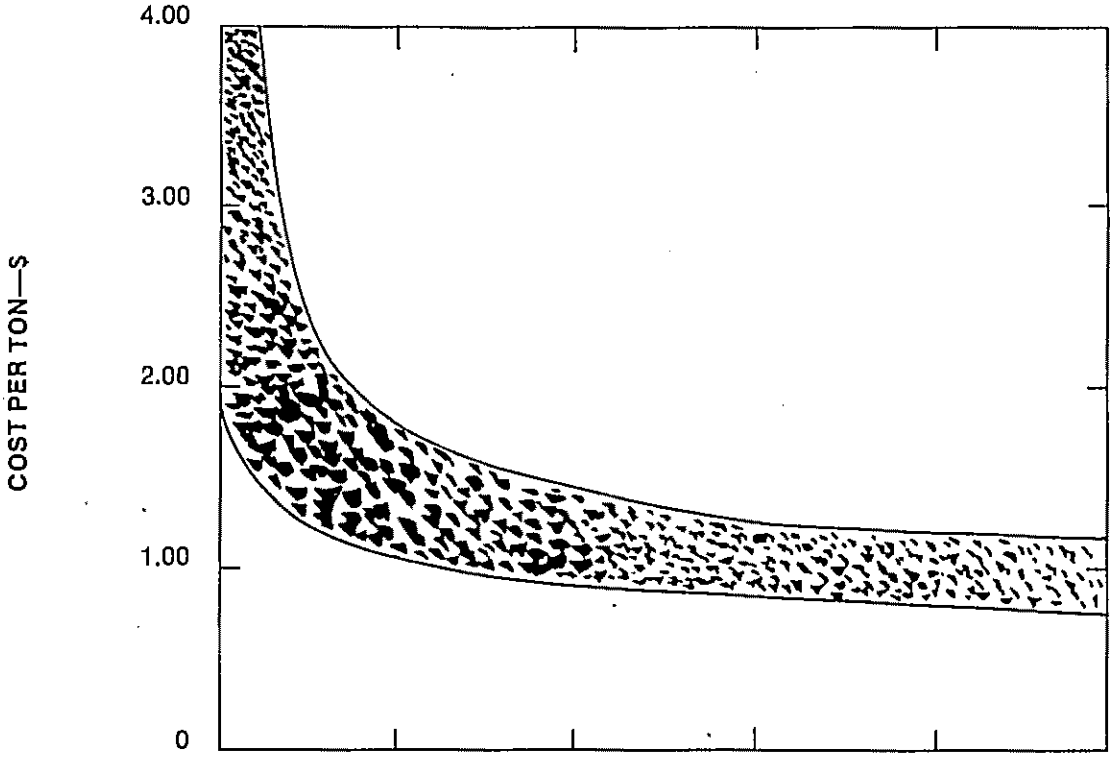
The operating cost of a small operation handling less than 50,000 tons per year varies from $1.25 to approximately $5.00 per ton. This wide range is primarily due to the low efficiency of the smaller operations which are usually operated on a part-time basis.

Full-time personnel, full-time use of equipment, specialized equipment,

better management, and other factors that lead to high efficiency are possible at large sanitary landfill operations. The increased efficiency results in lower unit cost of disposal. The unit cost of a large landfill handling more than 50,000 tons per year will generally fall between $0.75 to $2.00 per ton.

To compare the true cost of sanitary landfilling with that of incineration or composting, it is essential that the costs and returns of the initial investments and the hauling costs be considered along with the total disposal costs including the disposal of incinerator residue and noncompostable materials. The hauling costs of a collection system that uses the sanitary landfill disposal method may be higher than the hauling costs of a system using incineration or composting, since sanitary landfills are generally located farther from the waste-generating area than are incinerators or compost plants. A sanitary landfill, however, may increase the value of a plot of unusable land by converting the site to a playground, golf course, park. . . . , thereby obtaining a major investment cost advantage over incineration and composting.

FIGURE 4. SANITARY LANDFILL OPERATING COSTS



TONS PER YEAR	0	100,000	200,000	300,000	400,000	500,000
TONS PER DAY[1]	0	320	640	960	1280	1600
POPULATION[2]	0	122,000	244,000	366,000	488,000	610,000

[1] Based on 6-day work week.

[2] Based on national average of 4.5 lbs per person per calendar day.

14. MODEL CODE OF PRACTICE

With a master plan for disposal sites, a plan of operation and a detailed schedule of operation practice, a fairly effective model code of practice could be laid down.

A. MASTER PLAN FOR WASTES DISPOSAL SITES

1. The solid wastes management agency should identify:

— Sources of solid wastes within its area,
— rates of wastes generation,
— constituent analyses and densities of wastes,
— projections for at least 10 years for population growth, wastes generation and characteristics,

and should make outline plans and comparative cost estimates for viable alternative disposal methods.

2. The land-use planning agency should review the area within the city boundary, and up to 10 km outside the boundary where necessary, and identify sites, manmade or natural, which would be *improved* by landfilling. The planning agency will evaulate potential sites in terms of:

— ultimate use after filling; parks, playgrounds, sports grounds, agriculture, industry,
— the quality of environmental improvement which would result from filling,
— risk of pollution transfer during filling,
— ecology of the area,
— social and economic factors,

and will submit selected sites to the water and river authorities.

3. The water supply and river authorities will evaluate potential sites in relation to the hydrogeology and drainage of the area, and will reject sites where underground source of water would be at risk. Where appropriate, the water and rivers authority will define the measures that must be taken to avoid pollution of surface water and to control the production of leachate.

4. The solid wastes management, land-use planning, and water and river authorities should maintain a continuing relationship with the aim of ensuring a 10-year rolling programme of landfill sites.

B. PLAN OF OPERATION

1. Site survey. Each selected site should be surveyed and a plan prepared on a scale of about 1:2 500 showing:

— water courses,
— 2 m contour lines,
— boundaries,
— buildings within 200 m of the area to be filled,
— approach routes,
— prevailing wind direction.

2. Site protection plan. Detailed plans will be prepared for the execution of (*inter alia*) the following engineering works:

— diversion of surface drainage,
— culverts,
— formation of bunds,
— pumping out of static water.

3. Site operation plan. The site operation plan will designate:

— area to be filled,.
— depth of fill and total volume,
— grading of final levels,
— depth and quality of final covering material, in relation to the ultimate use of the site,
— any necessary improvement of external roads,
— location and specifications for internal roads,
— where appropriate, a specification for fencing and gates,
— the design of the control area and facilities which may include: office, welfare, garage, stores, site designation and information board,
— soil stripping programme and stockpile areas,
— sources of covering materials, internal and imported,
— filling programme in precise terms such as numbered strips and direction of filling for each layer,
— fire control measures,
— rodent control measures,
— use of insecticides,
— designation of reserved area near entrance for deposit of wastes during emergencies.

C. OPERATING PRACTICE

1. Unloading wastes. Wastes should be delivered in tipping vehicles and they should unload only at a defined "working face". For manual operation the unloading point should be immediately over the working face or within 2 metres; during mechanized operation an unloading area up to 15 metres back from the face is necessary to permit a bulldozer to operate.

2. Approach to the working face The approach to the working face should be made safe for vehicles by covering the necessary area with steel sheets, old railway sleepers, or a sufficient thickness of "hardcore", unless the character of the wastes is such that they can support a vehicle without

these measures. The width of a prepared approach should be single or multiple track according to the frequency of traffic movements.

3. Formation of wastes. Wastes unloaded at the working face should be formed into a continous embankment 2 metres high after initial compaction, and having a width of approximately 6 metres per vechicle when more than one vehicle has to unload at the same time. The side slopes (or flanks) of the strip being filled should be 45° for manual operation or 30°, or less to the horizontal, for mechanized operation.

4. Covering of formed wastes. The top surface and the flank(s) of the strip being formed should be covered progressively with a layer of soil or other suitable sealing material not less than 20 cm thick. This should be beaten flat and smooth if applied manually, or consolidated by repeated traverses if a machine is used. At the end of every working day, covering should be completed on the top and flank(s) of the fill. At intervals, which may be daily, or not less frequent than weekly, the forward slope of the working face is to be formed and covered in the same manner as described for the flanks, in order to achieve a cellular construction.

5. Deep sites. If the required total depth of fill exceeds two metres, then, the site will be filled in multiple layers, and to facilitate natural settlement and the dispersal of gases, a long interval, never less than three months, should be allowed to elapse before one layer of wastes is covered by another.

6. *Hollow articles.* Articles such as large hollow containers should be crushed by being placed in the path of a tracked machine, or should be put at the toe of the working face in an upright position and filled with other wastes. This is to minimize the creation of voids within the fill, which would lead to uneven settlement.

7. Offensive wastes. Any load which consists mainly of fish wastes, abattoir wastes, carcasses of animals or medical wastes*, should be deposited at the lower level, immediately in centre front of the advancing face, and should be covered with other wastes so that no part of the offensive wastes is within one metre of the top surface of the hill, and is not less than two metres from a flank.

8. Litter control. Portable wire mesh screens should be erected in an arc of sufficient length to trap airborne litter blown from the working face.

9. Manning levels. Adequate staff should be provided to ensure compliance with all requirements of this code. For manual formation of the

*Hospitals and clinics should be equipped with properly designed incinerators for the treatment of pathological wastes, and sanitary landfill should not be regarded as a normally acceptable disposal method for such wastes. In the absence of proper facilities the above method may be used provided that the wastes are delivered to the site in impermeable disposable packages which are not opened. Hypodermic syringes should always be broken before being discarded.

fill, and the spreading of covering material delivered to the working area, not less than two labourers for the first 10 tons/day and one labourer for each further increment of 10 tons/day are necessary. Additional staff must be provided to keep the whole of the site clean, including the removal of litter from screens and the daily removal from the surface of all hollow articles such as cans and motor tyres which may have been dropped accidentally. Further staff are needed for traffic control, inspection for rodents, etc.

10. Welfare facilities. Staff required to stand in wastes should be supplied with protective clothing: boots, gloves and overalls, for which suitable laundry arrangements should be made. Washing and toilet facilities should be maintained in a clean condition.

11. Salvage. Only organized and controlled salvaging should be permitted and must be confined to the sloping forward surface of the working face. Portable containers are to be provided to contain salvage which has been picked out of the wastes, and full containers should be immediately transferred to an enclosed store or to a vehicle.

12. Fire. No fires are to be started deliberately. An emergency supply of water should be available and staff must be trained in fire control.

13. Dust control. When necessary, dusty roads will be sprayed with water or an alternative treatment, such as the application of used engine oil, will be adopted.

14. Vector control. A daily inspection will be made and the location of rodent burrows or insect infestations will be recorded and appropriate control measures taken. Salvage stored on a site for periods exceeding two days will be sprayed with insecticide daily.

15. Progressive cultivation. As soon as a convenient area has been raised to the final level and covered with topsoil, it will be brought into cultivation by sowing grass or another suitable crop, in order to prevent the establishment of weeds, and also to preserve the visual amenities of the area.

ACTION PLAN FOR THE IMPROVEMENT OF FINAL DISPOSAL

Date : _____

Name of Local Authority:

_____

Name of Study Team Members:

_____

_____

1. Objectives

2. Brief Description of Present Final Disposal System

   . Number, name, location, distance from town centre, size, remaining life and ownership of landfill sites.

   . Condition of access road

   . Availability of cover material

     - on-site

     - off-site (How far is it? How much does it cost?)

   . Type, number and condition of equipment

   . Personnel

   . Basic infrastructures (fence, gate, weighbridge, drains, etc.)

   . Existence of open burning, animal feeding and scavenging

   . Population served

   . Estimated amount of disposed waste (t/day)

   . Use of contractors for landfilling operation

   . Complaints from nearby residents

   . Water and air pollution cases recorded by DOE

. User charge

. Recording system

. Estimated cost

  - capital cost (land, equipment, infrastructure)

  - operation and maintenance cost (wage, supplies, cover material, overhead, etc.)

. Overall evaluation of final disposal system

  - sanitary landfill
  - controlled tipping
  - open dumping

3. Preliminary Identification of Problems in Present Final Disposal System.

Examples :

. Very short remaining life of actual landfill site.

. Difficulty to get future sites within reasonable distance.

. Lack of town planning with due consideration on the siting of future final disposal facilities.

. Lack of cover material/High cost of cover material.

. Frequent breakdown of equipment.

. Lack of trained operators.

. Lack of the design prepared by professionals.

. Encroaching residential areas.

. Lack of control on the inflow of industrial solid wastes.

. Poorly designed contracts and/or poor supervision on private contractors.

. Difficulty to convince decision makers of the necessity of assigning more resources to final disposal.

. Long distance and/or bad access to landfills.

. Environmental pollutions.

- Complaints from nearby residents.
- High cost of final disposal.

4. Possible Measures to Overcome Identified Problems.

   Note : All possible measures should be listed up through a "brain-storming session" by study team members. Both the improvement effect and the implementability of each measure should be evaluated and the result of the evaluation shall be classified as follows :

   Improvement effect : Large, Medium, Small
   Imprementability : High, Medium, Low

5. Preliminary Identification of First Priority Project.

   Project A : Improvement of Existing Landfills

   Project B : Preparation for New Landfills

   Note : Both projects are considered to be equally important. Therefore action plans should be prepared for both projects and at least one of the action plan should be completed during the Workshop.

6. Action Plan

   6.1 Action Plan (combination of measures with large improvement effect and high implementability).

   6.2 Necessary Resources

   - Existing resources
   - Additional resources

   5.3 Implementation Schedule

7. Expected Benefits of Action Plan Implementation

EXTRA WORK

Each study team is required to prepare its own strategies and tactics to convince its boss, colleagues and workers of the necessity, possibility and benefits to implement the Action Plan.

Your Plan to Convince Boss, Colleagues and Workers :

A GUIDE TO GROUP DYNAMICS

Workshop on the Sanitary Landfilling of
Municipal Solid Wastes, 1-6 August 1988

1. Problem-solving and the KJ Method

In their works of municipal solid waste management, participants may face with a variety of problems. In this Group Dynamics, some of the problems are selected and shared by a group or participants as their common problem(s). Among the group, the selected problem(s) should be solved by employing a specific problem-solving technique.

There have been proposed a number of methodology for solving problems in a systematic way. The KJ Method, named after Prof. KAWAKITA Jiro; currently at Chubu University, Japan is one of such problem-solving techniques which is widely employed and very popular in Japan among QC (Quality Control) circles and other professional groups. In this workshop, participants are expected to learn this methodology by exercising on a selected typical problem to be encountered in municipal solid waste management.

The basic concept of this method (KJM) is an interactive, stagewise integration of all ideas for problem-solving, each to be presented and contributed systematically by all members of the group in a series of discussion sessions. Each bit of knowledge and ideas is to be written down by the participating member on a piece of special label sheet and shared by all the members. In practice, the KJ procedure consists of four sequential sessions; introductory, brain-storming, organizing, and concluding.

The KJM does not require any sophisticated special tool such as a large computer, instead only needs a bunch of detachable label sheets of different size, pens and colour markers, clips, rubber bands, and a large sheet of paper for presenting the result: all of the stationery are available at a relatively lower cost anywhere in the world. In order to practice the KJM, participants must follow a certain formal procedure that is described in the following.

2. "Introductory Session"

In this Session which usually takes first 10 to 30 minutes, a group usually of several participants will select a specific "problem", on which the members will discuss, share, and search for the solution in a cooperative manner. The following four points must be clarified in this order before the group proceeds to the next Session.

1) Get-acquaintance of All Members:

Members of the group must know each other well so that they can freely discuss the problem in later Sessions. Introduce yourself to others briefly in turn, giving your backgrounds, your specific interest(s) in your profession, etc. Make a friendly, cooperative, and constructive atmosphere of the group.

2) Designation of the Work-leader:

Members of the group will first elect and name the work-leader. The work-leader is expected to lead the Sessions by taking the initiative and encouraging the members in discussion and work. Members cooperate with the work-leader and support him or her in their own capacity.

3) Submission of Problems to Be Discussed:

Each member will submit a problem by writing down on a prepared label sheet to be discussed. Make one entry on each label sheet. Be concise. One line statement of the problem description will suffice. For example, "How to phase out the activities of scavengers in dumping sites".

4) Determination of the Theme to Be Discussed:

Among problems that have been proposed, select and eventually pick up one, by discussing, that can be interesting to many and shared by all members. The theme chosen must be as practicable as possible in your profession.

3. "Brain-storming Session"

Purpose of this session is to produce as many written original labels as possible that will be informative on the theme and helpful in solving the problem.

5) Collection of the Information:

The group will discuss the relevant information on the theme and, if necessary, take some time for collecting and making information materials (literature and other sources) handy before the discussion session.

6) Production of Original Labels:

The leader will conduct a brain-storming session on the theme among the group for a certain period of time, say, one hour or two hours. During the session, each member, including the leader, is expected to jot down his or her ideas, suggestions, etc., each on a piece of label in an

explicit and legible manner, while participating in the on-going discussion. The leader will try to urge every member of the group to speak out and keep the discussion both stimulating and exciting to all the group members. In the course of discussion, members shall be constructive and refrain from criticizing other's ideas or opinions. Near the end of the first period of time, the leader will make sure that the number of labels produced per member will reach around 15 on average, and, if not, continue the session for another additive period of time until the enough number of original labels will be accumulated.

4. "Organizing Session"

Based on the original labels obtained in the previous sessions, the result of the discussions will be organized and integrated by following and repeating a specific procedure on a large table in this session.

7) Categorization and Classification of Original Lables by Dealing:

The following procedure will be taken to categorize and classify the original labels:

a) The leader will collect all the labels and shuffle and deal them just like playing cards. Each member of the group will then carefully examine the content of dealt labels and accordingly arrange them in front of him on the table, (This will take some time).

b) Starting from the leader, a dealer will read loudly and place his first label at an appropriate position in the center of the table, while other members, in turn, will place their own label(s) of similar or related content with the back side up at a position close to it. Members without any label whose content is in the same or similar category of the dealer's will simply "pass' their turn.

c) The dealer will turn out the right side of each "attached" label, see how it is related to his own, and judge if it belongs to the same category by asking other members' opinions. If he judges that it does not belong to his, he has right to return it.

d) In this way the dealer will collect and clip the labels with his own on the top. Usually three to five labels will be clipped at most; not too many.

e) The dealer will continue this process from (b) to (d) from one label to another until the last of his labels. Naturally some of his labels will remain as singles. A single label without any attached labels is called a "stray wolf" label often showing a very unique idea or suggestion. Never disregard or discard it.

f) The process from (b) to (e) will be repeated until every member of the group will become a dealer. In practice, some of the members will use up all his labels by attaching before they themselves become a dealer.

8) Preparation of Clipped Labels:

By this stage of work, the number of original labels of about 120 (assuming an eight-member group) will be reduced to around 50 by categorization and classification. For each bunch of clipped labels, prepare a cover label and, on it, jot down in red (or in colour being different from the original writing) a statement summarizing the contents of all clipped labels. All the clipped labels with this summary label placed on the top of them will be bundled with a rubber band and thereafter treated just as a single label. Needless to say, the cover summary label is not necessary for originally single "wolf" labels.

9) Further Integration of Labels:

The group will then repeat the processes of 7) and 8) until reduction of labels by a further stage of integration will become impractical. Usually a three stage integration will be enough, which will take about 90 minutes.

5. "Concluding and Presentation Session"

In this Session, reviewing the organization work so far, the group will arrange all the labels on a large sheet of white paper according to a scenario that lead to a conclusion or solution of the posed problem.

10) Spatial Configuration of Labels:

On a large sheet of white paper placed on the table, the group will arrange, by discussion, first the bundles of labels of last stage integration, carefully considering that eventually all the labels will be arranged on the same paper. Then the group will proceed to arranging labels of next lower integration. In this way, the group will continue the work until every label will be arranged properly on the paper. Perhaps an agreed scenario leading to a conclusion which might have been

figured out by them during the earlier discussions will be helpful for this configurational work. After having confirmed the right position of each label, the group will peel off the base and paste the labels.

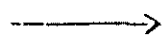
11) Preparation of an Illustrative Sheet:

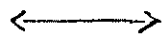
The sheet of paper on which every label is pasted will be used for presentation of the result. Therefore, some artistic preparatory works on this sheet will be necessary for this purpose:

a) The theme or problem statement is clearly written in large letters at the uppermost portion of the sheet. Also a corresponding conclusion in the next line.

b) Using different colour markers, encircle the labels of same category at different levels of integration. (A set of labels encircled is customarily called an "*island*".) Many other *illustrative drawings* and the following relational symbols may be inserted to make the whole sheet attractive for presentation:

a close relation exists between labels or islands.


a casual relation exists from one label to another.


an interactive relation exists between labels or islands.


a contradictory relation exists between labels or islands.

an equality has been identified between the statement of labels.

c) In the lower right portion, identify the name of group, names or initials of members, working date and place for keeping the record.

12) Presentation of the Group Work:

Before presenting the result based on the prepared sheet, the group will select a speaker or two among members and possibly prepare a note for oral presentation. Arrange a special presentation meeting. During presentation and the following Q's and A's, all the members will assist the speaker.

Reference :

Kawakita, J. : Hassouhou (Way of Creative Thinking), Chuko Books #136, Chuo Koron Pub. Co., Tokyo, June 1967.

PROBLEMS TO BE DISCUSSED IN GROUP DYNAMICS SESSIONS

Workshop on the Sanitary Landfilling of Municipal Solid Wastes, 1-6 August 1988

Group A : How to ensure the availability of future SLF site?

Group B : What are the basis of a SLF and how to ensure that they are incorporated in the design, construction and operation?

Group C : How to improve the existing landfilling operation?

Group D : How to use the weighbridge to improve the productivity of refuse collection?

EXERCISE I

VISIT TO THE PRESENT DUMPING SITE AND FUTURE LANDFILL SITE OF THE DISTRICT COUNCIL OF KULIM

OBJECTIVE

The objective of this exercise is to give a practical training to the participants of the Workshop on :

- How to identify the points to be improved in the present landfilling practice;
- How to work out corrective measures to overcome the identified problems;
- How to carry out the site selection for future landfilling; and
- How to design the sanitary landfill.

INFORMATIONS

Each participant, or each group, has to collect all the necessary informations through :

- Briefing by the Workshop organizer;
- Briefing by the staffs of the District Council of Kulim;
- Reports and drawings prepared by the Technical Section;
- Field visit.

DUTIES

1. Evaluate the characteristics of the present landfilling practice on the following aspects :

   a. Site selection

      - Land use plan
      - Distance from the town
      - Access condition
      - Wind direction
      - Soil characteristics
      - Cover material availability
      - Utility
      - Life, etc.

b. Design of periferal infrastructure

- Peripheral drainage system
- Access, etc.

c. Design of landfill infrastructure

- Internal access
- Special lot
- Internal drainage system
- Gas vent, etc.

d. Design of auxiliary constructions

- Gate
- Office
- Toilet
- Weighbridge
- Workshop
- Depot
- Fence
- Notice board, etc.

e. Design for pollution control

- Leachate
- Landfill gas, etc.

f. Landscaping

g. Operational plan

- Excavation, transport and storage of cover material

- Sequence of cell construction, etc.

2. Identify the problems of the present landfilling practice.

Examples :

- Very short remaining life of actual landfill site.

- Difficulty to get future sites within reasonable distances

- Lack of town planning with due consideration on the siting of future final disposal facilities.

- Lack of cover material/High cost of cover material.

- Frequent breakdown of equipment.

- Lack of trained operators.

- Lack of the design prepared by professionals.
- Encroaching residential areas.
- Lack of control on the inflow of industrial solid wastes.
- Poorly designed contracts and/or poor supervision on private contractors.
- Difficulty to convince decision makers of the necessity of assigning more resources to final disposal.
- Long distance and/or bad access to landfills.
- Environmental pollutions.
- Complaints from nearby residents.
- High cost of final disposal.

3. Propose corrective measures to overcome the identified problems of the present landfill practice.
4. Evaluate the appropriateness, as the future site, of the visited site from urbanistic, economic and environmental points of view.
5. Evaluate the usefulness of a weighbridge for the efficient and effective municipal solid waste management.

EXERCISE II

VISIT TO THE PRESENT DUMPING SITE AND FUTURE LANDFILL SITE OF THE MUNICIPAL COUNCIL OF SEBERANG PERAI

OBJECTIVE

The objective of this exercise is to give a practical training to the participants of the Workshop on :

- How to identify the points to be improved in the present landfilling practice;
- How to work out corrective measures to overcome the identified problems;
- How to carry out the site selection for future landfilling; and
- How to use a weighbridge for the efficient and effective municipal solid waste management.

INFORMATIONS

Each participant, or each group, has to collect all the necessary informations through :

- Briefing by the staffs of the Municipal Council of Seberang Perai.
- Field visit.

DUTIES

1. Evaluate the characteristics of the present landfilling practice on the following aspects :

   a. Site selection

      - Land use plan
      - Distance from the town
      - Access condition
      - Wind direction
      - Soil characteristics
      - Cover material availability
      - Utility
      - Life, etc.

b. Design of periferal infrastructure

- Peripheral drainage system
- Access, etc.

c. Design of landfill infrastructure

- Internal access
- Special lot
- Internal drainage system
- Gas vent, etc.

d. Design of auxiliary constructions

- Gate
- Office
- Toilet
- Weighbridge
- Workshop
- Depot
- Fence
- Notice board, etc.

e. Design for pollution control

- Leachate
- Landfill gas, etc.

f. Landscaping

g. Operational plan

- Excavation, transport and storage of cover material.

- Sequence of cell construction, etc.

2. Identify the problems of the present landfilling practice.

Examples :

- Very short remaining life of actual landfill site.

- Difficulty to get future sites within reasonable distances.

- Lack of town planning with due consideration on the siting of future final disposal facilities.

- Lack of cover material/High cost of cover material.

- Frequent breakdown of equipment.

- Lack of trained operators.

- Lack of the design prepared by professionals.
- Encroaching residential areas.
- Lack of control on the inflow of industrial solid wastes.
- Poorly designed contracts and/or poor supervision on private contractors.
- Difficulty to convince decision makers of the necessity of assigning more resources to final disposal.
- Long distance and/or bad access to landfills.
- Environmental pollutions.
- Complaints from nearby residents.
- High cost of final disposal.

3. Propose corrective measures to overcome the identified problems of the present landfill practice.

4. Evaluate the characteristics of the future landfill site on the aspects a - g shown in 1.

5. Identify the points to be improved in the design and operation of the future landfill site.

REPORT ON THE PROPOSED SANITARY LANDFILL FOR MAJLIS DAERAH KULIM, KEDAH

APRIL, 1985

TECHNICAL BRANCH
LOCAL GOVERNMENT DIVISION
MINISTRY OF HOUSING AND LOCAL GOVERNMENT

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REPORT ON THE PROPOSED SANITARY LANDFILL FOR MAJLIS DAERAH KULIM, KEDAH

1. INTRODUCTION

1.1 Kulim town is the largest urban centre within the administrative area of the Majlis Daerah Kulim. The 1980 census shows that in 1980 Kulim Town had a total population of 27,067 residing in 5,604 dwelling units. Based on an estimated annual growth rate of 2.5%, Kulim is estimated to have a total population of about 30,000 in 1985.

1.2 Like many other similar towns in the region, agriculture and other agro-based development have the greatest influence on the local economy in Kulim. However, Kulim has also embarked on industrial development with the setting up of the industrial estate near Kulim.

1.3 Accompanying the population growth and the industrial development the solid wastes in Kulim, both Municipal and industrial, have increased over the years both interms of volume as well as complexity. As a result, the Majlis Daerah Kulim, being the local authority responsible for the management of solid waste in that area and with limited man-power and financial resources has been under tremendous pressure to cope with the solid waste management problems.

1.4 At present, all solid wastes, both municipal and industrial, from and around Kulim township are disposed of in the landfill at Junjong. However, the existing landfill at Junjong will be filled up very soon. As such, the Majlis Daerah Kulim has been searching for other suitable landfill sites for the disposal of municipal as well as industrial solid wastes. In 1984 a piece of land about 3 km north of Kulim town on Lot 671 Mukim Kulim situated along Sg. Kulim, was identified as a potential landfill site by Majlis Daerah Kulim. It is also the intention of the Majlis Daerah Kulim to use part of Lot 671 as a trenching ground for the disposal of excreta from bucket latrines and sludge from individual septic tanks.

1.5 In early 1985, Majlis Daerah Kulim requested the assistance of the Technical Branch of the Local Government Division, Ministry of Housing and Local Government to evaluate the suitability of the proposed landfill site and subsequently to recommend appropriate measures and actions to be taken by the Majlis Daerah Kulim.

1.6 In response to the request of Majlis Daerah Kulim, two Public Health Engineers from the Technical Branch were sent to carry out a preliminary study with the objective to :-

(i) Evaluate the suitability of the proposed site to be used as sanitary landfill;

(ii) Recommend appropriate actions to be taken by Majlis Daerah Kulim based on the findings of the preliminary study.

1.7 This report outlines the investigations carried out in the course of the preliminary study, the findings of the study and the recommendations and actions to be taken.

2. INVESTIGATIONS CARRIED OUT

2.1 Site inspections of the proposed landfill on Lot 671 Mukim Kulim were carried out by the two Public Health Engineers from the Technical Branch to ascertain the topographical and geological characteristics of the proposed site as well as to determine the landuse of the surrounding areas and the benefical uses of the surface and ground water which may be affected by the operation of the proposed landfill.

2.2 Subsequently, discussions were held with officers of the relevant agencies in Kedah and Penang as well as Federal Agencies to gather relevant informations and data which are needed in the study.

3. THE FINDINGS

3.1 Under the existing legislations, the Majlis Daerah Kulim is responsible within its area of jurisdiction, for the collection, treatment and disposal of Municipal and industrial solid wastes as well as the collection, treatment and disposal of the excreta from bucket latrines and sludge from septic tanks. Municipal wastes includes both domestic as well as commercial solid wastes.

3.2 At present the municipal wastes are collected by the employees of the Majlis with four open trucks and one modern compaction vehicle. Data on the amount of municipal waste being collected per day was not available.

However, based on an average percapita generation rate of 0.6 kg/day, the total amount of Municipal waste being generated is estimated to be approximately 18 tons per day. The Municipal wastes collected are disposed of in the existing landfill at Junjong which is about 10 km away from Kulim township.

3.3 According to the records given by the Majlis Daerah Kulim, at present there are a total of 23 factories operating in the Kulim Industrial estate. A list of these factories is given in Appendix I. There is a complete lack of data on the industrial wastes being generated from the Kulim Industrial Estate. However, judging from the size and the number of the factories located in the Kulim Industrial Estate, it is expected that the total amount of industrial wastes generated could be substantial. Furthermore because of the nature of the various processes involved in the operations, the characteristics of the industrial wastes being produced is expected to be complex. The possibility of some hazardous industrial wastes being generated cannot be ruled out unless a detailed study is carried out and proved otherwise.

3.4 At present, the industrial wastes produced in Kulim Industrial Estate are being collected either by the owners themselves or by the contractors employed by the owners and disposed of at the Junjong landfill together with the Municipal wastes. There is no control or supervision on the disposal of solid wastes at the Junjong site.

3.5 At present there are 642 bucket latrines and 2167 individal septic tanks and 19 communal Imhoff tanks in District Council of Kulim. Excreta collected from the bucket latrines and sludge collected from the septic and Imhoff tanks are being disposed of in three trenching grounds located at Junjong, Mahang and Naga Lilit.

3.6 The Junjong solid waste landfill has almost reached the end of its life and would have to be phased out as soon as possible. The Majlis Daerah Kulim has selected a potential new landfill site about 3 km east of Kulim on Lot 671 mukim Kulim. The total area of Lot 671 is approximately 40 hectares. The Majlis also intends to use the same site as the central excreta and sludge trenching grounds and phase out the 3 existing trenching grounds stated earlier.

3.7 It was reported that Majlis Daerah Kulim selected the proposed landfill site at Lot 671 based on the following reasons :-

3.7.1 The proposed site is only about 3 km from Kulim township and therefore would greatly reduce the transport cost of solid waste.

3.7.2 Since only a single land title is involved, the acquisition of Lot 671 would be relatively easy.

3.7.3 No development has been planned at the nearby areas. Further more, the high ground in part of Lot 671 will act as an effective barrier between the proposed landfill and the Kulim township. Therefore public complaints on the operation of the landfill is expected to be minimal.

3.8 The location of the proposed landfill site at Lot 671 in relation to Kulim Town Centre is shown in Appendix 2. The boundary map of District Council of Kulim as well as the location of the present dumping site in Junjong is shown in Appendix 3. The location of water treatment plants that treat water from Sungai Kulim and the proposed landfill site is shown in Appendix 4. Appendix 5 shows the existing condition of the proposed site when the site inspection was carried out. The proposed site consists of an undulating land formation with the higher part of the land at the southern lot boundary facing Kulim town. From the southern boundary it slopes downwards towards Sg. Kulim near its northern lot boundary. Lot 671 therefore falls within the catchment of Sg. Kulim.

3.9 The soil formation of the proposed site consists of mainly sandy clay with high porosity. Detail ground water survey has not been carried out at the proposed site. However, judging from the water level in the wells of the nearby residents the ground water table at the lowest part of Lot 671 was estimated to be about 5 meters below ground surface. It must be pointed out, however, that the ground water table of the areas may be considerably higher during the rainy season. It was reported by the residents in the area that during rainy seasons, the ground water level could rise up to less than 0.5 meter below ground level.

3.10 The existing land use of Lot 671 as well as the nearby areas are rubber plantations. As shown in Appendix 2, a laterite road runs along Sg. Kulim and cuts across Lot 671. According to JKR this road will be upgraded into metalled road in the near future. At the moment it was reported that there are 60 odd wooden houses with as many households scattered at the nearby areas along the existing laterite road. The

nearest house from Lot 671 was barely 60 meters away.

3.11 The houses found in this area are typical of the estate houses having no JKR potable water supply. The residents of these houses mainly rely on shallow wells for water supply. Due to its shallow nature, water from these wells are from the first acquifer and therefore are easily subjected to pollution originating from the contamination of land surface and sub-soil. Appendix 6 shows a typical shallow well within a dwelling near the proposed site.

3.12 Sg. Kulim which is one of the upper tributeries of Sg. Perai flows in an east to west direction at about 150 meters from the boundary of Lot 671 which runs along the laterite road mentioned earlier. The strip of low land in between Sg. Kulim and Lot 671 was covered with bushes and swamp and patches of rubber plantations. Since this strip of land is so narrow it cannot offer any significant purification effect on the leachate run off from the proposed landfill should it be allowed to occur.

3.13 According to the information given by JKR and Penang Water Authority, there are two water treatment plants having water intake points at Sg. Kulim downstream of the proposed landfill site. The nearest of the two is Bukit Toh Allang Filtration plant which has its raw water intake at Sg. Kulim approximately .8 km downstream of the proposed landfill site. Another water intake point at Sg. Kulim is called Mengkuang Mak Sulong Pumping Station and is located about 2.5 km down stream of the first intake point. The second intake point supplies raw water to the Sg. Dua Filtration Plant. The Bukit Toh Allang Filtration Plant has a capacity of about 60,000 m^3/day (13 million gallons/day) is supplying water to residents in Kulim and Seberang Perai areas. Whereas the Sg. Dua Filtration Plant has a capacity of approximately 230,000 m^3/day (50 million gallons/day) supplying water to Seberang Perai and Penang Island.

3.14 At the beginning of 1984, on the request of the Majlis, the Northern Regional Office of the Department of Environment studied the proposed site and concluded that it has no objection on the use of the proposed site as a landfill for solid wastes provided a number of conditions are met. A copy of the reply of DOE is given in Appendix 7. The conditions stated are :-

3.14.1 Only normal refuse may be allowed for disposal at the proposed site. Toxic and hazardous wastes must not be disposed of at the proposed site. Disposal of hospital and pathological wastes must be closely supervised and buried immediately.

3.14.2 Open burning should not be permitted at the proposed site.

3.14.3 Sanitary landfill practices must be followed. Solid wastes must be compacted and covered with suitable covering materials. If 'cut and cover' method is to be used, the base and walls of the trenches should be lined with impervious materials to prevent polluting the ground water. The procedures outlined in the 'code of Practice For the Disposal of Solid Waste On Land' prepared by the Department of Environment must be followed. At the same time, vehicles and equipments needed for the sanitary landfill operation should be made available to facilitate the operation.

3.14.4 The invert level of the trenches should be at least 30 cms above the highest ground water table.

3.14.5 The nearest residential dwelling should be at least 500 meters away from the proposed landfill. It was suggested that the residents in the surrounding areas should be notified about the use of the proposed site for landfill.

3.14.6 Disposal of solid wastes at the proposed site should be carried out in such a way that wastes will not be spilled into Sg. Kulim.

3.14.7 The proposed site should be made a security area and should be fenced and guarded round the clock to prevent undesirable events from taking place.

3.14.8 All water accumulated at the proposed site should be drained before disposal of solid wastes can be carried out.

4. EVALUATION OF THE FINDINGS

4.1 There is a drop of about 30 meters in height from the highest point to the lowest point. However, there is a strip of land in Lot 671 alo the existing laterite road where the slope is not as steep. It is believed that only this strip of land can be used for the landfill operation without having to involve elaborate and costly engineering measures for slope stabilization. As the compacted solid wastes takes considerable time to consolidate it will be totally uneconomical to do so. The usefulness of Lot 671 as landfill is therefore greatly limited.

4.2 As stated earlier the soil formation in Lot 671 is predominantly sandy clay with high porosity. Therefore the lining of trenches to prevent the escaping of leachate must be carried out properly. Suitable lining material such as clay within economical distance from the proposed site has to be found. In anycase the stringent lining requirement will definately push up the overall cost.

4.3 In addition to the unfavourable soil characteristics, as has been reported earlier, majority of the 60 odd families residing near Lot 671 are relying on shallow wells for potable water supply. Since the nearest house is only 60 meters away from Lot 671, the risk of contamination of the well water is very high. Therefore, it may be necessary to consider relocating some of these households if Lot 671 is to be used as landfill. If the social-political problems involved in relocation cannot be accepted, alternatively, piped potable water supply must be made available to these households. However, both alternatives involve considerable cost.

4.4 As reported earlier, Lot 671 falls within the catchment of Sg. Kulim upstream of two major potable water supply intakes at Sg. Kulim. The water from these two points are treated and supplied to the population in Kulim, Seberang Perai as well as Georgetown. In view of the possible grave consequences on Public Health, comprehensive engineering measures and operating procedures beyond what has been prescribed by DOE in Appendix 7 should be strictly implemented. Toxic and hazardous wastes must not be allowed for disposal on Lot 671. Unfortunately even with these expensive measures no one can be absolutely certain and rule out the public health risk because no one can be absolutely sure that human error or negligence will not occur in the whole operation. This is especially critical since Majlis Daerah Kulim intends to allow the disposal of industrial wastes

as well as excreta and sludge on Lot 671. Even the most elaborate and comprehensive control system can only reduce the risk to the minimum but cannot completely eliminate the risk.

4.5 The existing land use on Lot 671 is rubber plantation. To use an existing productive land for landfill can only be justified if it has been proven to be the most cost-effective solution after all possible sites have been evaluated. The advantage of sanitary landfill operation to turn useless land into usefull land should not be over looked let alone reversed.

5. RECOMMENDATIONS

5.1 Based on the above study, it is obvious that Lot 671 is not satisfactory to be used as landfill. Though costly engineering measures can be implemented to overcome some of the unfavourable condition of the proposed site, it cannot eliminate completely the Public Health risk involved in using Lot 671 for the intended purposes. It is strongly recommended that Majlis Daerah Kulim should endeavour to look for alternative sites for these purposes.

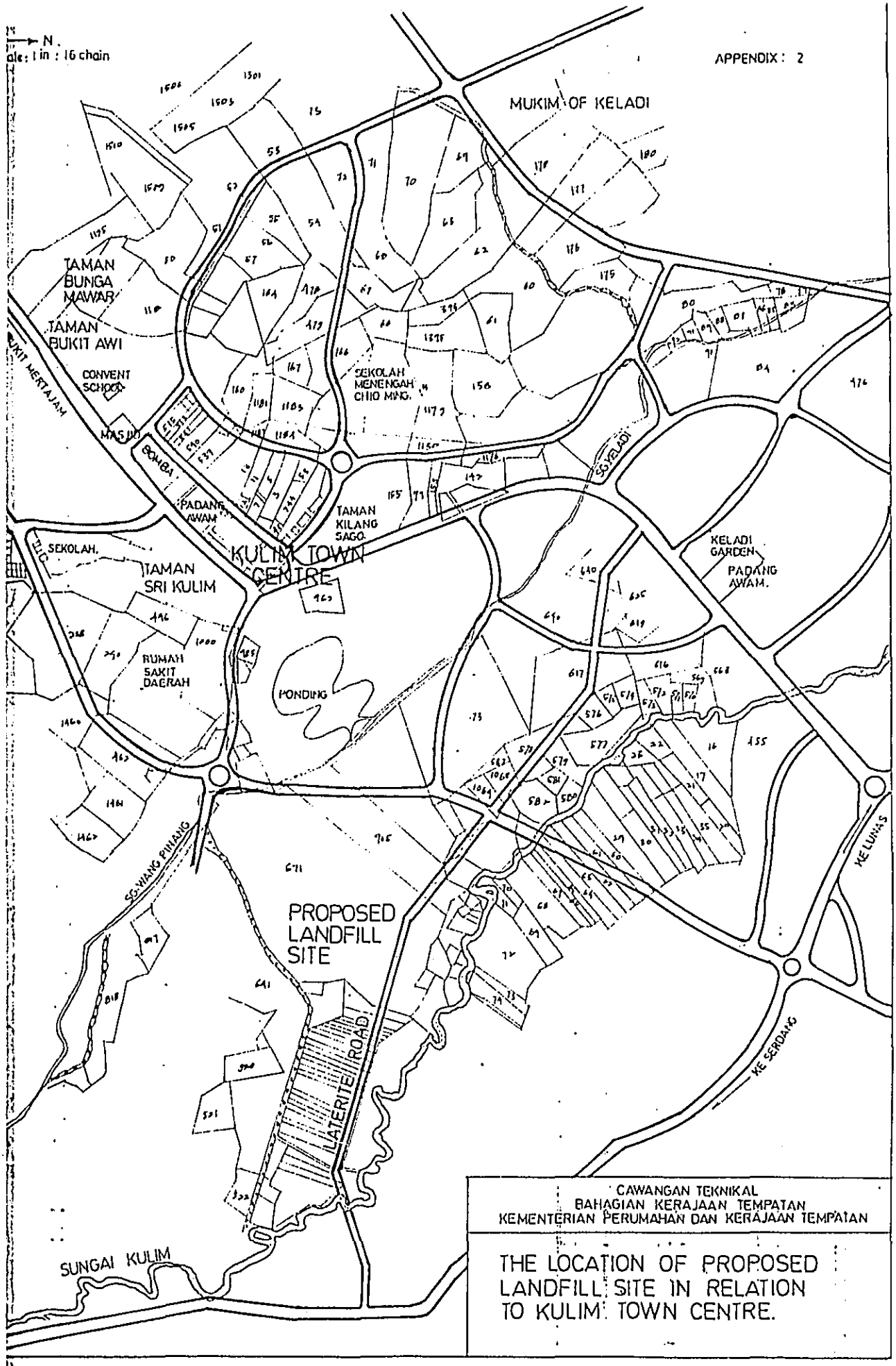
5.2 The 'Guideline on the Selection of Landfill Site' proposed by the Department of Environment should be used in the selection and evaluation of potential landfill site. The Northern Regional office of the Department of Environment should be approached to assist Majlis Daerah Kulim in the process. Technical Branch of the Local Government Division will provide technical assistance should the need arise.

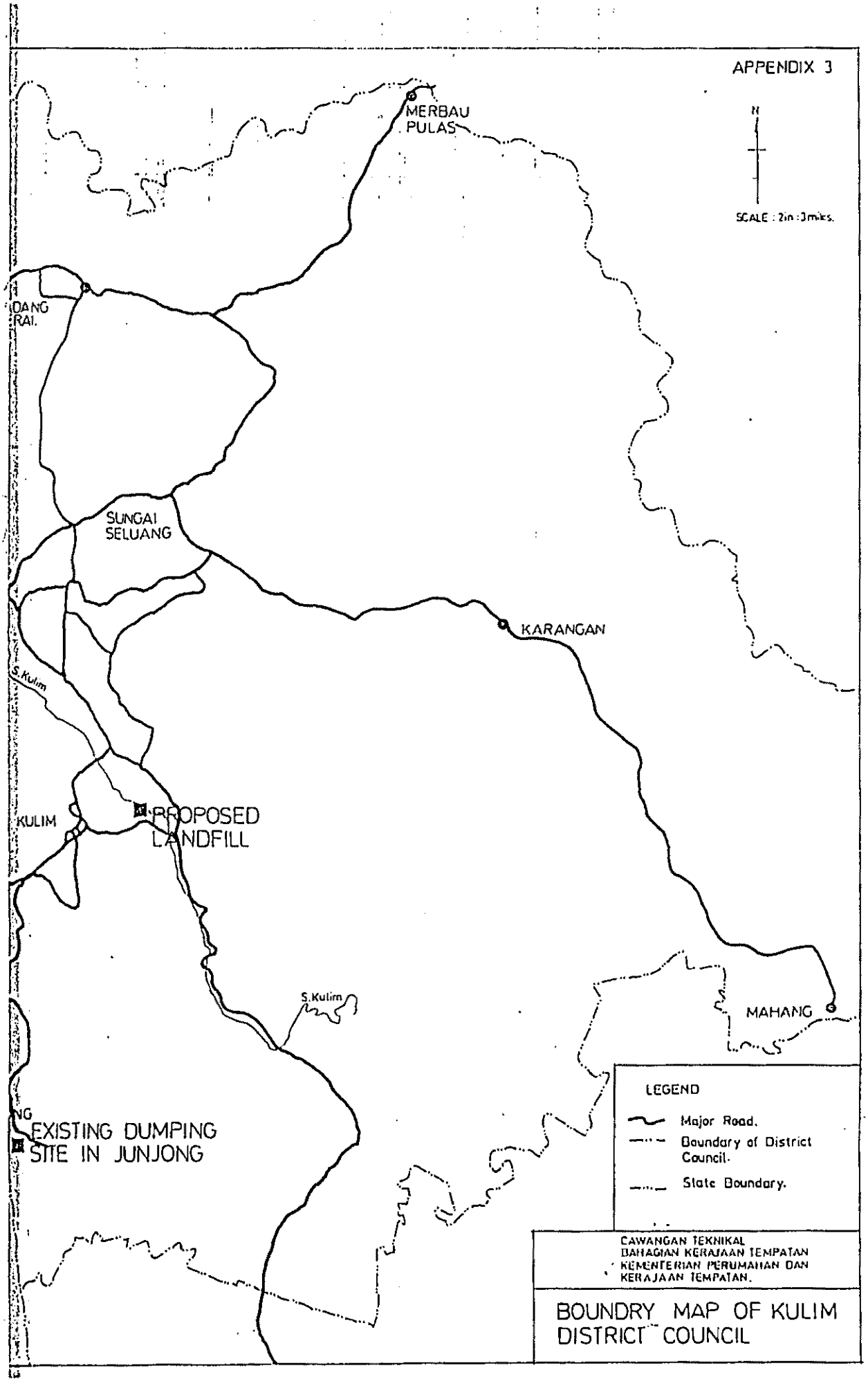
APPENDIX 1

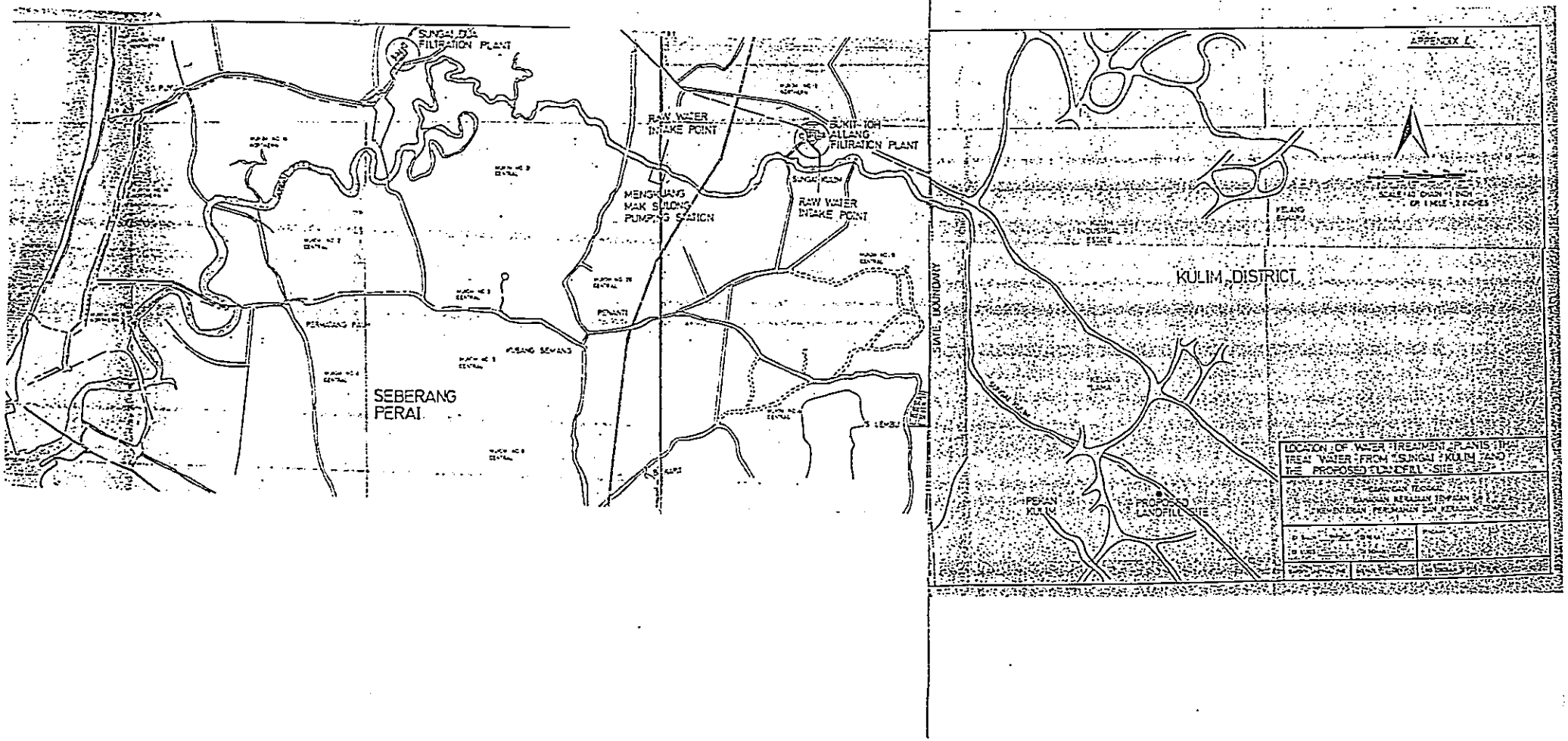
LIST OF FACTORIES OPERATING IN THE DISTRICT COUNCIL OF KULIM.

NAME OF FACTORIES

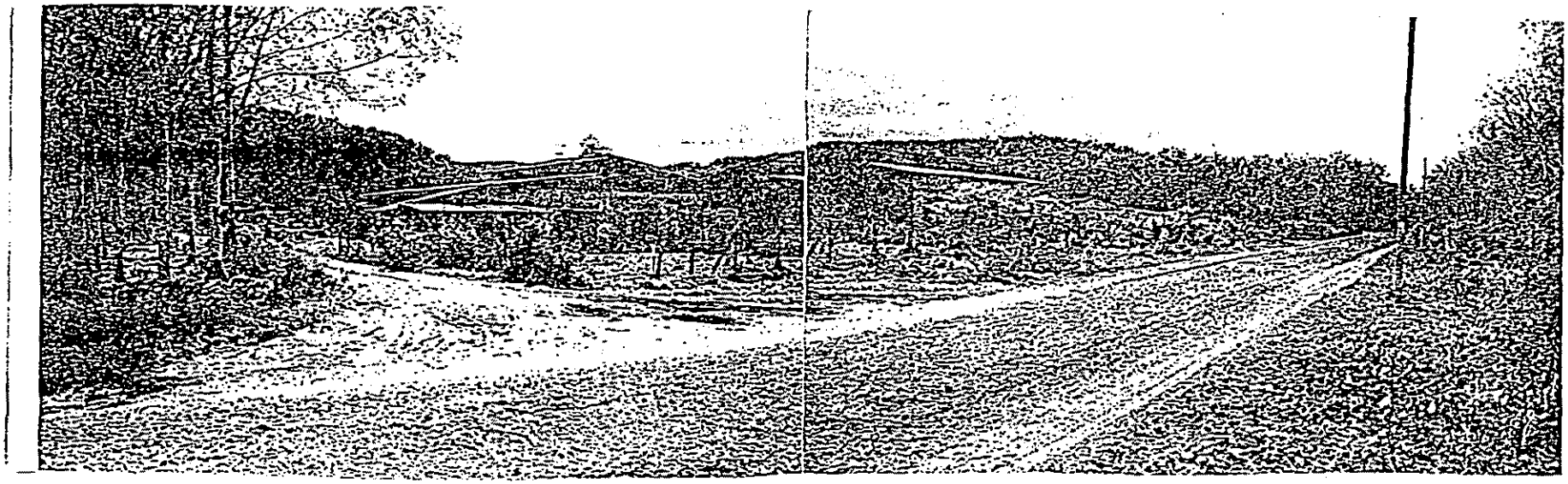
1. Scansia Sdn. Bhd.
2. Goldon Metal Industries (M) Sdn. Bhd. & Goodfriend Cutlery.
3. Kelga Sdn. Bhd.
4. Hesi Saw Chain (M) Sdn. Bhd.
5. Ontex Woollen Mills Sdn. Bhd.
6. Polykin Sdn. Bhd.
7. Maica Wood Industries Sdn. Bhd.
8. Body Fashion (M) Sdn. Bhd.
9. Telina Development Sdn. Bhd.
10. Franklin Porcelain Sdn. Bhd.
11. Optical Glass Sdn. Bhd.
12. MUDA FIBRE MANUFACTURING SDN.BHD
13. NIKE (M) Sdn. Bhd.
14. Trallfa (M) Sdn. Bhd.
15. HARPER BTR. Industries Sdn. Bhd.
16. Heng Leong Industries
17. Hitachi Semiconductor (M) Sdn. Bhd.
18. Asiamax (M) Sdn. Bhd.
19. General Electric (USA) Audio (M) Sdn. Bhd.
20. Unioncon Enterprise Sdn. Bhd.
21. Amirwood Sdn. Bhd.
22. Singatronics (M) Sdn. Bhd.
23. Malaysia Industrial Estate Sdn. Bhd.


N.
ale: 1 in : 16 chain
APPENDIX : 2
MUKIM OF KELADI
TAMAN BUNGA MAWAR
TAMAN BUKIT AWI
CONVENT SCHOOL
MASJID
BOMBA
PADANG AWAM
SEKOLAH MENENGAH CHIO MING
TAMAN KILANG SAGO
SG.KELADI
KELADI GARDEN
PADANG AWAM.
KULIM TOWN CENTRE
SEKOLAH.
TAMAN SRI KULIM
RUMAH SAKIT DAERAH
PONDING
SG.WANG PINANG
PROPOSED LANDFILL SITE
LATERITE ROAD
KE LUNAS
KE SERDANG
SUNGAI KULIM
CAWANGAN TEKNIKAL
BAHAGIAN KERAJAAN TEMPATAN
KEMENTERIAN PERUMAHAN DAN KERAJAAN TEMPATAN
THE LOCATION OF PROPOSED LANDFILL SITE IN RELATION TO KULIM TOWN CENTRE.

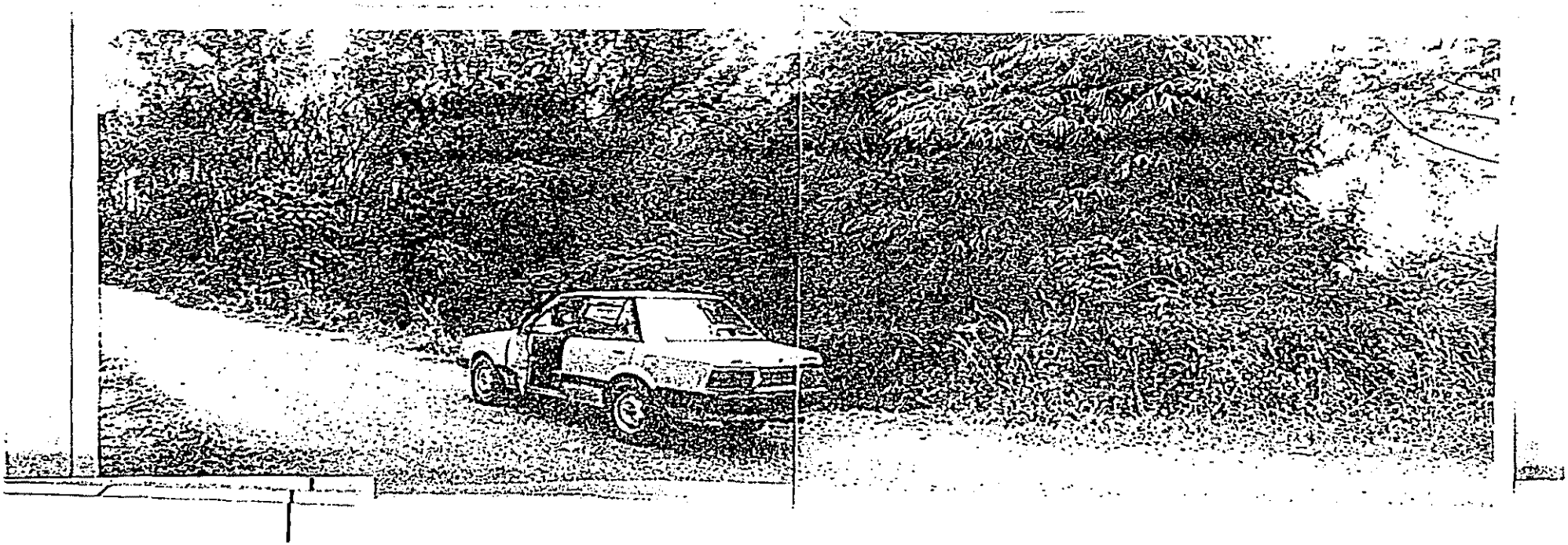

APPENDIX 3
N
SCALE : 2in : 3miles.
MERBAU PULAS
DANG RAI.
SUNGAI SELUANG
KARANGAN
S.Kulim
KULIM
PROPOSED LANDFILL
S.Kulim
MAHANG
NG
EXISTING DUMPING STIE IN JUNJONG
LEGEND
Major Road.
Boundary of District Council.
State Boundary.
CAWANGAN TEKNIKAL
BAHAGIAN KERAJAAN TEMPATAN
KEMENTERIAN PERUMAHAN DAN
KERAJAAN TEMPATAN.
BOUNDRY MAP OF KULIM DISTRICT COUNCIL


SUNGAI DUA
FILTRATION PLANT
RAW WATER
INTAKE POINT
SUKIT TOH
ALLANG
FILTRATION PLANT
MENGKUANG
MAK SULONG
PUMPING STATION
RAW WATER
INTAKE POINT
SEBERANG
PERAI
STATE BOUNDARY
KULIM DISTRICT
PERAK
KULIM
PROPOSED
LANDFILL SITE
APPENDIX L
LOCATION OF WATER TREATMENT PLANTS THAT
TREAT WATER FROM SUNGAI KULIM AND
THE PROPOSED LANDFILL SITE

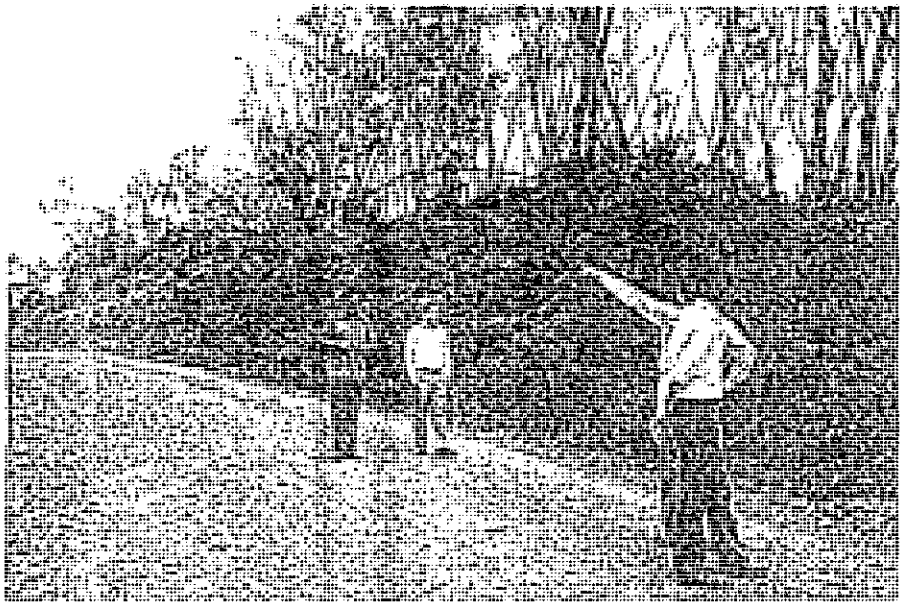
APPENDIX 5



Houses around the proposed ground for sanitary landfill.

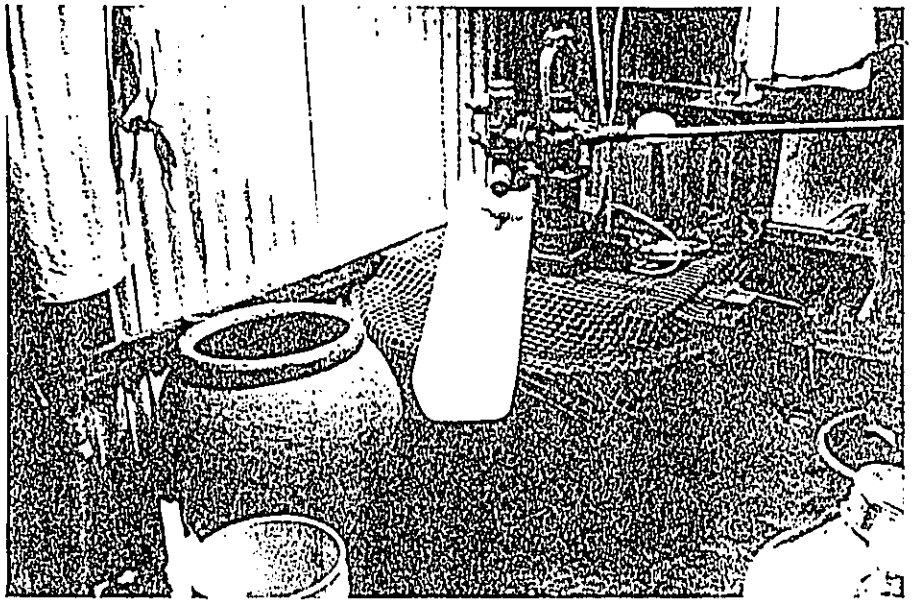


APPENDIX 5



Part of the Proposed Ground For Sanitary Landfill

APPENDIX 6



Well water being used for consumption

JABATAN ALAM SEKITAR
(WILAYAH UTARA)
KEMENTERIAN SAINS, TEKNOLOGI
DAN ALAM SEKITAR
4768-A, JALAN BAGAN LUAR
BUTTERWORTH
SEBERANG PERAI.

Telefon: 340441

APPENDIX

Ruj. Tuan:

Ruj. Kami: AS(WU) 1045/((

Tarikh: 11 Jun 1984

Yang Di Pertua
Majlis Daerah Kerajaan Tempatan
Kulim
KEDAH.

Tuan,

Cadangan Tapak Pelupusan Sampah Di Daerah Kulim
Bagi Majlis Daerah Kerajaan Tempatan Kulim

Adalah saya diarah merujuk kepada surat tuan MDKT(K)995/(2) bertarikh 25 Februari 1984 berhubung dengan perkara yang tersebut di atas.

2. Jabatan Alam Sekitar (Wilayah Utara) tiada mempunyai apa-apa halangan terhadap cadangan di atas tertakluk kepada syarat-syarat berikut :-

i) Sampah sarap biasa sahaja dibenarkan dilupus di tapak yang dicadangkan. Pelupusan buangan-buangan toksik dan merbahaya adalah dilarang sama sekali. Pelupusan buangan-buangan hospital, 'pathological waste' hendaklah diawasi dengan ketat agar buangan-buangan tersebut ditimbus dengan segera sebaik sahaja pelupusan dibuat;

ii) Pembakaran terbuka tidak boleh diamalkan di tapak pelupusan tersebut;

iii) Pelupusan hendaklah dilakukan secara 'sanitary landfilling' di mana sampah sarap dirata, dimampat dan kemudian ditimbus dengan bahan penutup dengan sempurna. Sekiranya kaedah 'cut and cover' hendak diamalkan parit yang digali itu hendaklah dilapisi dengan tanah liat pada bahagian lantai dan dinding parit tersebut. Ini dapat menghalang dari berlakunya pencemaran terhadap air bawah tanah. Kaedah ini telah diterangkan dalam 'Kod Amalan Yang Disyorkan Untuk Lupusan Buangan Pepejal Ke Atas Tanah' yang telahpun diedarkan ke Pejabat tuan. Sila rujuk garis panduan tersebut untuk keterangan selanjutnya. Di samping itu jentera pengorek tanah dan traktor perlu disediakan di tapak tersebut bagi memudahkan kerja-kerja pelupusan sampah sarap.

2/...

iv) Bahagian lantai parit yang akan digali itu mestilah sekurang-kurangnya 30 sentimeter dari paras permukaan air bawah tanah yang paling tinggi yang dapat dijangkakan;

v) Tapak tersebut mestilah sekurang-kurangnya 500 meter dari kawasan penempatan penduduk-penduduk. Disyorkan supaya penduduk-penduduk di persekitaran diberitahu terlebih dahulu mengenai tapak pelupusan yang dicadangkan itu;

vi) Pelupusan hendaklah dilakukan dengan cara supaya sampah tidak akan masuk atau boleh masuk ke dalam aliran Sungai Kulim;

viil. Tapak tersebut hendaklah dijadikan sebagai kawasan larangan, dipagar dan dijaga sepanjang masa agar perkara-perkara yang tidak diingini tidak berlaku;

viii) Sebarang takungan air mestilah dikeringkan dahulu sebelum pelupusan sampah sarap dilakukan.

Sekian dimaklumkan, terima kasih.

"BERKHIDMAT UNTUK NEGARA"

Saya yang menurut perintah,

(HASKAH H.RUN)
Pmg. Pegawai Kawalan Kanan Alam Sekitar
Wilayah Utara

s.k.

Ketua Pengarah
Jabatan Alam Sekitar
Tingkat 1, MUI Plaza
Jalan P. Ramlee
KUALA LUMPUR.

ABM/so.

NECESSARY IMPROVEMENTS IN KULIM LANDFILL DESIGN

Date : 6 August 1987
Author : Dr.Kunitoshi Sakurai, JICA Expert.

1. INTRODUCTION

The field visit to the future landfill site for the Majlis Daerah Kulim (MDK), which is located on Lot. 671, Mukim Kulim, Kulim, Kedah, was made by Mr.Ridhuan and the author on 16 May 1987. Then, the following two documents were studied by the author:

- Report on the proposed sanitary landfill for Majlis Daerah Kulim, Kedah; April, 1985; Technical Branch, Local Government Division, Ministry of Housing and Local Government.

- Proposed Sanitary Landfill on Lot. 671, Mukim Kulim, Kulim, Kedah; Cawangan Teknikal, Bahagian Kerajaan Tempatan, Kuala Lumpur.

After the field visit and the study, the author feels the necessity and possibility of the improvements in the design and operation concepts shown in the second document above mentioned. These improvements will not only make the landfilling operation easier but also reduce the capital cost and the undesirable environmental impact.

2. NECESSARY IMPROVEMENTS

2-1 In the original design, the traffic routes of lorries within the site are not clear and some proposed concepts seem to be technically unfeasible. Use of ramps having a slope of at least 1:6 from one platform fill to the next is proposed, but the unpaved ramps with this slope (16.7%) are not negotiable for lorries especially in rainy seasons. A twenty feet wide laterite peripheral road is proposed, but it is not clear why this road is necessary and how it will be used when ramps are proposed on the other hand. To give the lorries a reliable access to the working face with the minimum cost, it will be better to abandon the idea of ramps and construct only the half (probably the right half = south-west half) of the laterite peripheral road with some unloading platforms. The refuse unloaded from these platforms will be pushed to the working face by the proposed buldozer. The road construction can be done in stages using the idle time of the buldozer. The width of the road can also be reduced to ten feet because the MDK has only six lorries in operation. The junction design should also be improved so that the driving of comming-in and going-out lorries will be more smooth.

2-2 The final topography of the proposed fill is cocave. It is preferable to establish covex topogaraphy to direct the run-off towards

peripheral drain. Otherwise, the peripheral drain will work only to intercept the run-off from outside the fill area and the run-off in the fill area will go down towards the drain along the existing laterite road travelling a long distance on the fill surface, and increasing the infiltration of rain water and the production of leachate.

2-3 Section c-c of LF-5, Section b-b of LF-6, Section a-a of LF-7 and Section d-d of LF-8 are inappropriate because the elevation difference caused by two percent slope is neglected. This difference is too large to be neglected (400 ft distance means 8 ft elevation difference). Lift design should be made taking into account this slope effect.

2-4 In the original design, it is not clear how and where to get the cover material. One of the main reasons why in many Local Authorities in Malaysia open dumping method is used is the difficulty to get the continuous supply of cover material with reasonable price. Therefore, this point should not be neglected in the design. Maybe, the outer area along the proposed right half of the laterite peripheral road will be the best place to get the cover material because of the convenience of its transportation to the working face. The fill area with the elevation higher than 100 ft should also be excavated to get extra cover material. The best place foe this excavation will be the slope in the south-east corner of the proposed landfill area. This excavation should be made before the landfilling in that area. Therefore, the cover material derived from on-site excavation should be used before that from the outer area.

2-5 The concept of bund cum road acting as filter of leachate seems to be inappropriate because main pollutants of the leachate are the soluble ones which are not likely to be removed by the sand filter. Therefore, this bund should be modified into a simple earth bund without sand filter. The width can also be reduced to 6 ft because this bund is only expected to contain the refuse and is not expected to function as an access road in new design (see 2-1). However, the side slopes of this bund should be reduced to 1:2 to improve its stability. The internal side of this bund which will have contact with refuse may be treated with clay soil to enhance the impermeability. The best place to get the material for this bund construction will be the high elevation area just along the existing laterite road and next to the proposed site.

REPORT ON THE DESIGN OF SANITARY LANDFILL FOR MAJLIS DAERAH KULIM, KEDAH.

SEPTEMBER 1987

TECHNICAL SECTION

LOCAL GOVERNMENT DIVISION

MINISTRY OF HOUSING AND LOCAL GOVERNMENT

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1. INTRODUCTION

1.1 The problem of disposing solid waste in Majlis Daerah Kulim has become acute as the present dump site in Junjong is now full and its continous operation is a danger to public health especially to the surrounding population living adjacent to the site.

1.2 With the problem, Majlis Daerah Kulim has acquired a site nearby Kulim town to be converted to a sanitary landfill. However preliminary report done by the Technical Unit at the Local Government Division, Ministry of Housing and Local Government concluded that the proposed site is unsuitable for disposing of solid waste as the area is in close proximity to a river from which water is taken for domestic use. The report also recommended that Majlis Daerah Kulim should look for an alternative site for the purpose of disposing solid waste.

1.3 The Majlis Daerah then responded that no other land is available from the State Government for the intended purpose and that the already acquired land on Lot 671 Mukim Kulim must be used and that the Ministry should assists the Majlis in preparing the design for the disposal of solid waste on the area.

1.4 The Technical Unit was again involved with the visit of its Director and a Senior Engineer to the proposed site in Kulim followed later by a team of an engineer and 2 technical assistants to survey the site in preparing the engineering design.

1.5 The design was completed in 1986 and then sent to M.D. Kulim for project implementation. However with the arrival of a JICA expert attached to the Technical Unit, he was requested to review the design and make appropriate recommendations so as to improve on it. The new design was completed in September 1987 and this report outlines the concept of the design, with the cost estimation of the project.

1.6 In the design, precautionary measures in minimising the pollution of water courses was considered and only through proper operation that polution could be controlled and life of the landfill be prolonged.

1.7 It is hoped that Majlis Daerah Kulim would adhered strictly to the operational procedures of a sanitary landfill in order to obtain the best result of the design and a model for which all other Local Authorities could follow.

2. DESIGN CONCEPT

2.1 It was firstly thought that the operation of the landfill could start at the furthest end of the ravine from the existing latrite road. However this idea was not taken up in the design because it was felt that procedure of creating a cell would be difficult since the slope is rather steep and that ensuring all the refuse dumped reach the bottom will be difficult. Furthermore the manouvreability of a dozer cum compactor will be limited and an access to the operational area would have to be constructed. This would then incur additional cost to the project. Filling shall thus begin close to the latrite road progressing inwards as indicated in the drawings.

2.2 It is utmost important to minimize the contact of surface water to solid waste at disposal site and as such peripheral earth drains would have to be constructed enclosing the site. The drains shall cater for surface runoff in the catchment.

2.4 The filling shall begin with the first cell running parallel to the existing latrite road. The cell then shall progress perpendicular to the bund and shall cover the whole 90' contour. The cell built up procedure is based on a 18 ton daily refuse being disposed by Majlis Daerah Kulim.

2.5 The second phase will start at the furthest end of the 100' contour with the first cell being pressed to the face of the whole ravine. The cells progress side ways until the whole face of ravine at the 100' contour is covered then the next row of cells shall be constructed behind the first and the creation of cell progresses backwards.

2.6 The filling continues similarly at the 110' and 120' contour. It is estimated that the whole ravine could be used as a sanitary landfill for a period of nearly 6.5 years.

2.7 For the first portion of filling operation the cover material should be obtained from the cell construction area. After excavation, the earth should be stored at the side to be used later to cover the cell at the end of the day's operation.

2.8 As the cell construction continues, more cover material should be obtained from nearby hilly portion of the area. Such operation of obtaining stock for cover material could be done during idle time of the bulldozer.

3. PROPOSAL

3.1 A 10ft wide latrite road with dumping platforms should be constructed half-way round the site. However a peripheral drain with dimensions given in the drawings must be constructed before any filling operation could be done. The drain should join the existing 'V' - shaped side drain of the road though extension of the 'V' - shaped drain is necessary as indicated in the drawings.

3.2 For proper operation of the landfill a track-type dozer should be purchased or hired by the Majlis. The proposed specifications for the equipment is as follows :-

3.2.1	Horsepower	80 Hp
3.2.2	Weight	20,000 lb

3.3 The existing site at Junjong must be covered with at least 9" of earth fill.

4. COST ESTIMATES

4.1 The estimates are done with total referal to the JKR's schedule of rates. Though some job specifications are not specifically stated in the schedule of rates, the nearest available item is taken for the purpose of cost estimation.

4.2 The estimated financial commitment for the project are divided as below :

4.2.1 Construction of road, dumping platforms and side drains

Cost includes the cutting and clearing from site of all rubber trees planted within the road pavement and drain. Also included is the massive cutting for road formation level. The estimated cost is $52,920.00

4.2.2 Construction of concrete drain along the laterite road

The drain shall divert most of the runoff resulting from the catchment so as not to come in contact with the waste being disposed. It will join the existing 'V' shaped concrete drain. Estimated cost is $1,300.00

4.2.3 Buying of a track-type dozer

The machine shall spread, compact refuse and cover material. It will also be useful for site preparation, rip cover material and remove obstructions such as stumps. Cost of the machine is $120,000.00

4.3 Summary of estimated cost is as below :

4.3.1	Road dumping platforms and drain	=	$ 52,920.00
4.3.2	Conc. drain along latrite road	=	$ 1,300.00
4.3.3	Track-type dozer	=	$120,000.00
	TOTAL		$174,220.00

5. FURTHER RECOMMENDATIONS

5.1 The clearing of rubber trees from site for various job specification could be done without cost if not revenue generating by tendering it out to the private sector. Rubber trees are quite demanding around the area for the charcoal production.

5.2 Majlis could avoid purchasing the recommended track type dozer by hiring one instead. There are various financial institutions which offer the hiring service.

5.3 Further reduction in cost could be achieved by properly utilising the back excavator (backhoe) which the Majlis had already purchased.

6.0 CONCLUSION

6.1 The non availability of other areas has forced the Majlis Daerah Kulim to use the land on lot 671 Mukim Kulim as a landfill. Adequate engineering design would have to be done to prevent acute pollution of the area. The proposed implementation plans for the sanitary landfill are submitted with this report.

6.2 The cost of preparing the site is quite expensive. However it is useful to note that the cost estimation is based on the schedule of rate in case the whole project needs to be tendered. The Majlis however could use its own resources in implementing the project with minimal involvement from the private sector in order to cut cost.

6.3 It is important to remphasise that only through proper preparation and practice that a sanitary landfill would help the overall management of solid waste in the area.

A Time and Motion Study Report for the Municipal Council of Petaling Jaya (MPPJ)

20 June 1988
Technical Section
Local Government Division
Ministry of Housing and
Local Government

1. Introduction

Time and motion studies of nine refuse collection crews of MPPJ were carried out on 16 June 1988 by the participants of the training course "Kursus Pengurusan Pengutipan Dan Pelupusan Sisa-Sisa Buangan". This report summarizes the findings made by these studies as well as recommendations for MPPJ.

2. Methodology

The methodology used in this study is the one shown in the text of the training course and it is the standard method of time and motion study for refuse collection. Each study team which consists of three to four members followed a collection vehicle by a passenger car covering one day's complete work. During this field survey, necessary data were collected using the Form 2 and the weight measurement was done hiring a private wieghbridge located at 11, Jalan Tadang. Collected data were analyzed later in the classroom using the Form 3.

3. General Findings

3.1 The under utilization of working hours and of vehicles' loading capcity was widely observed as shown in the following table :

Study Group	Study Area	Area/System Type	Collection Frequency	Number of Trips	Total Working Hours	Working Hour Utilization Efficiency (%)	Amount of Waste Collected	Loading Capacity Utilization Efficiency (%)
A	K1	Commercial	Daily	2	4hrs 40 min	66.7%	2.62 ton	26.2%
B	29U	Residential/ Flat	3 times/week	1	4hrs 12 min	60.0%	3.90 ton	39.0%
C	K8	Side Loader	Daily	1	4hrs 20 min	61.9%	1.30 ton	52.0%
D	K11	Commercial	Daily	1	4hrs 57 min	70.7%	2.20 ton	22.0%
E	5U	Residential	3 times/week	1	4hrs 04 min	58.1%	3.68 ton	36.8%
F	7U	Residential	3 times/week	1	4hrs 01 min	57.4%	3.64 ton	36.4%
G	16U	Residential	3 times/week	1	4hrs 55 min	70.2%	2.78 ton	27.8%
H	-	Roll-on Roll-off	Daily	4	6hrs 12 min	88.6%	6.56 ton	54.7%
I	-	Mechanical Bin	Daily	1	5hrs 14 min	74.8%	3.36 ton	33.6%

Notes : (1) Legal working hours = 7hrs = 420 min.

(2) Loading capacity of a compactor vehicle (13 yd3)
13 yd3 x 0.76 m3/yd3 x 0.5 ton/m3 x 2 trips/day = 10 ton/day

(3) Loading capacity of a side loader (8 yd3)
8 yd3 x 0.76 m3/yd3 x 0.2 ton/m3 x 2 trips/day = 2.5 ton/day

(4) Capacity of a big bin for Roll-on Roll-off vehicle (20 yd3)
20 yd3 x 0.76 m3/yd3 x 0.2 ton/m3 = 3.0 ton/bin

3.2 Collection workers were picked-up every morning at the old workshop and after the completion of the assigned work they were released at the same point. This caused long non-productive trips to all vehicles reducing the available time for refuse collection.

3.3 Wide range of storage containers were used in MPPJ in tgerms of type, size and material showing the insufficiency in the standardization of storage containers. Many of storage containers were considered to be inappropriate.

3.4 Per capita waste generation rate was calculated as follows :

Residential Area

Group B (29 U)	.....	437 gr/capita/day	]
Group E (5 U)	.....	426 gr/capita/day	] Average 414
Group F (7 U)	.....	461 gr/capita/day	] gr/capita/day
Group G (16 U)	.....	331 gr/capita/day	]

Commercial Area

Group A (K1)	.....	587 gr/capita/day	]
Group C (K8)	.....	520 gr/capita/day	] Average 500
Group D (K11)	.....	392 gr/capita/day	] gr/capita/day

4. Special Findings for Each Study Area

Please see the attached Study Report Format (Form 3) for each study area. There are some miscalculations in these Reports because this was the first trial for the participants. These miscalculations are left as they are.

5. Conclusion and Recommendations

5.1 For the participants of the training course, this was the first trial of the time and motion study. However, all the study groups could point out the possibility of productivity improvement in their assigned area using this methodology. This shows that the time and motion study is a simple but very useful methodology to identify the collection efficiency improvement possibilities. If the participants try this technique once or twice more in their own local authorities with the data collection format (Form 2) adapted to the local conditions, the output will be much more improved.

5.2 The usefulness of a weighbridge in the productivity improvement of refuse collection work has been widely recognized through the training course. It is recommended that a local authority with 10 refuse collection compactors (2 side-loaders are equivalent to one compactor) would

consider the installation of a weighbridge before the purchase of the eleventh compactor. In the case of MPPJ, a weighbridge should be installed at the entrance of the existing dumping site Kampong Pinang to carry out a continuous control of loading capacity utilization efficiency.

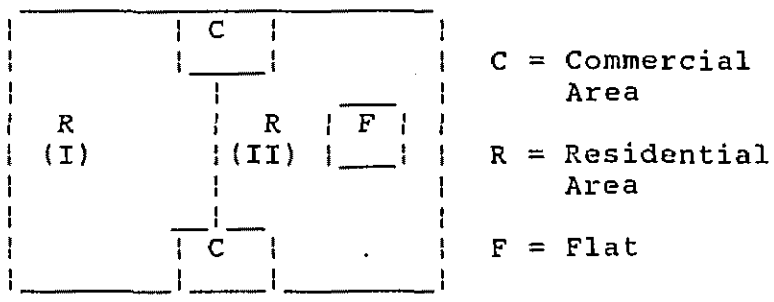
5.3 Under the present work system of MPPJ, it is very difficult to expect two trips with full load for each compactor vehicle (13 yd3). To realize two trips with full load, the system should be modified as follows :

(1) The use of standard storage containers should be promoted with stringent enforcement programme to increase the collection efficiency.

(2) Roll call of workers should be carried out at the new workshop to eliminate the unproductive trip caused by the roll call at the old workshop. Facilities such as a canteen, changing rooms, toilets, etc. should be installed in the new workshop for worker's convenience.

(3) More workload should be assigned to each crew. In the case of study areas K1, 29U, K11, 5U, 7U and 16U, their workload should be doubled at least. Assigned area should be geographically compact to avoid the unnecessary trips. In this connection, the combination of residential and commercial area collection as shown in the following figure may be worth studying with the aim of assigning more compact area.

Combination of Residential and Commercial Area Collection



Present System : Vehicle 1 ----- Commercial Area (Daily)
Vehicle 2 ----- Residential Area (I)
(Mon, Wed, Fri)
----- Residential Area (II)
(Tue, Thu, Sat)
Vehicle 3 ----- Flat

Proposed System : Vehicle No.1 ----- C + R(I)
(Mon, Wed, Fri)
----- C + R(II) + F
(Tue, Thu, Sat)
Vehicle No.2 ----- Commercial Area
(Sunday)

(4) Working conditions of labourers should be improved so that the labourers can also enjoy the fair share of the improvement effects.

5.4 Loading capacity of the side loader is too small (1.25 ton/trip) compared with a compactor (5.0 ton/trip). Therefore, side loaders should be used as stand-by vehicles in conjunction with the improvement of loading capacity utilization of compactors aforementioned in para 5.3.

5.5 This analysis is based on the study which lasted only one day. Work measurement system should be established together with the installation of a weighbridge to monitor continuously the performance of crews.

... Attachment : Study Report Format (Groups A-I)

MOTION PICTURE SCRIPT
"SANITARY LANDFILL--YOU'RE THE OPERATOR"

VIDEO	AUDIO
Establish: Side view of station wagon in motion; Burrell at the wheel. Pan down to Radio Station Call Letters on the door. Car enters landfill gate entrance.	SOUND: BG OF CAR AND TRAFFIC. BG MUSIC
CUT TO: Burrell POV. The camera becomes his eyes as we hear what he is thinking.	BURRELL: (VOICE OVER) Well, this area has certainly changed. I don't remember seeing anything as attractive as that entrance a year ago
Freeze, and cut to brief shot of entry area as it looked a year ago	
DISSOLVE TO: Burrell again. This time he sees houses on the hillsides, some finished, some under construction.	BURRELL: (VOICE OVER) Houses, too. Who would have

	expected to see home construction this near a landfill.
Burrell POV again. He is going around a bend, just past the entrance gate. LS of fill area, showing some bare earth, some grassy areas, but clean. No litter.	BURRELL: (VOICE OVER) No paper....no debris....no mess. What a difference a year makes!
Freeze and cut to similar area, littered with paper, cans, etc. Thinks of area as seen one year previously.	
CUT TO: Burrell POV.	BURRELL: (VOICE OVER) I don't know what I expected to find up here, but for sure nothing like this!
CUT TO:	
POV from working area. LS of Burrell car coming up the access road	SOUND: BG SOUNDS OF EQUIPMENT WORKING

The car arrives near the working area.

CUT TO: Landfill site activity

CUT TO: POV is to one side of the landfill foreman.

NARRATOR: I'm Larry Burrell, with KWLA; you're the operator?

As they are shaking hands, the camera freezes on the foreman.

When frozen, roll the titles--"SANITARY LANDFILL--YOU'RE THE OPERATOR," presented by the Environmental Protection Agency.

FOREMAN: I'm Jack Johnson. We're always happy to have visitors to tell our story to. What's KWLA's angle?

POV from where the foreman and the narrator are standing, near the working area. The dozer is pushing trash up the working face.

NARRATOR: Frankly, Jack, the reason we're doing this story is because a year ago this was a pretty messy area. People are

very impressed with how you've brought it under control. I know I sure am.

I guess the place to start is for you to tell me what a sanitary landfill is.

FOREMAN: Well, Larry, the official definition is that "SANITARY LANDFILLING IS AN ENGINEERED METHOD OF DISPOSING OF SOLID WASTE ON LAND BY SPREADING THE WASTE IN THIN LAYERS, COMPACTING IT TO THE SMALLEST PRACTICAL VOLUME AND COVERING IT WITH SOIL BY THE END OF EACH WORKING DAY IN A MANNER THAT PROTECTS THE ENVIRONMENT."

Foreman paraphrases the definition in a halting manner.

NARRATOR: I guess in plain English what you're really saying

is that a sanitary landfill is a safe and efficient way of disposing of refuse.

FOREMAN: Yes, a real sanitary landfill operation, like this one, is one of the best ways to dispose of nearly 1 ton of refuse from each person per year.

He gestures over his shoulder. Pan the operation, then walk toward pickup.

Over here is the equipment it takes to operate a sanitary landfill.

Jack and Larry get into Jack's pickup.

I'll show you later how each piece contributes to making this a properly operated landfill, but first let's go down to the scale house for an overall look at what we're doing.

DISSOLVE TO:

As they walk into the scale house, Jack points to various drawings on the wall.

BG MUSIC

FOREMAN: This is a set of plans prepared by our engineer to guide

the construction of our landfill. The engineer selected this site after a thorough engineering study to protect against environmental hazards.

As Jack talks about the various things, he points them out on the site plan.

The engineer prepared this site plan to show the original topography, finished grades and ditches and culverts, and location of the cover materials. The map also shows our wet weather operation site, roads, buildings, fencing, and utilities. This other plan shows how we're planning to use the site after filling is completed. The grades shown on the plan were set so the completed site can be used as a park.

Show a simplified layout of the ultimate site plan.

CUT TO: Foreman introduces weighmaster to Larry inside the scale house.	FOREMAN: Larry, I'd like you to meet Meyers, our weighmaster. NARRATOR: Mr. Meyers, how are you? Nice to meet you.
Daily truck weight record forms.	FOREMAN: Every load of trash brought in here is weighed and the amount recorded on these forms. After calculating the charges for disposal, he instructs the driver to follow the signs to the dumping area.
CUT TO: One or more trucks come through and are weighed as foreman speaks.	
Weighmaster in action.	It's important for us to know the rate at which the available space in our landfill is being used up and to keep track of where our income is coming from. The regulatory agency here also requires us to keep certain records on our operation.

We charge based on the tonnage of trash delivered, so we've got to maintain accurate records.

We can determine from these records where our costs lie in order to minimize expenditures. The Federal Government has provided us with these forms to help organize our records for this purpose.

NARRATOR: By the way, Jack, I've heard that sanitary landfills have a very poor accident record. What's your experience in this area?

FOREMAN: Actually, Larry, a sanitary landfill is relatively safe. It is the dumps that have the poor safety record. Our operating practices help eliminate accidents. We also have emergency procedures

Telephone in scale house

to follow. A pickup is always on duty at the fill. In any emergency, word can reach me here in a matter of a few minutes. When it does, I can get an ambulance here within minutes.

NARRATOR: No first aid?

FOREMAN: Yes, we have one trained first aider on the job. He mainly treats for minor cuts and bruises. For anything more serious we call on professional help.

NARRATOR: Does the landfill have to be fenced?

CUT TO:

Exterior of HQ building. Narrator and foreman come out the door, go to the pickup truck, climb in and drive to entrance.

FOREMAN: Yes, because we have to control access. The entrance must have a gate so that vehicles can't get into the fill when it is

closed. This protects us against the possibility of lawsuits from people who might wander in here and get hurt.

CUT TO:

Entrance with dump boxes, fence, and landscaping.

We have these drop boxes for people who get out here after we close. The drop boxes are emptied back at the fill each morning. C'mon, let's go back there, and I'll show you how we landfill.

DISSOLVE TO:

Pickup arrives at the working area. They climb out.

CUT TO:

Bulldozer is pushing refuse. An earth bank is visible adjacent to the exposed refuse.

We're standing on a 30 ft refuse fill. That mound over there is yesterday's refuse covered with earth. It's what we call a "cell." A cell is simply refuse surrounded on all sides by earth. And over here is where we're building one today.

CUT TO:

Establishing shot from the operator's POV. As the foreman talks, intercut various shots of the proper spreading and compacting of refuse.

FOREMAN: As you can see, we're compacting on a 3 to 1 slope. We spread the refuse from the bottom up, keeping the working face as small as possible. The trucks unload right at the toe of the slope.

NARRATOR: Why can't they dump at the top?

FOREMAN: They could, but unloading at the bottom and pushing up gives us better compaction, leaves the top free for covering, reduces blowing litter, and is easier on the operator and the machine.

NARRATOR: How is the equipment affected?

FOREMAN: Well, tractors are designed to work more efficiently when moving forward. That's because the rear sprockets, which do all the work, are pulling the bottom of the track when it's tightly held down by the weight of the tractor. When in reverse, it's pulling the loose part of the track. Tractor wear is increased whenever it moves in reverse. This wear is increased even more whenever the tractor pushes refuse down a slope and then has to go in reverse up the slope.

NARRATOR: How do you get good compaction?

FOREMAN: We get the best compaction when the waste is spread in layers 2 ft thick on a 3 to 1 slope

and then run over 3 to 5 times before adding another layer.

NARRATOR: How do you know when you're working on the right slope?

FOREMAN: The dozer can climb it with a blade-load without over-working. If it's too steep, we have to go to another gear and the tracks start spinning and lose speed. It's a matter of feel.

NARRATOR: Before that refuse is compacted, it looks pretty loose. How do you keep it from getting away from you in the wind?

CUT TO:

Narrator and foreman are standing at or near the face of the fill.

FOREMAN: Larry, I'm glad you asked me that question. Because it's here that the public loses confidence in a landfill and where most

operators fail. It's really quite simple. First of all, we make use of the wind by working the face of the cell into it. In this way, the wind presses the loose paper against the rough surface of the slope.

Foreman sketches cell face and wind direction in dirt at their feet for illustrative purposes.

FOREMAN: We know the direction of prevailing winds here. So we set up portable fences downwind of the working area. We use two types: those 10 footers are pulled from spot to spot. Hog fences are used where we need to cover a relatively large area.

Camera PANS to both types of fences.

You've got to make sure the fences are kept clean. Otherwise they act as a barrier to the wind, which then simply moves over them.

Then too, we keep the working face as small as possible.

NARRATOR: And how do you do that?

CUT TO:

CU of spotter directing trucks to the proper place for dumping. Spotter is wearing an orange vest.

FOREMAN: First, by being aware that if left uncontrolled, the working face can easily get spread out. That's the "spotter's" responsibility.

NARRATOR: What is spotting?

FOREMAN: Spotting is like traffic directing. When trucks are coming in heavy, they have to know where to dump. We try not to delay the trucks. The homeowner with his small trailer can be a problem; most don't know how to back up to the fill. The spotter can be helpful here and prevent collisions. During

Car with small trailer arrives; spotter walks over to give assistance in backing the trailer to the fill.

Return to narrator

slack times he also fills in as our laborer cleaning litter fences and even goes outside our property to pick up litter. He also runs our water truck.

NARRATOR: Is that all there is to spotting?

FOREMAN: No. Sometimes we get a "hot load" . . . that is a truck with a fire somewhere in the refuse. We have to put him off in a separate area where he can dump out of the way.

CUT TO:

Burning of refuse.

NARRATOR: Then what?

Camera PANS to water truck parked near the fill area.

FOREMAN: The dozer spreads the load right out and we put out the fire with the water truck. We also call the fire department.

NARRATOR: Then does the refuse go into the fill?

FOREMAN: Not until the end of the shift, when we're sure the fire is out and won't start again. It could spread to the whole face, you know.

NARRATOR: Anything else?

FOREMAN: Sometimes a load of bulky stuff comes in . . . white-goods, tree trunks, you name it.

NARRATOR: And what do you do with that?

A truck dumps its load of white-goods, the dozer rolls over it a number of times and then walks it into the toe of the fill.

FOREMAN: We have him dump to one side of the working face. Then the dozer smashes the stuff by walking over it. It is then worked into the bottom of the lift. By doing it this way, the dozer won't

dig it out the next time he comes along.

NARRATOR: What other problems do you have?

FOREMAN: Well, we have to operate 52 weeks a year in good weather and bad. If we stopped for rain, snow, or cold weather, the entire fill would get out of control.

NARRATOR: So what do you do?

He points.

CUT TO:

Wet weather site. We don't see the narrator and foreman, but everything we do see is from their POV.

FOREMAN: We have a wet weather site. It's over here. Come on--we'll have a look.

As you can see, most of the roads are temporary dirt roads and the refuse is covered with dirt. In wet weather they get muddy. So we do two things: we fill in an

View illustrating proximity of fill area to access roads

Stockpiles of surfacing materials.

area near our all-weather blacktop roads, and surface the access roads and dumping pad with asphalt burnings, klinker from nearby power plants, or perhaps broken-up rubble from construction sites.

CUT TO:

Stockpile of cover material adjacent to the wet weather site.

We also stockpile cover earth near the wet weather site to cover the refuse daily. And by the way, it's a lot easier to do this work during dry weather.

NARRATOR: If you have to be that prepared for wet weather, what do you do during cold weather and heavy snows?

FOREMAN: Actually, Larry, snow and cold weather is not such a problem. Do you remember last winter?

NARRATOR: I'll never forget it; I couldn't get to work for nearly a week.

FLASHBACK:

Clearing snow.

(Snow scenes shot at the Heaps Peak site in the San Bernardino mountains. The site to the extent possible, resembles at least to the movie watcher, the other sites shown previously.

FOREMAN: Our major problem was keeping the roads open. A lot of time was spent by our operator clearing snow drifts from the roads and dumping areas.. Aside from this, operations were not much different from any other time.

Show operations in the snow.

Show snow-covered stockpile, and the machine pushing soil cover over the landfill.

Cover dirt is stockpiled near the fill prior to cold weather setting in. It is spread over the rubbish every day. As long as snow covers the stockpiled cover dirt, it doesn't freeze. We've had problems in years when we got cold weather prior to the snows. The earth

cover froze, and we had to rip the earth to loosen it.

NARRATOR: I don't imagine the equipment operators like winter operations.

FOREMAN: Actually, they're better protected than anyone else out here. The machines have heated cabs. Operator efficiency drops off due to restricted visibility mostly when the wind blows snow.

Return to present time CU of dozer cab.

NARRATOR: Seems to me that this operation is rough on equipment.

FOREMAN: Man, you're not wrong there. All of our equipment has special accessories to guard against damage, and we still have to check them regularly.

We house our equipment in that building to protect it against vandals and the elements. The building is heated so that the operator can perform routine maintenance and minor repairs anytime regardless of the weather. We have to keep the machines going to maintain a sanitary land-fill. Preventive maintenance is absolutely necessary. I insist that repairs be made immediately before a minor defect becomes a major breakdown which is costly to fix and can extend down time.

DISSOLVE TO:

Dozer and scraper going up to working area from building area.

FOREMAN: Well, it looks like we're ready to start covering.

NARRATOR: Why is cover necessary?

CUT TO:

Excavation site. Follow a pull-type scraper as it picks up a load and hauls it to the face. The same dozer seen earlier on refuse is pulling the scraper.

During this conversation intercut various shots of spreading and

FOREMAN: Actually it's one of the most important elements of a sanitary landfill. By covering all the refuse with earth, the site looks neat and the cover keeps paper from blowing around.

Earth also helps to prevent fires by sealing off the combustible material within each cell. This way if a fire should break out, it won't spread to adjacent cells.

Without daily cover, the refuse would draw rats and insects. You want to get it sealed before it gets to rotting and smelling bad. Rats won't come around or stay around if there's nothing to eat. So cover keeps the landfill sanitary.

The ideal cover is something that can be excavated easily on-site,

compacting operation for cover.

spread and compacted evenly, and won't be too slippery when wet; yet contains enough moisture to prevent dusting. But you seldom have such ideal conditions. We have to rip some of our cover soil, and when we use rocky soil, we've got to lay down more to get equivalent cover.

NARRATOR: How do you know how much cover to put on?

Medium-distance shot of spreading soil cover and then a CU showing the working face with the first course of soil and some paper showing through; then zoom back to MD and show second thin layer being placed. No more refuse shows through.

FOREMAN: If you can see refuse through the cover earth, you need more. Normally, it takes about 6 inches to cover the cell to hold its shape and keep the refuse in. It's sort of up to the operator's judgment how much it takes to get this amount of cover. It's something he gets a feel for after awhile.

Then show dozer compacting soil by rolling over it.

When a fill is completed--that is, when it is brought to finished grade--we put on at least 2 feet of final earth cover.

NARRATOR: The refuse is worked from the bottom up, but it looks like you place the earth from the top down. Why is that?

Show a shot of a machine pushing stockpiled soil down slope.

FOREMAN: Well, flexibility I suppose. You want to keep the stockpiled earth out of the way of the delivery vehicles but close enough to where it's needed. We bring it during the day when refuse deliveries are slow. Having earth at the top is especially helpful on windy days because you can cover the refuse as needed rather than waiting till the end of the day. Bear in mind that earth is heavy

compared to refuse, and it's easier to drift earth downhill feathering it as you go.

CUT TO:

Narrator and foreman

NARRATOR: Jack, when we talked over the phone, you said you had another site. Is it like this one?

FLASHBACK TO:

Overall shot showing a small trench landfill in operation. Enough of the area is shown to indicate that the land is flat with no hills for cover.

FOREMAN: No, on that site I use the trench method of landfilling. There are no available canyons for filling, so I excavate a trench to place the refuse in and use the excavated material for cover.

CU of rig working refuse in trench. Show CU of truck dumping at bottom of trench.

CU dozer spreading refuse and then covering it with soil stockpiled near face.

For the trench method, the refuse is placed in the trench, compacted, and then covered with earth just as it is in the area method used here.

DISSOLVE TO:

CU Narrator.

NARRATOR: Well, I guess that covers it for me.

Equipment operator is walking toward narrator and foreman.

FOREMAN: Before you go, I'd like you to meet my equipment operator. He's a key man here on our landfill.

Hey, Dick, do you have a minute? I'd like to introduce you to Larry Burrell. Larry is out here doing a story on our operation.

Shaking hands.

NARRATOR: How do you do Dick. I understand that you've been on the job quite some time. How do you like it?

OPERATOR: Good. I know what I have to do every day, and how it's supposed to be done. I take the attitude that it's something constructive, something to be

CUT TO:

Shots of playgrounds, parks, ball field.

proud of. Some of the operators may think landfill is just a fancy dump. Me . . . I think it's a good operation, and an important one. It's taking nearly useless land and making something useful out of it. When this fill is finished, I can bring my family up here for a picnic, and let them share a little of the pride that went into making this sanitary landfill one of the best in the country.

FOREMAN: Many of the improvements you have seen were the suggestion of Dick and other men out here. We may be the operators, but I like to think that some day the public will realize the value of sanitary landfilling, too. Thanks very much, Dick.

CUT TO:

Narrator and foreman are standing outside the scale house. A packer truck is traveling out of the site.

There's a feeling of constant movement and progress on a sanitary landfill. No matter where you look, everybody is on the job. That packer's been here twice today. We've got to hustle to keep up with the deliveries. Efforts at resource recovery are helping to reduce the amount, but there will always be some material left over for land disposal. Nobody within sight or sound of this project can be offended by what he sees or hears. Everybody who works here understands that.

CUT TO:

Narrator shakes hands with Jack.

NARRATOR: Thanks a lot for the tour of your sanitary landfill, and congratulations on the way you've improved it. As far as I'm concerned, sanitary landfilling is here to stay.

FOREMAN: We're always glad to have visitors. We're proud of what we're doing.

View of car driving out of gate and down the road.

MUSIC

DISSOLVE TO:

Finished landfill, in use as a public park. There is action on the site, such as boys playing catch. As we watch this action, a series of fast intercuts are shown, "playing back" what it took to make this landfill. Progressing from building access road, truck traffic at scale, spreading refuse, spotting, covering, and planting.

CUT TO:

Full screen freeze of the finished landfill as botanical gardens. Hold

MUSIC. HOLD UNDER UNTIL END, THEN UP AND OUT.

on this picture as credits roll,

followed by EPA logotype.

AND OUT.

A Final Municipal Waste

Disposal Facility

ゴミの収集

Collecting discharged wastes

Q1 Every home discharges wastes daily, and the amount of waste seems to be increasing everyday and every year.

Q2 The disposal of wastes is generally the responsibility of local city governments.
Some wastes can be burned in a plant, but ashes still remain.

粗大ゴミ破砕プラント

Conpression plant of 粗大ゴミ

Q3 Plastics or styro foam cannot be burned because they produce poisonous gas. Refrigerators, bicycles, and othersuch items cannot be burned either and they are too big to handle easily. These incombustible wastes are crushed and shreaded to a manageable size. All of the ashes, crushed and shreaded wastes must then be dumped and burried somewhere. But where? That is the problem.

トラックが出ていく

Truck is leaving.

Q4 It is always very difficult to locate garbage disposal sites because nobody likes to have one in their neighborhood, and because it always creates controversy among the community people.

タイトル

Title

A Final Municipal Waste Disposal Facility

:

砂利採掘の跡地

Abandoned quarry

Q5 This is an abandoned quarry which is in Hamura-city beyond the suburbs of Tokyo.
The quarry covers an area of about 21,000 square meters. Nine cities in the surrounding area established a Waste Disposal Management Union and reached an agreement with Hamura-city to construct a final municipal waste disposal facility here.

今にも崩れそうな周りの崖

Unstable slope

Q6 In order to utilize the abandoned quarry for the construction of a waste disposal facility, the construction must be done in compliance with the relevant laws and regulations, and without causing any conflicts with the people in the vicinity.

起工式の情景

~~Opening~~ ceremony
Earth breaking

Q7 An ~~opening~~ earth breaking ceremony for the construction was conducted by the Waste Disposal Management Union on May 15, 1980.

Q8 It's been three years since the announcement of the plan to construct the facility here. More than fifty meetings had been held with the people in the vicinity before an environmental protection agreement was signed by the parties.

公害・防止協定書

The environmental protection agreement

Q9 The intent of the agreement is to protect the citizen's health and the environment from possible pollution created by the waste disposal facility. The agreement consists of nine clauses which specify the facility's system and maintenance requirements, the method of disposal, and the rights and the duties of the citizens.

工事開始・排水作業

Commencement of work, Drainage work

Q10 The construction work, done by Ohbayashi Corporation one of the leading contractors in Japan, started with the discharging of the water in the abandoned quarry.
This abandoned quarry, a huge hole, will be changed to a new waste disposal site.

Q11 After discharging the water from the hole, the bottom ~~is~~ needs to be compacted and graded.

法面整形・浮き石落し等

Grading slope, Removal of floating rocks

Q12 Since the slope, nearly twenty meters in height, had been exposed to rain and weathering for a long time, loose rocks had to be removed and uneven areas smoothed off.

整地作業

Grading work

Q13 Soft alluvium in the bottom of the hole is unsuitable for the heavy loads expected from the wastes, and therefore, must be mixed with suitable material to improve the bearing capacity.

Q14 Imported material is used for the mixing.

ダンプが土を運びブルドーザーが地均しをする。

Dump truck carrying material & Grading work by bulldozer

Q15 The imported material is thoroughly mixed with the alluvium and graded by bulldozers.

Q16 In this way, the bottom of the hole is made firm and stable for supporting wastes of more than 10,000 tons.

Q17 After wastes are deposited here, however, rainwater or groundwater will collect in the disposal area and will be contaminated by the wastes. The contaminated water must be pumped up and treated by a waste water treatment plant before discharge.

汚水処理施設

Waste Water Treatment Plant

Q18 Thus, the waste water treatment plant plays an important role for this facility. Here, the foundation work of the plant has begun.

図面

Drawings

Q19 The slopes will be stabilized by reinforced shotcrete and then a special lining will be placed to prevent water seepage and to properly contain the wastes. The bottom will be paved with an asphalt sealer.

Water within the disposal site will be collected by drainage pipes to a sump pit and then pumped up to the waste water tratment plant before discharge to the public sewage system.

ＯＶフィルターの施設

Installation of OV filter

Q20　50cm wide filter drains are to be installed under the shotcrete for drainage.

Q21　This filter is made of synthetic fabric containing spirals made of polyethylene. These filters drain water from the slope to the bottom of the disposal area, preventing failure of the slope due to water pressure.

ラス張り

Installation of wire mesh

Q22　After the installation of the filters, wire mesh is placed.

Q23　Here, mass production of shotcrete has begun by mixing cement and sand.

モルタル吹き付け

Spraying shotcrete

Q24　Now, shotcreting begins.

Q25　Shotcrete is sprayed on to the slope by compressed air.

処理施設工事

Construction of Water Treatment Plant

Q26 Construction of the water treatment plant is progressing as well.

そして吹き付け作業

Shotcreting

Q27 The thickness of the shotcrete is 6 cm. The workers are equipped with life lines on the 13m high slope.

Q28 In order to prevent water seepage and to properly contain the wastes, a double layer of water impermeable lining will be placed on top of the shotcrete layer.

排水ピット工事

Sump pit construction

Q29 Here you can see the foundation work of the sump pit for collecting contaminated water.

Q30 Re-bar has been installed.

Q31 The shotcreting has now been completed.

ＯＨシート第一層の不織布敷設（Page 5）

OH Sheet placing initial lining of nonwoven fabric

Q32 After the shotcrete is completely dried, placing of the initial layer of impermeable lining is started.

Q33 This method uses a 2 mm thick chemically made nonwoven fabric which will not decay when placed underground.

Q34 To provide water sealing, a synthetic rubber and asphaltic emulsion solution is sprayed on the fabric.

ＯＡの吹き付け作業

Spraying work of OA

Q35 Spraying of the "sealing" solution has started. The fabric and the shotcrete are strongly bonded together. This improves the stability of the surrounding slopes and enhances the waterproofing.

The representatives of related regional groups also observe and supervise the work progress.
Local inhabitants' cooperation and consent play an important part in the construction of the facility.

ピット工事
Construction of the pit

Q36 Above the sump pit, a chimney like structure has been installed. From here contaminated water will be pumped to the water treatment plant.

Q37 The control building for the water treatment plant has started to take shape.

二層目の不織布敷設
Placing second nonwoven fabric

Q38 Now, placing of the second layer of impermeable lining has started.

Q39 Here, the edges of the fabric are being overlapped.

Q40 The entire slope will be covered completely without any gaps.

二回目のＯＡ吹き付け（Page 6）
Second spraying of OA

Q41 The sealing solution is carefully sprayed in a uniform manner to maintain high quality.

Q42 (Deleted)

作画　：法面の工法

Introducing slope protection methods using illustration.

Q43　This kind of method is usually applied on slopes of various types of projects such as for reservoir slopes or slime disposal pits.

Q44　Slope protection work by hardening the slopes is completed in such a manner.

排水ピット側の盛土作業

Filling work at the sump pit side.

Q45　In the area around the sump pit, where installation work of inlets and drainage lines have been finished, backfilling work proceeds quickly.

The contaminated water will be transported to the water treatment plant through pipes coming out of the chimney-like structure.

テニスコート側の盛土作業

Filling work at the tennis court side

Q46 Filling work on this final remaining slope which consists of soft ground is taking place. This slope would likely collapse without improvement to make the slope more stable. Here, the soft ground is improved by adding lime to the fill material.

Q47 Of course, the same impermeable liner as was shown previously will be placed on this slope to form a completely impermeable slope protection wall.

最後の整地作業

Grading work (Final stage of construction)

Q48 Grading work at the bottom of the abondoned quarry is now mostly completed.

Q49 After grading the bottom, an asphalt sealer pavement is placed and various kinds of catchment facilities are provided as an extra measure to ensure that contaminated water will not flow out to the surrounding area.

Q50 Work proceeds smoothly.

排水処理施設（Page 7）
Waste water treatment facility

Q51a The control building for the water treatment plant is now completed. Main facilities for the plant are arranged underground. The only remaining work is to install the various required equipment.

洗車場
Car-wash

Q51b A truck-wash pit will also be completed soon.

ドレーンパイプの敷設
Installation of drainage pipe

Q52 Drainage pipes for collecting underground water are installed underneath the bottom of the disposal area. Unless the drainage pipes are provided, the asphalt pavement would be lifted up due to water pressure when the groundwater level is high.

Q53 The pipes are 80mm in diameter and are perforated with small holes to allow inflow of the water.

Q54 All the surrounding groundwater which infiltrates under the disposal area will be collected by these perforated drainage pipe.

Q55 The drainage pipe is backfilled with gravel to prevent clogging of the small holes with soil. The total length of perforated piping installed is 1,980 m.

アスファルト舗装
Asphalt pavement

Q56 The asphalt sealer pavement is placed above the installed drainage pipes.

アスファルトフィニッシャーによる作業
Work done by asphalt finisher

Q57 13,000m² of asphalt pavement is required to cover the entire bottom of the disposal area. The pavement is 10cm thick.

そしてロードローラー
Then, work is done by a roadroller.

Q58 The asphalt sealer pavement work is rigidly performed under strict quality control to prevent leakage of water from the bottom of the facility.

多孔管の敷設

Installation of perforated pipe

Q59 After completion of the asphalt pavement work, 300 mm diameter perfrated pipes are installed with gravel enclosed around the pipes.
Water pooled within the disposal area is collected and transported to the sump pit.

側溝部分

Ditches

Q60a At the foot of the slope, ditches filled with gravel are prepared to collect water coming from filter drains on the slope or from rainwater.

Q60b Check valves are installed in the ditches at 5m intervals.

逆止弁

Check Valves

Q61 These check valves, which allow underground water to flow up, protect the asphalt pavement from being damaged by water pressure when the groundwater level becomes high. At the same time, they also prevent contaminated water in the sump from flowing down and out.
Thus, careful consideration is provided in the design to avoid environmental pollution.

完成した処理場全景

Overview of completed waste disposal facility

Q62 All of the water from drainage pipes and perforated pipes is transported to the sump pit and then pumped up to the waste water treatment plant.

Q63 A new waste disposal facility is now finished, complete with a water impermeable liner and proper drainage.

開所式 テープカット

Tape cutting Ceremony

Q64 The tape cutting ceremony of the Waste Disposal Facility was held on Nov.1,1982.

ゴミの搬入開始

Commencement of Operation

Q65 The expected usable period of the disposal area is only 3 years. By then, it will ~~have been~~ be filled to capacity.

The limited and precious space will be used by nine cities and two towns.

It is necessary for people in the communities to give serious consideration to waste disposal problems and to make efforts to discharge less waste in the future.

消火栓　Fire hydrant
消化器　Extinguisher

Q66　For the facility, various fire fighting equipment have been provided in case of an emergency.

Q67　The waste water plant treats the contaminated water in accordance with standards for discharging into public waters.

投棄
Disposal

Q68　Only ashes from wastes which have been incinerated or inconbustible wastes which have been crushed and shreaded are allowed to be disposed at this site.

転圧
Compaction

Q69　Wastes are compacted by a special compactor.

Q70a　Various measures are taken to protect the enviroment around the facility.

出ていくトラック

Trucks are leaving.

Q70b Here, the wheels of the trucks carrying wastes to the site are washed before leaving the facility.

覆土

Soil covering

Q71 For every 3m of compacted waste material, a 50cm thick cover layer of soil is placed.

Q72 Disposal, compaction of wastes, and placing of soil cover are repeated in this fashion to manage the waste.

作業が続く

Treatment of waste is continued.

Q73a Thus, the huge waste disposal facility will be filled by municispal wastes.

Q73b The expense for this facility is paid by local taxes.

トラックが去っていく

trucks are leaving.

Q74 It is necessary for all of us to think and to discuss how to reduce the amount of waste.

Municipal wastes are becoming a more and more serious problem in our daily life.

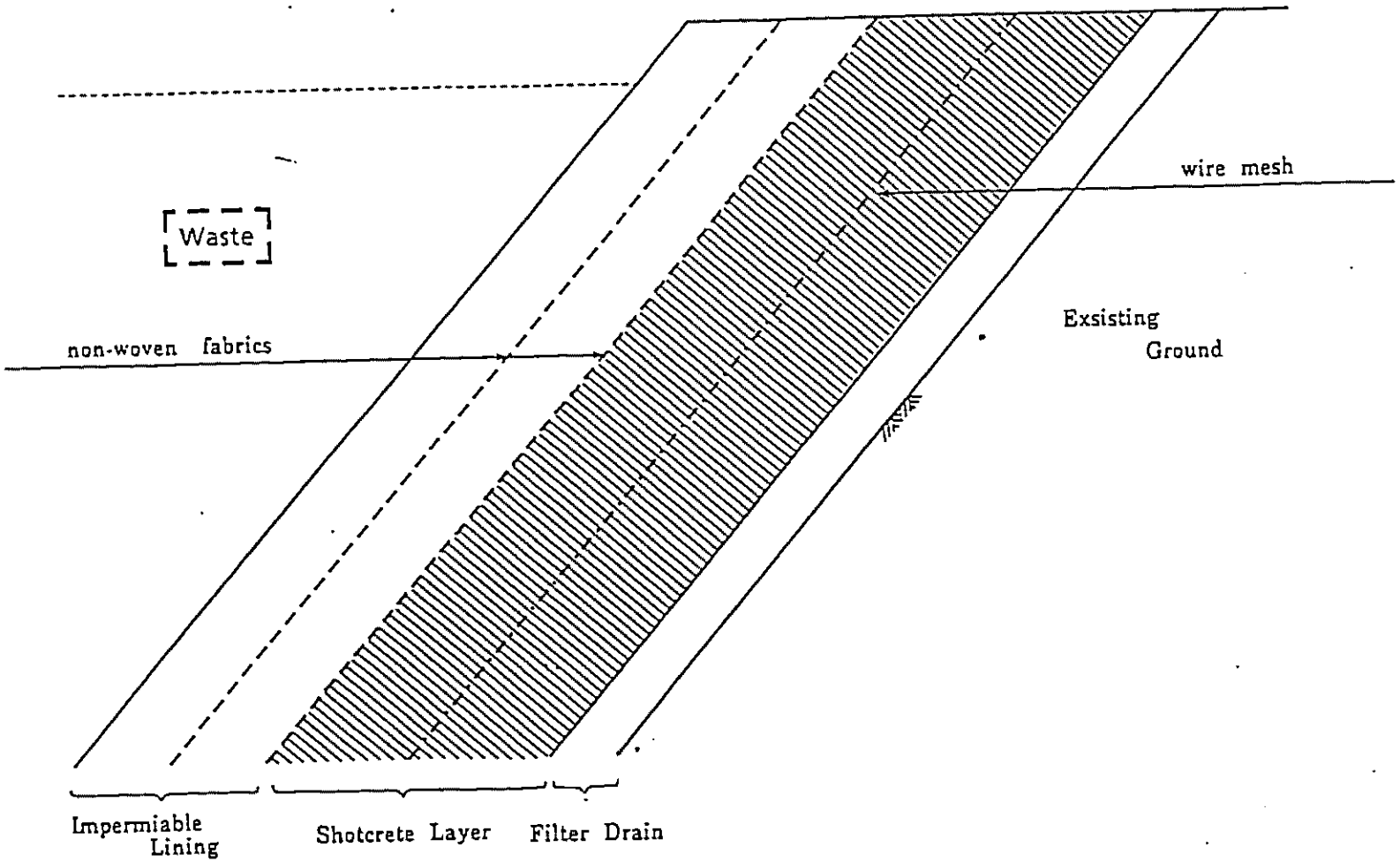
We must make an effort to produce less and reduce wastes.

It is important that we all consider waste disposal as a problem we should all participate in solving.

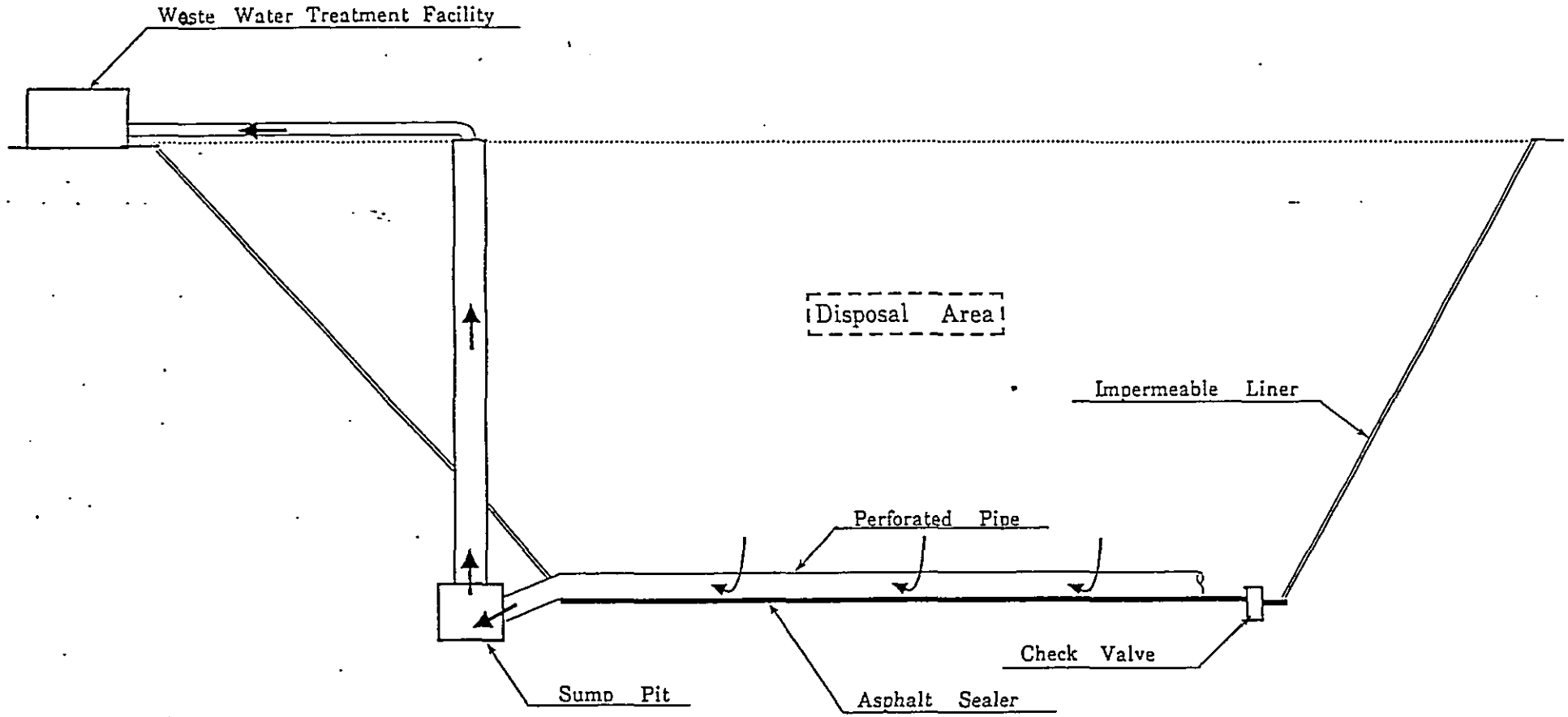
エンドタイトル

End Title

Standard Section of Slope



Profile of Disposal Site



MALAYSIA - JAPAN MEETING

ON

THE INDUSTRIAL - MUNICIPAL SOLID WASTE MANAGEMENT

KUALA LUMPUR

26 - 27 OCTOBER 1988

THE GOVERNMENT OF MALAYSIA

AND

JAPAN INTERNATIONAL CORPORATION OF WELFARE SERVICES (JICWELS)

1. INTRODUCTION

Inappropriate management of hazardous industrial wastes is becoming a very serious problem in many developing countries because of their rapid industrialization. Malaysia is no exception to this although the Government of Malaysia has been making tremendous efforts to establish their appropriate management system.

At present there are no specialized facilities in Malaysia for the treatment and final disposal of these wastes. As such they are requested to be stored by generating industries until the time of installation and operation of specialized facilities.

However, because of the soaring storage cost and weak monitoring system, some of these wastes may be dumped in municipal landfill sites or other clandestine places causing irreversible damages to the environment. To make the situation worse, Local Authorities are not prepared to deal with this situation technically and institutionally. The experiences in other countries show that even after the installation of specialized facilities this undesirable flow of hazardous wastes cannot be easily wiped out.

So far in Malaysia, almost all discussions on hazardous wastes have been had from the viewpoint of Federal Government. However, as understood from the above mentioned, it is also important to analyze this problem from the viewpoint of Local Authorities which are responsible for municipal solid waste management. And this new approach will pave the way to the close coordination between hazardous waste management and municipal solid waste management.

Under such circumstances, the Government of Malaysia through the Ministry of Housing and Local Government (MOHLG) and the Department of Environmental (DOE), and the Japan International Corporation of Welfare Services (JICWELS) which is now tackling the issues of industrial solid waste management in developing countries from the standpoint of technical cooperation have agreed to have a meeting entitled "Malaysia-Japan Meeting On The Industrial - Municipal Solid Waste Management" in order to analyze the hazardous wastes problems from the viewpoint of Local Authorities.

Considering that the first master plan study for municipal solid waste management is being carried out for the Municipal Council of Penang (MPPP) and the Municipal Council of Seberang Perai (MPSP) by JICA Penang Study Team and that the State of Penang is one of the most industrialized states in Malaysia with urgent necessity of appropriate hazardous waste management, this Meeting will use the case of Penang as an example with the aim of making the discussion more practical.

2. OBJECTIVES

2.1 To identify the "grey area" where the management responsibility or capability is not clear or sufficient through the review of both the hazardous and municipal solid waste management systems to be established by DOE and Local Authorities respectively.

2.2 To achieve the transfer of Japanese experiences both positive and negative in dealing with this grey area.

2.3 To develop general consensus about the actions to be made to deal with this grey area in Malaysia.

3. TOPICS TO BE DISCUSSED

1A : National stragegy for municipal solid waste management

1B : National strategy for hazardous waste management

1C : Identification of "grey area" (discussion only)

2A : Conceptual framework of municipal solid waste management master plan for MPPP and MPSP

2B : Actual situation of hazardous waste management in the State of Penang

2C : Positive and negative experiences in the control of the inflow of hazardous wastes into municipal landfills including the control of illegal dumpings

3 : Question of co-disposal of industrial and municipal solid wastes

4 : Experiences on hazardous household waste management

5 : Monitoring of environmental pollution caused by municipal landfills

4. METHODOLOGY

4.1 This Meeting will be carried out using the following methods :

4.1.1 Paper presentation (At least one paper will be presented on each topic aforementioned except the topic 1C.)

4.1.2 Round table discussion under the chairmanship of moderators

4.1.3 Drafting of conclusions and recommendations (Drafting will be left to the drafting committee. The members whereof will be appointed during the Meeting.)

4.2 Ten (10) papers will be presented by the agencies and on the topics as shown below :

4.2.1 Ministry of Housing and Local Government (MOHLG) (Malaysia) 1A

4.2.2 Department of Environment (Malaysia) 1B, 2B

4.2.3 Municipal Councils of Penang and Seberang Perai (MPPP and MPSP) 2C

4.2.4 JICWELS ..... 1A + 1B, 2A, 2C, 4, 5

4.2.5 PEPAS/WHO 3

4.3 Four (4) moderators from MOHLG, DOE, JICWELS and PEPAS (one each) will chair the Meeting (half day each).

4.4 Rapporteurs will be assigned from the staffs of MOHLG and DOE.

4.5 The Technical Section of the Local Government Division, MOHLG will work as the Secretariat of the Meeting.

4.6 The tentative programme of the Meeting is given in Appendix.

5. PARTICIPANTS

5.1 Twenty (20) persons will be invited to sit at the round table including the moderators and speakers. The breakdown is as follows :

5.1.1	MOHLG	3
5.1.2	DOE	3
5.1.3	MOH	1
5.1.4	EPU (Social Section)	1
5.1.5	Penang State Government	1
5.1.6	MPPP	2
5.1.7	MPSP	2
5.1.8	JICWELS	5
5.1.9	PEPAS/WHO	2

5.2 Approximately thirty (30) observers will be invited from Federal and State Government, Local Authorities and other related agencies. Observers may be allowed to participate in the discussion if the moderators think it is convenient.

5.3 The total number of participants will be around fifty (50).

6. TIME AND PLACE

6.1 This Meeting will be held from 26 to 27 October 1988 at United Nations Room, Regent Hotel, Kuala Lumpur.

7. DEADLINE FOR PAPER SUBMISSION

7.1 All papers should not exceed thirty (30) pages (A4 double space). Malaysian writers should submit their papers to the Secretariat by 30 August 1988.

APPENDIX

Programme of
Malaysia-Japan Meeting On The Industrial - Municipal Solid Waste Management

Kuala Lumpur, 26 - 27 October 1988

Time / Date	Morning	Afternoon
26 October 1988 (Wednesday)	- Registration - Inauguration - Topics 1A and 1B	- Topics 1C and 3
27 October 1988 (Thursday)	- Topics 2A, 2B and 2C	- Topics 4 and 5 - Closing

(First Draft)

SEMINAR/WORKSHOP
ON
THE FORMULATION AND IMPLEMENTATION OF
MUNICIPAL SOLID WASTE MANAGEMENT MASTER PLANS
27 - 31 March 1989

June 1988

Technical Section
Local Government Division
Ministry of Housing and Local Government

1. INTRODUCTION

Solid waste service is the most expensive service in many Local Authorities in Malaysia. Although substantial amount of resources are committed to this service every year, its cost-effectiveness is very doubtful because of the lack of appropriate planning at short-term, middle-term and long-term levels.

As such, the formulation and implementation of municipal solid waste management master plans has been adopted as one of the most important strategic programmes in the recently launched Action Plan for a Beautiful and Clean Malaysia (ABC).

Through this programme (Programme 3 : Master Plans for all Municipal Councils), ABC tries to formulate and implement master plans in all Municipal Councils in Peninsular Malaysia (15 in total) by 1995. The first step of this programme is the formulation of a model master plan which is now being carried out by a JICA Study Team for the Municipal Councils of Penang and Seberang Perai. Also in the first step, a part of the immediate improvement plan will be put into practice even before the completion of the study. The second step is to trasfer this valuable experiences and know-how of master plan formulation and implementation from the aforementioned two Municipal Councils to the remaining thirteen Municipal Councils and from foreign consultants to local consultants.

As a part of the above mentioned second step, a five-day seminar cum workshop will be held in Georgetown in March 1989 in conjunction with the submission of Draft Final Report of the Study under the auspices of Japan International Cooperation Agency (JICA) and the Malaysian Government.

2. OBJECTIVES

2.1 To publicize through one day seminar the conclusions and recommendations of the Solid Waste Management Study for Pulau Pinang and Seberang Perai Municipalities.

2.2 To convince the delegations of fourteen (14) Local Authorities with the imminent necessity of master plan formulation and implementation through a four-day workshop.

2.3 To give a practical guidance on master plan formulation and implementation to the delegations of fourteen (14) Local Authorities as well as local consultants through a four-day workshop.

2.4 To get the delegations of fourteen (14) Local Authorities to prepare respective action plans for the formulation and implementation of master plans.

3. VENUE AND DATE

3.1 Venue : An international hotel in Georgetown

3.2 Date : 27 - 31 March 1989

Seminar (27 March 1989)
Workshop (28 - 31 March 1989)

4. PARTICIPANTS

4.1 Seminar (27 March 1989)

- Member agencies of the Steering and Technical Committees of the Master Plan Study for MPPP & MPSP
- Delegations of all Municipal Councils and Dewan Bandaraya Kuala Lumpur

- Local universities
- Vehicle and equipment manufacturers
- Mass medias

(100 - 150 in total)

4.2 Workshop (28 - 31 March 1989)

- Delegations of all Municipal Councils and DBKL : Each delegation consists of the Secretary (or Deputy Secretary) and the Director of Health Department (or Urban Services Department). (16 x 2 = 32)

- Local consultants (8) (40 in total)

5. PROGRAMME

A tentative programe of the five-day seminar cum workshop is shown in ANNEX 1

6. HANDOUTS AND TRAINING MATERIALS

In the seminar, the copy of executive summary of the Draft Final Report will be distributed as a handout. (Subjected to the approval of EPU and Penang State Government)

In the workshop, a 50 page manual for the formulation of municipal solid waste management master plans will be distributed to the participants. This manual will be developed by JICA Study Team and their Malaysian counterparts based on the experience of the Study.

7. GROUP WORK

Fourteen (14) delegations will be requested to work out actions plans for the formulation and implementation of master plans for their respective Local Authorities through the group work. The staffs of MPPP, MPSP and the Technical Section as well as JICA Study Team members and local consultants will be attached to these delegations as resource persons forming fourteen (14) groups in total.

The guideline for the preparation of action plans will be shown in the first session of 28 March 1989 (Mechanism of the Workshop). Because of the limitation of time, only four (4) groups will be given a chance to present their action plans in the last session of 31 March 1989.

8. FINANCING

It is hoped that all the costs of the five-day seminar cum workshop except the ones for travel and accomodation of Malaysian participants be kindly covered by JICA.

ANNEX 1

PROGRAMME

27 March 1989 (Monday)

08 : 00 - 09 : 00	Registration
09 : 00 - 09 : 30	Inauguration : Speeches by - JICA Resident Representative - Penang State Secretary - Secretary General of the Ministry of Housing and Local Government
09 : 30 - 10 : 00	Coffee Break
10 : 00 - 10 : 30	Presentation of ABC (by the Technical Section of the Local Government Division Ministry of Housing and Local Government)
10 : 30 - 11 : 00	An overview of JICA Study (by Prof. Naito, Chairman of JICA Advisory Committee)
11 : 00 - 11 : 45	Presentation of the Master Plan (by JICA Study Team)
11 : 45 - 12 : 30	Presentation of the Feasibility Study (by JICA Study Team)
12 : 30 - 14 : 00	Lunch
14 : 00 - 14 : 10	Comments from MPPP
14 : 10 - 14 : 20	Comments from MPSP
14 : 20 - 14 : 30	Comments from Penang State Government
14 : 30 - 14 : 40	Comments from the Ministry of Health
14 : 40 - 14 : 50	Comment from DOE
14 : 50 - 15 : 00	Comments from the Ministry of Housing and Local Government
15 : 00 - 15 : 15	Coffee Break
15 : 15 - 16 : 00	Q & A
16 : 00 - 16 : 15	Closing

28 March 1989 (Tuesday)

08 : 30 - 09 : 00	Mechanism of the Workshop (by the Technical Section)
09 : 00 - 10 : 00	Lecture 1 : Flow-diagramme of master plan formulation and implementation (by JICA)
10 : 00 - 10 : 15	Coffee Break
10 : 15 - 11 : 15	Lecture 2 : Present condition survey (by JICA)
11 : 15 - 12 : 15	Topic 1 : Solid waste analysis (by the staffs of MPPP)
12 : 15 - 13 : 45	Lunch
13 : 45 - 17 : 00	Field visit (MPPP)

29 March 1989 (Wednesday)

08 : 30 - 09 : 30	Lecture 3 : Identification of problems (by JICA)
09 : 30 - 10 : 30	Topic 2 : Collection productivity improvement based on the use of a weighbridge (by the staffs of MPSP)
10 : 30 - 10 : 45	Coffee Break
10 : 45 - 11 : 45	Lecture 4 : Projection of planning framework (by JICA)
11 : 45 - 13 : 15	Lunch
13 : 15 - 18 : 00	Field visit (MPSP)

30 March 1989 (Thursday)

08 : 30 - 09 : 30	Lecture 5 : Determination of reasonable service level (by JICA)
09 : 30 - 10 : 30	Lecture 6 : Possible system alternatives and their advantages and disadvantages (by JICA)
10 : 30 - 10 : 45	Coffee Break
10 : 45 - 11 : 45	Lecture 7 : Selection of the cost-effective, technically feasible, environmentally sound and socially implementable combination of system alternatives (by JICA)
11 : 45 - 12 : 45	Lecture 8 : Formulation and implementation of the Immediate Improvement Plan (by JICA)
12 : 45 - 14 : 00	Lunch
14 : 00 - 15 : 00	Lecture 9 : Feasibility Study (by JICA)
15 : 00 - 17 : 00	Group work : Action plan formulation

31 March 1989 (Friday)

08 : 30 - 09 : 30	Lecture 10 : Implementation plan (Institutional and financial arrangement, personnel training, equipment procurement, etc.)
09 : 30 - 10 : 30	Lecture 11 : EIA of strategic facilities of solid waste management (by JICA)
10 : 30 - 10 : 45	Coffee Break
10 : 45 - 12 : 15	Group work (continued)
12 : 15 - 14 : 45	Lunch
14 : 45 - 15 : 45	Presentation of Action Plans (4 examples)
15 : 45 - 16 : 15	Closing