TECHNICAL GUIDELINES
ON
SOLID WASTE MANAGEMENT IN SRI LANKA

Prepared by

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Message of Chairman

Disposal of Solid Waste has become one of the major environmental issues in Sri Lanka. Dumping of garbage on road sides and sensitive areas such as wetlands, marshy lands, reservation etc. is a common practice adopted by the public and some local authorities. This is due to the attitude of people towards the disposal of garbage and the difficulties faced by the relevant institutions due to their inability to handle proper methods to solve the problem.

The difficulty in finding suitable lands by the Local Authorities for waste disposal, lack of technical knowledge in waste management, and public protest against the development of suitable lands and the financial restriction can be identified as the main problems confronted by local authorities in solving the waste problems. The increase in public complains and their contents indicate this situation.

This technical guideline is prepared to provide necessary information for proper handling of wastes form its point of collection to final disposal in an environmentally friendly manner.

Basically, these guidelines provide technical guidance required for the waste management and also focus attention on legal background in waste management. It is expected that these technical guidelines would guide local authorities which are the main institutions responsible for the solid waste management. Further, I expect this would help solve the waste problems in a sustainable way in order to maintain a clean environment.

I would like to appreciate the service of all the officers of Central Environmental Authority and other institutions who contributed to achieve this goal successfully.

Tilak Ranaviraja
Chairman
Central Environmental Authority

Message of Director General

"Solid Waste" has received a unique place in Sri Lanka. Everyone demands proper disposal of the garbage that each individual generates. However these individuals are not willing to contribute in finding solutions. In other words "solid waste" is "somebodies responsibility" other than the persons who is responsible in generating it.

In such a scenario the CEA initiated an action to develop technical guidelines that will enable any party interested in applying technical solutions to this ever increasing issue.

This document provides technical guide for waste collection, transportation, incineration, composting and sanitary land filling, and the proven technical options to solve the solid waste issue.

Further, it draws attention to legal background of solid waste management while introducing new colour code system for dustbins.

It is expected that these guidelines would facilitate proper solid waste management that will eventually minimize the negative environment effects.

Manel Jayamanna
Director General
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Acknowledgement

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PREAMBLE

Solid waste, especially Municipal Solid Waste [MSW], is a growing problem in urban areas of Sri Lanka and this problem is aggravated due to absence of proper solid waste management systems in the country. At present in many instances solid waste are collected in mixed state and being dumped in environmentally very sensitive places like road sides, marshy lands, low lying areas, public places, forest and wild life areas, water courses etc. causing numerous negative environmental impacts such as ground and surface water pollution, air pollution.

Further, the open dumps of solid waste are ideal places for breeding of disease vectors like mosquitoes. Haphazard throwaway and dumping of solid waste reduce aesthetic value and scenic beauty of the environment thereby creating negative visible impacts to human beings and badly affects tourism.

The rate of generation of solid waste in the society is increasing with the increase of population, technological development, and the changes of the life style of the people. National Strategy for Solid Waste Management [NSSWM] available at present highlights the importance of waste avoidance, reduction, reuse, and recycling and final disposal in an environmentally sound manner and still giving high priority for waste recycling over disposal. And also it is very important to separate waste at the source of generation to different components to facilitate subsequent waste management practices, especially recycling.

No comprehensive technical guidelines are available at present in Sri Lanka addressing all important elements of waste management systems. This guideline attempts to fill this gap as a general guidance to the investors, local authorities, and any other entity that initiate or operate any solid waste management activity in an environmentally sound manner adhering to legal obligations.

The present set of guidelines is aimed to cover only the municipal solid wastes. Therefore, sewage, hazardous waste including medical wastes and hazardous industrial waste do not come under the purview of this guideline. Various components of Solid Waste Management such as waste collection, waste transfer, recovery of useful components of solid wastes, waste incineration, composting, bio gas generation and land filling are covered in this guidelines giving a technical guidance to do these operations with minimal impacts to the environment.

A guidance has been given at the beginning on general requirements, legal requirements and operational requirements which are common to all components of solid waste management. Facility specific requirements applicable to each component have been addressed separately under the sub headings such as introduction, general requirements, design requirements and operational requirements for the convenience of the reader / user.

Criteria to be adhered to in, proposed colour codes for garbage bags, environmental standards for wastewater quality and air emissions, specification for compost and site selection for landfills are indicated in the annexures to this guideline.

N.B

1. ***This document contains only a guideline for solid waste management. Any information, in full as parts thereof contained in this document should not be used for any legal purpose***
2. ***Application of any appropriate environmentally friendly Technology regardless of the technologies suggested is promoted as long as it could meet the relevant standards specified in the annexure of this document***

TECHNICAL GUIDELINES ON SOLID WASTE MANAGEMENT

1 TARGET SOLID WASTE

1.1 Municipal Waste

- Domestic waste (exclusive of sewage and hazardous waste)
- Commercial waste (Market waste)
- Institutional wastes (schools, hospitals (non-clinical), public offices, etc.)
- Street sweeping and beach cleansing waste
- Garden waste (Tree cuttings and grass cutting wastes)
- Wastes collected from drains and water courses in urban areas

1.2 Construction wastes

1.3 Industrial wastes which can be accepted in municipal landfills (hazardous wastes are excluded).

2 GENERAL GUIDELINES

2.1 General requirements

Priorities must be given for promoting source separation and sorted waste collection .

In the waste management plan priorities must be given on waste recycling and resource recovery and to reduce the amount of final disposal

The existing recommended colour code must be used for waste collecting bins and garbage bags. (please see the Annexure A)

When handling biodegradable waste and waste not containing any toxic contaminants priorities must be given for biological processing such as composting, anaerobic digestion or any other appropriate biological processing for stabilization of waste.

Land filling shall be encouraged to non biodegradable, inert waste and other waste that are not suitable either for recycling or for biological processing.

Labour Ordinance, Factory Ordinance, other relevant regulations and guidelines stipulated by the Central Environmental Authority (CEA) approval procedures and relevant Local Authority approval procedures shall be followed. All designs shall comply with the requirements of relevant agencies

Operator should take adequate mitigatory measures to minimize possible pollution of air, water and soil.

Adequate training should be given to workers involved in solid waste management operations and operator should endeavour to involve trained workers as far as possible

Any person wishing to operate a solid waste disposal (including transfer station, materials recovery, incineration, composting etc) shall provide to the CEA the following information and any further information as may be requested by the CEA for approval procedure.

2.1.9.1 A topographic map showing the location and boundaries of the proposed site and land use within one Kilometre radius of the proposed site

2.1.9.2 A clear lay out plan with appropriate scale showing full details of the proposed locations for different activities.

2.1.9.3 The capacity of the facility, all machineries and equipments to be used in the facility, operating hours, number of working days, number of workers for each activity.

2.1.9.4 The details of the operation flow diagram for the proposed facility, origin, composition, and expected weight or volume of solid waste to be accepted as well as the projected waste quantity expected in future years.

2.2 Legal requirement

2.2.1 If any of the solid waste management facilities mentioned hereinafter meets the requirement of the Gazette (Extra Ordinary) No. 772/22 of 24th June 1993 and the subsequent amendments, then it shall follow the Environmental Impact Assessment Process in order to obtain the environmental clearance.

2.2.2 The noise levels shall be maintained at the boundaries of the site as stipulated in the Gazette (Extra Ordinary) No. 924/12 dated 23rd May 1996.

2.2.3 Effluents or leachate quality should be monitored and treated to conform to the standards / tolerance limits as mentioned in the Annexure B

2.2.4 Prior approval for the building plan needs to be obtained from the relevant Local Authority

2.2.5 An environmental recommendation prior to initiate any activity and a permit for construction and operation of the facility shall be obtained from the CEA

2.3 Operational requirement

2.3.1 Authorized officer shall be on duty during operating and non-operating hours at the waste reception point to control unauthorized access. (This is not applicable in the case of Waste Collection System)

2.3.2 Any infectious waste or hazardous waste should not be accepted into the facility. A proper screening procedure or mechanism shall be established for preventing the solid waste from the infectious waste or hazardous waste that may be mixed.

2.3.3 Litter, insects, odour and vectors shall be controlled to prevent sanitary nuisance and unsightly appearance.

2.3.4 Adequate fire protection shall be installed and available at all times.

2.3.5 A contingency plan to cover the machine / vehicle breakdown or any operation interruptions and delay.

2.3.6 Attention should be given to collect and transport obnoxious waste separately as much as possible

3 Waste collection

Introduction

Waste collection is the act of picking up wastes at homes, businesses, institutions, commercial and industrial plants and other locations; loading them into a collection vehicle and hauling them to a facility for further processing or transfer to a disposal site. Collection of wastes is the one of the basic elements of any waste management system.

Collection of unseparated (commingled) and separated solid waste in an urban area is difficult and complex because the generation of wastes takes place in every house, every apartment building and commercial and individual facility as well as in the streets, parks, and even vacant areas. Therefore in any waste collection operation it is important to look into; types of waste collection services/systems, type of equipment to be used and associated labour requirements, collection routes etc.

Any person wishing to operate a waste collection system shall have the following information under 3.1

3.1 General Requirements

3.1.1 The waste collection areas and transport routes, the number and type of the collection vehicles to be used, frequency of waste collection and the schedule for collection and transport.

3.2 Design Requirements

3.2.1 Specifications of all machineries, equipment and vehicles to be used in the facility.

- Type, numbers, capacities shall be detailed.

- Collection vehicles shall be fully covered and leachate collection box shall also be prepared to prevent littering and leachate spill during transportation.

3.3 Operational Requirements

3.3.1 Heavily travelled roads should not be served or used during rush hours.

3.3.2 Any infectious waste or hazardous waste should not be accepted into the normal waste collection vehicles

3.3.3 Daily records of the quantity of solid waste collected, the origin of waste, the quantity of solid waste transferred to disposal site, shall be maintained.

4 TRANSFER STATIONS

Introduction

After collecting wastes, wastes has to be transported either into a material recovery facility/Further processing facility or a landfill facility. Transfer means the act of transferring wastes from the collection vehicles to larger transport vehicles. A transfer station is necessary to transfer waste from smaller collection vehicles to larger transport vehicles for movement to a processing facility or a disposal area, usually a landfills. In some transfer operations compaction or separation may be done at the station

Any person wishing to operate a transfer station shall have, in addition to the relevant information stipulated under 2.1.9, the following information under 4.1.

4.1 General Requirements

4.1.1 The collection and transport routes, the number and type of the transfer vehicles to be used, frequency of waste transfer and the schedule for collection and transport.

4.2 Design Requirements

4.2.1 Design of the proposed structures and areas designated for unloading, storage, compaction and loading which are in an enclosed building or covered areas with all the instruments or devices must be installed for ventilation and controlling dust, litter and odour.

- The proposed unloading area in the transfer building shall accommodate at least two times of the hourly-average number of incoming collection vehicles of the normal weekday.

- Provisions may be made for weighing or measuring all incoming and transferred solid waste

4.2.2 Specifications of all machinery, equipment and vehicles to be used in the facility.

- Type, numbers, capacities shall be detailed.

- Large transfer vehicles shall be fully covered at loading compartment and leachate collection box shall also be prepared to prevent littering and leachate spill during transportation.

4.2.3 Design of the on-site road ways, odour controlling mechanism, transfer route of transfer vehicles to the disposal site and the efficient on site traffic control system. The designed site roads shall be either asphaltic concrete or reinforced concrete type. The minimum width of the one way road is 3.5 meters and 6.0 meters for the two way traffic road.

4.2.4 Design of an efficient storm water management system. Storm water discharged from the facility shall be free of components which pose a serious danger to the environment.

4.2.5 Design of wastewater treatment system for treating the effluent to achieve the of legal requirements

4.2.6 Design of other necessary components as appropriate to the allocated area, i.e. office building, maintenance shop, vehicle parking area, truck wash bay, wheel cleaning equipments, staff rooms, gate, guard house, fence, green belt, buffer zone, landscaping and utilities.

4.3 Operational Requirements

4.3.1 Daily records of the quantity of solid waste received, the origin of waste, the quantity of solid waste transferred to disposal site, shall be maintained at the facility.

5 MATERIALS RECOVERY FACILITY

Introduction

Material recovery and further processing is one of the functional elements of a waste management system. Material recovery facility is a physical facility used for the further separation and processing of wastes that have been separated at the source and for the separation of commingled wastes. Processing at a material recovery facility may include separation of bulky items, separation of waste components by size using screens, manual separation of waste components, size reduction by shredding, separation of ferrous metals using magnets, volume reduction by compaction and combustion.

Material recovery is the only way to complete recycling after wastes are separated. However, materials can be recovered from waste that have not been separated at the source.

Any person wishing to operate a material recovery facility shall have, in addition to the relevant information stipulated under 2.1.9, the following information under 5.1

5.1 General Requirements

5.1.1 A description of sources of waste, planned areas for unloading, collection and processing of solid waste, temporary on-site storage area for recyclables, non-processable wastes and residues.

5.2 Design Requirements

5.2.1 Design of the proposed structures and areas designated for unloading, sorting, storage and processing of the recyclables. Good ventilation system, odour and litter control devices

must be installed. The allocated storage area of recyclable materials shall accommodate at least three times of the daily peak volume of recyclables sorted out and processed.

5.2.2 The designed site roads shall be either asphalt concrete or reinforced concrete type. The minimum width of the one-way road is 3.5 meters and 6.0 meters for the two-way traffic road.

5.2.3 Specification of all machineries and equipment to be used in the facility. Type, number capacities shall be detailed.

5.2.4 Design of an efficient storm water management system. Storm water discharged from the facility shall be free of components which pose a serious danger to the environment.

5.2.5 Design of waste water treatment system for treating the effluent to achieve the 2.2.3 of legal requirements.

5.2.6 Design of other necessary components as appropriate to the allocated area, i.e. office building, maintenance shop, vehicle parking area, truck wash bay, staff house, gate, guard house, fence, landscaping and utilities.

5.3 Operational Requirements

5.3.1 Provision of operation and maintenance manuals of machinery and equipment as well as operational safety shall be prepared and make available.

5.3.2 Daily records of the quantity of solid waste received, its origin, the quantity and type or recyclables sorted and processed non-processable wastes and residues which shall be sent to a disposal or treatment facility

6. INCINERATION FACILITY

Introduction

Incineration is a controlled process by which solid, liquid, or gaseous combustible wastes are burned and changed into gases, and the residue produced contains little or no combustible materials. Incineration without adequate control systems leads to release gases which cause air pollution for which suitable precautions should be taken to minimize air pollution. Incineration of Residue- Derived Fuel [RDF] i.e. materials remaining after the selected recyclable and non-combustible materials that have been removed from MSW, can be given an attention when limited lands are available for land filling of such materials.

Any person wishing to operate an incineration facility shall have, in addition to the relevant information stipulated under 2.1.9, the following information under 6.1

6.1 General Requirements

6.1.1 The capacity and burning process of the incinerators, all machineries and equipments used in the facility, operating hours, number of working days, number of workers for each activity and operational safety measures.

6.1.2 The air pollution control mechanism, water source, collection and handling of ash including final disposal, heat recovery or control methods, fuel source, operating temperatures and retention time in deferent steps

6.2 Design Requirements

6.2.1 Design of the site plan with appropriate scales showing details of the proposed areas going to be used for the facility and lay out plan of equipment installation.

6.2.2 Design of the proposed building structures and areas designated for unloading, storing, loading, burning, bottom ash and flue ash collection and ash storing until final disposal. The proposed waste storing area in the facility shall accommodate at least three times of the daily average tonnage of waste.

6.2.3 Specifications of all machineries, equipment and vehicles to be used in the facility. Type, numbers, capacities or efficiencies shall be detailed.

6.2.4 Design of the on-site road ways, odour controlling mechanism, transfer route of transfer vehicles to the disposal site and the efficient on site traffic control system. The designed site roads shall be either asphaltic concrete or reinforced concrete type. The minimum width of the one way road is 3.5 meters and 6.0 meters for the two way traffic road.

6.2.5 Design of wastewater treatment system for treating the effluent to achieve the 2.2.3

6.2.6 Design of air pollution control system and stacks.

6.2.7 Design of other necessary components as appropriate to the allocated area, i.e. office building, maintenance shop, vehicle parking area, truck wash bay, wheel cleaning equipments, staff rooms, gate, guard house, fence, green belt, buffer zone, landscaping and utilities.

6.3 Operational requirements

6.3.1 Operation and maintenance manuals of all machinery and equipment shall be prepared. Provision of operational safety measure shall be kept at all times in the facility

6.3.2 Any person who operates the facility shall maintain the following guidelines as the minimal criteria. Monitoring requirements should comply to relevant standards in the annexure B

Parameter	**Incinerator Type**	
	Modular Excess Air and Starved Air Incinerator	**Mass Burn Incinerator**
Minimum incineration temperature	1000 ^{o}C at fully mixed height	1000 ^{o}C determined over all design review
Minimum residence	1 second after final secondary air injection ports	1 second calculated from where most of combustion has been completed
Primary Air	Utilize multi-port injection to minimize disturbance	Use multiple plenums with individual air flow control

Parameter	Incinerator Type	
	Modular Excess Air and Starved Air Incinerator	**Mass Burn Incinerator**
Secondary Air	Up to 80 % of the total air required	At least 40% of total air
Auxiliary burner capacity	Secondary burner 60% of total rated heat capacity and that required to meet start up and part load temperature	60% of total output and required to meet start up load temperature
Oxygen level at the incinerator outlet	6 to 12%	6 to 12%
Turndown restrictions	80 to 110% of designed capacity	80 to 110% of designed capacity
Maximum CO level	55 mg/Nm3 @ 11% O2 (4 hr to average)	55 mg/Nm3 @ 11% O2 (4 hr to average)
Combustion efficiency	99.9% (8hr. rolling average)	99.9% (8hr. rolling average)
Emissions Control System		
Flue gas temperature at inlet or outlet at emission control device	Not to exceed 140 ^{o}C	Not to exceed 140 ^{o}C
Opacity	**<10%**	**<10%**

Where N means the values are expressed at normal conditions of 0 ^{o}C temperature , 1 bar (760mm Hg) pressure and dry (Zero moisture)

6.3.3 Daily records shall be kept on quantity of solid waste received, its origin, the quantity and type of recovered materials and residues; the quantity of collected ash and quantity of water used for the facility.

6.3.4 Monitoring of stack emission shall be performed. Air pollutants to be measured include particulates, sulphur dioxide, oxides of nitrogen, hydrogen chloride.

6.3.5 The ash generated in the incineration process shall be disposed under the guidance of the CEA.

7 COMPOSTING FACILITY

Introduction

Composting is the controlled biological decomposition of organic solid wastes materials under aerobic conditions. Compost can be used as a soil conditioner. In general , the chemical and physical characteristics of compost vary according to the nature of starting material , the conditions under which the composting operation was carried out, and the extent of decomposition.

In Sri Lanka, most of the solid wastes contains biodegradable materials and suitable for composting. Therefore the composting organic waste as much as possible may be a valuable

option , which should be given a serious attention by waste management organizations. It should be noted that the quality of compost will depends mostly on the degree of contamination and the type of organic wastes. Segregation of waste at source plays and important role in production of better quality compost

Any person wishing to operate a composting facility shall have, in addition to the relevant information stipulated under 2.1.9, the following information under 7.1

7.1 General Requirements

7.1.1 The composting method, processing period, solid waste sorting method, raw materials, additives, capacity of the facility, total amount of the final product, all machineries and equipments used in the facility, operating hours, number of working days, number of workers for each duties.

7.1.2 The collection and transport routes, the number and type of the transfer vehicles to be used, frequency of waste receiving.

7.1.3 The quality of final compost should comply with the relevant specifications published by the Sri Lanka Standards Institution (Please see Sri Lanka Standard 1246 : 2003 given in the Annexure C)

7.2 Design Requirements

7.2.1 Design of the site plan with appropriate scales showing details of the proposed areas used for particular activities in the facility, with contour lines

7.2.2 Design of the proposed structures and areas designated for unloading, storage, sorting out, composting, processing, final product storage with all the instruments or devices which must be installed for ventilation, controlling dust, litter and odour.

- The base of the composting area shall be impermeable.

- Provision shall be made for weighing or measuring all incoming and transferred solid waste.

- Buffer zone: an adequate area for a buffer zone shall be designed for inside surrounding area next to the property boundary. This area may be dedicated for road, drainage ditch, selective tree planting for visual screening or reducing scenery and odour problems. However, the CEA must be consulted regarding the exact distance to be maintained depending on the capacity of the composting plant and the proposed site

7.2.3 Specifications of all machineries, equipment and vehicles to be used in the facility.

- Type, numbers, capacities shall be detailed.

- The designed site roads shall be either asphaltic concrete or reinforced concrete type. The minimum width of the one way road is 3.5 meters and 6.0 meters for the two way traffic road.

7.2.4 Design of an efficient storm water management system. Storm water discharged from the facility shall be free of components which pose a serious danger to the environment.

7.2.5 Design of wastewater treatment system for treating the effluent to achieve the 2.2.3

7.2.6 Design of other necessary components as appropriate to the allocated area, i.e. office building, maintenance shop, vehicle parking area, truck wash bay, wheel cleaning equipments, staff rooms, gate, guard house, fence, green belt, buffer zone, landscaping and utilities.

IMPORTANT DESIGN CONSIDERATIONS FOR AEROBIC COMPOSTING PROCESS

Item	***Comment***
Particle Size	For optimum results the size of solid wastes should be between 25 and 75 mm (1 and 3 in)
Carbon-to-nitrogen (C/N) ratio	Initial carbon to nitrogen ratios (by mass) between 25 and 50 are optimum for aerobic composting. At lower ratios, ammonia is given off. Biological activity is also impeded at lower ratios. At higher ratios, nitrogen may be a limiting nutrient.
Blending and seeding	Composting time can be reduced by seeding with partially decomposed solid wastes to the extent of about 1 to 5 percent by weight.
Moisture content	Moisture content should be in the range between 50 to 60 percent during the composting process. The optimum value appears to be about 55 percent.
Mixing/turning	To prevent drying, caking, and air channelling, material in the process of being composted should be mixed or turned on a regular schedule or as required. Frequency of mixing or turning will depend on the type composting operation.
Temperature	For best results, temperature should be maintained between 122 and 131^{o} F (50 and 55^{o}C) for the first few days and between 131 and 140^{o} F (55 and 60^{o}C) for the remainder of the active composting period. If temperature goes beyond 151^{o} F (66^{o}C), biological activity is reduced significantly.
Control of pathogens	If properly conducted, it is possible to kill all the pathogens, weeds, and seeds during the composting process. To do this, the temperature must be maintained between 140 and 158^{o} F (60 and 70^{o}C) for 24h.
Air requirements	Air with at least 50 percent of the initial oxygen concentration remaining should reach all parts of the composting material for optimum results, especially in mechanical systems.

pH control	To achieve an optimum aerobic decomposition, pH should remain at 7 to 7.5 range. To minimize the loss of nitrogen in the form of ammonia gas, pH should not rise above about 8.5.

7.3 Operational Requirements

7.3.1 Site safety and security measures shall be established to control unauthorised dumping and scavenging activities

8. ANAEROBIC DIGESTION / BIOGAS PRODUCTION FACILITY

Introduction

Highly organic waste has a potential to produce bio gas as a source of energy for lighting and heating etc. while producing compost after digestion. Here the production of methane [bio gas] from solid waste takes place by anaerobic digestion/anaerobic fermentation. Utilization of bio gas for the disposal of highly organic waste can also be considered as a strategy for the disposal of highly organic waste

Any person wishing to operate a anaerobic digestion / biogas production facility shall have, in addition to the relevant information stipulated under 2.1.9, the following information under 8.1

8.1 General Requirements

8.1.1 The anaerobic digestion method, processing period, solid waste sorting method, raw materials, additives, capacity of the facility, total amount of the final product (gas, organic fertilizers, residues, liquid or effluents), all machineries and equipments to be used in the facility, operating hours, number of working days, number of workers for each duty.

8.1.2 The collection and transport routes, the number and type of the transfer vehicles to be used, frequency of waste receiving.

8.2 Design Requirements

8.2.1 Design of the proposed structures of the digesters, gas collection facilities, gas utilisation facilities and areas designated for unloading, storage, sorting out, , processing, final product storage with all the instruments or devices which must be installed for ventilation, controlling dust, litter and odour.

- The digesters and gas collection facilities must be fully air tight and gases should not be released without utilisation.

- Provision may be made for weighing or measuring all incoming and transferred solid waste.

- Buffer zone: an adequate area for a buffer zone shall be designed for inside surrounding area next to the property boundary. This area may be dedicated for road, drainage ditch, and selective tree planting for visual screening or reducing scenery and odour problems. However, the CEA must be consulted regarding the exact distance to be maintained depending on the capacity of the plant and the proposed site

8.2.2 Specifications of all machineries, equipment and vehicles to be used in the facility.

- Type, numbers, capacities shall be detailed.

- The designed site roads shall be either asphaltic concrete or reinforced concrete type. The minimum width of the one way road is 3.5 meters and 6.0 meters for the two way traffic road.

8.2.3 Design of an efficient storm water management system. Storm water discharged from the facility shall be free of components which pose a serious danger to the environment.

8.2.4 Design of effluent treatment system for treating the effluent to achieve the 2.2.3

8.2.5 Design of other necessary components as appropriate to the allocated area, i.e. office building, maintenance shop, vehicle parking area, truck wash bay, wheel cleaning equipments, staff rooms, gate, guard house, fence, green belt, buffer zone, landscaping and utilities.

8.2.6 Design of fire protection system / fire control system in the facility

8.3 Operational Requirements

8.3.1 Site safety and security measures shall be established to control unauthorised dumping and scavenging activities

9 LANDFILL FACILITY

Introduction

Although source reduction, reuse, recycling can divert large portion of Municipal Solid Waste (MSW) from disposal some waste still might be placed in landfills. Landfills should be properly engineered facilities that are located, designed, operated, monitored, closed, and cared for after closure to ensure minimal impacts on environment and human health.

Preferably, Land filing should be for non-biodegradable, inert waste and other waste that are not suitable either for recycling or for biological processing. Land filling shall also be carried out for residues of waste processing facilities as well as pre-processing rejects from waste processing facilities. Land filling of mixed waste should be avoided unless the same is found unsuitable for waste processing.

Any person wishing to operate a landfill facility shall have , in addition to the relevant information stipulated under 2.1.9, the following information under 9.1

9.1 General Requirements

9.1.1 The collection and transport routes, the area/s of collection, any transfer stations envisaged, the number and type of the vehicles to be used for haulage

9.1.2 The design period of the landfill, all machineries and equipments used in the facility, types and sources of the covering materials, operating hours, number of working days, number of workers for each activity.

9.1.3 Hydro geological investigation: Description of the hydro geological condition of the proposed landfill site, highest water levels and quality of groundwater and surface water, topography, public and private water wells within one kilometre radius of the landfill site.

9.1.4 Geotechnical Investigation: Explore and describe subsurface conditions, groundwater table conditions, soil permeability, landslide areas, sink holes, fault areas, foundation analysis to support the loads and stress from the landfill and sub-grade settlement after land filling.

9.1.5 Design of the site plan with appropriate scales showing details of the proposed areas used for particular activities in the facility.

9.1.6 Topographic maps at a scale of not smaller than 1:2,500 showing the contour lines

9.1.7 Design of other necessary components as appropriate to the allocated area such as the area prepared for landfill trenches, onsite roads and traffic system, office building, scale house, staff house, maintenance shop, parking area, truck wash bay, entrance-exit gate, fence, landscaping, utilities, and specify types and number of machinery and equipment.(This is not required in the case of Class A and Class B)

9.1.8 Details of the Post-Closure design including details of closure procedures showing the existing topographic map and the final elevation of the landfill after closure

9.2 Design Requirements

9.2.1 For the purpose of facilitation of implementation and evaluation and monitoring the Landfills are classified according to the tonnage of waste received:

- Class A: those landfills which receive the general municipal solid waste amounting 10 tons or less per day.
- Class B: those landfills which receive the general municipal solid waste between more than 10 tons and less than 50 tons per day
- Class C: those landfills which receive the general municipal solid waste between more than 50 tons and less than 200 tons per day
- Class D: those landfills which receive the general municipal solid waste more than 200 tons per day

9.2.2 The bottom of landfill trench shall be higher than the groundwater table no less than 3 meters unless special design of the hydrostatic uplift control is provided or consult the CEA for specific guidance.

9.2.3 Pollution control systems

9.2.3.1 Liner Systems

9.2.3.1.1 Application of liner system

Liners shall be constructed of materials that have appropriate properties to prevent failure due to physical contact with the waste or leachate to which they are exposed. Liners must be installed upon the geologic condition that can support the applied stress and to cover all surrounding earth which could come into contact with the waste or leachate.

Any *environmentally accepted* technology which totally prevents pollution by way of the leachate coming into contact with the ground water can be applied.

However, as a general guidance the following technologies are recommended with required specifications. (If Low permeable soil or bed rock is available, liner facilities are not required in the case of Class A & B landfills).

a) Low Permeable soil liner

The low permeable soil liner is composed of 100 cm compacted clay and has a maximum hydraulic *conductivity* $1X10^{-7}$ *cm/sec. A leachate collection and removal system and a drainage layer shall be installed above the liner to limit hydraulic head of leachate not greater than 30 cm.* A minimum of 30cm soil layer for protection on top of the drainage layer prior to the placement of solid waste.

b) Bentonite- Soil mixtures

The bentonite – soil mixtures can be used as a bottom liner. The mixture must be with high concentration of bentonite (more than 5% by weight) and the hydraulic conductivity of the mixture must be less than $5 \text{ X } 10^{-10}$ cm/sec. The thickness of the layer must be higher than 60 cm.

c) Flexible Membrane Liners

Flexible membrane liners can be used as bottom liner. A single synthetic liner such as HDPE 1.5 mm or thicker with low permeable soil ($1 \text{ X } 10^{-5}$ cm/sec) can be used as a bottom liner.

9.2.5.2 Leachate collection and removal system

- The leachate collection and removal system shall be constructed of materials that are chemically resistant to leachate and have sufficient mechanical properties to prevent collapse under pressure exerted by overlying wastes, cover materials, and by any equipment used at the landfill.

- For Class A landfills, leachate collection system *may not be necessary. Anyway the landfill should be designed and operated in such a way that leachate generation is minimal and natural degradation of leachate takes place*

- For Class B and C, *an acceptable* leachate collection system could be applied, subject to prior approval from the CEA.

- For Class D landfills, the leachate collection and removal system lying above the liner consists of a minimum 4-inch PVC or HDPE perforated pipe overlying or surrounding with the synthetic geotextile filter and 30 cm thick granular material such as coarse sand and gravel that have the hydraulic conductivity not less than $1X10^{-3}$ cm/sec. The interval and bottom slope of leachate collection pipes depends on the allowable designed hydraulic head over liner, normally not less than 30 cm. In addition, the design of leachate collection pipe shall have a method to test clogging in pipes and a cleaning method if they become clogged.

9.2.5.3 Leachate treatment system

A).The leachate treatment system in the landfill facility shall be designed to control and treat leachate from the leachate collection and removal system of landfill unit

B) Design of leachate and wastewater treatment system for treating the effluent to achieve the 2.2.3

9.2.5.4 Gas control system

Landfills shall be designed and installed with gas monitoring and control system. The major landfill gas is methane. To prevent explosions and fires and to minimize off-site odours, the gas control system in the landfill shall be designed to prevent the concentration of methane gas from:

- Exceeding the lower explosive limit (5% of methane) at or beyond the landfill property boundary. (Lower explosive limit means the lowest percent by volume of a mixture of explosive gasses in air that will propagate a flame at 25^0C and atmospheric pressure)

- Exceeding the 25% of the lower explosive limit (1.25% of methane) in structures on or off-site

- Causing objectionable odours at or beyond the landfill property boundary

One of the following methods may be applied.

a) *Passive control methods* : Installation of horizontal or vertical pipes or trenches in the landfill to release gas pressure to the atmosphere naturally. The interval of vertical trenches or pipes is normally 30-40 meters. The pipes can be made with used oil drums, PVC, Clay, HDPE(This is mostly recommended for Classes A, B and C)

b) *Active control methods*: Installation of vertical pipes and gas suction equipment. This method can be used for gas recovery as the energy source in the case that has high quantity of gas. However, in no case, the methane gas is allowed to release into the atmosphere. As far as possible the management should take efforts to collect and use methane gas for useful purposes such as heating, lighting etc.

9.2.5.5 Storm water management system

Strom water management shall include detention/retention ponds and drainage ways and shall be designed which, at a minimum, prevents storm water from the peak discharge of the *25-year storm* event from running on to those portions of the landfill which have not been closed. And this system shall collect and control, at a minimum, the volume of runoff from *a 25-year, 24 hour* storm event and prevent the mixing of storm water with leachate.

9.2.6. Buffer zone

Buffer zone shall be designed for Class C and D inside surrounding area next to the landfill property boundary, preferably not less than 200 meters, dedicated for road, drainage ditch, selective tree planting for visual screening or reducing scenery and odour problems. It could be 150 m for Class A and B landfills.

9.2.7 Types, sizes, and number of machinery and equipment used in landfill operation

9.2.8 Fire protection system –The fire control system in the landfill facility shall be designed to control surface fires and sub surface fires

9.2.9 Scavenger controlling plan - Site safety and security plan shall be designed to control unauthorised dumping and scavenging activities.

9.2.10 Closure design[following design considerations may be applied]

a. The design of landfill lift above ground, especially the height of the lift, must consider the scenery of the facility, the stability, and the safety in the operation.

b. The final side slope design, side slopes of above- ground disposal units shall not be steeper than 3 horizontal to 1 vertical and have the drainage system to control erosion of the final cover.

c. Final cover design
The final cover shall be a minimum 60 cm soil layer with maximum hydraulic conductivity of 1×10^{-5} cm/sec

9.3 Landfill Operational Requirements

9.3.1 Prepare the operation plan that provides written, detailed instructions for the daily operation of the landfill.

9.3.2 Operating record shall consist of all records, reports, analytical results, demonstrations, etc.

9.3.3 Waste records and inspection facility. Landfill operators shall record the amount of solid waste as it is received, in tons per day. It should also have waste inspection facility to monitor waste brought in for landfill, office facility for record keeping and shelter for keeping equipment and machinery including pollution monitoring equipments, 3 phase electricity supply to facilitate testing and monitoring.

9.3.4 Control of access. To prevent unauthorized waste disposal, public access and receipt of wastes shall occur only when a supervisor is on duty. Owners/operators must control public access and prevent unauthorized vehicular traffic and illegal dumping of waste by using official barriers, natural barriers or both as appropriate to protect human health and the environment. Landfill site shall be fenced/hedged and provided with proper gate to monitor incoming vehicles or other mode of transportation.

9.3.5 Controlling of Scavengers - Site safety and security measures shall be established to control scavenging activities. It shall also be well protected to prevent entry of stray animals

9.3.6 Landfill operation. In the case of Class B, C & D landfills, the first layer of waste placed above the liner and leachate collection system shall be at least 1 meter in compacted thickness and consist of selected waste containing no large rigid objects that may damage the liner or leachate collection system.

(However, if Low permeable soil or bed rock is available, liner facilities are not required in the case of Class A & B landfills).

Solid waste shall be formed into cells to construct horizontal lifts. The waste shall be spread as a thin layer as practical before the next layer is applied. The daily cover shall be applied after each day of operation and this cover must be at least 15 cm of thickness. If necessary it should be covered at more frequent intervals to control disease vectors, fires, odours, etc (here disease vectors mean any rodents, flies, mosquitoes or other animals including insects, capable of transmitting disease to humans)

9.3.7 Leachate management.

a. Leachate or any waste water contaminated with solid waste could be reintroduced to the landfill site as a means of recirculation.

b. Whenever, leachate or any wastewater contaminated with the solid waste is meant to be discharged into the environment, it shall be treated to achieve the 2.2.3.

9.3.8 Gas monitoring for landfill receiving organic waste.(For Class C and D landfills)

a. Location of gas monitoring. At 4 sides of property boundary at least 4 monitoring points, and inside the property at least 1 monitoring point.

b. Random sampling the gas at least twice a year.

c. Measuring the methane gas concentrations shall not exceed those specified in the Design requirement Section 7.2.6.4

9.3.9 Fire protection

a. It is important to establish and maintain a fire prevention and remediation plan. All site personal need to be aware of and trained in its application.

b. When practicing active gas extraction method a suitable technology must be applied for prevention from over extraction of landfill gasses

9.3.10 Storm water management system. - The storm water management system shall control the storm water; avoid the mixing of leachate with storm water to allow an acceptable discharge out of the landfill facility. The discharge shall be free of components, which pose a serous danger to environment. The storm water management system shall be maintained in good conditions at all times.

9.3.11 Equipment and operation features.- The landfill shall have sufficient equipment to proper operation and reserve including the fire protection equipment, communication equipment for emergency, first aid equipment and personnel shelter. Provisions like weigh bridge to measure quantity of waste brought at landfill site may also be provided

9.3.12 Maintain the on-site roads in the landfill facility to be accessible in all weather conditions

9.3.13 A contingency plan should be in place to tackle any accident or disaster such as fire, flood, uncontrolled gas emissions, landslides, etc,.

9.3.14 Water Quality Monitoring Requirements

a. The operator shall perform random sampling and analysis of monitoring well, surface water, leachate, and effluent from waste-water treatment plant at least semi-annually by the beginning of rainy season and dry season.

b. Ground water monitoring. The monitoring well shall be installed to detect leachate releases . At least 3 monitoring wells shall be selected, out of which 2 wells in the down gradient direction and 1 well in the up gradient direction at the boundary of the site.

c. Surface water monitoring. All surface water bodies that may be affected by a contaminant release from the facility shall be monitored. In bodies of standing water, at least 1 representative monitoring point shall be located as close as practical to the facility. For flowing water bodies, there should be at least a monitoring point in the upstream [100m distance] and downstream [100m distance].

d. Assessment monitoring and corrective action. If monitoring parameters are detected in concentrations, which are significantly above background water quality, they will be checked and investigated and initiate corrective actions immediately. Short account of the incident and remediation measure shall also be recorded.

9.3.15 Plantation at Landfill – A vegetative cover shall be provided over the completed site and below mentioned guideline shall be followed

a. Selection of locally adopted perennial plants that are resistant to drought and extreme temperatures

b. Root of the plant should not disrupt the low-permeability layer

c. Plantation to be made in sufficient density to minimize soil erosion

9.3.16 Closure of Landfill site and Post-care

The post-closure care of landfill site shall be conducted for at least 10 years and long-term monitoring /care plan shall consist of the following

a. Maintaining the integrity and effectiveness of final cover, making repairs and preventing run-off and run-off from eroding or otherwise damaging the final cover.

b. Maintaining leachate collection system to achieve the 2.2.3

c. Monitoring of groundwater in accordance with the requirements and maintaining groundwater quality

d. Maintaining and operating the landfill gas collection system to meet the standards stipulated in these guidelines.

e. For landfills with a final elevation of less than 6 meters above natural land surface, concrete benchmarks shall be installed to mark the boundaries of the landfill property.

Use of closed landfill sites for activities that involve human or otherwise shall be considered after ensuring the gaseous and leachate analysis comply with the standards laid down.

Annexure A

The Proposed Colour Codes for Garbage Bags

Green Colour	**-**	**Organic Waste**
Blue Colour	**-**	**Paper**
Red Colour	**-**	**Glass Bottles**
Brown Colour	**-**	**Metals / Coconut shells**
Orange Colour	**-**	**Plastic & Polythene**

Annexure B

The Gazette of the Democratic Socialist Republic of Sri Lanka

EXTRAORDINARY

No. 595/16 – FRIDAY, FEBRUARY 02, 1990

PART I: SECTION (I) - GENERAL

Government Notification

NATIONAL ENVIRONMENTAL ACT, NO 47 OF 1980

REGULATIONS made by the president under section 32 of the National Environmental Act, No 47 of 1980, as amended by Act No 56 of 1988, read with Article 44 (2) of the constitution.

R. Premadasa
President

Colombo, 08.01.1990

Regulations

1. These regulations may be cited as the National Environmental (Protection & Quality) Regulations No. 1 of 1990.
2. No person shall, on or after the relevant date discharge, deposit or emit waste into the environment which will cause pollution, or cause noise pollution, except :
    a) Under the authority of a licence issued by the Central Environmental Authority (hereinafter referred to as " the Authority"); and
    b) In accordance with the standards and criteria specified in Schedule I hereto:
    Provided that, where a licensee who does not conform to the standards or criteria specified herein, is at the discretion of the Authority, directed to implement a programme of action within a specified period, so as to conform to the aforesaid standards and criteria and to observe certain conditions during such period such licensee shall, so long as he observes such conditions, be deemed to comply with the preceding provisions of this regulation.

3. Notwithstanding anything contained in regulation 2, the Authority may, by a direction issued under regulation 13, impose more stringent standards and criteria than those specified in schedule I hereto in respect of any particular industry, operation or process, having regard to the need to protect the receiving environment.

4. Where an activity in respect of which an application for a licence is made is not covered by the standards and criteria specified in Schedule I hereto, the Authority will decide on such application on its merits and the applicant shall comply with all such directions as may be issued to him by the Authority for the protection of the environment.

5. The licence issued under these regulations shall be known as the "Environmental Protection Licence" (herein after referred to as "the licence").

6. (1) *An application for the licence shall be made*:
    a) Separately, in respect of each premises at which the acts authorized by the licence are carried out;
    b) Substantially in Form A in Schedule II hereto;

c) accompanied by a receipt for the payment of the fee specified in Schedule III hereto;
d) at least 30 days prior to the relevant date or to the date on which the applicant is required to have the licence whichever is earlier.

(2) For the purpose of these regulations " Premises" means the totality of buildings and installations used separately or in combination to carry out the acts authorized by the licence.

(3) Every applicant shall furnish all such particulars as may be required to be stated in the aforesaid Form A and any other information that may be called for by the Authority for the purpose of deciding on the application.

7. *Every licence issued by the Authority shall be:*

a) in Form B in schedule II hereto;
b) valid for a period of one year, subject to any suspension of the licence under section 23 D of the act; and
c) renewable.

8. The Authority shall issue the licence only if it is satisfied that:-

a) The licence will not be used to contravene the provisions of the Act or these regulations;
b) No irreversible damage or hazard to man and environment or any nuisance will result from the acts authorized by the licence;
c) The applicant has taken adequate steps for the protection of the environment in accordance with the requirements of the law.

9. (1*) An application for a renewal of a licence shall be made:*

a) at least one month before the date of expiry of the licence or one month before effecting any changes, alterations, or extensions to the premises at which the acts authorized by the licence are carried out, as the case may be;
b) Substantially in Form C in Schedule II hereto;
c) accompanied by a receipt for the payment of the fee for the renewal of licence specified in schedule III hereto

(2) Every applicant for a renewal of the licence shall furnish all such particulars as may be required to be stated in the aforesaid Form C and any other information that may be called for by the Authority for the purpose of deciding on the application.

10. The Authority may, before issuing an order suspending or cancelling a licence under section 23D of the Act give the holder of the licence an opportunity to show cause why such order should not be issued :
Provided that, where, since the issue of the licence, the receiving environment has been altered or changed due to natural factors or otherwise or where continued discharge, deposition or emission of waste into the environment under the licence will or could affect any beneficial use adversely, the Authority shall forthwith issue an order suspending the licence for a period to be specified in the order or cancel such licence.

11. (1) Any applicant for a licence who is aggrieved by the refusal of Authority to grant a licence, or , any holder of a licence who is aggrieved by the suspension or cancellation of a licence or the refusal to renew a licence may, within thirty days after the date of notification of such decision to him, appeal in writing against such refusal, suspension, cancellation or refusal to renew, to the Secretary of the ministry in-charge of the subject of policy Planning and Implementation.

(2) Such applicant shall be given an opportunity of marking representations in person or by authorized representative in connection with his appeal.

(3) The Secretory may set aside, very or confirm the decision appeal from, and the Authority shall give effect to the secretary's decision .

(4) The decision of the secretary shall be final and conclusive.

12. *The holder of a licence shall forthwith notify the Authority of :*
    a) Any changes made or proposed to be made in the particulars furnished in connection with his application for a licence;
    b) Any decision to terminate any activity to which the licence relates;
    And shall comply with any directions that may be issued by the authority to prevent or mitigate environmental pollutions and hazards.

13. Every applicant or every holder of a licence shall comply with any direction given by or on behalf of the Authority for the purpose of protecting the environment.
14. Every person who acts in contravention of any regulations commits an offence punishable under section 31 of the Act.
15. In these regulations :

" The Act means the National Environment Act, No 47 of 1980 as amended by Act No 56 of 1988.

SCHDULE I

GENERAL STANDARDS FOR DISCHARGE OF EFFLUENTS INTO INLAND SURFACE WATERS

No	*Determinant*	*Tolerance limit*
1.	Total suspended solids, mg/l, max	50
2.	Particle size of total suspended solids	Shall pass sieve of aperture siz size 850 micro m.
3.	P^H value of ambient temperature	6.0 to 8.5
4.	Biochemical Oxygen Demand-BOD5 in 5 days At 20 ^{0} C, mg/I max	30
5.	Temperature of Discharge	Shall not exceed 40 ^{0}C in any of Section of the Stream within 15m down stream from the effluent outlet.
6.	Oils and greases, mg/ I max	10.0
7.	Phenolic compounds (as phenolic OH)mg/I, max	1.0
8.	Cyanides as (CN) mg/I, max	0.2
9.	Sulfides, mg/I, max	2.0
10.	Flourides, mg/I, max	2.0
11.	Total residual chlorine mg/I, max	1.0
12.	Arsenic, mg/I, max	0.2
13	Cadmium total, mg/I, max	0.1
14.	Chromium total, mg/I, max	0.1
15	Copper total, mg/I, max	3.0
16	Lead, total, mg/I, max	0.1
17	Mercury total, mg/I, max	0.0005
18.	Nickel total,mg/Imax	3.0
19.	Selenium total ,mg/I max	0.5
20	Zinc total,mg/I,max	5.0
21	Ammoniacal nitrogen,mg/I,max	50.0
22.	Pesticides	undetectable
23	Radioactive material	
24	(a) Alpha emitters micro curie/ml	10^{-7}
	(b) Beta-emitters micro curie /ml	10^{-8}
24.	Chemical Oxygen Demand (COD), mg/I, max	250

Note 1 : All efforts should be made to remove colour and unpleasant odour as far as practicable.
Note 2 : These values are based on dilution of effluents by at least 8 volumes of clean receiving water. If the dilution is below 8 times, the permissible limits are multiplied by 1/8 of the actual dilution.
Note 3 : The above mentioned General Standards shall cease to apply with regard to a particular industry when industry specific standards are notified for that industry.

TOLERANCE LIMITS FOR INDUSTRIAL EFFLUENTS

DISCHARGED ON LAND FOR IRRIGATION PURPOSE

No	*Determinant*	*Tolerance Limit*
1.	Total dissolved solid, mg/I, max	2100
2.	PH value at ambient temperature	5.5 to 9.0
3.	Biochemical Oxygen demand (BOD_5) in 5 days at 20 ^{0}C, mg/I, max	250
4.	Oils and grease, mg/I, max	10
5.	Chloride (as CI), mg/I, max	600
6.	Sulfate (as SO_4) mg/I, max	1000
7.	Boron (as B) mg/I, max	2.0
8.	Arsenic(as As), mg /I, max	0.2
9.	Cadmium as (as Cd) mg/I , max	2.0
10.	Chromium (as Cr) mg / I max	1.0
11.	Lead (as Pb), mg/I max,	1.0
12.	Mercury (as Hg) mg/I, max `	0.01
13	Sodium adsorption ratio: (SAR)	10 to 15
14	Residual Sodium Carbonate, mol/l,max.	2.5
15	Radio active material:	
	(a) Alpha emitters, micro curie/ml	10^{-9}
	(b) Beta emitters, micro curie/ml	10^{-8}

TOLERANCE LIMITS FOR INDUSTRIAL AND DOMESTIC EFFLUENTS DISCHARGED INTO MARINE COASTAL AREAS

No	*Determinant*	*Tolerance Limit*
1.	Total suspended solids mg/1, max	
	(a) For proses waste waters	150
	(b) For cooling water effluents	Total suspended matter content of effluen cooling water plus 10 per cent.
2.	Particle size of-	
	(a)Floatable Solids, max	3mm
	(b)Settlable solids, max	850micro m.
3.	P^H range at ambient temperature	6.0 – 8.5
4.	Biochemical oxygen demand (BOD_5) in 5 day at 20°C, mg/I, max	100
5.	Temperature, max	45°C at the point of discharge
6.	Oils and grease, mg/l, max	20
7.	Residual Chlorine, mg/1,max.	1.0
8.	Ammonical nittrogent mg/1,max.	50.0
9.	Chemical oxygen demand (COD) mg/1,max.	250
10.	Phenolic compounds (as phenolic OH) mg/1,max	5.0
11.	Cyanide (as CN) mg/l, max	0.2
12.	Sulfide (as S), mg/l, max	5.0
13.	Flurorides (as F), mg/l, max	15
14.	Arsenic (as As), mg/l, max	0.2
15.	Cadmium (as Cd) Total, mg/I, max	2.0
16	Chromium, (as Cr) Total, mg/I, max	1.0
17.	Copper (as Cu) total, mg/l, max.	3.0
18.	Lead (as Pb) total. mg/l, max.	1.0

19.	Mercury (as Hg) total. mg/l, max.	0.01
20.	Nickel (as Ni) total. mg/l, max.	5.0
21.	Selenium (as Se) total. mg/l, max.	0.05
22.	Zinc (as Zn) total. mg/l, max.	5.0
23.	Radio active material:	
	(a) Alpha emitters, micro curie/ml	10^{-8}
	(b) Beta emitters, micro curie/ml	10^{-8}
24.	Organo – Phosphorus compounds	1.0
25.	Chlorineted hydrocarbons (as CL), mg/l, max.	0.02

Note 1: All efforts should be made to remove colour and unpleasant as far as practicable.

Note2: These values are based on dilution of effluents by at least 8 volumes of clean receiving water. If the dilution is below 8 times, the permissible limits are multiplied by 1/8 of the actual dilution.

TOLERANCE LIMITS FOR EFFLUENTS FROM RUBBER FACTORIES DISCHARGED INTO INLAND SURFACE WATERS

No	***Determinant***	***Tolerance Limit***	
		*Type I Factories**	*Type II Factories***
1.	P^H value at ambient temperature	6.5 to 8.5	6.5 to 8.5
2.	Total suspended solids, mg/l, max.	100	100
3.	Total Solids, mg/l, max.	1500	1000
4.	Biochemical Oxygen Demand (BOD5) in five days at 20 0C, mg/l, max.	60	50
5.	Chemical Oxygen Demand (COD), mg/l, max.	400	400
6.	Total Nitrogen, mg/l, max.	300	60
7.	Ammoniacal Nitrogen, mg/l, max.	300	40
8.	Sulfides, mg/l, max.	2.0	2.0

* *Type Type I Factories - Latex Concentrate*

*** Type Type I I Factories – Standard Lanka Rubber; Crape Rubber and Ribbed Smoked Sheets*

Note I: All efforts should be made to remove colour and unpleasant odour as practicable.

Note I I: These values are based on dilution of effluents by at least 8 volumes of clean receiving water. If the dilution is below 8 times, the permissible limits are multiplied by 1/8 of the actual dilution.

TOLERANCE LIMITS FOR EFFLUENTS FROM TEXTILE INDUSTRY

DISCHARGED INTO INLAND SURACE WATERS

No	*Determinant*	*Tolerance Limit*
1.	P^H value at ambient temperature	6.5 to 8.5
2.	Temperature ^0C, max.	40 measured at site of sampling
3.	Total suspended solids, mg/l, max.	50
4.	Biochemical Oxygen Demand (BOD_5 in five days at 20 ^{0} C) mg/1,max.	60
5.	Chemical Oxygen Demand (COD), mg/1,max.	250
6.	Oils and grease, mg/1,max,	10.0
7.	Phenolic compounds (as phenolic OH), mg/1,max.	1.0
8.	Sulfides, mg/1,max.	2.0
9.	Chromium total, mg/1,max.	2.0
10.	Hexavalent chromium, mg/1,max.	0.5
11.	Copper, total, mg/1,max.	3.0
12.	Zinc, total, mg/1,max.	5.0
13.	Ammoniacal nitrogen, mg/1,max.	60
14.	Chloride (as cl), mg/1,max.	70

Note I: All efforts should be made to remove colour and unpleasant odour as practicable.

Note I I: These values are based on dilution of effluents by at least 8 volumes of clean receiving water. If the dilution is below 8 times, the permissible limits are multiplied by 1/8 of the actual dilution.

TOLERANCE LIMITS FOR EFFLUENTS FROM TANNING INDUSTY

No	*Determinant*	*Tolerance Limit*	
		Discharged in to Inland Surface Waters	Discharged in to Discharged in to Marine Coastal
1.	P^H value at ambient temperature	5.5 to 9.0	5.5 to 9.0
2.	Total suspended solids, mg/1, max.	100	150
3.	Biochemical Oxygen Demand, (BOD_5 in five days at 200 C) mg/1, max.	60	100
4.	Chemical Oxygen Demand (COD), mg/1, max.	250	300
5.	Alkalinity (as CaCo3), mg/1,max.	750	not applicable
6.	Chloride (as cl), mg/1,max.	1000	not applicable
7.	Hexavalent Chromium, mg/1,max.	0.5	0.5
8.	Chromium total, mg/1,max.	2.0	2.0
9.	Oils and grease, mg/1,max.	10.0	20.0
10.	Phenolic compounds (as phenolic OH) mg/1,max.	1.0	5.0
11.	Sulfides, mg/1,max.	2.0	5.0

Note I: All efforts should be made to remove colour and unpleasant odour as practicable.

Note I I: These values are based on dilution of effluents by at least 8 volumes of clean receiving water. If the dilution is below 8 times, the permissible limits are multiplied by 1/8 of the actual dilution.

Annexure C

SRI LANKA STANDARD 1246 : 2003
UDC 628.477.4

SPECIFICATION FOR
COMPOST FROM MUNICIPAL SOLID WASTE AND AGRICULTURAL WASTE

SRI LANKA STANDARDS INSTITUTION

.

SPECIFICATION FOR
COMPOST FROM MUNICIPAL SOLID WASTE
AND AGRICULTURAL WASTE

SLS 1246 : 2003

Gr. 7

SRI LANKA STANDARDS INSTITUTION
17, Victoria Place
Elvitigala Mawatha
Colombo 08
SRI LANKA.

SRI LANKA STANDARD
SPECIFICATION FOR COMPOST FROM MUNICIPAL SOLID WASTE AND AGRICULTURAL WASTE

FOREWORD

This standard was approved by the Sectoral Committee on Chemical and Polymer Technology and was authorized for adoption and publication as a Sri Lanka Standard by the Council of the Sri Lanka Standards Institution on 2003-04-30.

This specification prescribes the requirements for compost from municipal solid waste and agricultural waste. This is intended to promote the conversion of plant/animal or biodegradable municipal solid waste/agricultural waste into compost which minimizes environmental pollution.

Compost shall not contain any materials hazardous to plant, animal and human health. It provides plant nutrients and enhance physical, chemical and biological characteristics of the soil.

For the purpose of deciding whether a particular requirement of this standard is complied with, the value, observed or calculated expressing the result of a test or an analysis, shall be rounded off in accordance with **CS 102**. The number of significant places retained in the rounded off value shall be the same as that of the specified value in this standard.

Guidelines for the determination of a compliance of a lot with the requirements of this standard based on statistical sampling and inspection are given in Appendix **A**.

In the preparation of this standard the assistance obtained from the following publications is gratefully acknowledged.

Official Methods of Analysis 15 th edition, Volume 1 (1990) Association of Official Analytical Chemists, INC , 2200 Wilson, Boulevard, Arlington, Virginia 22201, USA.

PNS 928 : 1995 Phillippine National Standard for Fertilizers -organic fertilizer – specification

Standards for organic food and farming (1997), Soil Association Certification Ltd; Bristol House, 40-56 Victoria Street, Bristol BS1 6BY

1 SCOPE

This specification prescribes the requirements and methods of test for compost, which shall consist of biodegradable plant / animal / municipal solid waste and agricultural waste. Extracts 0from such material shall not be used.

SLS 1246 : 2003

2 REFERENCES

ISO 10390	Determination of pH
CS 102	Presentation of numerical values
CS 124	Test sieves
SLS 428	Random sampling methods
SLS 516	Microbiological test methods

Part 3: Detection and enumeration of coliforms, faecal coliforms and Escherichia coli
Part 5: General guidance for detection of salmonella

SLS 544 Code of practice for handling and storage of bagged fertilizers

SLS 559 Method for sampling fertilizers

SLS 645 Methods of test for fertilizers
Part 1: Determination of nitrogen content
Part 2: Determination of moisture content
Part 4: Determination of potassium content
Part 5: Determination of phosphorous content
Part 6: Determination of calcium and magnesium content

3 DEFINITIONS

3.1 agricultural waste : Agricultural wastes are of two types, namely farm sector wastes and agricultural process wastes. Farm sector wastes are generated post harvest in the farm such as cotton stems, cereal straw etc; Process wastes are generated in the processing of agricultural produce such as bagasse from sugar mills, rice husk from rice mills, saw dust from saw mills, cotton fibre process waste from cotton fibre mills etc;

3.2 compost : Compost is a relatively stable decomposed/processed product resulting from composting with similar characteristics as humus, made from constituents of plants, animal or biodegradable municipal solid waste/ agricultural waste which contain considerable amounts of nutrients. Composting is a degradation process brought about by micro-organisms.

3.3 friable : Easily crumble, pulverize or reduce to powder.

3.4 industrial hazardous waste : Industrial hazardous waste shall consist of waste exhibiting one or more hazardous characteristics, such as being flammable, oxidizing, poisonous, infectious, corrosive, ecotoxic or radioactive and includes health care, clinical and related wastes.

3.5 municipal solid waste : The discarded materials, substances or objects which originate (or refuse) from domestic, business and industrial sources, including household wastes which are typically disposed of in municipal type landfills, but not including industrial hazardous or ‘special wastes’.

3.6 special wastes: Wastes (not hazardous) that require special handling considerations during disposal.

4 DESCRIPTION

The texture of the material shall be friable when moist.

5 REQUIREMENTS

5.1 Physical requirements

5.1.1. *Colour*

The colour of the material shall be brown / grey to dark black.

5.1.2 *Keeping properties*

The material shall comply with the requirements specified in this standard, after storage in packages/containers as prescribed in **6.1** at room temperature for not less than 12 months from the date of production.

5.1.3 *Moisture content*

The material shall not contain more than 25 per cent moisture by dry mass, when tested as prescribed in **SLS 645 : Part 2.**

5.1.4 *Odour*

The material shall not have any unpleasant odour.

5.1.5 *Particle size*

The material shall not leave a residue of more than 2 per cent by mass when tested as prescribed in Appendix **B**.

5.1.6 *Sand content*

The material shall not contain more than 10 per cent sand when tested as prescribed in Appendix **C**.

5.2 Nutrient requirements

5.2.1 The material shall also comply with the requirements given in Table **1.**

TABLE 1 - Nutrient requirements for compost from municipal solid waste and agricultural waste

Sl. No. (1)	Characteristic (2)	Requirement (3)	Method of test (4)
i)	pH	6.5 – 8.5	ISO 10390
ii)	Organic carbon, per cent by mass, min.	20	Appendix D
iii)	Nitrogen content, per cent by mass, min.	1.0	SLS 645 : Part 1
iv)	Phosphorous content, as P_2O_5 per cent by mass, min.	0.5	SLS 645 : Part 5
v)	Potassium content, as K_2O per cent by mass, min.	1.0	SLS 645 : Part 4 Section 1
vi)	Magnesium content, as MgO per cent by mass, min.	0.5	SLS 645 : Part 6
vii)	Calcium content, as CaO per cent by mass, min.	0.7	SLS 645 : Part 6

5.2.2 *Carbon to Nitrogen ratio (C to N ratio)*
The carbon to nitrogen ratio of the material shall be in the range 10 to 25 when calculated as in Appendix **F**.

5.2 Limits for heavy metals

The material shall not exceed the limits for heavy metals given in Table **2**.

TABLE 2 – Limits for heavy metals

Sl. No. (1)	Characteristic (2)	Requirement (3)	Method of test (4)
i)	Cadmium content, ppm, max.	10	AOAC (975.03) (Digestion)
ii)	Chromium content, ppm, max.	1000	
iii)	Copper content, ppm, max.	400	Suitable Atomic
iv)	Lead content, ppm, max.	250	Absorption Spectrophotometer
v)	Mercury content, ppm, max.	02	(Detection)
vi)	Nickel content, ppm, max.	100	
vii)	Zinc content, ppm, max.	1000	

5.4 Biological requirements

The material shall not contain more than 16 viable weed seeds per square metre when tested as prescribed in Appendix **E .**

5.5 Microbiological requirements

The material shall also comply with the requirements given in Table **3.**

TABLE 3 – Microbiological requirements

Sl. No. (1)	(1) Characteristic	Limit (3)	Method of test (4)
i)	Faecal coliforms per g	Free	SLS 516 : Part 3
ii)	Salmonella per 25 g	Free	SLS 516 : Part 5

6 PACKAGING AND MARKING

6.1 Packaging

The material shall be packed in sound, strong and moisture proof packages or containers. Suitable packages include polypropylene, or jute bags with an inner lining of low density polyethylene having a minimum thickness 37.5 μm or any other material with barrier properties superior (High Density Polyethylene) or equal to low density polyethylene of 37.5 μm thickness. It shall be of mass 1 kg, 2 kg, 5 kg, 10 kg, 20 kg or 25 kg . The material may also be supplied in bulk containers as agreed between the purchaser and the supplier.

6.2 Marking

The bags shall be legibly and indelibly marked with the following information :

a) Name of the material as "Compost from municipal solid waste and agricultural waste";
b) Name and address of the manufacturer, including country of origin;
c) Brand name and / or trade mark, if any;
d) Date of production;
e) Net mass in kilogrammes;
f) Instructions for storage and use;
g) Main ingredients used;
h) Date of expiry;
j) Moisture content;
k) N-P_2O_5-K_2O per cent;
l) Organic carbon per cent; and
m) Use no hooks.

7 HANDLING AND STORAGE

The handling and storage of the material shall be as prescribed in **SLS 544**.
NOTE : *Attention is drawn to the certification marking facilities offered by the Sri Lanka Standards Institution. See the back cover of this standard.*

8 METHODS OF TEST

8.1 Tests shall be carried out as prescribed in Column **4** of Table **1** and Table **2** and Appendices **B** to **F** of this specification.

8.2 Unless specified otherwise, chemicals of analytical grade and distilled water or water of equivalent purity shall be employed in tests.

APPENDIX A

COMPLIANCE OF A LOT

Sampling scheme given in this appendix should be applied where compliance of a lot to the requirements of this standard is to be assessed based on statistical sampling and inspection.

A.1 LOT

In any consignment all the packages of the same size belonging to one batch of manufacture or supply shall constitute a lot.

A.2 SCALE OF SAMPLING

A.2.1 The sampling shall be carried out as prescribed in **SLS 559.**

A.3 NUMBER OF TESTS

A.3.1 Each package selected as prescribed in **SLS 559** shall be inspected for packaging and marking requirements.

A.3.2 Tests for the requirements specified in **5** shall be carried out on the composite samples prepared as in **SLS 559.**

A.4 CRITERIA FOR CONFORMITY

A lot shall be declared as conforming to the requirements of this specification, if the following conditions are satisfied:

A.4.1 Each package inspected as in **A.3.1,** satisfies the relevant requirements.

A.4.2 The composite sample, when tested as in **A.3.2,** satisfies the relevant requirements.

APPENDIX B
DETERMINATION OF PARTICLE SIZE

B.1 APPARATUS

B.1.1 Sieve of aperture 4 mm

B.2 PROCEDURE

B.2.1 Weigh, to the nearest milligram, 100 g of the sample and transfer to a sieve of 4 mm aperture size (conforming to **CS 124**) with the lower receiver attached. Shake the sieve for 5 minutes, frequently tapping the sides.

B.2.2 Disintegrate soft lumps which can be crumbled by the application of the fibres of a soft brush, taking care that the hard part of the brush does not make contact with the sieve, and that the brush is not used to brush particles through the sieve. Brush out the powder in the lower receiver and weigh. Replace the receiver and repeat the shaking and tapping procedure for 2 minutes.

B.2.3 Add the powder in the receiver to the first portion and weigh. Repeat the process until not more than 0.04 g passes through the sieve during 2 minutes. Calculate the mass of the material retained on the sieve as a percentage by mass of the sample taken for the test.

B.3 CALCULATION

$$\text{Residue per cent by mass} = \frac{m_1}{m_0} \times 100$$

where,

m_0 is the mass, in grammes, of the sample; and

m_1 is the mass, in grammes, of the material retained on the sieve.

APPENDIX C
DETERMINATION OF SAND CONTENT

C.1 APPARATUS

C.1.1 Measuring cylinder – 1000 ml

C.1.2 Oven - maintained at 103 ± 2 °C

C.2 PROCEDURE

C.2.1 Weigh to the nearest milligram, 100 g of the sample. Transfer into a 1000-ml measuring cylinder with a stopper. Add distilled water up to the mark and shake well. Leave to settle.

C.2.2 Decant the water and the floating particles, leaving the sand at the bottom. Wash the residue thoroughly with water. Repeat washings until all the other particles are removed.

C.2.3 Transfer the sand into a petri dish and dry in an oven maintained at 103 ± 2 °C for 1 hour. Cool in a desiccator and weigh to the nearest milligram. Repeat the process of heating, cooling and weighing at 30 minute intervals until the difference between two consecutive readings does not exceed 0.002 g. Record the final mass.

C.3 CALCULATION

$$\text{Sand content per cent by mass} = \frac{m_1}{m_0} \times 100$$

where,

m_0 is the mass, in grammes, of the sample; and

m_1 is the mass, in grammes, of sand.

APPENDIX D
DETERMINATION OF ORGANIC CARBON AND ORGANIC MATTER (WALKLEY-BLACK METHOD)

D.1 APPARATUS

D.1.1 Erlenmeyer flask

D.2 REAGENTS

D.2.1 Diphenylamine indicator - dissolve 0.5 g of diphenylamine in 20 ml of distilled water, add 100 ml sulfuric acid and mix.

D.2.2 Ferrous sulfate solution (0.5 N) - dissolve 140 g of ferrous sulfate or 200 g of ferrous ammonium sulfate in 15 ml concentrated sulfuric acid and make up to 1000 ml with distilled water.

D.2.3 Phosphoric acid (85 per cent)

D.2.4 Potassium dichromate solution - dissolve 49.04 g of potassium dichromate dried at 200 °C

D.2.5 Sulfuric acid – concentrated

D.3 PROCEDURE

D.3.1 Weigh 0.025 g of the sample. Transfer to the Erlenmeyer flask using 10 ml of potassium dichromate. Add 20 ml of sulfuric acid. If the colour changes immediately to green, reduce the sample. Leave for 30 minutes and dilute to 200 ml.

D.3.2 Add 10 ml of 85 per cent phosphoric acid, then add 1.0 ml diphenylamine indicator.

Titrate against ferrous sulfate solution till the colour changes to blackish green. Perform a blank titration.

D.4 CALCULATION

D.4.1 Normality of ferrous sulfate solution (N) = $\frac{10}{V_s}$

Organic carbon per cent by mass (% O.C.) = $\frac{(V_b - V_s)\ N \times 0.399}{M}$

where,
N is the normality of ferrous sulfate solution;
V_s is the volume in millitres of ferrous sulfate used for the sample;
V_b is the volume in millitres of ferrous sulfate used for the blank; and
m is the mass in grams of the sample used.

APPENDIX E
DETERMINATION OF VIABLE WEED SEEDS

E.1 APPARATUS

E.1.1 Propagation tray of dimension 20 cm x 20 cm x 5 cm

E.2 PROCEDURE

E.2.1 Take 1 *l* of the sample and moisten with distilled water to an optimal content of 85 per cent. Transfer the wet mixture into a propagation tray of dimension 20 cm x 20 cm x 5 cm. Cover the propagation tray with a transparent plastic cover with two ventilation openings.

E.2.2 Leave the propagation tray for four weeks maintaining the temperature at 23 °C to 30 °C, and the moisture content between 80 per cent to 90 per cent and optimal lighting shall be 12 hours of daylight and 12 hours of darkness per day. After four weeks count the seedlings.

E.3 CALCULATION

No. of viable weed seeds per square metre = n x 2.5

where,
n is the number of seedlings counted (viable weed seeds).

APPENDIX F

DETERMINATION OF CARBON TO NITROGEN RATIO

F.1 CALCULATION

$$\text{Carbon to Nitrogen ratio} = \frac{C}{N}$$

where,

C is the organic carbon content per cent by mass of the material; and

N is the nitrogen content per cent by mass of the material.

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Annexure D

Guidelines for the Identification of Solid Waste Disposal Sites

1. Scope of Guidelines

These guidelines are designed to provide a framework for the development of procedure to protect the community and the environment in setting up of new facilities for disposal of solid waste in environmentally compatible sites in accordance with the environmental regulation in force.

These guidelines are primarily for the setting up of independent solid wastes disposal facilities located away (off-site) from the premises of solid waste generator.

2. Site Approval Procedure / Regulatory Approvals

The National Environmental Act No 47 of 1980 (NEA) is an act for protect and manage of the environment in Sri Lanka. The NEA was amended by act No 56 of 1988 and Act No 53 of 2000.

Under the provisions of Section 23Z of the NEA the EIA(Environmental Impact Assessment) apply only to "Prescribed Projects" which have been specified in Gazette Extraordinary No 772 / 22 of 24.06.1993 and implemented throughout designated Project Approving Agencies (PAA).

Accordingly, construction of any solid waste disposal facility having a capacity exceeding 100 tones per day is a prescribed projects as per the Section 23Z of the NEA and requires approval under the provisions of Part IVC of the NEA.

Hence it is very important to note that if a solid waste disposal facility having a capacity exceeding 100 tones per day is to be constructed, approval is necessary under the provisions of part VC of the NEA before commencement of construction.

Details of the approved procedure under Part IV C can be obtained from Environment Management & Assessment Division of CEA

3. Siting of Solid Waste Disposal Facility

The goals of site selection should be to

- Minimize health risks
- Minimize environmental impacts
- Maximize the public acceptability
- Minimize costs

Risks to human health, environmental impacts and public acceptabilities are important factors to be considered in the site selection process.

3.2 Siting factors

A general listing of various factors to be considered for siting of solid waste disposal facilities are as follows

Physical Constraints

- Surface soils
- Subsurface geology and aquifers
- Topography
- Surface water streams, flooding
- Seismic stability
- Land stability
- Wind direction

Ecological Constrains

- Flora and fauna
- Conservation value
- Habitat value

Human Values

- Landscape
- Recreation value
- Historical / archeological / cultural value
- Population density
- Employment opportunities

Land Use

- Agricultural value
- Extractive industry / mining
- Water supply (surface and subsurface)
- Development potential
- Transportation corridor or utility use
- Land use designation (residential industrial etc)

Waste Disposal Suitability

- Proximity to users
- Transport access
- Availability of utilities and services
- Adjacent land use ; zoning
- Site modification

Potential Ultimate Uses for the Completed site

Eg. Park, recreational area, nature preserves ,botanic gardens, crop production, commercial development etc.

4. Landfill Site Selection Criteria

Engineering

- Physical Site : Should be large enough to accommodate all community (of particular L/A) waste for a minimum of 5 year, but preferably 10 to 15 year; area for buffer strips or zones, office service building must also be included

- Proximity : Locate as close as possible to where solid waste being generated to minimize handling and reduce transport cost. Locate away from water supply (Suggested minimum 500 feet) and property line (suggested minimum 200 feet).

- Access : Should be paved all weather, have adequate width with minimum traffic congestion. Temporary roads to unloading areas within the facility.

- Topography : Should minimize earth moving. Take advantages of natural conditions. Avoid natural depressions and valleys where water contamination is likely.

- Geology / Hydrogeology : Avoid areas with earth quakes, slides, faulty, underlying mines, sinkholes and solution cavities, should at least 200 feet away from a fault line. There should be facilities to control / treat leachates and gasses from land fill

- Soils : Should have natural clay liner or clay available for liner and final cover material available. It is

Environmental

- Surface Water : Locate outside 100 year flood plain. No direct contact with navigatable water avoid wetland. Mitigation measure must be developed to direct surface un-off from the landfill site.

- Ground Water : No contact with ground water. Base of fill must be above high ground water table. Avoid sole-source aquifer. Avoid areas of ground water recharge.

- Air : Locate to minimize fugitive emissions and odour impacts. Wind strength and wind patterns also should be considered. To avoid blowing or flying debris wind breaks must be provided.

- Terrestrial and Aquatic ecology : Avoid unique habitat area (Important to propagation of rare and endangered species) and wetlands.

- Noise : Minimize truck traffic and equipment operation noise

- Land Use : Avoid populated areas and areas of conflicting land use such as parks and scenic areas

- Cultural resources : Avoid areas of unique archeological historical and paleontogical interest

- Legal / Regulatory : Consider national regional and local requirements for permits.

- Public / Potential : Gain local acceptance from elected officials and local interest groups.

- Vector Control :

5. Site characteristics that are unacceptable for solid waste disposal sites.

Geology

- Bedrock outcrops
- Irregularities such as fissures or faults overlying ground water.

Hydrology

- Aquifer recharge zone
- Flood prone areas
- Wetlands
- Seasonally high water tables
- Near private or community water supply wells or reservoirs

Climate

- Extremely

Topography

- Overly steps slops
- Broken Terrain

Soils

- Thin solid above ground water
- Highly permeable soils above shallow ground water
- Soils with extreme erosion potential

Land Use

- Areas normally used for land fills

- Areas contaminated with persistent residues from part chemical spills or waste treatment processing.
- Within 10000 ft from an Air Port

Final selection of a solid waste disposal site / facility is based on

- Site survey
- Engineering design
- Cost studies
- EIA (if required)