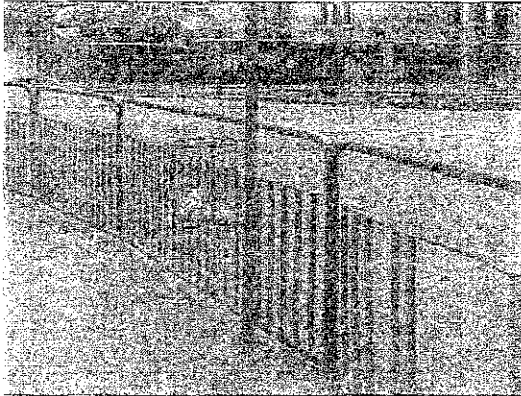
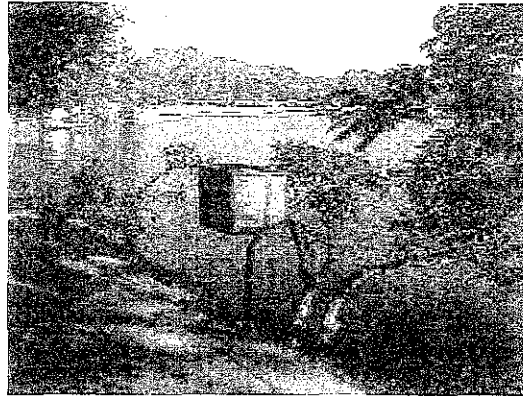


Litter Bins



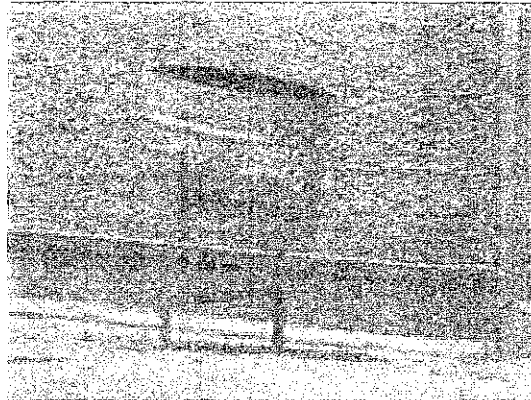
Trash box



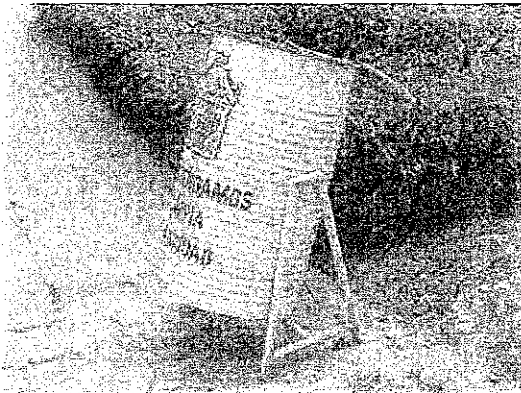
Trash box



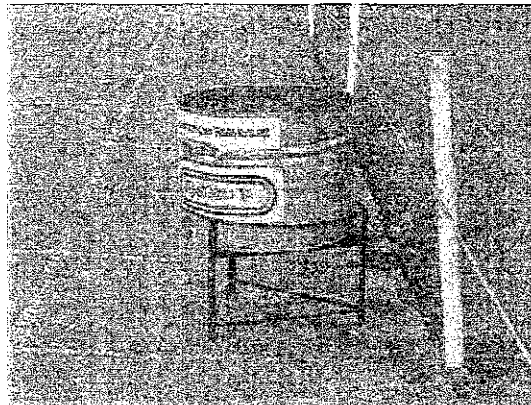
Trash box



Fixed litter bin



Movable Litter bin



Movable litter bin



Good distribution of garbage bins

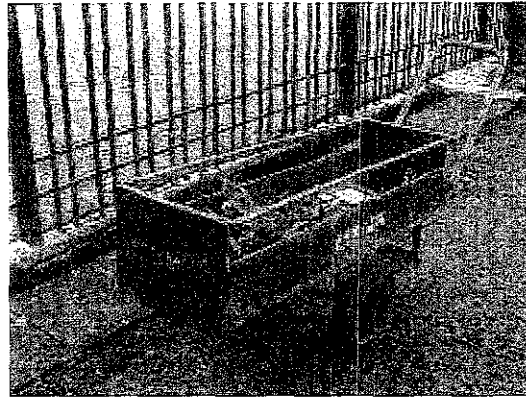


Trash box

Transportation equipment



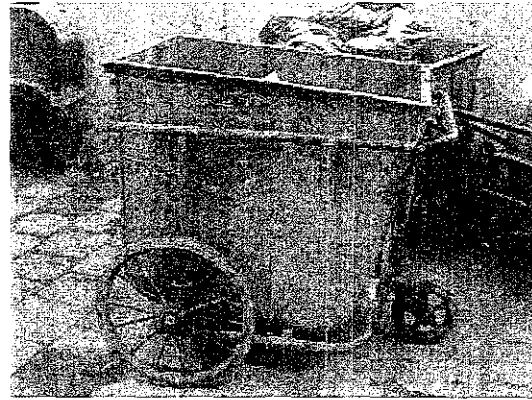
Handcart



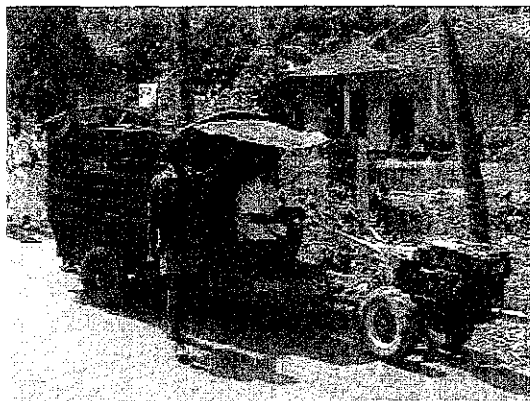
Handcart



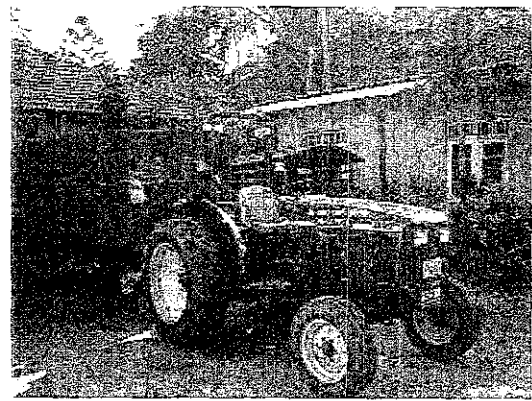
Bin cart



Handcart



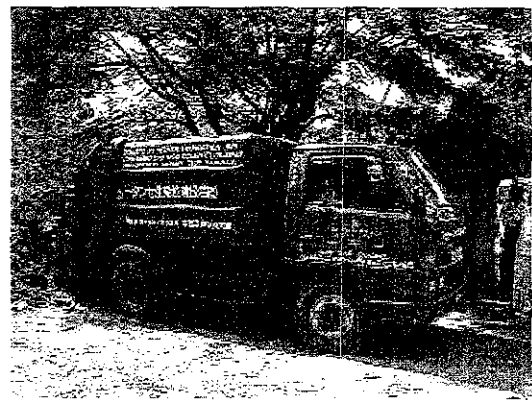
2 wheel tractor



Tractor - trailer



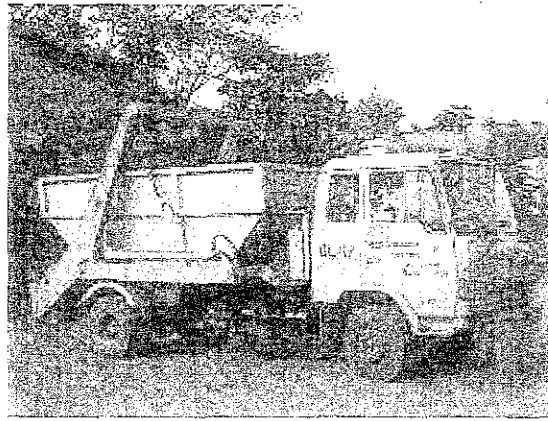
Truck



Compactor

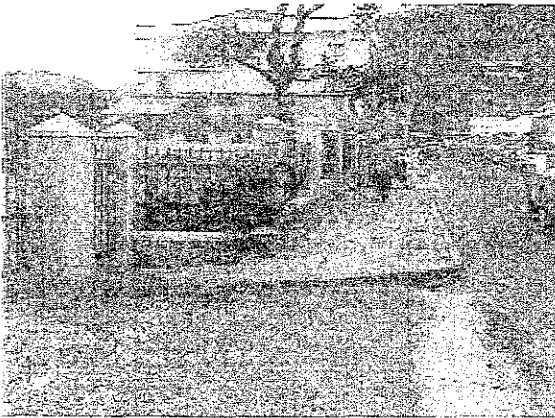


Roll-on Roll-off



Skipper

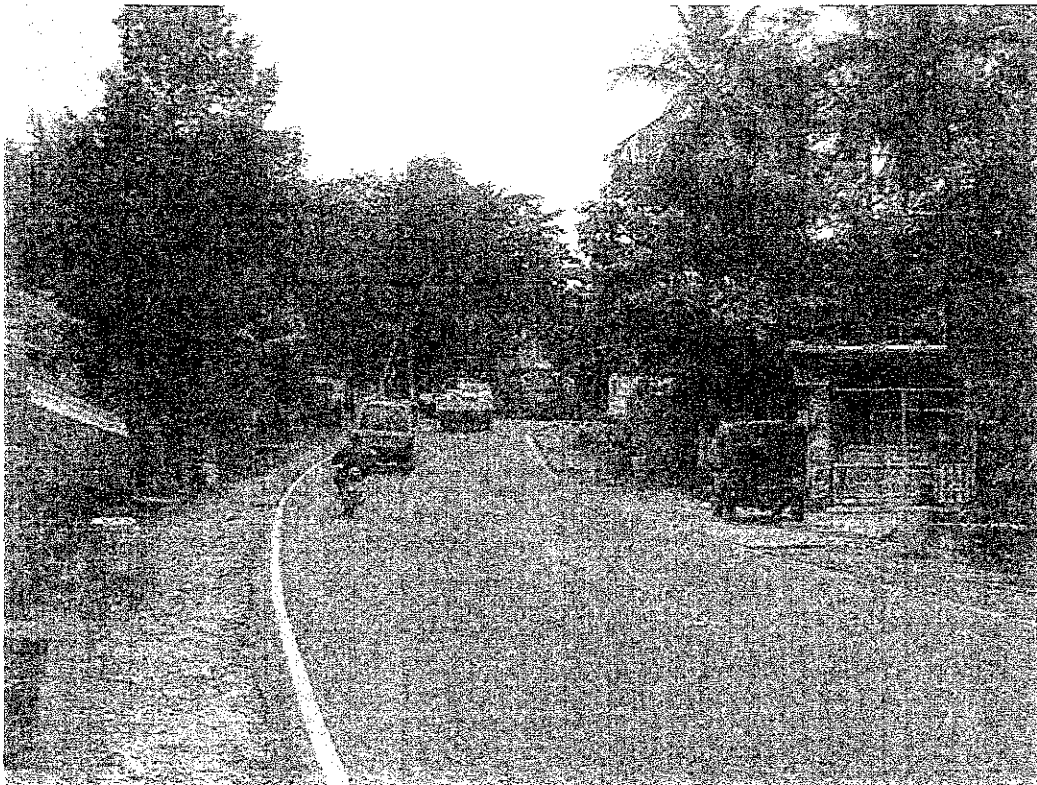
Collection Method



Curbside collection

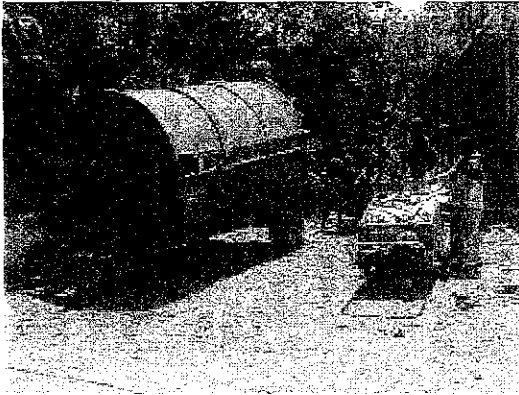


Tractor for bell collection



Curbside collection by home pipes for garbage

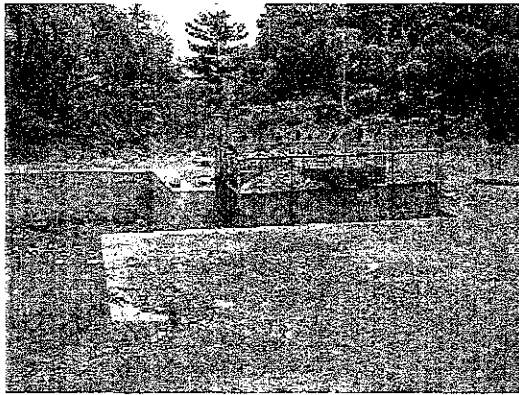
Garbage transfer



Transferring garbage to a stationery tractor



Pullinb a stationery tractor



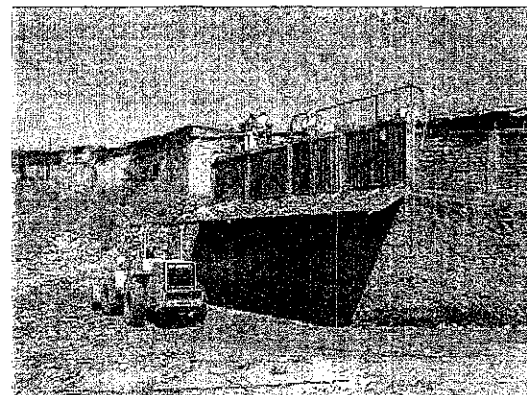
Garbage transfer bay



Transferring garbage to a stationery trailer



Garbage transfer station



Garbage transfer station



Garbage collected by bycycles



Garbage is transferred

D.2.2 Bell Collection

D.2.2.1 Bell Collection Amplifier – Operational Manual

Installation (*please read before installing*)

1. The system comprises the following:
 - Amplifier – this is a sealed unit, that has been modified so that it only plays the garbage collection music. Type A amplifiers contain two AA size batteries to power the music chip inside the amplifier. Type B amplifiers have no internal power source.
 - Waterproof speakers (2).
 - Connecting wires (12V).
2. Fix the amplifier unit, as follows:
 - Turn the on/off switch on the amplifier unit to the off position.
 - Install the amplifier unit so that it is protected from rain, splashing and excessive vibration. Suitable locations include:
 - a. Open tractor: under the seat.
 - b. Tractor with roof: under the roof.
 - c. Tractor with cab, lorry or compactor: inside the cab.
3. Connect the amplifier to a 12V vehicle battery (red = positive; black = negative).
 - If the vehicle has two 12V batteries (e.g. compactor), connect the amplifier to only one battery using clips.
 - If the vehicle has only one 12V battery (e.g. four wheel tractor), connect the amplifier wires either:
 - a. Directly to the battery using clips or,
 - b. To the keyboard (main switch). This means that the garbage collection music can only be played if the tractor engine is running.
 - If the vehicle has no 12V battery (e.g. two wheel tractor), you may connect the amplifier:
 - a. To the headlamp (between the dynamo and light but before the switch). In this case, the power supply is less regulated and the tractor engine must be kept running for the music to continue playing.
 - b. Or, using clips, to a 12V battery purchased specially for this purpose and placed under the driver's seat. However, in this case, the battery must be recharged approximately every two weeks.
4. Fit the amplifier speakers, one to each side of the vehicle using a piece of rubber tube or thin (3-5 mm) rubber pad to minimize vibration and secure using screws/rivets. Suitable locations include:
 - Tractors: on bonnet, buffer¹ or driver safety bar; inside the grill at front of engine, etc.
 - Lorries/compactors: roof of cab or other suitable place.
5. Wires from the amplifier to the speakers should be parallel for both speakers (black wires together; white wires together).

Operating Instructions

1. When you want to play the music, switch the amplifier on. If the system is fitted correctly, the red light on the amplifier unit will be lit.
2. Control the music volume according to the work area. If the volume is too loud, this may annoy people. If it is too soft, people may not be able to hear it.
3. When stopping for a long time while collecting waste, switch the amplifier off, except when you need to keep playing it to inform people of the tractor's location (e.g. in an area with many by-lanes).
4. Do not keep the amplifier switch "ON" for a long time. It is important to keep the amplifier in the "OFF" mode at least five minutes per hour to prolong its life.

¹ This is the common English word used in Sri Lanka for bumper.

Precautionary Measures

1. Vibration during vehicle operation may damage the amplifier. To minimize the possibility of such damage, fix the amplifier where it will experience the least vibration (e.g. under the seat, on dashboard, etc.) and/or fix the amplifier using rubber pads, washers, etc.
2. For open tractors, you may wish to install the amplifier within an aluminium or similar box, both for protection from water damage and security reasons. This box can be opened when the tractor is in use to turn the amplifier on/off and closed and padlocked when the tractor is not in use. Suggested box specifications are given below:
 - Box dimensions should be at least one inch larger on all sides than the amplifier.
 - The box can be riveted together, except for one side (front panel) which should be able to be removed or opened, to facilitate easy removal of the amplifier for maintenance purposes.
 - Around 10 small holes should be made in the sides of this box to allow proper ventilation, this being essential to dissipate heat generated by the amplifier during use. Be careful to locate these holes so they will not be blocked when the box is mounted on the vehicle and to avoid any water entering the box, either from rain or from splashing off the road.
 - Two bigger holes should be made in the aluminum box, with the wires supplying power to the amplifier being threaded through these holes.
 - Rivet, or otherwise fix the amplifier to the bottom of the aluminum box, ideally inserting a rubber pad between the box and amplifier to minimize vibration. If this is not possible, a rubber pad should be inserted between the box and the part of the vehicle to which it is attached.
 - Make bigger holes on the front of the box so that the amplifier controls can be operated without having to open the box. Alternatively, mount a hinge on the front panel, so that the front panel can be opened and closed to operate the amplifier.
 - The front panel can be secured shut by fitting a padlock.
3. Water getting into the amplifier can cause severe damage. Please protect the amplifier from rain and other water (e.g. splashing off road, during servicing), as suggested above or by any other appropriate means.

Maintenance and Problem Solving

1. For amplifier units (type A) containing two AA size batteries, replace the batteries after not more than one year of use.
2. Frequent removal and reinstallation of the amplifiers is not recommended as this may damage them.
3. For type A amplifiers, If the music stops suddenly, this may be due to the battery inside the amplifier becoming loose. Open the amplifier to check this and fix the battery correctly if it is loose.
4. If the music gradually gets softer or there is no sound, this may be due to a low charge of the vehicle battery or loose connections in the supply from the vehicle battery to the amplifier. Check the condition of the tractor battery and wiring. Recharge or replace the battery if necessary.
5. If water gets into the amplifier, DO NOT switch it "ON". Instead, open the amplifier and detach the internal batteries (if present) and supply from the vehicle battery. Place it in sunlight to dry and replace with new AA batteries, if relevant. If it still does not function properly, contact the supplier for advice.

Other

1. Expected amplifier life = 2,000 hours, assuming it is protected from rain and vibration.
2. Approximate replacement cost = 5,000Rs.
3. Warranty period = 12 months

For additional information/help, contact:

Anurudda, 0777 808831, or

Manufacturer: Dammika Pitawalage, Govindala, Pilimalalawa; 0777 578342

D.2.2.2 Operation of Bell Collection System

The introduction of the bell collection method requires people to change their way of life. It is asking people to do something which is likely to be more inconvenient for them. Getting people's co-operation, especially when it involves changing habits, can take a long time – months, even years. Hence, it is a very sensitive trial and may give negative social impacts. Therefore, it has to be done very carefully. The following points should be noted.

1. Motorised Vehicles

The bell collection method is primarily intended for use with motorised vehicles – hand tractors, tractors, lorries, compactor trucks, etc. In the case of the hand tractor, an extra battery must be fitted to provide a power source for the speaker/amplifier system.

a. Volume of Music

Playing music outside can be a nuisance and “noise pollution” - a kind of environmental pollution if the music is too loud. Therefore, the music volume should be minimized – loud enough for people to hear but not too loud to disturb them. The proper volume should be *from ?? to ??*.

b. When Should Music be Played?

Music may be played only when waste collection work is carried out.

Music should not be played at the following times:

- on the way to the collection area
- on the way to the disposal site
- returning to the MC/garage.

Music should not be played during the following times:

- Early morning, maybe before 7am.
- Late night, maybe after 9pm.

c. If no Public Cooperation

If people don't cooperate for the new bell collection system even though they can hear the music, it is due to insufficiency of public education. Don't make the music louder – this never encourages people to cooperate for the bell collection - it only discourages them. Do the public education again.

2. Handcarts

A “bell” type system may also be installed on handcarts for use in narrow streets and congested areas.

a. Bell Selection

There are many kinds of bells that may be used, including a simple bell, air horn and battery

powered multi-tune playing device. All of these are commonly available from many local bicycle shops at a price ranging from 60-175Rs. If implementing such a system, the following points should be considered:

- **Noise:** Most of these devices can not have their volume adjusted. Hence, the noise volume should be appropriate – neither too soft to be difficult to hear or too loud to annoy people. The noise should also be attractive (to avoid annoying people) and unique – not too similar to other common noises, like the ice-cream music or the bread man.
- **Sustainability:** Bells and airhorns are simple, durable devices that are operated manually. Battery powered, tune playing, flashing light/horns are more complex and less durable. They may break more easily while the batteries require regular replacement, which costs money while there may be some delays in getting new batteries from the Council Stores.
- **Acceptability.** The selected device must be acceptable to the majority of handcart workers. If they don't like the noise or device, then they may not use the device. Discuss different options with them.

b. Use

The bell/horn should be played only when waste collection work is carried out.

The bell/horn should not be played at the following times:

- on the way to the collection area
- on the way to the transfer area.
- returning to the MC/garage.

Music should not be played during the following times:

- Early morning, maybe before 7am.
- Late night, maybe after 9pm.

3. Garbage Collection Labourers

From a number of meetings held with LA garbage collection labourers, we have come to realise that garbage collection labourers, especially handcart workers, have a low status in society here. Sometimes, people treat them badly – abusing or hitting them. They have explained to us their fears that people may treat them worse than now, due to the new more inconvenient bell collection system being introduced, particularly if they are required to tell people to comply with the new system and associated waste discharge rules. Please be aware of this and be sensitive about what you ask garbage collection labourers to do!

As stated previously, education and awareness raising are the most important tools for achieving the necessary change in people's behaviour for the bell collection system to succeed.

කැලි කසල බැහැර කිරීම පිළිබඳව බදුල්ල මහ නගර සභාවේ නීති



- ඔබ නිවස / ගෙවත්ත / ආයතනය / වෙළඳසැල / කර්මාන්ත ශාලාව / සිද්ධස්ථානයෙන් දැවත් කරන කැලි කසල පහත ආකාරයට ඉවත් කළ යුතුය.
- බදුල්ල නගරයේ කැලි කසල එකතු කරන වාහන (ට්‍රැක්ටර් හා අත් කරත්ත) මින් ඉදිරියට ඔබ ප්‍රදේශයට හියමිත කාල සටහනක් අනුව ගමන් කිරීමට කටයුතු යොදා අත.
- එම වාහන විශේෂ සංඥා නාදයක් සමඟ ඔබ ප්‍රදේශයේ මාර්ග වල ගමන් කරවීමට කටයුතු යොදා අත.
- එසේ එන අවස්ථා වලදී පමණක්ම ඔබගේ කැලි කසල එම වාහනයට ලබා දෙන්න.
- නැවත භාවිතයට ගත හැකි භාජනයක්, කැලි කසල ලබා දීමට යොදා ගන්න.
- ඔබ ස්ථානයේ ඉදිරිපිට කැලි කසල විසිරෙන පරිදි තැබීම, විසි කිරීම හෝ තිබෙන්නට හැරීම දඬුවම් ලැබිය හැකි වරදකි.
- ඔබ විසින් ඉහත සලලු නීතිය යටතේ සඳහන් පරිදි ගස් අතු, ගොඩනැගිලි අප දූව්‍ය පාරට හෝ වෙනත් ස්ථානයකට දැමීම තහනම්ය.
- සත්ව අප දූව්‍ය, අතුනු ඔහන් පාරට හෝ වෙනත් ස්ථානයකට දැමීම තහනම්ය.
- කාණු කපුරු අලු දොල ඔය ■ ආදී ස්ථාන වෙත කැලි කසල දැමීම තහනම්ය.
- ඔබ ස්ථානය පවිත්‍රතාවය රැක ගැනීම පූර්ණ අයිතිය ඔබ සතුය.
- ඉහත උපදෙස් පිළි නොපදින අයට නීති මගින් කටයුතු කිරීමට සිදුවන බව දැන්වමි.

" පිරිසිදු නරගයක් නීති කිරීමට අපට සහාය වන්න "

මෙහෙයවීම :
 බදුල්ල නගර සභාවේ
 හෙ අංදුව්‍ය සලමභාගරණ ඒකකය .

නාගරික කොමසාරිස් මහ නගර සභාව,
 බදුල්ල.

අනුමතය : ප්‍රධාන ආයතනය

சூய்யமனை அபற்றவற சய்யந்றமாக

பறனை பறபற சய்யமிவால் விற்றியய்யிட்டுள்ள சட்ட ஶுறிடுறவை

- * உங்களது வீடு, வீட்டுத் தோட்டம், தொழில் ஂ்தாபனம், ஂயாபார நிலையம், தொழிற்பேட்டை, வழிபாட்டு ஂ்தலங்கள் ஆகியவற்றிலிருந்து அப்யறப்படுத்தும் குப்பைகளை பின்வரும் முறைகளுக்கு அமையவே அகற்றுகல் வேண்டும்.
- * பசுளை நகரில் குப்பை அகற்றும் வாகனங்கள் (டிரக்டர், தள்ளுவண்டி) கிளியேல் கிவ்வாகனங்கள் நேர அட்டவணைப் பரகாரம் தங்கள் பகுதியில் சேவையில் ஈடுபடுத்தப்படும்.
- * வாகனங்கள் விசேட சமக்கை ஒலியை எழுப்பியபடி தங்கள் பரதேசத்திற்கு வரும்.
- * அத்தருனம் குப்பைகளை கிவ்வாகனத்திற்குக் கொடுத்து உதவுங்கள்.
- * மீண்டும் மீண்டும் பாவணையில் இருக்கக்கூடிய பொருட்களை போடுவதற்கு (கூடையை) உபயோகியங்கள்.
- * குப்பைகளை சீதறி ஏறிவதோ, போட்டு வைப்பதோ தண்டனைக்குரிய குற்றமாகும்.
- * மேற் கூறப்பட்ட இடங்களில் இருந்து பெறப்படும் பரங்களின் கழிவுகள், கட்டிடக் கழிவுப் பொருட்கள் என்பவற்றை விதியில், பொது இடங்களில் போட்டு வைத்தலும் தண்டனைக்குரிய ஂசயலாகும்.
- * மிருகங்களின் கழிவுகள், உறுப்புக்கள் போன்றவற்றையும் கிவ்வாறு விசே ஏறிதல் பெருங்குற்றமாகும்.
- * கான், ஓடை, கால்வாய், ஆறு, நீர்நலைகள் என்பனவற்றிலும் குப்பைகளைப் போடுதல் தடை ஂசய்யப்பட்டுள்ளது.

தங்களின் திருப்பிடங்களை தூய்மையாக வைத்திருத்தல் தங்களின் கடமையாரும்.

- * மேற்கூறிய ஒழுங்குமுறைகளை கடைப்பிடிக்காதவர்களுக்கு எதிராக சட்ட நடவடிக்கை எடுக்கப்படும் என்பதனை கித்தால் அறியத் தருகின்றோம்.

"தூய்மையான நகரம் உருவாக்குவதற்கு எங்களுடன் ஒத்துழையுங்கள்"

அமைப்பு : பசுளை மாநகர சபை
ககாதார பகுதியின் கழிவுகற்றும் பரிவு

பசுளை மாநகர சபை
ஆணையாளர்

அனுசரணையாளர்

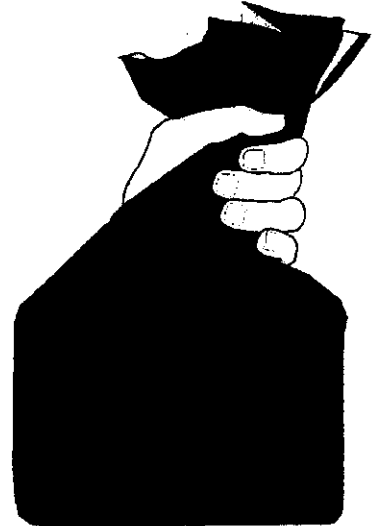
லுய்க்கா திட்டம்

හිතවත් නගර වැසියනි !

කසල එකතු කිරීමේ නව ක්‍රමයක්



මාතලේ මහ නගර සභාව විසින් පරිසර හිතකාමී කසල ඉවත් කිරීමේ නව ක්‍රමයක් හඳුන්වා දෙයි.



සංගීත භව සමහින් ඔබ ප්‍රදේශයට එන කසල එකතු කිරීමේ රථයට ඔබේ කසල ලබාදෙන්න.

නැතහොත්



ඔබ නිවසේ කුණු කසල වසන ලද බදුනක තබා ඒදින උදෑසන ඔබගේ නිවස අසල තබන්න.

දිරාපත්වන කසල වෙන්ව එකතු කර ඔබ ගෙවත්තේ කොමපොස්ට් පොහොර නිපදවන්නේ නම් මෙම අංශය විසින් පූර්ණ සහයෝගය ලබාදෙනු ලැබේ.



කසල එකතු කිරීමේ රථය පැමිණෙන දිනය වේලාව සහ අනෙකුත් විස්තර ඔබ ප්‍රදේශයේ දැන්වීම් පුවරු මගින් ඉදිරියේදී ප්‍රදර්ශනය කරනු ලැබේ.

නාගරික සෞඛ්‍ය දෙපාර්තමේන්තුව
මහනගර සභාව
මාතලේ.

அன்பான நகர வாசிகளுக்கு,

குப்பை கூழங்களை சேகரித்தல் தொடர்பான புதிய முறை



மாத்தளை மாநகர சபை மூலமாக சுற்றாடல் நேயமான புதிய குப்பை கூழங்களை அகற்றல்முறை ஒன்று அறிமுகப்படுத்தப்படவுள்ளது.

இசை ஒலியுடன் உங்கள் பகுதிக்குள் பிரவேசிக்கும் குப்பை கூழங்கள் சேகரிக்கும் வாகனத்திற்கு உங்கள் குப்பை கூழங்களை எகயளிக்கவும்.

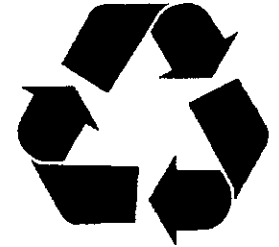


கில்லாவிட்டால்



உங்கள் வீட்டில் குப்பை கூழங்கள் சேகரிக்கும் மூடிய பாத்திரம் ஒன்றில் குப்பை கூழங்களை இட்டு உங்கள் வீட்டின் முன் வைக்கவும்.

உக்கிப் போகக்கூடிய குப்பை கூழங்களை வேறு வேறாக சேகரித்து உங்கள் வீட்டு தோட்டத்தில் கொம்போஸ்ட் உரம் தயாரிப்பீர்களாயின் அதற்கு இப்பிரிவு முழு ஒத்துழைப்பை வழங்கும்.



குப்பை கூழங்கள் சேகரிப்பு வாகனம் வரும் திகதி, நேரம் மற்றும் ஏனைய விபரங்கள் உங்கள் பிரதேசத்தில் அறிவித்தல் பலகை மூலமாக பின்பு விளக்கமளிக்கப்படும்.

நகர சுகாதார திணைக்களம்,
மாநகர சபை,
மாத்தளை.

D.3 Final DisposalD.3-1

D.3 අවසන් වැහැර කිරීමD.3-1

D.3 Sanitary Landfill

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1 Introduction

a. Definition

The term 'landfill' is used herein to describe a unit operation for the final disposal of 'Municipal Solid Waste' on land, designed and constructed with the objective of minimum impact on the environment by incorporating the following seven components;

- a) An impermeable layer at the base and sides of the landfill which prevents the migration of leachate or gas to the surrounding soil, either natural or artificial
- b) A leachate collection and control facility which collects and extracts leachate from within and from the base of the landfill and then treats it
- c) A gas collection and control facility (optional for small landfills) which collects and extracts gas from within and from the top of the landfill and then treats it
- d) A final cover system at the top of the landfill which enhances surface drainage, prevents water from infiltrating, offensive odour, fire and smoke, and supports surface vegetation
- e) A surface water drainage system which collects and removes all surface runoff from the landfill site
- f) An environmental monitoring system which periodically collects and analyses surface water and ground water samples from around the landfill site
- g) A closure and post-closure plan which lists the steps that must be taken to close and secure a landfill site once the filling operation has been completed and the activities for long-term monitoring and maintenance of the completed landfill

The term 'landfill' can be treated as synonymous to a 'sanitary landfill' of Municipal Solid Waste, only if the latter is designed on the principle of waste containment and is characterised by the presence of a liner and leachate collection system to prevent ground water contamination.

b. Rationale

There are two main issues concerning the current landfill site conditions in Sri Lanka. One is how to mitigate the environmental pollution that is caused by existing landfill sites and the other is how to establish new sanitary landfill sites.

Mitigation of environmental pollution, the first issue, is urgently needed at most of the existing landfill sites. However, the necessity of mitigation has not been recognized because the investment for the improvement of existing landfill sites does not produce any output. Furthermore, as improvement technologies are not known to the relative authorities in charge of solid waste management, few improvement projects of existing landfill sites have been implemented. Therefore, showing the effect of the improvement of an existing landfill site

through the pilot project at the Gohagoda landfill site implemented by Kandy Municipal Council and Japan International Corporation Agency (JICA) is very useful not only for the transfer of technology but also for raising awareness of the necessity of mitigation

The establishment of new sanitary landfill sites, the second issue, is also necessary. However, as there was no sanitary landfill site in Sri Lanka before the establishment of Moon Plain sanitary landfill site in Nuwara Eliya, most people did not realize this need. Therefore, people had a strong prejudice against landfill sites operated by local authorities, which caused strong public opposition to landfill sites. In addition, the relative authorities in charge of solid waste management were not able to account for the idea of a sanitary landfill site because they had no knowledge based on actual experience. The pilot project which established a new sanitary landfill site in Nuwara Eliya was very useful in terms of not only the improvement of the existing landfill site run by the local authority but also the introduction of the idea of the sanitary landfill site to the people and relative authorities in Sri Lanka.

In order to introduce the idea of the improvement of existing landfill sites and the establishment of new landfill sites in Sri Lanka, this guideline is described based on the two pilot projects.

2 Environmental Impact and Its Minimisation

The impact of dumping municipal solid waste on land without any containment is shown in the following figure.

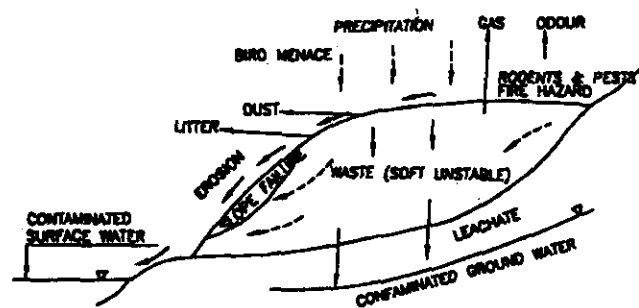


Figure 2-1: Impact of a Waste Dump on the Environment

(Source: Manual on Municipal Solid Waste Management (first edition), Central Public Health and Environmental Engineering Organization (CPHEEO), Ministry of Urban Development, Government of India, New Delhi, May 2000)

One notes from this figure that such dumps cause the following problems:

- a) Groundwater contamination through leachate
- b) Surface water contamination through runoff
- c) Air contamination due to gases, litter, dust, and bad odour
- d) Other problems due to rodents, pests, fire, bird menace, slope failure, erosion, etc.

Sanitary landfills minimise the harmful impact of solid waste on the environment by the following mechanisms: (a) isolation of waste through containment; (b) elimination of polluting pathways; (c) controlled collection and treatment of products of physical, chemical and biological changes within a waste dump- both liquids and gases; and (d) environmental monitoring until the waste becomes stable.

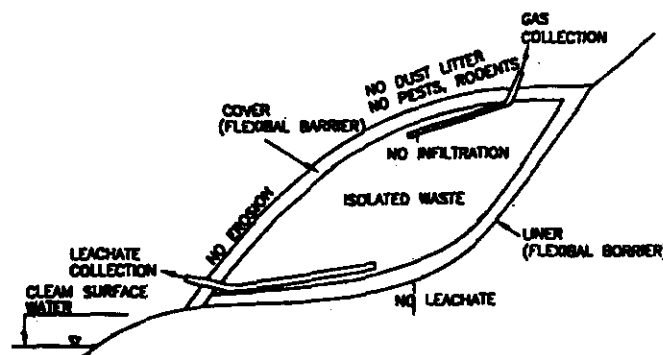


Figure 2-2: Concept of Waste Containment

(Source: Manual on Municipal Solid Waste Management (first edition), Central Public Health and Environmental Engineering Organization (CPHEEO), Ministry of Urban Development, Government of India, New Delhi, May 2000)

3 Site Selection

When a large number (eg. 4 to 8) of landfill sites are available, selection of a landfill site usually comprises of the following steps:

- (i) setting up of locational criteria
- (ii) identification of search area
- (iii) drawing up a list of potential sites
- (iv) data collection
- (v) selection of a few best-ranked sites
- (vi) environmental impact assessment
- (vii) final site selection and land acquisition

However, in municipalities where the availability of land is limited, the selection process may be confined to only one or two sites and may involve the following steps: (i) setting up of locational criteria; (ii) data collection; (iii) initial environmental evaluation or environmental impact assessment; and (vi) final site selection.

3.1 Locational Criteria

Locational criteria may be specified by a regulatory agency (eg. Central Environment Authority). In the absence of regulatory requirements, the following criteria¹ are suggested.

- 1) **Lake or pond:** No landfill should be constructed within 200 m of any lake or pond. Because of concerns regarding runoff of waste water, a surface water monitoring program should be established if a landfill is sited less than 200 m from a lake or pond.
- 2) **River:** No landfill should be constructed within 100m of a navigable river or stream. The distance may be reduced in some instances for non-meandering rivers but a minimum of 30m should be maintained in all cases.
- 3) **Flood Plain:** No landfill should be constructed within a 100 year flood plain. A landfill may be built within the flood plains of secondary streams if an embankment is built along the stream side to avoid flooding of the area. However, landfills must not be built within the flood plains of major rivers unless properly designed protection embankments are constructed around the landfills.
- 4) **Habitation:** A landfill site should be at least 500m from a notified inhabited area. A zone of 500m around a landfill boundary should be declared a No-Development Buffer Zone after the landfill location is finalised.
- 5) **Public parks:** No landfill should be constructed within 300m of a public park. A landfill may be constructed within the restricted distance if some kind of screening is used with a high fence around the landfill and a secured gate.
- 6) **Critical habitat area:** No landfill should be constructed within critical habitat areas. A critical habitat area is defined as an area in which one or more endangered species live. It is sometimes difficult to define a critical habitat area. If there is any doubt then the regulatory agency should be contacted.
- 7) **Ground water table:** A landfill should not be constructed in areas where the water table is less than 2m below ground surface. Special design measures should be adopted, if this cannot be adhered to.
- 8) **Airports:** No landfill should be constructed within the limits prescribed by regulatory agencies from time to time.
- 9) **Water supply well:** No landfill should be constructed within 500m of any water supply well. It is strongly suggested that this locational restriction be abided by at least for down

¹ (Source: Manual on Municipal Solid Waste Management (first edition), Central Public Health and Environmental Engineering Organization (CPHEEO), Ministry of Urban Development, Government of India, New Delhi, May 2000)

gradient wells. Permission from the regulatory agency may be needed if a landfill is to be sited within the restricted area.

- 10) **Costal regulation zone:** A landfill should not be sited in a coastal regulation zone.
- 11) **Unstable zone:** A landfill should not be located in potentially unstable zones such as landslide prone areas, fault zones, etc.
- 12) **Buffer zone:** A landfill should have a buffer zone around it, up to a distance prescribed by regulatory agencies.

Other criteria may be decided by the planners.

3.2 Search Area

To identify the potential sites for a landfill a 'search area' has to be drawn. The search area is usually governed by the economics of waste transportation. It is usually limited by the boundaries of the municipality. Typically search areas are delineated on a map using a 'search radius of 5 to 10 km, keeping the waste generating unit as the centre. Alternatively, the search area may be identified by adopting a range of 5 km all around the built-up city boundary. One should start with a small search area and enlarge it, if needed.

3.3 Development of a List of Potential Sites

After demarcating the search area and studying the various restrictions listed in the locational criteria, potential areas for site development should be identified. A road map may be useful to show the potential areas that satisfy the locational criteria. Preliminary data collection should be undertaken in order to narrow the list of sites to a few best-ranked sites.

In areas where land availability is scarce, degraded sites such as abandoned quarry sites or old waste dump sites can be considered. Special design measures are required for such sites.

To estimate the area required for a landfill, the landfill capacity may be computed and the area required for the operative life of the landfill should be evaluated.

3.4 Data Collection

Several maps and other information need to be studied to collect data within the search radius. Some are discussed below.

- a) **Topographic maps:** The topography of the area indicates low and high areas, natural surface water drainage pattern, streams, and rivers. A topographic map will help find sites that are not on natural surface water drains or flood plains.

- b) **Soil maps:** These maps, primarily meant for agricultural use, will show the types of soil near the surface. They are of limited use as they do not show the types of soil a few metres below the surface.
- c) **Land use plans:** These plans are useful in delineating areas with definite zoning restrictions. There may be restrictions on the use of agricultural land or on the use of forest land for landfill purposes. These maps are used to delineate possible sites that are sufficiently away from localities and to satisfy zoning criteria within the search area. Such maps are available with the Town Planning authority or the Municipality.
- d) **Transportation maps:** These maps, which indicate roads and railways and locations of airports, are used to determine the transportation needs in developing a site.
- e) **Water use plan:** Such maps are usually not readily available. However, once potential areas are delineated, the water use in those areas must be investigated. A plan indicating the following items should be developed: private and public tube wells indicating the capacity of each well, major and minor drinking water supply line(s), water intake wells located on surface water bodies, and open wells.
- f) **Flood Plain Maps:** These maps are used to delineate areas that are within a 100 year flood plain. Landfill siting within the flood plains of major rivers must be avoided.
- g) **Geologic maps:** These maps will indicate geologic features and bedrock levels. A general idea about soil type can be developed from a geologic map.
- h) **Aerial photographs/Satellite imagery:** Aerial photographs or satellite imagery may not exist for the entire search area. However such information may prove to be extremely helpful. Surface features such as small lakes, intermittent stream beds, and current land use, which may not have been identified in earlier map searches, can be easily identified using aerial photographs.
- i) **Ground water maps:** Ground water contour maps, which indicate the depth to ground water below the land surface as well as regional ground water flow patterns, are available in various regions.
- j) **Rainfall data:** The monthly rainfall data for the region should be collected from the Meteorological Department.
- k) **Wind map:** The predominant wind direction and velocities should be collected from the Meteorological Department.
- l) **Seismic data:** The seismic activity of a region is an important input in the design of landfills. Seismic coefficients are earmarked for various seismic zones.

3.5 Site Walk-Over and Establishment of Ground Truths

A site reconnaissance will be conducted by a site walk-over as part of the preliminary data collection. All features observed in various maps will be confirmed. Additional information pertaining to the following will be ascertained from nearby inhabitants: (a) flooding during monsoons; (b) soil type; (c) depth to G.W. table (as observed in open wells or tube wells); (d) quality of groundwater and (e) depth to bedrock.

3.6 Preliminary Boreholes and Geophysical Investigation

As part of the preliminary data collection, one to two boreholes will be drilled at each site, and samples will be collected at every 1.5 m interval to a depth of 20 m below the ground surface. The following information will be obtained: (1) soil type and stratification; (2) permeability of each strata; (3) strength and compressibility parameters (optional); (4) ground water level and quality and (5) depth to bedrock.

In addition to preliminary boreholes, geophysical investigations (electrical resistivity/ seismic refraction / others) may be undertaken to assess the quality of bedrock at different sites.

3.7 Assessment of Public Reaction

The public/nearby residents should be informed of the possibility of the siting of a landfill in a nearby location even as soon as the list of potential sites is developed. A preliminary assessment of public opinion regarding all the sites in the list is essential.

A site may be technically and economically feasible yet may be opposed heavily by the public. The “not in my backyard” (NIMBY) sentiment is high initially. However, with proper discussion it can be overcome in some cases. Early assessment regarding how strong the NIMBY sentiment is can significantly reduce the time and money spent on planning for a landfill site which may not materialise. In many instances residents around a proposed site cooperate if the landfill site owner’s representative listens to concerns of the area residents and considers those concerns in designing and monitoring a site. Noise, dust, odour, increases in traffic volume, and reduction in property value concern the area residents more than the fear of ground water contamination.

Public reaction is less hostile if landfilling is done in an area already degraded by earlier municipal waste dumps or other activities such as quarrying, ash disposal, etc.

3.8 Selection of a Few Best-ranked Sites

From amongst a large number of sites, the selection of a final site will emerge from a two-stage approach.

- (a) Selection of a few best-ranked sites (usually two sites, sometimes three) on the basis of pathway and receptor related attributes

- (b) Selection of a final site on the basis of an environmental impact assessment, social acceptance and cost disposal

For the selection of a few best ranked sites, the following attributes should be considered:

- (a) population within 1 km
- (b) distance to drinking water well/tube well
- (c) use of site by residents
- (d) distance to nearest offsite building
- (e) presence of airport
- (f) presence of roads
- (g) current land use
- (h) distance to critical habitat nearby
- (i) distance to nearest surface water
- (j) depth to ground water
- (k) soil permeability
- (l) depth to bedrock
- (m) susceptibility to flooding
- (n) susceptibility to water erosion
- (o) slope stability of final landform
- (p) air pollution potential
- (q) susceptibility to seismic activity

On the basis of the ranking/scores received by various sites, one or two sites (sometimes up to three) may be chosen for environmental impact assessment and final selection.

3.9 Final Site Selection

The final selection of the site from amongst the best-ranked alternatives should be done by comparing:

- (a) the environmental impact;
- (b) social acceptance; and
- (c) transportation and landfilling costs.

Transportation costs may be compared on the basis of the average hauling distance from the centre of the waste generating unit (city or part thereof). Landfilling costs are difficult to compute at the preliminary stage but may be compared on the basis of the shape of the completed landfill and material costs for the liner system, leachate collection system, daily covers and final cover system.

A landfill site with low environmental impact, high social acceptance and low costs is the most desirable. If conflicting results appear for (a), (b) and (c), environmental impact minimisation should normally be given top priority.

4 Site Investigation and Site Characterisation

The data collected during site selection is not sufficient for designing a landfill. To be able to undertake the detailed design of a landfill at a selected site, it is essential to characterise the landfill site and evaluate the parameters required for design. It is necessary that all data listed in Table 4-1 on 'Data Collection' is collected for site characterisation. If some data has not been collected, the same should be obtained before site investigations are undertaken for site characterisation.

A proper site investigation programme comprises of a subsoil investigation, ground water/hydrogeology investigation, hydrological investigation, topographical investigation, geological investigation, environmental investigation, traffic investigation and leachate investigation.

The following table indicates the types of investigations to be carried out for site characterisation including suggested minimum requirements of such investigations. The output expected from each investigation is listed below.

Table 4-1: Data Collection for Site Investigation and Characterisation

Type of Investigation	Suggested Scope of Work	Detailed investigation plan
Subsoil /Geotechnical Investigation	<p>(a) For landfill design</p> <ul style="list-style-type: none"> ■ Two boreholes per hectare of land; minimum of 3 boreholes; up to 10m below base of landfill; recording soil strata, ground water level, bedrock level ■ One to two in situ permeability tests per hectare of land ■ Performance of SPT test and collection of undisturbed samples from boreholes. ■ Laboratory tests on undisturbed samples for permeability, strength, and compressibility, and classification tests. <p>(b) For borrow area of liner material and cover material</p> <ul style="list-style-type: none"> ■ Two test pits or shallow boreholes per hectare of borrow area; minimum of five pits 	<ul style="list-style-type: none"> ■ Stratification of subsoil-type of soil and depth ■ Depth to ground water table and bedrock(if located within 10 m of base of landfill) ■ Permeability of various strata beneath the landfill ■ Strength and compressibility properties of subsoil ■ Extent of availability of liner material, drainage material, top soil, and protective soil in adjacent borrow areas ■ Subsoil properties along approach road

Type of Investigation	Suggested Scope of Work	Detailed investigation plan
	<ul style="list-style-type: none"> ■ Laboratory test-classification, Proctor compaction, permeability and strength tests (c) For approach road to landfill ■ As per IRC codes 	
Ground water/ Hydrogeological investigations	<ul style="list-style-type: none"> (a) One ground water well (per aquifer) for every hectare of land; minimum of four wells-one up-gradient, three down-gradient (b) Observations of g.w. level fluctuations and groundwater flow (c) Collection of groundwater samples (monthly / bimonthly) for g.w. quality testing for 1 year prior to landfill construction. 	<p>A detailed investigation plan may be drawn up in consultation with a ground water specialist / water resources engineer or a hydrogeologist. The output from such an investigation should yield the following:</p> <ul style="list-style-type: none"> (a) Depth to groundwater table and its seasonal variations (b) Groundwater flow direction (c) Baseline ground water quality parameters-all drinking water quality parameters
Topographical investigation	Surveying of landfill area and preparation of a topographical map with 0.3m contour interval.	Construction of a landfill involves a large quantity of earthwork. It is essential to have an accurate topographical map of the landfill site to compute earthwork quantities precisely. A map of 0.3 m contour interval is considered desirable.
Hydrological Investigation	<ul style="list-style-type: none"> (a) Collection of detailed topographical maps of surrounding area (b) Collection of hydrometeorological data from Meteorological Department (c) Performance of flood routing analysis for one in 100 years flood (d) Collection of surface water samples (monthly/bimonthly) for water quality testing one year prior to landfill construction 	<p>The objective of a hydrological investigation is to estimate the quantity of surface runoff that may be generated within the landfill to enable appropriate design of drainage facilities. If additional run off from areas external to the landfill is likely to enter the landfill, this quantity should also be estimated to design interception ditches and diversion channels. Such an investigation should yield estimates of peak flows. If seasonal rivers or streams run close to the site, the hydrological investigation should indicate the possibility of flooding of the site under one in 100 year flood flows.</p> <p>Surface water samples for water quality analysis may be collected from during hydrological studies.</p>
Geological & Seismic Investigations	<ul style="list-style-type: none"> (a) Geophysical survey-seismic refraction of microgravity for bedrock profiling (b) Joint mapping of exposed rock outcrop/quarry face (c) Collection of seismic data 	<p>Geological investigations should delineate the bedrock profile beneath the landfill base, if not confirmed by subsoil investigations. Geophysical surveys may be designed in consultation with a geologist.</p> <p>In hilly areas or in quarried rocks, geological investigations should indicate the quality of surficial rock, depth to sound rock and the possibility of interconnected aquifers beneath the landfill base in the rock mass.</p>

Type of Investigation	Suggested Scope of Work	Detailed investigation plan
		Detailed seismic data may be obtained as a part of geological investigations (if required)
Environmental Investigation basis	<p>(a) Collection of samples on monthly/bimonthly surface water samples ground water samples, and air samples</p> <p>(b) Transportation to certified testing laboratory and testing for regulatory parameters</p> <p>(c) Vegetation/ecology mapping survey</p>	<p>The following baseline parameters must be established for a one year period prior to construction of a landfill:</p> <p>(a) Ground water quality: Minimum of three samples from each aquifer analysed on a monthly basis for drinking water quality parameters.</p> <p>(b) Surface water quality: Minimum of three samples from a stream/storm water drain analysed on a monthly basis and for parameters relevant for wastewater drains.</p> <p>(c) Landfill gas: Sampling and analysis for methane, hydrogen sulphide and other gases on a monthly basis.</p> <p>(d) Dust: PM ten (Particle size less than ten Microns) monitoring on a monthly basis, specifically at noon, on hot, dry, windy days.</p> <p>(e) Odour: Monthly analysis at the site and at 200m intervals from the landfill boundary to the nearest inhabited zone.</p> <p>(f) Noise: Peak noise analysis at the site and nearby inhabited zone on a monthly basis.</p> <p>(g) Vegetative cover: Vegetative mapping on a seasonal basis.</p>
Traffic Investigation	<p>(a) Collection of data on existing traffic-daily traffic volume and peak hour traffic volume-for six months</p> <p>(b) Road condition survey for existing roads with suggestions for strengthening/ widening.</p>	Traffic investigations must be conducted to identify peak traffic volume as well as the quality of existing roads near the landfill. The influence of increased heavy vehicle traffic due to landfilling should be analysed with a view to widening the existing road.
Waste & Leachate Investigation	<p>(a) Waste characterisation of fresh waste collected from bins</p> <p>(b) Waste characterization of old waste collected from different depths in existing waste dumps or sanitary landfills</p> <p>(c) Collection and laboratory testing of at least six samples of leachate from just beneath existing waste dumps or sanitary landfills.</p> <p>(d) Estimate of leachate quality from laboratory testing.</p>	<p>Waste characterisation is normally conducted as a part of waste management studies or environmental impact assessment studies. Waste from all sources must be tested for the following properties:</p> <p>(a) composition</p> <p>(b) physical properties;</p> <p>(c) chemical properties;</p> <p>(d) biological properties;</p> <p>(e) thermal properties;</p> <p>(f) toxic properties</p> <p>(g) geotechnical properties.</p> <p>Leachate quality can be assessed from both</p>

Type of Investigation	Suggested Scope of Work	Detailed investigation plan
		laboratory studies and field studies. Laboratory leachate tests may be performed. In addition, (if feasible), leachate samples should be analysed from existing waste dumps or landfills near the new site. This will help in a leachate treatment strategy.

5 New landfill Planning and Design

5.1 Design Life

A landfill design life will comprise an 'active' period and a 'closure and post-closure' period. The 'active' period may typically range from 10 to 25 years depending on the availability of land area. The 'closure and post-closure' period for which a landfill will be monitored and maintained will be 25 years after the 'active period' is completed.

5.2 Waste Volume and Landfill Capacity

The volume of waste to be placed in a landfill will be computed for the 'active' period of the landfill taking into account (a) the current generation of waste per annum and (B) the anticipated increase in the rate of waste generation on the basis of past records or the population growth rate.

The required landfill capacity is significantly greater than the waste volume it accommodates. The actual capacity of the landfill will depend upon the volume occupied by the liner system and the cover material (daily, intermediate and final cover) as well as the compacted density of the waste. In addition, the amount of settlement a waste will undergo due to overburden stress and due to biodegradation should also be taken into account.

The density of waste varies on account of large variations in waste composition, the degree of compaction and the state of decomposition. Densities may range from as low as 0.4 t/m^3 to 1.25 t/m^3 . For planning purposes, a density of 0.85 t/m^3 may be adopted for biodegradable wastes with higher values (typically 1.1 t/m^3) for inert waste².

The total landfill area should be approximately 15% more than the area required for landfilling to accommodate all infrastructure and support facilities as well as to allow the formation of a green belt around the landfill.

There is no standard method for classifying landfills by their capacity. However, the following nomenclature is often observed in literature:

² (Source: Manual on Municipal Solid Waste Management (first edition), Central Public Health and Environmental Engineering Organization (CPHEEO), Ministry of Urban Development, Government of India, New Delhi, May 2000)

- Small size landfill: less than 5 hectare area
- Medium size landfill : 5 to 20 hectare area
- Large size landfill: greater than 20 hectare area

Landfill heights are reported to vary from less than 5 m to well above 30 m.

5.3 Landfill Layout

A landfill site will comprise the area in which the waste will be filled as well as additional area for support facilities. Within the area to be filled, work may proceed in phases with only a part of the area under active operation. A typical site layout is shown in Figure 5-1. The following facilities must be located within the site:

- (a) Access road
- (b) Garage for heavy equipment
- (c) Weighing scale (if necessary)
- (d) Control house & facility for visitors
- (e) Waste inspection and transfer station (if used)
- (f) Temporary waste storage and/or disposal sites for special wastes
- (g) Areas to be used for waste processing (if used)
- (h) Fence and gate to demarcate
- (i) Drainage facilities (for diversion of storm water)
- (j) Landfill gas management facilities
- (k) Leachate collection & treatment facilities
- (l) Tire wash pit
- (m) Monitoring wells