Garbage in Sri Lanka

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IRMP Colombo, October 2000

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An Overview of Solid Waste Management in the Ja-Ela Area

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Integrated Resources Management Programme in Wetlands (IRMP), Sri Lanka
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Contents

Foreword

This report was written for IRMP as part of a placement for the Institute for Environmental Studies (IVM) and the Department of Biology of the Free University of Amsterdam. It summarises the results of a survey carried out by Mr. Nalaka Siriwardena and myself, under supervision of Mr. Henk Renken, in the months of July, August, September and October of 2000. This report was mostly written during the second half of September.

I would like to thank a number of people, without whom this survey and this report would not have been possible: Firstly of course, Mr. Nalaka, with whom most of the fieldwork was carried out, and who always managed to keep grinning – even during my frequent recitals of the infamous and list of Things We Still Have To Do. Without his social skills, this report would definitely have been a lot thinner.

I would also like to thank Ms. Chulani, for helping out on several occasions, in interviewing households (together with Nadeera), translating the answers and helping me sort some bags of waste. And of course Mr. Dias, our very own garbage-van-driver, who was unsurpassable (except maybe by Nalaka) in standing by me, grinning widely while I was going through several kilos of other people's refuse. And rightly so.

Many thanks also go out to Henk, Nadeera, Tissa, Hans Rolloos, Dr. Samarakoon and the rest of the IRMP-staff, and of course to the people at The Marsh, who kept me alive with food and drink. Last but not least, I thank all the people who provided the information used for this report, through interviews or otherwise. We couldn't have done it without you. And I mean that.

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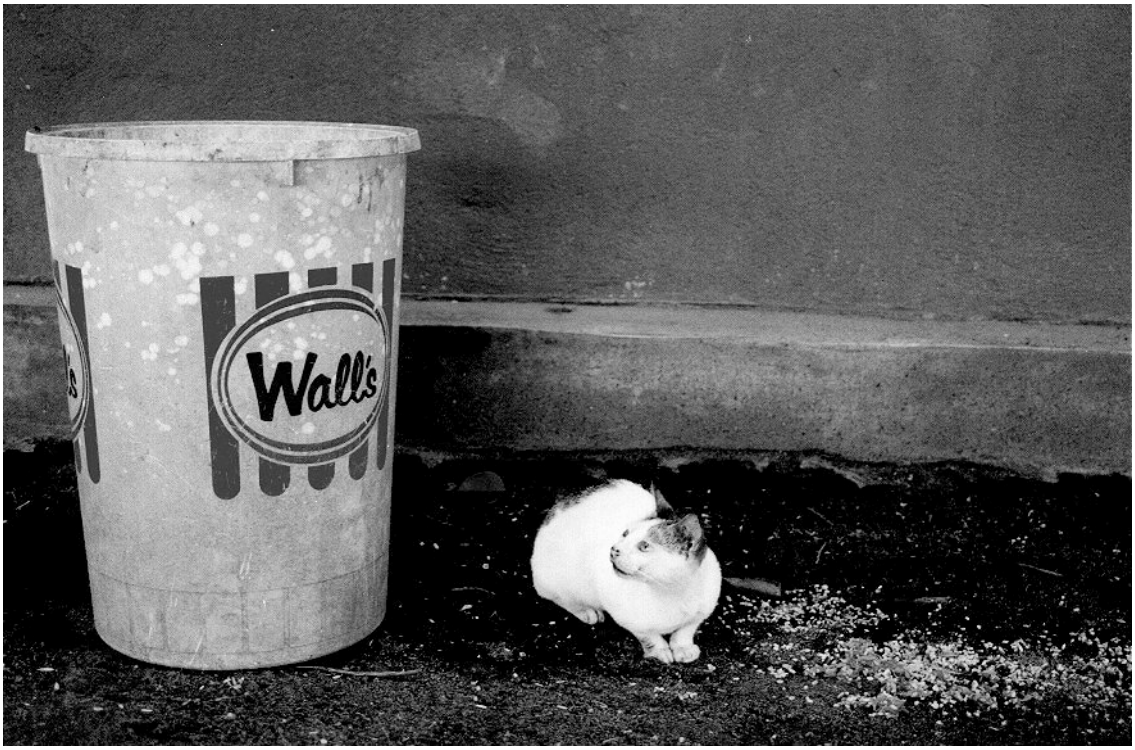


List of Acronyms

BOD	Biological Oxygen Demand
BOI	Board Of Investments
CBO	Community Based Organisation
CEA	Central Environmental Authority
CEC	Cation Exchange Capacity
DHF	Dengue Haemorragic Fever
DS	Divisional Secretary
EDA	Environmental Development Assistant
EIA	Environmental Impact Assessment
GA	Government Agent
GCEC	Greater Colombo Economic Commission
GN	Grama Seva Nildari (see § 1.5)
HDPE	High Density Polyethylene (see § 1.7)
IEE	Initial Environmental Examination
IRMP	Integrated Resources Management Programme in Wetlands
LDPE	Low Density Polyethylene (see § 1.7)
MC	Municipal Council
MFE	Ministry of Forestry and Environment
NERD	National Engineering and Research Department
NGO	Non-Governmental Organisation
NSSWM	National Strategy for Solid Waste Management
PAH	Poly-Aromatic Hydrocarbon
PE	Polyethylene (see § 1.7)
PET	Polyethylene terephthalate (see § 1.7)
PHI	Public Health Inspector
PP	Polypropylene (see § 1.7)
PS	Pradeshiya Sabha (see § 1.5)
PVC	Polyvinyl chloride
RDA	Road Development Authority
Rs	Sri Lankan Rupees
UC	Urban Council
UDA	Urban Development Authority
WCP	Wetland Conservation Project

Summary

1. Introduction

1.1 About this survey

The aim of this survey is to describe the various aspects of solid waste and its management in the Ja-Ela Divisional Secretary (DS) division, and to investigate the possibility of a participative community project in waste-management under the Integrated Resources Management Programme in Wetlands (IRMP).

1.2 IRMP

IRMP is a five-year project of the Central Environmental Authority (CEA), which currently operates in the wetland area of Muthurajawela Marsh and Negombo Lagoon. It aims to develop a workable model for participative and integrated management of wetlands in Sri Lanka. Activities are first run as pilot projects, to see whether they work and how they can best be implemented.

1.3 The area

The Ja-Ela DS Division lies in the Gampaha District of the Western Province, and is located just north of Colombo. It covers some 65 km^2, has about 190,000 inhabitants, and is subdivided into the Pradeshiya Sabha (PS) areas of Kandana, Ragama, Batuwatta and Dandugama, and the Ja-Ela Urban Council (UC) area. Both its population density and population growth are relatively high. A small strip on the western side of the division is part of the Muthurajawela Marsh.

1.4 The waste problem

Infrastructure and resources for waste collection are lacking in most parts of the country, so uncontrolled scattering and dumping of garbage is widespread. There are no proper facilities for final disposal of most of the solid waste produced by households and industries. Waste that is improperly dumped can impede water-flow in drainage channels, and provides breeding places for disease vectors such as rats and mosquitoes. Open dumping sites in natural areas cause pollution of ground- and surface-water, and will facilitate encroachment. Open burning of waste at low temperatures is also widespread. It contributes to atmospheric pollution and may cause serious health problems.

1.5 Government organisation

The government levels in Sri Lanka include the National Government (the President, Parliament, and the Ministries and their departments, agencies, boards, etc.), Provinces (headed by Provincial Councils), Districts (headed by a Government Agent), Divisions (headed by a Divisional Secretary), Pradeshiya Sabhas (PS) and Municipal and Urban Councils (MC and UC), and Grama Seva Nildaris (GN). The PS, MC and UC are assigned a Public Health Inspector (PHI) by the Ministry of Health, who usually also takes care of solid waste management. At the national level, the Ministry of Forestry and Environment (MFE) and the Central Environmental Authority (CEA) are responsible for policies regarding solid waste.

1.6 Legal Aspects

Important laws and regulations with regard to solid waste are the National Environmental Act, the Pradeshiya Sabha Act, and the Urban Council and Municipal Council Ordinances. The Environmental Act restricts the emission of waste materials into the environment, and states the responsibilities and powers of the CEA. The local Government Acts and Ordinances state that the local authorities are responsible for proper removal of non-industrial solid waste, and for providing suitable dumpsites.

1.7 Life cycles

Organic waste consists of materials that will naturally degrade within a reasonable time period. It can be composted or converted into methane (biogas), and some of it can be fed to animals.
Paper and cardboard waste are essentially also a form of organic waste. When to too dirty, they can be recycled or re-used (e.g. for wrapping, as bags or envelopes, and for writing on the unused side). When dirty, they could be composed, but caution may be needed because of the printing ink.

Glass can be recycled, and glass bottles can be re-used. Other silicate (stony) materials can be used in things like road construction, but might first need to be grinded.

Most metals can be recycled. Care should be taken with dumping, as heavy metals can cause serious pollution.

Plastics will degrade naturally, but only very slowly. Addition of certain materials during production can speed up this process. Some types of plastic waste (mostly PET, PE and PP) can be recycled mechanically, but will have to be sorted and cleaned. Tertiary (chemical) recycling of plastics is also possible, and can often handle more contaminated waste, but these techniques are not yet widely available.

2. Methodology

2.1 Interviews

To get more insight into the workings and organisation of solid waste management, interviews were conducted with national and local government agencies, "town-cleaning" firms, waste resellers and local residents. The reliability and completeness of the information obtained through these interviews might in some cases be questionable, so care should be taken in its interpretation.

2.2 Collection survey

We accompanied a group of town cleaners on their morning shift, to gain familiarity with their methods, to get an idea of the composition and amounts of collected waste and to see which materials are kept apart by the cleaners for reselling.

2.3 Dumpsite survey

The main dumpsites in Ja-Ela DS were visited and detailed observations were made (see appendix IV). Quantitative measurements of any kind proved difficult, so were not really performed. The size of the sites was estimated.

2.4 Measurement of waste production

Waste production and composition were measured for 15 households, half of which were located in a more "rural" area (Delature), and half in a more "urbanised" area (Ekala). The households were further divided into two or three income groups. Waste was collected four times over three weeks, sorted into several material types and weighed. Waste from some retail-shops and eating-houses was also collected and analysed. The results obtained are mostly indicative, as precision and representation of the measurements leave something to be desired.

3. Survey Results

3.1 Waste production

The reliability of the figures is somewhat questionable, due to small sample-size and large variation. Collection by the households might also have been selective, leading to a slightly biased result.

Waste production of the households measured seems to be in the range of 100-300 g per day, not including waste materials that were recycled or re-used. Households in more rural areas often seem to use their organic waste as animal feed (not necessarily for their own animals) or for composting.

The average composition of the household waste we measured (by weight), seems to be roughly as follows: 15%–30% plastics, 30%–40% paper, 0–30% organic fraction and 10%–30% rest-fraction. The plastic and paper fractions make up most of the volume of household waste, but can be significantly compressed. The organic fraction makes a relatively large contribution to the total weight, due to its high density and water-content.

Packaging materials make up more than half of the plastic and paper fractions, both by weight and by volume. A significant part of the paper-fraction is already made of recycled materials. Only a small part (less than half) of the plastic fraction would be easy to recycle mechanically. Most packaging materials produced in Sri Lanka do not state the material type.

Restaurants and eating-houses produce a lot of food and kitchen remains, which are usually collected by local pig farmers, who use it as animal feed. Retail shops produce mostly packaging waste.

3.2 Waste collection

Some relevant information on the waste collection resources of the various local authorities is listed in table 3.3. Cleaning of (main) roads and markets has been recently privatised in Kandana PS and Ja-Ela UC, and seems to function better than the former public cleaning systems.
Waste collection and cleaning is mostly paid out of assessment tax and trade licences. Frequent cleaning and collection of roadside waste is mostly restricted to main roads and town areas. Cleaning of the roadside drains is included in the duties of the local authority cleaners, but is currently insufficient.

The cleaners proceed along their daily route, sweeping and shovelling up roadside litter and garbage (including a lot of sand and stones), and throwing it in a tractor-trailer or handcart. There seems to be an increasing tendency, especially among shop owners and higher-income households on the town-edges, to use bags or bins, instead of just dumping the garbage along the roadside. Centrally placed garbage barrels, which are provided by the

private cleaning companies in Ja-Ela and Kandana, are also effective, although many barrels get stolen.

Plant material makes up a very large part of the collected municipal waste. Estimates give around 60%–90% for the organic fraction (by weight).

3.3 Waste disposal

Households generally dump or burn their waste materials. Dumping is usually done in a shallow pit in the ground, along the roadside, on a nearby dumpsite, in low-lying marshland or in waterways or waterbodies. Dumped material is often periodically burned.

Local authorities usually dump their collected waste on privately owned land. Finding suitable sites is difficult, and current sites are therefore often over-used. Officially, waste is not burned by the authorities after dumping, but it does happen.

No regulations or guidelines have been made to govern dumping of solid waste by private companies or industries. Uncontrolled dumping of (hazardous) industrial waste and of slaughterhouse waste is problematic, and poses a potential health risk. Other problems with disposal include smell, prolonged exposure to noxious gases from the burning of waste, scattering of waste materials, presence of potential container habitats and ingestion of plastic bags by cows, pigs and other animals. Serious water pollution (mostly eutrophication) was observed in a few places, but does not (yet) seem widespread. Measurements are needed, however.

There do seem to be any usable laws or regulations that deal with unauthorised dumping of non-hazardous solid waste. Sometimes the Nuisance Ordinance is used by local authorities to stop undesired dumping.

3.4 Re-use and recycling

Especially households in more rural areas re-use organic waste as animal-feed and/or for composting. Pieces of cloth are also sometimes re-used. In more urbanised areas, re-use of waste materials seems virtually non-existent.

Town cleaners seem to keep several materials separate from the rest of the collected waste. Especially corrugated cardboard, metal cans, scrap metal, glass bottles, firewood and some food remains are re-used or sold to waste buyers for recycling.

Waste buyers (re-sellers) often have small shops, where they buy, sort and store things like (news)paper, corrugated cardboard, scrap metal, glass, barrels, plastic containers, sacks and sometimes black-coloured plastics. These materials are obtained from companies, town cleaners, house-to-house collectors, scavengers and other individuals, and are either sold locally for re-use or are sold to recycling-companies, usually through a middleman.

House-to-house collectors buy mostly (news)paper, glass and metal from households, and sell these to the re-sellers at a small profit.

3.5 Public awareness and attitude

The results below might not be representative, because of the small sample group and superficiality of the answers.

Many people do not seem aware of the (potential) environmental problems caused by disposal of solid waste. Garbage is often only seen as a problem because of practical reasons.
Most people seem to know about health problems (especially mosquitoes) relating to garbage, from school education or media. The extent and depth of this knowledge was not determined.
Waste materials that can still be sold or re-used are not seen as waste, but as something which still has value. However, it is usually thrown away when not collected.

Proper collection (and dumping) is seen by many residents as a solution to garbage problems.

3.6 The role of the Government

Lack of resources makes it difficult for local authorities to do anything about the waste problem other than clean the main roads. According to them, the National Government should provide the necessary legislation and resources.

According to the CEA, waste management is a task for the local authorities. The CEA have neither a license-system, nor any regulations, standards or guidelines for solid waste disposal (except for some hazardous materials). The relevant sections of the National Environmental Act have not been implemented. Measures of National Government agencies to help solve the waste-problem seem currently limited to some awareness-material, mostly for schools.

3.7 Future policy

The Ministry of Forestry and Environment is working on a National Strategy for Solid Waste Management (NSSWM), aimed at municipal solid waste. A three-year implementation plan has already been made. Responsibilities are to be shared between national Government bodies (Ministries, the CEA, etc.), local authorities, the private sector, and the general public. Implementation is co-ordinated through committees at national, provincial and local levels. Details and the matter of funding are still unclear.

Waste reduction is mostly envisaged through public awareness and regulation. Re-use and recycling are to be promoted, partly through tax-measures. Properly engineered landfills are to be set up on a regional level and are to be shared between various local authorities.

4. Conclusions and Recommendations

The main conclusions and recommendations are not summarised here, and can be found in chapter 4.

List of Figures and Tables

1. Introduction

1.1 About this survey

This survey on Solid Waste Management was carried out as a part of the Integrated Resources Management Project in Wetlands (IRMP) in Sri Lanka, by a Dutch student and one of the IRMP Project Assistants. The aims of the survey are twofold:

1) To highlight the current situation (and the problems) regarding solid waste in Sri Lanka, by describing the various aspects of solid waste production, management, disposal and recycling in one administrative division of the country.
2) To investigate the possibility of a participative pilot project run by IRMP, to locally help deal with the "garbage"-problem.

For these purposes, the survey focussed on the following aspects:

- Responsibilities of Government agencies with regard to solid waste management
- Organisation and functioning of solid waste collection
- "Informal" collection and re-use of solid waste materials
- Disposal of solid waste
- Production of solid waste by households
- Public knowledge on and attitudes toward solid waste and waste-management

The administrative division selected for the survey was the Ja-Ela Divisional Secretary (DS) Division, situated just north of Colombo.

Information was gathered through interviews, observations, literature and some measurements, as described in *Chapter 2* of this report. *Chapter 3* lists the main results of the survey whereas *Chapter 4* summarises the most important points raised in the preceding chapters. Upon this, conclusions are drawn about the main problems and recommendations are made on how they might be solved, and on what IRMP can do to this effect.

This following chapter will provide some background information about IRMP, the survey area, the problems with solid waste in countries like Sri Lanka, the basic organisation of Government agencies in the country and some of the laws and regulations governing the various aspects of solid waste. Note that some of the information in *Chapter 1* was collected as part of this survey; but as this information is of a more general nature and is more or less publicly available, it is included here instead of in *Chapter 3*. Readers who are familiar with waste management and/or the situation in Sri Lanka may want to skip some parts of this chapter.

1.2 IRMP

The Integrated Resources Management Programme is Wetlands (IRMP) is a five-year project under the Central Environmental Authority of Sri Lanka. It is financed in part by the Government (Directorate General) of The Netherlands, and technical assistance is provided by the Dutch company Arcadis Euroconsult. The project basically serves three main goals:

- to ensure future conservation and sustainable management of the Muthurajawela Marsh and Negombo Lagoon wetland area, in accordance with the Conservation Management Plan (WCP, 1994);
- to identify opportunities and structural methods to this effect (development of a model for integrated management of natural resources), which include participative income-generating activities for the local population and the bringing together of various actors; and

- to use the developed model for replication of successful project activities in other wetland areas in Sri Lanka.

Planned activities (usually of a participative nature) for income generation, ecosystem restoration and removal of pollution are initially carried out as “pilot-projects”, in order to test their effectiveness. Most of these pilot-projects are carried out in close co-operation with one or more CBO’s, NGO’s or Government agencies, all of whom are usually on the implementing side. These partners are to eventually take over the management and expansion of successful pilot-projects, when IRMP terminates in 2002.

Several of IRMP’s pilot-projects are currently related to waste-management. One of these is a community solid-waste-collection and -recycling programme in Negombo, which is implemented by an NGO known as the Arthacharaya Foundation. This programme was modelled after a similar successful project in Galle, also run by the same NGO. However, an analysis made by IRMP of this programme (IRMP, Jan. 2000) shows that a number of conditions particular to the Negombo-region are drastically reducing the effectiveness of the Negombo Arthacharaya programme. Therefore it was decided to search for other approaches that may reduce the solid-waste problem in the IRMP project area. In order to establish what the best approach might be, an overview was needed of the current situation regarding production, collection, disposal and recycling of solid waste, as well as the main problems associated with these subjects. It is for this reason that this survey was originally conducted.

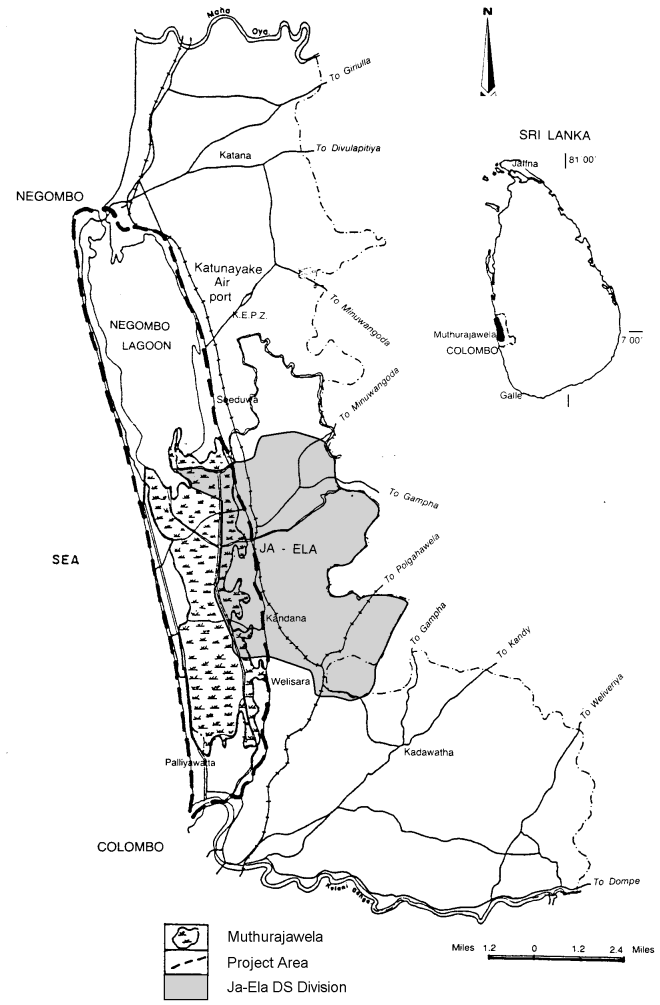


Figure 1.1
The locations of the Ja-Ela DS Division and the IRMP project-area of Muthurajawela Marsh and Negombo lagoon.

1.3 The area

The Ja-Ela Division was chosen for this survey for several reasons. Most of the area can be easily covered from the IRMP field office, which is located at the Muthurajawela Visitor Centre ("The Marsh") in Delature. IRMP already had contacts with some of the local authorities, making it easier to collect reliable data from them. Furthermore, the Division partly overlaps with the IRMP project-area of Muthurajawela Marsh, making the findings of this survey relevant to the management of the Marsh and the organisation of potential pilot-projects. Finally, the area is fairly close to Colombo and therefore contains both urbanised and more rural areas, so that the major differences in solid waste management between rural and urbanised areas might easily be identified.

Geography

The Ja-Ela Divisional Secretary (DS) division lies in Sri Lanka's Western Province, in the Gampaha District. It is located between Colombo and Negombo and covers an area of about 65 km^2 (MFE, 1999). Its precise location and extent are shown in *figure 1.1* and on the map in appendix II.

The Division includes the *Pradeshiya Sabha* (PS) areas of Kandana, Ragama, Batuwatta and Dandugama, and the *Urban Council* (UC) area of Ja-Ela (see also § 1.5). It is further divided into 57 *Grama Niladari* (GN) subdivisions, as shown in *figure 1.2*.

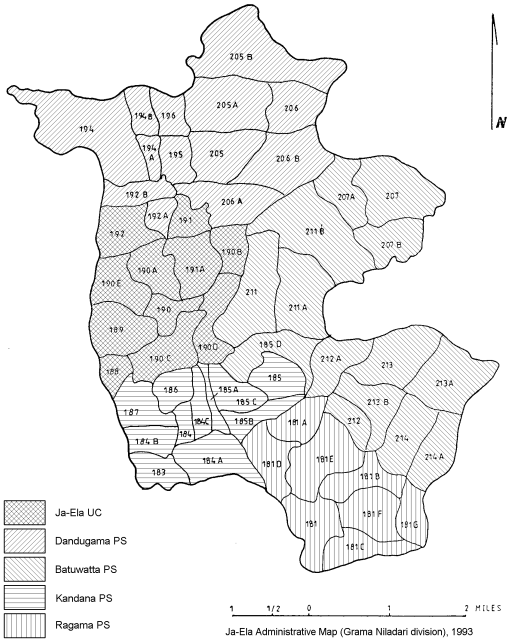


Figure 1.2 The Grama Niladari (numbered) and Pradeshiya Sabha (shaded) subdivisions of the Ja-Ela DS Division.

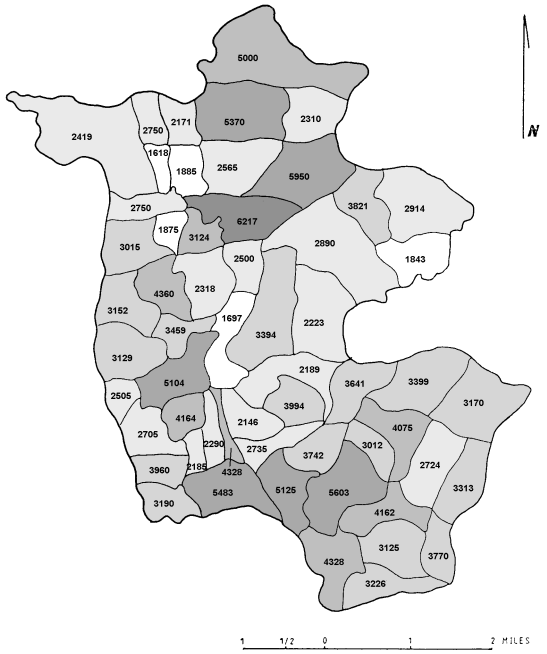


Figure 1.3 The population numbers of the Grama Niladari divisons (1999).

Its principal towns (and most densely populated areas) include Ja-Ela, Kandana, Ragama, Ekala and a fair number of smaller and less densely built population centres such as Batuwatta and Tudella. Major roads running through the Ja-Ela Division are the A3 (Negombo Road), the A33 (past Ekala to Gampaha) and the B13 (past Ragama). The most-

urbanised areas are found along these main roads, as are most of the shops and industries in the area. A large part of the area around Ekala is an industrial estate. The eastern side of the Ja-Ela Division (Batuwatta PS) is an area with a relatively low degree of urbanisation. The same goes for the western edge, which lies within the area of Muthurajawela Marsh.

Socio-economics

The Division has a population just over 190,000 people, of which about 95% is Sinhalese, 3% is Tamil and 1% is Muslim (1999 figures, Ja-Ela DS). The most densely populated areas are near the towns of Ekala, Ragama, Ja-Ela and Kandana (see *figure 1.3*).

The Ja-Ela Division and surrounding areas have a relatively high population density and a relatively low amount of agriculture, when compared to the rest of the country. The rate of population increase in the District is also above the annual country average of 1.8% (1998 estimate). It is generally around 2.5%, but can be as much as 5% in and around population centres such as Ja-Ela and Kandana (GCEC, 1991). These high figures are mainly due to immigration from other parts of the country.

In most GN subdivisions of the Division, some 10%–30% of the population are Samurdhi beneficiaries, which means that their households earn less than Rs. 6000 per month (Samurdhi data for 2000).

Muthurajawela

The north-eastern edge of Muthurajawela Marsh lies within the Ja-Ela DS Division (see *figure 1.1*). The marsh is part of the combined marsh-lagoon wetland for which a development Masterplan (GCEC, 1991) was drawn up in the early 1990's, followed by a Conservation Management Plan (WCP, 1994) three years later. This particular wetland area was the focus for many of the activities of the CEA's Wetland Conservation Project (WCP), which ran from 1991 to 1997, and was later followed up by the IRMP programme.

The marsh covers some 3,164 hectares, and is an important wetland area, part of which is declared a sanctuary. It forms a joint ecosystem with Negombo Lagoon, with which the northern segment is hydrologically linked. The marsh is not very suitable for housing and agriculture due to the extremely wet conditions and the soil type, and therefore has a fairly low economic value. It does however have a high natural value due to its high bio-diversity. It supports a wide range of species, of which many are endemic and/or threatened. Furthermore, it functions as a buffer area for excess rainwater, a sink for industrial and residential effluents, and a "green lung" for the Greater Colombo area. Most measures to increase its economic value (like sand filling for housing), would inevitably lead to a decrease in natural value and buffer capacity.

Especially in the last decade, housing expansion in the marsh has greatly increased, mainly due to the availability of “free” Government-owned land (IRMP, 1998). Mostly low-income squatter families have immigrated from other areas, and are now living in the marsh. Many households lack basic facilities for drinking water and waste-disposal. During the raining-season, the lower areas of the marsh are prone to flooding.

The marsh proper has a peat-bog soil, while the surrounding areas have mostly laterite soils (see *figure 1.4*). The peat bog has a high organic carbon content, a high cation exchange capacity (CEC) and a relatively low density (GCEC, 1991).

There is not much known about the groundwater flow systems in the area (GCEC, 1991). It is likely though, that surface water plays a much more important role in transporting water and solubles. The area has a network of canals that ultimately flow into Negombo Lagoon, and can facilitate water flow and drainage (see *figure 1.5*). The water level in the marsh is generally somewhat higher than in the surrounding area, as the retention time is fairly long.

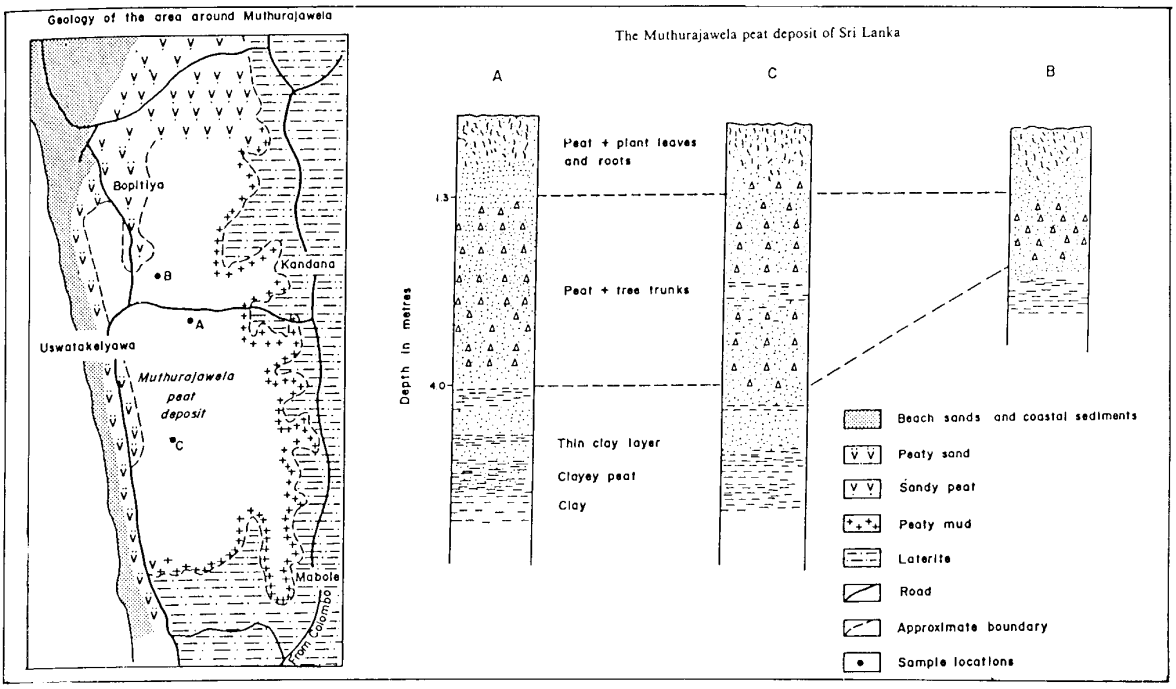


Figure 1.4 The geology of Muthurajawela Marsh (taken from GCEC, 1991).

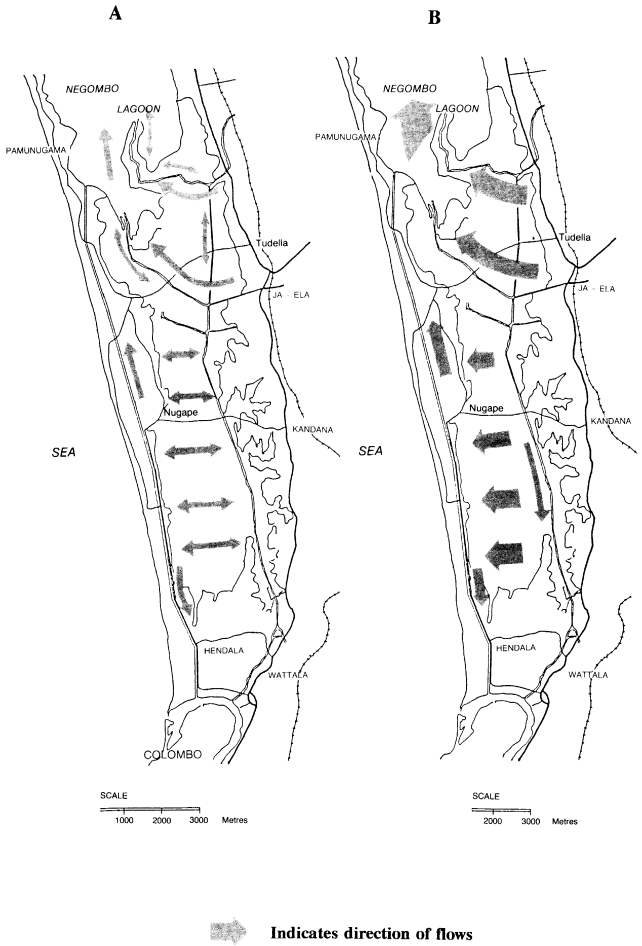


Figure 1.5
Approximate flow patterns of surface water in Muthurajawela, during (A) the dry and (B) the wet season (taken from CGEC, 1991).

1.4 The waste problem

In countries like Sri Lanka, most of the problems surrounding solid waste seem to arise from a lack of infrastructure, a lack of resources and especially an absence of proper waste-disposal provisions. Because of this, most people simply dump their garbage at the most convenient place available to them, or better – the least inconvenient place, which is often the roadside or some natural area (see *figure 1.6*). This results in a scattering of waste materials, which attract all kinds of animals. For some of these animals, including cattle, goats and pigs, eating from the garbage might result in ingestion of plastic bags, etc, which can damage their health. Other animals, especially dogs, crows and monkeys, help spread the waste even further. Finally, some of the animals attracted by the waste might pose a threat to the public health, as is discussed in more detail below.

From a more social viewpoint, the garbage scattered along the roadsides and in other (often naturally and culturally important) areas does not look very nice, and can generate a rather offensive smell. This is certainly not good for the tourism industry, which is why tourist attraction sites and hotels sometimes spend significant amounts of money to remove garbage from their immediate surroundings.

Scattered or dumped garbage often ends up in drainage channels and other waterways, where it may cause pollution and can disrupt the water-flow. This may cause flooding during periods of rainfall, and cause stagnant pools to be formed afterward, which again form a perfect habitat for various disease-vectors.

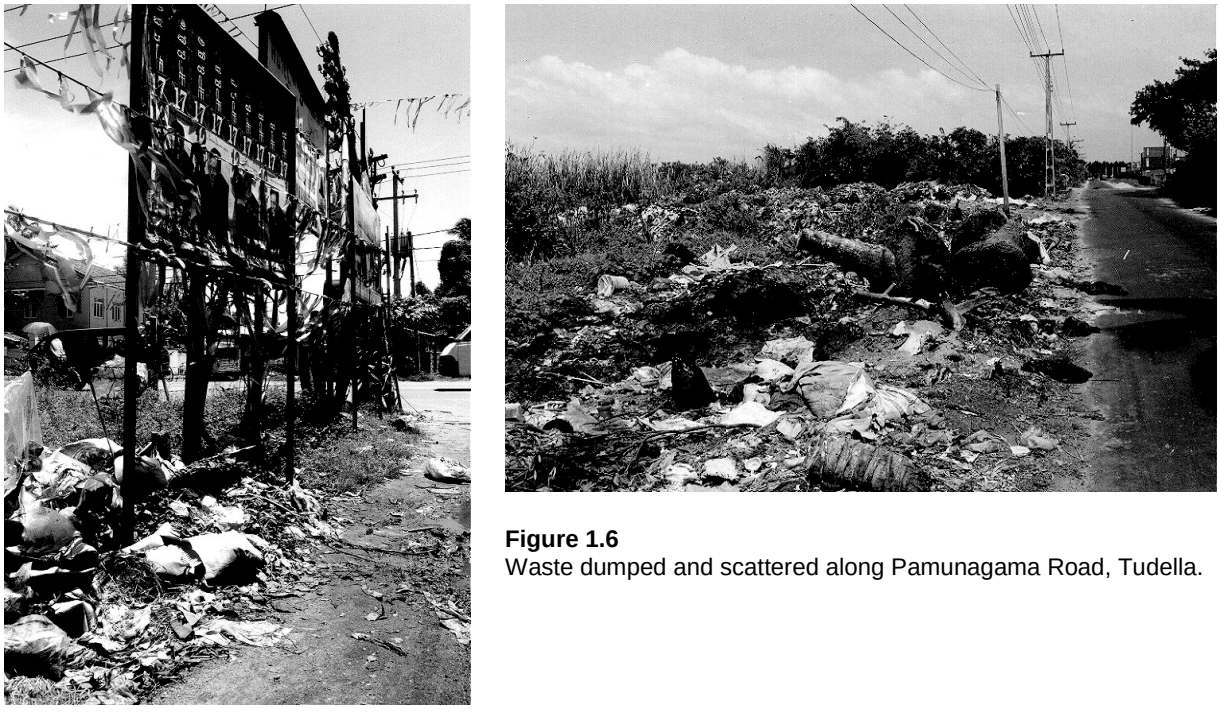


Figure 1.6
Waste dumped and scattered along Pamunagama Road, Tudella.

Disease vectors associated with solid waste are mainly rats and mosquitoes. Rats (*Rattus rattus* and *Rattus norvegicus*) live of food remains in the waste, and spread diseases mostly through their urine and faeces. The potentially fatal bacterial disease *Leptospirosis* is spread through human contact with rat urine, and occurs relatively frequently in some parts of Muthurajawela Marsh (GCEC, 1991).

Mosquitoes (*Culex sp.* and *Aedes sp.*) can spread a whole range of viral, bacterial and parasitic diseases, of which *Malaria* is best known and most widespread throughout the tropics, including many parts of Sri Lanka. Mosquitoes generally breed in stagnant water, but the preferred conditions differ among various species (see *figure 1.7*). Some of the *Culex*

species who breed in stagnant, polluted waters, can transmit diseases such as *Filiarisis* and *Japanese Encephalitis*, both of which also occur in the Muthurajawela area (GCEC, 1991). The *Aedes* species *A. aegypti* and *A. albopictus* can transmit the common *Dengue Fever* and the potentially lethal *Dengue Haemorrhagic Fever (DHF)*, both of which have also been recorded in the Ja-Ela District and in the marsh (GCEC, 1991). The latter mosquito species prefers to breed in small puddles of clear, stagnant water. Such conditions are often provided by man-made containers (or discarded coconut shells) filled with rainwater, the so-called *container habitats*, which are generally found in household waste.

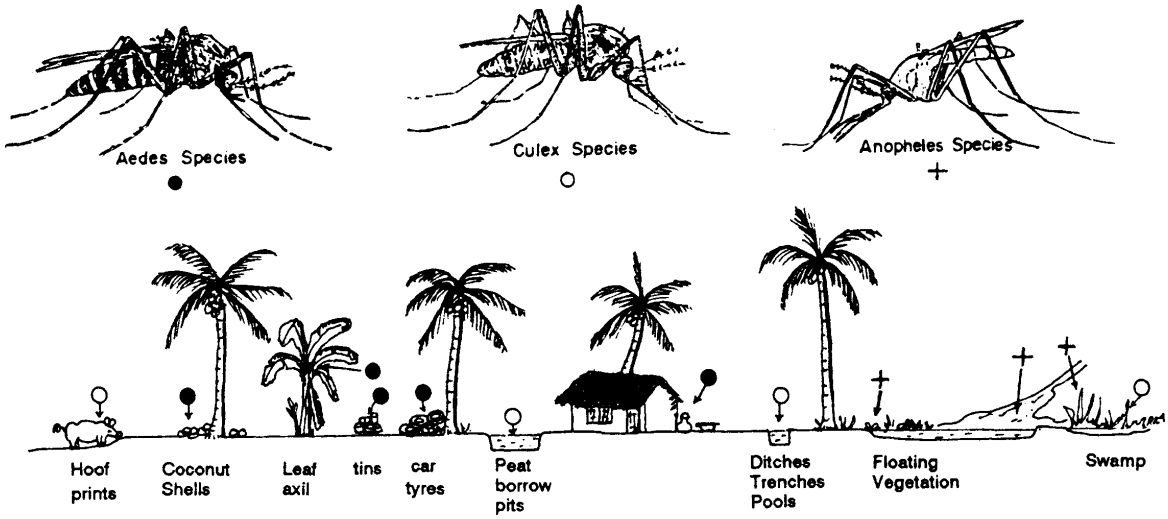


Figure 1.7 The three main mosquito disease-vectors found in Muthurajawela, and their usual habitats (taken from GCEC, 1991).

There are some areas in Sri Lanka, mostly town areas, in which waste is collected and centrally disposed of in open waste-dumps. A lot of people also use waste to fill up low-lying areas, which can then be used for building, etc. Both of these activities reduce some of the problems and unsightliness associated with scattered garbage. However, such large accumulations of waste material may also create new problems.

Firstly, finding suitable space for dumpsites is often a problem. Town dumpsites are sometimes located near residential areas, and therefore still give problems with smell and public health, especially when waste is also burned at the site (see below). As an alternative, unused natural areas are often used for dumping, preferably low-lying areas such as marshlands. However, many of these areas have a fairly high ecological value. This is lost or reduced when (part of) the area is used as a waste-dump, because of pollution and encroachment. Both large-scale and small-scale filling of natural wetland areas with household or industrial waste will lead to encroachment, so that the natural area gets increasingly smaller.

There are various ways in which open dumpsites contribute to pollution of natural systems. Animals, rain and wind will cause especially the lighter materials (plastics, paper) to be scattered over the area surrounding the dumpsite. Rainwater percolating through the dump (leachate) ends up polluting surface waters and the groundwater table. Due to the high organic content of most household waste / municipal solid waste, the leachate has a high Biological Oxygen Demand (BOD), and its release into the environment will lead to eutrophication. The leachate may also contain significant amounts of heavy metals, PAH's and other toxic chemical residues normally present in dumped waste. Finally, anaerobic decomposition of organic matter inside the waste dump will produce significant amounts of methane gas, which contributes to the global greenhouse effect.

When, as is usually the case, a dumpsite is not frequently covered with soil, the same problems may occur that were described above for non-central dumping of garbage, namely ingestion of plastics by animals and the presence of container-habitats.

Besides dumping or scattering, another much-used method to get rid of waste is burning. This does get rid of most waste materials, but causes problems with smoke production, and can contribute significantly to atmospheric pollution (CO_2, NO_X, etc.). The smoke is again not socially desirable and can be bad for the tourist industry, but more importantly, it may cause serious health problems when frequently inhaled. Burning of especially plastics at low temperatures will lead to the formation of a whole range of toxic gaseous compounds, like poly-aromatic hydrocarbons (PAH's), furans and dioxines. Many of these are carcinogenic, and may therefore cause (long) cancer as a result of prolonged and/or frequent exposure. In less serious cases breathing problems may occur, caused by particles and gases in the smoke.

Figure 1.8 Bits of half-burned PVC-pipe, on a roadside-dumpsite in Tudella.

1.5 Government organisation

The Sri Lankan Government has many levels of national, regional and local Government, and in addition to this a large number of ministries, departments, agencies and authorities at each of the levels. This can make the mutual relationships and sharing of responsibilities between the various agencies somewhat complex, or at the very least a bit obscure.

The highest level in the Government of the Socialist Democratic Republic of Sri Lanka is the President, who is officially controlled by the Parliament but has rather extensive executive powers. The President appoints the Ministers, who form the Cabinet and head the Ministries. Any legislation or regulations made by the Ministries has to be approved by Parliament. Each Ministry has a number of departments and authorities, which – although falling under a certain Ministry – are often separate, independently functioning entities.

The two national Government institutions that are of most relevance to solid waste management are the *Ministry of Forestry and Environment* (MFE), and the *Central Environmental Authority* (CEA), which falls under this Ministry. More about the responsibilities of these two authorities can be found in paragraph 1.6 and in paragraph 3.6.

The northwestern provinces of Kurunagala and Puttalam do not fall under the CEA, but have their own *North-Western Province Environmental Authority*, which has its own statute. The CEA and many other government bodies are also not or hardly active in much of the east and north of the country, because of the current civil conflict.

On the regional level the country is divided into 9 Provinces, which were created to serve in decentralisation of Government control, and are each headed by a Provincial Council. These Provinces in turn contain a number of Districts (typically 2-4 per Province) which, although geographically part of a Province, fall under the Ministry of Public Administration. Each District is headed by a Government Agent (GA) and is subdivided into a number of Divisions, which are headed by an authority called the Divisional Secretary (DS). The DS Division incorporates yet smaller administrative areas, governed by Pradeshiya Sabhas (which in turn usually divide their area into a number of smaller sub-office-areas) and, in more urbanised areas Urban Councils or Municipal Councils. The Grama Seva Nildaris (GN) form the lowest level of local Government. They also fall under the Divisional Secretary and take care of matters at the neighbourhood level.

The provinces and local government agencies all fall under the Ministry of Provincial Councils and Local Government.

The President, the Parliament, the Provincial Councils, the Pradeshiya Sabhas and the Urban and Municipal Councils are all elected Government bodies. The Ministers, Government Agents, Divisional Secretaries and Grama Seva Niladaris are not elected, but are appointed Government servants.

Each local authority (at levels higher than GN) in principle has a Public Health Inspector (PHI), who works for the Ministry of Health and has to oversee local health related issues, like disease control and health education. His tasks normally also include the organisation of removal and proper disposal of solid waste, as this can pose a threat to the public health.

In addition to a PHI, many local authorities also have an Environmental Development Assistant (EDA), who is employed by the Central Environmental Authority. Although these were originally meant to perform a wider range of tasks at the local level, their main task currently seems to be the organisation of environmental education in schools.

In the Ja-Ela Division, the Divisional Secretariat and the Urban Council both have an EDA. The Ja-Ela Pradeshiya Sabha (in Kandana) has no EDA, but does have a Community Development Officer.

For low-income families (less than Rs. 6000 per month), the Sri Lankan Government has a social benefit system, which is run on a local level through the Samurdhi Authorities. Benefits are calculated based on family size.

One more peculiarity about the Sri Lankan political system that should be noted is the role of some local politicians. It is not uncommon in Sri Lanka that political influence and public resources are misused by politicians to acquire more wealth and power. Therefore, some politicians have a disproportionately large (and often not very constructive) influence on the functioning of local authorities and public life.

1.6 Legal aspects

There are a number of laws and regulations that apply to the various aspects of solid waste management. The most important of these is the National Environmental Act No. 47 of 1980 (as amended by Amendment Act No. 56 of 1988). This document states the powers, functions and duties of the Central Environmental Authority (CEA), and constitutes the basic legal framework for (among other things) preventing the disposal of waste materials into the environment.

For municipal solid waste the local government acts and ordinances are of importance, as they state the responsibilities of the local authorities relating to the removal and disposal of solid waste.

The National Environmental Act

According to section 10 of the Act, the CEA is responsible for implementing the provisions made within the act and the regulations made thereunder. It also has a number of other powers, functions and duties, of which the following are of particular relevance to solid waste management:

- advise the minister on national environmental policy and criteria;
- regulate (directly or though other authorities) the discharges of wastes and pollutants into the environment;
- ensure compliance with the Act and with regulations made, or require local authorities to do so;
- require the submission of proposals for projects (e.g. waste-dumps), for the purpose of evaluating the impacts of such proposal on the environment; and
- provide information and education to the public regarding the protection and improvement of the environment.

In order to execute its tasks, the CEA gets yearly funds allocated to it by the Parliament, as well as additional income from the levy of licence fees and fines (section 5).
Section 9 of the Act requires that a District Environmental Agency be appointed for each administrative district, of which the Government Agent for that district shall be the Chairman. The CEA may delegate any of its powers, duties or functions to this District Environmental Authority, and under section 26 also to any other Government body, in concurrence with the relevant Minister.
The executive powers of the CEA (section 24) are limited to collecting data (entering any premises to take samples, etc.) and issuing directives (which are legally binding) to persons engaged in environmentally harmful activities.
According to section 32 the Minister (advised by the CEA) may make regulations on all matters stated in the Act. These regulations may come into effect on the date of publishing in the Gazette, but can still be disapproved by Parliament afterwards.

With regard to environmental protection, section 23 of the Act states that no person shall discharge, deposit or emit waste into the environment which will cause pollution, except under the authority of a licence issued by the CEA and in accordance with standards and other criteria which may be prescribed under the Act. Such a license can be valid for a maximum period of one year, after which it can be renewed. The license may be suspended or cancelled by the CEA when violated or when environmental damage is likely to result.
Section 23 also lists a number of general and specific criteria for the maintenance of environmental quality, of which some are relevant to the disposal of solid waste:

- Under section 23H no person may pollute or cause or permit to cause pollution of any inland waters of Sri Lanka which may make the waters in any way harmful to life or be

detrimental to any beneficial use made of those waters. Specifically, a person shall be deemed to contravene these provisions if he places (knowingly or otherwise, directly or indirectly, or if he causes or permits it to be placed) any waste in a position where it may end up in any waters or on the bed of any waterway.

- Under section 23K the same general restrictions hold for the atmosphere. The specific limitations described for solid waste disposal are that no person may cause or permit the discharge of odours which are obnoxious or unduly offensive to the senses of human beings, and that no wastes may be burned otherwise than at times or in the manner or place prescribed.
- Under section 23N again the same general restrictions are given for soil or the surface any land. In this case it is also stated that no person may use land for the disposal of or repository for solid and liquid wastes (refuse dump, garbage tip, soil and rock disposal site, etc.), so as to be obnoxious or unduly offensive to the senses of human beings or will pollute or adversely affect underground water or be detrimental to any beneficial use of the soil or the surface of the land.

Every person who contravenes the above provisions shall be guilty of an offence. On conviction such a person is liable to a fine between Rs. 10,000 and Rs. 100,000*. An additional fine of Rs. 500 is imposed for each day the offence continues to be committed. In the cases of water and atmosphere, the aforementioned person must also take corrective measures to prevent further damage to the environment. In these cases there is also the possibility of closing down any factory, trade or business upon continuation of the offence.

In addition to the provisions given above for water, atmosphere and soil, section 23 contains yet another provision that is related to solid waste:

- Under section 23S if any litter deposited in any place, in the opinion of the CEA may become detrimental to the health, safety or welfare of members of the public, unduly offensive to the senses of human beings or a hazard to the environment, the CEA may direct a written notice to the person responsible for depositing the litter or to any public authority whose function is to dispose of such litter or to take such action in relation to such litter as may be specified in the notice. The cost of removal of the litter may be recovered in court against any person proved to have deposited the litter. Any person, who fails without reasonable cause to comply with the requirements of the notice shall, if proved be guilty of an offence.

In any prosecution for an offence committed under sections 23G – 23W (part IVB) of the Act, a certificate issued by the Director General of the CEA is admissible as evidence that pollution has been caused.

The definitions for “waste” and “litter” as described in the Act are as follows:
“Waste” includes any matter prescribed to be waste and any matter, whether liquid, solid, gaseous, or radioactive, which is discharged, emitted, or deposited in the environment in such volume, constituency or manner as to cause an alteration to the environment.
“Litter” for the purpose of section 23S means unwanted waste material, whether a by-product which has arisen during a manufacturing process or a product which has passed its useful working life and has been discarded.

The Act also includes provisions for the approval of projects, which may include dumpsites or other methods of waste disposal. All organisations or individuals submitting a prescribed project for approval must, under section 23BB of the Act, also submit an initial environmental examination report or an environmental impact assessment report. In certain cases (as

* At the time of writing this translates to a range of roughly 130 to 1300 US$.

determined by the Minister) a project-approving agency may only grant its approval with the concurrence of the CEA.

Under the current EIA regulations (Gazette No. 772/22, June 1993), approval is only necessary for solid waste disposal facilities if they have a capacity exceeding 100 tons per day.

Finally, section 29 states that, in case of inconsistencies or conflicts between the Act and other written law, the National Environmental Act shall prevail. (Although it does not say what will happen if the other written law also contains such a clause.)

Local government law

The Pradeshiya Sabha Act (sections 93 and 94), the Municipal Council Ordinance (sections 129, 130 and 131) and the Urban Council Ordinance (sections 118, 119 and 120) state that it is the duty of these local authorities to provide for:

- properly sweeping and cleaning of the streets, including the footways, and collection and removal of all street refuse;
- due removal at proper periods of all house refuse, and due cleansing and emptying at proper periods of all latrines and cesspits; and
- proper disposal of all street refuse, house refuse and night-soil.

Furthermore they state that all street refuse, house refuse, night-soil or other similar matter collected under the provisions of the relevant Act or Ordinance, shall be the property of the local authority, and the authority shall have full power to sell or dispose of all such matter. The local authority must also from time to time provide places convenient for the proper disposal of all street refuse, house refuse, night-soil and similar matter removed in accordance with the provisions of the relevant Act or Ordinance. They must keep all vehicles, animals, implements and other things required for this purpose and shall take all such measures and precautions as may be necessary to ensure that no such refuse, night-soil, or similar matter removed in accordance with the relevant Act or Ordinance is disposed of in such a way as to cause a nuisance.

1.7 Life cycles

Organic waste

Organic solid waste consists of materials that will naturally degrade over a reasonable time-period. It includes mostly food remains (e.g. rice & curry leftovers, bread), gardening waste (leaves, branches, grass clippings, etc.), straw, animal remains, and kitchen waste (peelings, fruit, vegetables, curry leaves, etc.). It generally has a high water content, although leaves and branches form a relatively dry fraction. Some other types of waste, like paper, cardboard and various kinds of cloth can also be considered (and treated as) organic waste.

Organic waste can easily be re-used or recycled in various ways. Most food remains (except meat and bones), peelings and vegetables can be fed to pigs, and some of the organic waste is also suitable for goats, cows and chickens. Crows, dogs and cats will often eat meat leftovers and animal remains (except bones). Some plant materials (e.g. palm leaves, wood, coconut fibre, coconut shells, etc.) may be used to make various products, which can also be sold to generate income. Organic waste can be made into compost, which can then be used to fertilise soil and to grow new plants, thus completing the nutrient cycle.

Woody components of organic waste (branches, trunks, coconut shells) are not very suitable for home composting, as they may take a relatively long time (months to years) to

decompose. These "long-term biodegradable" components can often be used for burning (e.g. for cooking), if treated (dried) correctly.

Finally, it is also possible to extract methane (biogas) from the microbial decomposition of organic waste, usually by feeding it through a biogas-digestor, or alternatively by extracting it from a fully closed landfill. The recovery of methane from the decomposition of organic waste has the added advantage of decreasing its contribution to the global greenhouse effect.

Normally, organic material decomposes naturally though a number of steps. It is first fragmented by larger animals and insects (ants, beetles, millipedes, etc.), after which it is further broken down into organic macromolecules and smaller compounds by fungi and micro-organisms, either aerobically or anaerobically (which is a lot slower). However, its is possible to greatly increase the rate of decomposition by the process of composting, which takes place mostly through micro-organisms that operate at (and generate) high temperatures. The same is true for biogas-generation.

In the case of composting, there are a number of factors that influence the rate of the process and the quality of the resulting compost:

- Fragmenting organic (especially woody) material will increase its effective area, and will thus increase the rate of composting.
- The carbon to nitrogen (C/N) ratio of the composting material should be around 30:1. This can be achieved by mixing “green” plant material (e.g. grass, fruit, vegetable, weeds, etc.) and “dry” plant material (e.g. fallen leaves, straw, woody material, shredded paper and cardboard) in approximately equal amounts. A smell of ammonia during the composting process may indicate an excess of “green” material (rich in nitrogen). Some “dry” (carbon-rich) material can be added in this case to restore the balance (sawdust is very effective).
- The moisture content of the composting material should be around 50%. When too wet (“soggy”) it will start to smell (H_2S-production by anaerobic bacteria) and will decompose badly, and when it is too dry decomposition will be very slow.
- For heat retention it is preferable to use a compost barrel, or a pile of at least $1m^3$. The optimum internal temperature for decomposition should be around 710°C.
- The compost pile or contents of the barrel should be turned regularly (preferably daily), for aeration and to prevent overheating. However, this would require that no new material be added during the composting period (2–3 weeks), which is not practical for composting of household waste as a disposal method. When the contents of a compost barrel is not turned, new material can be added on top and compost can be extracted at the bottom (provided there is a hatch), but the composting process will take somewhat longer (4 weeks or more).

Paper & cardboard waste

Paper and cardboard are made up mostly of cellulose-fibres (wood-fibres), and can therefore be considered a type of organic material and be processed as such. However, it is also possible to utilise used paper and cardboard to make new paper and cardboard, be it of slightly less quality than the original material. Recycled paper is mostly used in newspapers, some packaging-materials, cardboard and "eco"-products.

In some types of paper packaging (e.g. candy wrappers, soap bar wrappers, etc.), a thin layer of plastic is added to the paper, making it unsuitable for recycling. Recycling is more efficient when paper is sorted according to grade, and when contamination is kept to a minimum. Dirty paper is not very suitable for recycling, and is best fragmented and treated as “dry” organic waste (although the presence of printing ink might become a problem if large quantities of printed paper are composted).

Before resorting to recycling, it is also possible to *re-use* paper for various purposes. Paper that is only printed on one side can be re-used in households and especially in offices,

for writing or printing on the unused side. Newspaper can be used for packaging (wrapping) around products to protect them during transport or storage, or for insulation around food-packets. Other types of paper can be made into small bags or protective envelopes, or into bigger "eco"-shopping bags. In eco-products it is customary to use very coarse, hand-made paper. This can easily be produced on a local lever from any grade of paper, and even from other dry organic materials (including water plants and elephant-dung).

Glass waste

Glass is a silicate (SiO_2), and is therefore essentially a very pure form of "stone" (quartz). When discarded, it is subject to slow mechanical degradation and is eventually turned into sand over a course of years to decades. It can easily be recycled by melting and incorporating it in the production of new glass. The recycling is made more efficient when the waste glass is cleaned beforehand, and is sorted according to colour. Use-products like glass plates and drinking glasses are less easy to recycle than glass packaging (bottles and jars). Bottles and jars can also be re-used several times before recycling, if some return-system is in place (usually though return-fees). This is currently the case in Sri Lanka for soft drink and beer-bottles, and for some glass jars.

Other silicates

Other types of silicate materials in waste range from ceramics and pottery to stones and building material. These materials are essentially inert, although some may contain heavy metals. Mechanical and chemical degradation will eventually cause silicates to degrade into sand.

Silicate materials can be dumped, but are preferably re-used. Finer material (or course materials after grinding) can be used for things like road construction, levelling up building sites, etc. Larger materials can for instance be used for reinforcement of dykes. Asbestos should be disposed of separately, as its fibres pose a health risk when inhaled. It is best stored under wet conditions, so that the fibres are retained.

Metal waste

Metal objects are subject to oxidation when dumped, and will disintegrate (usually dissolve) with a rate depending on the type of metal, and on things like aeration, humidity and temperature. Heavy metals can be harmful to biological organisms when released into the environment.

Most metal waste can be recycled relatively easily by melting, providing it is not too much contaminated. Ferrous metals can be sorted out of household waste by using a strong magnetic field, but non-ferrous metals (like aluminium) are somewhat more difficult to sort out this way.

Plastic waste

Plastic is a collective name for a range of synthetic carbon-polymer materials, which usually have a low mass-to-strength ratio and are relatively stable and inert, and do therefore not easily decompose. Some commonly used types of plastic are:

- Polyethylene (PE), usually either low-density (LDPE) or high-density (HDPE), which is used a lot for packaging, plastic bags and insulation.

- Polyethylene terephthalate (PET), often used in recyclable packaging, especially for containers (e.g. plastic bottles).
- Polypropylene (PP), which is used a lot in packaging as (relatively heavy) films or woven sheets/bags.
- Polystyrene and similar materials, which often contain small bubbles filled with gas and are used for protection or insulation.
- Polyvinyl chloride (PVC), which is mostly used for building materials (pipes, plastic doors, flooring, etc.) and can be harmful when burned.

Plastics are photodegradable, and decompose under the influence of UV-radiation. However, this process may take months to years, depending on the type and form of plastic and the intensity of the UV-radiation. Most plastics are not biodegradable, but polyolefines (PE, PP) can be made biodegradable through the addition of certain additives (like cornstarch), although mineralisation is still slow. Even without additives, polyolefines are susceptible to (photo)oxidation, which is why stabilisers are usually added. This makes decomposition of plastics through oxidation a very slow process. (Narmathaa Group, 2000)

Plastics can, in principle, be recycled either mechanically (secondary recycling) or chemically (tertiary recycling), or alternatively be burned with energy recovery (quaternary recycling). Some items, like PET bottles and (better quality) plastic bags can also be re-used several times (primary recycling).

Mechanical recycling is possible for at least PET, PE and PP, and requires that the materials are fairly clean. The recycled plastic is usually of less quality then the original products, and can be used for hard plastic items, garbage bags, etc.

Tertiary recycling methods include depolymerisation, pyrolysis and refinery recycling. Depolymerisation requires that the waste is clean, and produces relatively high-valued end products. Though currently it seems to hold no environmental or economical advantage over mechanical recycling. Pyrolysis allows some contamination, and converts the plastic waste to basic chemicals (like olefins, aromatics, organic gases and distillate naphtha). Refinery recycling can utilise significantly contaminated plastic waste streams as substitutes for crude oil in refinery operations. (Randall Curlee & Das, 1996)

2. Methodology

2.1 Interviews

In order to get more insight into the organisational and practical aspects of solid waste management, a number of interviews were conducted. These interviews were with Government officials, people in the private sector and local residents.

Transcripts of the interviews can be found in appendix V. Most of the interviews were conducted in Sinhala for reasons of efficiency and clarity, with the help of Mr. Nalaka Siriwardena in translating answers and questions to and from English.

National government agencies

For information on policy, laws, regulations, responsibilities and organisation, on a national level, we talked to several people at the CEA, and to the Director of Solid Waste Management of the Ministry of Forestry and Environment.

Local government agencies

In order to obtain information on the responsibilities and activities pertaining to solid waste management of the various local government agencies, interviews were conducted with the appropriate government officials. These include the Public Health Inspectors (PHI's) of the Ja-Ela Urban Council and the four Pradeshiya Sabha sub-offices, as well as the secretary of the Urban Council. Transcripts of these interviews can be found in appendix V. Additional documents on collection schemes and divisional borders were also collected from several of the agencies. Copies of the collection schemes can be found in appendix II. Finally, recent data on population numbers was obtained from the Ja-Ela Divisional Secretary.

Private firms

As became clear from the interviews with the local government agencies, (part of) the waste-collection responsibilities of two of these had been sub-contacted to private cleaning firms. Interviews were conducted with the Operations Manager of Super Shine Service in Ja-Ela, and a supervisor of Carekleen (Pvt) Ltd. in Kandana. Transcripts of these interviews are found in appendix V.

We also obtained some information from local people who collect, buy and/or re-sell waste materials on a small scale. Some of this information can also be found in appendix V.

Local residents

To get an idea of the knowledge level of the local residents on various aspects of solid waste, and their attitudes towards these subjects, a list of questions was drawn up. This questionnaire was then used to interview a number of residents at their homes. For practical reasons and because of limited time, the people interviewed were members of the households that were also selected for the collection of waste samples (see § 1.4). The interviews were done by Ms. Chulani Kulatunga and Ms. Nadeera Rajapakse, and the resulting answers were written down in Sinhala. These answers were later translated into English for inclusion in this report. The questionnaires and the results can be found in appendix V.

Unfortunately, the small amount of people interviewed, the limited area in which they live and the fact that the questions were somewhat superficial, make that not much useful information could be obtained with these interviews.

Problems

Although interviews are generally a good way to gather information, there are also several drawbacks associated with their use. Firstly, the information is often somewhat subjective and not always fully reliable. One person cannot know everything, and may therefore at times provide incomplete or even incorrect information. In the case of this survey, we have noted a few instances in which the information provided by one person, contradicted information given by another.

Another problem is that people often don't provide detailed or additional information unless specifically asked to do so. Again, there have been a few instances in this survey in which, some time after an interview with a Government official, we (sometimes indirectly) found out certain relevant details that the interviewed had neglected to mention in the earlier conversation.

A third problem arises from language-differences. It has some clear advantages to conduct an interview in the native tongue of the person interviewed, as it can prevent misunderstandings and because people are generally more inclined to talk in their own language. But the use of a translator may also lead to loss of detail, and makes it more difficult to steer the interview (i.e. to get more information on certain subjects brought up in the course of the conversation).

Some effort has been made to verify the information obtained through interviews, when time and resources allowed us to do so. However, keeping in mind the problems mentioned above, it is still possible that part of the information might be incomplete, inaccurate or insufficiently detailed.

2.2 Collection survey

In order to get more insight into waste collection, we accompanied a group of cleaners from the Super Shine Service in Ja-Ela on their morning shift. This part of the survey served three main purposes:

- to gain familiarity with the day-to-day workings of waste collection and town-cleaning;
- to get an idea of the composition and quantities of the collected waste; and
- to see which materials were collected for re-use or re-selling by the cleaners, and in which quantities.

Detailed observations can be found in appendix V. It was not possible to determine the exact amounts of materials kept separate for re-use or re-selling, because at the time we did not have any weighing equipment at our disposal. The results of precise measurements also would not have been very representative, as it would have been just a single sample. However, some estimates were made, based on observations and on conversation with the labourers.

Further data obtained on public waste collection include information from the interviews (see § 2.1 and appendix V), detailed collection schemes for Dandugama and Kandana (see § 2.1 and appendix II), and field-measurements of tractor-trailers (see appendix V).

In addition to the public waste collection services, there is also an informal system of house-to-house collectors (buyers) of re-usable materials and small shops that buy and sell these

materials to other people for re-use, and to bigger companies for recycling. To get an idea of the workings of this “informal circuit” we talked to several of the shop-owners (see also § 2.1) and house-to-house waste-buyers. The results are included in appendix V.

2.3 Dumpsite survey

There are a number of sites used for dumping solid waste in the Ja-Ela area. Some of these sites are “official” (i.e. designated and used by the local government), some are unofficial, although the distinction between these two cannot always be clearly made.

We have tried to establish the main sites used for dumping solid waste by the local government agencies. In addition we have mapped some of the larger sites used by others (e.g. individuals and private companies) for dumping, although the survey of such sites was not carried out systematically and is therefore in no way complete. Of the sites visited during this survey, the locations and some more detailed descriptions can be found in appendix IV.

The information gathered for all sites described includes the following:

- Approximate location of the site
- The former land-type
- Estimated size of the site, including volume
- Notes on the types of material dumped (waste composition)
- The presence of any residential areas nearby
- Signs of waste-burning
- If possible, information about the ownership of the site
- Other relevant observations

To estimate the size of the site, a 50-m measuring tape was used to measure the average height (usually above marsh-level) and the maximum dimensions of the current dumping-area. Exact figures are hard to give without extensive measurements, as the distribution of waste over the site (in all three dimensions) is far from uniform. Because of this, most of the figures are rough estimates based on simple measurements.

The precise location of the sites is also difficult to give, because the maps used (mostly the 1:50,000 topographical map of 1990) are somewhat dated and not very detailed, resulting in a lack of reference points. There are no recent 1:10,000 maps or aerial photographs available of the area, in part because of the current military situation in the country.

It is very difficult to give an estimate of the amounts (weight) and composition of the dumped waste. Small samples would not be very representative, because of the varying composition of the waste and the irregular spatial distribution of material types. Large samples would give more useful results, but cannot be taken or analysed due to lack of proper equipment and time.

Further problems include the exact extent of the sites and their age, which proved difficult to establish in most cases. It is often hard to see which parts were previously filled with waste and are now covered with soil. This also makes estimates of the amounts of garbage difficult, as the extent of compaction and the amounts of cover-sand (and mixed soil) are not known. Finally we were not able to even begin to map all small-scale garbage dumps on “private property”, as these are many and are often out of view of the main roads.

In addition to measurements and observations, rough sketches were made of all sites and photographs of some. Where possible we also talked to the owner of the site and some local residents.

2.4 Measurement of waste production

An important part of the survey consisted of measuring the production of solid waste for a number of households. This measurement was done through the periodical collection of waste from the households, and served three main purposes:

- to get an idea of the amount of waste produced by an average household;
- to get an idea of the average composition of this waste; and
- to see what effects income and location (urbanised areas vs. rural areas) may have on the production of solid waste.

In addition, persons from these households were also asked a number of questions, pertaining to their usual behaviour and their knowledge and attitudes toward waste (see also § 2.1, and for the results appendix V).

Selection

For the waste collection, a total of 15 households were selected in two regions, which for practical reasons were fairly close to the IRMP field-office at *The Marsh,* Muthurajawela Visitor Centre. In each of the regions, 3 households were selected per income group, for redundancy and to determine data consistency and variation. In the more "rural"-area of Delature (see appendix III), a total of 9 households were chosen (note that Delature falls outside of the Ja-Ela DS Division). The remaining 6 households were selected from the more urbanised areas of Ekala-west and Tudella-east (see appendix III). The income groups were as follows:

R: "Rural" area (Delature)

A. Very low income (<3000 Rs. per month)
B. Low income (3000-6000 Rs. per month)
C. Normal income (6000-10,000 Rs. per month)

U: "Urbanised" area (Ekala)

A. Low income (<6000 Rs. per month)
B. Normal income (6000-10,000 Rs. per month)

In the more urbanised areas, the "very low income"-category is very small (as it is hard to sustain). Therefore it was not included in the survey of the "urbanised" area. The three selected households for each category are listed in appendix III, along with information on the number of people in each household. At the moment, the poverty line for households in Sri Lanka is considered by the Samurdhi authorities to be at Rs. 6000 per month.

The selection of households according to income category was done by estimate, mostly by looking at the size and state of the house and at the inventory. The reason for using estimates of income rather than inquiry or official data is that people tend to be somewhat reluctant to give their true income. The main reason for this is the fact that the social benefits allocated to poor families by the Government (through the Samurdhi authorities) are directly linked to family income. In addition, the income situation of many households is somewhat complicated by extra sources of money, such as short-term jobs, financial support from family members abroad and loans, all of which are usually not mentioned as income (IRMP, 1998).

It should be noted that, because of the use of rough income estimates, the division of households into income categories might be somewhat inaccurate. One should also keep in

mind that the expenditure-pattern of a household does not necessarily reflect its income, which may have unpredictable effects on the link between income, expenditure and waste production.

Collection

Household waste was collected in principle every three days (which was not always possible, though), for slightly under three weeks, making a total of four collection rounds. The families were asked to collect organic material, plastics and others separately into three polythene bags. Only the waste that was normally discarded was to be collected (e.g. no waste used for compost, animal feed, selling to house-to-house buyers or other forms of re-use). Some information on re-use of waste materials by these households was obtained through the interviews (see appendix V).

Retail shops and restaurants

As many people seem to get at least some of their meals (mostly lunch-packets) from restaurants and eating houses (which are often confusingly called "hotels"), it is also useful to look at the waste production of such establishments. Getting representative figures for waste production would require a great number of measurements from many establishments. As this was not practical, we have taken only a few samples and have focussed mainly on the composition of the waste. This should give a fair idea of what one might find in restaurant waste, and roughly in which quantities.

Furthermore, besides "Chinese" restaurants and eating houses, most neighbourhoods seem to have a significant number of small retail shops, which sell mostly small use-items, drinks and (mostly non-perishable) foods. For this reason, we have also measured the waste of two of such shops.

In total, one Chinese restaurant (and bar) and two small retail shops were selected along Pamunagama Road, and one eating house along the busy Negombo-Colombo Road, all in or near Tudella. These establishments are listed in Appendix III. The owners or people in charge were asked to keep their daily waste for collection, but only those materials that they would normally discard. The waste samples were collected every afternoon for 3–5 days.

Analysis

The contents of the bags of waste for each household (or shop) were sorted where needed and weighed per material type. The total amount of waste collected per household for each collection round was also measured, to determine the cumulative error in weighing the separate waste components. In some cases an attempt was made to measure the volume of some of the waste fractions, often both uncompressed and compressed. However, the variations in compression and the rather crude method used for volume measurements (several cardboard boxes and a ruler) make the accuracy and degree of representation of these volume-figures somewhat questionable. Note also that the weight of the garbage measured is the *fresh* weight. The dry-weight or water-content of the waste fractions could not easily be determined, so this was not done.

The material types were classified according to the following categories:

- Plastics, including laminates and other compound products containing plastic
- Paper, including cardboard
- Organic materials, including food remains, leaves, etc. This usually included most of the sand-fraction, which was not taken separately. Long-term biodegradable materials (e.g.

coconut shells, wood) were also counted to this category, although these materials have also been weighed separately.
- “Incombustible materials”, in this case meaning pottery and stone
- Glass
- Metals
- Cloth

For two of the collection rounds a further analysis was made of the paper- and plastic-fractions. The plastic fraction was separated into plastic bags/foil, remaining packaging material and others. The paper fraction was separated into newspaper (usually used for packaging), remaining packaging material and others. In one of the collection rounds the “remaining plastic packaging materials” were further separated into recognisable laminate materials, recyclable materials (e.g. recognisable PE, PET and PP) and unknown/non-recyclable materials.

Problems with the analyses resulted mostly from the equipment with and the circumstances under which the measurements were performed. They include wind, and disturbance from animals. The scales used for measuring the weight were also not really suited for this job. Although they were calibrated trade scales, they were not guaranteed to be fully linear below 500 g. Also, the scales could be read reliably with a resolution of only about 25 g. The amount of error in weight-measurement caused by the equipment and by wind disturbance can be estimated by comparing the total weight of the waste with the (cumulative) weight of its components.

3 Survey Results

3.1 Waste production

Amounts

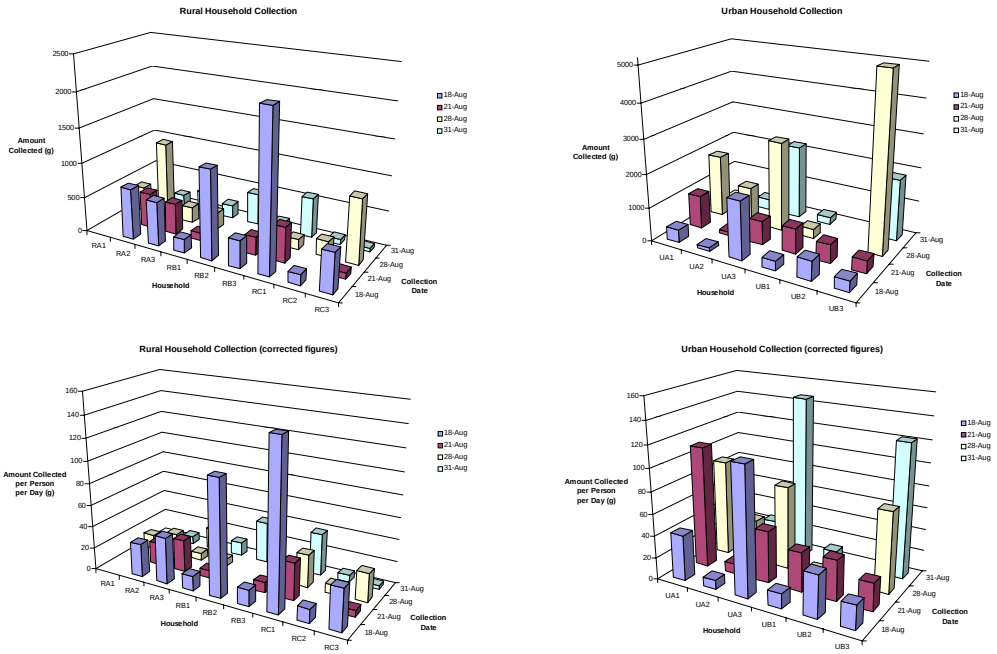


Figure 3.1 The variation in collected amounts of household waste. The two lower graphs were corrected for household size and the number of days between collection. See also appendix VI.

As can be seen from *figure 3.1*, the amounts of waste collected show significant variation between households and within a single household. This is not surprising, as the samples are quite small and the number of factors governing waste production for any one day can be enormous. The phenomenon of “selective collection” can also be a source of error and variation that is not accounted for: People may not always throw all of their waste into the provided bags, causing a lower production to be measured, and possibly also a shift in composition. Or lack of understanding the purpose of the survey might cause them to sometime include waste from other sources as well, thereby increasing the amounts measured.

The variation makes it difficult to establish the average amount of garbage produced by the households. When calculated directly from the weight of the collected bags, the results are as shown in *table 3.1*. Note that the samples on which the data in this paragraph is based *only* include materials that would normally be dumped or burned, and does *not* include waste that is re-used, composted, given away or sold.

Table 3.1: Average garbage production and standard deviations, calculated from the total amount of waste collected from each household in each collection round (see also appendix VI).

	Average amount per collection (g)	s.d.	Average amount per day (g)	s.d.	Average amount per person per day (g)	s.d.
All households	616	624	179	175	36	38
“Rural area” households	451	446	136	144	25	30
“Urbanized area” households	864	770	239	198	52	42

Statistically speaking the figures in *table 3.1* do not say much, because of the large standard deviation. However, they do indicate the order of magnitude of solid waste production by these households. This seems to be roughly 100–300 grams per household per day, depending on the sort of area in which the households are located and a number of other factors, such as income and family size*. The fact that more urbanised areas seem to produce more garbage, is mostly due to the inclusion of organic waste (largely food remains). In the more rural areas this organic portion is often used as animal feed, or for making compost.

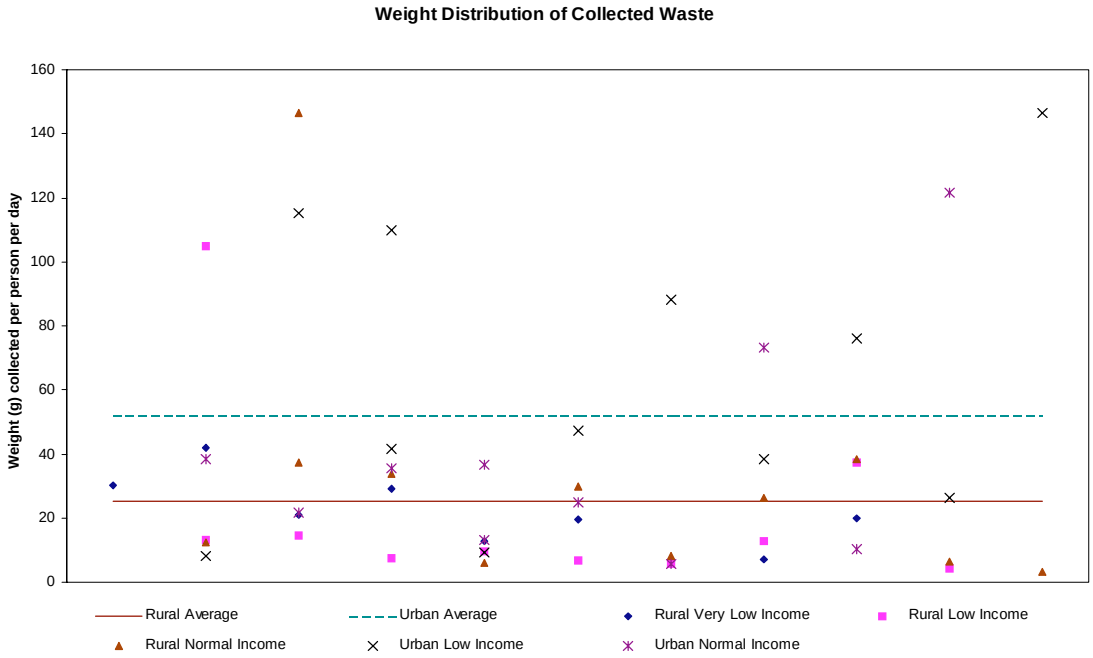


Figure 3.2 The distribution of the samples of collected household waste (in chronological order from left to right). The weight is corrected for the size of the household and the number of days between collections. A bigger version of this figure can be found in appendix VI.

When we look at the weight distribution of the collected samples, as shown in *figure 3.2*, we can see what appear to be trends that were not directly apparent from the numeric data. First of all, the “rural” data seems to have less variation than expected, while the “urban” data seems to have somewhat more. Secondly, the highest income groups seem to show both the highest production of waste and the most variation in waste production. The differences in waste production between higher- and lower-income households also seem somewhat larger in the urbanised areas. Finally, the average waste production for “rural” households and for low-income “urban” households should probably be a bit lower than calculated, as they currently include a small number of “extreme” values (which have a significant effect on the average, due to the small number of samples).

It should be noted that the water-content of the waste greatly influences the final weight. The organic fraction usually has the highest water-content, and is therefore the heaviest. Plastics, metals and glass hardly absorb any water, so water retention is often marginal and usually does not contribute much to the weight (except when low weight is combined with a large surface so that relatively large amounts of water can be trapped, as is the case with plastic

* Note that all of our figures, whether corrected or not, implicitly include something of the variation in family size. A large family will often produce more waste than a small one, but the *relative* amount of waste produced per person will be smaller.

bags and some types of foil). A simple measurement has shown that the weight of paper (newspaper) can increase by some 300% if saturated with water, while the (compressed) volume can decrease by more than 60%. In other words, the density of paper-waste can greatly increase (up to almost 5 times) when wet.

As was already mentioned in *paragraph 2.4*, it proved very difficult to measure the volume of the collected waste. The figures given are based on very few and often somewhat inaccurate measurements, so some caution is advised in interpreting them. *Table 3.2* shows the average volume (uncompressed) of the various waste-fractions produced per household per day. The total waste production of an average household seems to be about 3–5 litres per household per day, uncompressed.

Table 3.2: The average production of the various waste-components in litres per household per day. Also given are the uncompressed densities of the waste-components, as well as the compressed density and the amount of compression (expressed as a percentage of the original volume) for both plastic- and paper-waste. The figures for organic waste (marked with *) are based on a single measurement in one collection round only, and may therefore be inaccurate.

	Volume produced per household per day	*Density (uncompressed)*	*Density (compressed)*	*Compression*
Plastics	1.4 l	15 g/l	40 g/l	38%
Paper	1.8 l	20 g/l	99 g/l	20%
Organic	0.3 l*	187 g/l*		
Others	0.1 l	214 g/l		
Plastic Bags/Foil		11 g/l	30 g/l	37%
Plastic Packaging		18 g/l	58 g/l	30%
Other Plastics		25 g/l	50 g/l	50%
Paper Packaging		21 g/l	108 g/l	20%
Newspaper		13 g/l	73 g/l	18%
Other Paper		24 g/l	123 g/l	20%

Composition

Although numeric attempts to determine the average waste-composition also came upon the same problem of high variation, this variation seemed to be somewhat less for the composition than it was for the amounts. The average composition, based on the composition of the separate samples, is given in *figure 3.3*.

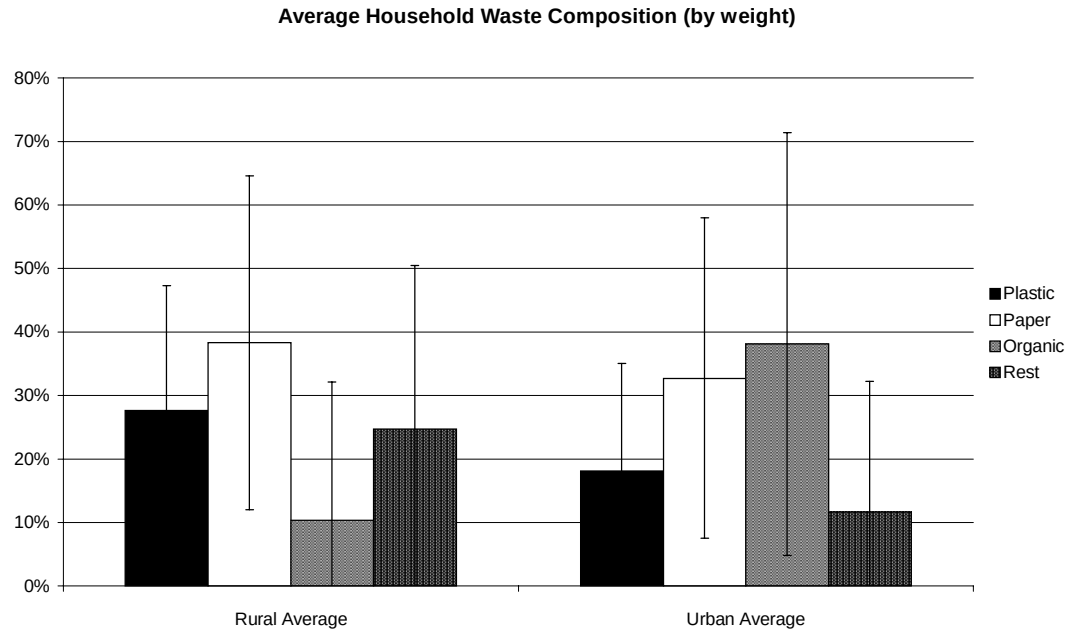


Figure 3.3 The average weight-composition of the waste collected from households in the "rural" and the "urbanised" areas. Also shown is the standard deviation. The rest-fraction shown includes glass, metal, stone and cloth. See also appendix VI and figure 3.4.

As can be seen from the standard deviation, the variation is still quite large. Again this is due to the small number of samples, and the many factors influencing waste-composition. But we can use this data to make a pretty good estimate of what the waste from the average household will look like, by weight. The plastic-fraction (including composite materials) will be around 15%–30%, the paper fraction some 30%–40%, and organic waste can vary from 0–30% (on average it is about 10%) in "rural" regions, but is around 40% in more "urbanised" areas (where it can even be as much as 60%–70%).

The components of the rest-fraction show quite a lot of variation, which is to be expected. The disposal of glass, metal and stone is not very frequent in most households, and cloth is only disposed of regularly in families who work with this material to make their own clothes or other items. Glass can contribute up to 10%–20% on average, but metal does not seem to be much more than 1%–2%. Pottery and other stony materials (except the sand-fraction, which was not separated and is mostly included in the organic fraction) can contribute up to 6%, and cloth can be up to about 5%. Note that these percentages are averages over a number of households of fractions that do not occur very frequently, so that the actual amount of glass, metal, stone or cloth collected from a given household is usually either lower (e.g. absent) or higher. *Figure 3.4* gives a general indication of what the average household waste looks like, including glass, metal, stony ("incombustible") materials and others. Be aware though that this chart is less precise than the one in *figure 3.3*. For practical reasons, figures *3.4* and *3.5* were drawn using averages of values that were already averages themselves, thus somewhat distorting the exact fractions.

Figure 3.4:
Average Waste Composition (by weight)

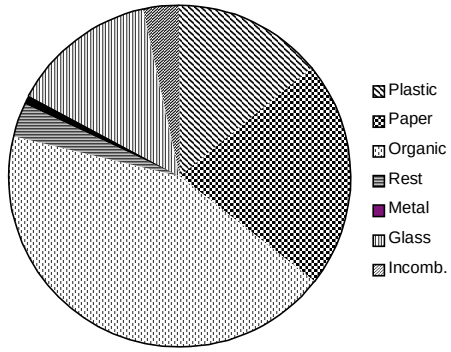
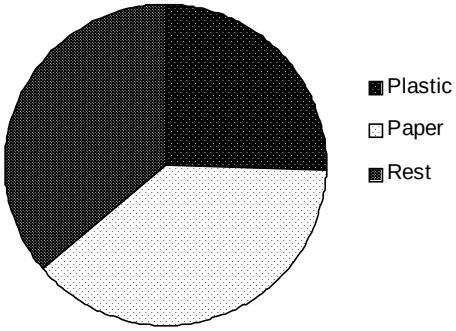


Figure 3.5
Average Composition of Non-Organic Fraction (by weight)



When we consider only the non-organic fractions, it appears that the variation is somewhat less (as the organic fraction is relatively heavy and can vary significantly between collections). In this case plastics make up roughly one fourth (20%–30%) of the non-organic fraction, and the rest is shared more or less equally between paper and the rest, each contributing about 30%–50% as shown in *figure 3.5*.

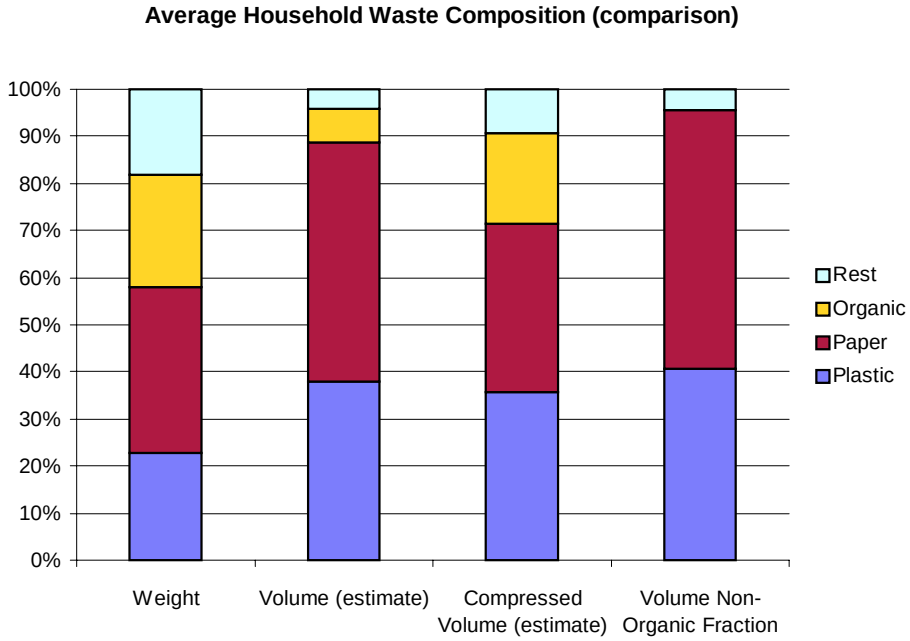


Figure 3.6 A comparison between the compositions of the collected household waste by weight and by volume (uncompressed and compressed). As the volume of the organic fraction was only measured once, its contribution has been assumed to remain at 7% (uncompressed). This might be incorrect. The other three fractions *were* measured for three of the collection rounds, and their relative contributions are shown in the rightmost bar.

When, as in *figure 3.6*, we compare the waste composition by weight with the composition by volume, we see that the organic- and rest-fractions contribute significantly less to volume than they do to weight. This is because their average densities are much higher than those of plastics and of paper, as can be seen from *table 3.2*. For this same reason, plastics and paper can be significantly compressed. Most plastic waste can easily be compressed to

about 20%–40% of its original volume, and paper waste even more, down to about 10%–25%.

The large range in possible densities makes that the volume of the garbage can vary significantly in relation to the weight, depending on modes of storage, transport, disposal, etc. This makes it difficult to give a reliable estimate for the average composition of household-waste by volume. If we assume that compression is not (or hardly) possible for the organic- and rest-fractions, then plastics usually seem to make up some 30%–40% of the waste-volume, paper contributes about 30%–60%, organic waste around 10%–25%, and the rest usually no more than 5%–10%.

A slightly more detailed examination of the various waste-fractions was done to determine more about their general composition. The organic fraction consists mostly out of food remains (e.g. rice & curry, bread, etc.) and kitchen waste (e.g. peelings, vegetables, fruit, curry leaves, coconut fibre and shells, etc.). It is often mixed with some plastic and paper, mostly wrapping materials and other bits of packaging. Sometimes the organic fraction contains some gardening-waste, like leaves and small portions of soil.

The metal fraction is usually made up of small items like bottle-caps and mosquito-coil holders, and sometimes also contains metal cans. The glass fraction contains mostly broken use-items, like drinking glasses and shards of windowpanes. The stony fraction is in most cases made up of broken ceramics.

The paper fraction (see *figure 3.7*) can be separated into packaging materials, newspaper and others. Newspaper constitutes some 25%–40% of the paper waste by weight (and about 30%–50% by volume), and has in most cases been used as packaging material for food and other purchased items. The newspaper-fraction therefore consists mostly of small, wrinkled and in the case of food packaging often also dirty bits of newspaper. The rest of the paper packaging materials, about 20%–50% by weight and 10%–40% by volume, are mostly small cardboard boxes (e.g. of mosquito coils, toothpaste and powdered milk), matchboxes, wrappers (for soap, candy, etc.) and paper bags, some of which are made out of used pieces of paper. Note that a significant part of paper packaging (including newspaper) has been made of recycled materials. The remainder of the paper-fraction contains things like notes, letters, cards, envelopes, documents, brochures, bills, calendar-pages, tissues and (school) books, and its contribution can vary greatly over households and collection rounds. In general, higher-income households seem to produce more of this non-packaging paper-waste.

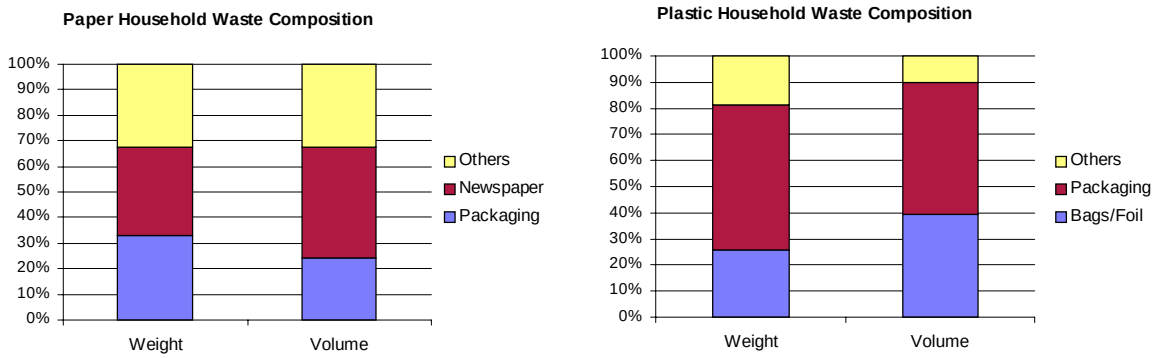


Figure 3.7 The average composition of the paper and plastic household-waste-fractions by weight and by volume, based upon measurements from the last two collection rounds.

The plastic fraction (see *figure 3.7* and *table 3.2*) consists mostly of packaging materials, which have been separated into plastic bags and foil (used for wrapping food) on one hand, and factory-added packaging material from consumer items on the other hand. The latter category seems to contribute about half of the weight and volume of the plastic-fraction. It can be separated further into “easily” recyclable materials (such as PE, PET, PP, which can all be recycled mechanically) and laminated materials, which are currently somewhat difficult to recycle. Each of these seems to make up roughly half of the plastic packaging (excluding the “bags/foil” category). Note that a significant portion of the “easily” recyclable materials is polluted with food remains and other substances, and is not always easily cleaned, which makes it very hard to recycle (see also § 1.7).

The laminated materials are mostly used for packaging of dehydrated and/or powdered substances (like soup, sauce, fruit juice, washing powder and especially powdered milk), and for things like crackers, chips, cookies and small amounts of shampoo and toothpaste. Strips of tablets and plastic laminated paper wrappers for things like soap and candy also belong to this group.

The recyclable materials include most yoghurt, ice and margarine cups (except the aluminium/plastic cover foil), plastic bottles and PE and PP foils and bags. As the packaging often does not state the material type, it can be very hard (if not impossible) to distinguish between the various types without specialised tests.

The separate category of plastic bags and foil constitutes lightweight (transport) packaging materials that were added by the local retailer. It generally seems to contribute some 20%–30% by weight and around 40% by volume to the plastic-fraction. Plastic carrier bags (“polythene bags”), which are supplied with most purchases in Sri Lanka, makes up a rather large part of this category (by weight and volume, but often not by numbers). One household seems to discard some 4–10 plastic carrier bags each week. Smaller plastic bags are often used to pack things like spices and small items. And plastic foil is mostly used to wrap food-packets (which are then usually wrapped in newspaper, and often put in a plastic carrier bag).

Finally, the rest of the plastic fraction, some 10%–20% by weight and volume, consists of discarded use-items like pens and toys, which are often made up of several different materials.

Shops and restaurants

The Blue Island restaurant and the Lakmani "Hotel" (eating-house) both produce a lot of organic waste, in the form of food remains and kitchen waste. The kitchen waste contains a large amount of eggshells, which seemed to be kept separate from the rest of the waste at the Blue Island. It is not known if the Lakmani Hotel also does this, and what finally happens to the eggshells.

Organic waste at both of the places (an estimated 1–3 kg per day) and also from the restaurant of The Marsh (Muthurajawela Visitor Centre) is collected by pig-farmers. In the cases of the Blue Island and The Marsh restaurant, these farmers are part of IRMP's animal husbandry project.

The paper waste produced by the Lakmani Hotel (some 300–700 g per day) and by the Blue Island (about 150–400 g per day) consisted mostly of remains of newspaper and other wrapping materials, bills, tissues and also a small amount of packaging materials (mostly cigarette packets, especially at the Lakmani Hotel). The Lakmani Hotel gets its newspapers (used for wrapping food packets or cut up as serviettes) from the unsold stock of a kiosk.

The plastic waste (around 75–300 g per day) included normal plastic bags, rice bags (woven plastic fibre, probably PP), some insulating food containers (only at the Blue Island), dirty plastic sheets used for wrapping food, some packaging of food ingredients, the plastic foil around cigarette packets, drinking straws (in larger amounts from the Lakmani Hotel), and yoghurt cups (only at the Lakmani Hotel).

The metal fraction was mostly bottle caps (sometimes in significant amounts, over 50–100 g per day) and aluminium beer cans (only at the Blue Island). These materials remain after burning of the waste, and are then buried or dumped.

The groceries produce mostly plastic and paper packaging waste, which includes a lot of transport and sales packaging. The paper fraction (around 100–200 g per day) is for the most part cardboard. The plastic fraction (some 50–150 g per day) also includes a fair amount of drinking straws. The metal fraction is generally small (although it can be up to 100 g per day) and consists almost entirely of bottle caps. Organic waste is mostly the lunch of the shop owner, and the odd fruit peeling.

3.2 Waste collection

Organisation

Under the Urban Council and Municipal Council Ordinances and the Pradeshiya Sabha Act (see § 1.6), it is the responsibility of the relevant local authorities to remove and dispose of all solid waste in their jurisdiction. In practice, the Public Health Inspector (PHI) of each local authority is responsible for implementing and supervising the waste collection (cleaning) systems, for which funds are provided by the local authority. Some information about the waste collection systems in each of the local authority areas of the Ja-Ela Division is given in *table 3.3*.

Table 3.3: Information about the waste-collection systems (town cleaners) of each of the local authorities in the Ja-Ela DS Division. Most of the figures were obtained from interviews with local Government officials, therefore some may not be completely reliable (see also § 2.1).

	Ja-Ela UC		**Kandana PS**	**Ragama PS**	**Dandugama PS**	**Batuwatta PS**
Population[1]	± 34,500		± 37,500	± 40,000[2]	± 43,000	± 43,000[1]
	Super Shine Service (Pvt)	*Public System*	*Carekleen (Pvt) Ltd.*	*Public System*	*Public System*	*Public System*
Monthly cost	Rs. 168,185	Unknown	Rs. 310,000	± Rs. 75,000	± Rs. 125,000	Unknown
Labourers	28	50 (35)[3]	25	16 (12)[3]	9	2
Daily Wages	Rs. 210	Rs. 137	± Rs. 165	Rs. 137	Rs. 130	Rs. 130
Supervisors	1	2	3	1	1	–
Equipment	2T, 5C	4T, 4C	2T, 10C, 1GT	2T, 1C	2T	(1T)[4]
Amount collected daily	± 5,000 kg	± 4,000–7,000 kg[5]	± 7,000 kg	± 2,500–3,000 kg	± 5,000 kg	± 250–300 kg
Coverage	Main roads, markets, Ekala market (all 2x daily)	Remaining main roads, byroads	Main roads, market (2x daily), byroads (1–2x weekly)	Ragama town area, market, sometimes some byroads	Main roads, some smaller roads, Ekala Ind. Estate roads	Batuwatta town
Capacities T, C, GT	T ± 1,000–2,000 kg (7 m^3)	T ± 1,000–2,000 kg (7 m^3), C ± 150–200 kg	T ± 1,000 kg, GT ± 3,000 kg	T ± 500 kg	T ± 500 kg (3–4 m^3)	

T Tractor Trailers
C Hand Carts
GT Garbage Truck (with compression)

[1] These population figures are based on numbers for each Grama Niladari subdivision in 1999, which were provided by Ja-Ela DS and were rounded upward to 500. However, according to the Batuwatta PHI, the population of Batuwatta PS is around 25,000, while the DS data say it should have been 42,608. We have assumed here that the detailed GN figures provided by the DS are somewhat more reliable.

[2] This figure was given by the Ragama PHI and includes the population of the three hospitals. The population in 1999 according to the data provided by Ja-Ela DS was around 33,100.

[3] Indicated between brackets is the number of labourers that usually attend.

[4] Batuwatta PS and Dandugama PS share one tractor.

[5] The amount given by the UC office was around 13.000–15.000 kg, for trailers that can transport 3.000 kg at a time. As this is somewhat unlikely, we have estimated a new figure assuming around 1.000–2,000 kg of waste transported by one trailer.

There is no separate tax for waste management; the money for funding the collection systems comes mostly from assessment tax and trade licences. In some cases (e.g. Dandugama PS) money provided by the National Government (Dept. of Local Government Services) is also used.

Kandana PS has privatised all of its waste collection duties, which are now performed by Carekleen (Pvt) Ltd (a company that also operates in Colombo and Kandy). Ja-Ela UC has privatised the cleaning of the town area, markets and most of the main roads, which is now done by a local company called Super Shine Service. Both companies were given a one-year contract. Dandugama PS is also considering to privatise waste collection. The private

companies seem to perform their duties somewhat more efficiently than was the case under the public collection system.

The labourers employed by the local authorities can be divided into permanent and temporary employees. Both earn around Rs. 130–140 per day, but permanent labourers are entitled to additional grants and leaves. Labourers employed by the private companies seem to earn slightly more.

Cleaning activities are mostly restricted to roadside cleaning along main roads and cleaning of market places, due to lack of resources. Smaller roads and areas outside of the main town are only cleaned occasionally. Ja-Ela UC is a bit of an exception, as they use the public cleaning system for cleaning the smaller roads and the areas just outside the town. In some cases (e.g. Ja-Ela town) cleaning duties also include maintenance of green spaces (grass clipping, cutting branches, etc.).

Removal of litter from of the roadside drainage channels should be done by the local authorities. However, in most cases this is done only occasionally. Only the Super Shine Service seems to do systematic weekly cleaning of a part of the drains in the centre of Ja-Ela town. The drainage channels are often poorly maintained. In Ragama and part of Ja-Ela, the drains are owned by the Urban Development Authority (UDA). Some drains in the town of Ja-Ela are also owned by the Urban Council, and yet others by the Super Shine Service. In Dandugama and Kandana the drains along the main roads are owned by the Road Development Authority (RDA), but some drains along the smaller roads in Kandana are owned by Kandana PS.

Collection and disposal of solid waste produced by private companies is not the responsibility of the local authorities, but of the companies themselves. In the case of the Ekala Industrial Estate in Dandugama, the Board of Investments (BOI) seems to be formally responsible for proper disposal of solid waste (see § 3.3).

Operation

In the areas where roadside collection takes place, most households simply dump their garbage by the side of the road. The cleaners then proceed along their scheduled route. The main roads are usually cleaned once (local authorities) or sometimes twice (Supershine and Carekleen) a day. The smaller roads are usually cleaned once or twice a week. The cleaners pick up, shovel up and/or sweep up most of the roadside litter, which is then deposited into a tractor-trailer, handcart (see *figure 3.8*) or garbage truck. Handcarts are usually emptied into the tractor-trailer or garbage truck, or the collected waste is dumped at some central point along the road and later collected by a tractor-crew (except in Kandana, where the labourers are instructed not to dump the waste from the handcarts intermittently). In Ja-Ela a trailer is left standing near the market during the night, so that the cleaners from the night shift can collect waste in the trailer, which is then emptied in the morning.

The cleaners are supervised by one or more supervisors, and some PHI's (Kandana, Ragama) also perform infrequent checks. When there is no supervisor around, it is usually the tractor driver who decides where to pick up waste, and who ensures that not too much is left behind. The local residents also play an important role in supervision; they will often point out litter for the labourers to remove, and can complain to the labourers or to the local authorities if cleaning is done improperly. The number of complaints seems to have decreased in Ja-Ela and Kandana, where waste collection was privatised. The local residents confirm that the private cleaners (at the moment) generally perform their duties better than the public cleaners used to do. In one street in Ja-Ela the residents used to have to pay the public cleaners extra money, in order to get them to clean their neighbourhood. Another problem seems to be that local politicians sometimes misuse public cleaners for cleaning their own private property (e.g. in Dandugama), thus tying up public resources.

There now seems to be an increasing tendency (especially among the higher-income households on the edges of town) to leave the garbage by the roadside in bags, bins or neat piles. In some areas there are barrels at certain points along the road, in which waste can be deposited. These barrels are sometimes placed by the local authority, or by local companies or residents, and are often used by many people when available. As such barrels ease the task of waste collection, Super Shine Service has started to place some (initially 34) barrels at several strategic points in town. But already after about one month half of the barrels had been stolen. Carekleen has placed a total of about 40 barrels around town, but mostly around the market area and at butcher shops. At these locations the barrels also have more supervision, and are therefore less easily stolen. Nevertheless, even here some 10 barrels have already disappeared.

In some town areas (e.g. Ja-Ela) the cleaners collect waste from shops, restaurants and the town hospital (using either a handcart or a tractor), provided that the garbage is kept in a bag or a bin. Outside of the towns, household and shop waste is not collected house-to-house, and only the roadsides are sometimes cleaned. Industries have to properly dispose of their own waste, but especially small industries often just dump it somewhere, often along the roadside (see also § 3.3).

Figure 3.8 A Carekleen "city cleaner" with handcart, at work in Kandy.

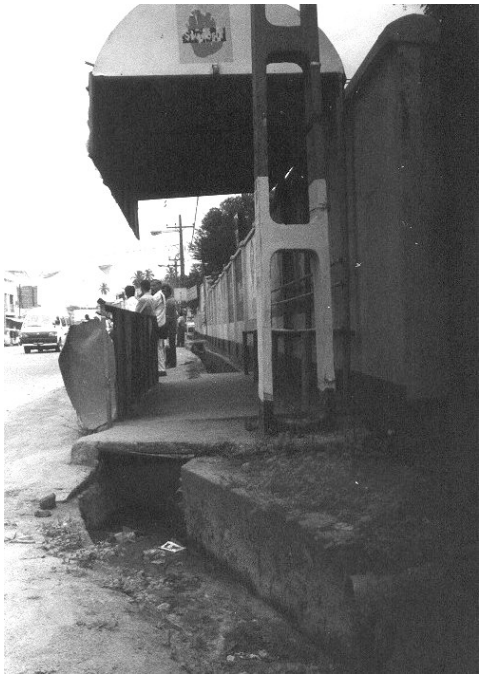


Figure 3.9 A bus-stand built over a drainage channel along Negombo Road, Kandana.

Litter and soil often accumulates in roadside drainage channels, where it can obstruct the flow of drain-water. During heavy rain, when there is enough water, most drains still seem able to perform their function. When the water level falls after rain however, stagnant pools of rainwater often form behind the obstructions. These pools are potential breeding places for mosquitoes. Additionally, in some places parts of the channel have been completely filled with soil (e.g. to provide access to private property), making that the drains can no longer lead away the rainwater. Thus they are reduced from drainage channels to reservoirs of stagnant water.

Cleaning of the drainage channels is often not done systematically and/or frequently by the local authorities, due to lack of resources. Many drainage channels are in a state of

disrepair, but as ownership and the responsibilities for maintaining the drainage system are often unclear or shared between various authorities (e.g. PS/UC, RDA, UDA and private companies), nothing is done about it. Sometimes structures (for instance bus-stands, see *figure 3.9*) are built over the drainage channels, making cleaning very difficult.

Especially in town areas, (parts of) the channels are often covered with heavy concrete slabs. Although these may reduce the amount of litter getting into the drains, they can also inhibit frequent cleaning. In order to properly clean the drains, at least some of the covers have to be removed. Many shop owners along the channel object to this happening during daytime, as it causes them inconvenience. However, it cannot be done during the night, as this would require lamps, which the cleaners do not have.

Amounts and composition

The collected waste probably has an average density of some 150–350 kg/m^3 (or g/l) (see § 3.1 and Abracosa), due to the relatively high compaction and water-content, and the large share of organic material and sand/stones. According to figures from the World Bank in Colombo, the water-content of municipal solid waste is around 70%, and the caloric value of the waste some 600–1000 calories per gram (Sunday Observer, 1999).

The manner in which the roadside waste is shovelled up or swept together, scooped into a basket and thrown into a trailer or handcart, makes that significant amounts of sand, gravel and stones from the side of the road are collected together with the litter, as well as leaves and branches. Furthermore, plant material (gardening waste, fallen leaves, etc.) seems to be treated as garbage by most people, and is therefore burnt or left by the roadside for the cleaners to collect.

Another important organic component that is not present in normal household waste, but is found in fairly large quantities along the roadside, are the empty shells of the King Coconut. These are discarded after the coconut milk is consumed, and do not easily decompose (see *figure 3.10*).

Figure 3.10 Coconut shells and other waste materials on the streets and in the waters of Negombo.

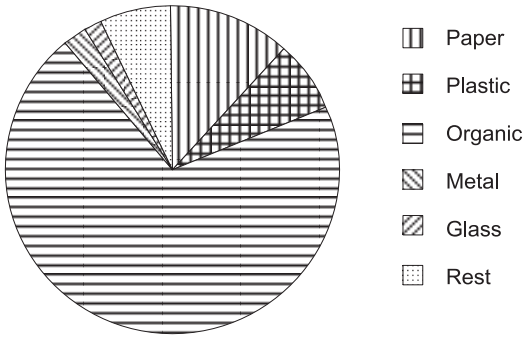
We have estimated that sand/gravel and organic materials (which in turn consist mostly of plant material) make up at least half the weight of the collected waste, probably even a lot more. At least half of the volume of the collected waste seems to consist of paper, cardboard and plant material. Plastics, glass and metals probably make up less than 5% of weight and less than 15% of volume, although no measurements have been made to confirm this. Other sources claim that municipal solid waste (in South Africa) generally contains about 7% plastics by weight and 11% by volume (Independent Newspapers, 1999). Plastic waste is

very well fragmented and mixed with the rest of the waste, making separation for recycling almost impossible.

Other possible components of roadside waste worth which might be worth noting are the empty oil containers discarded by garages, and the large amounts of plastic decorations (mostly streamers and banners, see also *figure 1.6*) left behind after major feasts and especially after elections.

The Ministry of Forestry and Environment has collected data on the composition of collected municipal solid waste from a total of 150 local authorities in 4 provinces. However, as no standard method was stated to measure this composition, this data is essentially useless. There is no record on how the figures were obtained, and it is not even clear whether the numbers are contributions by weight, by volume, or otherwise. However, we did still attempt to use the data from Gampaha District to make a *very* rough estimate of the composition of the collected solid waste, presumably by weight. This has yielded the following result:

Figure 3.11 **Very Rough Estimate of Average Composition of Collected Municipal Waste (by weight)**



Paper	10%–15%
Plastic	5%–10%
Organic	65%–85%
Metal	2%–5%
Glass	1%–5%
Rest	2%–20%

This seems fairly consistent with figures quoted by the World Bank, which give approximately 7% (by weight) for paper, 6% for plastics, 85% for organic material and the remaining 2% or so for metals, glass, sand and other inert materials (Sunday Observer, 1999). It was not stated where or how these figures were obtained.

3.3 Waste disposal

Households

There are basically two methods used by households to get rid of solid waste, namely dumping and burning. Dumping of garbage is usually done in one of the following manners:

- By digging a (shallow) pit in the ground, usually in the garden, where the waste is dumped (see *figure 3.12*). After dumping the pit is either filled or the waste is periodically burned.

- By simply throwing the garbage in the most convenient place. Usually this is either the roadside in front of the house, or some unused land (often a natural area) around the house. Garbage dumped by the roadside is often (infrequently) collected by local authority cleaners, or periodically burned. The lighter materials (plastic sheets, bags, and paper) are usually scattered by wind, animals and passing vehicles.

- By dumping the garbage in a place which is also used by others. This can either be a "formal" dumpsite, which is also used by the local authorities, or an informal site, which is more common.
  Informal sites can appear in convenient locations (unused land, often along main roads) as a result of a vicious circle: People keep dumping on the site because there is already waste there anyway, but the waste is there because people keep dumping it there. In the case of some smaller dumps of this type along main roads, the waste is periodically moved by the local authorities. In other cases the waste is often periodically burned by local residents.
  Another type of informal site can be a piece of "private" property that someone wants to have filled. See also below.

- By dumping the garbage on a piece of low-lying land (usually marshy land) for filling. This can be done on a small scale by individual households who simply want to extend their property, or on a larger scale (e.g. by also using municipal and/or industrial waste) to fill a larger piece of land for building. In the latter case the "owner" is usually a wealthy and/or influential individual.

- By dumping the waste into waterways or waterbodies, where it is (periodically) washed away. This is mostly seen in (low-income) areas that are located along rivers, canals, lagoons, tanks, drainage channels or the sea.

Figure 3.12 Restaurant waste, dumped in a shallow pit in the ground.

Burning of solid waste is often periodically done after dumping, but sometimes it is also done for instant disposal. Especially plant material (gardening-waste) seems to be disposed of immediately by burning. Burning is usually done in the late afternoon or at night, and decreases markedly during the wet season (for obvious reasons).

Practical problems in waste disposal faced by households include limited space for dumping (especially in closely populated areas), the fact that burning or burying waste is difficult during rainy periods, and the fact that "wet" organic materials are very hard to burn.

Local authorities

Finding suitable dumpsites for the disposal of collected waste is the responsibility of the local authority (UC, MC or PS). In the Ja-Ela Division, the Ja-Ela Urban Council is the only authority who allegedly perform a suitability check before approving a site for dumping.

The current "official" dumpsites in use by local authorities are listed in table 3.4 below, and in more detail in appendix IV.

Table 3.4: The current “official” dumpsites used by the local authorities in the Ja-Ela DS Division. The map references refer to the dumpsite map found in appendix IV.

Local Authority	*Current “Official” Dumpsite(s)*	*Map Reference*
Kandana PS (Carekleen)	Jayasiriya Road, Kandana	D1
Ragama PS	Ragama Town	D2
Ja-Ela UC	Along the Ja-Ela Canal (Supershine and UC);	D7
(also Supershine)	Ekala Industrial Estate (Supershine)	D6
Dandugama PS	Sri Wijerama Temple, Kudhahapola, Dandugama	D8
Batuwatta PS	Jayasiriya Road, Kandana	D1

Sites used for dumping are privately owned in most cases, except in Ragama, where the town dumpsite is the property of the Urban Development Authority. Usually with private sites, a loose agreement is made with the owner: The local authority may dump their waste, provided it is properly distributed, levelled, and/or covered after dumping. Apparently this is often not done, as it takes some extra time and effort on the part of the town cleaners. For this or other reasons, some owners at times disallow dumping (e.g. at Kandana), or have asked dumping to be stopped (e.g. at Suduwella, Ja-Ela UC).

In the past, the Ja-Ela UC used to issue dumping tenders to landowners who wanted their property filled with waste. The landowner would pay a monthly fee to the UC for receiving the collected municipal waste. This tender system has been discontinued though, for unknown reasons.

In many cases (Ragama, Ja-Ela, Kandana), local authorities have difficulties finding suitable sites close to the collection area. In Ja-Ela and Kandana the "official" dumpsites are sometimes unavailable or unusable, and the sites at Kandana, Ja-Ela and Ragama are lacking in capacity and are therefore currently over-used. Accessibility of the sites (especially in Ja-Ela) is often a big problem during wet periods, as the dumped material and the access paths tend to get very muddy. In Dandugama the dumpsite still has sufficient capacity and does not seem to get very muddy. However, the location of the site is somewhat remote, and it is only reachable over narrow roads, which may be hard to navigate by tractor.

Currently, the Super Shine Service in Ja-Ela is using the same dumpsite as the Urban Council cleaners, although this site does not have enough capacity and is practically inaccessible during rainy periods. If the UC is not able to provide a suitable dumpsite for the Super Shine Service, then according to the contract, the monthly payment to the Super Shine Service is increased from Rs. 149,498 to Rs. 164,490 (+ 12.5% GST). The UC has not

yet designated a new site for dumping, but seems unwilling to pay more money. The management of the Super Shine Service claim they would not have much problems finding dumpsites, if the higher fee were paid.

Labourers from all the cleaning services except Ragama PS, are allegedly instructed not to burn waste and to use only the site(s) designated by the local authority. However, labourers from the Ja-Ela UC claim that they have been instructed to dump anywhere they want, on request of the owner of the premises. Furthermore, the cleaners from Ja-Ela UC and Super Shine Service often have no choice but to find alternative sites, as the "official" site can not always be used. In some cases, labourers have also been known to burn waste, as this saves some time and space. During outbreaks of Dengue Fever, all waste containing potential container habitats is apparently burned.

Private companies

The National Environmental Act (see § 1.6) states that all companies and industries have to acquire licenses for dumping solid waste that “will cause pollution”. However, according to the Pollution Control Department of the CEA, no regulations or standards to this effect have currently been implemented. There are some guidelines for disposal of certain hazardous materials (e.g. asbestos), but generally the CEA consider solid waste management a task for the local authorities.

As was already mentioned in paragraph 3.2, many small companies and industries simply dump their solid waste by the roadside. Especially in the case of slaughterhouse waste this is a problem, as the discarded carcasses (see *figure 3.13*) can constitute a serious health risk and generate a terrible smell.

Figure 3.13 Animal remains dumped along Pamunagama Road, Tudella.

In the Ekala Industrial Estate in Dandugama, waste disposal is formally the responsibility of the BOI. However, the BOI does not seem to employ any activities to this effect. Many companies allegedly employ their own people to collect and dispose of their solid waste materials. In most cases the waste is transported to and dumped at some privately owned piece of land. Often this is the same site as is (or was) used by the local authorities (e.g. Suduwella, Kandana, Ragama).

Hospitals are apparently required to have their own facilities to burn potentially hazardous waste. Nevertheless, some remainders of medicines (possibly from pharmacies, hospitals and/or households) were found on dumpsites (see *figure 3.14*).

At the moment it is known of at least three companies in Ekala (Rhino Roofing Products, Union Carbide and PLL Packaging) that they pay a monthly fee to a private landowner for

dumping waste. The PLL Company dumps plastic laminate waste at the Suduwella site in Ja-Ela. The owner of this site collects the material, which amounts to about three tractor loads every two days. The company pays Rs. 10,000 per month for collection and dumping.

There are at least two known problem cases of large amounts of industrial waste being dumped on private property. Union Carbide has a large dumpsite for battery-components in a piece of marshland in the Dandugama-area. And Rhino Roofing Products Ltd. has dumped large amounts of white asbestos powder and fragments on an open site near the Ekala residential area (see *figure 3.15* and *appendix IV*). The asbestos is also being transported in an open tractor, and plaques of asbestos powder cover the road between the Rhino company and the dumpsite. Local residents have apparently started a court-case against Rhino, because of the dumpsite.

Impacts

Impacts of dumping and burning of solid waste have not been quantitatively measured for this survey. However, we did make several observations regarding environmental problems caused by solid waste disposal.

Figure 3.14 Hospital waste (including used syringes, medicine bottles, gloves and a potential container habitat) on a roadside dump in Battaramula.

Figure 3.15 White asbestos powder, dumped behind a petrol station in Ekala.

Burning of waste in residential areas at night-time often leads to prolonged exposure of residents to gaseous and particulate by-products. An important cause for this seems to be the fact that the waste does not burn properly (presumably because of the high water-content), so the burning-rate is low, incomplete combustion takes place, and large amounts of smoke and gases are produced.
Especially food remains and slaughterhouse waste usually generate problems with offensive smell, when dumped along or close to a road or residential area (see *figure 3.16*).

Pigs and cows have been observed to eat plastic sheets and bags covered in food remains (see *figure 3.17*). This might be damaging to the health of the animals. One farmer has complained about his animals getting sick from ingesting plastic bags.

Lighter waste materials on dumpsites and along roads were observed to have been scattered by animals, wind and vehicles. The areas surrounding dumpsites are often littered

with pieces of plastic, and waste dumped along roads often ends up in roadside drainage channels.
Container habitats and potential container habitats were observed on dumpsites and along roadsides. These mostly included coconut shells and plastic containers.

According to information quoted by the World Bank, the Biological Oxygen Demand (BOD) of leachate from municipal solid waste is very high, in the range of 25,000 to 40,000 mg/l, although it is unknown on what these figures are based (Sunday Observer, 1999). The maximum allowable BOD for drinking water is considered to be 3 mg/l in Sri Lanka. Some evidence of eutrophication of surface water surrounding dumpsites was observed, but this did not (yet) seem to be very serious in most cases. The effects on groundwater are currently unknown.

In the Ekala Industrial Estate, there is indication of serious surface water pollution, and also of possible groundwater pollution. It is unknown if this has any relation to the dumping of solid waste, but the current situation in some places in the Estate is definitely reason for concern.

Figure 3.16 Bags full of decomposing chicken-remains, dumped in the waters of the marsh near Tudella.

Figure 3.17 Pigs looking for food on a dumpsite along Pamunagama Road, Tudella.

Almost all of the dumpsites in the Ja-Ela Division are located in marshy areas. The high Cation Exchange Capacity of the peat-bog soils (GCEC, 1994) found in such areas (e.g. Muthurajawela Marsh) might somewhat reduce the immediate effects of pollutants from leachate, although it is not known if this is indeed the case. Anaerobic conditions may also reduce or hide the immediate effects of high BOD, but also this is not sure.

The low pH of the surface water in Muthurajawela Marsh will probably facilitate the dispersion of heavy metals from the dumpsites. Increased levels of chromium have already been measured near one dumpsite in the marsh (GCEC, 1994). It is likely that other polluting substances such as PAH's will also be present in leachate from municipal solid waste, as several chemical residues were observed among the collected and dumped waste.

The low density of the peat-bog soil in Muthurajawela Marsh might facilitate infiltration of leachate into the groundwater. On the other hand, the high water table and the many hydrological linkages of the surface water might cause much of the pollution to be diluted and

dispersed before harmful concentrations are reached. And the presence of sandy peat (or peaty sand) on the edges of the marsh, and possible clay layers in the underground, will undoubtedly also be of some influence.

More research would be required to provide insight into the processes regarding pollution of surface water and groundwater by the leachate from open dumps. Measurements of shallow groundwater might be taken from the groundwater wells, which are present at or near some of the sites. Another site that may be used in determining the longer-term effects of dumped waste is The Marsh, Muthurajawela Visitor Centre, part of which was constructed on a former dumpsite.

Legal action

As there are currently there do not seem to be any usable laws or regulations that deal specifically with the dumping of non-hazardous solid waste, there is not really a concept of "illegal dumping". However, when the local authority receives (usually the PHI) complaints about an "illegal" dumping, they may prosecute the "offender" on the grounds of the Nuisance Ordinance. There does not seem to be a record of such a thing happening in the Ja-Ela Division (although we did not specifically search for it), but according to the PHI of Ja-Ela UC this would be the approach he would follow in case of "illegal" dumping. First a warning would be issued by the PHI to stop dumping. If the activities continue, a written order is sent to stop dumping within a given time period. If the offender does not comply within the time, given prosecution will follow.

3.4 Recycling and re-use

Households

According to the interviews in appendix V, households re-use the following materials themselves:

- Food remains and vegetable and fruit waste are used for animal feed in less urbanised areas. This food waste is kept apart by household members and either given to their own animals if they have any, or given to others who keep animals nearby. Animal farmers often also collect the remains from restaurants and eating-houses. Especially pigs and goats will eat food remains.
- Kitchen waste and gardening waste is sometimes used for making compost in less urbanised areas. Composting seems mostly done in metal compost barrels (see *figure 3.18*), or in holes in the ground. In Batuwatta local authorities have started selling compost barrels, at Rs. 350 per barrel. The demand for these barrels is high.
- Pieces of cloth are used to make things like dusters and pillow covers in a few lower-income households.

In more urbanised areas it seems that hardly any waste is being re-used. Organic waste here is usually either buried, burned or left for the local authority cleaners to pick up.

Containers like glass bottles, glass jars, plastic bottles, etc. are sometimes re-used by households to store things. In some cases, home-made products (including liquor) are sold in such containers. When buying soft drinks and beer in glass bottles, usually a deposit is paid. Such bottles are normally returned to the sale point, collected by transporters when a new batch is delivered and transported back to the manufacturers. This way, each bottle gets re-used several times. There is also a return-fee (around Rs. 2) on glass jars from some brands.

These days most of the bigger glass soft drink bottles have been replaced by plastic (PET) ones. However, contrary to their glass counterparts, the PET bottles have no return fee and are therefore not re-used or recycled by the manufacturer. Sometimes empty (used) mineral water bottles are sold on the market, apparently for re-use.
Plastic bags are re-used by many people for a variety of purposes, but the low quality of most bags and the large quantities with which they are supplied with purchases, make that the effects of re-use are hardly noticeable in the waste-stream. On most sale points, a plastic bag is automatically supplied unless this is specifically declined. In most cases it is also not allowed to take your own bags into the store, making it difficult to use a reusable shopping bag.

Some stores, like the Odel warehouse in Colombo, supply plastic bags of better quality, which are easier to re-use than the low-quality ones (although they do of course contain more material, and are slower to decompose). Odel also prints an advice on their plastic bags, pleading for re-use. Outside of the entrance is a box for depositing unused bags, although this facility does not seem to be used very frequently.

Figure 3.18 A compost barrel of the type most used by households.

Figure 3.19 A waste-buyer and reseller in Ja-Ela.

Town cleaners

In areas where waste is collected (e.g. main roads, town areas), the labourers from the collection service seem to keep certain materials separate from the rest of the collected waste. These materials are then sold for re-use or recycling. Labourers have been observed doing so with the following materials:

- Corrugated cardboard, when in big pieces and not too dirty.
- Glass bottles, usually only when intact.
- Metal cans, when easily accessible.
- Scrap metal in larger pieces.
- Firewood, mostly as small branches and some slats, small planks, etc. These are then probably used at home, for cooking, although they might also be sold.
- Food remains (mostly bread), which are taken home and fed to pigs.

The labourers from the Super Shine Service are encouraged by their boss to collect such materials, and to rear at least one pig. Table 3.5 lists the estimated daily amounts of the materials that were kept separate, per tractor crew. The income from this was quoted to be around Rs. 600-700 per tractor crew per week.

Table 3.5: Estimated amounts of materials that were separated from the collected waste by one Super Shine Service cleaning crew (4 persons), after their morning-round on 2000-08-25.

Material	*Quantity*	*Estimated value*
Corrugated cardboard	± 15 kg	± Rs. 30
Metal cans	10–20 cans	± Rs. 5 – 10
Glass bottles	15–25 bottles	Rs. 15 – 25
Firewood	1–2 large sacks	–
Food remains	5–10 small plastic bags	–

Waste buyers

In and around town areas and along main roads there are many small shops (see *figure 3.19*) that deal in recyclable or reusable waste materials, usually some or all of the following:

- Old newspapers, which are mostly sold (to restaurants, etc.) as packaging material.
- Paper, which is made into small bags or envelopes, or which is sold to paper companies for recycling.
- Corrugated cardboard, which is sold for recycling.
- Scrap metal and electrical components (often containing heavy metals), which are sold to metal companies (to be melted for re-use).
- Black coloured plastics (of unknown type), which are sold for recycling.
- Glass, which is sold to glass companies for recycling. Intact glass bottles are usually sold for re-use, although they are sometimes also smashed and sold for recycling.
- Empty containers and barrels, which are sold for storage, mostly of drinking water. It has to be noted that many of these containers and barrels have previously been used to store toxic chemicals.
- Sacks, which are sold for re-use, or used for storage and transport of their own goods. The sacks include mostly woven sacks (usually of polypropylene fibre), and some large plastic bags.

The materials are obtained from various sources:

- Private companies, mostly in Ekala, Colombo, Wattala and Katunayake. In these cases the materials are usually collected by the owner of the shop in larger batches. A lot of scrap metal, paper, containers and barrels are obtained this way.
- House-to-house collectors, who go along the houses in “their” neighbourhoods and buy certain waste materials (see below), especially (news)paper and glass bottles. Most neighbourhoods seem to be covered by such a collector.
- Town cleaners, who separate various materials from the roadside waste collected by them (see above) and periodically sell these at one of the shops.
- Scavengers, who go along roadsides and garbage dumps to collect materials they can sell. This seems to be a relatively small-scale activity in most parts of Sri Lanka, as during the research period we have only observed it once or twice.
- Other individuals, who might have something to sell. The extent of such small-scale trade is not known.

The buyers (re-sellers) sort and pack the materials by type. Sometimes the products (e.g. glass, electronic equipment) are broken up into smaller fragments, before selling. They are sold either directly to a local shop or restaurant, a consumer, a recycling company or, more frequently, a middleman. The middlemen then sell the materials to the recycling companies, which are sometimes located abroad (e.g. paper-factories in India). A middleman can deal in a range of materials, and several middlemen seem to operate in the same area, visiting the same resellers. Resellers can deal with several different middlemen, so do not necessarily have one fixed client.

Quantities of waste material bought and sold allegedly range from about Rs. 1.000 to Rs. 15.000 kg per month. The buyers make some Rs. 0.50-2.00 profit on each item or quantity unit (for instance a kilogram, see also *table 3.5*). The total income quoted by one buyer was about Rs. 10.000 per month, of which about Rs. 5000 is profit, which is then also used to pay the salaries of the people employed for sorting and transport of the materials.

The profit made by the middlemen is not known, but is probably in the same range as that from the buyers. Apparently, the most profit is usually made by the end-buyers, the recyclers themselves.

Some recycling companies offer loans to small resellers, whereby some money can be borrowed, and the payback is in goods.

House-to-house collectors are individuals who go along the houses in certain neighbourhoods, and buy reusable or recyclable waste materials. These materials mostly seem to include (news)paper, glass and metals, and in some cases also some black-coloured plastics. Transport of the goods is usually by bicycle or hand-cart, and each neighbourhood is visited once or twice a week. The collected materials are sold to the re-sellers, sometimes up to three batches a day. (Part of) the money obtained from these re-sellers is used to buy new waste materials. The profit made by the house-to-house collectors is in the range of some Rs. 0.50-1.00 per item or quantity unit (see *table 3.6*), and the average income of one of these collectors was said to be around Rs. 100-300 per day, which can provide a full (though fairly low) income. The total amount of materials collected per month was said by one collector to be around 2000 kg.

Table 3.6: Prices for some waste materials as reported by waste-buyers around Ja-Ela.

Material	*Quantity*	*Bought from households*	*Sold to shops*	*Sold to consumer or middleman*
Paper	1 kg	Rs. 8.00	Rs. 8.00 – 9.00	Rs. 9.00 – 10.00
Corrugated cardboard	1 kg		Rs. 2.00 – 2.50	Rs. 2.50 – 3.50
Glass bottles	1 piece	Rs. 0.50	Rs. 1.00	Rs. 1.50 – 5.00
Glass	1 kg			Rs. 1.50
Scrap metal	1 kg	Rs. 4.00	Rs. 5.00	Rs. 5.50
Bags	1 bag		Rs. 1.50 – 2.00	Rs. 2.00 – 2.50
Black coloured plastics	1 kg		Rs. 5 – 20	Rs. 5 – 20

3.5 Public awareness and attitude

As we were only able to complete the questionnaires for a small number of people in a very limited area, the results are few and might not say very much. In order to establish the main subjects and angles for a good awareness campaign, more study would be required. However, even in the few and often superficial answers we did get, some trends could be discerned.

Awareness

In general people do not seem much aware of the (possible) environmental problems caused by the disposal of household waste. Most have never thought about what happens to garbage after disposal. It seems that garbage is only seen as a problem when practical issues occur in storage or disposal. Storage problems occur mostly from lack of space, and disposal problems from lack of a good place to dump or burn, and from difficulties with burning or burying waste in bad weather. Most people who have enough space (outside) do not see garbage as a problem.
From media (mostly TV) and school education most people do know about the connection between waste and health problems, and many people are also aware that mosquitoes are involved. However, it is not known how widespread and detailed this knowledge is, and whether people know how to treat waste properly, so that health problems are prevented.

The Ministry of Health does seem to have (had) a fairly extensive publicity campaign to combat disease vectors, especially mosquitoes. Information materials include posters in schools, government institutions, community centres and on buses, and apparently also a media campaign. On most of the posters observed, the link was made between mosquitoes, diseases and garbage. It is not precisely known if and what practical advice was given in such campaigns, but probably burying and/or burning of household waste was advised.

Attitude

It seems that waste materials that are sold by households to house-to-house collectors are not really seen as "garbage". These things are seen as something that still has some value, which is a good thing for future recycling programmes. However, even these materials are thrown away when not collected. Most people will not go to any trouble to store much of the material for collection, or to deliver it to a buyer themselves.

"Proper" collection and subsequent central disposal is seen as the solution to most garbage-related problems in areas where waste is not collected. Most people think that the Government should take the initiative to organise collection. As final disposal is not really considered a problem by most people, they don't really care what happens to the garbage once it is removed from their line of sight.

When asked what they consider as possibilities for community participation, most people see their possible role to collect their own garbage, either at home (presumably in a bin or bag) or in a central bin no too far from the house. This will ease the task of waste collection. Some people think however that not everyone in the neighbourhood would participate in such an activity.

3.6 The role of the Government

According to most local authorities, the national Government has to supply the necessary resources for proper collection and disposal of solid waste. Due to lack of resources, solid waste is only collected frequently along main roads.

There seems to be a serious lack of enforcement of environmentally related regulations and laws. Most of the legislative instruments for the enforcement of proper disposal of solid waste by individuals and companies seem either not usable, not known or simply not used by local authorities. Apparently EIA's are also not always performed for new industries, although this is formally required.

Currently, the CEA issue no licences for landfills, or for any kind of solid waste disposal by anyone. They also have no regulations, standards or guidelines for solid waste disposal. There only seem to be some guidelines for hazardous materials like asbestos. The relevant sections of the National Environmental Act have not been implemented. According to the CEA's Pollution Control Division, solid waste management and disposal are the responsibility of the local authorities.

Measures by the CEA and the Ministry of Forestry and Environment to reduce the garbage problem seem up to now mostly limited to poster campaigns, advertisements and commercials, and some education at schools.

The Ministry of Forestry and Environment produces an instruction sheet on how to build and use a compost barrel. However, the content of this piece of paper is unnecessarily difficult. The compost barrel is referred to as an "organic waste converter", and the instructions are too complicated, too long and often unclear.

3.7 Future policy

The Ministry of Forestry and Environment is currently working on a National Strategy for Solid Waste Management (NSSWM). A global framework and a three-year implementation plan have already been drawn up and approved by Parliament, and a Cabinet paper on the mitigation of plastics-use is still awaiting approval.

The Strategy focuses on three main points:

- Waste reduction
- Re-use and recycling
- Final disposal

These points are in accordance with the Solid Waste Management Hierarchy, which ranks waste management methods in descending order of priority, starting with waste reduction, then recycling and composting, and regarding land filling and incineration only when there is no alternative (Schall, 1992).

Responsibilities

The Strategy puts the responsibility for collection and proper disposal of waste with the local authorities. In order for the local authorities to perform this task, the national Government is to provide some technical and financial resources. The private sector is also expected to provide infrastructure for collecting and recycling waste materials. In addition, facilities (especially for final disposal) are to be shared among several local Government authorities, thus increasing efficiency.

The national Government agencies (ministries, departments) should make new policies and, if needed, adjust the existing ones, to facilitate waste-reduction, proper collection and disposal and to enhance the market for recycling and recycled products. This can be done by providing infrastructure facilities and initial funding, and by regulation and tax-measures. The CEA should perform EIA's or IEE's (see § 1.6, 1.7) for all new dumpsites.

The general public is expected to contribute to the recycling of solid waste by sorting their waste at the household level, into separate colour-coded bags for plastics, paper, metals and glass. Organic waste is to be composted by the households, in a compost-barrel which they can purchase from their local Government agency at Rs. 250 (taxpayers) or Rs. 500 (non-taxpayers). In addition, the Ministry plans to provide colour-coded wastebaskets for central placement in busy urban areas. To facilitate sorting, the packaging industry is to provide colour-codes for material types on their products. An extensive campaign for awareness and education is needed to bring around the required changes in attitude and behaviour. The plan is to implement this through school-programmes (in co-operation with the CEA and the Ministry of Education), NGO's and mass media. An important focus is on school children, as they are easy to reach, and it is hoped to also educate the parents though their children.

Waste reduction

There are several ways in which the Strategy hopes to reduce the amount of potential waste. Education and creation of awareness among the public and among private companies is to decrease the demand for and the use of packaging materials. Improvement of transport and storage facilities should reduce the currently high degree of product-loss, especially at market places. The use of plastics is to be avoided as much a possible, especially in packaging. Alternatives should be promoted, and biodegradable plastics made cheaper if possible. A ban on the use of polythene for certain applications (e.g. decorations, low-quality bags) is also considered. Finally, industries should have closed production cycles as much as possible.

Re-use and recycling

In fabricating packaging and use-products (e.g. plastic bags, bottles), priority should be given to long-life and multi-use products. Re-use of certain products and materials within households should be encouraged.

Recycling of waste is to be facilitated by sorting of materials at the household level and a proper system for separate collection of these materials. The market for recycling and recycled products is to be enhanced by providing tax breaks for purchasing recycling equipment and use of secondary materials.

Compost barrels should be promoted and made available to households, and the market for compost must be enhanced (e.g. by promoting use among farmers), and a collection system set up for surplus compost generated by households.

Final disposal

The waste materials that cannot be recycled should be disposed of in sanitary (or at least semi-engineered) landfills, which comply with regulations made by the CEA. These landfills should have proper facilities to prevent water contamination, to cover the waste and, if possible, to retain the combustible gases produced. To reduce costs and location-problems, several local authorities could share one landfill-site. Law-enforcement has to be improved to prevent illegal dumping of waste.

For certain hazardous materials and things like hospital-waste, incineration is considered. Biogas fermenting is also considered as a viable option for disposal of waste with a large organic fraction.

Organisation

For the implementation of the Strategy, co-ordinating committees are to be established at the national level, the provincial level and the local level. The national committee shall be co-chaired by the secretaries of the Ministry of Forestry and Environment and the Ministry of Provincial Councils and Local Governments and will include representatives from all relevant parties (e.g. ministries, departments, private sector organisations, industry chambers, community groups, local governments). It is to co-ordinate implementation of the Strategy, develop policies to facilitate implementation island-wide, and periodically review and adjust the Strategy and the policies.

The Provincial-level co-ordinating committee will include representatives from each Ministry, various NGO's and one of the CEA; the chairman and secretary of each Local Authority and the Commissioner of Local Government. Its task is to co-ordinate implementation among Local Authorities.

The committee at the Local Government level will consist of the Chairman, the Secretary, all relevant officers (including EDA and PHI), and representatives of private companies if applicable.

Funding

The matter of funding of the proposed measures has not yet been explicitly addressed, but can come from central Government money, user-fees, sponsoring and more efficient use of local government resources. An additional consideration is that, through proper management of solid waste, money can be saved on things like healthcare and removal of litter.

Timeframe

A three-year implementation plan has been made, globally stating the responsibilities and a timeframe for the implementation of various aspects of the Strategy. Creation and execution of an awareness programme is given first priority, especially in the first 6–7 months. One month is allocated for the establishment of each of the co-ordinating committees. After the committees are in place, the CEA is to prepare guidelines for implementation of the Strategy, and the Local Authorities have to make time-bound action plans. Development of infrastructure facilities for collection and disposal by the Local Authorities and the private sector take up the remaining time. Financial assistance (by the Ministry of Finance and the Ministry of Provincial Councils and Local Authorities), market development, public awareness creation and monitoring & evaluation are to continue for the entire period.

4 Conclusions & Recommendations

4.1 Main conclusions

General

- The relation between weight and volume of household waste can vary greatly with water content and the amount of compression, and is thus partly dependant on methods of storage, transport and disposal. This means that some care should be taken in interpreting figures that state weight or volume of household waste, without giving additional information about water content and/or density.

- The main solid-waste streams in the Ja-Ela District can be depicted as follows:

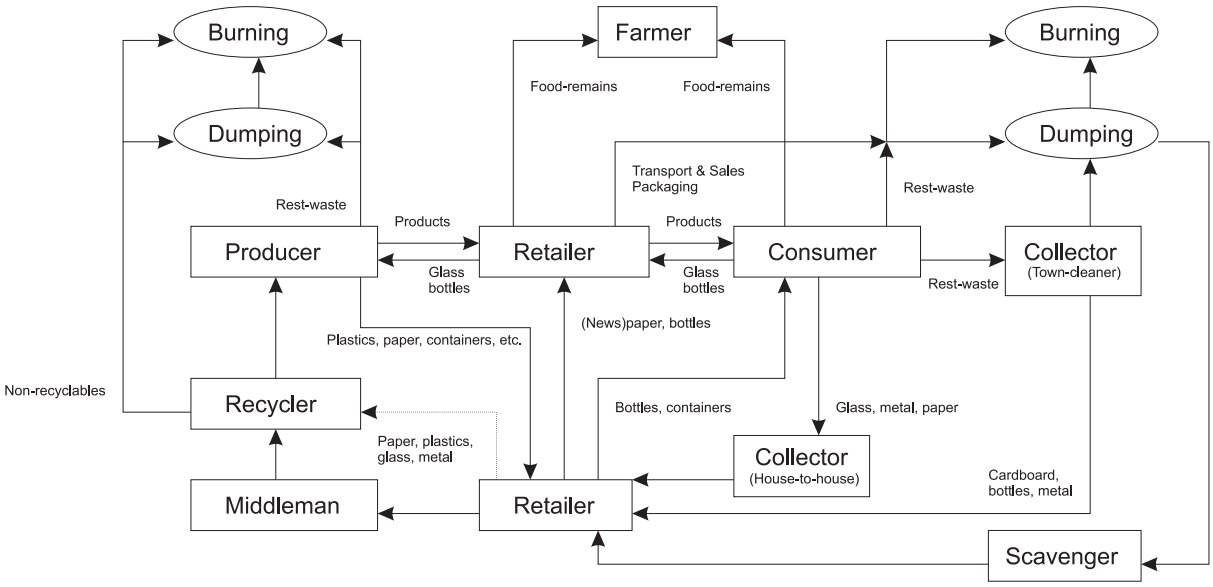


Figure 4.1 The main product- and solid-waste streams in the Ja-Ela DS Division.

Institutional

- Responsibilities of Government agencies with regard to solid waste management (and the maintenance and cleaning or drainage channels) often overlap. This leads most of the agencies involved to pass responsibility for solving the problems to each other, without taking any action themselves.

- Several parts of the National Environmental Act seem currently unimplemented and/or not used, including the provisions for solid waste disposal.

- There are currently no regulations, standards or guidelines for the disposal of solid waste. There are only some guidelines for certain hazardous materials.

Waste production

- Relatively little can be said about the waste production of a given household based on its income and location.

- The plastic and paper fractions of household waste make up most of its volume, but the organic fraction often contributes the most to its weight. This is mainly because of the high water-content of the organic fraction, when compared to the other fractions.

- Packaging waste makes up more than half of the paper and plastic fractions of household waste, both by weight and by volume. In the case of the households we measured, some 60%–80% of the plastic and paper waste consisted of discarded packaging material.

- The "municipal solid waste" as collected by town cleaners contains a lot more organic material and sand/gravel/stones than the household waste that was measured outside the towns. This is partly because the methods used to collect the waste, which make that a lot of sandy material and leaves from the roadside are included. It is also likely that not all of the organic waste produced by households was measured. Gardening waste seemed largely absent (and is possibly re-used in the garden), and selective collection might also have played a role, making that the size of the organic fraction was possibly underestimated.

Waste collection

- Waste collection (or "town cleaning") involves sweeping and the removal of waste from the roadsides. It covers mostly town areas and main roads. Byroads are sometimes also cleaned, but less frequently.

- Household waste is only collected when deposited along the side of the road. Some households just dump it there, but especially shops and (higher-income) households at the edges of towns are also starting to use garbage bins or plastic bags.

- The manner in which the roadsides are swept and garbage is picked up, makes that relatively large amounts of leaves, soil, gravel and small stones are included in the waste which is collected and subsequently dumped.

- Privatisation of the collection / cleaning system seems to significantly increase its effectiveness.

- Cleaning and maintenance of roadside drainage channels is currently insufficient.

- Possibilities to improve the efficiency of roadside waste collection include promoting the use of garbage bags and bins, and placement of central barrels or depots for disposal of household waste. The main problems are that barrels are often stolen, and that bags inhibit the extraction of recyclable or re-usable waste materials by town cleaners.

Waste disposal

- Finding suitable dumping sites for collected waste poses a problem for most local authorities.

- Most dumpsites in the Ja-Ela District are located in marshy areas, especially along the edges of Muthurajawela Marsh.

- Although plastics make up a relatively small fraction of the dumped waste (especially by weight), they do dominate the dumpsites because they do not easily decompose (like paper and organic waste) and are not recycled (like metal and glass waste).

- Access to many dumpsites can be a problem, especially in rainy periods.

- The majority of dumping sites may constitute a hazard to the public health and to the environment. The dumped waste is not covered frequently, waste materials (especially plastics) are spread by wind and water, and leachate and runoff are free to reach ground- and surface water.

- Solid waste disposal is also a problem for most industries, both large scale and small scale. There are no facilities, no regulations, and in most cases no guidelines or standards.

- Uncontrolled dumping of slaughterhouse waste takes place at a fairly large scale and constitutes a nuisance as well as a risk to the public health.

Re-use and recycling

- Most households do not seem to re-use much. Bottles and containers are often re-used, as are some plastic bags. Organic material is mostly used as animal feed or compost in the more rural areas. But especially in urbanised areas, re-use of organic materials is currently insufficient to non-existent, and can easily be much higher.

- Most paper and organic waste could theoretically be easily recycled, but sorting and quality of the materials would be a problem.

- Plastics are difficult to recycle and sort. Plastic waste contains a lot of laminate materials and other composite products, and is sometimes very dirty.

- Contaminants, including heavy metals and other toxic substances, might become a problem when organic material is re-used (by composting, or in a biogas-digestor) on a larger scale.

- It seems that in the current situation, a number of recyclable and/or reusable materials are almost completely removed from the waste stream by the "informal" circuit of waste collectors and resellers. The materials involved are mostly:

    - newspaper, books and plain paper (before re-use);
    - corrugated cardboard, when dry and relatively clean;
    - glass bottles and jars;
    - larger sized metal objects, sometimes also including cans;
    - food remains, in some (rural) areas and households;
    - gardening waste, in some (rural) areas and households; and
    - empty barrels and good-quality (plastic) containers of larger size;

- The waste materials which are currently not collected for recycling, include:

    - paper and cardboard packaging;
    - newspaper and paper, after re-use;
    - plastic packaging and other plastic articles;
    - most composite materials;

- organic waste (depending on the area and the household); and
- hazardous waste, such as chemicals, oil remains, batteries, etc.

- The "informal" circuit creates a significant amount of jobs, for collection, buying and selling, processing and sorting, transport, and recycling.

- Collection and/or re-selling of recyclable and re-usable waste materials has a low profit margin, but can nevertheless provide a full income in many cases.

4.2 Recommendations

Reduction

- Measures for waste reduction at the source, should probably focus on reducing the number of plastic bags provided at shops (or used by consumers), and on reducing the amount of (plastic) packaging waste. Better alternatives should be provided.

Recycling

- Plastic packaging materials should be marked for material type, to ease sorting for mechanical recycling. Many imported products are already marked.

- Plastic products which might be suitable for recycling (and are relatively easy to sort and clean) include cups (of yoghurt, ice, etc.), bottles (PE/PET), pots and other containers (usually PE), and PE/PP packaging foil and bags, although distinguishing between material types might be difficult.

- The possibilities for tertiary recycling of plastics should be investigated (see § 1.7).

Disposal

- Properly engineered dumpsites are needed. At the very least, suitable locations should be selected for new sites (which means that a suitability check has to be performed).

- The biogas-digestors which are being developed and tested at the National Engineering and Research Department (NERD) in Ekala, could provide a cheap and effective method for disposal (or at least reduction) of municipal solid waste with energy recovery, as the organic content of the waste is very high.

- More research is needed into the effects of the current open dumpsites. Some samples of groundwater and surface water in the vicinity of some dumpsites should at least be taken and analysed.

Awareness and instruction

Proper awareness and instruction campaigns are needed on the effects of the current solid-waste disposal practices, and on solutions for (some of) the problems.

Awareness material and usage instructions for things like compost barrels should be suitable for the *entire* target group intended. This is currently not always the case, as most material produced is only suitable for better-educated people who already have an interest in the

subject. If needed, various versions of the same material can be produced for different target groups.

The channels used to distribute the message should also be able to reach the entire target group. Newspapers are often only read by a small portion of the population, and each newspaper has a slightly different target group. Television is effective, but does not reach the lowest income groups. Radio is somewhat less effective, but can also reach some people with lower incomes, and especially people at work. Posters are usually the least effective, but may gain something in effectiveness when put up at places where they will be frequently and easily seen. Brochures can be very effective, but are also expensive and difficult to distribute.

Usage instructions should give clear and short instructions, preferably using additional illustrations. They should be written in simple and unambiguous language, and should also include information on what not to do.

4.3 Suggestions for local action

As waste is seen more as a practical than as an environmental problem, it will be difficult to mobilise community support for a participative waste-collection and recycling programme. Most people feel that waste management is a task for the Government, and would only be willing to take action themselves if it yields sufficient benefit. Experiences with the Arthacharaya community waste collection programme have already shown that financial benefits from selling sorted garbage are fairly low on a household level (IRMP, 2000). Therefore such a programme would only be effective in very low-income areas, where even small benefits count.

The low benefits for selling waste materials are mostly caused by the fact that one household does not produce much waste, and does therefore not get much income from selling it. This problem is avoided if the benefit is spread over fewer people. A house-to-house buyer for instance, can make a living out of buying and selling waste materials from a number of neighbourhoods (see § 3.4). His profit margin is low, but this is because the major part of the financial benefit actually goes to the households!
To start a successful and self-sustainable community/neighbourhood waste-management project, it would be most efficient to incorporate the informal collection and recycling routes that already exist. This existing system of "informal waste collection" can then be extended to include the waste materials that are currently not (sufficiently) collected and/or recycled. When implemented correctly, this could result in benefits for everyone involved (households, collectors, resellers, recyclers).

In such a system it is absolutely essential to have the support of the community. The households are the ones that have to initially sort and store the waste materials that are to be collected for recycling. Therefore to ensure co-operation, the local population must be involved in setting up the system. It is very important that they are correctly informed on proper sorting of waste materials, on composting and on management of household waste in general. For most people, the incentive for co-operation will probably be the fee for selling the waste (IRMP, 2000), and the fact that waste is now properly collected (see § 3.5), so that it is no longer their worry.

It would probably not be difficult to get support from waste buyers and recyclers, as such a project would mean an expansion of their market, by which they have something to gain. One potential problem might be that they might get more competition, which (especially considering the nature of the Sri Lankan society in this regard) might not always be appreciated.

The project would have to focus mostly on collection of paper and plastic packaging materials, and on collection and/or local re-use (composting, feeding animals) of organic waste (in areas where this is not already happening). In a proper collection system, provisions also need to be made for the rest-fraction and for hazardous waste (chemicals,

etc.). This might pose a problem, as no profit can be obtained from collection and disposal of these fractions, and these activities will have to be funded somehow.

The local residents should be briefed in a workshop on how to sort waste and make compost, and also on what *not* to do. This last point is very important, and can help to avoid many problems. This is often forgotten: instruction briefings for many projects only seem to focus on what to do, but not on what to avoid.
Expected problems include the following:

- *Lack of space for storage*, especially among low-income households, and in more urbanised areas. Collections will have to be more frequent (which will result in decrease of benefits for the collector), or other provisions need to be made. Central storage could be considered, but is impractical and involves extra cost.

- *Lack of space for composting, or no use for compost*. In this case organic waste will have to be collected for composting by someone else, for biogas production or for animal-feed. This might be a problem, as storage of organic waste is near to impossible, due to smell and animals.

- *Animals*. Especially dogs, cats and crows will often go through waste, looking for something to eat. This may cause the (sorted) material to be scattered again, and will make (storage for) collection very difficult. The animals are usually able to open plastic bags, so these offer no protection. A (heavy) bin would help, but will involve extra costs.

- *Improper sorting*. For many people it is difficult to distinguish between waste-types, even with proper instruction. Also, quality of the waste is of importance. Dirty paper should for instance be deposited with the organic fraction or the rest-fraction. Very dirty plastics are difficult to clean and recycle, so should also go with the rest-fraction. The organic fraction often contains small bits of plastic, which are difficult to sort out. If the waste materials are improperly sorted at the household level, the quality (and with it the value) will go down.

- *Plastics*. For (mechanical) recycling, plastics will have to be cleaned and sorted to material type. This will involve extra costs, which might outweigh the benefits, except when done by volunteers. Sorting plastic types is also very difficult, as most locally produced packaging materials are currently not marked.
  An alternative would be to only recycle product types that are easy to sort, to clean and to recycle. Things like plastic bottles, yoghurt cups, etc. The rest would have to be dumped, or burned at elevated temperatures (for which no installation seems to be currently available in Sri Lanka). Tertiary recycling (see § 1.7) is also an option, but the technology for this might not yet be available in Sri Lanka or around.

- *Residual waste*. As was already mentioned, collection of these (usually non-recyclable) waste fractions will involve extra cost (except when done by volunteers – perhaps schoolchildren). The rest-fraction would have to be dumped or burned. It is likely that there are currently no proper facilities on the island to dispose of hazardous materials (chemical residues, batteries, etc.) in residual household waste.
  Meat remains are best not composted, so these will go into the rest-fraction. However, this will make it more difficult to store, because of smell and animals.

Besides the sort of larger-scale community project suggested above, initiatives for waste collection and recycling are also possible on a smaller scale, and for a more limited target group. An example of this could be the following:

Hotels and restaurants, especially in tourist areas, produce a significant amount of plastic (PET) drink bottles. These are relatively easy to collect, store and clean, and also easy to recycle mechanically. Therefore, it might be useful to set up a kind of bottle-collection system

for hotels, restaurants and guesthouses in the Negombo area. Hotels and guesthouses could have a separate bin in which tourists can deposit PET bottles. This would be good for the "environmental" image of the participating hotels, restaurants and guesthouses, and might also provide some positive publicity for IRMP.

4.4 Comments on the NSSWM

The proposed National Strategy for Solid Waste Management is fairly complete, in that it covers the entire waste-cycle from production (avoidance) through re-use, collection, recycling to disposal. This is done in a fairly integrated manner, and according to the established hierarchy of waste management. In the light of this report however, a few notes need to be made on the strategy:

- Some practical aspects of the proposal are still very vague. For example, the motto of "reduce, re-use and recycle" is one of the pillars of the plan. But nowhere is it mentioned *which* kinds of products might be re-used (for instance containers, bottles and plastic bags might be possible candidates). The measures for waste reduction on the consumer side are also somewhat unclear. But more importantly, it is still not fully known where the initial money for implementation of the plan has to come from.

- The proposal does not consider the fact that many materials are already being sorted out of the waste stream for re-use and recycling, by the "informal" circuit (see § 3.4). Integration of the existing informal systems into the proposed collection system might somewhat simplify implementation of segregated waste collection.

- Practical problems with collection and with sorting of waste at the household level are not considered. See *paragraph 4.3* for examples. Especially storage of waste will be a problem for many households.

- The plan only targets municipal solid waste. And more importantly, through the proposed methods of sorting, composting and awareness building, it implicitly targets mainly better-educated and higher-income households located in more urban areas. This is not really a problem, as this group is the easiest to start with, but nowhere is this explicitly mentioned. It is however an important realisation, as it implicitly limits the initial scope of the plans for segregated waste-collection. It means that low-income and poorly educated families, and households in more rural areas will or can not easily be included in the waste-collection and recycling schemes. At least, not at first. In other words, the majority of households in the country would initially not be covered by the measures proposed in the strategy.

And finally of course, as is the case with all proposals: The *plan* looks good, but it is always the question if it can and will be implemented properly. The proposed three-year timeframe sounds good, but may be a bit optimistic considering previous experiences.

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