5. Gampaha

5.1 Conventional Hospitals

There are three main conventional hospitals within the Gampaha Municipal Area (GMA): Gampaha Base Hospital, Arogya Hospital and the Co-operative Hospital, as well as a number of medical centres/dispensaries. The main survey findings for these three hospitals, including hospital statistical data are set out in Tables 9 and 10 and summarized below:

(a) The combined hospital facilities in Gampaha are :
- A total of 570 beds.
- Average bed occupancy equivalent to 464 beds per day (81%).
- Average total clinical and outpatients of 1,544 patients per day.
- Total staff of 709.

Corresponding hospital waste generation is estimated to be 0.86T/d, equivalent to 0.316kg/(staff+patients).d.

(b) Food/kitchen waste is the most common waste type, followed by paper, plastic, garden, cardboard and healthcare hazardous waste.

(c) The Base Hospital generates ~710kg/d of normal waste (1/2 trailer load/d) and 33kg/d of healthcare hazardous wastes. Hospital waste is collected by private contractors within the hospital, with normal waste being taken to the waste storage/disposal area, where it is stored in the hospital's own covered trailer[4] for collection by the Gampaha Municipal Council (GMC). The hospital indicated it was satisfied with the performance of its private contractors but complained about the irregularity of the GMC collection service, meaning that it frequently resorts to burning a lot of its normal waste on-site. This was verified by the JICA disposal site survey which found that only two half full loads of hospital waste were brought to the final disposal site over a continuous seven day period (8-14 Aug, 2002). On this basis, it is assumed that 70% of base hospital normal waste is normally disposed of by burning on-site, while only 30% is collected by GMC.

The Base Hospital disposes of most of its healthcare hazardous wastes (clinical waste, body parts, sharps, highly infectious wastes) by burning and/or burial on-site, except for post-mortem waste and placentas, which are taken to the cemetry for burial and urine/blood samples which are disposed of to the hospital drainage system/toilets, thus ending up in the hospital's wastewater treatment plant.

The Base Hospital reuses waste containers. For example:
- Saline and penicillin bottles are reused (e.g. as containers for blood and urine specimen collection.
- Cardboard boxes are used as sharps storage containers.

The Base hospital recycles some cardboard, used plastic/glass/metal containers/bottles and coconut shells. Cardboard is given/sold to individual collectors while most other items are auctioned at yearly intervals. The average quantities recycled per month are 200kg of cardboard, 400kg of plastics, 4kg of polythene bags, 675kg of glass, 15kg of metal items and 118kg of coconut shells. Recently, the hospital cleaners have started collecting saline bottles for recycling, with about 6,270 bottles being reused and/or recycled per month.

[4] Rectangular base with semi-circular top and sliding side doors; Vol = 5.77m^3.

(d) Most normal waste is collected by GMC from the other two hospitals, except for small quantities of cardboard and plastic/glass bottles/containers which are given to staff or sold at daily-three monthly intervals: 40 bottles/mth and 50kg/mth of metal items by Arogya Hospital and 3-4kg/mth of cardboard and 10kg/mth of glass by the Co-operative Hospital.

The Arogya Hospital transports the small quantities of healthcare hazardous wastes it produces to a private "local" incinerator in Kochchikade, Negombo for disposal. On the few occasions when body part waste generation is high, they usually transfer this waste to the Base Hospital for disposal. The Co-operative Hospital produces very small quantities of clinical and sharps waste which it burns on site.

(e) Both the Base and Arogya hospitals are not satisfied with the present waste collection system[5] for a variety of reasons related to the discharge system being poor, the poor quality and irregularity of GMC's cleaning service, problems handling healthcare hazardous waste, etc.

(f) Only the Arogya Hospital pays garbage collection workers an unofficial collection fee of 1,000Rs/yr.

(g) Desired SWM improvements ranked in descending order are (numbers shown are weighted average ranks (WAR) for desired improvements):

- Greater recycling/composting of garbage 4.0
- Improved collection frequency 3.0
- Other (give MC facilities, labourers should be more careful) 3.0
- Education to change peoples' bad habits 2.5
- Improved collection and disposal of hospital hazardous waste 2.0
- Improvement of landfill operation 2.0
- More reliable garbage collection service 2.0.

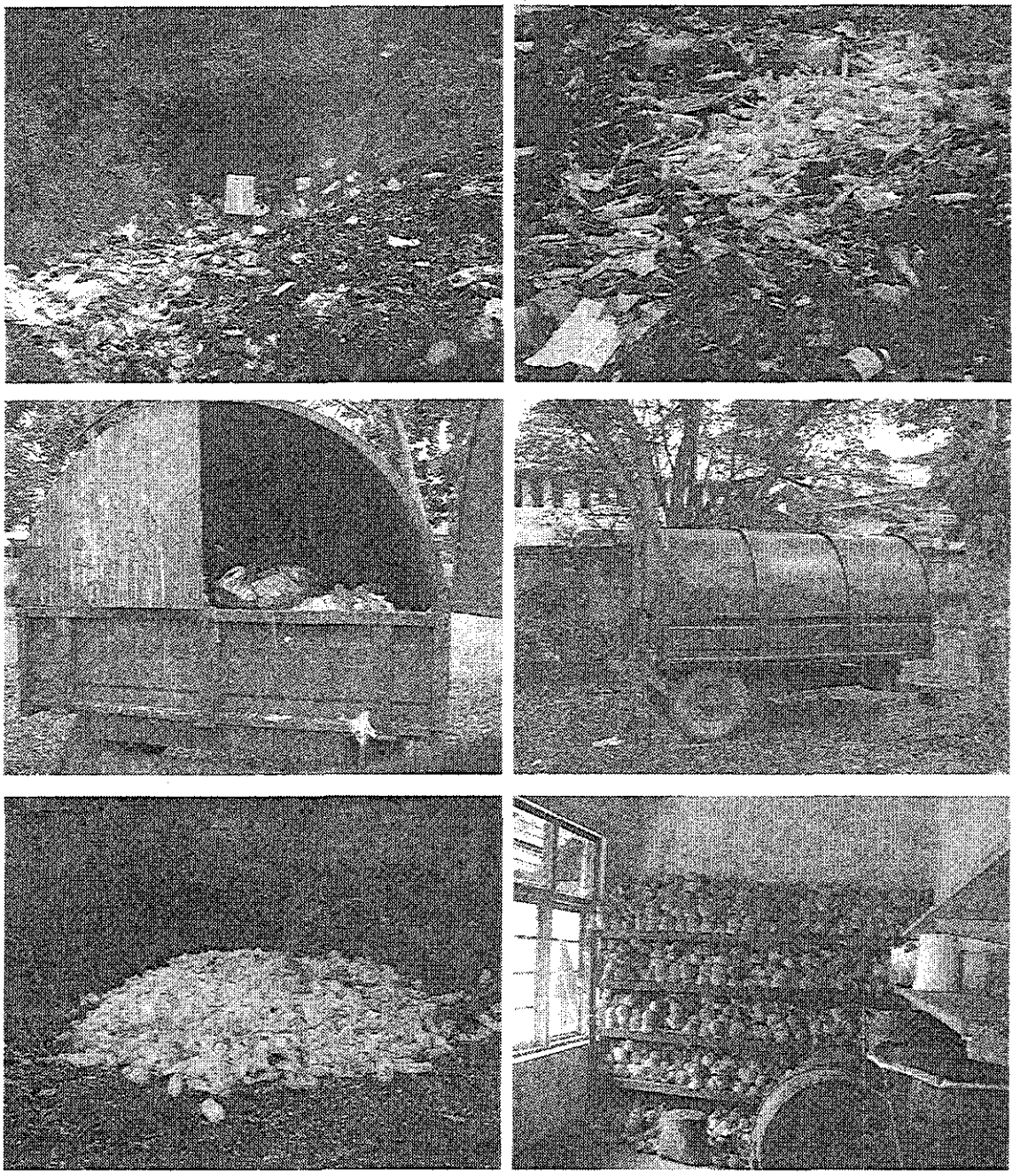
The Base Hospital would also like an incinerator, while it needs financial assistance to implement the colour coded garbage discharge system recommended by the Ministry of Health and to provide hospital labourers with appropriate garbage collection equipment (e.g. gloves). The Arogya hospital transports its hazardous healthcare wastes a relatively long distance for disposal by incineration and would like to have incineration facilities located closer to them.

The collection and disposal of healthcare hazardous waste could possibly be improved by constructing an incinerator at the Gampaha Base Hospital for use by all hospitals within GMA for the incineration of clinical, body parts, sharps and other infectious wastes, as appropriate. This matter is beyond GMC's jurisdiction, but GMC can recommend such a proposal to the Ministry of Health for further consideration.

(h) The Co-operative hospital is willing to pay 1,200Rs/mth for improved garbage collection services, while the Arogya Hospital interviewee was not able to answer this question directly but indicated that 1,200Rs/mth seemed a reasonable figure. The Base Hospital said that this question should be referred to the Deputy Director of Health Services, Western Province for a response.

(i) All three hospitals supported recycling, with the Base Hospital and Arogya hospitals both being very willing to cooperate in separating their waste into different categories for recycling, if requested. However, the Co-operative hospital is not willing at all to co-operate in the source separation of waste.

[5] The Co-operative Hospital did not respond to this question.



Gampaha Base Hospital: Top = on-site disposal; middle = hospital garbage collection trailer; bottom = saline bottles and coconuts being stored separately for recycling.

Table Annex B-9 : GMA Hospital General Statistics and Waste Generation

Hospital	Type	No of Beds	Bed occup-ancy (%)	Out-patients (no/d)	Clinical patients (no/d)	Staff	Waste compos-ition	Normal waste (kg/d)	Clinical waste (kg/ mth)	Body parts/ placenta (kg/mth)	Sharps (per month)	Highly infect-ious (/mth)	Other
Base Hospital	Govt	501	79	985	334	595	F/K>Pl>Ga >P>HH	710	Clin + BP: 314 Plac: 210		480	ND	31
Arogya Hospital	Private	42	100	60	40	54	P>F/K>M> HH	70	60	Small	Small	Small	Small
Co-operative Hospital	Semi-govt	27	95	80	45	60	F/K>P>Pl> Ga>HH	40	60	0	0.01	0	Small
Total		570	81	1125	418	709	F/K>P>Pl> Ga>HH	820	Clin + BP: 434 Plac: ~210		~480	ND	~31

Notes:

1. Data for hospitals obtained from interviews with relevant staff members of each institute.
2. Average total number of beds occupied = Sum of (number of beds x bed occupancy rate) for all hospitals = 464.
3. Abbreviations: F/K = food/kitchen waste, Ga = garden, Gl = glass, HH = healthcare hazardous waste, M = metal, O = other, P = paper, Pl = plastic; BP = body parts, Clin = clinical, Plac = placentas; ND = no data.
4. An accuracy check has only been made on the amount of normal waste, with survey data being amended based on GMC data, as required.

Table Annex B-10 : GMA Hospital Waste Disposal Practices

Hospital	Normal waste	Clinical waste	Body Parts and/or placentas	Sharps	Highly infectious	Other	WW-TP	Incin-erator	Comments
Base Hospital	~70% of non-recycled waste burnt on-site with remaining 30% collected by GMC. Recycling of cardboard, plastic/glass/metal bottles/containers and coconut shells amounts to 49kg/d.	Burned on site, except for post-mortem remains and placentas which are taken to the cemetery.		Burned on site.	Burned on site except for urine/blood samples which are disposed to drains/toilets (i.e. to WWTP)	No answer	Yes	No	Would like incinerator and financial support to set up colour coded waste discharge system, supply labourers with gloves, etc.
Arogya Hospital	Collected by GMC except for some recycling of plastic bottles and glass.	Incinerated				No answer	No	No	Use incinerator in Kochchikade, Negombo.
Co-operative Hospital	Collected by GMC except for some recycling of cardboard and glass.	Burned on site	Burned on site	Burned on site	Not applicable	No answer	No	No	

5.2 Wikkrama Arrachchi Ayurveda Vidyayatanaya (WAAV)

Wikkarama Arrachchi Ayurveda Vidyayatanaya (WAAV) is an ayurvedic university and hospital located in the Yakkala area of GMA. The university has 155 staff and 275 students. The hospital has 120 beds with a 90% occupancy rate, 300-350 outpatients/d, 60 clinical patients/d and 65 staff, giving a total of 558 patients+staff/d. Together, these combined facilities have 988 staff+students+patients/d.

Combined waste generation from the university and hospital is estimated to be 1.36T/d, which is relatively large, primarily due to high garden waste generation from a large herbal garden situated within WAAV's grounds. Hospital waste is estimated to comprise 14% of total waste generation and is mainly organic, with hazardous healthcare waste being negligible (due to the different nature of ayurvedic medicine compared with conventional medicine). About 1.5mths ago (mid-August 2002), WAAV privatized its waste collection service, following which private contractors collect the combined hospital and university waste, burning it all on-site.

6. Nuwara Eliya

There are three main hospitals within the Nuwara Eliya Municipal Area (NEMA) – Nuwara Eliya Base Hospital, Cooperative Hospital and Ideal Hospital Pvt Ltd[6] - as well as a number of medical centres/dispensaries. The main survey findings for these three hospitals only, including hospital statistical data are set out in Tables 11 and 12 and summarized below:

(a) The combined hospital facilities in Nuwara Eliya are :
- A total of 289 beds.
- Average bed occupancy equivalent to 366 beds per day (127%).
- Average total clinical and outpatients of 1,003 patients per day.
- Total staff of 328.

Corresponding hospital waste generation is estimated to be 0.51T/d, equivalent to 0.301kg/(staff+patients).d.

(b) Food/kitchen waste is the most common waste type, followed by paper, healthcare hazardous waste and cardboard/plastic waste. Healthcare hazardous waste was listed as the most common waste type by the Ideal Hospital.

(c) Most normal waste is collected by NEMC, except for small quantities of paper, plastic/glass bottles/containers and coconuts recycled by the Nuwara Eliya Base Hospital, as described further below, while Cooperative Hospital burns some of its normal garbage on-site.

(d) Currently, the Base Hospital discharges its clinical waste for collection by NEMC, while body parts, placentas, sharps and highly infectious wastes are burned/buried on-site. The Ideal Hospital discharges very small quantities of clinical waste for collection by NEMC, while the Cooperative hospital burns/buries clinical waste and sharps on-site.

(e) The Base Hospital has a relatively new incinerator but this is not used due to its inappropriate location, proximity to staff living quarters, and inadequate height. They have also recently acquired an autoclave but have yet to start using this.

(f) The Base Hospital reuses waste containers. For example:

[6] Ideal Hospital should possibly be categorized more as a medical centre as it has no bed or clinical patient facilities.

- Saline and penicillin bottles are reused (e.g. as containers for blood and urine specimen collection.
- Cardboard boxes are used as sharps storage containers.

(g) The Base hospital has banned people bringing polythene into the hospital. However, polythene bags are used for dispensing medicines to patients and observation during JICA field investigations suggests the polythene ban is not being strictly enforced.

(h) The Base hospital recycles some of their used paper, plastic/glass containers/bottles and coconut shells. Glass/plastic/metal containers/bottles are generally stored on-site and sold by auction at approximately yearly intervals, while paper is collected by the Hospital Welfare Society. Coconuts are collected by the hospital caterer with 200Rs/mth deducted from catering contract payments. Indicative data on the quantities of materials recycled was obtained from the Base Hospital, showing they recycle around 40 25L plastic cans and 14 24L metal cans per 3-6 months, 2kg/mth of paper and 20 coconuts per day. No quantities data was available for plastic containers, glass bottles and penicillin vials. Total recycling was estimated to be 7.8kg/d.

(i) Ideal Hospital pays garbage collection workers an unofficial collection fee of 600Rs/yr.

(j) Both the Base and Cooperative hospitals are not satisfied with the present waste collection system, the main reasons being garbage collection/sweeping is not properly done (2) and a lack of recycling (2). The Base Hospital also identified problems with handling hospital hazardous waste and complained about the irregularity of the NEMC collection service, with garbage sometimes remaining uncollected for several days. They do not have a Hospital PHI and said that inspections by NEMC PHIs are very infrequent.

(k) Desired SWM improvements ranked in descending order are (numbers shown are weighted average ranks (WAR) for desired improvements):

- Improved garbage discharge system 7.0
- Improved collection and disposal of hospital hazardous waste 5.5
- More reliable garbage collection service 4.0
- Greater recycling/composting of garbage 2.0

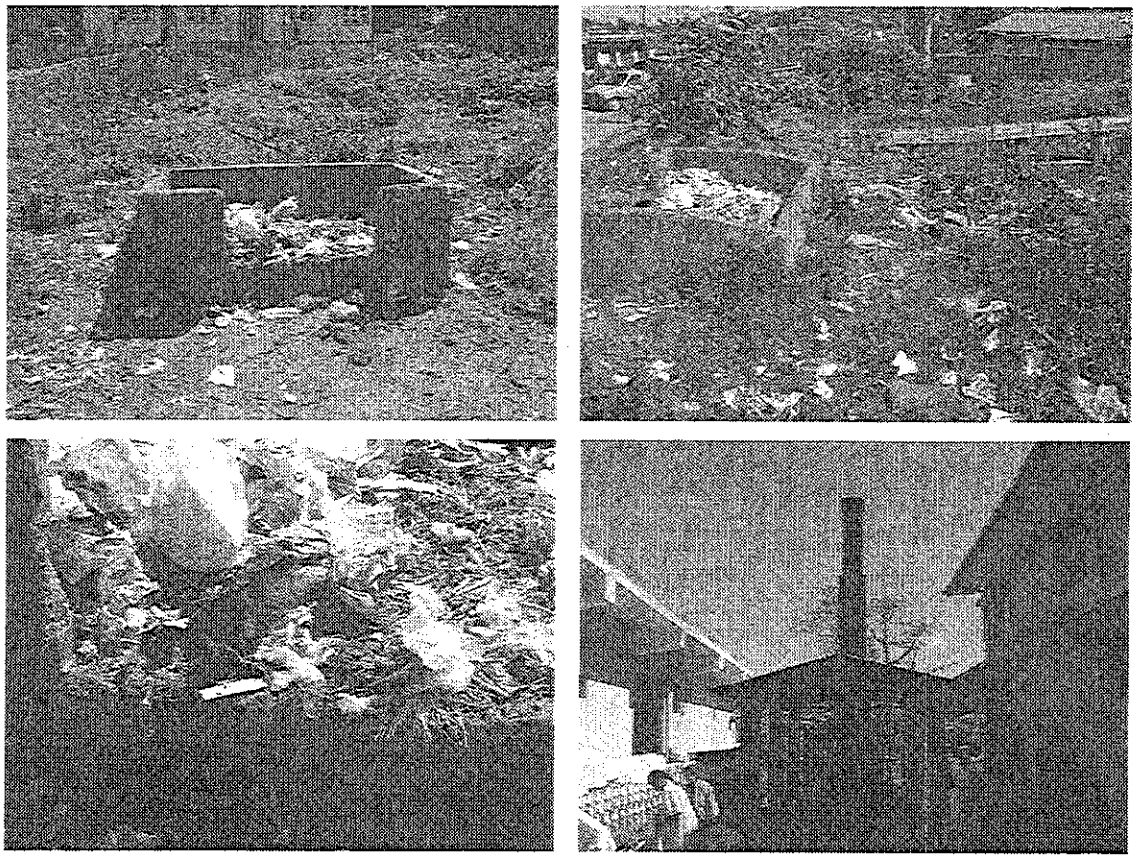
The Base Hospital would also like an incinerator and a covered trailer for garbage transport, while it considers their existing bin is inadequate.

The collection and disposal of healthcare hazardous waste could be improved by constructing a covered, secure concrete bin within the Base Hospital premises for storage of its normal garbage and improved management of its healthcare hazardous wastes. It would also be beneficial to construct a proper incinerator at the Nuwara Eliya Base Hospital or other suitable location in the city, which would be used by all hospitals/medical centres within NEMA for the incineration of clinical, body parts, sharps and other infectious wastes, as appropriate. This matter is beyond NEMC's jurisdiction, but NEMC can recommend such a proposal to the Ministry of Health for further consideration.

(l) No hospitals were willing to pay for improved garbage collection services.

(m) All hospitals are very willing to cooperate in separating their waste into different categories for recycling.

It should be noted that the base hospital is located on marshy land and is slowly sinking, resulting in some buildings being abandoned. A new 10MRs hospital has been proposed for Nuwara Eliya, comprising 545 beds with maternal and child care units. Funding for the new hospital is currently being sought from Japan under their grant aid scheme, while NEMC has to provide a site. NEMC have indicated that they have reached an agreement with the brewery company, whose brewery is now closed in Nuwara Eliya, to procure their land in exchange for NEMC giving them some other land. However, the hospital authorities have not been officially informed of this.



Nuwara Eliya Base Hospital: Top – hospital bin located outside hospital premises next to byroad; bottom left – blood stained bandages present amongst normal waste in the hospital bin.

Table Annex B-11 : NEMA Hospital General Statistics and Waste Generation

Hospital	Type	No of Beds	Bed occup-ancy (%)	Out-patients (no/d)	Clinical patients (no/d)	Staff	Waste compos-ition	Normal waste (kg/d)	Clinical waste (kg/ mth)	Body parts (kg/ mth)	Sharps (kg/ mth)	Highly infect-ious	Other
Base Hospital	Govt	265	129	431	460	304	F/K>P>Pl> Gl>HH	482	25	BP: 25 Plac: 37	200	Small	0
Cooperative Hospital	Semi-govt	24	100	12	45	14	F/K>P>HH >Ga	5	Small	BP: 0 Plac: Small	Small	0	Small
Ideal hospital	Private	0	0	55	0	10	HH>F/K> Pl>P	7.5	1	0	0	0	2.5
Total		289	127	498	505	328		494.5	26	62	200	Small	2.5

Notes:

1. Data for hospitals obtained from interviews with relevant staff members of each institute.
2. Average total number of beds occupied = Sum of (number of beds x bed occupancy rate) for all hospitals = 366.
3. Abbreviations: F/K = food/kitchen waste, Ga = garden, Gl = glass, HH = healthcare hazardous waste, O = other, P = paper, Pl = plastic; BP = body parts, Clin = clinical waste, Plac = placentas.
4. An accuracy check has only been made on the amount of normal waste, with survey data being amended based on NEMC data, as required.

Table Annex B-12 : NEMA Hospital Waste Disposal Practices

Hospital	Normal waste	Clinical waste	Body Parts and/or placentas	Sharps	Highly infectious	Other	WW-TP	Incin-erator	Comments
Base Hospital	Collected by NEMC except for some recycling of paper, plastic/glass/metal containers/bottles and coconut shells.	Discharged for collection by NEMC	Body parts and placentas are buried on-site.	Burned on site	Burned on site	Not relevant	Yes (see note)	Yes (see note)	Would like new incinerator, covered trailer and new bin
Cooperative Hospital	Collected by NEMC, with some garbage burnt on-site.	Burnt/buried on-site	Placentas: NA	Buried on-site	Not applicable	Collected by NEMC	No	No	
Ideal Hospital	Collected by NEMC.	Collected by NEMC	Not applicable	Not applicable	Not applicable	Collected by NEMC	No	No	

Note: The Base Hospital has a relatively new incinerator but this is not used due to its inappropriate location. It also has a wastewater treatment plant (WWTP) but this had been abandoned for some time.

7. Badulla

There are three main medical institutions within the Badulla Municipal Area (BMA): Badulla General Hospital, Central Hospital and the Lanka Nursing Home, as well as a number of medical centres/dispensaries. The main survey findings for these three medical institutions only, including medical institution statistical data are set out in Tables 13 and 14 and summarized below:

(a) The combined medical institution facilities in Badulla are :
- A total of 1,053 beds.
- Average bed occupancy equivalent to 1,186 beds per day (113%).
- Average total clinical and outpatients of 1,733 patients per day.
- Total staff of 1,135.

Corresponding medical institution waste generation is estimated to be 1.47T/d, equivalent to 0.363kg/(staff+patients).d.

(b) Paper is the most common waste type, followed by food/kitchen, plastic, garden/glass waste. Healthcare hazardous waste is produced by all three medical institutions.

(c) The General hospital uses a two colour polythene bag system for the discharge and storage of hospital waste – black for normal garbage and yellow for hazardous waste.

(d) All normal medical institution waste is collected by Badulla Municipal Council (BMC), except for small quantities of cardboard, plastic/glass bottles/containers and coconuts recycled by the General and Central hospitals as described further below.

(e) Currently, the General Hospital disposes of its clinical waste on-site, while sharps and highly infectious wastes are burnt on-site in its own incinerator. Body parts and placentas are taken directly to the cemetery every 10 days. Some highly infectious liquid wastes (e.g. laboratory wastes) are disinfected and then discharged to the hospital drainage system which conveys them to the hospital wastewater treatment plant.

The incinerator is about four years old and was constructed with funding from the Provincial Council. It is a basic incinerator, comprising one chamber, fueled by firewood/coconuts and with a 7.6m chimney. It is in relatively poor condition, given its age. Ash from the incinerator is placed in a pit on-site.

(f) The Central Hospital discharges very small quantities of clinical wastes for collection by BMC, while some body parts are sent to Colombo for experiments; others are discharged to the drainage system and others are burnt on-site, together with placenta and sharps waste.

(g) The Lanka Nursing Home disposes of small quantities of clinical, placenta and sharps waste by on-site burning/burial.

(h) The General Hospital reuses waste containers. For example:
- Saline and penicillin bottles are reused (e.g. as containers for blood and urine specimen collection). The hospital has recently started to stockpile surplus saline bottles and is planning to send these to Colombo for recycling.
- Cardboard boxes are used as sharps storage containers.

(i) The General hospital recycled around 5,630 plastic items, 1,500 glass bottles and 230 metal items in its most recent auction, which are held at approximately six month

intervals. It also uses coconut shells as fuel for its incinerator. The Central hospital recycles around 5kg/mth of cardboard and 15kg/mth of plastics.

(j) Overall, it is estimated that 95.5% of medical institution waste is collected by BMC, 1.7% disposed of on-site, 0.7% recycled and 2.0% directly hauled to the cemetery.

(k) The Central Hospital pays garbage collection workers an unofficial collection fee of 500Rs/yr.

(l) Both the General hospital and Lanka Nursing Home are not satisfied with the present waste collection system, the main reasons being garbage collection/sweeping is not properly done (2), is irregular (2) and of too low a frequency (2). The Lanka Nursing Home also identified problems with handling hospital hazardous waste.

(m) Desired SWM improvements ranked in descending order are (numbers shown are weighted average ranks (WAR) for desired improvements):

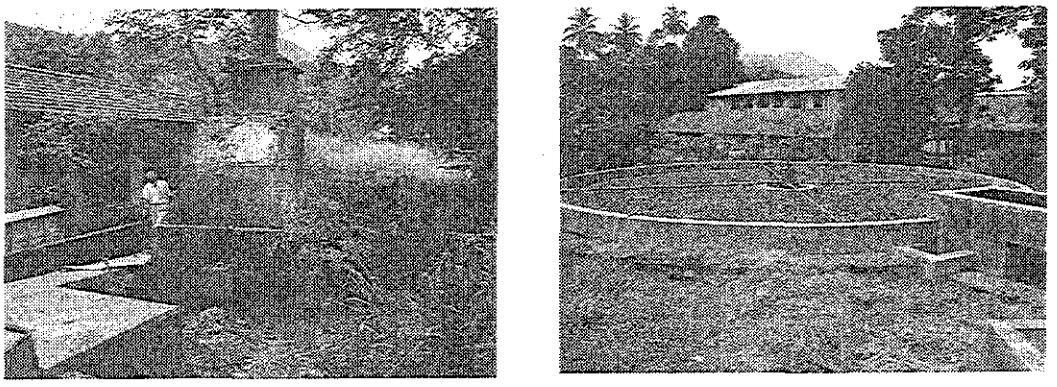
- Education to change peoples' habits 4.5
- Greater recycling/composting of garbage 3.0
- More reliable garbage collection service 2.5
- Fine system for irresponsible behaviour 2.5

The General Hospital would also like a covered trailer to reduce waste scattering during transportation of hospital waste to the BMC disposal site; financial and technical assistance to start a composting project at the hospital[7], and a better incinerator. The Lanka Nursing Home would also like a proper healthcare hazardous waste disposal system.

The collection and disposal of healthcare hazardous waste could possibly be improved by constructing a better incinerator at the Badulla General Hospital for use by all three hospitals within BMA for the incineration of clinical, body parts, sharps and other infectious wastes, as appropriate. This matter is beyond BMC's jurisdiction, but BMC can recommend such a proposal to the Ministry of Health for further consideration.

(n) The General Hospital and Lanka Nursing Home are willing to pay 1,200Rs/mth and 200Rs/mth for improved garbage collection services.

(o) All medical institutions are very willing (2) or somewhat willing (1) to cooperate in separating their waste into different categories for recycling.



Badulla General Hospital: left – hospital incinerator; right – hospital wastewater treatment plant.

[7] They also have an interest in a biogas project, but think a composting project may be more feasible.

Table Annex B-13 : Medical institution General Statistics and Waste Generation

Medical institution	Type	No of Beds	Bed occup-ancy (%)	Out-patients (no/d)	Clinical patients (no/d)	Staff	Common Waste Types	Normal waste (kg/d)	Clinical waste (kg/ mth)	Body parts (kg/ mth)	Sharps (kg/ mth)	Highly infect-ious	Other
General Hospital	Govt	1,004	115	916	757	1,061	F/K>P> Pl>Ga	1,365	675	BP: 5 Plac: 900	62	Small	Small
Central Hospital	Private	29	40	5	25	34	Gl>P>Pl >Ga	12.7	1.5	BP: small Plac: 6	0.25	0	Small
Lanka Nursing Home	Private	20	100	20	10	40	F/K>P>M	30	Small	BP: 0 Plac: 9	2	0	Small
Total		1,053	113	941	792	1,135		1,407	~226.5	~45	~64	Small	Small

Notes:

1. Data for medical institutions obtained from interviews with relevant staff members of each institute.
2. Average total number of beds occupied = Sum of (number of beds x bed occupancy rate) for all medical institutions = 1,186.
3. Abbreviations: F/K = food/kitchen waste, Ga = garden, Gl = glass, HH = healthcare hazardous waste, M = metal, O = other, P = paper, Pl = plastic; BP = body parts, Clin = clinical waste, Plac = placenta.
4. Quantity of normal waste specified above excludes recyclables.
5. An accuracy check has only been made on the amount of normal waste, with survey data being amended based on BMC data, as required.

Table Annex B-14 : Medical institution Waste Disposal Practices

Medical institution	Normal waste	Clinical waste	Body Parts and/or placentas	Sharps	Highly infectious	Other	WW-TP	Incin-erator	Comments
General Hospital	Collected by BMC except for some recycling of plastic/ glass containers/ bottles and coconut shells.	Disposed of on-site.	Taken to cemetery every 10 days.	Incinerated on-site	Incinerated on-site	Not stated	Yes (see note)	Yes (see note)	Would like covered trailer, technical/financial assistance for composting; better incinerator
Central Hospital	Collected by BMC, except for some recycling of paper and plastics.	Collected by BMC (small)	Some body parts sent to Colombo for experiments; some discharged to drainage system; others + placentas disposed of on-site	Burned/ buried on-site	Not applicable	Not stated	No	No	
Lanka Nursing Home	Collected by BMC.	On-site disposal	BP: Not applicable Plac: on-site disposal	On-site disposal	Not applicable	Not stated	No	No	Would like proper healthcare hazardous waste system

Note: The Base Hospital's incinerator is about four years old but is in relatively poor condition for its age. The hospital's wastewater treatment plant (WWTP) is quite old (>50yrs?) and is under capacity according to hospital staff. However, a brief inspection of the WWTP showed that most of the system capacity is being bypassed due to poor operational procedures.

Chapter G

Geological Study for Potentiality of Landfill

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Chapter G Geological Study for Potentiality of Landfil

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G.1 Topography Classification

Sir Lanka is an island country, with the total territory area of 66,815km^2. In this JICA Study, a country wide topography map was created by using the USGU GTOPO30 DEM (Digital Elevation Model) data.

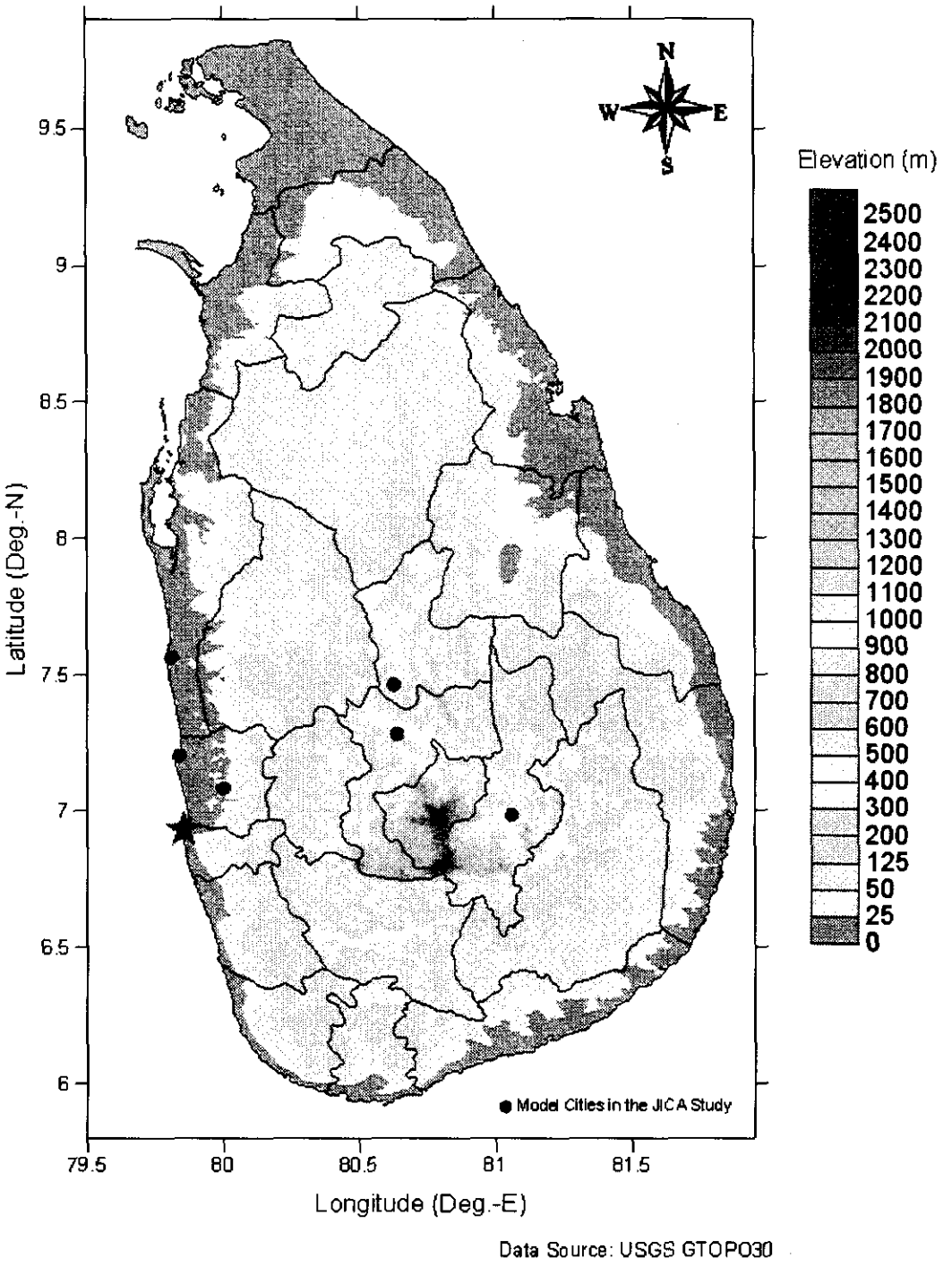

Figure G-1: Topography of Sri Lanka

The USGU TOPO30 data was also used to classify the topography on the basis elevation above sea level as: *plain zone* 0 – 25m, *peneplain zone* 25 – 50m, *hilly zone* 50 – 200m, and mountainous zone over 200m. Area and percentage in national territory for each zone are shown in Table G-1.

Table G-1: Result of Topography Zoning

Classification	Plain	Peneplain	Hilly Zone	Mnt. Zone	Total
Elevation (m)	0-25	25-50	50-200	>200	---
Area (km^2)	3606	9479	20508	33220	66815
Percentage (%)	5.4	14.2	30.7	49.7	100

Totally, topography in Sri Lanka is characterized by relatively low northland and high southland. Majority of plain and peneplain zones distribute in northern part of the country, whereas the mountainous zone stretches and takes about half of area in southern Sri Lanka. This topography zoning can be used to examine the features of landfill in different place of the country.

G.2 Type of Landfill

From plain to mountainous zone, the change is not only known in average land surface elevation, but also deduced in the following general geomorphologic features:

- Land form changes from flatland to many ups and downs
- Valleys change in depth from shallow to deep, and
- Slopes change in gradient form gentle to steep

These features will influence the selection of type, when a landfill is to be designed as final soild waste disposal method.

Landfills may have different types of sections as: (A) above ground landfills (area landfills); (B) below ground landfill (trench landfills); (C) slop landfills; (D) valley landfills (canyon landfills); and (E) a combination of the above.

In the north Sri Lanka, because of gently sloping landform, A and B types should usually be suitable type of landfill, whereas type C and D will be commonly taken in hilly and mountainous zones, which account for about 80% of Sri Lanka area and mainly distributed in southern Sri Lanka, like the landfills improved in Nuwala Eliya and Kandy , and designed in Matale and Badulla by JICA Study Team. Therefore, C and D type landfill should be main types of landfill in Sri Lanka.

Within the 4 basic types of landfill, type D, the valley landfill makes maximum advantage of natural

topography features, using the slopes in both side of valley to skip the materials and job for construction of enclosing bund around the landfill. Because surface water, therefore, leachate from filled waste will easily gathered to bottom of valleys, the design of leachate collection system would be simple, effective, reliable and generally less expensive.

The design work can be expected simple for valley type landfill because that in most cases, it would be a suitable plan just to draw the leachate collection pipe line along the bottom of valley, and no complicated system needs to be elaborated. Efficiency results from not only the certainness of water collection, but also rapid drainage of leachate because of relatively steep sloping, which generally results in larger land gradient than the minimum necessary design gradient of 1/100. Because basement rocks in hilly and mountainous zones in Sri Lank are principally composed of granitic igneous rocks or their metamorphic rocks, which are generally considered as aquicludes, leakage through slopes can very hardly occur, to make type D the highest reliable one in all landfill types. Because no or just little reinforcement work is needed for preventing leakage, such as excavation and/or mounding to ensure the gradient of the pipe line and the work, the construction can be implemented in the least cost.

G.3 Type of Liner

The problem of pollution of leachate to groundwater and/or surface water is the most important matter to be dealt with in the design of a landfill. The possibility of the pollution depends on not only the efficiency of the leachate collection system, but also some other factors like the depth of water table (groundwater surface) and permeability and depth of strata between landfill and groundwater. The risk of groundwater pollution by leachate from landfill will increase with decrease of water table and increase of permeability of strata.

As the relatively shallow water table in plain and peneplain zone, the risk of groundwater pollution is higher there than that in hilly and mountainous zone. In plain and peneplain zones, top soils are composed of variously kinds of materials, like sand, silt and clay, and mainly originated from alluviation of rivers.

Clay, as its very low permeability (usually as low as 10^{-7} cm/sec or below) is expected in landfill site, in the viewpoint of leachate prevention. However, it is not the common case in Sri Lank that a continuous thick clay layer exists near the ground surface to intercept percolation to groundwater. And even though clayey soil can be found in most part of Sri Lanka, it is usually inhomogeneous with some kinds of soil structure to become relatively permeable. Therefore, natural soil may not be considered as a suitable for the bottom of landfill. Liner work is basically necessary in plain and peneplain zones.

In developed countries like Japan, artificial material such as synthetic rubber or ethylene is usually used for liner. Artificial material is brilliant in its reliability, but ordinarily as expensive as over 5,000 Rs per

square meter. In some cases, cost for liner could take up half or more of the total landfill construction budget. In this study, for example, if the artificial liner were used in Matale landfill, which is designed as about 15,500m^2 in landfill area, the cost for liner would be over 77.5 million Rs.

It is obviously impractical to use this kind of liner for secondary cities in Sri Lanka before the economy get more developing. A practical method for leachate control is a liner system comprising of a leachate drainage and collection layer and barrier layer, as shown in Figure-2. Both layers can use natural materials such as sand and gravel for drainage layer and clay or well compact fine soil for barrier layer.

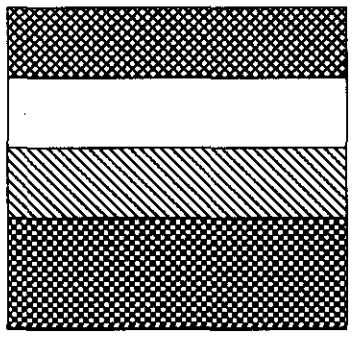

Figure G-2: Composition of a simple liner system

Comparing with plain and peneplain zones, in hilly and mountainous areas the water table is deep but the top soil layer is thin. Leachate form landfill would get basement rock before getting groundwater. Therefore, permeability of basement rock is essential factor for the decision of whether a liner work is necessary.

Based on the "The Geology of Sri Lanka", which was published by National Museums of Sri Lanka Publication, strata in Sri Lanka can be simply divided into 4 formations form the viewpoints of hydrogeology.

Table G-2: Strata Formations and Their Distribution

Classification	Limestone	Crystalline Rocks	Littoral Deposits	Laterite	Total
Area (km^2)	5,153	53,718	4,046	3,898	66,815
Percentage (%)	7.7	80.4	6.0	5.9	100
Topo. Zone	Plain	Hilly & Mountainous	Plain	Various	---
Permeability	High	Low	Various	Various	---

Limestone formation distributes in a belt like zone form the northernmost rejoin of Sri Lanka along coast line. This is the best aquifer in Sri Lanka. Because of the hydrogeology features of limestone, if a

contaminating substance gets its way to the aquifer, it would expand its influence to vast area within short period. Therefore, the prevention of limestone aquifer form contamination of landfill leachate is the most essential matter for landfill design in this area. In case of the clay materials is taken for liner, it would be necessary at least to double the liner structures shown in Figure 2.

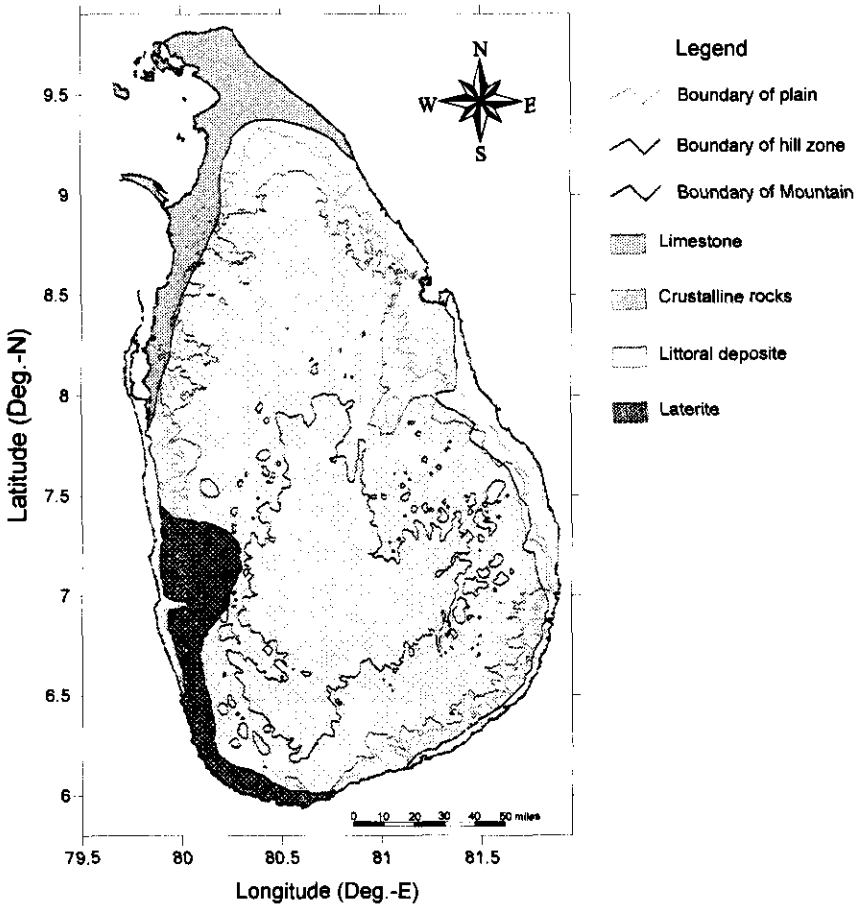

Figure G-3: Main Strata Formations in Sri Lanka

Crystalline rock is a formation with the most extent occurrence to cover almost all the area of hilly zone and mountainous zone in Sri Lank. Main rock type in this formation is granitic igneous rocks and/or granitic gneiss. Fresh granite is a typical impermeable type of rock, but hydraulic conductivity of the rock can increase to10^{-5} cm/sec, when it is weathered. As seen in Nuwala Eliya, Badulla and Mataly, weathering of basement rocks in the hilly zone and mountainous zone in Sri Lanka, is not so strong that the granitic basement rock can be directly used as the liner of a landfill to simplify construction method and ensure the leakage prevention.

Littoral Deposits, as expressed in its formation name, distributes alone coast line. This formation is mainly composed by a series of alluvial sediments. In the major river valleys, thickness of alluvium sediments may vary form a litter more than 10m to several 10 m. Although several clay layers are embedded in the formation, sand and gravel layer in the formation are usually used as an aquifer for

water supply. Therefore, leachate prevention in this area is one of the most important issue for landfill plan. Double structure liner system, therefore, is recommended for this area.

Laterite is a product of the weathering of rocks underlying it. Though a large portion of grains in this formation are clayey soils, the cellular or vesicular nature of typical laterite gives it a high porosity and permeability. Laterite itself can be used as liner material, but a thoroughly compact work is necessary to destroy the cellular and vesicular structure.

G.4 Location Restriction

When a new landfill is being constructed or a lateral expansion being planned, several location restrictions have to be taken into consideration, such as floodplain, fault area, unstable area etc.

In plain and peneplain zones, the problem occurs mainly concerning the floodplain. Generally, no landfill should be constructed within a 100 year floodplain, however, if a landfill can not de addressed any other place rather than a floodplain, a reinforced bund that is higher than the 100 year flood level has to be constructed to enclose the whole landfill area.

On contrast, no influence of floodplain needs to be taken into consideration when a landfill site is selected in hilly and mountainous zones. However, the attention has to be paid to the unstable area that subject to mass movement such as landslides, debris slides and flows, because of relatively steep slope. If a landfill can only be constructed in an unstable area, engineering measures have to be incorporated into the appropriate landfill design to protect the structural integrity of the landfill. This deservedly makes the structure of landfill complicated and the cost for construction increasing.

G.5 Land Utilization Efficiency

The efficiency of land utilization for landfill does not directly depend on geology condition, but landfill type is basically determined with topography condition and the efficiency changes with landfill type.

Within the 4types of landfills, the land use efficiency of trench type landfill is the lowest. This type is widely used in plain zone or peneplain zone, where the water table is relatively shallow. The trench can hardly be dug to a large depth because of the difficulty of operation and high risk of groundwater contamination. Therefore, the amount of solid waste to be interred in a unite land area is small, and then this type can hardly be a good choice for a middle or long term waste disposal plan in a town, unless the population in the town is very small.

In plain and peneplain zones, area landfills are relatively common type. For this type, the efficiency of land use can be improved by increasing the height of landfill, but an area landfill is not expected to be to high because this will cause the difficulty in operation and impact to landscape. The following table

gives a reference of several main components of area landfills with different scales.

Table G-3: Components and Land Use Efficiency of Area Type Landfills

Case #	1	2	3	4	5	6	7	8
Height (m)	5		10		15		20	
Top Area Type	A	B	A	B	A	B	A	B
Bottom Area (ha)	0.5	1.4	0.9	2.1	1.4	2.8	2.0	3.7
Landfill Capacity (1000m^3)	17.6	59.7	52.8	149.4	111.0	274.1	198.1	439.6
Enclosing Bund (m)	240	440	336	536	432	632	528	728
Bund Volume (m^3)	1,560	2,860	2,184	3,484	2,808	4,108	3,432	4,732
Road length (m)	600	1,000	800	1,250	1,000	1,450	1,200	1,600
Main leachate collection pipe L (m)	80 140	130 240	104 188	154 288	128 236	178 336	152 284	202 384
Adjustment Pond Volume (m^3)	230	700	430	1,000	670	1,350	950	1,800
Total Site Area (ha)	1.2	2.8	1.9	3.9	2.7	5	3.7	6.4
Land Use Efficiency (%)	3.5	4.3	5.9	7.19	7.9	9.8	9.9	11.9

Notes : height of enclosing bund is fixed as 3m in the above reference case.
A Type: top area of landfill = 50m X 50m = 2500 m^2
B Type: top area of landfill = 100m X 100m = 10000 m^2

Land Use Efficiency = Landfill Capacity / Landfill Bottom Area

Land use efficiency changes largely according to height and scale of a landfill. Even though he land use efficiency for a large scale landfill with a height of 20m can be about 4 times that of a small scale one, this efficiency usually can not achieved because of height problem and the scale is too big for a secondary city in Sri Lanka.

It has been revealed in the JICA Study that daily waste discharge amount changes from nearly 10 T/day to a little less than 80 T/day in the seven model cities. Taking the volume of covering soil into consideration, the landfill should have capacities from approximately 36,000 to 292,000 cubic meter for a 10 year solid waste disposal plan. Therefore, if an area landfill type is adopted, the landfill should be similar in scale and compositions to cases among #2 to #5 for a small or middle population town, and among #6 to #8 for a middle or large town.

As comparison, in hilly and mountainous zones in Sri Lanka, the land use efficiency of a landfill is usually relatively high. Components and land use efficiency of landfills designed and/or improved in Nuwala Eliya, Matale and Baddula are summarized in the following table.

Table G-4: Land Use Efficiency of Slop and Valley Types Landfills in Model Cities

Case #	9	11	10
Town	Nuwara Eliya	Badulla	Matale
Type of Landfill	Valley	Valley	Slope
Landfill Area (ha)	1.9	1.5	2.3
Landfill Capacity (1000m^3)	191.0	125.0	162.0
Enclosing Bund (m)	No need	No need	93
Liner	No need	No need	Soil compact only
Bund Volume (m^3)	No need	No need	47
Road length (m)	740	670	650
Main leachate collection pipe L (m)	225	300	---
Adjustment Pond Volume (m^3)	450	Weir type	490
Total Site Area (ha)	2.3	---	2.77
Land Use Efficiency (%)	10.1	8.3	7.0

G.6 Conclusion

In selection of landfill site and planning of landfill facilities, it is indispensable to take the topography and geology conditions into consideration. Not only the type, but also the contents and construction method will change with the conditions. What type or components of facilities and how to implement the construction of a landfill, can only be decided after detailed topography and geology survey, however, generally characteristics of landfills for each topography zone has been examined in this section and summarized into the following table.

Table G-5: Characteristics of landfills according to topography zones in Sri Lanka

Zone		Plain	Peneplain	Hilly	Mountainous
Elevation		0-25	25-50	50-200	>200
Distribution		Along coast line	Near coat line	Central to southern part	Southern part
Slop		Minim	Gentle	Steep	Steeper
Geomorphology		Flat	Microrelief	Hilly	Rough terrain
Top Soil Depth		Deeper, over 10 m to several decades m	Deep, generally more than 10 m	Shallow, several m to 10m	More shallow, less than 10 m
Basement Rock Foemation		Mainly Limestone and Littoral Deposits	Crystalline Rocks	Crystalline Rocks	Crystalline Rocks
Water Table Depth		More shallow	Shallow	Deep	Deeper
Permeability of Basement Rock		High	Various	Low	Low
Landfill Type		Area or Trench	All types except Valley	Mainly Slop and Valley	Mainly Slop and Valley
Location Restriction		Flood Plain	Flood & Unstable Area	Unstable Area	Unstable Area
Main Landfill Facilities	Excavation or Mounding	Necessary	Necessary	Necessary for Slop type	Necessary for Slop type
	Enclosing Bund	Generally necessary	Case by case	Generally unnecessary	Generally unnecessary
	Earth drain	Simple	Moderate	Need to be reinforced	Need to be reinforced
	Liner	Generally need to be reinforced	Generally necessary	Simple	Generally unnecessary
	Leachate Collection System	Relatively simple	Simple for Valley Type	Simple for Valley Type	Simple for Valley Type
	Harzad Prevetion Work	Bund Strengthening for flood	Case by case	Generally unnecessary	Generally Unnecessary

Chapter H

Study on the Improvement Project of the Moon Plains Landfill Site in Nuwara Eliya

Summary

The Study on the Solid Waste Management for Secondary Cities in Sri Lanka which targets the improvement of the solid waste problems in all local towns has been implemented by JICA (Japan International Cooperation Agency) since May 2002. The study targets especially seven model towns selected and one of seven towns is Nuwara Eliya Municipal Council. The Study deals with not only the formulation of the improvement plan but also the actual improvement of the condition as a pilot project within the scope of the Study.

The most serious solid waste problem in Nuwara Eliya is poor landfill condition. The present Moon Plains landfill site causes the following serious problems.

a) Many large trees planted are dying due to fire caused by inflammable waste.
b) Leachate generated from waste is deteriorating shallow ground water and could affect the water quality in the Bomuruella reservoir which is located at the downstream side.
c) The number of stray dogs near the site which sometimes attack people is increasing.
d) There are many pests, especially flies, in the landfill site.

The most serious foreseen threat by the present landfill operation is the high possibility of wide forest fire by inflammable waste dumped. However, all of these problems can be eliminated or reduced within the permissible level by the improvement of it to the sanitary method.

The Study has found that the improvement project of the Moon Plains existing Landfill Site in Nuwara Eliya would be excellent not only for Nuwara Eliya but also for the whole country because of the following reasons.

a) The social and natural site condition is idealistic for the sanitary landfill site. There are no existing neighbourhoods and very good valley topography with very low permeable ground.

b) The estimated acquired landfill capacity is sufficient for receiving all waste from Nuwara Eliya for 20 years.

c) Not only the investment but also the operation and maintenance cost will be the least with the sanitary landfill due to its very suitable natural and social conditions.

d) The Moon Plains Landfill Site will be the model sanitary landfill site in Sri Lanka where people can experience with the sanitary landfill method after the improvement.

Therefore, the implementation of the improvement project is highly recommended not only for Nuwara Eliya but also for the whole country.

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H.1.1 Objectives and justification of the proposed project

The objective of project is to improve the Moon Plains Existing Landfill Site in Nuwara Eliya.

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Therefore, the implementation of the improvement project is highly recommended not only for Nuwara Eliya but also for the whole country.

H.1.2 Objective of the IEE report

Before the implementation of improvement work at the Moon Plains Existing Landfill Site, key environmental impacts, the measures proposed to mitigate the environmental impacts and monitoring programme shall be done as Initial Environmental Examination.

H.1.3 Background to the proposed project

The Study on the Solid Waste Management for Secondary Cities in Sri Lanka which targets the improvement of the solid waste problems in all local towns has been implemented by JICA (Japan International Cooperation Agency) since May 2002. The study targets especially seven model towns selected and one of seven towns is Nuwara Eliya Municipal Council. The Study deals with not only the formulation of the improvement plan but also the actual improvement of the condition as a pilot project within the scope of the Study.

H.1.4 Extent and scope of the project

The extent and scope of the scope of the project consists of three items as follows.

- Improvement of Moon Plain Existing Landfill site at Nuwara Eliya
- Training of proper operation and maintenance for the sanitary landfill
- Establishment of monitoring committee for the sanitary landfill operation

H.1.5 Brief outline of the methodologies and technologies adopted in IEE report

The methodologies and technologies adopted in IEE report are as follows,

- Topography survey: to identify the site of Moon Plain Existing Landfill Site and catchments area etc.
- Geological survey: to identify the geological condition such as clay layer, bed rock and ground water level at the site.
- Water quality analyses: to identify the quality of ground water and surface water at the site.

H.1.6 Main beneficiaries of the project and expected socio-economic effects

Main beneficiaries of the project and expected socio-economic effects are described at "1.1 Objectives and justification of the proposed project"

H.1.7 Policy

Policy, Legal and Administrative frame work with reference to Solid Waste Management.

The responsibility of collection, transport and disposal of solid waste falls within the purview of Local Authorities in Sri Lanka.

Municipal Council

According to the Municipal Council Ordinance and By laws, Section 129, 130 and 131 etc., the function of Solid Waste Management in the Municipal City falls within the legal Provisions of the Municipal Council.

Other than the above enactment, the following ordinances and the Act also provides legal Provision for the Solid Waste Management in Sri Lanka.

1. Nuisances Ordinance
2. Housing and Town Improvement Ordinance
3. Urban Development Authority law
4. Central Environment Authority law

H.1.8 Approvals

Approval/ Permits should have to obtained from the land owner, The Forest Conservator General.

- With reference to THE NATIONAL ENVIRONMENT ACT, No. 47 OF 1980 Order Under Section 23Z it is necessary to grant approval by the Central Environment Authority.
- The proposed "Improvement of Moon plains Municipal Solid Waste Disposal Facility" is not exceed 100 tone capacity neither handle/Treat Toxic nor Hazardous Waste. (Described at (18) *Disposal of **Waste***). And,

- With respect to Part II , The project is located wholly or partly within 100 m from the boundaries of a land that declared under The National Heritage Wilderness Act No. 3 of 1988, the Forest Ordinance (Chapter 451).