Health Care Wastewater Management in Sri Lanka

CORDAID 312/10085A

CORDAID Tsunami Reconstruction 5

Project Report

Authors: G. Anand & V. Post

Editors: V. Post, I. Haenen

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WASTE advisers on urban environment and development

Nieuwehaven 201
2801 CW Gouda e-
the Netherlands

fax:+31 182 550313
mail: office@waste.nl
website: http://www.waste.nl

Cover photo: Photo of partially repaired Hambantota Base Hospital wastewater treatment plant, Hambantota November 2007, Sri Lanka

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LIST OF ACRONYMS

AGD	Assistant Government Division
AIDS	Acquired Immune Deficiency Syndrome
BOD_5	Biochemical Oxygen Demand, 5 days at 20^oC
CEA	Central Environment Authority
COD	Chemical Oxygen Demand
CTF	Common Treatment Facility
CWL	Constructed wet land
^oC	Degree Celsius
d	Day(s)
DDPHS	Deputy Director Provincial Health Services
DGHS	Director General Health Services
Dia	Diameter
D.S.	Dry Solids
d.w.	Dry weight
EPL	Environmental Protection License
ETP	Effluent Treatment Plant
ft	Foot
GP	General Practitioners
h	Hour(s)
H	Height
HCl	Hydrochloric acid
HCWL	Horizontal flow constructed wetland
HCWM Cell	Health Care Waste Management Cell
HDPE	High density polyethylene
HIV	Human immunodeficiency virus
HP	Horse power
ISBR	Integrated Settler cum Baffled Reactor
kg	Kilogram
kWh	Kilowatt hour
LDPE	Low density polyethylene
l/d	Litre(s) per day
l/s	Litre(s) per second
m	Meter(s)
m^3	Cubic meter (1000 litres)
mg/l	Milligrams per litre
min	Minute(s)
mm	Millimeter
MOH	Medical Officer of Health
N	Nitrogen
NEA	National Environment Act
No	Number
NWS&DB	National Water Supply & Drainage Board
OR	Operation Room
P	Phosphates
PCC	Plain Cement Concrete
pH	Negative logarithm of hydrogen ion concentration
PHMW	Peripheral Health Mid Wives

PHO	Provincial Health Officer
PVC	Polyvinyl Chloride
RCC	Reinforced Cement Concrete
s	Second(s)
SLR	Sri Lanka Rupees
Sp	specie
SS	Suspended Solids
t	Tonne (1000 kg)
TCL	Tropical Chloride of Lime
ToT	Training of Trainers
TSS	Total Suspended Solids
UAF	Upflow anaerobic filter
UNICEF	United Nations Children's Fund
UNIDO	United Nations Industrial Development Organisation
UNOPS	United Nations Office for Project Services
W	watt(s)
WHO	World Health Organisation

FOREWORD

The project started as a response to the disaster that struck Sri Lanka on the 26th of December 2004. Based on request on the Central Environment Authority an assessment was made of the solid waste situation caused by the Tsunami in the coastal zones of Sri Lanka. The first assessment – partially supported by CORDAID – resulted amongst others in debris management guidelines issued by the Central Environment Authority end of January 2005.

In the course of 2005 it became clear that many organisations quite rightly at that time focused on immediate relief efforts, but much less attention was given to longer term reconstruction efforts. Waste management systems that were not very well functioning before the Tsunami had collapsed and in relief it was noticed as an important area so as to prevent outbreak of diseases and other human health related areas, but hardly ever as a reconstruction area. At the same time there was a widely voiced demand for show-how projects as there was very little practical experience as to how things could be improved.

This was the background to the current project. As much as possible show how projects and initiatives would be undertaken that would not only target local needs but also be essential building blocks of reconstruction efforts. As needs were so high, a relatively large number of projects were identified by local counterparts. Our aim was therefore to assist these counterparts with technically correct guidance that would make their interventions sustainable in all aspects, institutional, financial etc.

As the lack of knowledge and expertise about waste management was one of the striking factors, it was also deemed critical that efforts would be undertaken to share knowledge and disseminate whatever projects were implemented to a much wider audience. This is the background to this series of project reports.

The following areas were tackled and similar reports are available on each of these subjects: sanitation management; hospital liquid waste management; hospital solid waste management; solid waste management; wastewater management; faecal sludge management; debris management and composting.

By no means these are the last words that can be said about any of these subjects. In the case of health care waste management, final disposal remains a critical issue, in case of hospital waste water management, we believe we have made an appropriate design for a waste water treatment plant after a very elaborate consultative process with the client, but this still ahs to be built, in the case of debris management, the delay between project conception and the final approval proved too long, by then most of the debris in Kalmunai had disappeared and in Hambantota it was only those partially damaged buildings that were still standing that constituted debris, so it has become much more of a theoretical exercise than what we would have liked. Yet we do believe it is important to document what can be done with debris in case a next disaster strikes. Solid waste management is very diverse, form plastic recycling (two projects) to landfill improvement, solid waste management policy and strategy advocacy, setting up a national platform, feasibility studies for gasification of waste (and once it turned out to be not viable) stopping this initiative etc. Solutions for faecal sludge management are still a priority for organisations working with internally displaced persons in the Northern and Eastern Provinces of Sri Lanka (though from an environmental point of view we would suggest that it should be the entire country), we believe we have managed to significantly improve an existing design for a faecal sludge treatment system. Yet till today, the UN agency that wishes to implement this together with the municipal council of Kalmunai are still struggling to actually implement it. In case of Hambantota - as there is an existing site and additional VNG funds - the implementation of a different design is just beyond the current project period.

Valentin Post, December 2007

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WASTE would like to acknowledge the support of Energy Forum (Asoka Abeygunawardene and Chinthaka Jayaratne in particular) for facilitating the logistics of the Health Care Waste Water Management. Gratitude also goes to Dr. Hemanth, for his support in the health care waste situation and training needs assessment, to Dr. D. Gopinath, Dr. Pruthvish and Dr. Kumar for providing the training on site, and for establishing valuable contact to take the project to the next level, and for preparing the proceedings and reports.

Dr. Kumar is the Principle and Dean of MS Ramaiah Medical College, Bangalore and Group of Hospitals. Dr. Prutvish is Professor of Community Medicine and Director Health Care Waste Management Cell, Department of Community Medicine, MS Ramaiah Medical College, Bangalore. Dr. Hemanth is Lecturer of Community Medicine, and coordinator Health Care Waste Management Cell, MS Ramaiah Medical College, Bangalore.

Additionally, Dr. Pruthvish and Gopinath assessed which of the Sri Lanka health care institutions would be most suitable and appropriate as counterpart organisation. Following their assessment Colombo Medical College which falls under the University of Colombo were recommended and joint training in health care waste management of medical staff in Hambantota Base Hospital resulted. Colombo Medical College has shown keen interest in curriculum development in health care waste management. As this is a longer term objective and it falls outside the project period of Tsunami reconstruction, WASTE has identified additional resources for the national curriculum development in health care waste management in Sri Lanka.

Also, I would like to acknowledge contribution of Mr. Malaka Dasanayaka Southern Province Coordinator Ministry of Health who extended much appreciated support during the entire project.

A final word of thanks to our friends from CORDAID (Ilse du Pied, Christine Fenenga, Gemma Claessen, Bernadette Hermans, Astrid van den Berg and Hans Scheen). All have been actively involved at one stage or the other from preparatory assistance, to project design and / or have been a continuous source of support during the entire implementation.

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CHAPTER 1 INTRODUCTION TO CORDAID PROJECT & THIS DOCUMENT

1.1 Background of the Project

After the Tsunami struck Sri Lanka in December 2004, waste management systems virtually collapsed and waste was disposed of indiscriminately. The local authorities were faced with a post-tsunami situation which was beyond their resources. This resulted in unplanned coastal zone dumping practices, poor urban environment planning, substandard water management and sanitation practices and a general waste of resources.

The project "Rapid implementation of community based short and middle term measures to improve the functioning of solid waste management in Tsunami affected areas of Ampara and Hambantota districts" was approved by CORDAID on March 1st 2006.

As of such, the project team arranged interventions in the following thematic areas:

- Health care solid waste management (Report series 1);
- Faecal sludge management (Report series 2);
- Master Composting (Report series 3);
- Solid waste management: Policy and Strategy (Report series 4);
- Health care liquid waste management (Report series 5);
- Plastic recycling (Report series 6), and
- Debris management (Report series 7).

1.2 Objective of this document & intended audience

The project team felt a strong need to express and share the lessons learned from the project interventions. So the purpose of this document is to provide thematic and practical knowledge on improving solid waste management and sanitation systems in reconstruction efforts. However, we also see that this document has value in 'ordinary' development initiatives that aim on improving these environmental management aspects. Note that this document is not intended to be a guiding manual for safe health care waste management.

WASTE has prepared a similar document for each of the project interventions described in the first paragraph of this Chapter. The documents can be obtained electronically from the website www.waste.nl.

1.3 Terminology

This document uses the terms health care waste water to refer to waste water generated by health care institutions. Health care is used instead of hospitals as small health are units also generate waste water and the treatment thereof is not much different from that of hospitals.

1.4 ISWM methodology for structure

In this document, the project team has opted to use the Integrated Sustainable Waste Management (ISWM) methodology to provide a structure for presenting, and analysing

information.[1] The ISWM methodology is a tool that supports to describe and analyse any waste management system in a systematic way. The methodology describes three parts: identifying relevant stakeholders, waste system elements (generation, collection, transport, storage, treatment, disposal), waste system aspects (technical, institutional/political, legal, environmental/health, socio-cultural, and financial/economic).

1.5 Structure of this document

This document is structured as follows:

Chapter 2 will touch briefly upon the risks associated with the management of waste water in hospitals, and the need for safe health care waste water management, in general, and more specifically, in post-disaster or reconstruction areas. Also, it will broadly explain some relevant steps in health care waste water management, based on the ISWM methodology.

Chapter 3 describes the project objectives and provides an overview of the activities that representatives of the project team carried out.

Chapter 4 gives the situation in Kalmunai Base Hospital (a separate design document has been prepared and this has been forwarded to the authorities for clearance). Chapter 5 gives the story of Hambantota Base Hospital. Chapter 6 describes the treatment plant at Ashroff Memorial Hospital. Chapter 7 gives a set of conclusions drawn from the experiences from the and gives advice on how to follow-up.

[1] The ISWM Methodology has been developed by WASTE. The Manual 'Putting ISWM into Practice' can be obtained from the WASTE website at http://www.waste.nl/content/download/561/4346/file/ISWM%20ass%20eng%20screen.pdf

CHAPTER 2 HEALTH CARE WASTE WATER MANAGEMENT

2.1 Why does health care waste water require safe management?

The disposal of waste water originating from health care establishments is likely to have effect on the health and human well being, the environment (air, water, soil, animals, plants, and land), issues relating to the public security and order. Nevertheless experience has proven that, waste water originating from health care establishments, when properly managed, generally pose no greater risks than other waste water. This applies to waste water from operating theatres also.

The safe management of health care waste water is essential for community and environmental health. It is also important that, irrespective of technologies used for treatment and disposal, the standards for the protection of the environment and human health are uniform across all the health care establishments. This in turn ensures a more viable and efficient health sector. However, it should be noted that in many countries, the national authorities, in addition to health industry, is an active participant in health care, either providing services or paying for them. Additionally, the lack of resources or of experience in developing standards may be significant factors affecting the capacity to treat biomedical and healthcare waste water.

Introduction of improved solutions for the segregation of waste water at source, within health care facilities can result in reduced amounts of waste water requiring special treatment, and therefore in reduced waste water treatment costs. In addition, simple technologies have become available to disinfect and treat biomedical and healthcare waste water so that they finally can be managed safely.

2.2 Why health care waste water management in Post-Tsunami reconstruction?

The Tsunami literally swept away the lives of thousands of people living in Sri Lanka. But in addition, it paralysed the waste management infrastructure that was already facing challenges towards safe management. And moreover, the victims and injured people further stressed the capability to manage health care waste and waste water safely.

Safe health care waste water management is always a must-have, and the Tsunami further stressed this essential need. When reconstructing (waste management) infrastructure in densely populated areas, health care waste water management therefore deserves its share of attention.

Risks associated with improper health care waste water management are considered high, in terms of environment, but also in terms of occupational health. It not only concerns those that could be in direct contact with health care waste water – that is all hospital staff and patients – but also those living in the immediate vicinity. Chances of diseases spreading from untreated health care waste water are high as the volumes are relatively large and the waste water is discharged untreated in or near residential areas. In addition to this, most of the hospitals have a relatively high number of residential staff who are [likely to be] directly affected by the discharge of this untreated wastewater.

2.3 What constitutes health care waste water management?

The project focuses specifically on improving health care waste management in hospitals in Sri Lanka. Health care waste water, in theory, travels among the same **elements** of waste management system as solid waste management. This means that, at a certain stage, specific substances 'become' waste water. This is referred to as **generation**. When someone disposes waste water, there should be a receptacle for the specific waste water for **storage**. Usually there is a need to get the waste away from the location of generation – **collection** is then a next step, together with **transport** to get the waste water, mostly by pipelines to a secondary storage or collection place, or more often directly to a **treatment** plant where the waste water is treated so that it renders no risk to people and environment. This is a very basic explanation of how health care waste water should move from generation to treatment.

However, when managing hospital waste, it is important to consider each of these steps. Table 1 provides a list of important aspects.

Table 1 System elements in health care waste water management

Waste system element	Relevant steps in safe health care waste water management
Generation	♦ Identification of waste waters, quantity and quality ♦ (Possible) segregation at source based on categories o Black water (sewage) o Grey water (sullage)
Collection	♦ Septic tanks, grease traps etc.
Transport	♦ Pipes / gulley sucker
Storage	♦ (Possible) collection / equalisation tank
Treatment /disposal	♦ Appropriate treatment – aerobic and / or anaerobic ♦ Appropriate disposal

The success factor of health care wastewater management system elements is depending on a committed and educated staff, that fully understands the relevance of each of the steps.

2.4 Key Issues in Health Care Waste Management in the South

This section briefly describes some of the key issues in health care waste water management. The section is structured based the ISWM aspects.

2.4.1 Health and environmental issues

Exposure to untreated health care waste water causes a risk to a broad range of people, directly and indirectly. Directly it includes hospital staff, including residential staff, working in these health care institutions; patients and their attendees; and the public in general, when health care waste water comes in contact with the water table or water streams.

Health care waste water is voluminous (in each of the three target hospitals in Sri Lanka quantities range from 175,000 – 250,000 litres per day). This is much beyond the absorptive capacities of the receiving environment. Hence, it puts many people unnecessary at risk if no proper precaution is taken in the form of waste water treatment.

The quality of health care waste water has to be taken into consideration too.[2] Hospitals use a variety of chemical substances such as pharmaceuticals, radionuclides, solvents and disinfectants for medical purposes as diagnostics, disinfections and research. After application, some of these substances and excreted non-metabolized drugs by the patients enter into the hospital effluents, which may or may not be treated. The contact of hospital pollutants with aquatic ecosystems leads to a risk directly related to the existence of hazardous substances that could have potential negative effects on biological balance of natural environments. Risk is the probability of appearance of toxic effects after organism's exposure to hazardous substances. The most frequent contaminants in hospital wastewater are: viruses and pathogenic bacteria (some of them are antibacterial resistant characters), molecules from unused and excreted non-metabolized pharmaceuticals, organ halogen compounds, such as the halogenated organic compounds absorbable on activated carbon (AOX[3]), radio-isotopes.

Numerous studies have shown that a multitude of drugs, some of them with toxic, carcinogenic, endocrine or resistance promoting effects, are present in different aquatic systems. Main sources for pharmaceuticals and their active metabolites are excretions of patients and animals undergoing medical treatment with these drugs. Especially hospital waste water may contain significant amounts of hazardous pharmaceuticals, approximate 1 mg/l of antimicrobial and 0.01 to 0.1 mg/l of cytotoxic drugs.

In addition, laboratory tests for biodegradability as well as measurements of numerous antibiotic and cytotoxic drugs in the influent and effluent of sewage plants have shown that the majority of the investigated compounds is persistent and consequently may reach the surface water.

Table 2 estimates of the levels of pollutants in hospital and domestic wastewater:

Table 2 Estimates of pollutants levels in hospital and domestic wastewater

Pollutant	Hospital wastewater	Domestic wastewater
Total antibiotics load (µg/l)	---	50
Individual antibiotic concentration (µg/l)	2-83 measured; 5-50 estimated	<LOD – 0.6, -1.7, -6, -51
Antibiotic resistant propagates (N/l)	-[1]	-[1]
Individual therapeutics conceniration (µg/l)	5 – 50 estimated	< LOD – 5.7
Iodinated contrast media (µg/l)	---	< LOD – 6.6
Estrogens (ng E2-eq/l)	> 100[2]	20 – 100

LOD: limit of detection; 1: no data on total amount of antibiotic resistant propagules available; 2: estrogen concentration is dependent on the number of pregnant women present in the hospital; --- means data not available.

Hospital wastewaters generally contain up to 100 times higher levels of antibiotics. Individual antibiotic concentrations were measured ranging from 0.1 to 100 µg/l, which are considerably higher than 0.1 to 1ug/l measured in domestic wastewater. About 10,000 tonne of antibiotics

[2] Information below is obtained from the final report of Guo Longbo, Health Care Waste Management, Intern WASTE /CORDAID March – July 2007

[3] ***AOX:*** AOX (absorbable organic halogen)-concentration of hospital waste-water varies between 0.41mg/l and 0.94 mg/l. AOX up to 10mg/L were also proved in the effluents of the hospitalization services of a university hospital center. AOX is produced by chlorine and organic matter in the water. The major mass carriers for the AOX in hospital effluents are most likely iodized X-ray contrast media, solvents, disinfectants, cleaners and drugs containing chlorine.(In general, the maximum contribution of drugs to the AOX is not above 11%; the AOX concentration in the urine of patients not treated with drugs is very low. It is normally between 0.001 and 0.2 mg/l)

are consumed annually in Europe, of which roughly half are used in human medicine; the other half is used for veterinary purposes as a therapy or as a growth promoter. Of the antibiotics used for human purposes, 26% are used in hospitals. Antibiotics and their metabolites end up in the WWTP, since they are excreted with urine and faeces in wastewater. Total antibiotic load of municipal wastewater (which contains the contribution of hospitals) is estimated at 50 mg/l. This concentration takes into account outdated medicaments or remainders which are disposed of in household drains. These account for up to 20–40% of the total antibiotics.

2.4.2 Technical issues

As can be seen from the above section health care waste water present some real technical challenges. Table 3 below[4] gives an overview of some of the (sometimes advanced (ozonation, UV photolysis and reverse osmosis)) treatment technologies that are applied for health care waste water treatment and their effects on some of its characteristics.

Table 3 Removal characteristics of different hospital related pollutants by various processes

	Natural attenuation	Activated sludge	PAC/ GAC	Ozonation	Ultraviolet photolysis	Reverse osmosis
Antibiotics	Poor	None-poor (67%)	50-99%	95%	50-80%	90%[1]
Antibiotic resistant progagules	Poor	1,2, 3i log units	n.a.	-	-	n.a.
Therapeutics	None-poor	7-90%[2]	90-99%[3]	Poor to 95%[4]	$t_{1/2}$=2.4-100d	50 to 90%[5]
Iodinated contrast media	None[6]	None-85%[6]	-	Poor- 14 to 80%	$t_{1/2}$=5-10h for metabolite	-
Estrogens	Poor	65-99%	99.8%	80%	-	95-99%

1: 99 and 99.9% reduction can be reached with two stage (resp. three stage) reverse osmosis units.
2: Low removal efficiencies for more polar compounds.
3: Specific throughput of 70m^3/kg sorbent, except for diclofenac (15–20m^3/kg sorbent).
4: Not much information available on by-product formation.
5: Lowest removal obtained at low feed concentrations (100mg/l) and for non-charged compounds.
6: Stable transformation products accumulate; experiments were conducted at environmentally irrelevant concentrations.
PAC: powdered activated carbon; GAC: granular activated carbon; n.a.: not applicable; –: not available.

Some other technologies also have been applied to health care waste waters, most notably constructed wetlands (horizontal flow). In Nepal a two staged constructed wetland was designed and constructed in Nepal to treat 20 m^3/d of wastewater. It was constructed within 3 months and has been in operation since July 1997. The total cost of the system including sewer lines was US$ 27,000 whereas the cost of the constructed wetland was only US$ 16,400. The system showed a high treatment efficiency throughout the one-year monitoring period. Median load elimination rates were for TSS: 97 to 99%; BOD_5: 97 to 99%; COD: 94 to 97%; NH4–N 80 to 99%; PO4–P: 5 to 69%; Total Coliform: 99.87 to 99.999% (3 – 5 log steps); E.coli: 99.98% to 99.999% (3 – 5 log steps); and Streptococcus: 99.3 to 99.99% (2 – 4 log steps).

Research data from the Netherlands indicate that constructed wetlands do also have an effect on breaking down of antibiotics.

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[4] Information below is obtained from the final report of Guo Longbo, Health Care Waste Management, Intern WASTE /CORDAID March – July 2007

Usually, problems emerge with safe health care waste management when some of the waste system elements are disregarded. In order for the system to work effective all system steps need to be in place – this is true for all waste management systems. In the case of health care waste water systems the most important is that all systems need to be maintained and operated properly.

2.4.3 Institutional issues

Internally, responsibilities need to be clear for all staff involved, and they know the consequences of mismanagement of health care waste water. At the same time, it is necessary that the issues of health care waste water management are included in educational courses, so to ensure that newly trained staff are aware of the reasons for safe health care waste water management. In this respect, there is little support infrastructure in the country as environmental management is very much in its infancy. There are very few waste water treatment plants operational in the entire country and environmental engineering is part of the technical universities main subject areas. There are only few waste water engineering companies operating in Sri Lanka and most are engaged in primary treatment for industries.

2.4.4 Legal issues

Externally, the situation is somewhat complex as the Central Environment Authority has to give permission for waste water treatment systems (license), in the case of health care waste water permission is also to be obtained from the Ministry of Health. At present health care waste water has to conform to standards as applicable to domestic waste water. Hence, it does not consider some of the more difficult parameters present in hospital waste water. This can be considered a pragmatic approach. First achieve the simpler standards and in the next stage identify what can be done with respect to the more difficult ones (in the case of Kalmunai Base Hospital through constructed wetlands, we are trying to tackle both).

It is important that politicians also recognise the relevance of separating hazardous waste streams from ordinary, household and commercial waste streams, and to set requirements for treatment options.

2.4.5 Financial issues

It is often claimed that equipment for safe treatment of health care water waste comes with a price. While not denying that there are various treatment systems that require substantial investments, there are also lower-cost waste water treatment options for hospitals that operate with lower budgets. At present most of the hospitals if they have treatment system are not able to operate it properly, thereby they are not able to achieve results as per standard.

Operation and maintenance of the treatment plants is in some cases contracted to outside parties. However, funding allocation for operation and maintenance is from the Ministry of Health and often hospital authorities are not really aware about the different technologies and the requirements of each (e.g. the case that most aerobic systems need to be operated 24 hours a day, 7 days a week with the corresponding electricity bills is news to most).

2.4.6 Socio-cultural issues

Lastly, the socio-cultural aspects of waste water in general, and health care waste water specifically, can have a large effect on the system. Often it is not seen as being part of the

health care system and is handled by the not highly regarded maintenance staff. The fact that management in none of the hospitals visited by the project team both inside and outside the project area was able to hand over design of treatment plant is just underlining the disregard in which waste water treatment is generally held.

CHAPTER 3 PROJECT OBJECTIVES & OVERVIEW ACTIVITIES

3.1 Need for health care waste water management in reconstruction

3.1.1 Why health care waste water management in post-Tsunami reconstruction?

Immediately after the Tsunami hit the island of Sri Lanka, the affected communities were first in need for safe shelter, medical care, food provisions, and all other basic needs necessary for survival. After the immediate needs where (partially) fulfilled, the reconstruction activities began, in the form of repair or rebuilding infrastructure such as roads, housing, and supporting communities with livelihoods. Rebuilding waste management and sanitation infrastructure were frequently overlooked in the rebuilding process, despite the common understanding that safe management of both are very important for human health, and for environment in general.

Safe hospital or health care waste water management should also be part of reconstruction, as the effects of these materials on human health and environment can be very serious. The characteristics of health care waste water are especially believed to be dangerous as well as high in volume. If disposed uncontrolled in an area that shares the features of high groundwater tables and high population density, the situation could become very adverse indeed.

At the same time, the daily practice of health care waste water management should leave as little risk possible to those who are directly related to it – maintenance and medical staff, but also patients and nearby residents.

3.2 Project objectives

The project objectives are to:

- ♦ review health care waste management data related to Tsunami in Sri Lanka, particularly in the identified districts/ project areas;
- ♦ analyse the health care waste management situation in Sri Lanka;
- ♦ identify training needs for sound and effective health care waste management, at different levels;
- ♦ prepare the health care waste management training programme;
- ♦ deliver the health care waste management training programme;
- ♦ identify and implement in a consultative manner options for final disposal (biogas and others)

3.2.1 SMART objectives and results

Table 4 provides the overall objective and result of the project. Annex 1 provides the Logical Framework related to Healthcare wastewater management.

Table 4 Overall objective and result

Overall Objective:	In target areas, safe management and disposal of medical and sanitation waste, focus on increased amount of waste due to Tsunami.
The overall result is:	There is an improvement compared to the assessment data survey in the health, and environment status in project areas of Ampara and Hambantota districts by June 2007 directly benefiting 10,000 people and indirectly 20,000 people.

3.2.2 Overview of activities

This document is mainly based on information from the field. Table 5 gives a broad impression of important moments and activities of the project.

Table 5 Overview project activities related to health care waste water management

Time	Activity	Carried out by
March 2006	♦ Cordaid approves project proposal prepared by WASTE – start of project	
Nov- Dec 2006	♦ Situation analysis in three hospitals in Sri Lanka	Mr. G. Anand & Dr. Corea
May 2007	♦ Review treatment plant Ashroff, Hambantota Base Hospital, and preparation of three designs for Kalmunai Base Hopital	Mr. G. Anand
June – July 2007	♦ Presentation findings to hospitals	Chinthaka Jayarathne
October 2007	♦ Submission of project report treatment system Kalmunai Base Hospital to CORDAID for support	WASTE
Nov 2007	♦ On site fine-tuning final design selected by management Base Hospital Kalmunai and new recommendations Hambantota Base	Mr. G. Anand
December 2007	♦ Final design	Mr. G. Anand

CHAPTER 4 DESIGN KALMUNAI BASE HOSPITAL

The hospital management has repeatedly stated that their top priority is to treat their effluents to acceptable standards. Designing an effluent treatment plant is a specialised affair, yet it should as much as possible involve clients including their needs, wishes and desires.

4.1 Introduction Kalmunai Base Hospital

This is a very old hospital which has undergone expansion without any planning for over decades. The population to which this hospital caters is high and taking into consideration the same, remodelling the whole complex is planned.

Certain buildings are proposed to be demolished and many new buildings will be built to accommodate the increased requirements in infrastructure. At present, the hospital does not have any proper wastewater treatment or disposal system. Each block was provided with a soakage pit initially.

The relatively new buildings are provided with septic tanks and soakage pits. However, many of the septic tanks are very old and have weak structures and hence functioning as seepage/soakage pits. The details of the existing buildings with location of the septic tanks and soakage pits are given separately as the levels are currently taken.

The expansion work has already commenced and the work on Outpatient Section, Gynaecology and Neonatology sections are nearing completion.

There is a utility and services of approximately 1200 m^2 area marked in the future plan. As for the effluent treatment plant, the area earmarked Utility/Service area in the new layout plan is to be utilised. Other services in the area will be solid waste management, generators etc. The storm water drain runs through this area. The detailed site plan of the hospital after expansion according to the proposal for expansion is given in Annex 2. The current and proposed future distribution of beds in the in patient section is as in Table 6.

Table 6 Current and future distribution of beds

Sl. No.	Department	No. of Beds	
		Current	Future
1.	Gynaecology	30	100
2.	Paediatrics	30	60
3.	Neonatology	0	30
4.	Paediatric Medicine	30	30
5.	Orthopaedics	30	60
6.	Nephrology	30	30
7.	Gastro Entrology	30	60
8.	Cardiology	30	30
9.	ENT	30	60
10.	General Surgery/ Medicine	60	120
TOTAL		300	580

The average number of outpatients in the hospital is currently 300/d and the maximum is 600/d. The expansion planned will increase the number of in patients to 580 and the outpatients expected are 1000/d.

The Sri Lankan average figures for hospital wastewater generation are not known. Since the conditions in Sri Lanka and India are similar, Indian figures are used for calculation of flow rates. The calculation based on Indian figures is given below.

Total No. of beds in the complex	580
Max. wastewater generated/ bed	355 l/d
No. of outpatients	1000
Max. wastewater generated/outpatient	30 l/d
No. of resident staff	25
Max. wastewater generated/residents	135 l/d
No. of non resident staff	60
Max. Wastewater generated/non-res	15 l/d
Max. Wastewater generated	240.175 m^3/d
Say	**250 m^3/d**

Based on the future requirements, the capacity of the ETP required will be 250 m^3/d.

4.2 Quality of waste water

Similarly the quality of the raw hospital wastewater is not known in Sri Lanka. In view of the similar conditions, Indian data is used, with an average BOD load of 350 mg/l and an average SS load of 200 mg/l.

The quality of the treated effluent will be as per Sri Lanka standards specified by the Central Environment Authority. Discharge standards to inland surface waters are given in Table 7 below.

Table 7 Applicable discharge standards

Determinant	**Tolerance limit**
Total Suspended Solids mg/l, max	50
Particle size of total suspended solids	Shall pass sieve of aperture size 850 micro m
pH value at ambient temperature	6.0 to 8.5
Biochemical Oxygen Demand-BOD_5 In 5 days at 20 ^oC, mg/l, max	30
Temperature of discharge	Shall not exceed 40 ^oC in any section of the stream within 15 m downstream from the effluent outlet
Oils and greases, mg/l, max	10
Phenolic Compounds (as phenolic OH) mg/l, max	1.0
Cyanides as (CN) mg/l, max	0.2
Sulfides, mg/l, max	2.0
Fluorides, mg/l, max	2.0
Total residual chlorine mg/l, max	1.0
Arsenic, mg/l, max	0.2

Determinant	Tolerance limit
Cadmium total, mg/l, max	0.1
Chromium total, mg/l, max	0.1
Copper total, mg/l, max	3.0
Lead, total, mg/l, max	0.1
Mercury total, mg/l, max	0.0005
Nickel total, mg/l, max	3.0
Selenium total, mg/l, mg	0.05
Zinc total, mg/l, max	5.0
Ammoniacal nitrogen, mg/l, max	50.0
Pesticides	Undetectable
Radio active material (a) Alpha emitters micro curie/ml (b) Beta-emitters micro curie/ml	 10^{-7} 10^{-8}
Chemical Oxygen Demand (COD), mg/l, max.	250

Note I: All effort should be made to remove colour and unpleasant odour as far as practicable.
Note II: These values are based on dilution of effluents by at least eight volumes of clean receiving water. If the dilution is below eight times, the permissible limits are multiplied by one-eighth of the actual dilution.
Note III: The above mentioned General Standards cease to apply with regard to a particular industry specific standards are notified for that industry.

Various technology options are available for Effluent Treatment in this hospital.

Depending on the conditions in which the ETP will be operated an appropriate process has to be selected. To achieve the standards a minimum two stage treatment needs to be selected (primary and secondary), though a polishing treatment (tertiary) may be required too. Various technology options are available for Effluent Treatment in this hospital. The options include:

1. Natural Processes like Constructed Wetland (CWL)
2. Aerobic processes like Activated sludge Process, Carousel Ditch, Submerged Aerobic Fixed Film Reactor, Fluidised Aerobic Bed Reactor etc
3. Anaerobic processes

If constructed wetland is used as main (secondary) treatment, it requires an area that far exceeds the area available at Kalmunai Base Hospital. Hence, constructed wetland can not be considered as a main treatment option, but can be considered only as a final (tertiary) treatment option. There are various options open for selection while considering aerobic processes. They include:

- Activated Sludge Process (ASP) and its known variants
- Rotating Biological Contactor (also known as Bio disk) (RBC)
- Submerged Aerobic Fixed Film Reactor (SAFF)
- Submerged Packed Bed Reactor (SPBR)
- Fluidised Aerobic Bed Reactor (FAB)

In the options listed above, the Activated Sludge Process is the only suspended system in which recirculation of sludge can ensure adequacy of Mixed Liquor Suspended Solids (MLSS). One of the characteristics of hospital wastewater is its relatively high presence of several bacteriostats and bactericides. These will have a negative effect on bacterial growth and thus on treatment of the effluent. The MLSS levels are extremely difficult to adjust in attached growth system, but through appropriate recycling can be adjusted in an ASP system. So, although Activated Sludge Process requires larger land area and consumes more power than other aerobic options, it is the most flexible of the processes particularly in a hospital

environment and hence selected. If the Kalmunai Base Hospital will face a situation like the Hambantota Base Hospital, which though having a well designed treatment plant, did not have sufficient funds for paying for its operation and maintenance. If in Kalmunai payment for operational cost will also be an issue, all aerobic systems are to be eliminated and an anaerobic system has to be selected for treatment of the effluent. The anaerobic alternative will consist of Integrated Settler cum Baffled Reactor and Upflow Anaerobic Filter as the two stages of treatment.

The detailed designs of the two options are given below.

4.2.1 Activated Sludge Process

The ETP with Activated Sludge Process shall consist of the following units.

- A collection cum equalisation tank where the wastewater received will get homogenised
- An aeration tank for biological reaction to reduce parameters like BOD, COD etc
- A clarifier to allow the effluent from the aeration tank to settle where the sludge settles and the clear fluid overflows to the collection tank
- A sludge well for collection of sludge from the clarifier
- A sludge pump for recycling the necessary quantity of sludge to the aeration tank for maintaining the Mixed Liquor Suspended Solids (MLSS) in the aeration tank as well as for pumping the sludge to the dewatering system
- Two twin sludge drying beds for dewatering of sludge
- Treated water collection tank for collection and storage of the clear fluid from the clarifier.
- Disinfection (Chlorination) as tertiary treatment unit for sewage in a disinfection tank
- Float type level controller in the disinfection tank for automatic operation of the filter feed pump
- Pressure sand filter
- Activated carbon filter

The details of the plant are given below.

4.2.2 Details of Activated Sludge Process Plant

Manholes	
No. of units	21
Dimensions proposed	0.5 m dia x 1.5 m
Collection cum Equalisation Tank	
Dimensions proposed	5.0 m dia x 3.0 m
Aeration Tank	
Dimensions proposed	8.0 x 7.0 m x 4.0 m
Clarifier	
Dimensions proposed	4.0 m dia x 3.0 m
Air Blowers	
No. of Air Blowers required	2 (100% standby)
Capacity of Air Blowers required	

Diffusers

Type of diffusers suggested	Membrane Tube
Type of diffusers for Aeration Tank	Fine Bubbles
No. of diffusers	24
Capacity/diffuser	10 m^3/hr
Type of Diffusers for Equalisation Tank	Coarse bubble
No. of diffusers	16
Capacity/diffuser	5 m^3/hr

Collection cum Chlorination Tank

Retention time required	1 hr.
Capacity required	25.0 m^3
Dimensions proposed	5.0 x 5.0 x 1.3 m

Chlorine Doser

Total quantity of treated water	250.0 m^3/d
NaOCl solution required @5 % conc	9 Lpd

Alternatively a dripper system consisting of a Plastic Bucket with a tap and a flexible hose can be considered to reduce the O & M costs.

Filter Feed Pump

Pressure recommended	3.5 kg/cm^2
Max. Flow Rate	250.0 m^3/d
No. of hours of operation	16 hrs.
Capacity required	15.6 m^3/hr

Pressure Sand Filter

Max. Flow Rate	250.0 m^3/d
No. of hours of operation	16 hrs.
Capacity required	15.6 m^3/hr
Next higher standard size available	17.0 m^3/hr
PSF capacity suggested	17.0 m^3/hr
MoC	FRP

Activated Carbon Filter

Max. Flow Rate	250.0 m^3/d
No. of hours of operation	16 hrs.
Capacity required	15.6 m^3/hr
Next higher standard size available	17.0 m^3/hr
ACF capacity suggested	17.0 m^3/hr
MoC	FRP

Sludge Well

Dimensions of Sludge Well suggested	2.5 x 2.5 x 1.5 m

Sludge Drying Beds

No. of units	2 Twin Beds
Dimensions Proposed	2.5 x 1.5 x 1.2 m

Depth of media	a. 100 mm deep broken stone of size 40 mm at the bottom b. 100 mm deep broken stone of size 20 mm c. 100 mm deep broken stone of size 10 mm d. 50 mm deep sieved coarse sand of size 5 mm e. 100 mm deep sieved sand of size 2 mm at the top
Slope of Drying Bed	1:20
Slope of Percolate Channel	1:100

4.2.3 Option 3: Anaerobic Reactors

To achieve the desired result, the system consists of a three stage process. The raw sewage will be taken separately to the primary reactor, an Integrated Settler cum Baffled Reactor (ISBR). After primary treatment (separation oil, grease and settleable particles) in a Grit Chamber cum Grease Trap (GCGT), sullage along with the semi treated sewage from the ISBR will be fed to the secondary treatment, the Upflow Anaerobic Filter (UAF). In order to reduce the operational problems only one GCGT is proposed. The manholes are designed in such a way as to separate any non degradable solids in the sullage. The effluent from the UAF while meeting the general standards as far AS BOD and COD are concerned but is likely to have unpleasant odour and could be blackish in colour. Thus tertiary treatment in a vertical flow constructed wetland with an optional treatment of chlorination will ensure acceptable quality for the treated effluent in all parameters.

Photo 1 Location of proposed primary & secondary treatment at KBH

Photo 2 Location of proposed tertiary treatment at KBH

4.2.4 Design Details of Anaerobic Reactors

Max. Wastewater generated	250.0 m^3/d

Grit Chamber cum Grease Trap cum Bar Screen Chamber

No. of units	1
Retention time required	30 min.
Capacity required	5.3 m^3
Dimensions proposed	5.0 x 1.50 x 1.3 m

Manholes

No. of units	42
Dimensions proposed	0.5 m dia x 1.5 m

ISBR

Max. quantity of sewage generated	100.0 m^3/d
No. of ISBR units proposed	4
No. of compartments	4
Dimensions of 1st compartment	2.0 x 3.0 x 2.1 m
Bottom slope of the 1st compartment	1/10
Dimensions of subsequent compartments	1.0 x 3.0 x 2.1 m

Upflow anaerobic filter

Max. quantity of wastewater generated	250.0 m^3/d
No. of UAF units proposed	4
Type of UAF proposed	Double Chambered
Dimensions suggested	8.00 x 3.00 x 0.55 m
Media proposed	20 mm broken stone

Collection cum Chlorination Tank

Min. Retention time required	1 hr.
Dimensions proposed	5.0 x 5.0 x 1.3 m

Chlorine Doser

Total quantity of treated water	250 m^3/d
NaOCl solution required @5 % conc	2.1 Lpd

Select a doser of next higher standard capacity. Alternatively a Dripper system can be considered. It has been found that a reusable dextrose bottle fixed with a suitable IV line can be the most effective way of chlorination. For a hospital, it is easy to procure reusable Dextrose/Sodium chloride bottles.

The Vertical Flow Constructed Wetland (VFCWL) as the final treatment reduces operational costs considerably as compared to more conventional options like pressure sand filter and activated carbon filter. The design of the VFCWL is essentially as a *Planted Gravel Filter*. The details are given below.

Max. Flow Rate	250.0 m^3/d
Total surface area required @ 0.6 $m^2/m^3/d$	150 m^2
No. of units	3
Dimensions provided	16.0 x 3.0 x 1.0 m
Media suggested	Graded gravel
Inlet & Method of distribution type	Perforated PVC Pipe
Vegetation proposed	Scripus Grossus Typha sp.

4.2.5 *Sewage Transmission system*

The lay of the land within the property is such that gravity flow is possible from the sources to the ETP area. The level difference between the farthest collection point to the ETP area is about 0.7 m. It can be seen that at present there are 5 septic tanks and 16 soakage/seepage Pits for collection and disposal of the effluents from the various points in the hospital. All of these have to be converted to manholes and connected to the ETP. In the case of anaerobic reactors, it is preferable to have gravity feed to avoid pumps with constant flow rates and possibly an intermediate tank to eliminate turbulence in the reactors. It is proposed to have separate lines for wastewater if anaerobic process is employed and hence separate grit chamber cum grease trap cum bar screen chambers is to be constructed. In this case it will still be required to construct 21 manholes.

The effluent line length required will be approximately 220 m in the case of activated sludge process (ASP) and 440 m in the case of anaerobic process. The diameter of the pipes suggested in either case is 150 mm Nominal Bore (NB). For convenience of installation, operation and maintenance, PVC pipes are proposed for the transmission system for both sewage and sullage. Since the pipes will have to be laid under internal roads frequented by several types of vehicles like trucks, tractor-trailers and cars, the pressure rating should be 10 kg/cm^2.

From the above it can be seen that pumping of raw effluent is completely eliminated in the case of anaerobic process (should be preferred if the type of material of construction is specified) while retained in the case of ASP while the cost of construction of Grit Chamber cum Grease Tarp cum Bar Screen Chambers and laying of additional pipeline are required in the case of Anaerobic Process.

The project cost estimates for each of the options are given below.

- Option-2 ASP - SRL 5,538,886
- Option-3a Anaerobic Reactors with Disinfection and Filtration- SRL 4,309,738
- Option-3b Anaerobic Reactors with planted gravel filter instead of pressure filter – SRL 4,379,475

The operational costs for the ETP will be as follows.

- Option-2 ASP- SRL 11000/d
- Option-3a Anaerobic Reactors with Disinfection and Filtration- SRL 4400/d
- Option-3b Anaerobic Reactors with Planted Gravel Filter instead of pressure filter – SRL 2400/d

The hospital believes it can allocate about SRL 100,000 on a monthly basis and this is probably the reason why they selected option 3b. Following discussion on site, more area could be allocated to the treatment plant than originally stated. The additional area will be taken up by the horizontal flow constructed wetland (total investment cost SRL 10,869,880). Though costs increase substantially, operational cost are not increasing and yet the hospital will be able to achieve a very good effluent treatment result, whereby even some of the notorious difficult to treat medicines present in the waste water (see Chapter 2) gets treated too. Though standards today do not prescribe these, it will only take time before these will be included in the standards.

A complete design report has been sent to Energy Forum for onward transmission to Kalmunai Base Hospital in order to obtain permission from the environment authorities.

At the same time WASTE has prepared a project report and submitted this to CORDAID seeking for support in actual construction and operation and maintenance of the effluent treatment plant at Kalmunai base Hospital.

CHAPTER 5 HAMBANTOTA BASE HOSPITAL

The hospital has a well designed effluent treatment plant (ETP) based on the oxidation ditch process. The location of the ETP is in a level about 3.0 m below the ground level of the hospital. The treatment plant consists of:

- A collection tank which functions as an equalisation tank
- An oxidation ditch of dimensions 25.0 x 6.0 x 1.5 m
- A settling tank
- 3 sludge drying beds each of dimensions 9.0 x 3.0 x 0.7 m
- A chlorination tank

The reported sewage generation is 175 m^3/d. Standard equations used for oxidation ditches are:

$\Gamma = L_i Q/SV$ and
$t^* = V/Q$

where,
Γ= Sludge loading factor d^{-1}
L_i= Influent BOD_5 in mg/l
Q= Flow in m^3/d
S= Ditch Liquor Suspended Solids in mg/l
V= Ditch volume in m^3
t^*= Mean hydraulic retention time in d

Assuming a maximum influent BOD_5 of 350 mg/l, and a flow rate of 175 m^3/d, it can be seen that the system designed and constructed is adequate to treat the wastewater generated from the hospital complex so to meet the general effluent standards in Sri Lanka.

However, hospital authorities do not wish to operate the ETP due to their inability to meet the power charges. Currently the plant is operated for one hour a day which has a far worse effect on the treatment than not operating it at all.

The effluent from the outlet of the ETP is drained out to a common area located beyond the boundaries of the hospital. Nearby population is negatively affected by this discharge of untreated hospital wastewater. This method of operation is causing problems to the resident staff too since the staff quarters are located close to the ETP.

In November 2006, hospital management was informed that one of the rotors was damaged (at that time, reportedly for over a year already) and in April 2007 it was still to be replaced or repaired. Algal formations could be seen at the top layer of the effluent in the oxidation ditch, thereby converting it into an inadequately sized waste stabilisation pond at present.

It can be seen that the situation in November 2007 had somewhat improved as the hospital had managed to replace one of the rotors. Unfortunately, the rotor was not properly aligned and hence it is again dysfunctional. The only somewhat longer lasting improvement is that the plant is at least partially operated (see Photo 3 and Photo 4).

Photo 3 Hambantota SDBs April 2007

Photo 4 Hambantota SDBs November 2007[5]

Options:
So based on request of the hospital authorities, project team looked at alternatives that could reduce the operation and maintenance costs and / or increase efficiency of the treatment system at lower or the same costs.

- Regarding power consumption, it can be seen that the collection cum equalisation tank is located in the ETP area which warrants pumping to the oxidation ditch. Relocating the collection cum equalisation tank itself will reduce power consumption through elimination of pumping.

- However, the power charges for operating the rotors of the oxidation ditch have to be still met. Thus three options are considered.

    1. To increase efficiency: Rehabilitation of the existing system, replacement of rotors etc. with possible relocation of the collection tank so as to eliminate pumping.

The two low maintenance options to consider in this case are

2. Anaerobic Reactor
3. Constructed Wetland

- Ad 2) For conversion of the oxidation ditch to an anaerobic reactor, the main capital expenditure required will be for casting a cover slab for the oxidation ditch and providing bio growth medium within the reactor. The second part is optional. The volume available is approximately 225 m^3/d, which is adequate anaerobic processing of the effluent.

- Ad 3) The conversion of the oxidation ditch in to a CWL may not be feasible technically since the area and volume available are far less than what is required. The area requirement for a horizontal flow CWL will be approximately 1500-1800 m^2.

- In both cases (2 and 3), the existing sludge drying beds will be available for some application. The fact that neither the SDB has not been used nor the settling tank cleared of sludge at any point of time proves the way the ETP had been functioning.

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[5] Fresh sludge indicates that plant is at least partially operated

- ♦ The SDBs can be converted into CWL for polishing (tertiary) treatment if the oxidation ditch is converted into anaerobic reactor. Although the area available is too low for a conventional CWL and the hydraulic loading will be too high if standard design parameters are adopted, since it is only a polishing treatment, reasonably good results are expected. The present facility for chlorination can be retained and used irrespective of the system used for biological processing of the effluent.

Taking into consideration all the aspects, it can be seen that the options for an effective wastewater treatment system narrows down to two as the third option is not really an alternative. These are

1. Rehabilitation of the existing ETP augmented with creation of a separate fund for meeting the operation and maintenance costs of the ETP. The rehabilitation of the existing system primarily consists of:
   - ♦ Replacement of the rotors in the oxidation ditch
   - ♦ Replacement of the clarifier mechanism

   The capital investment required in this case will be approximately SRL 1,050,000.

2. Conversion of the existing oxidation ditch into an anaerobic reactor and the SDBs into horizontal flow CWL. It can be seen that the second option will meet only a part of the treatment requirements. However, assuming that the logic of something being better than nothing, this can be adopted as a feasible solution.

   The list of the modification works are given below.
   a. One half of the oxidation ditch is to be converted in to a baffled reactor and the other half a upflow anaerobic filter. This essentially consists of
      - ♦ Casting of an air tight cover slab for the entire surface area
      - ♦ Building necessary partition walls for conversion of the tank in to anaerobic reactors.
      - ♦ Providing vent pipes for the reactors

   b. Convert the existing sludge drying beds into HCWLs. Since the feeding chambers and the sidewalls are in place, filling of media and planting of vegetation are the activities required.

The capital investment required in this case will be approximately SRL 1,500,000.

Regarding power consumption, it can be seen that the collection cum equalisation tank is located in the ETP area which warrants pumping to the oxidation ditch. Relocating the collection cum equalisation tank itself will reduce power consumption. However, the power charges for operating the rotors of the oxidation ditch have to be still met.

Since the total connected load is only 20 HP, creation of a separate fund for meeting the operational costs including maintenance of the existing facility may be considered as the most feasible option. At present Bleaching Powder is used for disinfection of the treated effluent. However, it can be seen that only 25 kg/ month is consumed which means the dosage is too low. The present system can be replaced with use of Sodium hypochlorite solution using used IV Bottles and IV lines which would be more efficient and economic as well.

CHAPTER 6 ASHROFF MEMORIAL HOSPITAL, KALMUNAI

The hospital has constructed an Effluent Treatment Plant (ETP) with the assistance of an International Non Governmental Organisation (INGO), Merlin. The contractor is M/s. Puritas, Colombo. The design capacity of the ETP is reported to be 250 m^3/d. The process adopted is a two stage biological reaction in which the primary treatment is anaerobic and the secondary treatment is aerobic. The design provided for the following units in the ETP:

- Collection cum Equalisation Tank
- Anaerobic Baffled Reactor
- Aeration Tank
- Settling Tank
- Chlorination Tank
- Filter

The dimensions of the tanks are given below.

- Collection cum Equalisation Tank-6.65 x 6.8 x 2.3 m
- Anaerobic Baffled Reactor-15.0 x 5.8 x 2.3 m
- Aeration Tank-11.4 x 3.8 x 2.3 m

During construction, the layout was altered to include an intermediate tank between the anaerobic reactor and the aerobic reactor.

While it is common practice to include an intermediate tank for collection of the partially treated effluent from an anaerobic reactor before feeding to the aerobic reactor, the absence of the same will have no serious effect on the treatment.

Thus, the actual construction consists of the following.

- Collection cum Equalisation Tank
- Anaerobic Baffled Reactor
- Intermediate Tank
- Aeration Tank
- Settling Tank
- Chlorination Tank
- Filter

The dimensions of the tanks are given below.

- Collection cum Equalisation Tank-6.65 x 6.8 x 2.3 m
- Anaerobic Baffled Reactor-15.0 x 3.8 x 2.3 m
- Intermediate Tank-15.0 x 2.0 x 2.3 m
- Aeration Tank-11.4 x 3.8 x 2.3 m

While the volume of the tanks provided appears adequate, the aeration depth provided in the aeration tank appears too low. Normal aeration depth is 3.0-4.0 m. However, it may be noted that the aeration is provided for as a secondary biological treatment. While there are provisions for insertion of gas vents in the anaerobic reactor, the height at which they will be fixed is not clear at present.

Ideally, the gas vents should be run along a suitable duct in the building to the top and should be at least 2 m above the top most point of the building. In the case of Ashroff Hospital, it can be seen that there are no buildings in the vicinity of the ETP, and hence the impact of the gas vent out from the anaerobic reactor is nebulous. Drawings do not indicate the location of the end point of the gas vent. The current sewage generation is reported to be less than 200 m^3/d. The design is expected to take the full load after future expansion of the hospital.

Photo 5 ETP Ashroff Memorial Hospital

Photo 6 Effluent ETP Ashroff Memorial Hospital

In November 2007 the plant was visited again and it was seen that the plant had just been commissioned. It is expected to be stabilised in a month's time. The effluent from the plant was physically examined and appeared to be of acceptable quality.

As the hospital does not yet pay for the operational cost, they are not yet aware how much their monthly operation and maintenance costs will actually be. However, they expressed their apprehension about the electricity costs. Keeping in mind what happened at Hambantota Base Hospital this may eventually hamper their actual operation of the treatment system.

Training of the staff of Ashroff Memorial Hospital will be undertaken by the contractor, and this will be done within the three month operation and maintenance contract held by Puritas.

ANNEX 1 LOGICAL FRAMEWORK RELATED TO HOSPITAL WASTE WATER TREATMENT

Table 8 Logical Framework for health care waste management

Objective In target areas, safe management and disposal of medical and sanitation waste, focus on increased amount of waste due to Tsunami .	
Result	**Activities**
2.2 Amount of solid waste generated by 3 hospitals and IDP, labelled as hazardous will have been reduced by at least 75% reducing spread of contagious diseases from dumpsites.	2.2.1 MoUs 2.2.2 Site visits of hospital staff 2.2.3 Health care waste management assessment 2.2.4 ISWM training waste management 2.2.5 Main stakeholders implementing health care waste management including needle ash burners 2.2.6. Solidarity (NGO) sustainable implementation of medical waste segregation in IDP camp. 2.2.7 Improved medical waste systems in at least two local 45 authorities using TOT and above demonstration sites. 2.2.8 Capacity built in dealing with Tsunami (or other disaster) related medical waste systems improved
2.4 Hazardous waste of at least one hospital (Hambantota) will be safely disposed minimizing risk of catching contagious disease for about 5,000 people.	2.4.1. Feasibility (technical, socio-economical, operational) of different options 2.4.2.Construction of and training for most appropriate option (subsequent to 2.2.2, 2.2.3, 2.2.4, 2.2.5) – after segregation in collaboration with crematorium facility Tangalle, burning using proper fuel (Kalmunai)
2.5 Urban dwellers and supporting institutions have increased their capacity in integrated sustainable health care waste management	2.5.1 Exposure visits 2.5.2 Providing trainings in health care waste management