**Nile Equatorial Lakes Subsidiary Action Program**

MARA TRANSBOUNDARY INTEGRATED WATER RESOURCES MANAGEMENT AND DEVELOPMENT PROJECT

# Final Report – Annex 3

# Water pollution and Sanitation Project

***Final version* – December 2012**

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# TABLE OF CONTENTS

## FIGURES



## TABLES

# List of Abbreviations and Acronyms

| | |
|---|---|
| ASM | Artisanal and small scale miners |
| CLTS | Community-Led Total Sanitation |
| CBO | Community Based Organisation |
| CMO | Community Mobilization Officer |
| DTO | District Technical Officer |
| IGA | Income Generating Activity |
| IWM | Integrated Watershed Management |
| IWRM | Integrated Water Resources Management |
| LGA | Local Government Authorities |
| MMNR | Maasai Mara National Reserve |
| MRB | Mara River Basin |
| MRBMP | Mara River Basin Management Project |
| MR-IWMP | Mara River Integrated Watershed Management and Investment Plan |
| NBI | Nile Basin Initiative |
| NELSAP | Nile Equatorial Lakes Subsidiary Action Program |
| NGO | Non-Governmental Organisation |
| PHAST | Participatory Health and Sanitation Transformation |
| PMU | Project Management Unit |
| PPP | Public-Private Partnership |
| SENAPA | Serengeti National Park |
| SWAT | Soil Water Assessment Tool |
| ToR | Terms of Reference |
| WASH | Water, Sanitation and Hygiene |
| WATSAN | Water and Sanitation |
| WB | World Bank |

# 1. INTRODUCTION

EGIS has been committed by the Mara River Basin Project – Project Management Unit to provide a preliminary investment project for Integrated watershed management through feasibility type studies.

The present document is the third annex of the Final Report for Mara River Basin IWMP.

**MR- IWMP FINAL REPORT**

| **Main report** | **Investment Project Proposal** |
|---|---|
| Annex 1 | Watershed Management and Investment Plan |
| Annex 2 | Sustainable Wetlands Management and Investment Plan |
| **Annex 3** | **Water Pollution and Sanitation Project** |
| Annex 4 | Cross-cutting activities |

# 2. GENERAL PRESENTATION

## 2.1. GENERAL CONTEXT

Water pollution and Sanitation is one of the 3 projects of the Mara River Integrated Watershed Management and Investment Plan (MR-IWMP).

The Mara River Basin (MRB) Management Project is one of the three transboundary integrated water resources management and development projects being implemented within the framework of the Nile Equatorial Lakes Subsidiary Action Program (NELSAP), an investment program of the Nile Basin Initiative. The MRB project targets economic growth opportunities through co-operative management of the shared water resources amongst Nile Equatorial Lakes countries, to alleviate poverty, enhance economic growth and reverse environmental degradation. It also contributes towards the wider Nile Basin Initiative (NBI) goal of achieving sustainable socio-economic development through equitable utilization of, and benefit from, the common Nile Basin water resources.

The MRB basin originates from the Mau escarpment and upper swamps in Kenya and drains into Lake Victoria. This catchment have experienced significant land use changes over the past years due, in particular, to increasing population pressure, as local inhabitants continue to clear forests and drain wetlands to create new agricultural land and establish new settlements.

The fast population growth in the MRB basin has led to excessive land fragmentation and has pushed farming activities into marginal areas that are vulnerable to soil erosion and nutrient loss; it has also led to increased encroachment of ecologically fragile areas such as wetlands and springs, riverbanks and protected forests (Mau forest and woodlands on hills) for farming purposes, charcoal making and illegal lumbering.

These trends threaten the future livelihood of the people and livestock as well as biodiversity and wildlife in the Maasai Mara/Serengeti Reserves. The current degradation of the basin, notably through deforestation and wetland degradation arises new challenges, like the steadily decline of average discharge in rivers during the dry seasons over the years and increased flash floods and high sediment transport during rainy seasons. Water scarcity and growing food insufficiency are some of the major issues facing these basins and the situation is expected to get worse as the population increases and as demand by the different water use sectors outmatches the existing supply and is exacerbated by the imminent effects of climate change.

Further, several sources of pollution like poorly controlled effluent discharges from mining industry (including small scale miners), untreated or poorly treated wastewater, sludge from septic tanks and solid waste from the few fast-growing urban centres, the nutrient and agro-chemical pollution from diffuse sources, have negatively impacted surface water and groundwater quality.

The Mara River Basin is also home to the World Renowned Maasai Mara-Serengeti ecosystem. Sustainable wildlife management and tourism development are central to the economic development of the Mara river basin, as well as the countries at large. Without effective and sustainable watershed conservation efforts, there will be inadequate water for wildlife and tourism services thus threatening these conservation areas, with negative consequences on revenue from tourism that supports the economic development of the countries. The ecosystems have potential livelihood opportunities especially for the communities to improve their socio economic standards through strengthening the Wildlife Management Areas (Serengeti) and Wildlife Conservancies Areas (Maasai Mara) in the context of integrated watershed management. Promoting investments in the basin will improve the current living standards of the basin population and allow the poor to tap the benefits from the resources endowment of the Mara River Basin.

An Integrated Watershed Management Project is therefore necessary to address the above issues and contribute towards reversal of the current trend of catchments degradation, without losing sight of the need to ensure livelihood for the whole population and also water of good quality and quantity.

The proposed project will address critical trans-boundary problems of pollution, soil erosion and loss of biodiversity and share of water resource, but also enhance collaboration between communities across the common border between Kenya and Tanzania and more so strengthen regional cooperation.

The present report on Sanitation and Waste Management, as a sector activity proposal, needs to be read in conjunction with the Main Report, which presents the project components.

## 2.2. REVIEW OF THE MRB CONDITIONS

As concluded in the NIRAS study reports, the “pollution hotspots” related to sanitation and (solid) waste in the Mara River Basin are mainly concentrated in the rapidly growing urban centres, which often lack sustainable management of wastewater and solid waste. Mining activities (large- and small-scale) in the lower watershed area (Tanzania) also contribute to a degradation of the water quality of the Mara River.

### 2.2.1. Sanitation conditions

Fast growing towns, mainly located in the upper part of the basin do not have a wastewater collection system and households mainly depend on pit latrines. Some households and/or commercial infrastructures have either holding tanks or septic tanks installed. Besides these limitations in proper sanitation facilities, more rural areas neither have proper access to clean water and women and children need to collect water from the river and/or are dependent on water from shallow-wells or springs. These water sources are often not protected and may be contaminated, exposing the inhabitants to water-borne diseases.

### 2.2.2. Management of solid waste

Solid waste is mainly generated by domestic and commercial activities. In the more developed urban centres, solid waste is collected from garbage collecting points and brought to an open dumping site. These dumping sites are usually not fenced and waste is dumped without being covered. Often children are seen at the dumping site looking for reusable waste items as well as cattle and goats scavenging the dumping site. The number of collection points in the urban centres is often few compared to the large population. In addition, these collection points are poorly maintained, which leads to littering in residential and commercial (market) areas. Furthermore, collection points are often exposed to wind and water run-off during heavy rain, resulting in additional spreading of solid waste.

### 2.2.3. Water pollution caused by mining activities

Gold mining activities take place in the Tigithe river sub-basin, near the city of Nyamongo; they appear as very large mining sites, like the North Mara Gold Mine managed by Barrick, or as very small mining business at village or family level.Because of the chemicals used in the process of separating gold from the ore, there is a risk of pollution of water by toxic heavy metals, and mainly Mercury. Such local rivers as Tekite may be affected, as well as the ground water layer which is fairly shallow in that area. The main mining company has made large efforts to mitigate the effects of leachate reaching the phreatic layer, with visible results, but small mining business may not be able to control their toxic wastes efficiently.

### 2.2.4. Constraints

The constraint for the development of an appropriate sanitation and waste management approach is that each town/village consists of various zones which need their own approach. Therefore, it is crucial to perform a detailed assessment at the beginning of the project to identify these zones and to identify the needs of the inhabitants;

Community participation depends on the success of awareness creation and the willingness of the people. For this participatory methods need to be used and for each area different methods will have to be applied, depending on local culture and habits;

Another difficulty is the choice of appropriate options for sanitation facilities, as this depends very much on the final users. If community involvement is not optimized, the risk is high that the sanitation facilities constructed will not be used and neglected in the end;

Solid waste recycling can only be successful if sufficient waste is collected. A regional approach could ensure bigger amounts of waste of plastics for example. Furthermore, communities will only be interested if an income can be generated from these activities. Again, community involvement is a crucial factor for success, especially when working at neighbourhood level (for example for composting activities).

Finally, inadequate enforcement or application of existing laws and regulations regarding water pollution is an important constraint.

# 3. PROJECT JUSTIFICATION

As part of Integrated Water Resources Management (IWRM), it is of great importance to develop proper sanitation facilities and apply sustainable management of solid waste in the concerned areas within the Mara River Basin. Improved management of wastewater, solid waste and other sources of pollution will subsequently improve the health and sanitation conditions of the population and also enhance the living environment. Furthermore, pollution of the river will decrease, resulting in improved water quality of the Mara River.

Actions for improvement in sanitation will be part of an integrated approach, involving identification of available budget, definition of local regulations, awareness creation and sensitization processes, set-up of local (community-based) units responsible for operation and maintenance (O&M), establishment of user tariffs, and installation of appropriate infrastructure and facilities, etc.

Solid waste management actions will encourage waste segregation, enhance possibilities for recycling as well as composting and possibly biogas production from organic waste as an alternative energy source. The potential for public-private funded/run sanitation facilities and waste collection will be explored and encouraged.

Actions to enhance proper management of mining activities nearby the rivers, taking into account the safeguarding of the water quality and the health risks to which the miners are exposed will contribute to a “healthy” river and watershed environment and ensure inhabitants’ well-being.

The proposed actions and activities will positively contribute to poverty reduction as through adequate sanitation conditions inhabitant’s health conditions will improve, allowing them to dedicate more time to income generating activities (IGAs) and to reduce medical costs. Furthermore, reuse and recycling of waste, composting and biogas production can be further developed as IGAs.

# 4. PROJECT OBJECTIVES AND KEY OUTPUTS

## 4.1. OVERALL OBJECTIVE

The Overall Objective of the Water Pollution and Sanitation Project conforms to that of the watershed management and aims to «*improve the living conditions of people while protecting the environment*».

In this it is crucial that all sanitation and waste management activities are prepared with the communities through community sensitization, mobilization and participatory methods to ensure that they feel empowered and in turn are willing contributors to the activities. In fact, the strategies to be developed for improvement of sanitation conditions and proper waste management are key elements of community development plans.

The main foreseen outcomes of the Sanitation and Waste Management Project are:

- Improve health and living conditions of the MRB inhabitants;
- Develop improved access to clean water in the MRB;
- Develop improved access to sanitation facilities for the MRB inhabitants;
- Develop sustainable solid waste management;
- Contribute to the development of alternative energy sources (biogas production);
- Decrease water pollution and improve water quality through improved management of mining activities;
- Enhance public awareness and community participation;
- Ensure capacity building at local government authority (LGA) level and community level;
- Improve technical resources and extension services;
- Improve structure for planning and monitoring of project activities, and for sensitization, training and mobilization of communities.

## 4.2. SPECIFIC OBJECTIVES

The specific objectives of the Water Pollution and Sanitation Project concern the sub-projects targeting the pilot towns of Bomet and Mulot in Kenya and Nyangoto, Kewanja and Weigita Village in Tanzania, located in the sub-basin priority areas of the MRB.

The specific objectives are:

- Operationalize mechanisms and tools for community driven sanitation and solid waste management;
- Improve inhabitant's access to water and sanitation (WATSAN) services;
- Decrease water-borne diseases and increase and better secure inhabitant's well-being;
- Enhance a "clean and green" environment;
- Promote Water, Sanitation and Hygiene (WASH) activities;
- Support communities in waste reuse, recycling, composting and biogas production as alternative sources of livelihoods for improved income;
- Enhance community networking to promote best WASH practices for up-scaling within the MRB;
- Increase miners' awareness on environmental risks as well as health risks;
- Promote alternative mining practices and techniques that are environmentally friendly.

## 4.3. KEY OUTPUTS

The sub-project key outputs are:

A. Targeted zones/clusters are identified and mapped in each pilot town or village according to various categories and subsequently Sanitation and Solid Waste Management Strategies/Plans are prepared for each pilot town or village;

B. Adequate water supply, sanitation and solid waste collection and disposal facilities are identified and designs for implementation/construction are prepared;

C. Community based organizations (CBOs) or committees are established and operational for each water supply, sanitation and solid waste collection facility;

D. NGOs with experience in WASH education and implementation of Community-Led Total Sanitation (CLTS) have been identified and recruited;

E. WASH education and Participatory Health and Sanitation Transformation (PHAST) have been implemented through LGAs and/or NGOs;

F. Extension staff are equipped and trained to organize, facilitate and provide on-going support to operational NGOs and/or CBOs and to apply participatory extension for sanitation and waste management;

G. Communities adopt and apply WASH activities, techniques and practices;

H. Miners adopt alternative mining practices and techniques to safeguard water quality and health conditions;

I. Partnerships between the community and the private sector for recycling of waste are created and communities are able to generate income from recycled waste;

J. New Eco-tourism, handicraft production activities and small scaled enterprises are developed in the watershed to promote commercialization of compost, reusable waste and handicraft products made from recycled plastics, metals, cardboard, etc.

K. Knowledge networks for exchanging experiences are established at local and transboundary levels.

# 5. PROVISIONAL PROJECT BENEFITS

## 5.1. ENVIRONMENTAL CONSERVATION

**Safeguarding of water quality:** The water quality in the MRB concerns both surface water and groundwater. Surface water is affected by discharge of wastewater effluents, leachate from solid waste dumping site, mining activities and solid waste spreading through wind and/or water run-off. Groundwater is affected by seepage and/or percolation into the groundwater of untreated wastewater effluents, as well as untreated leachate from dumping sites.

**Proper management of point source pollution:** It is of crucial importance to control and properly manage all the point sources of water pollution mentioned above, which will enhance the safeguarding of the water quality in the MRB.

**Clean and green environment:** Proper management of solid waste collection, reuse, recycling and final disposal will enhance a clean and green environment, which will provide healthy and pleasant living conditions for the MRB inhabitants.

## 5.2. INCOME GENERATION

**Poverty reduction:** Improved sanitation and waste management conditions directly improve the health conditions of the inhabitants. Consequently, people will be able to dedicate more time to IGAs and will have reduced medical costs. This all positively contributes the poverty reduction and enhancing of well-being.

**Development of IGAs:** Waste reuse and recycling (production of handicrafts, children's toys, bags, etc.) composting and biogas production from organic waste, human waste and manure can all be developed to IGAs.

**Market access:** Market access concerning recycling of plastics, metals and others can be developed through partnerships with private entrepreneurs that are interested to commercialize reusable waste at regional level.

## 5.3. INSTITUTIONAL STRENGTHENING

**Access to technical advice and professional network:** The double capacity building process intended for the Sanitation and Waste Management Project is expected to give good results in terms of professional advice (e.g. through NGOs). First at community level through CBOs and/or other community committees and extension officers, and then at coordination level promoting exchanges among the different LGAs groups and other involved stakeholders.

# 6. PROJECT INTERVENTION AREAS AND BASELINE

The priority project intervention areas for the Water Pollution and Sanitation Project are the urban centres of the MRB, mainly those located in proximity to the mayor tributaries of the Mara River. For this project, sub-projects have been identified, consisting of pilot towns/villages for three sub-basin priority areas. The pilot areas are:

- **Mid-Amala sub-basin priority area (Kenya):**
  - Bomet Town (semi-urban with peri-urban areas);
- **Mid-Nyangores sub-basin priority area (Kenya):**
  - Mulot Town (semi-urban with peri-urban areas);
- **Lower-Tigithe sub-basin priority area (Tanzania):**
  - Nyangoto and Kewanja Villages (semi-urban);
  - Weigita Village (rural).

Each pilot town/village can be sub-categorized in zones/clusters depending on specific characteristics. For each zone/cluster, possible options/measures are proposed concerning sanitation and solid waste management (see Chapter 7).

- A separate sub-project has been defined for promotion of alternative mining practices. The intervention area for this sub-project is located in the **Tigithe sub-basin**.

## 6.1. BOMET TOWN (KENYA)

### 6.1.1. Introduction

In the priority area of the ***Mid-Nyangores sub-basin***, Bomet Town has been identified as a pilot town for improvement of sanitation facilities and solid waste management. Bomet is one of the main fast-growing town centres in the area where these issues need to be addressed to enhance the living conditions of the inhabitants and ensure a sustainable and clean environment.


Bomet Town is the capital of Bomet District. The district has a population of 382,794 (1999 census) and an area of 1,882 km². Bomet Municipality has a total population of 42,024 and an urban population of 4,426 (1999 census). Bomet municipality has six wards (Cheboin, Emkwen, Itembe, Mutarakwa, Township and Tuluapmosonik).

### 6.1.2. Current sanitation conditions

Houses in the urban centre mostly have a water supply connection and their own toilets with either holding tank or septic tank facilities. There is no sewerage system, but preliminary plans have been prepared by local government. However, the identified site for wastewater treatment has now been resold for other purposes and no alternative has been identified. Holding and/or septic tank waste is collected upon request and is dumped at a designated dumping site (pond) located outside of the town centre; a higher area not far from the Mara river.

Around Bomet town centre, additional settlements are developing. It is probable that these neighbourhoods only have access to (private) latrine pits and or ventilated latrine pits (VIPs). These communities do not have a water connection and mostly collect water from the Mara River.

Bomet is an important regional centre with a very busy market place. Currently, there are no public toilet facilities here.

The figure above comes from Google Earth an indicates the location of the market place, the water treatment plant and intake, as well as the solid waste dumping site and the holding/septic tank waste dumping site.

### 6.1.3. Current solid waste management system

In the urban centre waste is collected by LGAs and brought to an open dumping site, located on the outskirts of the town; a higher area very close to the Mara River. The site is not fenced and during heavy rains all solid waste is carried down the slope through water run-off to the river.

## 6.2. MULOT TOWN (KENYA)

### 6.2.1. Introduction

In the priority area of the ***Mid-Amala sub-basin***, Mulot has been identified as a pilot area for improvement of sanitation facilities and solid waste management. Mulot is a fast-growing town in the Narok District and comprises an urban town centre on the west side of the river along the main road and a less densely populated town centre on the east side of the river. Mulot has a large rural population spread out over a surface of 720,3 $km^2$. The overall population is 68,432 with a density of 95%.

### 6.2.2. Current sanitation conditions

Mulot town seems less densely populated and less developed than Bomet. It is probable that not all houses have water connections. Furthermore, it seems that the most common sanitation facilities are (private) latrine pits and/or ventilated latrine pits (VIPs). The town has a market place in both centers (east and west of the river), which is attract a lot of inhabitants of the region on market days. There are no public toilet facilities for the market areas.

### 6.2.3. Current solid waste management system

There is no waste collection system and waste is mostly burnt by the inhabitants. From the eastern town there is a steep road going towards the bridge that crosses the river. This road is degraded because of erosion caused by heavy rain. Solid waste is carried down the road though runoff towards the river. Both market areas are polluted by the scattering of solid waste.

## 6.3. NYANGOTO & KEWANJA VILLAGES (TANZANIA)

### 6.3.1. Introduction


In the priority area of the ***Lower Tigithe sub-basin***, Nyangoto Village and Kewanja Village have been identified as pilot areas for improvement of sanitation facilities and solid waste management. The villages of Kewanja and Nyangoto are growing into small towns and are situated nearby to the large-scale private Barrick's North Mara Gold Mine. As the mine is further extending its mining area, it is probable that the inhabitants will have to be resettled and that the villages will disappear. Nyangoto is the closest village to the south-west of the Gold Mine and does not really function as a residential area, but more as a commercial center because of its market. Kewanja is located

further south along one of the main roads and has more of a residential characteristic with a population of approximately over 10,000.

### 6.3.2. Current sanitation conditions

It is probable that in both Nyangoto and Kewanja not all houses have water connections. Furthermore, it seems that the most common sanitation facilities are (private) latrine pits and/or ventilated latrine pits (VIPs). There are no public toilet facilities for the market place in Nyangoto.

### 6.3.3. Current solid waste management system

Solid waste management is a problem in both villages, as there is no collection system. However, in Nyangoto, waste has been collected, separated and dumped next to the market area. A security guard at the market place explained that a private company paid some people to collect and segregate waste (plastic bottles, organic waste and others). Now, the waste has been dumped here, without any protection from scavenging and has not yet been collected by the private company. Nevertheless, this does give some indication of the existence of a potential market for solid waste recycling.

## 6.4. WEIGITA VILLAGE (TANZANIA)

### 6.4.1. Introduction

In the priority area of the ***Lower Tigithe sub-basin***, Weigita Village has been identified as a rural pilot area for improvement of sanitation facilities and solid waste management. Weigita Village consists of numerous homesteads spread out over a vast rural area. Each homestead consists of “rondavels” (thatched round-shaped homes) with in the middle an enclosure for goats and cattle.

### 6.4.2. Current sanitation conditions

In this rural area there are no water connections. People have limited access to water through shallow wells and/or nearby springs. It is common to see women with buckets on their heads, as they walk to river tributaries to fetch water. The groundwater table is not very deep and the soil is very sandy. It is not clear if at a deeper level there might be another groundwater layer. Because of the sandy soil, the high groundwater table and the costs, it is difficult for the local population to construct pit latrines. People are used to “semi-open defecation” by digging a small hole and covering excreta/faeces up with soil.

### 6.4.3. Current solid waste management system

Solid waste management is not yet an urgent issue in Weigita as the rural population hardly generates any solid waste. There are a few small shops spread out over the village, where people probably burn their garbage.

## 6.5. MINING AREA IN TIGHITE RIVER BASIN (TANZANIA)

### 6.5.1. Introduction

The mineral resources of the Mara basin are substantial with active mining taking place for gold, slates and sand. In the priority area of the Lower Tigithe sub-basin, artisanal, small scale, medium scale and large-scale miners (Buhemba in Musoma and Nyamongo in Tarime districts) are occurring.

The project will focus on **artisanal and small scale mining (ASM)** which is operated in areas around the large scale mining at a small scale. ASM activity has been recognized as a mean of significant livelihood improvement in rural areas and the Government has recently improved the mining policy and legal framework related to this sector. Changes have been made to promote the acquisition of mineral rights and to simplify the mineral trading licensing procedures.

A commonly made distinction, although not always specified, is that between small-scale and artisanal miners. Distinction between artisanal and small-scale mining is commonly based on the level organization (associations), sophistication of the working techniques, levels on investment, variation in knowledge of minerals extraction and marketing techniques, varying awareness of the legislation and hence the varying levels of productivity and incomes.

- Artisanal miners are often defined as those who employ manual, low technology mining conducted on a small scale (World Bank, 1995) and involving smaller groups of 2 to 5 people working together in a pit. They are often considered illegal.

- Small-scale miners on the other hand can have some degree of mechanisation, have a legal license and/or are organised in some form of mining association. Indeed, in Tanzania, in accordance with the Mining Act, 1998, a small-scale miner is the holder of a mineral right through a Primary Mining License issued by the Commissioner for Minerals.

All mining activities in Tanzania fall under the responsibility of the Ministry of Energy and Minerals. Regional organizations, platforms or smaller and specialized associations already exist, even if not reaching all ASM workers. Nevertheless and in despite a willingness at central level to organize, promote and control such activity, the lack of means at the regional and local level doesn't solve acute environmental, health and social problems still remaining. Working techniques and worker conditions in ASM have remained the same and have perpetuated many long held conflicts between different stakeholders.

### 6.5.2. Current mining practices

In the lower-Tighite area, artisanal and small-scale miners make extensive use of mercury amalgamation techniques in the gold extraction process (see figure 1). These techniques are known for their potential contamination to the environment and risks to human health.

Mercury is one of the most toxic substances in the world causing significant damage to the environment and to the health of people who handle it. Mercury is absorbed by the human organism through drinking water, food or breathed air.
Hence, consequently to occurrence of the currents practices, there is a potential risk of human exposure to inorganic mercury (Hg), not only to those persons directly handling the Hg but also families, in whose

homes the Hg from the amalgam nodule is volatilized and also to those persons eating fish with elevated concentrations of methyl-mercury.

According to P. Van Straaten (2000)[1] between 20 and 30% of the introduced Hg in the gold extraction process is lost to soils, tailings, stream sediments and water close to the processing sites. Newly introduced use of concrete basin to limit Hg diffusion in natural environment isn't efficiently resolving the problem as far as no solution are organized to collect effluents, which are spread in streams or on soils when concrete basin is full.

Some of the Hg reaches aquatic environments, through either direct discharge or transport into the waterways ending up in the aquatic system, or indirectly through deposition from the air or through rain. Potentially the inorganic Hg can be transformed into the toxic form of methyl-mercury.

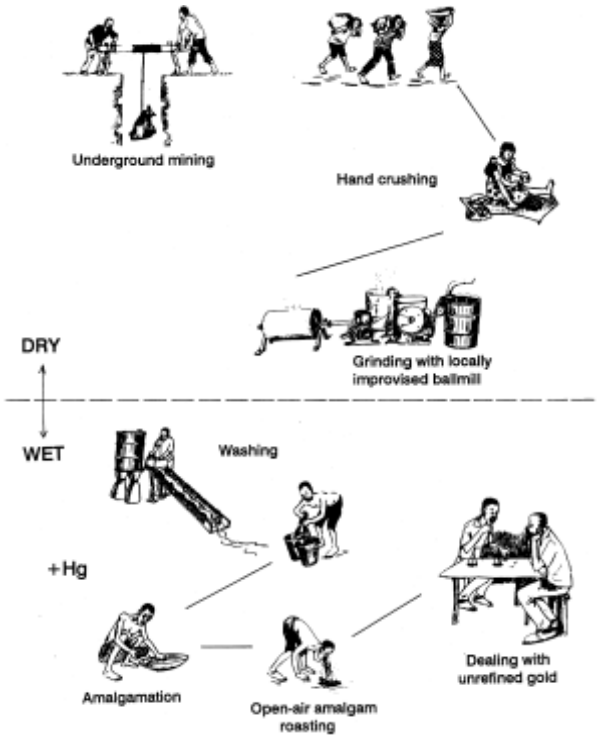



**Figure 2 : Generalized flow sheet of gold ASM and processing in Tanzania** *(source: P. Van Straaten, 2000)*

[1] *Peter Van Straaten, 2000. Human exposure to mercury due to small scale gold mining in northern Tanzania. The Science of the Total Environment 259 _2000. 45]53*

# 7. PROJECT DESCRIPTION

For the water pollution and sanitation project, various activities are proposed for the identified sub-projects. The activities concern the key issues of this project: water supply & sanitation, solid waste management and promotion of alternative mining practices.

## 7.1. SUB-PROJECT 3A: WATER SUPPLY & SANITATION

### 7.1.1. Proposed activities and means

For improvement of the sanitation conditions the following steps and activities are proposed for each sub-project:

a) *Detailed assessment of current existing water supply and sanitation facilities. The assessment should at least include, but not be limited to the following aspects:*

- Situation analysis regarding existing and planned water supply connections (in-house and/or yard connections, public taps), presence of private water vendors and other ways adopted by the population to access water for domestic uses (e.g. water from the river water or nearby springs, shallow wells, etc.)

- Situation analysis of existing sanitation facilities (indoor or outdoor toilets, pit latrines, VIPs, public toilets and/or practice of open defecation);

- Identification of responsible LGAs and analysis of the institutional arrangements concerning access to WATSAN facilities (O&M, water tariffs, tariff structure for public toilets, etc.) and of (peri-urban and rural) community roles and participation;

- Analysis of the role of the private sector in sanitation (e.g. management of public toilet facilities).

b) *Development of immediate/medium/long-term Sanitation Strategy addressing the following issues:*

- Zoning/clustering of similar areas (residential, commercial etc.). This needs to be linked with the existing urban/rural development plan and the existing proposal for centralized sewerage system and wastewater treatment plant in the case of Bomet Town (identification of suitable location for treatment plant, including assessment of land purchase possibilities);

- Selection of appropriate sanitation options; either *on-site facilities* (pit latrines, VIPs, leaching pits, holding tanks, septic tanks, etc.) or *on-site decentralized facilities* (Imhoff tanks, anaerobic baffler reactors, etc., also known as DEWATS, see Box 2) for public toilets and/or community based systems. A more detailed description of the components of sanitation infrastructure is given in Box 1;

- Analysis of the availability of financial resources and/or subsidies, including both capital (investment) costs and recurrent costs (O&M);

**Box 1: Components of Sanitation Infrastructure**

Sanitation infrastructure systems generally have four components. These are: 1) toilet, 2) collection, 3) treatment and 4) effluent/sludge disposal and reuse.

Each or all components can be located ***on-site***, meaning close to or at the source of waste generation. On-site systems usually serve a single or small group of households or enterprises. Complete on-site systems, where waste is collected, treated and disposed onsite, are called ***decentralized systems***.

Components or systems can also be located ***off-site*** or away from the source of waste generation.

***Centralized systems*** collect and treat large volumes of waste from households and establishments. The residual waste is then moved to areas located away from the communities.

*Source: Philippines Sanitation Sourcebook and Decision Aid*

- Social analysis, comprising an assessment of public awareness, willingness to connect (water supply and waste water treatment), willingness/ability to pay, appropriate tariff levels, potential role of semi-urban/rural communities etc. This analysis should result in an outline strategy for semi-urban/rural community development, social marketing, etc.;

- Calculation of indicative cost estimates (immediate, medium, long-term) and priority setting for implementation and/or construction;

- Outline action plan (immediate, medium, long-term), including funding arrangements for immediate and medium-term activities;

c) *Feasibility study and design of the preferred/selected alternative;*

d) *Organization of institutional arrangements and social marketing:*

- Comprehension of responsibilities of LGAs and existing community interest groups;

- Create public awareness through public campaigning and health & hygiene education, which could be facilitated by NGOs;

- Initiate semi-urban/rural community participation through involvement of Community Based Organizations (CBOs), which could be facilitated by NGOs;

- Create discussion and decisions-making platforms between LGAs and the users (semi-urban/rural community);

- Set-up of "committee" (community based or private organization) for O&M;

- Provide training and capacity building at local government and community level, including training of community facilitators;

e) *Construction of new and/or upgraded sanitation facilities;*

f) *Installation of house connections for water supply and sanitation and provision of improved services.*

### 7.1.2. Specific immediate and medium-term water supply and sanitation measures

Taking into account a project duration time of approximately five years, immediate and medium-term options for Decentralized Wastewater Treatment Systems (DEWATS, see Boxes 2 and 4) are proposed for the sub-project pilot areas. Options for centralized systems (conventional sewerage systems and wastewater treatment plants, see Box 3) are not included as they have much higher costs and are more appropriate as a long-term option in accordance with population density and growth.

**Box 2: Decentralized Wastewater Treatment Systems**

Decentralized wastewater treatment systems or DEWATS, is a client-centered approach to wastewater treatment, rather than simply a technical hardware package. It aims at introducing and designing the most appropriate combination of wastewater treatment technologies based on the needs of clients, considering their objectives, local conditions and financial means.

DEWATS seeks to ***involve the user in sanitation and wastewater management as much as possible***. Therefore, it combines participatory community/client consultation processes together with expert advice. DEWATS recognizes that one shortcoming of centralized systems is that they often leave users without any control over the provision of service.

The approach tries to avoid utilization of mechanical or energy-dependent parts and imported materials. Emphasis is on the utilization of locally available resources. It recognizes that centralized systems are often expensive to construct and difficult to operate and maintain. Thus, while the hardware introduced in DEWATS is based on standard engineering designs, the system includes only such technologies that are considered suitable for decentralized application, requiring only simple operation and maintenance.

It does not promote "ready-to-install prefabricated" technology. Instead, it uses a modular approach to system design in order to cater to particular needs. DEWATS engineers are trained to determine which modules to combine to deliver the best option for clients, depending on the kind of wastewater to be treated and the desired quality of the wastewater outflow.

*Source: Philippines Sanitation Sourcebook and Decision Aid*

#### 7.1.2.1. SEMI-URBAN AREAS – BOMET, MULOT, NYANGOTO & KEWANJA

The following options for sanitation facilities may be considered for the semi-urban areas, such as Bomet and Mulot in Kenya and Nyangoto and Kewanja in Tanzania (Sanitation Technology Fact Sheets are provided in Appendices A-M for the various sanitation options proposed):

1. *Developed urban area (households with water connections):*

For this area, the most appropriate option is improvement and/or development of on-site (per household) treatment or development of on-site decentralized (household clusters) treatment. The following options may be proposed:

A. Poor-flush toilets (Appendix A) with on-site treatment by a Septic Tank for individual houses;

B. Poor-flush toilets connected to a simplified "condominial" sewerage system (see Box 5) allowing several clustered households to be connected to a DEWAT: Septic Tank, Imhoff Tank or Anaerobic Baffled Reactor (Appendices B, C and D for more details on each treatment system). The effluent from these treatment systems is further treated through ground percolation or can be optimized by connecting to a simple trickling filter.

**Box 3: Sewerage System**

The ***sewerage system*** consists of a pit/hole, receptacle vessel and pipe network. Pipe networks can be conventional or simplified. A ***conventional sewer system*** uses gravity (and sometimes, pumps) to convey wastewater through the network. Pipes must be laid in a continuous incline. The system involves deep trenches and high digging costs.

***Simplified sewer*** *(or small bore sewerage)* systems operate similarly to their conventional counterpart, but pipe size is significantly reduced and laid in shallower trenches. This is made possible by adding a primary treatment step before conveyance, to separate solids and refine the wastewater that goes into the network. While conventional and simplified sewers transport wastewater only, *combined systems* transport household wastewater plus storm or rainwater. Storm drainage and canals are commonly used as combined systems.

*Source: Philippines Sanitation Sourcebook and Decision Aid*

2. *Less developed peri-urban area (outside town centre, households without water connections):*

For this area it is recommendable to install public taps for water supply throughout the area, unless people are able to afford and willing to pay for individual water connections. The choice of a sanitation facility depends on the income of the households. Lower-income households will most probably opt for private pit latrines or VIPs, while more well-off households may be able to afford a simple DEWAT. The following options may be proposed:

A. For lower-income households (on-site): (double) pit VIP latrines (Appendix E);

B. For higher-income households (on-site): DEWAT – Aqua Privy (small septic tank, Appendix F);

C. For small settlements and/or several clustered households (on-site):

- DEWAT simplified condominial sewerage system connected to one treatment system: Septic Tank, Imhoff Tank or Anaerobic Baffled Reactor;
- Public toilet block (Appendix G) with poor-flush toilets and possibly shower and laundry facilities, connecting to a DEWAT: Septic Tank, Imhoff Tank or Anaerobic Baffled Reactor.

**Box 4: DEWAT Technology**

The technology DEWATS uses is a combination of anaerobic and aerobic wastewater treatment processes. The use of combined processes allows DEWATS to link and enhance the treatment capacity of each independent stage/module. This addresses the limitations of a specific process when implemented as a stand-alone system. DEWATS uses four anaerobic process modules: ***bio-digester, septic tank, baffle reactor, and anaerobic filter***. There are two aerobic process modules: horizontal gravel filter and pond. These are implemented in combination with any or all of the anaerobic parts.

DEWATS is designed so that maintenance and daily management are reduced to a minimum. However, a trained person is needed to perform and record operation and maintenance. Though minimized, maintenance tasks are still necessary. For example, desludging due to the sludge accumulation in the tank needs to be done at regular intervals (once every two years). Monitoring and removal of scum in the anaerobic chambers, and harvesting of phragmytes plants in the horizontal gravel filter when over-grown are other required maintenance jobs.

DEWATS can be applied to housing settlements, as well as commercial, social and industrial uses, such as hospitals, hotels, universities/schools, slaughter houses, public markets, and food processing facilities.

*Source: Philippines Sanitation Sourcebook and Decision Aid*

**Box 5: Condominial Sewerage**

***Condominial sewerage***, a variation of *simplified sewerage* (see Appendix H) allows sewer pipes to pass through property lots rather than both sides of a street under conventional systems. The shorter grid of smaller and shallower feeder pipes running through the backyards allow shallower connections to the street sewers, effecting significant reductions in cost. In condominial sewerage, sewer pipes have to cross property lots. Property owners need to allow construction and maintenance of the infrastructure within their properties.

*Source: Philippines Sanitation Sourcebook and Decision Aid*

*3. Construction of public toilets in market place:*

For the market place and surrounding area, it is recommended to construct public taps for water supply and public toilet blocks (may also include shower and laundry facilities). The facility could either by operated, maintained and managed by the local community through a CBO or by a private operator. The collection of fees may be easily applied by applying a fee for toilet/shower use. The most appropriate option for treatment is to connect the public toilet block with poor-flush toilets to a DEWAT (Septic Tank, Imhoff Tank or Anaerobic Baffled Reactor). This treatment system can also easily be connected to a "condominial" sewerage system.

*4. Improvement of dumping site for septage[2] in Bomet:*

The existing dumping site for septic tank sludge in Bomet is now functioning more or less as a "leaching pit" (Appendix I), allowing the liquid portion of the wastes to seep into the ground whereas the solids are retained and accumulate in the pit and gradually seal the pores of the soil.

An assessment of the current location of the dumping site is recommended to determine if the site is environmentally friendly and that it does not generate any pollution of water sources. The site should be located downhill and at least 15m away from drinking water sources and wells. In this particular case, there should be sufficient distance from the river and its tributaries. If this is not the case, it is recommended to clean up the site and find a more suitable location, keeping in mind possible connection to a simplified sewerage system and possible future connection to a centralized sewerage system.

To improve the current dumping site, the following may be proposed:

A. As an immediate measure, it is recommended to rehabilitate the site with proper protection; installation of a tight cover to prevent access to mosquitoes, flies and surface water and rehabilitation of fence around the site;

B. Conversion of the dumping site from "leaching pit" to:

- an "engineered reed bed" (Appendix J) to treat the wastewater pollutants;

[2] *Septage* is the mix of liquid and solids in a septic tank (also referred to as "sludge"), which becomes a major source of pollution when it is disposed without effective treatment, either on land or in water bodies (*Source: Philippines Sanitation Sourcebook and Decision Aid*).

- a “sludge drying bed” (Appendix K) to dewater the sludge. The dried sludge needs to be removed and may be applied for agricultural use or sold as organic compost, possibly for use of biogas production (may be operated through a CBO or through private sector);

- a simple trickling filter system (Appendix L).

C. Introduction of a DEWATS by construction of an Imhoff Tank or an Anaerobic Baffled Reactor, keeping in mind possible future connection of nearby settlements or household clusters to this DEWATS.

#### *7.1.2.2. RURAL AREA – WEIGITA*

For a rural village like Weigita, a sanitation approach adapted to the rural situation and low-income of the people is recommended. Traditional sanitation programs, focusing on building latrines will be too expensive and most probably ineffective in changing behaviours which is needed to ensure that sanitation facilities are actually used over time.

In 1999, Dr. Kamal Kar from Bangladesh introduced the “Community-Led Total Sanitation (CLTS)” approach (see Box 6), which could be more appropriate for rural villages such as Weigita. CLTS emphasizes on communities’ own appraisal of their sanitation conditions and their realization of the need for behaviour change.

**Box 6: Community-Led Total Sanitation (CLTS)**

***Community-Led Total Sanitation (CLTS)*** is an innovative methodology for mobilising communities to completely eliminate ***open defecation (OD)***. Communities are facilitated to conduct their own appraisal and analysis of open defecation (OD) and take their own action to become ODF (open defecation free).

At the heart of CLTS lies the recognition that merely providing toilets does not guarantee their use, nor result in improved sanitation and hygiene. Earlier approaches to sanitation prescribed high initial standards and offered subsidies as an incentive. But this often led to uneven adoption, problems with long-term sustainability and only partial use. It also created a culture of dependence on subsidies. Open defecation and the cycle of faecal–oral contamination continued to spread disease.

In contrast, CLTS focuses on the behavioural change needed to ensure real and sustainable improvements – investing in community mobilisation instead of hardware, and shifting the focus from toilet construction for individual households to the creation of open defecation-free villages. By raising awareness that as long as even a minority continues to defecate in the open everyone is at risk of disease, CLTS triggers the community’s desire for collective change, propels people into action and encourages innovation, mutual support and appropriate local solutions, thus leading to greater ownership and sustainability.

*Source: http://www.communityledtotalsanitation.org/page/clts-approach*

The approach draws on and uses Participatory Learning and Action methods to enable communities to analyse their sanitation practices including open defecation, spread and flows of faecal-oral contamination that detrimentally affect them (*Source: Samuel Musembi Musyoki, 2007*). A very effective method is PHAST (Participatory Hygiene and Sanitation Transformation), which is a participatory approach that helps people to feel more confident about themselves and their ability to take action and make improvements in their communities. Feelings of empowerment and personal growth are as important as the physical changes, such as cleaning up the environment or building latrines (*Source: WHO, PHAST step-by-step guide, 1998*).

**Box 7: Factors for successful CLTS**

***At community level:***
- Starting in favourable conditions
- Ensuring right timing
- Good facilitation
- Supporting natural leaders
- Involving women, children and youth
- Verification, certification and celebrations
- Follow up: beyond ODF
- Timing of sanitation marketing

***Scaling up***
- Mentoring and coaching natural leaders
- Building high quality training capacity
- Organisational changes
- Supporting and multiplying champions
- Supportive policy environment and local ownership
- Role of the media
- Documentation, networking, sharing and learning

*Source: PLA 61, Tales of shit: Community-Led Total Sanitation in Africa, IIED, 2010*

Most proponents of CLTS advocate zero subsidies - no material support is given to households or communities - and focus on achieving sustained sanitation demand and behaviour change. Dr. Kamal Kar argues that subsidy only induces an attitude of expectation and dependency. Others are modifying this stance to argue for some subsidies for the poorest. CLTS does not prescribe latrine models- instead, it encourages the initiative and capacity of the community to take action and motivates them to spend their own money to build latrines themselves, not because they have been given the money to do so, but because they want to use them (*Source: USAID, Global Waters, January 2011*).

CLTS was effectively introduced in Africa in 2007. Cultural believes and taboos concerning defecation are key challenges in Africa where CLTS is concerned. Therefore, it is important to thoroughly understand and build on local cultural assumptions to initiate successful behaviour change.

The following sanitation measures may be proposed for Waigita Village:

1. *Introduction of CLTS by using PHAST:*

As an alternative to traditional sanitation, it is recommended to improve sanitation conditions through a participatory community approach. CLTS will ensure community involvement and behaviour change. A competent NGO with local experience and experience in CLTS should be mobilized to implement CLTS and PHAST. This should include the training of local leaders/champions and/or members of local CBOs.

2. *Awareness creation, WASH (Water, Sanitation and Hygiene) education and programming of WASH activities:*

In parallel with CLTS, it is recommended that awareness is created among the local community on WATSAN issues. This may be facilitated by NGOs by organizing trainings and workshops for WASH education and the programming of WASH activities (see Box 8). Furthermore, it is advisable to co-organize such awareness creation with the local dispensaries and LGAs and/or officers in charge of health safeguarding.

**Box 8: Priority WASH activities**

1. Treat and safely store drinking water at the point of use;
2. Wash hands with soap at critical times and with proper technique;
3. Safely handle and dispose of faeces;
4. Safely prepare, handle, and store food;
5. Ensure personal cleanliness of PLHIV (people living with HIV and AIDS) and OVCs (orphans and vulnerable children) and a clean environment.

*Source: Programming WASH activities, a toolkit for FY2010 planning, USAID)*

3. *Improvement of existing water sources and provision of additional water sources (wells, public taps, etc.):*

In Weigita people are partly depending on shallow wells. These wells need to be improved to ensure easier access to the well and to protected the water from pollution (e.g. from cattle). It is recommended to construct a cement ring around the well for easy access and provide a proper cover for protection.

To improve access to clean water, it is recommendable to install additional shallow wells and/or public taps for water supply throughout the area, which capture water from nearby natural springs (if present) and/or from groundwater (depending on quality and availability). It is recommended to set-up community water committees or train existing CBOs to manage the collection of water fees and O&M of these water supply facilities. These community mobilization activities can be facilitated by a NGO.

4. *Identification of suitable options for sanitation facilities:*

Due to the shallow groundwater level and the sandy soil, traditional pit latrines or VIPs are not really suitable for Weigita.

Two alternative solutions could be proposed:

- Construction of raised latrines. The walls of the pit can be extended above ground level using local materials such as wood, bamboo or stone. The lining is then surrounded by a bank of soil to prevent it collapsing and to support the toilet cubicle. In practice, it is normally only possible to raise latrines about 1 to 1.5m above ground level. Higher latrines are rarely acceptable to users (*Source: TNE 14.4, Technical options for excreta disposal in emergencies, WHO/WEDC, 2009*).

  In case of communal toilet blocks, an alternative is to construct the septic tank, Imhoff tank or anaerobic baffler reactor above ground and to construct the toilet block on top of the selected treatment system. For Weigita it is recommended to start with communal toilet blocks, managed, operated and maintained through the CLTS approach by the community through a committee or CBO.

- Construction of compost toilet (or eco-toilet/dry toilets) designed to be a highly effective solution to sanitation in high water table and waterlogged areas. The compost toilet is suitable for use by a family, or it can be built in clusters for institutions, schools, hostels and so on. However, it is recommended that the use of compost toilets is managed within the community and that very good education and awareness raising is done before building begins. Open access community compost toilets are not recommended other than in well-educated and highly motivated communities (*source www.practicalaction.com*)

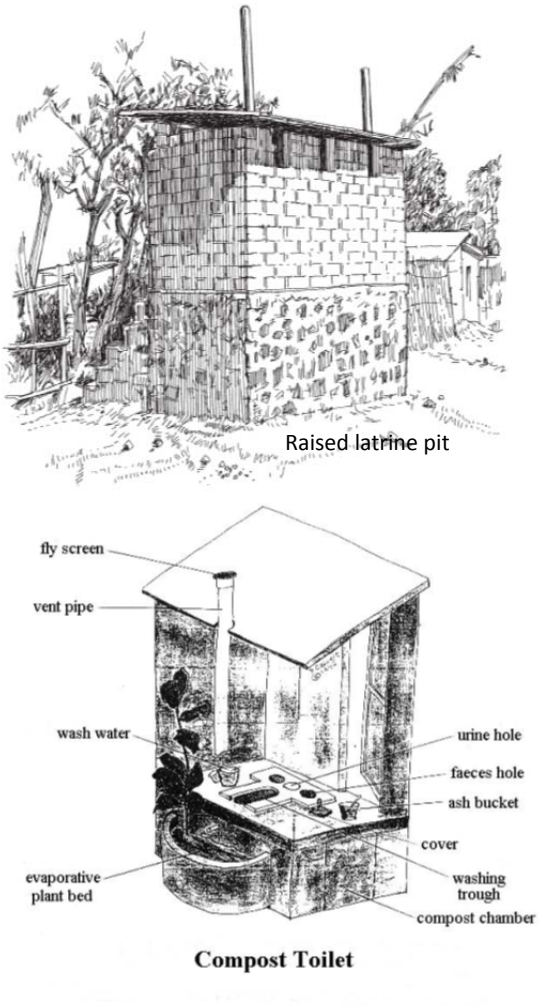



**Figure 2: Latrine Models**

*5. Installation of biogas reactor:*

As an alternative source of energy for use of household cooking and lighting, a biogas reactor (Appendix M) could be installed for the community of Weigita. To produce biogas, organic matter (animal manure, human waste, sludge, dried leaves and crop residues) can be used, which is readily available in a rural area such as Weigita. The biogas reactor should be community-owned and it is recommended that the same CBO and/or committee in charge of the communal toilet blocks takes responsibility of O&M for the biogas reactor.

### 7.1.3. Sub-project components

Four components have been designed to carry–out proposed activities under the sub-project 3A.

**Component 1: Preliminary activities**

- Participative identification of intervention areas
- Feasibility study and design for Sanitation Plan in each pilot area (DEWATS equipment and development of dumping sites for septage)

**Component 2: Community awareness and capacity building**

- Public campaigns for WASH education
- Creation of O&M committees
- Training sessions, workshops and visits for CMO, DTO/LGA officers and committee leaders
- Assist community groups to apply new technology: technical advice, improvement of organizational capacities (for households, LGA and government extension agencies)
- Production and dissemination of technical and communication support

**Component 3: Development of sanitation pilot projects in urban & semi urban areas (Bomet, Mulot, Nyangoto and Kewanja)**

- Technical and financial support to communities for the construction of public taps and toilet blocks (including showers and laundry) connected to a DEWATS at market place (provision of raw material and equipment)
- Technical and financial (subvention for raw material and equipment) support to individuals or clustered households for the construction of individual or simplified condominial DEWATS

**Component 4: Development of pilot water points/standposts and sanitation facilities in rural area (Weigita)**

- Geophysic survey of the water table to identify safe water sources
- Technical and financial support to communities for the construction of raised latrine pits or ecotoilets and standposts, water troughs for livestock (provision of raw material and equipment)

## 7.2. SUB-PROJECT 3B: SOLID WASTE MANAGEMENT

### 7.2.1. Proposed activities and means

For improvement of solid waste management the following steps and activities are proposed for each sub-project:

a) *Detailed assessment of current existing solid waste collection facilities and solid waste management. The assessment should at least include, but not be limited to the following aspects:*

- Situation analysis regarding waste characterization and waste generation (source, composition and quantities), primary and secondary waste collection and storage, waste transportation, waste segregation, reuse and recycling, waste treatment and waste disposal;

- Identification of responsible regional/local government authorities and analysis of the institutional arrangements concerning solid waste management and of (peri-urban/rural) community roles and participation;

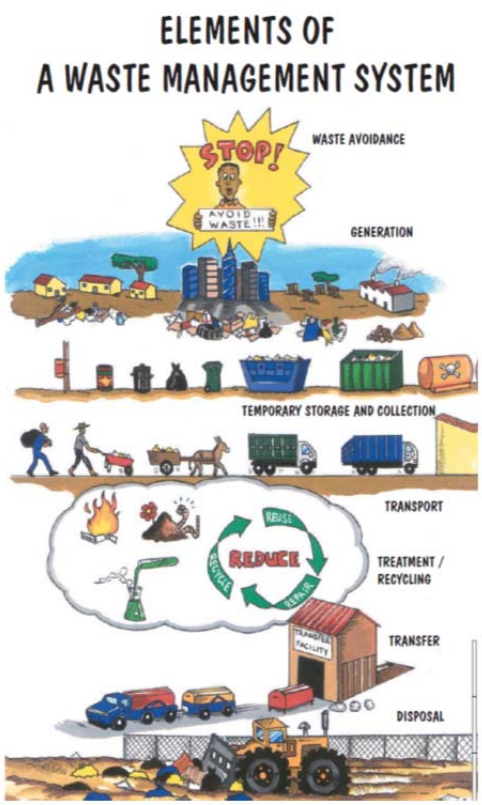
- Assessment of current expenditures for solid waste management;

- Assessment of current health and environmental impacts of solid waste;

- Analysis of the role of the private sector in solid waste collection, reuse and recycling.

b) *Development of immediate/medium/long-term Solid Waste Management Strategy/Plan addressing the following issues:*

- Determination of scale of the solid waste management strategy/plan; solid waste management at regional and/or local level, taking into account cost-saving and the need for higher quantities of waste for recycling. An assessment should be done of the cities/towns/centres in the area generating waste and how the neighbouring cities/towns can collaborate on the issue of final waste disposal (e.g. regional waste disposal site);




*Source: Guideline recycling of solid waste, Department Environmental Affairs &*

**Figure 3: Waste Management system**

- Determination of appropriate solid waste primary collection sites (depending on population density and road access), installation of appropriate collection equipment (waste bins, containers, skip loaders, etc.) as well appropriate transport modes (garbage collection vehicles, trucks, trailers, etc.) for secondary collection and transfer stations if needed;

- Determination of most appropriate method for waste disposal (protected dumping site for segregated waste, sanitary land fill, incineration, etc.), taking into account a long-term regional approach (more details on regional approach are given in the next paragraph);

- Analysis of the availability of financial resources and/or subsidies, including both capital (investment) costs and recurrent costs for (O&M);

- Social analysis, comprising an assessment of public awareness, willingness to reduce waste by reuse and recycling of waste, willingness/ability to pay for waste collection services, potential role of semi-/peri-urban/rural communities etc. This analysis should result in an outline strategy for semi-/peri-urban/rural community participation in waste reduction and proper solid waste management;

- Calculation of indicative cost estimates (immediate, medium, long-term) and priority setting for implementation and/or construction;

- Outline action plan (immediate, medium, long-term), including funding arrangements for immediate and medium-term activities;

g) *If applicable, feasibility study and design of the preferred/selected alternative;*

h) *Organization of institutional arrangements and social marketing:*

- Comprehension of responsibilities of LGAs (waste collection, street cleaning, final disposal, etc.);

- Create public awareness through public campaigning on environment, health and hygiene, which could be facilitated by NGOs;

- Initiate semi-/peri-urban/rural community participation through involvement of Community Based Organizations (CBOs), which could be facilitated by NGOs;

- Create discussion and decisions-making platforms between regional/local government authorities and the semi-/peri-urban/rural community;

- Set-up of "committee" (community based or private organization) for solid waste management, primary waste collection and O&M.

*i) Construction of new and/or upgraded solid waste collection sites/points and final waste disposal site;*

*j) Provision of improved waste collection and waste disposal services.*

### 7.2.2. Specific immediate and medium-term solid waste management measures

Taking into account a project duration time of approximately five years, immediate and medium-term measures to improve existing solid waste collection and disposal are proposed for the sub-project pilot areas.

#### *7.2.2.1. SEMI-URBAN AREAS – BOMET, MULOT, NYANGOTO & KEWANJA*

The following measures may be considered for the semi-urban areas, such as Bomet and Mulot in Kenya and Nyangoto and Kewanja in Tanzania:

*1. Development of a regional Solid Waste Management approach:*

A proper solid waste management strategy/plan should be developed with responsible regional/local government authorities. This plan should describe the approach for waste reduction, collection and disposal and contain short/medium/long-term measures. Taking into consideration population growth, a regional approach through partnerships between neighbouring towns and cities for solid waste management may be considered. This would allow for a regional disposal site, such as a sanitary landfill with proper treatment of leachate as well as possibilities to segregate waste at larger scale, as large amounts reusable waste are needed for recycling. Following the "economy of scale", a regional approach will reduce capital costs and provide more budget flexibility for purchasing of appropriate waste transportation vehicles, development of transfer stations and enhance provision of adequate collection services. Waste incineration is not considered as a viable option, due to very large capital investments and high maintenance costs.

*2. Solid waste collection points and waste transportation:*

- Improvement of existing collection points to avoid the scattering of waste. Proper collection bins or containers should be installed with easy access for people and transport vehicles, but protected from cattle or other animals. If adequate, it would be best to include separate compartments for waste segregation (separate plastics from glass and cardboard and organic waste, etc.). This could first be applied as a pilot at market places and centres;

- Procurement of appropriate waste collection transport facilities (trucks, trucks with trailers, etc.). Primary collection from households could be managed by the peri-urban/rural community through CBOs and segregated waste can be collected from door-to-door (push carts, trailers, animal-drawn carts, etc.). Households should be willing to pay a collection fee for these services;

- Improvement of street cleaning activities, which should be done on regular basis. Community involvement could be organized through CBOs.

*3. Public awareness creation and community mobilization:*

- Through CBOs, create awareness and sense of responsibility regarding solid waste reduction and environmental safeguarding as well as health. Possible methods are public campaigning at town level and/or "green and clean" campaigning and competitions neighbourhood/community level;

- Introduce and mobilize waste segregation activities with CBOs and/or women groups by applying the 4R strategy (Reduce – Reuse – Recycle – Repair), including composting methods.

**Examples of composting activities by communities in Tanzania and Mali (*Source: Internet*)**

4. *Identification of markets and private sector involvement:*

- Regional/local markets need to be identified for recycled waste such as plastics, glass, metal, etc. Through CBOs and women groups, plastic and metal can be reused and recycled by making baskets, bags, hats, children toys, etc.

- The private sector can be involved for the collection of segregated waste, which can then be sold to entrepreneurs at regional/local level.

**Examples of recycling activities in South Africa (*Source: Internet*)**

5. *Improvement and possible relocation of current dumping site in Bomet:*

- The current dumping site is not up to standard, is not protected from scavenging and is sensitive to wind and rain. Furthermore, it is located near the river which causes water pollution, especially in times of rain. Immediate measures need to be taken to improve the site and convert it into a controlled dumping site by fencing, planting of bushes or construction of walls to avoid waste scattering and run-off. Furthermore, the possibility to construct perimeter drains to catch run-off and leachate should be considered;

- Identification of alternative dumping site, which is adequate for the amount of waste collected and taking into account population growth and possible development of a regional disposal site. The site should not be located near the river and should be protected.

#### *7.2.2.2. RURAL AREA – WEIGITA*

As explained in paragraph 6.4.3, solid waste management is not yet an urgent issue in Weigita Village. However, it is recommended to include the topic of sustainable solid waste management and safeguarding a clean and green environment in the WASH trainings and workshops.

### 7.2.3. Sub-project components

Three components have been designed to carry–out proposed activities under the sub-project 3B.

**Component 1: Preliminary activities**

- Participative identification of intervention areas
- Feasibility study and design for Solid Waste Management Plan in each pilot area (including location and development of dumping site)

**Component 2: Community awareness and capacity building**

- Public campaigns for environment, health and hygiene education
- Creation of Management Committees for solid waste collection/dumping site O&M
- Training sessions, workshops and visits for CMO, DTO/LGA officers and committee leaders
- Assistance to community groups: technical advice, improvement of organizational capacities (for households, LGA and government extension agencies)
- Production and dissemination of technical and communication support

**Component 3: Development of waste management pilot projects**

- Technical and financial support to communities for primary collect organisation and waste segregation (including street cleaning operations) and collection points management
- Support creation or partnership with small business for secondary waste transportation and dumping site O&M
- Support to market research and partnership building with specialized firm for waste recycling

## 7.3. SUB-PROJECT 3C: ALTERNATIVE MINING PRACTICES

### 7.3.1. Proposed activities and means

The sub-project is focused on both artisanal and small-scale miner communities and could contribute to improvement of health, environmental and social conditions of the sector in the targeted area, through 2 main entry-points:

- Awareness and information:
  - on laws and regulation framing the ASM sector (mining policy), mainly through support to extension services;
  - on the benefits to establish "Miners Associations" or equivalent small organizations whose members have similar interests and can organize training through interaction with various institutions. Such associations could also adhere to the regional platform.
  - on health risks incurred by careless use of mercury, including natural environment pollution and bio-accumulation in fishes.
- Dissemination of practical solutions for the reduction of unacceptable occupational exposure to Hg vapours and Hg losses to the environment and cleaner technologies.

This sub-project will build on experience of a previous project driven in Tanzania by GEF-UNIDO-UNDP called Global Mercury Project (GMP), began in 2002, with similar objectives to introduce cleaner technologies in artisanal and small-scale gold mining. Notably this project edited booklets translated in Swahili with the following titles:

- Mercury and health
- How to use and re-use Mercury
- How to protect your water
- How to get more gold

#### *7.3.1.1. COMMUNITY AWARENESS AND INFORMATION*

A training needs assessment will be carried out, covering the various levels of participating stakeholders. On the basis of accumulative needs, a sensitization and training program will be defined and implemented.

The awareness campaign will be designed with the objectives of improvement in gold recovery and reduction in mercury use and or loss, and enhanced awareness of the health risks of exposure to mercury. The campaign will target the miner's communities as a whole in order to increase pression of the miners environment for improving mining conditions and particularly regarding air pollution by mercury.

#### *7.3.1.2. PROPOSED MEAN FOR DISSEMINATION OF NEW PRACTICES*

Introduction of ore processing centers is a good solution to improve and secure practices. Nevertheless a preliminary option could be, as developed during the GMP project, the use of a transportable demonstration unit (TDU) for demonstration of appropriate equipment throughout the mining area. It is easier to bring transportable demonstration unit to several thousand people than to bring people to a demonstration processing site.

The main components of the TDU are:

- a platform (or container) to transport and secure all pieces of equipment
- a tent or any type of structure to be used as a portable classroom
- a generator

These units must work as pilot plants only for training.

The capital cost for manufacture the Transportable Demonstration Unit (TDU) includes the costs of equipment, supporting structure (truck bed or container), all ancillaries (wires, pipes, etc.), the tentto be used as classroom and dormitory, power generator, and all labour, supervision and field expenses for first transportation, installation, start-up and short training

#### *7.3.1.3. IDENTIFICATION AND PROMOTION OF ALTERNATIVES TECHNIQUES*

The cyanidation process may not be financially or technically accessible to artisanal and small-scale miners. Moreover, it should be used and implemented with caution because of the significant risks it entails for human health and the environment. This cleaner technique is implemented in small plants by medium scale miners for re-processing tailings from ASM sites.

For ASM, alternatives techniques and equipment to be promoted will have to be chosen, targeting improvement in the successive steps of a simple mineral processing cycle used by artisanal miners.

The pieces of equipment to be demonstrated and promoted to miners must follow some criteria:

- Must not be very complex (technical knowledge)
- Must be accessible (preferentially locally manufactured)
- Must be inexpensive and locally maintained

The table below gives some example of cleaner equipment to be promoted

**Table 1: Example of cleaner equipment to be promoted**

| Gold extraction step | Equipment |
|---|---|
| Raw material preparation (comminution/classification) | Jaw Crusher / Ball mill |
| Gravity concentration | Sluice boxes |
| Amalgamation | Amalgamation barrels special amalgamation plates |
| Separation of heavy metals from amalgam | Panning in cement tanks / elutriator / Spiral pan |
| Removing excess mercury | Centrifuge to remove excess mercury |
| Retorting: Separation of gold from amalgams | Retorts / Home-made retorts (different types) |

The project will also particularly insist on:

- Building partnerships with medium scale miners for re-processing of tailings using cleaner cyanide extraction technics
- Organization of processing centers allowing more control in gold production and facilitating the introduction of cleaner techniques
- Dissemination of cleaner technologies/equipment and safety equipment

Training of local manufacturers in providing new equipment will be part of the sub-project

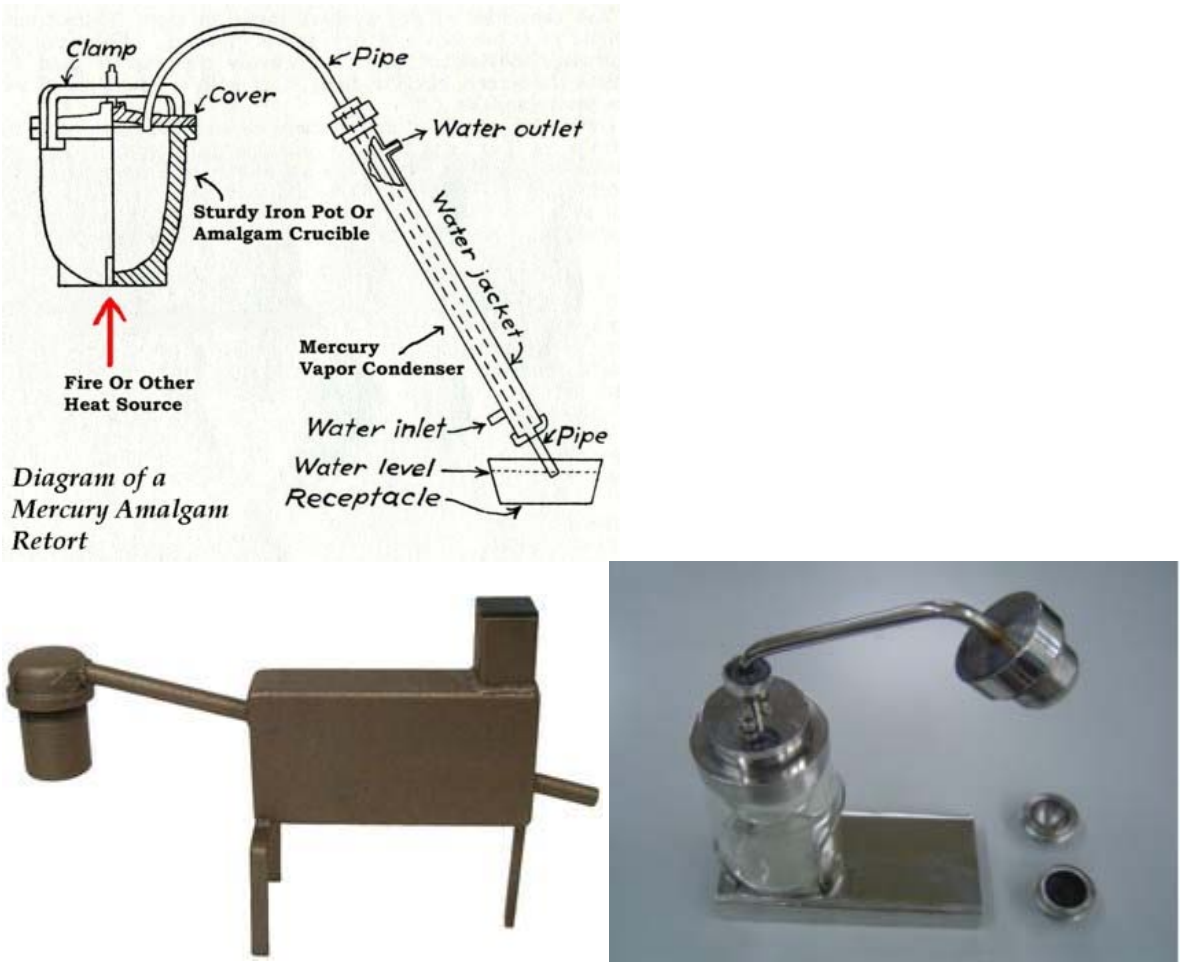



**Figure 4: Simple technology for retorts**

### 7.3.2. Sub-project components

In order to address the above issues and carry-out proposed activities, the sub-project 3C has been organized in 3 complementary components.

**Component 1: Preliminary Activities**

- Participative identification of miner communities that could be targeted by the project
- Preliminary identification of innovating techniques/practices to be promoted

**Component 2: Capacity Building and awareness campaign**

- Community organisation and implementation of miners associations
- Training sessions for technical officers and extension staff and ASM association leaders
- Production and dissemination of technical and communication supports
- Awareness campaign for ASM communities on field

**Component 3: Sustainable practices promotion**

- Organisation of processing centres equipped with cleaner techniques
- Building partnerships with medium scale miners (re-treatment of tailings)
- Support of suppliers and manufacturers of tools and machinery
- Revolving funds for establishment of improved techniques and equipment

# 8. IMPLEMENTATION FRAMEWORK

The project is planned to start with a first phase of five years, anticipating that donors see the necessity of longer term commitment to achieve tangible impacts on watershed conditions.

#### *8.1.1.1. IMPLEMENTATION FRAMEWORK FOR SUB-PROJECTS 3A & 3B*

The sub-projects 3A and 3B will be carried out from Kenya MR-IWMP coordination office since the most highly populated pilot areas of the sub-projects are located in Kenya.

The following full time staff members will be posted in the two IWMP coordination offices:

- A WATSAN specialist in Bomet
- A liaison officer in Tanzania
- 3 District Technical Officer (DTO) for Sanitation and 5 Community mobilization working with CBO's/O&M Committees leaders (5 persons)

Inputs will be provided by:

- Consultancies of international and national specialists (WATSAN, solid waste management, sustainable mining, community participation, etc.);
- Training and technical support possibly coming from NGOs with experience in WATSAN, solid waste management and community participatory methods working closely together with existing CBOs or newly set-up CBOs/WATSAN committees for the project;
- Equipment for Demonstration Transportable Units (DTU) for cleaner mining technology training
- Subsidiary for raw material and specialized equipment and access to revolving funds for implementation of new equipment

Some capacity will be reserved for unforeseen ad-hoc consultancies (10 months), for example for NGO program development and monitoring.

The project will employ community mobilization officers (CMO). For each pilot area one CMO will be specialized in WATSAN and the other in solid waste management. For the sub-project alternative mining practices the CMO should have experience in mining pollution issues. The CMOs will work closely together with DTOs seconded to the project.

The WATSAN coordination officer (based in Bomet at the IWMP coordination office) with its liaison officer (based in Musoma - Kenya at the IWMP coordination office) are responsible for coordination, planning of activities and monitoring progress. CMOs and DTOs will be the driving force in sanitation and waste management improvement in the sub-project areas. Contacts with other line agencies and stakeholder organizations will be more irregular and according to arising needs.

Experienced NGOs will be identified and requested to prepare a proposal for a WATSAN program (including all community facilitation and participation activities related to sanitation and solid waste management) for the pilot areas. The NGO with the winning proposal will be selected to implement the program (one NGO for Kenya and one for Tanzania) and perform community facilitation through CBOs and/or community WATSAN committees.

For the introduction of new technologies, contacts will be made with specialized organizations in the respective field, and contributions to the project will be effectuated on the basis of signed agreements.

In all technical, administrative or financial matters, the project will directly report to the PMU through technical reports, consultancy reports, progress reports, and monitoring reports. Funding lines will be

directly from the PMU to the project; or be directly from the PMU to a partner institution providing services to the project, on the basis of agreements that are also approved by the PMU.

#### *8.1.1.2. IMPLEMENTATION FRAMEWORK FOR SUB-PROJECT 3C*

The sub-project 3C will be carried out from Tanzania MR-IWMP coordination office since artisanal and small scale mining area is mainly located in the Tighite river basin.

A dedicated technical officer will be posted in the Tanzanian IWMP coordination offices:

- 1 District Technical Officer (DTO) for AS Mining working with 2 Community Mobilization Officers
- 2 Project-employed Community Mobilization Officers (CMOs) will guide the process of community sensitization and organization. They will work together with the District Commissioner for Mineral Resources in charge of the region.

Activities will target both already existing associations and small groups of more or less illegal miners. Therefore the CMOs and DTO will have to be very flexible in their way of intervention and implemented means to reach each type of community.

# 9. PROJECT MONITORING

## 9.1. INDICATORS

Performance indicators have been proposed to reflect the progress of the sub-project implementation and impacts of activities undertaken under the different components of the sub-project. The performance indicators for sub-project progress and outcomes are presented in the table below.

## 9.2. SCHEDULE

According to the general schedule proposed for monitoring and evaluation, indicators will be informed to allow drafting of semi-annual and annual reports.

Table 2 Performance indicators

| KEY OUTPUTS | PERFORMANCE INDICATOR<br><br>SUB-PROJECT PROGRESS/OUTCOMES | PERFORMANCE INDICATOR<br><br>SUB-PROJECT IMPACTS |
|---|---|---|
| A. Targeted zones/clusters are identified and mapped in each pilot town or village according to various categories and subsequently Sanitation and Solid Waste Management Strategies/Plans are prepared for each pilot town or village; | ▪ GIS files for mapping<br>▪ Plans prepared and submitted to village authorities | |
| B. Adequate water supply, sanitation and solid waste collection and disposal facilities are identified and designs for implementation/construction are prepared; pilot operations are implemented | ▪ Design of facilities | ▪ Implementation of pilot operations on field |
| C. Community based organizations (CBOs) or committees are established and operational for each water supply, sanitation and solid waste collection facility (pilote operations) | ▪ Minutes of regular CBO meetings | ▪ Adequate maintenance of pilot construction/equipement |
| D. NGOs with experience in WASH education and implementation of Community-Led Total Sanitation (CLTS) have been identified and recruited; | ▪ List of NGOs with relevant references | |
| E. WASH education and Participatory Health and Sanitation Transformation (PHAST) have been implemented through LGAs and/or NGOs; | ▪ Documents used for WASH education training | |
| F. Extension staff are equipped and trained to organize, facilitate and provide on-going support to operational NGOs and/or CBOs and to apply participatory extension for sanitation and waste management; | ▪ List of trained staff<br>▪ Content of training course | ▪ Extension staff and CMO familiar with new techniques and practices |
| G. Communities adopt and apply WASH activities, techniques and practices; | ▪ Report from communities | ▪ New techniques and practices in use |

| KEY OUTPUTS | PERFORMANCE INDICATOR<br><br>SUB-PROJECT PROGRESS/OUTCOMES | PERFORMANCE INDICATOR<br><br>SUB-PROJECT IMPACTS |
|---|---|---|
| H. Miners adopt alternative mining practices and techniques to safeguard water quality and health conditions; | ▪ Report from miners<br>▪ Reports from Government officers on mining practices | ▪ New cleaner equipment in use<br>▪ Miners Community health |
| I. Partnerships between the community and the private sector for recycling of waste are created and communities are able to generate income from recycled waste; | ▪ MOU or contract established with private groups for recycling | ▪ Recycling activity carried-out<br>▪ Income from recycling activities |
| J. Small scaled enterprises are developed in the watershed to promote commercialization of compost, reusable waste and handicraft products made from recycled plastics, metals, cardboard, etc. | ▪ Report and visual proof of use of recycled material and compost | ▪ Diversification of income |
| K. Knowledge networks for exchanging experiences are established at local and transboundary levels. | ▪ Minutes of inter-community and trans-boundary meetings | ▪ Level of solidarity and decision making power |

# 10. ROUGH COST ESTIMATES

## 10.1. QUANTITIES

Cost estimation is based on the following quantities:

**Pilot Bomet: (***For 1-2 pilot zones):*

- 1 condominial sewerage connected to a DEWATS (Imhoff tank, anaerobic baffled reactor…);
- 1 public toilet block connected to a DEWATS for the market area;
- A number of ventilated improved latrine pits;
- Convert leaching pit for septage into a “sludge drying bed”;
- Budget for improved waste collections points and for improvement final disposal site.

**Pilot Mulot, Nyangoto & Kewanja:**

- Public toilet blocks connected to a DEWATS for the market areas;
- A number of ventilated improved latrine pits;
- Budget for waste bins, and equipment for waste collection.

**Pilot Weigita:**

- 1 Pilot public toilet block connected to a DEWATS near the central meeting point or shops;
- A number of raised ventilated improved latrine pits.

**ASM practices:**

- 1 fully operational Transportable Demonstration Unit (TDU)

## 10.2. COST ESTIMATES

Based on the activities proposed above, the investment cost for a 5-year project has been assessed at an amount of **USD 4 461 000** with the following breakdown:

| Investment Project / sub-projects | **Cost (‘000 USD)** |
|---|---|
| Water supply and sanitation | 2,434 |
| Solid waste management | 765 |
| Alternative mining practices | 1,262 |
| **Total** | **4,461** |

The detailed cost estimates are given in the tables below for each of the 3 sub-projects.

## *Sub-project 3A. Water supply and Sanitation*

| Activity | Unit | Quantities | | | | | | Unit Cost | Totals USDx'000 | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | year 1 | year 2 | year 3 | year 4 | year 5 | Total | ($x'000) | year 1 | year 2 | year 3 | year 4 | year 5 | Total |
| 3A. Water supply & Sanitation | | | | | | | | | | | | | | |
| 1 WM Field staff = current cost | | | | | | | | | | | | | | |
| Sanitation Project officer /extension staff 2 (1 per district shared with 3B) | pmonth | 24,00 | 24,00 | 24,00 | 24,00 | 24,00 | 120,00 | 2,00 | 48,00 | 48,00 | 48,00 | 48,00 | 48,00 | 240,00 |
| Sanitation Community Mobilization facilitators 3 (1 per pilot site shared with 3B) | pmonth | 36,00 | 36,00 | 36,00 | 36,00 | 36,00 | 180,00 | 2,00 | 72,00 | 72,00 | 72,00 | 72,00 | 72,00 | 360,00 |
| Commiittee leader 3 = 1 per pilot site (10% time) shared with 3B | pmonth | 36,00 | 36,00 | 36,00 | 36,00 | 36,00 | 180,00 | 0,10 | 3,60 | 3,60 | 3,60 | 3,60 | 3,60 | 18,00 |
| Subtotal 1 | | | | | | | | | 123,60 | 123,60 | 123,60 | 123,60 | 123,60 | 618,00 |
| | | | | | | | | | | | | | | |
| 2 Equipment/Material | | | | | | | | | | | | | | |
| Equipement set for project staff | unit | 8,00 | | | 4,00 | | 12,00 | 1,20 | 9,60 | 0,00 | 0,00 | 4,80 | 0,00 | 14,40 |
| Subsidiary fund for sanitation committees equipement | Lumpsum | 3,00 | | | 2,00 | | 5,00 | 1,00 | 3,00 | 0,00 | 0,00 | 2,00 | 0,00 | 5,00 |
| Motorbikes for DTO & CMO + committee leaders | unit | 8,00 | | | 2,67 | | 10,67 | 3,00 | 24,00 | 0,00 | 0,00 | 8,00 | 0,00 | 32,00 |
| Subsidiary fund for sanitation raw material (subvention) | Lumpsum | 25,00 | 50,00 | 100,00 | 150,00 | 250,00 | 575,00 | 2,00 | 50,00 | 100,00 | 200,00 | 300,00 | 500,00 | 1 150,00 |
| Subtotal 2 | | | | | | | | | 86,60 | 100,00 | 200,00 | 314,80 | 500,00 | 1 201,40 |
| | | | | | | | | | | | | | | |
| 3 Workshops & meetings | | | | | | | | | | | | | | |
| Workshops and meetings (2 per year/site) | lumpsum | 10 | 10 | 10 | 10 | 10 | 50 | 1,75 | 17,50 | 17,50 | 17,50 | 17,50 | 17,50 | 87,50 |
| Community visits costs by location (5 persons from 5 locations during 3 days/year) | lumpsum | 5 | 2,5 | 2,5 | | 5 | 15 | 7,50 | 37,50 | 18,75 | 18,75 | 0,00 | 37,50 | 112,50 |
| Subtotal 3 | | | | | | | | | 55,00 | 36,25 | 36,25 | 17,50 | 55,00 | 200,00 |
| | | | | | | | | | | | | | | |
| 4 Transport & other operation costs | | | | | | | | | | | | | | |
| Motorbikes operating costs 12 (1 per DTO/CMO) | pmonth | 96 | 96 | 96 | 96 | 96 | 480 | 0,05 | 4,80 | 4,80 | 4,80 | 4,80 | 4,80 | 24,00 |
| Subtotal 4 | | | | | | | | | 4,80 | 4,80 | 4,80 | 4,80 | 4,80 | 24,00 |
| | | | | | | | | | | | | | | |
| 5 Consultancies | | | | | | | | | | | | | | |
| Preliminary surveys sanitation projects (national) | permonth | 6 | 3 | | | | 9 | 6,00 | 36,00 | 18,00 | 0,00 | 0,00 | 0,00 | 54,00 |
| Preliminary survey for Bomet waste dumping site (international) | permontth | 3 | | | | | 3 | 19,00 | 57,00 | 0,00 | 0,00 | 0,00 | 0,00 | 57,00 |
| Preliminary surveys for ASM subproject (national) | pmonth | 3 | 2 | | | | 5 | 6,00 | 18,00 | 12,00 | 0,00 | 0,00 | 0,00 | 30,00 |
| Community Mobilization officers trainer/adviser | pmonth | 2 | 2 | 1,00 | | | 5 | 6,00 | 12,00 | 12,00 | 6,00 | 0,00 | 0,00 | |
| Training district extension officers trainer/adviser | pmonth | 2 | 2 | 1,00 | | | 5,00 | 6,00 | 12,00 | 12,00 | 6,00 | 0,00 | 0,00 | 30,00 |
| Subtotal 5 | | | | | | | | | 135,00 | 54,00 | 12,00 | 0,00 | 0,00 | 201,00 |
| | | | | | | | | | | | | | | |
| 6 Revolving Funds | | | | | | | | | | | | | | |
| Fund to support DEWATS buidling | lumpsum | 5,00 | 15,00 | 15,00 | 15,00 | 15,00 | 65,00 | 2,00 | 10,00 | 30,00 | 30,00 | 30,00 | 30,00 | 130,00 |
| Subtotal 6 | | | | | | | | | 10,00 | 30,00 | 30,00 | 30,00 | 30,00 | 130,00 |
| | | | | | | | | | | | | | | |
| 7 Environmental and Social Monitoring | percent | | | | | | | 2,50% | 10,38 | 8,72 | 10,17 | 12,27 | 17,84 | 59,36 |
| Subtotal 7 | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | |
| Subtotal 3A | | | | | | | | | 425,4 | 357,4 | 416,8 | 503,0 | 731,2 | 2 433,8 |

## *Sub-project 3B. Solid Waste Management*

| Activity | Unit | Quantities | | | | | | Unit Cost | Totals USDx'000 | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | year 1 | year 2 | year 3 | year 4 | year 5 | Total | | year 1 | year 2 | year 3 | year 4 | year 5 | Total |
| 3B. Solid Waste Management | | | | | | | | | | | | | | |
| 1 WM Field staff = current cost | | | | | | | | | | | | | | |
| Sanitation Project officer /extension staff 1 (1 per district shared with 3A) | pmonth | 12,00 | 12,00 | 12,00 | 12,00 | 12,00 | 60,00 | 2,00 | 24,00 | 24,00 | 24,00 | 24,00 | 24,00 | 120,00 |
| Solid waste Community Mobilization facilitators 2 (1 per pilot site shared with 3A) | pmonth | 24,00 | 24,00 | 24,00 | 24,00 | 24,00 | 120,00 | 2,00 | 48,00 | 48,00 | 48,00 | 48,00 | 48,00 | 240,00 |
| Commiittee leader 2 (1 per pilot site (10% time) shared with 3A) | pmonth | 24,00 | 20,00 | 20,00 | 20,00 | 20,00 | 104,00 | 0,10 | 2,40 | 2,00 | 2,00 | 2,00 | 2,00 | 10,40 |
| | | | | | | | | | | | | | | |
| Subtotal 1 | | | | | | | | | 74,40 | 74,00 | 74,00 | 74,00 | 74,00 | 370,40 |
| | | | | | | | | | | | | | | |
| 2 Equipment/Material | | | | | | | | | | | | | | |
| Equipement set for project staff | unit | 5,00 | | | 2,00 | | 7,00 | 1,20 | 6,00 | 0,00 | 0,00 | 2,40 | 0,00 | 8,40 |
| Subsidiary fund for sanitation committees equipement | Lumpsum | 2,00 | | | 1,00 | | 3,00 | 1,00 | 2,00 | 0,00 | 0,00 | 1,00 | 0,00 | 3,00 |
| Motorbikes for DTO & CMO + committee leaders | unit | 5,00 | | | 1,67 | | 6,67 | 3,00 | 15,00 | 0,00 | 0,00 | 5,00 | 0,00 | 20,00 |
| Subsidiary fund for waste collection and storage | Lumpsum | 4,00 | | | 2,00 | | 6,00 | 2,00 | 8,00 | 0,00 | 0,00 | 4,00 | 0,00 | 12,00 |
| Subtotal 2 | | | | | | | | | 31,00 | 0,00 | 0,00 | 12,40 | 0,00 | 43,40 |
| | | | | | | | | | | | | | | |
| 3 Workshops & meetings | | | | | | | | | | | | | | |
| Workshops and meetings (2 per year/site) | lumpsum | 10 | 10 | 10 | 10 | 10 | 50 | 1,75 | 17,50 | 17,50 | 17,50 | 17,50 | 17,50 | 87,50 |
| Community visits costs by location (5 persons from 5 locations during 3 days/year) | lumpsum | 5 | 2,5 | 2,5 | | 5 | 15 | 7,50 | 37,50 | 18,75 | 18,75 | 0,00 | 37,50 | 112,50 |
| Subtotal 3 | | | | | | | | | 55,00 | 36,25 | 36,25 | 17,50 | 55,00 | 200,00 |
| | | | | | | | | | | | | | | |
| 4 Transport & other operation costs | | | | | | | | | | | | | | |
| Motorbikes operating costs 12 (1 per DTO/CMO) | pmonth | 60 | 60 | 60 | 60 | 60 | 300 | 0,05 | 3,00 | 3,00 | 3,00 | 3,00 | 3,00 | 15,00 |
| Subtotal 4 | | | | | | | | | 3,00 | 3,00 | 3,00 | 3,00 | 3,00 | 15,00 |
| | | | | | | | | | | | | | | |
| 5 Consultancies | | | | | | | | | | | | | | |
| Preliminary surveys sanitation projects (national) | permonth | 1 | | | | | 1 | 6,00 | 6,00 | 0,00 | 0,00 | 0,00 | 0,00 | 6,00 |
| Preliminary survey for Bomet waste dumping site (international) | permonth | 3 | | | | | 3 | 18,00 | 54,00 | 0,00 | 0,00 | 0,00 | 0,00 | 54,00 |
| Community Mobilization officers trainer/adviser | pmonth | 1 | 1 | 0,50 | 0,50 | 0,50 | 4 | 6,00 | 6,00 | 6,00 | 3,00 | 3,00 | 3,00 | |
| Training district extension officers trainer/adviser | pmonth | 1 | 1 | 0,50 | 0,50 | 0,50 | 3,50 | 6,00 | 6,00 | 6,00 | 3,00 | 3,00 | 3,00 | 21,00 |
| Subtotal 5 | | | | | | | | | 72,00 | 12,00 | 6,00 | 6,00 | 6,00 | 102,00 |
| | | | | | | | | | | | | | | |
| 6 Revolving Funds | | | | | | | | | | | | | | |
| Fund to support Waste collection and recycling activities | lumpsum | 2,00 | 2,00 | | 4,00 | | 8,00 | 2,00 | 4,00 | 4,00 | 0,00 | 8,00 | 0,00 | 16,00 |
| Subtotal 6 | | | | | | | | | 4,00 | 4,00 | 0,00 | 8,00 | 0,00 | 16,00 |
| | | | | | | | | | | | | | | |
| 7 Environmental and Social Monitoring | percent | | | | | | | 2,50% | 5,99 | 3,23 | 2,98 | 3,02 | 3,45 | 18,67 |
| Subtotal 7 | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | |
| Subtotal 3B: | | | | | | | | | 245,4 | 132,5 | 122,2 | 123,9 | 141,5 | 765,5 |

## *Sub-project 3C. Alternative Mining Practices*

| Activity | Unit | Quantities | | | | | | Unit Cost | Totals USDx'000 | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | year 1 | year 2 | year 3 | year 4 | year 5 | Total | ($x'000) | year 1 | year 2 | year 3 | year 4 | year 5 | Total |
| 3C. Alternative mining practices | | | | | | | | | | | | | | |
| 1 Field staff = current cost | | | | | | | | | | | | | | |
| ASM technical officer 1 | pmonth | 12,00 | 12,00 | 12,00 | 12,00 | 12,00 | 60,00 | 3,00 | 36,00 | 36,00 | 36,00 | 36,00 | 36,00 | 180,00 |
| ASM CMO 2 persons | pmonth | 48,00 | 48,00 | 48,00 | 48,00 | 48,00 | 240,00 | 3,00 | 144,00 | 144,00 | 144,00 | 144,00 | 144,00 | 720,00 |
| Subtotal 1 | | | | | | | | | 180,00 | 180,00 | 180,00 | 180,00 | 180,00 | 900,00 |
| | | | | | | | | | | | | | | |
| 2 Equipment/Material | | | | | | | | | | | | | | |
| Equipement set for project staff | unit | 3,00 | | | 1,00 | | 4,00 | 1,20 | 3,60 | 0,00 | 0,00 | 1,20 | 0,00 | 4,80 |
| Equipement for Demonstration Transportable Unit (DTU) | Lumpsum | 1,00 | | | 0,25 | | 1,25 | 70,00 | 70,00 | 0,00 | 0,00 | 17,50 | 0,00 | 87,50 |
| Motorbikes for DTO & CMO + committee leaders | unit | 3,00 | | | 1,00 | | 4,00 | 3,00 | 9,00 | 0,00 | 0,00 | 3,00 | 0,00 | 12,00 |
| Subtotal 2 | | | | | | | | | 82,60 | 0,00 | 0,00 | 21,70 | 0,00 | 104,30 |
| | | | | | | | | | | | | | | |
| 3 Workshops & meetings | | | | | | | | | | | | | | |
| Workshops and meetings | lumpsum | 2 | 2 | 2 | 2 | 2 | 10 | 1,75 | 3,50 | 3,50 | 3,50 | 3,50 | 3,50 | 17,50 |
| Subtotal 3 | | | | | | | | | 3,50 | 3,50 | 3,50 | 3,50 | 3,50 | 17,50 |
| | | | | | | | | | | | | | | |
| 4 Transport & other operation costs | | | | | | | | | | | | | | |
| Motorbikes operating costs 12 (1 per DTO/CMO) | pmonth | 36 | 36 | 36 | 36 | 36 | 180 | 0,05 | 1,80 | 1,80 | 1,80 | 1,80 | 1,80 | 9,00 |
| DTU operation | pmonth | 12 | 12 | 12 | 12 | 12 | 60 | 1,50 | 18,00 | 18,00 | 18,00 | 18,00 | 18,00 | 90,00 |
| Subtotal 4 | | | | | | | | | 19,80 | 19,80 | 19,80 | 19,80 | 19,80 | 99,00 |
| | | | | | | | | | | | | | | |
| 5 Consultancies | | | | | | | | | | | | | | |
| Preliminary surveys for ASM subproject (national) | pmonth | 3 | 2 | | | | 5 | 6,00 | 18,00 | 12,00 | 0,00 | 0,00 | 0,00 | 30,00 |
| Community Mobilization officers trainer/adviser | pmonth | 1 | 1 | 1 | | | 3 | 6,00 | 6,00 | 6,00 | 6,00 | 0,00 | 0,00 | |
| Training district extension officers trainer/adviser | pmonth | 1 | 1 | 1 | | | 3,00 | 6,00 | 6,00 | 6,00 | 6,00 | 0,00 | 0,00 | 18,00 |
| Subtotal 5 | | | | | | | | | 30,00 | 24,00 | 12,00 | 0,00 | 0,00 | 66,00 |
| | | | | | | | | | | | | | | |
| 6 Revolving Funds | | | | | | | | | | | | | | |
| Fund to support ASM new equipement | lumpsum | 2,00 | 5,00 | 5,00 | 5,00 | 5,00 | 22,00 | 2,00 | 4,00 | 10,00 | 10,00 | 10,00 | 10,00 | 44,00 |
| Subtotal 6 | | | | | | | | | 4,00 | 10,00 | 10,00 | 10,00 | 10,00 | 44,00 |
| | | | | | | | | | | | | | | |
| 7 Environmental and Social Monitoring | percent | | | | | | | 2,50% | 8,00 | 5,93 | 5,63 | 5,88 | 5,33 | 30,77 |
| Subtotal 7 | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | |
| Subtotal 3C | | | | | | | | | 327,9 | 243,2 | 230,9 | 240,9 | 218,6 | 1 261,6 |

# APPENDIX A – POUR-FLUSH TOILET

TOILET SYSTEM **PS-04**

## POUR-FLUSH TOILET

**Description:** The pour-flush toilet has a bowl with a water-seal trap. It is as hygienic as the conventional tank-flush toilet and requires only a small volume of water for flushing. Human waste or excreta is flushed with water poured into the bowl with a pail or scoop. Various types of bowls are commercially available. The bowl can be set in place with the concrete slab cover of the pit or septic tank or offset and pipe-connected to the pit or tank. The toilet can be within the house or a separate structure can be built outside. A pour-flush bowl can be used with compost privy, VIP, aquaprivy or public toilet.

**Design:**
1. Pour-flush bowl - Commercially available squat or seat types made of glazed ceramic. The squat type can be molded concrete.
2. Toilet structure - Permanent type of minimum 1.2 x 1.2 m shed, concrete hollow block walls 1.5 m high and G.I. sheet roofing, or non-permanent type of indigeneous materials.

**Applications:** The pour flush toilet can be installed in the toilet room of houses. The location of the toilet is very flexible and the toilet can be some distance away from the receiving pit/chamber. Hence, pour-flush toilet can be used in densely populated urban areas.

**Components:** Pit slope and pit lining; pit cover; plinth at least 150 mm above ground; Pipe-1:30 slope, 75 mm dia.; superstructures with vent up to overhang of the roof

**Capacity:** Most commonly used toilet in urban areas or even rural areas, as well as public/communal toilets.

**Costs:** Capital cost (toilet only, excludes super & substructure):
P 500 for squat-type
P 1,200 for seat-type

**Utility & Efficiency:** Clean and hygienic; proven efficient

**Reliability:** With proper sanitation practices, it is reliable

**Reapplication Potential:** Installation practices generally known; Hardware/materials commercially available.

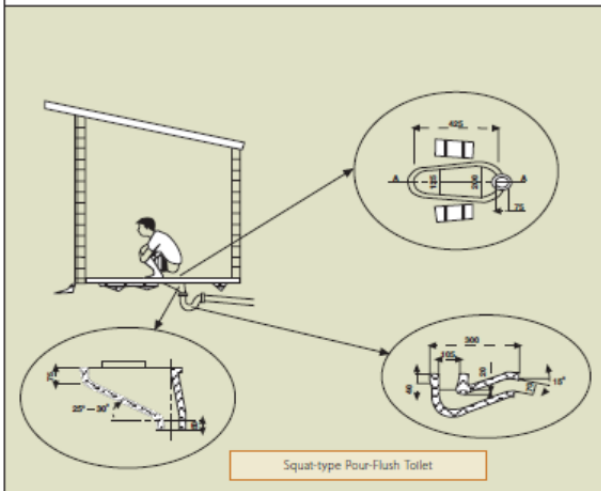
**Operating Principles:**
1. The flushing water (1-2 liters) and the liquid portion of the excreta percolate into the ground/soil in the soakaway pit, while it goes with the effluent, or discharge to septic tank, imhoff tank, aqua privy, interceptor boxes or direct to sewer pipes.
2. The water-seal trap prevents the odors of excreta from escaping and prevents insects from entering or leaving the unit.

**Maintenance:**
1. Regular washing of the toilet bowl and floor
2. No other solid waste should be put down the bowl
3. Use of flexible rods/materials for removing blockages

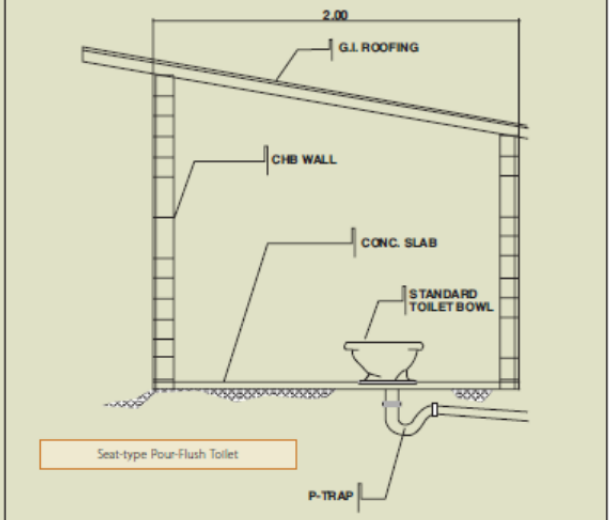
**Construction Materials:**
1. Lining materials - brick, stone or hollow blocks or precast concrete or burnt clay liners where there is a high water table
2. Reinforced concrete slabs for support/base
3. Porcelain, concrete or ferrocement, glass fiber, injection molded plastics and glazed ceramics toilet bowls

**Advantages:**
1. Readily available commercially
2. Inexpensive.
3. Less volume of water required ( 3,000 liters of water/person/year)
4. Upgradeability
5. Hygienic; very easy to clean
6. Reliable; convenient and comfortable

**Disadvantages:**
1. Requires availability of water
2. Clogs easily if bulky anal cleansing materials are used



Squat-type Pour-Flush Toilet




Seat-type Pour-Flush Toilet

*Source: Philippines Sanitation Sourcebook and Decision Aid*

# APPENDIX B – SEPTIC TANK

TREATMENT SYSTEM **TS-03**

## SEPTIC TANK

**Description:** The septic tank is an underground water tight chamber that receives both excreta and flush water from toilets with or without other household wastewaters (or sullage). The tank serves three purposes: as a sedimentation tank for the removal of incoming solids, while allowing the liquid fraction (or settled effluent) to pass; as a biochemical reactor for the anaerobic decomposition of the retained solids; and as a storage tank in which the non-degradable residual solids accumulate. Scum, such as fats and greases, rises to the top. The clarified liquid flows through the outlet pipe and is usually disposed through a subsurface soil absorption system. The effluent should not be discharged to surface drains, creeks, streams or lakes, without treatment.

**Design:** Design considerations are as follows:

1. Retention time of at least 24 hours
2. Two thirds of tank volume is reserved for sludge and scum storage
3. Wastewater inflow - 120 liter/person/day
4. Sludge accumulation rate = 40 liter/person/year
5. Maximum filled volume = 50% of tank volume
6. Desludging interval is approximately every 4 years
7. Provide ventilation pipe to permit gas produced in the tank to escape.
8. Must be water tight with one or two chambers.

**Applications:** Satisfactory and acceptable facility for excreta disposal and other liquid wastes from individual houses, cluster of houses, apartments, and institutions (schools).

**Components:** Inlet tee pipe; digestion chamber and settling chamber (for 2-chamber tank); outlet tee pipe; manhole cover, clean outs (CO)

**Capacity:** (typical design)

| No. of Persons Served | 4 | 8 | 12 | 16 | 20 |
|---|---|---|---|---|---|
| Dimensions (m) | | | | | |
| Lenght (L) | 2.0 | 2.5 | 3.0 | 3.8 | 4.0 |
| Width (W) | 0.6 | 0.9 | 1.1 | 1.2 | 1.4 |
| Liquid Depth (D) | 1.5 | 1.5 | 1.5 | 1.5 | 1.5 |
| Freeboad (B) | 0.3 | 0.3 | 0.3 | 0.3 | 0.3 |
| Tank Volume (m3) | 2.0 | 4.0 | 6.0 | 8.0 | 10.0 |

**Costs:** Construction cost: (2004)
Tank A: 2m³ tank (4 persons served) = P 45,000
Other Tanks: Tank A Cost + P 4,000/m³
Desludging cost = P 2,800 per 4-year interval

**Utility & Efficiency:** 30-60% BOD removal; 80-85% suspended solid removal; 50% coliform removal.

**Reliability:** Reliable if regularly cleaned and desludged. ST resistant against shock load.

**Flexibility:** Flexibility in the use of design criteria is unavoidable in order to fit existing conditions.

**Reapplication Potential:** Basic septic tank design, materials and technical know-how readily available. Can be upgraded to piped collection for secondary treatment.

**Regulatory/ Institutional Issues:**

- Conformance to Philippine Sanitation Code.

**Operating Principles:** The septic tank operates similar to an aqua-privy, i.e., settling solids, anaerobic digestion of solids and storage of digested sludge. Light solids float on the surface of the water in the tank, called scum, is also retained in the tank. Liquid effluent disposed to absorption fields/soil infiltration, leaching or soakaway pits, evapotranspiration mounds or soil conditioner on agricultural land. Sludge from septic tanks or septage is removed by vacuum tankers and co-treated with sewage or other sludge, undergoes own treatment, or disposed in lahar areas or various land applications or surface disposal.

**Maintenance:**

1. Effluent from septic tank should be inspected periodically to ensure that neither scum nor suspended solids are leaving the system.
2. Regular desludging of septic tank contents should be done when the sludge and scum occupy 2/3 of the tank's capacity. Normally done every 2 to 5 years.

**Construction Materials:**

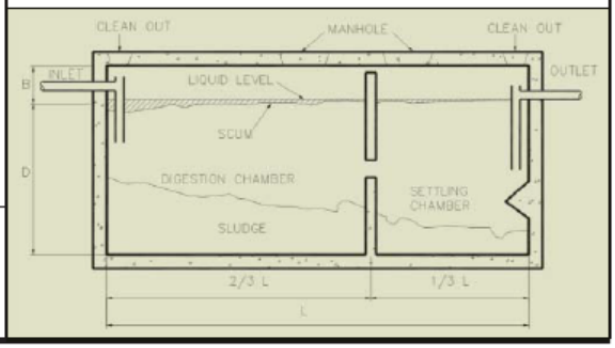
1. Concrete hollow block(CHB) walls, reinforced concrete (RC) top slab and bottom
2. RC manhole cover
3. Polyvinyl chloride (PVC) inlet and outlet pipes
4. Cast iron (CI) or PVC clean outs

**Advantages:**

1. Flexible and adaptable to a wide variety of individual household waste disposal requirements.
2. Essentially no maintainance needs except the periodic desludging.

**Disadvantages:**

1. More expensive than other on-site waste treatment systems.
2. Requires a permeable subsoil structure so the effluent can be distributed.
3. Space for drainage field may be required.
4. Drinking water sources must be set away from septic tanks (about 25m.)
5. Needs piped water supply.




*Source: Philippines Sanitation Sourcebook and Decision Aid*

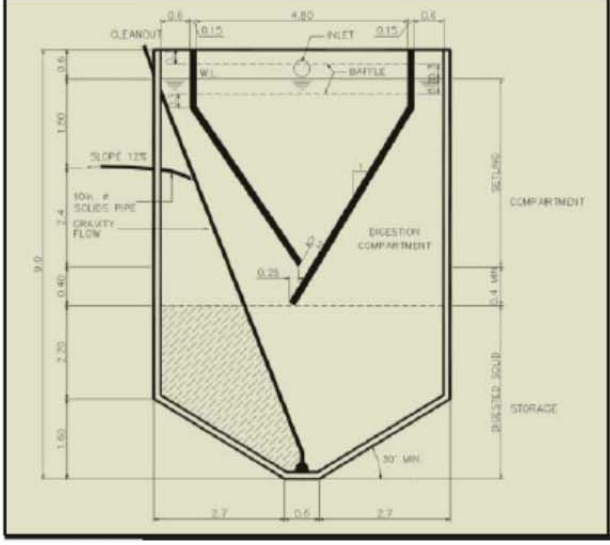
# APPENDIX C – IMHOFF TANK

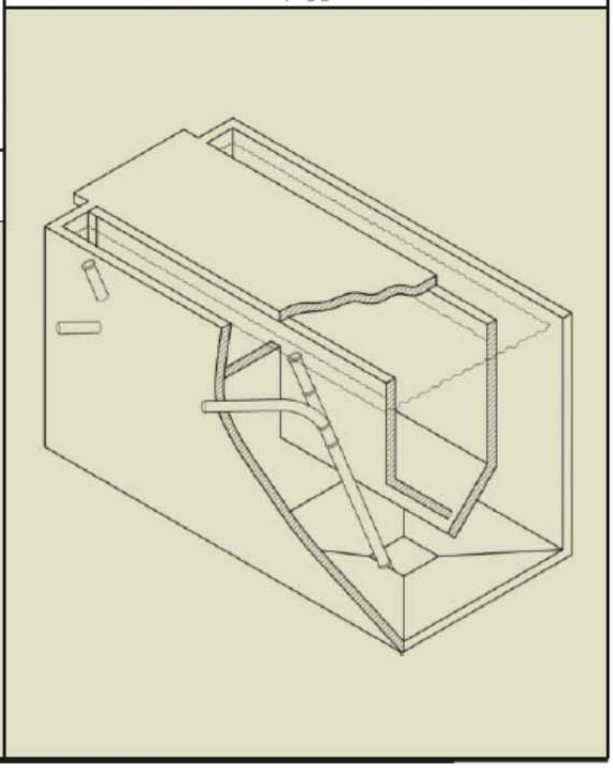
TREATMENT SYSTEM **TS-04**

## IMHOFF TANK

| | |
|---|---|
| **Description:** | Imhoff tanks are used by small communities with raw wastewater flows on the order of 950 m³/day (population about 8,000 people or 1,300 households). The Imhoff tank consists of a top compartment, which serves as a settling basin, and a lower compartment in which the settled solids are anaerobically stabilized. Scum and gas vent chambers are located at the sides of the tank. It can be an open or covered tank. |
| **Design:** | Imhoff tanks are normally designed to retain wastes for 2 to 4 hours; length equals 3 times its width with depth of 7.2 to 9 m, 20% of the total surface area is typically provided for gas vent with width of 0.45 to 0.75 m at both sides. 2.5 m³/capita storage capacity for sludge digestion is usually provided at the lower compartment. |
| **Applications:** | Applicable for small communities in urban or rural areas. |
| **Components:** | Settling compartment; digestion compartment; gas vent and gas chamber; inlet and outlet channels and piping; sludge withdrawal piping; gas vent pipe; tank structure with or without manholes |
| **Capacity:** | Mostly relatively small plants but it can range from 100-2,000 m³/day capacity depending in the design. Shown below is a tank for 2,000 m3/day capacity. |
| **Costs:** | A 1,000 population would need a 100 m³/day tank with a settling area of 3 m², total surface area of 3.75 m², total depth of 7.2 m. Using the typical values for the design of imhoff tank, construction cost is Php 1.2M for 2,000 m³/day capacity. |
| **Utility & Efficiency:** | BOD reduction is about 30-50%, depending on available discharge options; further treatment may still be needed. |
| **Reliability:** | Reliable if amply designed and desludging carried out routinely. Imhoff tank is resistant against shock loads. |
| **Flexibility:** | A number of collection, treatment and disposal options can be linked to the Imhoff tank. |
| **Reapplication Potential:** | Technology and operating procedures are available for Imhoff tanks. Construction materials are readily available. |
| **Regulatory/ Institutional Issues:** | • Requires skilled personnel to maintain the facility |

| | |
|---|---|
| **Operating Principles:** | Settling of solids occurs in the upper compartment. Sludge falls through the slot to the bottom of the settling compartment into the lower tank, where it is digested. Digestion process generates biogas which, is deflected by the baffles to the gas vent chamber, preventing the disturbance of the settling process |
| **Maintenance:** | 1. Daily cleaning of the scum and other floatables<br>2. Desludging periodically (once or twice a year)<br>3. Regular cleaning of the sides of the settling chamber and slot by rake or squeegee<br>4. Reversing the flow of water twice a month to even up the solids in the digestion chamber |
| **Construction Materials:** | 1. Reinforced concrete - cement, steel bars, formworks<br>2. Pipes - cast iron, PVC for inlet, outlet and sludge piping, gas vent |
| **Advantages:** | 1. Good for small settlements and clustered houses<br>2. Small area required; land use is limited as it can be constructed under roads or public places<br>3. Low capital costs<br>4. Simple operation and maintenance do not require highly skilled supervision<br>5. More efficient settling than septic tank |
| **Disadvantages:** | 1. Low treatment efficiency<br>2. Additional treatment might be needed<br>3. Requires more often desludging<br>4. Odor from escaping gases |



*Source: Philippines Sanitation Sourcebook and Decision Aid*

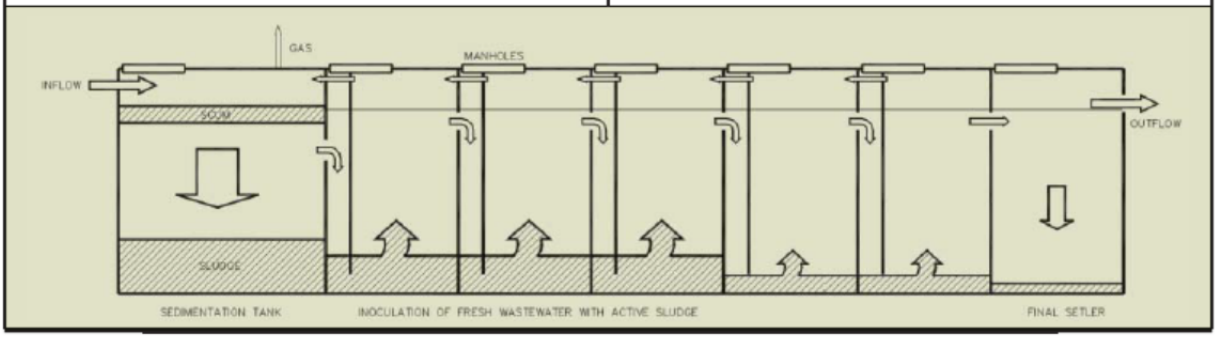
# APPENDIX D – ANAEROBIC BAFFLED REACTOR

TREATMENT SYSTEM **TS-05**

## ANAEROBIC BAFFLED REACTOR

| | |
|---|---|
| **Description:** | Anaerobic baffled reactor is actually a septic tank in series where wastewater is forced to flow down through the existence of down-shaft or down-pipe and distributed over the entire area of the floor where it inoculates with active sludge for digestion. The up-flow also causes sludge particles to settle. |
| **Design:** | Anaerobic treatment is preferred if BOD > 2,000 mg/l. Temperature should be 29° -38°C with pH=6.5-7.5. Not compatible with sulfur compounds. Recommended detention time is between 15-30 days. The design calculation must give detail attention on chamber's geometry, up-flow velocity, organic load, temperature, desludging interval, and retention time. |
| **Applications:** | The baffled septic tank is suitable for all kinds of wastewater such as wastewater from settlement, hospital, hotel/resort, public market, slaughter house, and food processing industries. The more organic loads, the higher its efficiency. |
| **Components:** | Settler/integrated with septic tank, designated series of baffled chambers, and down-shaft or down-flow pipe |
| **Capacity:** | The anaerobic reactor can be efficiently designed for a daily inflow of up to 1,000 population equivalent community wastewater and with BOD of up to 10,000 mg/l. Digester volume can be up to 150 $m^3$ with inflows up to 10 $m^3$/d. If used in combination with septic tank and horizontal gravel filter, baffled reactor increases its treatment scalability up to 1,000 $m^3$ |
| **Costs:** | Capital cost: P12,600 - P30,000/$m^3$/day flow rate for anaerobic baffled reactor.<br>Total construction cost depends on material cost and availability, labor costs, and site condition. Detailed feasibility study is required to calculate on-site cost.<br>O & M cost : P11,000/month plus desludging cost every 5-year interval. |
| **Utility & Efficiency:** | Reduction of BOD is about 75-90%. Area required ranges from 40 - 150 $m^2$ depending on the detention period used. Only moderate reduction of infectious organisms; effluent has slight odor (methane). |
| **Reliability:** | High reliability due to low effect when hydraulic and organic shock loads occur. |
| **Flexibility:** | Poor flexibility but can be upgraded. |
| **Reapplication Potential:** | Standardized designs and SOPs are available. It has high potential to be integrated with other post treatments such as anaerobic filter reactor and horizontal gravel filter plant |

| | |
|---|---|
| **Operating Principles:** | Settler or septic tank must be installed to avoid scum and solid particles to enter the baffled section. Inoculation or seeding is required to hasten the achievement of adequate treatment performance. If not, three months of maturation should be acknowledged. If possible, start with a quarter of the daily month. Such flow management will give time for bacteria to multiply before suspended solids are washed away. |
| **Maintenance:** | 1. Check scum blanket, break up if too thick<br>2. Control foaming<br>3. Monitor total solids build up and gas production<br>4. Regularly schedule cleaning of solid waste build up by manual or vacuum desludging. Desludging must regularly be done on a calculated interval and some sludge must be left to ensure continuous efficiency. Regular control of solid intervention to every chamber must be done |
| **Construction Materials:** | 1. Reinforced concrete or steel tanks or concrete hollow block (CHB) or bricks<br>2. Acid resistant pipes such as polyvinyl chloride (PVC) |
| **Advantages:** | 1. Suitable for smaller and larger settlements<br>2. Little space required due to underground construction<br>3. Low investment costs<br>4. Very low operation and maintenance costs. No moving parts power needed. Hardly any blockage<br>5. Simple and durable<br>6. High treatment efficiency |
| **Disadvantages:** | 1. Experts are required for design and supervision<br>2. Master mason is required for water-tight plastering<br>3. Effluent is not completely odorless<br>4. Slow growth rate of anaerobic bacteria means long start up period<br>5. Less efficient with weak wastewater |




*Source: Philippines Sanitation Sourcebook and Decision Aid*

# APPENDIX E – VENTILATED IMPROVED PIT (VIP) LATRINE

TOILET SYSTEM **PS-02**

## VENTILATED IMPROVED PIT (VIP) LATRINE

**Description:**
A pit latrine consists of a hole in the ground covered with either a squatting plate or a slab provided with riser and seat. A housing or toilet room is built over the pit. A pit latrine operates without water. Liquid portion of the excreta soaks away into the soil. The VIP is a pit latrine with a screened vent installed directly over the pit. The vent provides odor control and the screen on top of the vent prevents entry of insects attracted by the smell. Filled pits are covered with soil for composting. There are two types of VIP latrines: single pit and alternating-pit. For the latter, there are two adjacent pits below the toilet room and one pit is used at any given time. When one pit becomes full, it is closed and the other pit is used. By the time the second pit becomes full, the first has fully decomposed and becomes innocuous. Materials in the filled pit are removed and the pit can then be returned to service till it becomes full.

**Design:**
The pit volume is given by the product of:
Sludge accumulation rate x Number of people x Filling time
1. Sludge accumulation rate = 40 liters/person/year or rate decreased to 20 liters/person/year if pit is seasonally flooded or water from washings is added to the pit. Increase rate by 50% to allow bulky materials for anal cleansing.
2. Design use of single pit (filling time) = period of 2 years
3. Pit bottom not lined to enable liquid to soak away

**Applications:**
Single-pit VIP latrines are suitable for use in rural areas where the soil is deep and space is available to construct succeeding pits. Alternating double-pit VIP latrines are appropriate for urban areas where people can afford a permanent latrine that does not require relocating after every few years.
VIP latrines can be used in areas where there are no on-site water supplies. Water is needed for handwashing.

**Components:**
Pit; squatting plate or wooden seat & cover; cover slab; and a housing or toilet room.

**Capacity:**
1. Minimum pit volume = 1 $m^3$ for household of 6 persons for use in about 2 years
2. Increase in capacity can be achieved by making the pit at least 0.5 m deeper than the minimum since the latrine cannot be used after the sludge surface gets close to the slab cover.

**Costs:**
Options for the construction of a VIP Latrine are:
1. Use of permanent construction materials like concrete hollow block (CHB) walls for the pit and galvanized iron (GI) sheet for the housing. (See figure below)
2. Use of indigeneous materials like wood, bamboo sheeting or used drum for the pit wall, and wood or bamboo post, wood or sawali siding, and nipa roofing for the housing.

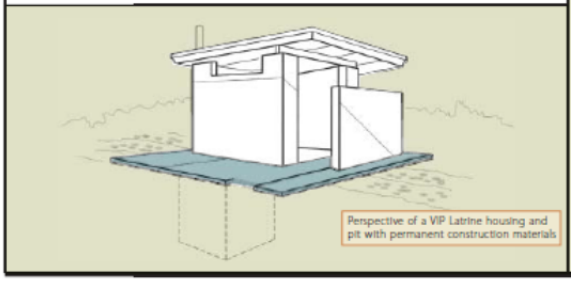
Estimated costs for the above options are:
1. For Option a), the cost is P 12,000 and P 55,000 respectively for the pit and housing shed;
2. For Option b), using indigenous construction materials, the major cost is on labor and variable for the local material. Estimated costs are P 2,000 and P 5,000 respectively for the pit and housing.

**Utility & Efficiency:**
50% reduction of solids by digestion. Can be single pit, double pit or multiple pit.

**Reliability:**
Can be relied upon to maintain protection with limited supervision for long periods of time.

**Flexibility:**
Flexible in the use of construction materials particulary indigenous materias. A toilet room in the house could be used in lieu of a separate structure.

**Regulatory/ Institutional Issues:**
- Compliance with the Philippine Sanitation Code



Perspective of a VIP Latrine housing and pit with permanent construction materials

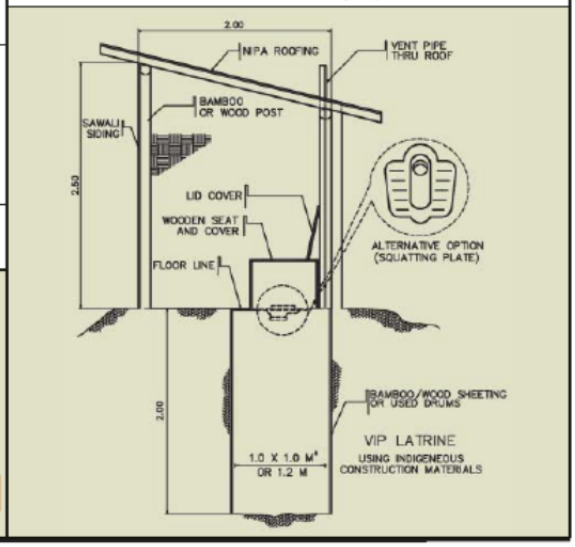
**Operating Principles:**
Two important actions take place in the pit which reduce the rate at which it fills:
1. The liquid portion of the excreta soaks away into the soil.
2. The solids in the excreta are broken down into simpler compounds by biological digestion. Soluble products are carried into the soil by the liquid portion of the excreta.
3. Gases (foul air) produced by the digestion are pushed out through the vent by fresh air entering the pit hole.

**Maintenance:**
1. Regular cleaning and repairs.
2. Periodic inspection of the fly screens and signs of erosion around the edges of the slab.
3. Use of a little bleach or disinfectant to wash the floor slab.
4. Where there is standing water in the latrine pit, small quantities of special oils, kerosene, old engine oil can be added to the pit to prevent mosquitoes from breeding.
5. Stop use of pit when level of solids reaches 0.5 m from the underside of the slab. Fill the pit immediately with soil.

**Construction Materials:**
1. Indigenous materials like rot-resistant wood, bamboo, nipa, stabilized soil blocks, stone bricks, etc. could be used for the pit or housing structure.
2. Permanent materials like concrete hollow block (CHB), cement mortar, stone or bricks, metal sheets, etc. could be used for the pit or housing.
3. Reinforced concrete for the pit cover slab or flooring.
4. PVC pipe for the vent pipe.

**Advantages:**
1. Easy construction using local materials.
2. Minimal water requirement
3. Low annual cost
4. Easy maintenance
5. All kinds of anal cleansing materials may be used

**Disadvantages:**
1. Lack of space for relocating; the pit is dense in urban areas
2. Potential for groundwater pollution
3. Does not dispose of large quantities of sullage water
4. Not suitable in areas with high groundwater table, due to possible infiltration with leachate
5. Not suitable in areas with impermeable, rocky underground, due to limited infiltration capacity



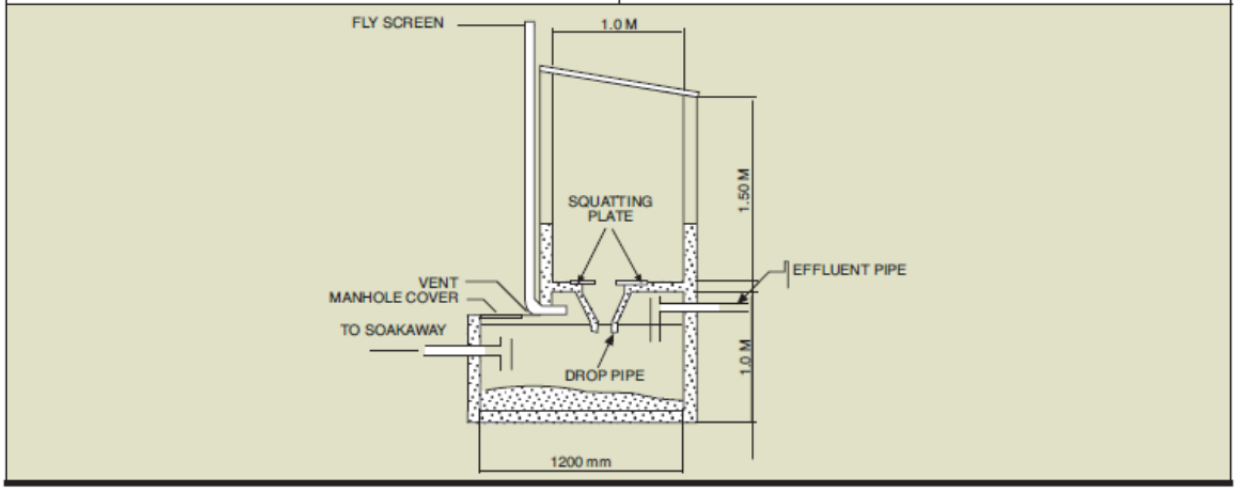

*Source: Philippines Sanitation Sourcebook and Decision Aid*

# APPENDIX F – AQUA PRIVY

TOILET SYSTEM **PS-03**

## AQUA PRIVY

| | |
|---|---|
| **Description:** | The conventional aquaprivy is essentially a small septic tank located directly below a squatting plate which has a drop pipe extending below the liquid level in the tank to form a simple water seal. To prevent odor, fly and mosquito nuisance in the toilet, the water seal has to be maintained by adding sufficient water per toilet visit to the tank via the drop-pipe to replace any losses. The excreta are deposited directly into the tank where they are decomposed anaerobically similar to a septic tank. A housing or shed is built over the tank. A vent pipe with a fly screen at the top end is attached to the housing. A water-tight tank is desirable to minimize losses. An effluent (overflow) pipe is installed above the level of the drop-pipe. |
| **Design:** | Design considerations are as follows:<br>1. Tank volume calculated on 1.5 liters per day plus 4.5 liters/ day/person to maintain the water seal (or 6 liters/person/day)<br>2. Effluent maybe discharged to a soakway pit, soil infiltration or disposed to storm drain or water body. |
| **Applications:** | The aquaprivy ranks high, with the pit privy, as a desirable sanitation system in areas where there is limited water supply. |
| **Components:** | Privy tank; floor or slab; housing or shed; toilet bowl or squatting plate with chute or drop-pipe; vent pipe |
| **Capacity:** | Minimum pit/tank size is 1 m³ for a household of 5 - 6 persons with desludging period of 2-3 years. |
| **Costs:** | Pit: concrete plastered CHB wall and concrete bottom (about 1-1.25 m³) - P 12,000<br>Housing: indigenous construction materials - major cost on labor and variable for the local material - P 5,000 |
| **Utility & Efficiency:** | 30-40% BOD removal. Needs further treatment such as leaching or secondary treatment processes |
| **Reliability:** | If properly operated and maintained, it can be a reliable system. |
| **Flexibility:** | Can be upgraded to full sewerage; medium process flexibility. |
| **Reapplication Potential:** | Local materials, labor and know-how are readily available. Easy to construct. |
| **Regulatory/ Institutional Issues:** | • Compliance with the Philippine Sanitation Code.<br>• Compliance with environmental regulations in the disposal of the sludge. |
| **Operating Principles:** | The tank must first be filled with water up to the level of the outlet pipe. After 6-8 weeks, the decomposition process will attain its desired level of operation. Seeding, however, with digested sludge from other privies can hasten the process |
| **Maintenance:** | 1. Periodic desludging through a manhole.<br>2. Regular cleaning of the drop-pipe or chute. |
| **Construction Materials:** | 1. Plain or reinforced concrete or concrete hollow blocks for the pit or housing<br>2. Indigenous materials (bamboo, wood, sawali, etc) can be used for the housing/shed. |
| **Advantages:** | 1. No danger of clogging by bulky anal cleansing materials<br>2. Low odor and insect problems<br>3. Potential for upgrading<br>4. Minimal risks to health |
| **Disadvantages:** | 1. Water seal is often broken particularly during cleaning.<br>2. Needs small but significant amount of water to maintain water level for a successful sanitation technology. Therefore, user education in operation and maintenance of the aqua privy is necessary.<br>3. The tank requires desludging, usually every 2-3 years.<br>4. Requires water tight tank, hence more expensive and needs skills to construct. |




*Source: Philippines Sanitation Sourcebook and Decision Aid*

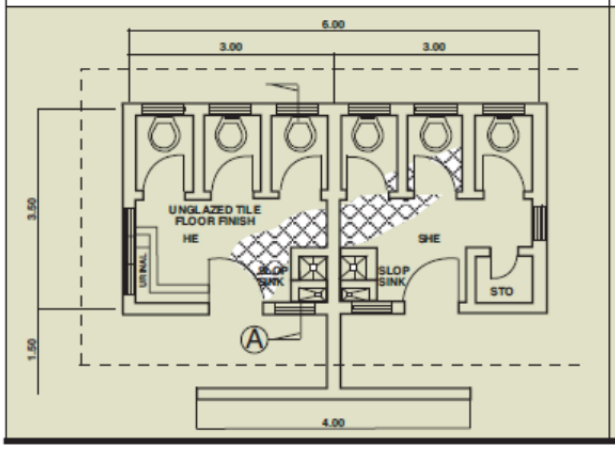
# APPENDIX G – PUBLIC TOILET

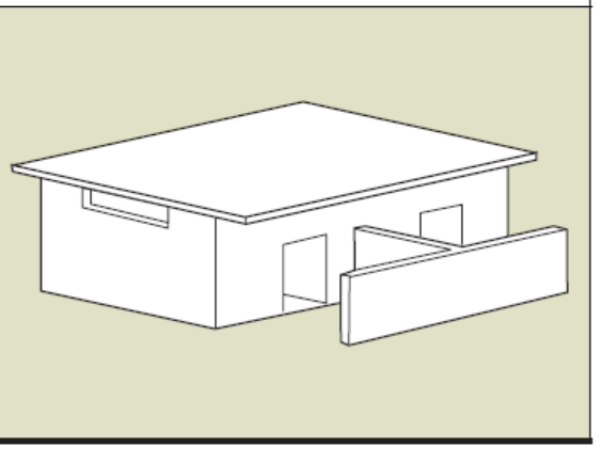
TOILET SYSTEM **PS-05**

## PUBLIC TOILET

| | |
|---|---|
| **Description:** | Public toilet is the more popular name in the Philippines for communal toilet or communal sanitation blocks/centers. It consists of several cells in a common structure with individual toilet bowls/squatting seats. Each toilet bowl is shared by several families. Bathroom and laundry facilities can also be included. Wastewater is discharged into a leaching pit, a septic or Imhoff tank, or an anaerobic reactor. |
| **Design:** | Each public or communal toilet with 4 cells is shared by at least four families, one cell per family. If there are more families participating, the cells become common to all. Typical design of public toilets provide 8 seats per 200 people. |
| **Applications:** | Suitable in areas/communities which are densely populated, where space is restricted, and no individual toilets can be set up. |
| **Components:** | Cells with pour-flush toilets or squatting seats; optimal shower section; optimal laundry section; urinal; nightsoil or excreta-receiving bowl or receptacle; superstructure; pit or treatment unit |
| **Capacity:** | Depending on the number of sanitation cells, a public toilet can serve 800 users or 20-200 households |
| **Costs:** | Capital cost: P 250,000 for the 6-cubicle toilet shown in the sketch below, or approximately P 12,000/m². |
| **Utility & Efficiency:** | Basic sanitation services can be provided to a good number of people. |
| **Reliability:** | Only reliable if toilet is cleaned regularly. |
| **Flexibility:** | Possible to upgrade collection, treatment and disposal compartments in the latter stage |
| **Reapplication Potential:** | Design of structure is very basic. Materials, labor and technical know-how are readily available. |
| **Regulatory/ Institutional Issues:** | • Compliance with the Clean Water Act.<br>• Need for community/local government support to operate and maintain the facility. |

| | |
|---|---|
| **Operating Principles:** | In densely populated areas, public toilets may be the only practical place for washing, bathing and toilets. |
| **Maintenance:** | Daily cleaning of facilities essential. |
| **Construction Materials:** | 1. Reinforced concrete slab<br>2. Concrete blocks, stones, bricks<br>3. Wooden trusses, galvanized iron (G.I.) Sheet roofing<br>4. Plumbing materials such as G.I. or plastic pipe<br>5. Toilet bowls, squatting seats, sinks, etc. |
| **Advantages:** | 1. It can provide basic sanitation requirement to many.<br>2. Low-cost compared to individual units. May be free if operated by municipal/city services.<br>3. Simple construction and maintenance. |
| **Disadvantages:** | 1. Limited number of users; inconvenient if one needs to defecate or urinate immediately.<br>2. Not much privacy.<br>3. Individuals have no control over maintenance and cleanliness of cubicle being used.<br>4. Proximity from house and availability at night, not favorable, and further security issues for females. |



*Source: Philippines Sanitation Sourcebook and Decision Aid*

# APPENDIX H – SIMPLIFIED SEWERAGE

COLLECTION SYSTEM **CS-01**

## SIMPLIFIED SEWERAGE

**Description:** A modified sewerage system which operates as conventional sewers with a number of modifications; the minimum diameter (small bore) and the minimum cover are reduced, the slope is determined by using the tractive force concept rather than the minimum velocity concept, sewers are installed below sidewalks or inside private properties where possible, and many costly manholes are eliminated or replaced with less-expensive cleanouts.

**Design:** The design concept takes advantage of having septic tank or aqua privy or Imhoff tanks in individual households or communal toilets. For new houses or communities, or houses without septic tank, aqua privy or Imhoff tank, a solids interceptor box/tank should be added between the house and sewer line/laterals, which captures and stores incoming solids, attenuates the flow, and allows the settled sewage to flow out by gravity. The absence of solids in the line permits self-cleansing velocities, flatter gradients and shallower depths. Attenuation of flow reduces the peak flow factor.

**Applications:** Suitable for areas with topography sloping downward toward treatment site, low-density population and high groundwater or shallow bedrock.

**Components:** House sewer connection; interceptor/septic/Imhoff tanks/privies; sewer network

**Capacity:** Can easily adapt to the population whether urban or rural, high or low density; minimum number of connections required.

**Costs:** Capital cost: P 56,160 per m³/day flow. Low to medium investment costs if population density is high, number of connections is large, and 3 to 4 households share one tank/box.
O & M cost: P 245/m³ or P 2,030/m of pipeline based on regular desludging of tanks, sewerline and inspection.

**Utility & Efficiency:** The concept is a new technology in the Philippines. Implementation, therefore, needs close monitoring.

**Reliability:** Reliable if tanks are properly maintained and no coarse materials infiltrate the piping system.

**Flexibility:** System can be upgraded and extended.

**Reapplication Potential:** Conditions for simplified sewerage design are available and standards set. All materials are available, locally.

**Regulatory/ Institutional Issues:**
- Excavation permits needed.
- Will need community participation.

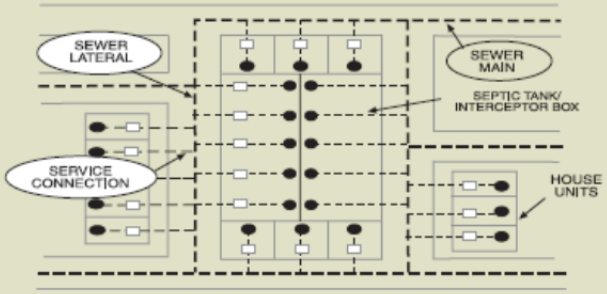
**Operating Principles:**
1. The sewage solids are intercepted by the interceptor box or baffled box, septic tank, aqua privy or Imhoff tank. The absence of settleable solids negates clogs or blockages in the sewer line despite the smaller diameter and flatter slope.
2. Variation occurs in the rolling terrain where there is a need for pumping. Generally, only one or two pump/lift stations are required in a simplified sewer system.

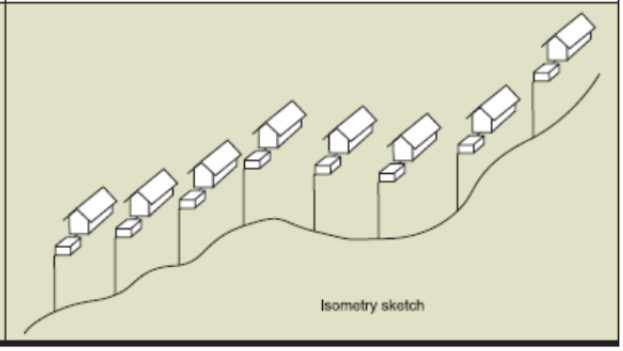
**Maintenance:**
1. Occasional flushing of the sewer lines.
2. Removal of blockages, rodding machines or flushing equipment.
3. Repairs of sewer lines, as needed.
4. Inspect manhole and conduct television inspection.
5. Desludging of interceptor/septic/Imhoff tanks/privies every 5 years or so.

**Construction Materials:**
1. Pipes - vitrified clay (VCP), cast iron (CI), brick masonry, steel, concrete or cast-in-place concrete, or polyvinyl chloride (PVC) pipes
2. Cement, reinforcing bars, rubber gaskets

**Advantages:**
1. Low to medium investment costs, if old septic tanks or aqua privies exist or new tanks are shared.
2. Low excavation, materials and operation costs compared to conventional sewerage (20-50%).
3. Less treatment costs (no pre-treatment).
4. Ease of construction - easily diverted; shallow depths, can follow contours.
5. Low maintenance costs.

**Disadvantages:**
1. Expert design and supervision required.
2. Each service connection requires a tank/box.
3. Periodic pumping and disposal of septage from tanks.
4. Decentralized maintenance and operation program are required. May require community participation.
5. Illegal connection may be a problem.




*Source: Philippines Sanitation Sourcebook and Decision Aid*

# APPENDIX I – LEACHING OR SOAKAWAY PITS

TREATMENT SYSTEM **TS-01**

## LEACHING or SOAKAWAY PITS

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|---|---|
| **Description:** | Leaching or soakaway pits are holes dug in the ground to receive effluent wastes to receive effluent from septic tanks or aquaprivies, and allow it to percolate into the ground. Sometimes used for disposal of kitchen, bathroom and laundry wastewater |
| **Design:** | Round holes dug into the ground, 1.8 m or more in depth with diameter of 1.0-3.5 m. Side walls are lined with hollow blocks, bricks or stones laid without mortar below the level of the inlet pipe. Design for 8 liters per person per day with infiltration rate of 10 liters/m² daily. |
| **Applications:** | Where water consumption is substantial enough, it will require a soakaway pit. It should be located downhill and at least 15 m away from drinking water sources and wells. |
| **Components:** | Stone lining (open joints), coarse gravel liners, inlet and outlet pipes, cover slab with a manhole. |
| **Capacity:** | Life span of a leaching or soakaway pit is normally 6-10 years, if the effluent is only slightly turbid from an efficient primary treatment. |
| **Costs:** | Cost: P 14,000 for minimun size shown in sketch (i.e. 19 cum volume). Plus P 540/cum for size larger than minimum. Practically no maintenance cost. |
| **Utility & Efficiency:** | Pit content can be treated in a waste stabilization pond or by composting. |
| **Reliability:** | Not reliable, it may pollute/contaminate groundwater. |
| **Flexibility:** | Flexible as it can be converted to higher levels of sanitation. |
| **Reapplication Potential:** | Recommended as alternative when absorption trenches are impractical, pervious soil is deep or where an impervious upper layer is underlain by porous layer. |
| **Regulatory/ Institutional Issues:** | • Compliance with Clean Water Act.<br>• Local ordinances in excavation permit. |

| | |
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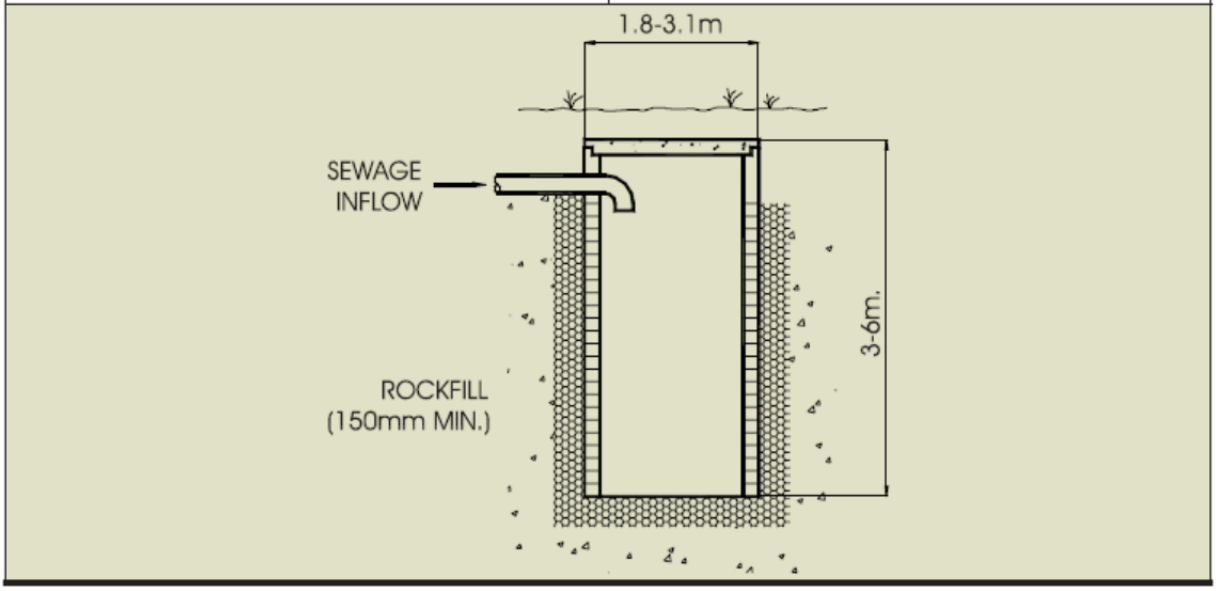
| **Operating Principles:** | The liquid portion of the wastes seep into the ground. The solids are retained and accumulate in the pit and gradually seal the pores of the soil. |
| **Maintenance:** | No maintenance required. The pit should be closed with a tight cover which will prevent access to mosquitoes and flies and to surface water, as well. Sludge layer can be effectively removed by a simple diaphragm pump, if need be. |
| **Construction Materials:** | 1. Cement grouts<br>2. Stones, adobe, hollow blocks<br>3. Reinforced concrete cover slab<br>4. Rockfill or coarse gravel<br>5. PVC pipe |
| **Advantages:** | 1. Accommodates high water consumption.<br>2. Digestion of the waste proceed more efficiently than in the conventional pit.<br>3. Contents are liquid enough to be pumped out easily.<br>4. Makes possible further upgrading of the latrine so that either shower units or conventional water-borne systems can be added, if required. |
| **Disadvantages:** | 1. Because of the ability of the pit to accommodate high water consumption, this type of pit becomes as popular as a washroom and water use going to the toilet is uncontrolled, thereby, water volume entering the pit is increased substantially and the earth base of the pit cannot cope with the excess liquid (soil conditions not satisfactorily permeable).<br>2. Not suitable in areas with high groundwater table, due to possible infiltration with leachate |




*Source: Philippines Sanitation Sourcebook and Decision Aid*

# APPENDIX J – ENGINEERED REED BED

TREATMENT SYSTEM **TS-07**

## ENGINEERED REED BED

**Description:**

Engineered Reed Beds are natural treatment systems, which are widely used for the removal of pollutants from domestic and industrial wastewater and sludge. These systems consist of a bottom-lined bed or channel filled with sand or appropriate soil media. Reeds are allowed to grow at the bed. Flow direction in the filter bed may be horizontal or vertical. The treatment mechanisms are biological conversion, physical filtration and chemical absorption. The mechanisms of BOD removal are aerobic, anoxic and anaerobic. Continues flow often results in saturated filter bodies and mainly anaerobic milieu. In the Philippines, engineered reed beds are mostly for treatment of industrial wastewater and is not yet common for domestic wastewater treatment. Effuent from residential septic tanks discharged to a reed bed green belt has great potential in urban areas.

**Design:**

The land area required for the horizontal subsurface flow reed bed system depends on the wastewater flow rate (or equivalent number of persons), filter media and plant specie. The table below shows an estimate of the reed bed size for a given number of user.

| No. of Users | Approx. Area ($m^2$) | Length x Width (m) | Depth (m) |
|---|---|---|---|
| 50 | 250 | 32 x 8 | 0.5 |
| 100 | 500 | 45 x 11 | 0.5 |
| 500 | 2500 | 100 x 25 | 0.5 |

The common specie used is Phagmytes spp, noted for its root growth and an endemic specie in the Philippines.

Note: For vertical flow reed bed systems, the area required is half that of the horizontal flow. A square bed layout is preferable.

**Operating Principles:**

The most important factors in decreasing the wastewater pollutants are the soil, aerobic and anaerobic microbes and the reed plant. The soil layer acts as a filter. Micro-organisms and plants alter organic matter, nitrogen and phosphorous to remove it through gaseous release, uptake, fixation, sedimentation and transformation into other compounds. Concentrations of heavy metals, organic chemicals and pathogens are reduced due to adsorption and natural die-off.

**Maintenance:**

1. Periodic harvesting of the reeds
2. Maintenance of dike from erosion, pipes from clogging and free-flowing drainage outfalls
3. Periodic washing of filter material

**Advantages:**

1. Easy and simple to maintain and operate
2. Low-cost secondary treatment option
3. Pleasant landscaping is possible

**Disadvantages:**

1. Requires larger land area
2. Low treatment efficiency
3. Professional/specialist needed in design & construction

**Applications:**

Wide applications for secondary treatment of industrial wastewater where large land area is available. For residential areas, a sewer network system collects the septic tank effluent and conveyed to the reed bed system.

**Costs:**

Estimated cost at P 1,500/$m^2$ for horizontal flowbeds and P 2,500/$m^2$ for vertical flowbeds excluding land cost. Operational cost mainly consist labor cost for reed cutting at 3-4 years interval.

**Utility & Efficiency:**

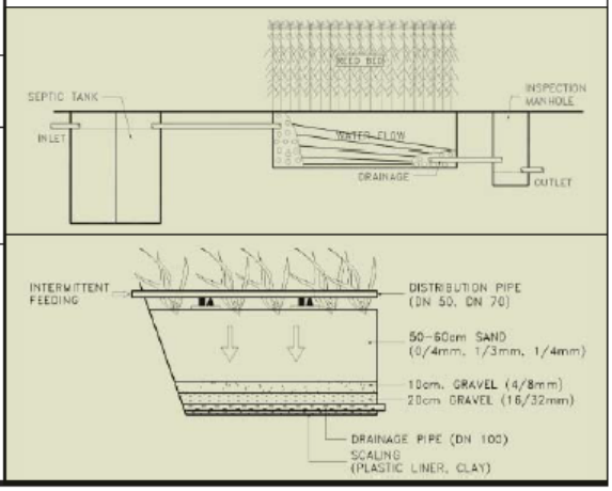
Low treatment efficiency. Reduction of BOD during secondary treatment about 10-30%. Reduction of infective organisms is high.

**Reliability:**

Usually reliable but shock load and flooding of the filter needs to be avoided.

**Regulatory/ Institutional Issues:**

- Compliance to Clean Water Act or DENR regulations







*Source: Philippines Sanitation Sourcebook and Decision Aid*

# APPENDIX K – SLUDGE DRYING BED

SLUDGE DISPOSAL **SD-01**

## SLUDGE DRYING BED

| | |
|---|---|
| **Description:** | Sludge drying bed is one method for dewatering sludge through reduction of moisture content by filtration and evaporation. The bottom of the filter bed is laid with perforated pipes for draining the filtrate or seepage water. After drying, moisture content is reduced by 35% or less. Sludge drying beds are normally located near treatment plants to receive/treat the sludge produced by primary/secondary treatment. |
| **Design:** | 0.21 - 0.58 $m^2$/capita of area requirements. Width of bed is usually 4 m and depth of sand and gravel layer is 70 cms average. 1-2 $m^3$ of sludge/$m^2$ of bed loading. |
| **Applications:** | Applicable where space is available. Most commonly used means for dewatering sludges. |
| **Components:** | Concrete structure for bed and walls; filter media (sand and gravel); splash block; underdrain system; inlet pipe |
| **Capacity:** | For treatment plants serving a population of 1,000 up to 20,000 |
| **Costs:** | Investment lowest among sludge dewatering methods.<br>O & M: No other cost except for labor |
| **Utility & Efficiency:** | Dried sludge is not fully disinfected, but solid content is increased to 50-70% total solids. |
| **Reliability:** | Reliable during dry season, but efficiency decreases during wet season. |
| **Flexibility:** | Good process flexibility. |
| **Reapplication Potential:** | Have good potentials for implementation by communities and/or local government. |
| **Regulatory/ Institutional Issues:** | • Requires a work force for operating and maintaining the facility. |

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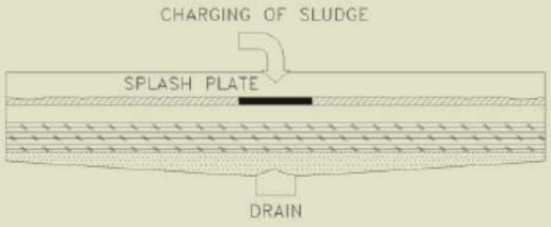
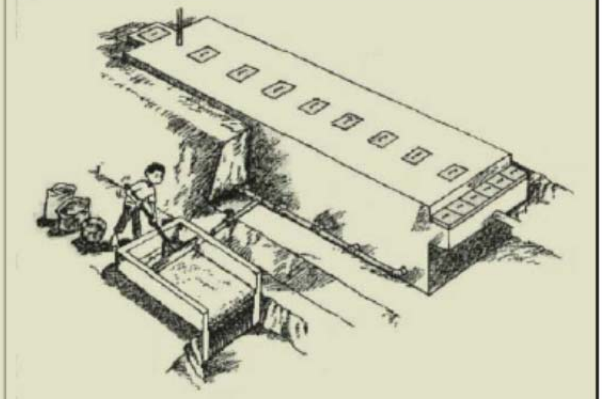
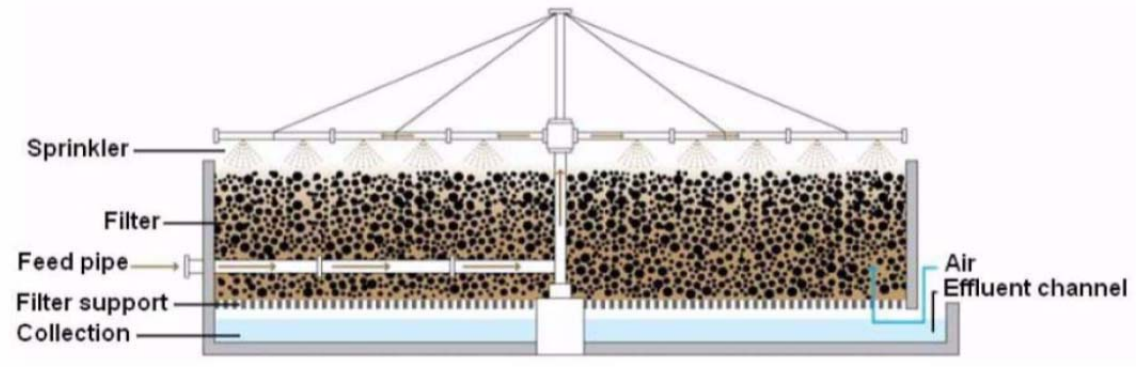
| **Operating Principles:** | Sludge is applied to the beds in 20 cm depth or layer. Drying take place due to evaporation and filtration or percolation. The dried sludge is removed manually and applied for agricultural use or sold as organic compost. The filtrate, however, needs to be treated further. |
| **Maintenance:** | 1. Replacement of sand every 6 months or 1 year<br>2. Prevent weed and grass encroachment<br>3. Regular dried sludge removal |
| **Construction Materials:** | 1. Concrete walls<br>2. Sand and gravel<br>3. Cast iron (CI) or polyvinyl chloride (PVC) pipes<br>4. Asphalt paved sludge beds |
| **Advantages:** | 1. Simple to operate<br>2. Lowest cost option among sludge dewatering methods<br>3. Energy-saving |
| **Disadvantages:** | 1. Filtrate/seepage water has to be treated<br>2. Requires solar power<br>3. May produce odor and flies nuisance |



*Source: Philippines Sanitation Sourcebook and Decision Aid*

# APPENDIX L – TRICKLING FILTER




A trickling filter is a fixed bed, biological filter that operates under (mostly) aerobic conditions. Pre-settled wastewater is 'trickled' or sprayed over the filter. As the water migrates through the pores of the filter, organics are degraded by the biomass covering the filter material.

The Trickling Filter is filled with a high specific surface-area material such as rocks, gravel, shredded PVC bottles, or special pre-formed filter-material. A material with a specific surface area between 30 and 900m2/m3 is desirable. The filter is usually 1–3 m deep but filters packed with lighter plastic filling can be up to 12 m deep. Pre-treatment is essential to prevent clogging and to ensure efficient treatment. The pre-treated wastewater is 'trickled' over the surface of the filter. Organisms that grow in a thin bio-film over the surface of the media oxidize the organic load in the wastewater to carbon dioxide and water while generating new biomass.

The incoming wastewater is sprayed over the filter with the use of a rotating sprinkler. In this way, the filter media goes through cycles of being dosed and exposed to air. However, oxygen is depleted within the biomass and the inner layers may be anoxic or anaerobic.

*Source: ADF Health Manual, volume 20, part 8, Chapter 2.*

# APPENDIX M – BIOGAS REACTOR

TREATMENT SYSTEM **TS-08**

## BIOGAS REACTOR

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|---|---|
| **Description:** | Biogas is a by-product of anaerobic decomposition of organic matter, such as animal manure, human waste, sewage sludge, dried leaves, and crop residues. It is an alternative source of energy for use in household cooking, heating, lighting and for municipal and industrial use. |
| **Design:** | 50 - 100 liters of waste to produce 2 m³ of biogas per day. Chamber must be air-tight. Approximately 15 - 28 m³ of methane gas per 1,000 persons per day. For pigs, it is 40 - 60 m³ of gas for 1,000 kgs. of waste. |
| **Applications:** | Of great benefit to rural areas in developing countries where organic matter is readily available. |
| **Components:** | Digestion tank; fixed or floating cover; sludge/waste inlet pipe; gas removal pipe; pressure relief and vacuum valve. |
| **Capacity:** | Small biogas plants can serve at least 200 households. |
| **Costs:** | Capital cost: P31,600/m³ of waste flow or P1.00/kg of sludge<br>O & M cost: P18,000/month, which includes cleaning of facility and desludging |
| **Utility & Efficiency:** | Utilization of methane gas. BOD/COD reduction through anaerobic digestion is 80 - 85% |
| **Reliability:** | Resistant against shock loads. Reliable if operated and maintained well. |
| **Flexibility:** | Upgrading of system not possible due to poor flexibility. |
| **Reapplication Potential:** | Basic biogas plant design, materials and technical know-how are available. |

| | |
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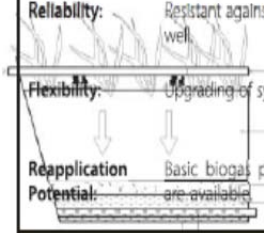
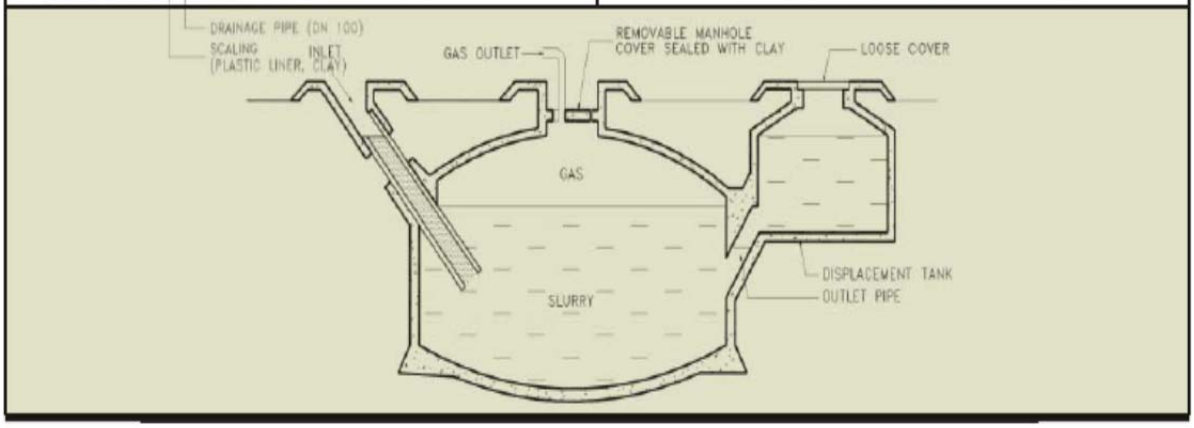
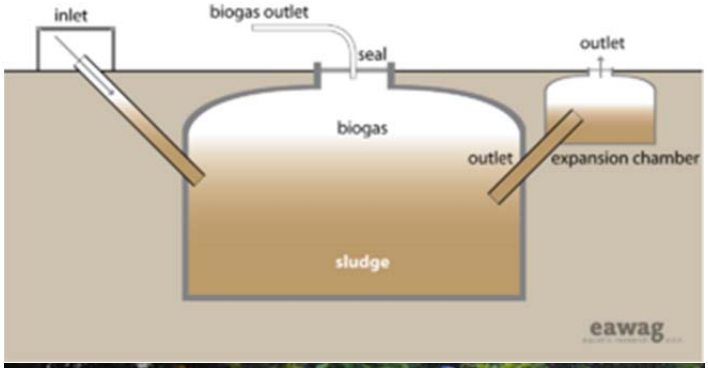
| **Operating Principles:** | Human waste is mixed with animal manure and crop residues in an anaerobic digester, where it is decomposed without oxygen at relatively high moisture content (90-99.5%). Wastes are decomposed into volatile acids and then, biogas. Other by products are amines, nitrates and ammonia (fertilizer) by the breakdown of proteinaceous materials. Pure sludge introduced continuously or intermittently, can also be retained in a reactor for varying periods of time, to produce biogas. |
| **Maintenance:** | 1. Check scum blanket; break up, if necessary<br>2. Monitor gas production, acidity/alkalinity ratio<br>3. Control foaming in digester<br>4. Monitor total solids |
| **Construction Materials:** | 1. Steel or reinforced concrete tanks<br>2. Heat and acid resistant piping system |
| **Advantages:** | 1. Self-reliant technology<br>2. Savings in power and foreign exchange<br>3. More efficient as fuel than firewood<br>4. Recycles nutrient back into the soil |
| **Disadvantages:** | 1. Needs proper proportioning of organic matter and wastes<br>2. Users need to be trained in the use and maintenance of the system; expert supervision is required<br>3. Requires expertise/craftsmanship in construction<br>4. High risk of corrosion problem and septic odor |




*Source: Philippines Sanitation Sourcebook and Decision Aid*





Some example of biodigesters