UNICEF

ASSESSMENT OF WASTE WATER TREATMENT PLANTS IN GHANA

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1. INTRODUCTION

1.1 Background

Ghana’s strong economic growth has been accompanied by rapid urbanization. Gross Domestic Product (GDP) annual growth rate averaged 6.4% from 2000 to 2014 (WDI, 2016), and 51% of the 24.7 million Ghanaians are living in urban areas, compared to 44% in 2000 according to the 2010 census (GSS, 2013). The GDP per capita was USD 1,441 in 2014 (WDI, 2016). The country attained a lower middle-income status in 2006 after the Ghana Statistical Service revised the base year for Ghana’s national accounts series from 1993 to 2006. As Ghana is a lower middle-income country the level of basic service delivery is now expected to be comparable to what exists in other lower middle-income economies. The provision of basic services, however, has not kept up with the rapid urban population growth, and is particularly affecting people living in low-income areas.

However, progress in terms of sanitation is very poor. Access to improved sanitation facilities at household level is only about 15% (WHO/UNICEF, 2015) compared to the national target of 54%. The Government of Ghana (GoG) along with development partners are making headways in addressing challenges faced in rural sanitation interventions such as development of clear rural sanitation strategy, complimenting policies and guidelines. On the contrary, urban sanitation interventions have been rather piecemeal, without a concerted national strategy. Consequently, developments in urban centres/small towns have been haphazard, affecting general population at large and urban poor the most.

Poor sanitation imposes significant cost to households, in particular to those in low-income areas. It is estimated that poor sanitation in Ghana costs about US$ 12 per person per year (WSP, 2012). The costs of poor sanitation are inequitably distributed and regressive, with the highest economic burden falling disproportionately on the poorest. The average cost associated with poor sanitation, constitutes a much greater proportion of a poor person’s income than that of a wealthier person.

To address the above concerns, the GoG-UNICEF WASH Programme (2012-2016) has developed the urban sanitation project, which is in line with the framework of the Ghana Shared Growth and Development Agenda (GSGDA). The programme covers the development of a national urban strategy to address household sanitation particularly in low income urban settlements such as slums and peri-urban communities. The programme is aligned with the National Environmental Sanitation Strategic Action Plan (NESSAP), Water Sector Strategic Development Plan (SSDP) and Environmental Health and Sanitation Policy.

UNICEF Ghana has received funding from the Government of the Netherlands to support the GoG-UNICEF WASH Programme by developing and implementing
a national urban strategy under the urban sanitation project titled ‘Improving Sanitation Access in Urban Ghana’. An urban sanitation strategy entailing components of sanitation behaviour change and demand generation, household sanitation, School WASH, appropriate, low-cost sanitation and waste water treatment technology options, sanitation marketing, supply chain and business development, service delivery, etc to address household sanitation particularly low income urban areas.

As part of the above project, UNICEF seeks to support improvement in sanitation services delivery by assessing types of technology options that are constructed/used in the three MMDAs and documenting the technical challenges faced. The findings will feed into the development a technology handbook/guide to support households make an informed choice, facilitate carpenters and masons during construction, and serve as reference document for officials both at the local government and national level.

To this end, UNICEF Ghana contracted the Civil Engineering Department of the Kwame Nkrumah University of Science and Technology (KNUST) to carry out technology assessment of sanitation facilities in the selected Metropolitan/Municipal Assemblies.

1.2 Objectives

The four main objectives of the assessment in the three MMDAs (Ashaiman, Ho and tamale) are:

• To assess challenges and opportunities of existing household sanitation technology options
• To explore new technology options that are suitable for household and for school, besides existing options
• To develop a sanitation technology options handbook/manual with designs of range of products which are affordable, suitable and sustainable.
• To assess challenges and opportunities of existing and defunct waste water treatment facilities in Ghana

1.3 Scope of Assignment and Deliverables

The assignment was implemented in the 3 municipalities – Ashaiman Municipality, Ho Municipality and Tamale Metropolitan. The deliverables are as follows:

• Technology Assessment Report –
• Household Sanitation Technology Options Handbook/Manual
1.4 **Focus of this report**

This report is focused on the Assessment of Wastewater Treatment Plants in Ghana, which is one of the outputs of this assignment. The other deliverables are in separate volumes.

The first part of this report contains findings of the field assessment of wastewater treatment plants in the three (3) municipality/metropolitan assemblies (MMDAs). The second part presents a snapshot of existing wastewater treatment plants in the Accra and Kumasi Metropolitan Assemblies based on contact with relevant officers in these Metropolitan Assemblies.
2. Wastewater and Faecal Sludge Treatment Plants in Ghana

Ghana has a very low coverage for wastewater and faecal sludge treatment which is mostly sewerage systems. The national average for sewerage coverage is as low as 4.5%. Tema is the only municipality with a comprehensive sewerage system. Accra has a sewerage system covering the State House and ministries area and parts of the Central Business District with low property connections. There are also a number of satellite sewerage systems for Dansoman, Teshie-Nungua, Burma Camp, University of Ghana, Legon, Achimota School, 37 Military Hospital and Ridge areas. The treatment facilities for both the Accra and Tema systems have broken down and not in use.

Subsequent sections of this chapter presents a list of wastewater/faecal sludge treatment facilities 5 MMDAs (Ho Municipal, Ashaiman Municipal, Tamale Metropolitan, Accra Metropolitan and Kumasi Metropolitan), technical challenges faced, operations and management arrangement other relevant information.

2.1 Ho Municipal Assembly

There is one waste water treatment plant in the Ho Municipality. The treatment plant is an Activated sludge system for treating waste from military barracks. The treatment units consist of a Sewage Pumping Station, two aeration tanks, sludge consolidation tank/thickener and treated water contact tank. The treatment system is functioning and managed by the military. Currently faecal sludge from the municipality is dumped in the wood lands at Tsito. Figure 1 shows various components of the wastewater treatment plant at Ho.

![Figure 1: components of the wastewater treatment plant at Ho](image-url)
2.2 Ashaiman Municipal Assembly

In the Municipality, it was reported that, there is a treatment facility which collects waste from the sewered portion of Ashaiman. However, the entire area was not accessible for assessment at the time of visit because has grown into a thick bush. Also in Ashaiman, there was waste to energy / Biofertiliser plant designed for co-digestion of municipal solid waste and faecal sludge, which is currently under construction. The bio fertiliser system consists of mixing tanks, digester, drying beds, duck weed pond, constructed wetland and waste stabilization ponds. The plant will be manged by Safi Sana Ghana Limited. Faecal sludge from Ashaiman is currently dumped at a facility in Nungua. Figure 2 shows various stages of construction of waste-to-energy plant in Ashaiman.

![Figure 2: stages of construction of waste-to-energy plant in Ashaiman](image)

2.3 Tamale Metropolitan Assembly

In the Tamale Metropolitan Assembly, there are three (3) wastewater/faecal sludge treatment facilities which are all operational. The treatment plants are waste stabilisation pond, septic tanks with constructed wetlands and filter systems.

Waste Stabilization ponds for treating faecal sludge and leachate from adjacent engineered landfill. This is made up of Anaerobic Ponds, Facultative Ponds and Maturation Ponds. The ponds usually dry up during the dry season. The systems appears to be overdesigned or does not receive enough faecal sludge to treat. The system is managed by Zoomlion Ghana Limited.
There is a number of septic tanks with constructed wet lands treating wastewater from SSNIT housing units. At the time of the assessment the wetlands was overgrown with weeds. During the dry season the wetlands also dry up.

At the Military barracks there is a filter bed with sludge drying beds treating wastewater. The systems consist of Primary settling tank, Filter bed and Sludge drying beds. The wastewater from the primary settling tank has been diverted directly into an earth drain and used by vegetable farmers. So the filter bed has been by passed. The system is managed by the military. Figures 3, 4 & 5 shows the various components of waste stabilization ponds, septic tanks systems for SSNIT area and treatment systems for the barracks respectively in Tamale.

Figure 3: State of various components of Waste stabilization ponds

Figure 4: Septic Tank Systems for SSNIT area in Tamale
2.4 Greater Accra Metropolitan Area (GAMA)

The waste water and faecal sludge treatment facilities in Accra and Tema are shown in Table 1. The assessment based on information presented in the National Environmental Sanitation Strategy and Action Plan (NESSAP) and updated with information and discussions with officers on the Accra Sewerage Improvement Project (ASIP).

Table 1: Waste water and fecal sludge treatment systems in Accra and Tema

<table>
<thead>
<tr>
<th>LOCATION OF SYSTEM</th>
<th>TYPE OF FACILITY</th>
<th>YEAR</th>
<th>MANAGEMENT RESPONSIBILITY</th>
<th>FINANCING FOR O &amp; M</th>
<th>CURRENT CONDITION</th>
</tr>
</thead>
<tbody>
<tr>
<td>Accra Central Sewerage Scheme</td>
<td>*UASB-Trickling Filter/Secondary Clarifier/Sludge Beds</td>
<td>2000</td>
<td></td>
<td></td>
<td>Undergoing rehabilitation</td>
</tr>
<tr>
<td>37 Military Hospital</td>
<td>Trickling Filter/Sedimentation</td>
<td>1972</td>
<td>Min. of Defence/MoH</td>
<td>Govt Sub.</td>
<td>Non operational</td>
</tr>
<tr>
<td>University of Ghana (UG)</td>
<td>Trickling Filter+drain field</td>
<td>1967</td>
<td>Health Services, UG</td>
<td>Govt Sub.</td>
<td>Converted to a sewage transfer pumping station</td>
</tr>
<tr>
<td>Location of System</td>
<td>Type of Facility</td>
<td>Year</td>
<td>Management Responsibility</td>
<td>Financing for O &amp; M</td>
<td>Current Condition</td>
</tr>
<tr>
<td>-------------------------</td>
<td>----------------------------------</td>
<td>------</td>
<td>---------------------------</td>
<td>---------------------</td>
<td>----------------------------------------------------------------------------------</td>
</tr>
<tr>
<td>Achimota School</td>
<td>Trickling Filter/Waste Stabilization ponds</td>
<td>1968</td>
<td>Ghana Edu. Service</td>
<td>Govt Sub</td>
<td>Converted to a sewage transfer pumping station</td>
</tr>
<tr>
<td>Burma Camp</td>
<td>Trickling Filter/Waste Stabilization Pond</td>
<td>1972</td>
<td>Ministry of Defence</td>
<td>Govt Sub</td>
<td>Damaged Filter Reconstruction</td>
</tr>
<tr>
<td>MATS, Teshie</td>
<td>Trickling Filter+Drain field</td>
<td>1972</td>
<td>Ministry of Defence</td>
<td>Govt Sub</td>
<td>Damaged Filter Reconstruction</td>
</tr>
<tr>
<td>Labone Estates</td>
<td>Activated Sludge</td>
<td>1974</td>
<td>PWD</td>
<td>Sewer Tariff/Gov</td>
<td>Damaged, Reconstruction</td>
</tr>
<tr>
<td>Ministries (Accra)</td>
<td>Activated Sludge</td>
<td>1972</td>
<td>PWD</td>
<td>Govt Sub</td>
<td>Damaged, Reconstruction</td>
</tr>
<tr>
<td>State House</td>
<td>Activated Sludge</td>
<td>1974</td>
<td>PWD</td>
<td>Govt Sub</td>
<td>Damaged, Reconstruction</td>
</tr>
<tr>
<td>Mental Hospital</td>
<td>Trickling Filter</td>
<td>1971</td>
<td>MoH/PWD</td>
<td>Govt Sub</td>
<td>Damaged, Reconstruction</td>
</tr>
<tr>
<td>Accra High School</td>
<td>Activated Sludge</td>
<td>1970</td>
<td>GES/PWD</td>
<td>Govt Sub</td>
<td>Damaged, Reconstruction</td>
</tr>
<tr>
<td>Roman Ridge</td>
<td>Imhoff Tank</td>
<td>1973</td>
<td>PWD</td>
<td>Govt Sub</td>
<td>Non operational</td>
</tr>
<tr>
<td>Dansoman Estates</td>
<td>Communal Septic Tanks</td>
<td>1975</td>
<td>SHC/AESC Hydro</td>
<td>MWRWH/Govt</td>
<td>3 out of 5 converted to sewage transfer pumping station</td>
</tr>
<tr>
<td>KorleBu Teaching Hospital</td>
<td>Imhoff Tank + Trickling Filter</td>
<td>1954</td>
<td>MoH/PWD</td>
<td>Govt Sub</td>
<td>Non operational</td>
</tr>
<tr>
<td>PRESEC School</td>
<td>Stabilization Pond</td>
<td>1976</td>
<td>GES/PWD</td>
<td>Govt Sub</td>
<td>Converted to a sewage transfer pump station</td>
</tr>
<tr>
<td>Teshie/Nungua Estates</td>
<td>Trickling Filter</td>
<td>1977</td>
<td>SHC/AESC Hydro</td>
<td>MWH/Govt.</td>
<td>Damaged, need reconstruction</td>
</tr>
<tr>
<td>Trade Fair Site, Labadi</td>
<td>Trickling Filter</td>
<td>1972</td>
<td>PWD</td>
<td>MWH/Govt.</td>
<td>Damaged, need Reconstruction</td>
</tr>
<tr>
<td>LOCATION OF SYSTEM</td>
<td>TYPE OF FACILITY</td>
<td>YEAR</td>
<td>MANAGEMENT RESPONSIBILITY</td>
<td>FINANCING FOR O &amp; M</td>
<td>CURRENT CONDITION</td>
</tr>
<tr>
<td>---------------------------------------------</td>
<td>--------------------------</td>
<td>------</td>
<td>-------------------------------</td>
<td>---------------------</td>
<td>-------------------</td>
</tr>
<tr>
<td>Labadi Beach Hotel</td>
<td>Packaged Plant</td>
<td>1992</td>
<td>Beach Hotel Ltd</td>
<td>Hotel Tariff</td>
<td>Functional</td>
</tr>
<tr>
<td>Golden Tulip Hotel</td>
<td>Packaged Plant</td>
<td>1993</td>
<td>Golden Tulip Hotel</td>
<td>Hotel Tariff</td>
<td>Functional</td>
</tr>
<tr>
<td>Teshie-Nungua (Fertilizer)</td>
<td>FSTP</td>
<td>1994</td>
<td>AMA-WMD</td>
<td>AMA</td>
<td>Functional</td>
</tr>
</tbody>
</table>

*Source: Base Information from National Environmental Sanitation Strategy and Action Plan, 2011 and updated with information from office of the Accra Sewerage Improvement Project (ASIP)*
2.5 Kumasi Metropolitan Assembly (KMA)

Facilities presented for the KMA were collated based on information in literature and discussions with officers of the assembly. List of the facilities and other relevant information is presented in Table 2-6.

Table 2: Wastewater / faecal sludge treatment facilities in Kumasi

<table>
<thead>
<tr>
<th>LOCATION OF SYSTEM</th>
<th>TYPE OF FACILITY</th>
<th>YEAR</th>
<th>MANAGEMENT RESPONSIBILITY</th>
<th>FINANCING FOR O &amp; M</th>
<th>CONDITION</th>
</tr>
</thead>
<tbody>
<tr>
<td>Teaching Hospital/ City Hotel/4BN Barracks</td>
<td>Trickling Filter / Oxidation Pond</td>
<td>1956</td>
<td>KATH/KMA</td>
<td>Min. of Health/Govt Subvention</td>
<td>Not operational</td>
</tr>
<tr>
<td></td>
<td>(1962-)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>University Campus (KNUST)</td>
<td>Trickling Filter</td>
<td>1967</td>
<td>Health services (KNUST)</td>
<td>Govt. Subvention</td>
<td>Non-functional</td>
</tr>
<tr>
<td>Ahinsan/ Chirapatre/ Kwadaso Low-Cost Housing</td>
<td>Septic Tank-Filter Beds /Waste stabilization ponds (WSPs)</td>
<td>2002</td>
<td>KMA</td>
<td>KMA</td>
<td>Functional</td>
</tr>
<tr>
<td>Asafo</td>
<td>Waste Stabilization Ponds</td>
<td>1994</td>
<td>KMA/Contractor</td>
<td>KMA</td>
<td>Functional,</td>
</tr>
<tr>
<td>Asokore-Mampong Buobai</td>
<td>FSTP</td>
<td>2002</td>
<td>KMA</td>
<td>KMA</td>
<td>Non-functional</td>
</tr>
<tr>
<td>Oti/ Dompoase Landfill</td>
<td>Septic &amp; Faecal Sludge Treatment Plan</td>
<td>2002</td>
<td>KMA</td>
<td>KMA</td>
<td>Non-functional primary settling ponds</td>
</tr>
</tbody>
</table>
3. Conclusion

The assessment revealed that most of the existing wastewater/faecal sludge treatment facilities are in a poor state. There is the need to pay attention to operations and maintenance of waste water and faecal treatment plants.

References

ANNEX

Brief Description of Treatments Units with their Advantages and Disadvantages of Treatment Facilities

This section presents a discussion on the working operations of some treatment units with some advantages and disadvantages of each.

Activated Sludge System

Activated sludge refers to a mass of microorganisms cultivated in the treatment process to break down organic matter into carbon dioxide, water, and other inorganic compounds. The activated sludge process has three basic components: 1) a reactor in which the microorganisms are kept in suspension, aerated, and in contact with the waste they are treating; 2) liquid-solid separation; and 3) a sludge recycling system for returning activated sludge back to the beginning of the process. There are many variants of activated sludge processes, including variations in the aeration method and the way the sludge is returned to the process. Activated sludge can be appropriate where high removal of organic pollution is required, funds and skilled personnel are available for operation and maintenance, and land is scarce or expensive. Since activated sludge requires the continuous operation of oxygen blowers and sludge pumps, a steady energy supply is a key requirement. The system usually needs some form of pretreatment, such as screening and primary sedimentation.

Advantages

Efficient removal of BOD, COD and nutrients when designed and professionally operated according to local requirements. The process itself has flexibility and numerous modifications can be tailored to meet specific requirements (e.g. for nitrogen removal). Activated sludge is the best documented and most widely used form of secondary wastewater treatment.

Disadvantages

Expensive in terms of both capital and O&M costs, requires a constant energy supply, needs trained operators who can monitor the system and react to changes immediately, and the availability of spare parts and chemicals may be an obstacle.
The track record of activated sludge plants in the developing world is very poor, and few operate as designed or intended.

**Ponds and Wetlands**

**Anaerobic Pond**

Anaerobic waste stabilization ponds are open basins in which wastewater is treated in the absence of oxygen. Solids settle to the bottom of the pond, where they are digested.

Anaerobic ponds are used as a first stage to treat wastewater prior to secondary treatment in facultative and maturation ponds, or to reduce land use requirements of other systems (e.g. constructed wetlands). Because they are open, anaerobic ponds will smell and they should therefore not be located close to housing. Some authorities suggest a minimum distance of 1000 meters from the nearest house but a separation of 500 meters and even less may be appropriate.

**Advantages**

Anaerobic waste stabilization ponds are simple and economical to build and operate. They are relatively inexpensive and can be managed relatively easily by small and medium-sized communities.

**Disadvantages**

Anaerobic ponds take time to reach full treatment efficiency. These systems require large amounts of land compared to “conventional” activated sludge or other secondary treatment technologies. The restrictions on location near to houses and their size mean that they may be more appropriate for use in larger schemes.

**Facultative and Maturation Ponds**

Facultative ponds are large shallow basins that hold sewage and allow treatment by a combination of aerobic and anaerobic processes. Treatment takes place through both physical and biological processes, which can be quite complex. Maturation ponds are smaller ponds placed in series after facultative ponds, and can reduce pathogen concentrations to safe levels. Waste stabilization ponds can be considered when land is available, there is a need to achieve a good reduction in pathogen levels and/or there is a probability that the sewage inflow will occasionally include large quantities of stormwater run-off. Land needs can be reduced by about a third through provision of anaerobic ponds ahead of the facultative ponds.
Advantages

Waste stabilization ponds are simple, robust and can deal with fluctuations in wastewater flows. With a retention time of at least 22 days it is the only treatment system considered by WHO to achieve the effluent standard required for unrestricted irrigation.

Disadvantages

The major disadvantage of waste stabilization ponds is their large land requirement. This varies depending on sewage strength and temperature but is likely to be in the range 3 – 5 m² per person. Their large land requirement means that they are unlikely to be a viable option where land is either expensive or in short supply.

Constructed Wetlands (reed beds)

Constructed wetlands are engineered wetland systems which can treat a variety of waste effluents: domestic wastewater, agricultural runoff, stormwater and even industrial effluents. Treatment takes place through a variety of complex natural chemical, physical and biological processes, including sedimentation, precipitation, adsorption, assimilation from the plants and microbiological activity. The system utilizes aquatic plants, such as Phragmites reeds, bulrushes and cattails. A cost-effective system is designed to work under gravity, thus minimizing any need for pumps or other electrical devices. The flow may be either horizontal or vertical and, in the case of horizontal flow wetlands, may be either above or below the surface. Most constructed wetlands in developing countries are of the horizontal sub-surface flow type. Above-surface designs are generally avoided because they create breeding sites for mosquitoes.

Wetlands can be considered for use when there is a need for a better quality effluent than can be achieved by purely anaerobic treatment. Constructed wetlands need land, typically 3 – 5 m² per person if the constructed wetland is to treat full-strength sewage. For this reason, it is often better to use them after primary anaerobic treatment, thus lowering the land requirement.

Advantages

Constructed wetlands are a relatively simple technology, with limited maintenance needs. They can achieve good BOD/COD reduction and can also remove pathogens fairly efficiently. Appropriately designed constructed wetlands are tolerant to fluctuations in both hydraulic and contaminant load, which make them an ideal solution where variable storm water quantity or wastewater quality may be a problem. The system can also provide a variety of indirect benefits, such as wildlife habitat, areas for educational or even recreational purposes. The wetland areas can also be used for growing crops with direct economic value, such as biomass for energy or agricultural purposes.
Disadvantages
The major disadvantage of constructed wetlands is their relatively large land requirement. They are also more complicated than waste stabilization ponds and have greater management requirements. They may also take a year or two to achieve the optimum treatment efficiency.

Anaerobic Digestion
Anaerobic digestion is a series of biological processes in which microorganisms break down biodegradable material in the absence of oxygen. One of the end products is biogas, which is combusted to generate electricity and heat, or can be processed into renewable natural gas and transportation fuels. A range of anaerobic digestion technologies are converting livestock manure, municipal wastewater solids, food waste, high strength, industrial wastewater, and various other organic waste streams into biogas.

Advantages
• Energy produced from biogas offsets the cost of the investment
• Digested faecal sludge is biologically stabilized, making it easier to store for long periods without odor problems
• Digested solids can be composted and directly applied to cropland
• Smaller footprint compared to other systems

Disadvantages
• High investment cost compared to other treatment options
• High technical knowledge of the digestion process and good management is required.
• Need for further treatment of effluent from anaerobic digestion

Trickling Filters
Trickling Filter also known as percolating or sprinkling filter is like a well having depth up to about 2m and filled with some granular media. The sewage is sprinkled over the media which percolates through filter media and is collected through the under-drainage system.

A modern trickling filter consists of a bed of highly permeable media to which micro-organism are attached and sewage percolates or trickle down and hence the name “Trickling Filter”. The filter media consists of rocks varying in size from
25-100mm. The depth of rock varies from 0.9-2.5m averaging 1.8m. A rotating arm (distributor arm) is provided to evenly distribute sewage. The air is also provided through under-drainage system from ventilation of filter.

Advantages

• Simple Process Control
• Resistant to Shock Loads
• Energy Requirement Low
• Low Sludge Production
• Sludge Thickens and Dewater Easily

Disadvantages

• Moderate Effluent BOD/TSS Typically Achieved
• High Capital Cost
• Low Operational Flexibility
• Moderate Odor and Nuisance Potential
• Poor Nitrogen Removal Typical
• Biological Phosphorus Removal Difficult.