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《SEWAGE TREATMENT》

Final Report

TOPIC: Wastewater treatment in Liberia

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INTRODUCTION

Proper treatment of wastewater is a problem faced by most developing cities as in the case of Liberia (especially its densely populated capital Monrovia. Waste treatment in Monrovia, Liberia is still in its infant stage. The city is still struggling with poor sanitation, clogged pipes, shortage of septic tanks, lack of resources/human capacity, inadequate treatment facilities, open defecation, absence of clear guidelines etc. The rapid urban population growth of Monrovia has severely stressed Monrovia's marginally functional urban WSS system caused by the civil conflict which led to break down in many sectors as well as infrastructure. The sewerage system which originally covered 17% of the population of Monrovia was down to serving about 7% because of bursts and blockages causing back flows in other areas. Prior to the Civil War, the average water production for Monrovia was about 68,000 m³/day, but has now dropped to about 10,000 m³/day. Only small parts of Monrovia currently have direct access to the piped water supply while most areas depend on trucked water delivered to community collection points or household tanks, and/or on water from unprotected dug wells or hand pumps. There are only two functional treatment plants; The Fiamah Treatment plant and the White Plains Treatment Plant. Prior to the civil unrest there were a number of sanitation facilities.

OVERALL SITUATION OF WWTPS

Sanitation Sector and Institutional Context

Large sections of Liberia's population are dangerously exposed to unsafe sanitation. Total improved sanitation remains below 17% and almost half of the population practice open defecation (WHO & UNICEF, 2015). In Monrovia, less than 3% use a toilet facility connected to the sewer system compared to over 10% practicing open defecation in the city. Barely 25% have access to improved toilet facilities. While access to some type of facility is considerably higher, these are often shared between many households or of low quality. The overflowing of sewage from damaged sewer pipes or, more commonly, pit latrines and open defecation areas into the streets are a common occurrence in densely populated, poor areas, especially in the rainy season. Table 1 below summarizes access by type of toilet facility in Monrovia.

Table 1: Access by type of Toilet Facilities in Monrovia (Source: DHS2013)

Type of Toilet Facility	Total	of which shared	Total Improved
Flush to piped sewer system	2.7%	45.9%	1.5%
Flush to septic tank	34.8%	33.9%	23%
Flush to pit latrine	2.4%	75.2%	0.6%
Flush to somewhere else	1.5%	39.1%	unimproved technology
Flush, don't know where	0.1%	0.0%	unimproved technology
Ventilated Improved Pit latrine (VIP)	20.6%	93.1%	1.4%
Pit latrine with slab	6.4%	98.7%	0.1%

Pit latrine without slab/open pit	4.7%	94.2%	unimproved technology
No facility/bush/field	11.3%	0.0%	unimproved technology
Bucket toilet	0.5%	0.0%	unimproved technology
Hanging toilet/latrine	14.2%	97.6%	unimproved technology
Other	0.8%	70.8%	unimproved technology
Total	100%		26.6%

NB: Any facilities (even otherwise improved ones) which are shared between households are counted as unimproved in the WHO/UNICEF methodology

The present access figures, combined with the continuing rapid urban growth, put the 2017 target of 61% access to safe sanitation in Monrovia set by the government's "Agenda for Transformation" beyond reach. Similarly, the goal of the Government's longer term "Liberia Rising 2030" plan to achieve universal access by 2030 is ambitious indeed and will require major interventions.

Given the present access to safe toilets, the 2012 Economics of Sanitation initiative estimated that Liberia loses at least US\$17.5m annually due to negative effects of poor sanitation (World Bank, 2012). WASH related diseases remain common due to the lack of access to safe sanitation. Diarrhea is widespread among children, with 22% of under-five year olds suffering from diarrhea in the past two-weeks, a value higher than in Haiti or the DR Congo, and more than twice the rate in India (Demographic and Health Survey, 2013).

Urban children are affected almost as often (20.1%) as their rural counterparts (23.8%). Cholera remains endemic with 60 registered cases in 2014 (UNICEF, 2015). Moreover, "lack of access to safe water [and] proper hygiene" also "contributed to the propagation of the [Ebola] virus" and was even a "critical factor" in schools, as a recent report on *Recovering from the Ebola Crisis* highlighted. The report went on to recommend to "improve access in underserved, urban poor communities and areas affected by epidemics" (UN / World Bank / EU / AfDB, 2015).

In urban areas, the Liberia Water and Sewer Corporation (LWSC) is responsible for water and sanitation supply. LWSC's mandate is to provide safe water supply and sanitation services to the urban areas with a population above 5,000 inhabitants. These currently include Monrovia, Buchanan, Kakata, Zwedru, Sanniquellie, Harper, Voinjama, Tubmanbourg, Greenville and Robertsport. On-site facilities in the capital (e.g. septic tanks) are, however, managed privately or by the Monrovia City Council, and the actual extent of the off-site sewer network run by LWSC is very limited (see detailed description below).

Investments in the sanitation sub-sector have remained limited relative to the enormous needs. Only US\$2.5m, or 0.4% of the national budget were allocated to the water and sanitation sector in 2013-14, and virtually no funds for urban sanitation. The only significant undertakings in urban areas are projects by the African Development Bank (AfDB) and OXFAM to increase access to *on-site* sanitation for Monrovia's poor. The AfDB project has a volume of approx. US\$ 1.5 million to build and rehabilitated communal toilets, carry out hygiene education and studies on septic tank emptying. The OXFAM project focuses on support to hygienic toilets in selected areas of Monrovia with a budget of approx. US\$ 3 million to improve

access for approx. 50,000 persons. By contrast, piped sewerage networks have not seen any significant investments since the war.

In view of the present dramatic lack of access to safe sanitation in Liberia's capital and the major public health risks this poses, at-scale interventions by the government and its donor partners will be required. A key target of such interventions may be the rehabilitation and extension of Monrovia's piped sewer system, which was built over fifty years ago and since then largely fallen into disrepair.

While a rehabilitated and extended pipe sewer system could potentially offer an at-scale solution, the challenge is enormous given its present deteriorated condition and the many unanswered questions ranging from technical options to treat or vacate sewerage for a population many times that of fifty years ago, to the (opportunity) costs of undertaking major investments in a piped sewer system and the ability of LWSC to subsequently maintain a potentially renewed system. For this reason, the 2012 national Sector Investment Plan called for a detailed review to bring clarity to these issues.

APPLICATION OF DIFFERENT TREATMENT PROCESSES

Present Condition of Monrovia's Sewer System

1. An off-site piped sewerage system was constructed in Monrovia in the 1950s and 1960s, covering an area of approximately 27 square kilometers in central Monrovia, Sinkor, Old Road and Bushrod Island (New Kru Town, Logan Town, Clara Town), less than 20% of the Greater Monrovia urban area. In the original design, sewage from these areas was transmitted through a total of 64 kilometers of pipes to the Fiamah Sewage Treatment plant located in Sinkor, which had a capacity of 6 million gallons per day.
2. Table 2 below lists the original length and location of sewage pipelines, Figure 1 outlines the design of Fiamah treatment plant and Map 1 illustrates the original extent of the sewage network. This original sewerage system of Monrovia, however, has become largely dysfunctional since the 1990s.

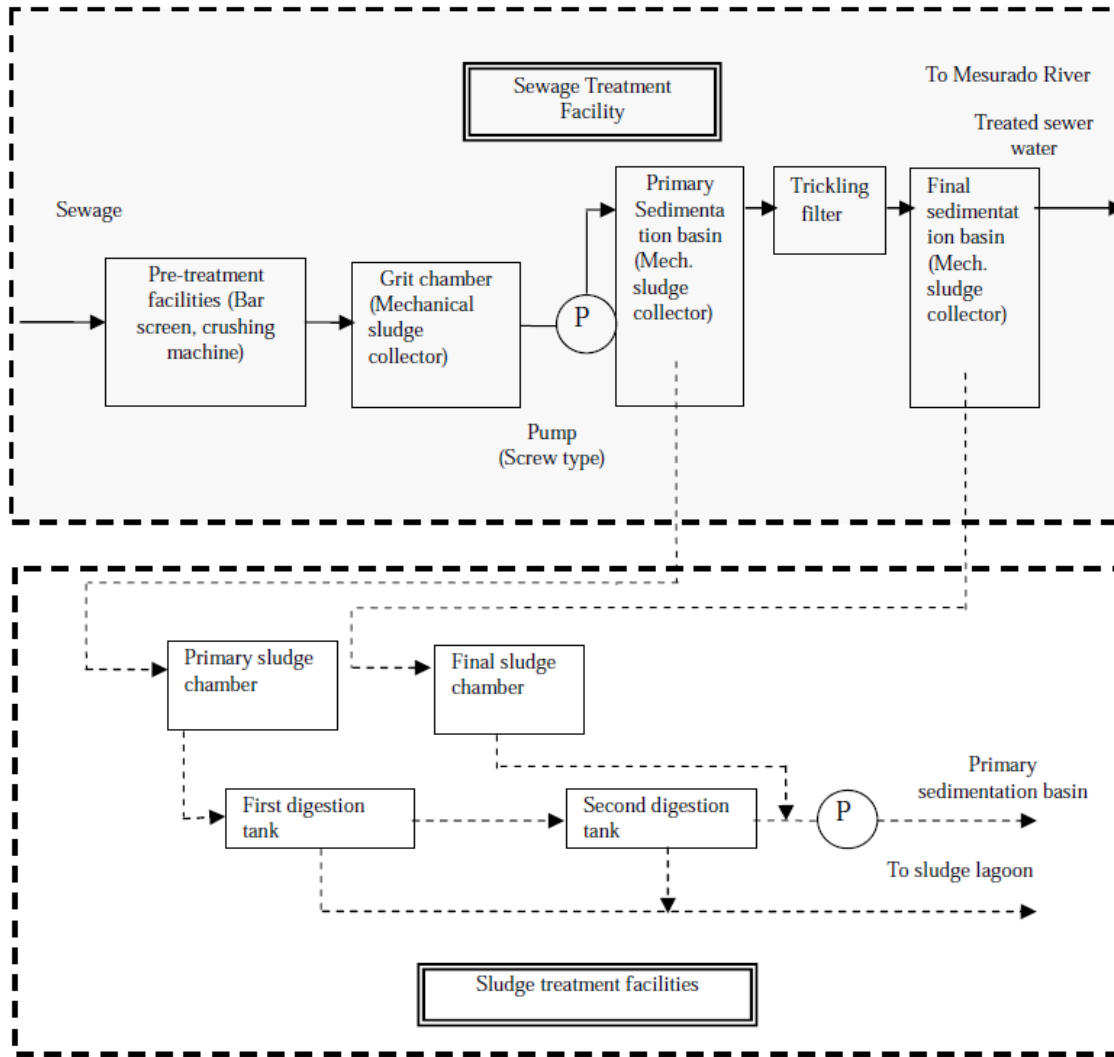
Table 2: Original location and length of sewage pipelines (Source: JICA)

Area	8"-12" Diameter (meters)	14"-20" Diameter (meters)	24"-42" Diameter (meters)	>42" Diameter (meters)	Total (meters)
New Kru Town Pump Station to New Kru Town	1,726	717	-	-	2,443
Bushrod Islands Pump Station to Logan Town and Clara Town	5,916	1,455	4,310	-	11,680
Mesurado River Pump Station to Central Monrovia (Central Monrovia A and B)	4,313	137	658	-	5,108
West Point	no sewer pipes				
BTC Pump Station to Central Monrovia (Central Monrovia A and B)	17,992	161	3,191	698	22,042

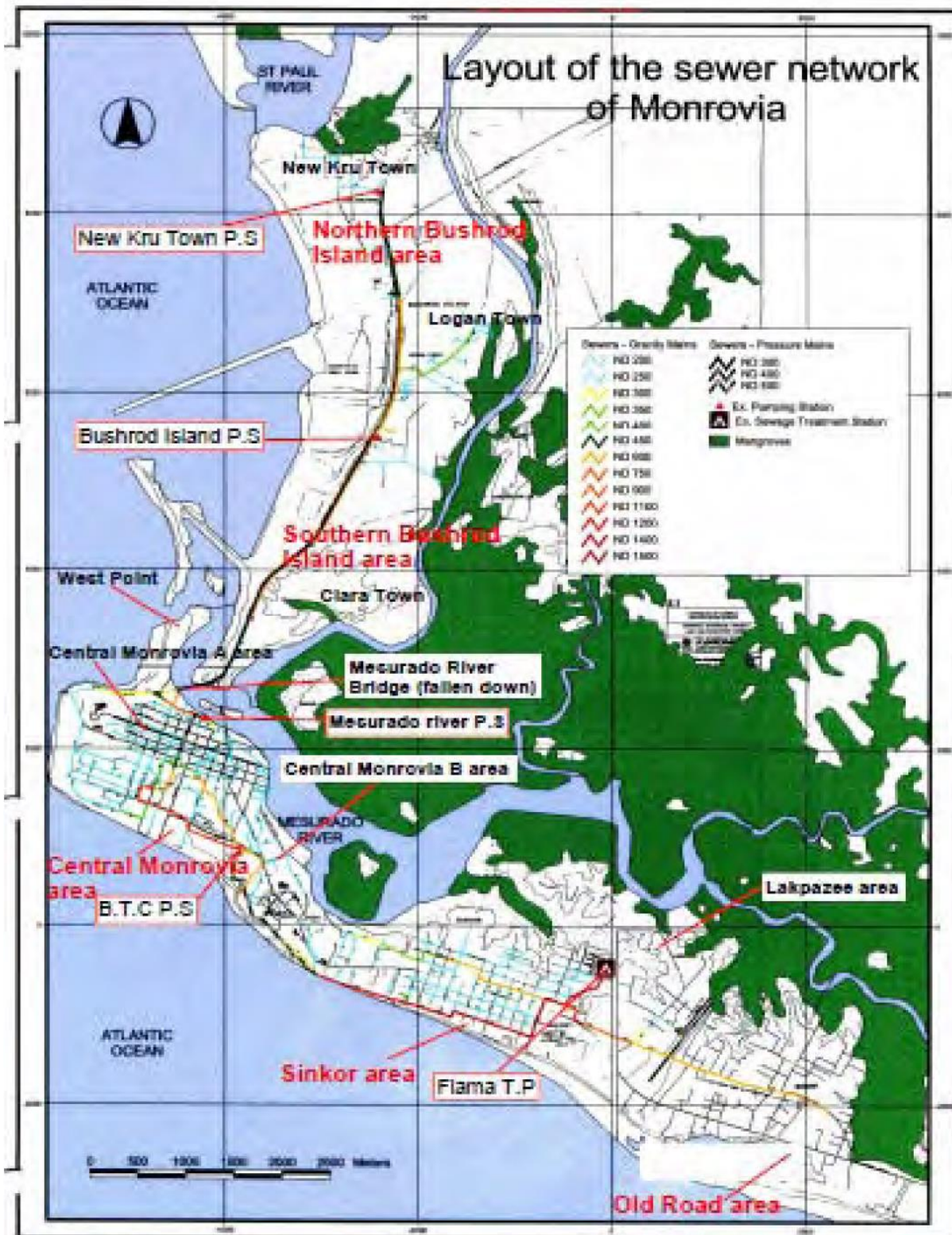
Fiamah Treatment Plant (incl. gravity pipes to Sinkor and Old Road areas)	14,136	970	4,283	3,600	22,989
Congo Town, Paynesville and other areas	no sewer pipes				
Total	44,083	3,440	12,442	4,298	64,262

3. Decades of neglect during and after the civil war have destroyed most of the piped sewage system of Monrovia, including all pumping stations and the Fiamah treatment plant. In some areas, in particular Sinkor, gravity-driven sewage pipes are still operational, carrying waste-water to the dysfunctional Fiamah treatment plant from which it is then discharged into Mesurado River through a sludge lagoon. LWSC still provides some trucking services to collect fecal sludge, which is similarly disposed of at Fiamah without treatment.

Figure 1: Design of Treatment Process at Fiama Plant (Source: JICA)



Map 1: Map of the original sewer network of Monrovia (Source: JICA)



4. The current number of sewage connections to the remnant of the network is not known, but it was estimated at 2,900 (of which 800 billed) in 2006. Table 3 below provides a more detailed summary of the condition of the sewage system facilities as of 2009.

Table 3: Condition of Sewage System Facilities as of 2009 (Source: JICA)

Sewerage Facility	Condition
<i>Relay Pumping Stations</i>	
New Kru Town Pumping Station	Designed to pump sewage from New Kru Town area to northern branch of Bushrod main sewer, but completely destroyed.
Bushrod Island Pumping Station	Designed to pump all sewage of Bushrod Island into the sewerage system of central town. Pump house building and underground structure remain, but mechanical and electrical equipment (e.g. pumps) damaged or stolen.
Mesurado River Pumping Station	Pump house building and underground structure remain, but mechanical and electrical equipment (e.g. pumps) damaged or stolen.
BTC Pumping Station	Pump house building and underground structure remain, but mechanical and electrical equipment (e.g. pumps) damaged or stolen
<i>Lifting Pump Station (to pump up sewage to manhole)</i>	
First Clara Town Lift Station	Pump house building and underground concrete structures remain, but are in deteriorated condition. All mechanical and electrical equipment (e.g. pumps) damaged or stolen.
Second Clara Town Lift Station	Pump house building and underground concrete structures remain but are in deteriorated condition. All mechanical and electrical equipment damaged or stolen.
First Slipway Lift Station	Pump house building and underground concrete structures remain but are in deteriorated condition. All mechanical and electrical equipment damaged or stolen.
Second Slipway Lift Station	Pump house building and underground concrete structures remain but are in deteriorated condition. All mechanical and electrical equipment damaged or stolen.
Matadi Lift Station	Pump house building and underground concrete structures remain but are in deteriorated condition. All mechanical and electrical equipment damaged or stolen.
<i>Main Sewer Pipelines</i>	
Pipes in central / central-northern Monrovia	Laid in 1950s and 1960s. Pipes in poor structural condition despite rehabilitation program in 1982. Pipes are broken and silted up, and especially during the rainy season they are surcharged and sewage flows out of manholes and broken sections. Main pipeline between Bushrod Island and Central Monrovia has been damaged, falling down from Mesurado Bridge
Pipes in Bushrod Island, central-southern Monrovia, Sinkor	Primarily put in place during a network expansion 1968-70 and in comparatively good condition. However, problems have been identified along specific sections: Damage in pipe from Curley Street to Center Street to Lynch Street; a broken pipe in 3 rd Street Sinkor; pipe broken and requiring replacement in Russel Avenue from 3 rd to 5 th Street in Sinkor;
<i>Fiama Sewage Treatment Plant</i>	
Fiama Plant	The original design of the plant consisted of intake, screen and grit chambers, low lift pumping and primary settling basins; trickling filters and secondary settling tank; two sludge digesters and sludge lagoons. The plant has not been operating since the late 1980s. It stopped operating when electricity supply failed and water production collapsed. At present, the small amounts of sewage arriving via tankers or through remaining gravity pipes in the Sinkor area is diverted at the intake towards the sludge lagoons and discharged into a densely vegetated branch of Mesurado River.

- On July 29, 2015, the Liberia Water and Sewer Corporation (LWSC) and a Chinese construction company Chongqing International Construction Corporation (CICO) have signed a \$10.6 million contract for the rehabilitation of the White Plains Water Treatment Plant 21 km transmission line, which runs from White Plains to Red-Light in Paynesville in Monrovia, Liberian capital.
- The contract which was awarded to a Chinese based company Chongqing International Construction Corporation (CICO) was set to be a big boost to Liberia's water industry as the plant which has been supplying water to the Northern parts of Liberia was out of age.
- The agreement between the the government and Chongqing International Construction Corporation sought to construct and rehabilitate Liberia's water treatment plant. It includes a 36 inch diameter pipeline covering 21 kilometers from White Plains to Red-Light in Paynesville.
- In Monrovia, the water supply service is mainly based on a surface water source from the nearby St. Paul's river.
- The raw water is pumped to the White Plains Treatment Plant (WTP) and treated water distributed to the population through a distribution system. Only small parts of Monrovia currently have direct access to the pipe water supply.
- While most areas depend on trucked water delivered to community collection points or household tanks, and/or on water from unprotected dug wells or hand pumps. AWF (AWF, 2008) (AWF, 2008).

Fig 2: Liberia White Plain Water Treatment Plant



SLUDGE YIELD OF DIFFERENT WASTEWATER TREATMENT PROCESSES

Sludge treatment

The treatment of sludge encompasses all processes that improve the suitability for usage, transportation or storage of sewage sludge. The methods of sludge treatment includes thickening, hygienization, biological stabilization, dewatering, drying and incineration.

Thickening involves the reduction of the sludge volume by removing as much water as possible.

The process of hygienization is to reduce the concentration of pathogens such as virus and worms eggs in the sewage sludge. The aim of this method is to minimize the risk of human and animal contamination whenever the sludge is used as a fertilizer.

Biological stabilization of sludge is carried out to reduce the concentration of organic substances that break down rapidly in order to avoid odors.

Sludge dewatering is done mechanically thereby reducing the volume of the sludge mixture and its water content. It is important in settings where the sewage sludge is transported to another site for treatment or disposal.

Challenges for water and wastewater treatment

1. Lack of access to safe, clean water

Access to water as a basic fundamental right of citizens has become a struggle for survival for most Liberians.

The lack of access to safe, clean water – especially mass shortages across the capital Monrovia and its surroundings, including the slum of West Point – during the continuing dry spell there remains a big challenge.

2. Insufficient infrastructure

Limited sewer collection is a bottleneck for wastewater treatment in Liberia.

3. Poor operation and maintenance

Poor operation and maintenance is a challenge for WWTPs and waterworks. For some manufacturers in Liberia, they cannot get applicable technologies to remove pollutants from their industrial wastewater due to limited available information and experiences. Some waterworks are facing challenges for the dosage of coagulants when the turbidity is too high or too low.

RECOMMENDATIONS

Based on the current practices and challenges, here are recommendations for the improvement of water and wastewater treatment in Liberia.

1. Transforming to green economy

It is imperative to move from the end-of-pipe water pollution control mode to more proactive pollution prevention. A green economy and cleaner production should be employed to reduce wastewater discharge and to recycle resources from wastewater. Green economy can also minimize the impact of human activities on the ecosystem, and the protection of ecosystem can conserve and preserve water quality.

2. Improving operation and maintenance

It is important to provide training and to enhance the expertise for the operation and maintenance of the facilities for water and wastewater treatment. Otherwise the facilities in waterworks and wastewater treatment plants cannot work effectively. Capacity building is needed to improve the knowledge of the workers in this sector. Only qualified and efficient operators and managers can ensure the smooth operation of these treatment facilities. In addition, those who construct the water and wastewater treatment facilities should establish necessary maintenance mechanisms so that these facilities can run sustainably.

3. Improving governance and management

The low priority accorded to water sector leads to poor water quality. The governments usually do not have political will to emphasize water and wastewater treatment because this is not considered as “vote winning”. It was suggested that local planning processes need to be reformed so that local politicians commit more strongly to improving water supply. To establish good governance with a better mechanism and institutional framework is a key to avoiding the lack of political will and commitment for water and wastewater treatment. The management of drinking water quality, wastewater discharge, and solid waste disposal should be enhanced. The regulatory authorities should put up legislations and rules to require industries to establish on-site pre-treatment facilities.

4. Harvesting energy

Energy is of vital importance for the water and wastewater treatment systems. However, Liberia lacks reliable energy supply systems. One possible solution is the utilization of solar energy. The other possibility is to recover energy from wastewater or waste sludge. For example, up flow anaerobic sludge blanket reactor makes it feasible to harvest biogas from wastewater, and a microbial fuel cell pit latrine is supposed to be used in Ghana to harvest electricity and to prevent groundwater pollution.

REFERENCES

G., B., & Foundation, M. G. (2009). Inclusive Municipal Governance in Monrovia- Annual Report

(OWAS), W. a. S. D. (2007). MONROVIA WATER SUPPLY AND SANITATION REHABILITATION PROGRAMME APPRAISAL REPORT-African Development Bank.

AWF. (2008). Study for the expansion of Monrovia water supply and sanitation system and rehabilitation of water supplies of 3 country capitals- Project appraisal report (African Water facility).

Fewtrell L, Prüss-Üstün A, Bos R, Gore F, Bartram, & WHO. (2007). Water, sanitation and hygiene: quantifying the health impact at national and local levels in countries with incomplete water supply and sanitation coverage.