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THE CURRENT CHALLENGES FACE BY THE LIBERIA WATER MANAGEMENT SECTOR IN IMPROVING WATER SUPPLY COVERAGE: A CASE STUDY ON THE WHITE PLAINS WATER TREATMENT PLANT IN MONROVIA, LIBERIA

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Abstract - Water is an essential component in the existence of man and his environments. Despite the tremendous effort made by the Liberia Government through the Liberia Water and Sewer Corporation in providing efficient, safe and affordable water supply to the inhabitants of Monrovia and its environs, water supply coverage is still low to meet the demand of the growing population of its inhabitants most especially during the dry season every year. Before the Liberian Civil War in 1990, the Liberia Water and Sewer Corporation supplied sufficient water for the inhabitants of Monrovia and its environs at that time the treatment Plant was in full operation and supplied 16 million gallons per day on the total population of 500, 000 people. After the 14-year Civil War the population of Monrovia and its surroundings has increased to 1,500,000 people thereby tripling the total population before the war and leading to water shortage in the city. There is no constant supply of water,

operation and maintenance of the system as well as revenue generation from bills distributed to customers however, leakages within the networks are alarming because the pipes have over-lived its life span. This research scrutinizes reports, literature, studies and other important details regarding the Liberia's Water Sector ensuring to outlines the primary causes of the challenges and constraints the management faces in delivering water to the people of Monrovia and its surroundings and also discusses the way forward ranges from technical, economic and social issues. The management has an opportunity of improving the current situation through adequate strategies for monitoring water services and water resources, making use of sustainable technologies and linking with target beneficiaries in the development of water supply systems within Monrovia and its environs and it can only be archived through proper planning and management system.



Keywords: Liberia Water and Sewer Corporation, Water shortage, Challenges, White Plains, Water Supply

I. INTRODUCTION

Water is important component to the survivability of man and other organisms. This commodity is used to carry out economic and social development of a nation. The earth has 3% of fresh water, with glaciers accounting for 77%, underground water for 22%, lakes covering about 0.33 percent, soil moisture about 0.18 percent, 0.03 percent rivers, and 0.03 percent in the atmosphere, while the majority of freshwater is locked up as glacier and polar ice, which is difficult to use and expensive to import. Domestic, industrial, and agricultural demands are putting a pressure on fresh water resources. Due to the effects of climate change, many parts of the world are experiencing a lack of clean and accessible drinking water, which will continue to be a problem. Fresh water has two major problems in relating to uses and availability to meet the needs of mankind. These two problems/issues are shortage and quality. Due to the impact of climate change, more than 2.8 billion people in the world will face water scarcity or intense water-stress in the year 2025. And also 2 billion people will lack access to improved sanitation, undermining efforts to protect public health. Human pressure such as dam diversions, industrial development and water withdrawals have created more pressure on water resources and watersheds. In 1973, the act to amend the Public Utilities Law established the Liberia Water and Sewer Corporation with the mandate to construct, install, establish, operate, manage and supply to safe drinking water, sewerage services to every area in Liberia and also maintain both water and sewer facilities. In 1960, the White Plains Water Treatment Plant and the entire water supply system in Monrovia including the distribution network were initially designed by the Chicago-Based Firm (AB & H), affiliate of Donohue Group with a capacity around 8 million gallons per day on a 24-hour operation basis. Their design also included the pipe distribution of the Mount Coffee Hydro Dam which pushed them to return to the use of onsite River (St. Paul) intake which allowed for the use of low lift pumps for raw water supply because the older intake was being affected by salty water due to low water levels in the Saint Paul River during the dry season. The treatment plant was designed to handle increase demand of the population of Monrovia and its environs after the infiltration galleries on Bushrod Island which was the main source of water supply could no longer withstand the growing population of Monrovia and its surroundings. Before the Liberian Civil War which started in 1990, the White Plains Water treatment Plant produced 16 million gallons

per day on a total population of 500, 000 people which was adequate to meet their needs to of increasing population using two major transmission mains (16" & 36") for water delivery. During this time, the White Plains Water Treatment Plant was operated on a 24-hour basis with an intake from a 42-inch pipe from the Mount Coffee Hydro-Plant as a raw water source which flowed by the means of gravity through 5km downstream toward the treatment Plant.

Currently, the total population of Monrovia and its environs is about 1, 500,000 people which triple the number of people before the war thereby creating huge demand for water supply in the study area.. This huge increase in population was created after the Liberian Civil War in 1990 which caused many people to migrate to urban areas most especially the capital city of Liberia. During this civil war, the White Plains Water Treatment Plant was vandalized by rebels and some community dwellers which caused filter, sedimentation basins, pumps and some other equipment to be non-functional and thus creating obstacles in the daily operation of the plant. Because to the growth in population, the plant's capacity was drastically decreased to less than five (5) million gallons per day, despite a daily demand of 32 million gallons. There was some rehabilitation works done with financing from the African Development Bank to restore the plant to its pre-war status. EleQtra was awarded the contract for the rehabilitation of the White Plains Water Treatment Plant which is a company that manages both public and private funds. The contract included capital improvement work that included restoring the main transmission network (36" concrete pipe) and performing 10 bar pressure testing on the transmission line to identify leaks and the total pressure the network could withstand, as well as capital improvement work that included the intake facility, storage, and some key parts of the distribution networks as well as the transmission.

One of the countries with abundant of water resources in Africa and the world at large is Liberia. It is the third highest in term of water availability per capita at 49,028 m³ in Sub-Saharan Africa. Despite these abundant water resources in Liberia, flows can be relatively low during the peak of the dry season. 2 The climate of Liberia is almost the same everywhere, but there are light rains and sunshine at certain times of the year, with only slight differences between regions. Annual precipitation varies from 1700 mm in the north to 4500 mm in the south, with temperatures of 22 to 28 ° C. Relative humidity is 65% to 85%. About 75% to 85% of the rainfall falls between June and October. Most areas of Liberia have been found to have excess water for up to 5 to 8 months, with an estimated evapotranspiration of 3.0 to 4.5 mm per day. There are nine major river systems characteristic of perennials, flowing from



northeast to southwest and into the Atlantic Ocean. The area of hydrography of freshwater bodies cover about 15,050 km² (14%) of the total area of Liberia and include rivers, lakes, lagoons, creeks and streams which drain directly into the Atlantic Ocean northeast-southwest direction. The country is one of Africa's leading countries with abundant renewable water resources of approximately 232 km³ per year. In most embankment basins with an average depth of 1.5 to 2.0 m, annual water requirements are approximately 250 mm / year in humid climates and up to 900 mm / year in very dry areas (such as desert areas). Draining the pond annually for harvesting and other losses can further increase the amount of water up to 3000 mm / year. This makes aquaculture a water-intensive sector compared to the rice sector, which requires only 1000 mm / year for staple foods (Yoo and Boyd 1994). Considering the worst-case scenario of 3000 mm / year water requirements and assuming a total aquaculture area of 20,000 hectares for sustainable aquaculture, the total water requirements are 6 billion m³ / year or 6 km³ / year. Despite the abundant water resources in Liberia, water production at the White Plains Water Treatment Plant is still low to meet the needs of the inhabitants of Monrovia and its environs. The below table shows the monthly water production at the White Plains Water Treatment Plant.

Table 1 Water Production in 2019

Months	Units	Raw Water Production	Finished Water
January	Gallons	131,662,328	118,570,063
February	Gallons	89,263,043	81,102,832
March	Gallons	168,434,792	133,046,578
April	Gallons	94,414,358	77,068,955.80
May	Gallons	181,210,053.20	151,667,922.10
June	Gallons	151,195,057.80	116,765,781
July	Gallons	150,154,228	128,111,883.20
August	Gallons	90,874,480	70,620,566.10
September	Gallons	119,114,253	95,360,086.60
October	Gallons	139,295,520.15	110,290,975
November	Gallons	143,579,565.85	104,997,008.20
December	Gallons	201,113,941.85	146,767,568.60
TOTAL		1,660,311,621 Gallons	1,334,370,219 Gallons

Source: Liberia Water & Sewer Corporation (LWSC)

Another problem faced by the Liberia Water & Sewer Corporation (LWSC) is the issue of its current cast iron and galvanized pipes that acted as transmission and distribution networks have outlived

their usefulness. There are numerous leaks in the current transmission, distribution, and servicing networks, resulting in a decline in daily water output and allowing trash and germs to infiltrate the network, causing health problems in some locations. Prior to the civil war, the Mount Coffee hydroelectric dam on the Saint Paul River, 27 kilometres north of Monrovia, supplied the majority of the city's power (46 MW base loads and 65 MW peak load in 1985). Despite the African Development Bank's efforts to restore the facility to its pre-war condition, there are more hurdles than before.

The water produce at the White Plains Water Treatment Plant meets the standard of drinking water of the World Health Organization (WHO). The treatment process is a conventional treatment considering sedimentation basins, coagulation, disinfections and clean water for distribution

Table 2 Water Quality Parameters and average test results at White Plains Water Treatment Plant (WTP) Source: Liberia Water & Sewer Corporation (LWSC)

Parameters	Raw Water	Settle Water	Finished Water	WHO STANDARDS
pH	7.23	6.85	7.2	6.5 - 8.5
Turbidity (NTU)	15.2	7.01	1.08	<5 NTU
Conductivity (µS/L)	36.1	60.5	78.2	< 500 S/l
TDS(mg/L)	18	30.2	39.1	< 500 mg/l
Chloride(mg/L)	-	-	1.75	0.2 – 2 mg/l
Fecal Coliform	-	-	0	0 count/ 100 ml
Total coliform (MPN/100m L)	Present	-	Absent	0 count/ 100 ml

II. MATERIALS AND METHODS

The study was carried out in Liberia, which is one of the world's developing countries with water shortages. The research uses data collected from published articles, Liberia Water & Sewer Corporation and reading various books. Liberia is rich in water resources, but lack proper planning and management of its water resources. The Liberia Water and Sewer Corporation is faced with administrative, technical and political challenges after the 14 year civil war. The need to set up an

effective framework to manage the water sector in Monrovia is paramount in tackling the challenges faced by the Liberia Water and Sewer Corporation. Water resources are managed through the below processes:

2.1. Supply Optimization

It is important for countries facing current and future constraints on water availability, from physical scarcity to lack of adequate financial resources to meet the needs of growing populations in a specific area. The Integrated Water Resources Management System will help bring stakeholders together to solve the problems facing the Liberia Water Supply and Sewerage Corporation. This unit should focus on meeting the immediate needs of the people of Monrovia by improving water supply management and ensuring good water quality and developing foundations to meet the water demand. Local capacity building, political and legal reforms, and enhanced water supply management, planning, and management will create more lasting changes in addressing water scarcity in Liberia. The Government of Liberia should participate fully in assisting in addressing water quality and quantity issues through programs that focus on other specific developments in the water sector. Optimizing supply requires assessments of groundwater, surface water, wastewater reuse, water balance, and environmental impact.

Water and energy connectivity is essential for water resource management; High energy costs for the efficient operation of the water supply system are essential to maintaining the water treatment plant, and the effects of subsidies, pricing, and other factors from the sector can affect the other.



Figure 1: Photo of burst 36” transmission main supplying water to Monrovia & its environs

Source: Liberia Water & Sewer Corporation (LWSC)

This transmission main has over-lived and such as it cannot withstand pressure within the pipe network. This burst 36” concrete pipe is of the main transmission in Monrovia that supply majority of the population in Monrovia and its environs. The cost to repair the 36” transmission main is high owing to the fact that there is no spare parts but rather to rehabilitate the burst section using reinforced concrete. The 36” concrete pipe got rapture one week to the 2019 Christmas and was repaired with the help of the World Bank Office in Monrovia and the Liberia Water and Sewer Corporation on the 7th of January 2021. There was no water available in the city of Monrovia and its environs for the past three weeks due to this major fracture in the transmission main.

2.2. Demand Management of water supply

This makes it more profitable to balance water supply and water demand through a reduction in the general population's water usage, which can be achieved in several ways, but most importantly, by eliminating leakage or other loss such as water without gas. Water demand can be further reduced through pricing, water-saving practices, conservation, and modern technologies. The Liberian government should continue to promote measures that reduce water demand as an alternative to cost and find appropriate efforts not to increase supply in less populated areas than it is with more populated areas. Shortly, the variability of climate change will create greater water stress and water scarcity in Liberia. The government of the Liberia Water Supply and Sewerage Corporation should use direct and indirect actions to monitor customer attitudes about water use and this can only be achieved through public awareness and financial incentives.

The government of Liberia, through the government of the United States, should continue to focus on the issue of water quantity and quality, which will also demonstrate that water is a "path" for many "purposes" of development and will encourage programs that will support best practices in integrated water management to address water scarcity and water quality in Monrovia. This can only be achieved through close collaboration with key players in water management by making additional investments to fill the gaps more holistically.

2.3. Mobilization of Financing

Fundraising is an important tool to support improvements and investments in water resource

management. The Liberian government must invest heavily in the water sector because water is life. Physical leaks in transmission, distribution and service networks need to be significantly reduced to maintain water supplies, introduce and implement demand management programs, and create communication/awareness programs to promote water efficiency by households and businesses. This reduction can be fully realized through funding.



Figure 2 Repair of the 36" Transmission Main
Source: Liberia Water & Sewer Corporation (LWSC)

This figure shows the repair work done on the 36" concrete pipe which the main transmission network. It was repaired through assistance from the World Bank Office in Monrovia. Financing will also help in the repairs of burst pipes which will help to reduce the non-revenue water.

2.4. Administrative Measures

Administrative measures are important to any organization in carrying out its duties and responsibilities to achieve its goals and objectives. The Liberia Water Supply and Sewerage Corporation needs direct administrative and technical measures to increase its accountability and will also help reduce water loss. Non-carbonated water is very alarming and thus technical measures are required to minimize leakage, thereby enhancing the unit's revenue income. Therefore, a qualified and efficient administrative and technical force will help the water supply authority to provide an adequate and efficient water supply to its customers. This measure can be achieved by adopting and implementing these good administrative ethics laws and by reorganizing the water authority. Budgeting procedures should be followed at all times, especially the spending process. The Liberia Water Supply and Sewerage Corporation should be independent in its day-to-day affairs and other high-ranking government officials should avoid politics. The workforce must be motivated by an increase in employee financing in terms of wages and

allowances, which will be an incentive to achieve better results. The management team encourages rigorous internal training for all employees in each department by international experts with the knowledge or expertise to meet challenges and to find solutions to their problems or challenges faced by the entity.

2.5. Technical Measures

The Liberia Water Supply and Sewerage Corporation should adopt smart technologies such as smart meters (prepaid), leak detectors, and also leak repair materials that take into account the life of the entire network. Qualified technicians must hone their unrelated or political duties and responsibilities, thus providing appropriate methods and materials to be used for infrastructure system maintenance. A strong site-specific maintenance team should be encouraged to correct leaks in the network, which will help reduce water, not in storage. During this 24 hour visit, technicians should have maps and charts showing line sizes and types of pipes and fittings and also know the main valves to quickly repair any broken lines in the system.

III. RESULTS AND DISCUSSION

Liberia's population is at 5 million people, with 49 percent of the population living in cities. With a population of 1.5 million inhabitants, Monrovia is Liberia's most populous city. In Monrovia, 80 percent of the population relies on point water sources (hand-dug wells), which may be upgraded in theory but are unsuitable in practice. According to a 2011 water quality survey, the majority of Monrovia's wells were filthy and unfit to drink (UHL and Associates, 2011). The African Development Bank (AfDB) restored the White Plains Water Treatment Plant from 5 million to 16 million gallons per day, restoring it to its pre-war condition. The plumbing network is in poor condition, indicating that it has to be repaired in order to provide reliable services to the residents of Monrovia. With a subscriber base of 10,000, the network stretches for nearly 231 kilometres, covering less than half of greater Monrovia. Nonrevenue Revenue Water (NRW) accounts for a large portion of the total volume of water produced, estimated to be over 80%. Some sections of the pipe network that haven't received water in 20 years are now operational. These network regions are currently suffering leaks, resulting in system water loss. The entire plumbing system has outlived its usefulness and must be replaced. The 16" and 36" transmission mains, for example, have burst numerous times and need to be replaced with by larger sizes due to population growth. The 36" concrete pipe was built in 1966 to

provide enough water supplies to the citizens of Monrovia and the surrounding area.

The Liberia Water and Sewer Corporation (LWSC) is dealing with a variety of infrastructural issues, including instructional and operational difficulties. Infrastructure constraints have been exacerbated by Liberia Water and Sewer Corporation's (LWSC) institutional and operational issues, according to a corporate audit. LWSC was found to be in crisis in 2012 by a corporate audit, which found the company to have "weak controls and nominal to little accountability for corporate resources," "no formal processes for making technical decisions "and" poor maintenance culture" (Global Business Solutions Incorporated, GBSI / GoL, LWSC External Audit Report 2012). Prior to the Liberian Civil War in 1990, the Liberia Water and Sewer Corporation provided piped water to around 18,000 consumers in 12 cities. Piped water service had just been in full swing in Monrovia and Kakata with an active billed customer base of less than 10,000 in the first half of 2018 after ten years of peace. The Liberia Water and Sewer Corporation (LWSC) main challenge is a lack of cost-recovery, which is caused by excessive non-revenue water, overstaffing, and high energy expenses. (US\$ 1.32 per m³), the present rate, is too costly, and the institution will need to enhance its operating performance in order to meet its operational and maintenance expenditures.

To tackle all of Liberia's water-related concerns, a solid framework for water resource management should be established. This framework will aid in the monitoring of all water issues, from water production to water quality, in order to fulfill the rising population's needs. Climate change unpredictability poses a threat to Liberia's water supplies, as predicted temperature increases over the next several years may result in longer dry weather episodes and harsh droughts, as well as greater and more variable rainfall events.



Figure 3 Water shortages in Monrovia
Source: Liberia Water and Sewer Corporation (LWSC)

This is a pictorial of a man who bought water from a water vendor in Monrovia to cook, wash and drink. There is a serious shortage of water that he had to travel from another community to this water kiosk to fetch for water. This shortage is mainly experience during the dry season which begins from November to March every year.



Figure 4. Rain Water being collected due to water shortage

Source: Liberia Water and Sewer Corporation (LWSC)

This figure shows that there is serious water problem. Rain water is collected and settled for domestic use. Rain water is mostly collected for house purposes in many regions that have water scarcity and shortages. The rain water is not safe for drinking, but many people collect it without using disinfectants for it to be save for cooking and drinking.

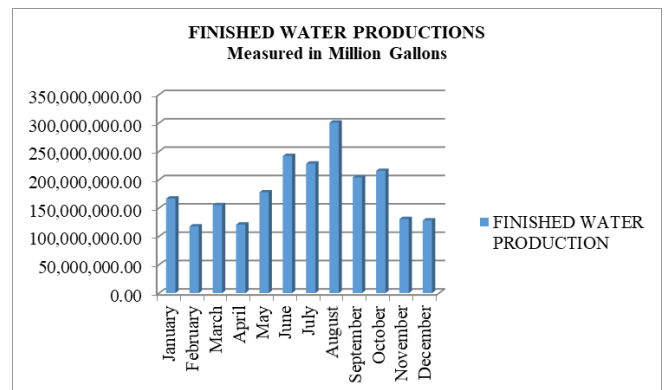


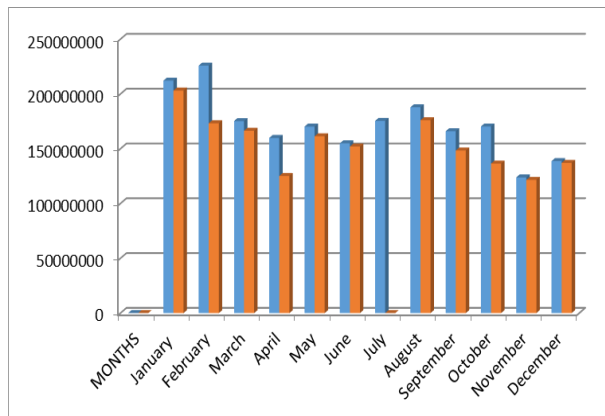
Figure 5 Finished water productions for the year 2017

Source: Liberia Water & Sewer Corporation (LWSC)

This figure shows the monthly water production in 2017. It suggests that there is huge shortage of water supply in the dry season beginning from November to March. The demand for water is high during this period. Many people in and around Monrovia do not have adequate water supply from the White Plains Water Treatment Plant which operated by the Liberia



Water and Sewer Corporation. The water supply during this period is not reliable and sufficient to meet the needs of the population.



Blue---Raw Water Red-----Finished Water

Figure 6. Water production in the 2018

Source: Liberia Water & Sewer Corporation (LWSC)

The production of water to meet the demand of the growing population is still a huge challenge. This figure shows that beginning from November which is the starting month that water shortage begins in Monrovia revealed a total monthly production of less than 150 million gallons. During the month of November, the demand of water in Monrovia start to increase and decline in the month of April when the rainy season begins. During this rainy season, some of the inhabitants collect rain water for use.

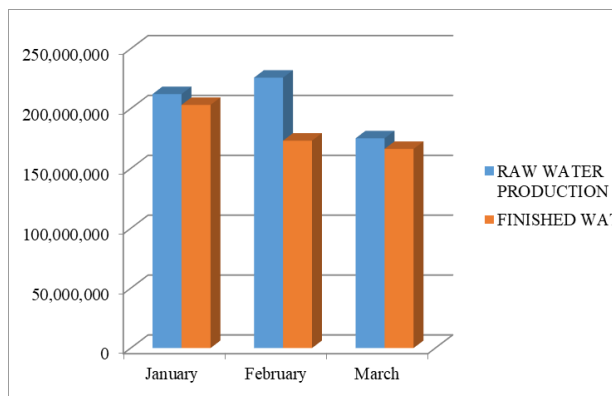


Figure 7. Quarterly water production in the year 2019(Gallons)

Source: Liberia Water & Sewer Corporation (LWSC)

In the month of February 2019, the total raw water produced was around 222 million Gallons while finished water was around 170 million Gallons. This indicates that more there was a huge in raw water and finished water. Some of the causes in the huge gap could be less pumping hours and also lack of sufficient chemical to conduct water quality analysis

within this month. There is no wide gap between January and March in term of raw water production and finished water.

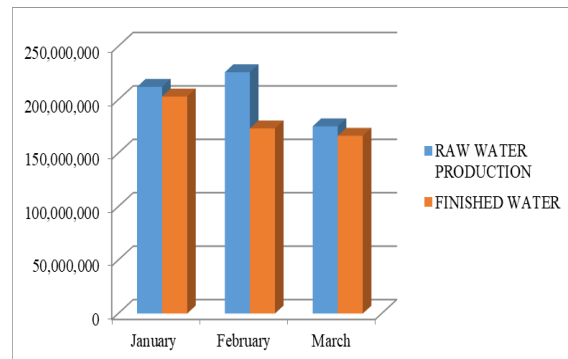


Figure 8. Quarterly water production in 2020 (Gallons)

Source: Liberia Water & Sewer Corporation (LWSC)

In the month of February 2020, the total raw water produced was around 222 million Gallons while finished water was around 170 million Gallons. This indicates that more there was a huge in raw water and finished water. Some of the causes in the huge gap could be less pumping hours and also lack of sufficient chemical to conduct water quality analysis within this month. There is no wide gap between January and March in term of raw water production and finished water. This figure is similar to 2019 quarterly production.

IV. CONCLUSION

Based on the above results, it can be concluded that water there is shortage of water most especially during the dry season. The current water treatment plant at the White Plains which is operated by the Liberia Water and Sewer Corporation is not capacitated to supply water to meet the current needs of the growing population of Monrovia and its environs. There are huge challenges which range from constant energy supply to chemical supply, physical leakages within the transmission, distribution and service networks and also maintenance of the plant. There is more demand of water during the dry season which begins from Mid-October to April every year. If the current plant is upgraded to meet its pre-war status of 16 Million Gallons per day, it won't still meet the current needs of the population of Monrovia. More is require by the government of Liberia through its developing partners and the Liberia Water and Sewer Corporation to deliver safe and affordable drinking water. In the aspect of monitoring and enforcing measure in water resource management in Liberia, the water governance is weak due to lack of



coordination across fragmented agencies. The 80% in non-revenue water generation is a serious issue that is causing so much challenge in the operation and maintenance of the water treatment. Another issue that the Liberia Water and Sewer Corporation is faced with is the high level of employment which is currently creating serious problems for salary payment within the entity. Comparing the number of staff to customer of 1000, the Liberia Water and Sewer Corporation has a high ratio of employees to that of Burkina Faso and Niger. These challenges are due to administrative, technical, demand management, financing and supply optimization. The cost of energy in operating the White Plains Water Treatment Plant is very high and will require a smart energy (solar energy) as vital solution. And also few physio-chemical parameters like pH, Turbidity, Conductivity, Total Dissolved Solids, Coliforms, Total Coliforms and Chlorine meet the standard requirement for World Health Organization (WHO) in relating to safe drinking water, there are other important parameters such as hardness, total iron, phosphate, nitrate, ammonia, alkalinity, that are not analyzed using standard methods of APHA (1998) due to the lack of testing equipment or apparatus. There is also a shortage of re-agents to conduct these tests. In Liberia, there is no solid framework for water resources management in looking at significant issues relating to the water sector. It is also observed that the rehabilitation of the White Plains Water Treatment Plant did not achieve its full desired objectives.

Finally, if the issues of power, leakages, demand management, financing, workforce reduction, quality administrative actions, supply optimization, chemical and modern technologies should be taken into serious consideration in order to resolve the challenges faced by the Liberia Water and Sewer Corporation.

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