PRESBYRERIAN UNIVERSITY COLLEGE, GHANA

FACULTY OF DEVELOPMEMT STUDIES

DEPARTMENT OF RURAL AND COMMUNITY DEVELOPMENT

INVESTIGATION OF INTERMITTENT WATER SUPPLY IN THE KOFORIDUA MUNICIPALITY

BY

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Dissertation submitted to the Department of Rural and Community Development of the Faculty of Development Studies, Presbyterian University College, Ghana in partial fulfillment of the requirements for the award of Master of Art degree in International Development Studies.

SEPTEMBER 2019

DECLARATION

Candidate's Declaration

I hereby declare that this dissertation is the result of my own original research and that no part of it has been presented for another degree in this University or elsewhere.

Candidate's Signature…….....Date……..……

Name: Badu Gladstone Joseph

Supervisor's Declaration

I hereby declare that the preparation and presentation of the dissertation were supervised in accordance with the guidelines on supervision of the dissertation laid down by the Presbyterian University College, Ghana.

Supervisor's Signature……..……Date…….…….…….....

Name Dr. Amfo-Otu Richard

ABSTRACT

The study aimed at investigating the intermittent water supply in the New Juaben Municipality of Ghana. The study adopted the descriptive design. A total of 105 respondents from various consumers were selected through multistage sampling approach to respond to the questionnaire and four (4) staff of Ghana Water Company Limited were selected purposively for interview. Data collected were analysed using Statistical Package for Social Scientist (SPSS) version 16 for the questionnaire and the interviews were presented in narration form. Ghana Water Company Limited in the New Juaben Municipality has one water treatment head works with capacity of 19,200m^3 per day. The head works receives a total of 19,200m^3 of raw water from two intake points which are from River Volta and River Densu. These two main sources are to ensure continuous raw water supply for treatment throughout the year. The quantity of water supplied from the head works have been found to be 18,200m^3 per day whiles the daily water demand for the Municipality is about 13,730.4m^3 which is less than the water supplied by the Ghana water company Limited. Intermittent water supply in the municipality is not based on the quantity of water available for supply but other factors such as failure in the network distribution, burst in distribution lines, electricity cut-offs, illegal connection and lack of funds to expand and change the old pipe networks. It is recommended that Ghana Water Company Limited should invest in technology to detect leakages, improved maintenance schedule, engage community members to report water leakages and acts promptly to the reports of citizens after validation of issues reported.

ACKNOWLEDGEMENTS

I first wish to glorify and honor the Almighty God who has been the light of my life. I thank him for keeping me focused and inspired throughout the duration of this course and most of all, for the immeasurable blessings that he has showered on my life. I will forever be grateful to him.

My profound gratitude goes to my supervisor Dr. Richard Amfo-Otu of Presbyterian University College for his sincere commitment, excellent guidance and advice in vetting every chapter of this work.

My gratitude also extends to every individual, company and institution who took their time to answer the questionnaires that I issued to them. I am forever indebted to them. Some respondents readily made certain brochures and magazines that were relevant to the topic available for the researcher to study. I thank you all very much.

DEDICATION

I dedicate this project to my children and the entire family.

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CHAPTER ONE

INTRODUCTION

1.1. Background to the Study

Development in Africa is being hampered by myriad of problems including the regular and safe supply of potable water. Intermittent access to improved urban water supplies is a large and expanding global problem. Considerable integrated water resources management (IWRM) work has focused on redressing causes of scarce water resources with efforts typically focused at trans-boundary, national, basin, or water utility scales (Dziegielewski et al. 1992; Scott et al. 2003; Wilchfort and Lund 1997). Availability of potable water for domestic use has been a major challenge in Sub-Saharan African countries. Sometimes the little water available to the people are unhygienic, unsafe and not adequate to meet their basic water demand thereby affecting the health of the people. It is therefore, not surprising that water and sanitation related disease dominate the top five disease in such countries. Jordan is a relevant case as water is generally available through the distribution network only 12 to 60 hours per week (Abu-Shams &Rabadi, 2003), most households' desire improved supply access, and the government is considering city and national conservation efforts plus mega-supply projects to improve water availability. Responsible for the provision, distribution and management of urban water supply in Ghana, The Ghana Water Company Limited (GWCL) meets only about 60% of the total water demands (Nyarko et al., 2008; WaterAid, 2008). As such, maintaining several access points to water sources is one practice through which the urban poor generate security

In Ghana, where the source of water is not hygienic, people suffer from water-borne diseases such as guinea-worm infection and river-blindness. Water is a basic necessity

to mankind, to plants, and for industrial growth. All life depends on water and it comes next to air in terms of indispensability. In fact, the provision of safe and regular water accelerates industrial growth in advanced countries and the third world countries need such water, among other things for their developments. For instance, Intravenous Infusion Limited situated at Effiduase in Koforidua uses water to manufactures the country's intravenous drips for use in the hospitals. Almost all firms heavily depend on water for their production. Apart from Koforidua, many localities in the country face rampant acute water shortages. Places like Donkorkrom and Fori-Fori in the Afram Plains in the Eastern region, the HoTownship, Sunyani and quite recently, the Cape Coast Municipality have all been victims of water shortages. It is common knowledge in Ghana that each year the Koforidua Township in the New Juaben Municipality in the Eastern Region, faces acute water shortage. This water shortage happens mostly in the dry season and sometimes in the wet season when there are technical faults of distribution pipelines and pumps.

1.2 Statement of the Problem

Availability of potable water brings a lot of relief to consumers all over the world because drinking water is one of the primary concerns of development. Intermittent access to improved urban water supplies is a large and expanding global problem. Considerable integrated water resources management (IWRM) work has focused on redressing causes of scarce water resources with efforts typically focused at trans-boundary, national, basin, or water utility scales (Dziegielewski et al., 1992; Scott et al., 2003; Wilchfort& Lund, 1997).

Ghana Water Company Limited being the urban water supply and management have tried their best to provide residents, industries and institutions with potable water

despite the rapid urbanization of Koforidua Township. However, for the past five years, intermittent water supply is one of the major challenges affecting people, businesses and household's water consumption in the New Juaben Municipality. The situation has encouraged households and businesses to rely on alternative sources of water supply which is partly affecting heath and also increasing water and sanitation related diseases in the Municipality. Speculations of the causes have included old water treatment plant, low network coverage among others. These have been accepted by some section of the society mainly because the causes of the intermittent water supply in the New Juaben Municipality have not been well documented by researchers through empirical studies.

Some researchers have examined the quality of water supplied by Ghana Water Company Limited in urban areas (Hansen, 2014; Quarcoo,Hodgson, Ampafo,Cobbina, &Koku, 2014), others have looked at the challenges of accessing water (Peloso&Morinville, 2014;), tank supplied water system to serve unserved areas (Alba et al. 2019). Limited work has been done on underlining causes of intermittent water supply generally in Ghana. Literature in this area is scant and require concerted research effort to help bridge the knowledge gap. This study seeks to contribute to fill the gap by focusing intermittent water supply situation in the New Juaben Municipality.

1.3 Objective

The main objective of the research is to assess the causes of the intermittent water supply to consumers in the New Juaben Municipality. The specific objectives include:

1. To assess the capacity of the available water treatment plants supplying water to the Municipality.

2. To analyse the population water demand and treated water supplied by GWCL per day.
3. To examine the factors causing the intermittent water supply from stakeholders' perspective.

1.4 Research Questions

The underlisted questions would be answered during the research:

1. What are the capacities of treatment plants at the various sources of water supply to the Municipality?
2. How is the water demand of the population in relation to the daily water supplied by the GWCL?
3. What are the stakeholders' perceptions about the factors causing the intermittent water supply?

1.5 Significance of the Study

The study will be beneficial to many stakeholders in the water sector. Upon completion, the research will provide information that can be used to improve water supply capacity of the Ghana Water Company Limited so as to meet the daily demand of the population and sustainability of and consistency in water supply. To improve both source management and resource management of the treatment plants. Alternative methods to adopt for water distribution and storage to improve 24hrs.daily demand. 4. Future extension road map to achieve universal access to sustainable water supply per the SDGs (6) by 2030.

1.6 Limitations

The study focused on the Koforidua Municipality and 6 peri-urban towns namely Agavenya, Nyamekrom, Trom, Adweso, Effiduase, Asokore, Industries eg: Sachet Water Producers, Intravenous Company. Small Scale Bussineses eg: Chop Bar Operators/ Resturants and Hair Dresses. Institutions eg: Hospitals, Schools. Due to this, the results may not be generalized for all water supply systems in Ghana. The lack of co-operation from the respondents means that the research might have no chance of being completed on time. The researcher therefore will ensure that all necessary authorizations are sought and cleared before beginning the research.

1.7 Delimitation

This study confines itself to interviewing Gahan Water Company Limited Staff at the New Juaben Municipality and administration of questionnaire to consumers of water from the Municipality. It was done such that most categories of consumers were captured to have representative views of these consumers.

1.8 Organization of the study

This study comprises of five distinct chapters. Chapter one comprises of the introduction, the statement of problem, justification of the study, aim of the study, objectives of the study, scope and limitations of the study, methodology, and project format. Chapter two is on review of current and past literature on the subject under study. Chapter three of the study describes the research methodology adopted in carrying out this research and how the data collected were analysed. Chapter four consists of data presentation, analysis and the discussion of findings. Chapter five which is the last chapter consists of the summary, conclusions drawn from the study and recommendations for practitioners and researchers.

CHAPTER TWO

REVIEW OFRELATED LITERATURE

This chapter deals with review of relevant literature related to the subject matter understudy. Areas covered are water sources, treatment plants, water demand sanitation, causes of intermittent water supply, managing intermittent water supply and consumer perception of causes of intermittent water supply. The review is important for learning from what methods were used by others and findings that can guide the current study.

2.1 Overview of Intermittent Water Supply

Water Supply Systems (WSSs) are usually associated with numerous bottlenecks and manager of such system are overwhelmed by the complexity of the challenges. This mainly due to the fact that water supply systems are very complex which require well designed and constructed infrastructures which is operated and well maintained to treat, store and deliver potable water to consumers at the time when they need it in sufficient quantities and quality always (Walski et al., 2003; Farmani, Walters &Savic, 2005). Managers of water systems are usually not ready to entertain intermittent water suppl but various issues saddle their effort and have to deal with the unexpected realities of intermittent water supply. It has been indicated that some water supply systems delver water consumers at different intervals including daily supply, less that 7 days a week (Sashikumar et al., 2003, Ingeduld et al., 2008; Danilenko et al., 2014).

In developing countries, the situation is alarming and appears to the a daily and routine feature of the water supply services. McIntosh (2003)indicated that intermittent what supply has been used as a tool to manage water demand by the

growing population of the developing countries. Klingel and Nestmann(2013) reported that close to one-third of consumers in Africa, half in Asia and two- thirds in Latin America are supplied water intermittently but Vairavamoorthy and Elango(2002)reported that in South East Asia, 91% of water supply systems are done intermittently. Klingel (2012) reviewed technical causes of intermittency and stated that intermittent water supply has consequences that aggravate its causes. Galaitsi et al. (2016) gave details of causal – consequence pathways of water sup-ply intermittency. Through pathways analysis, conditions that form the self-reinforcing mechanism of water supply intermittency and external inputs were identified. Kumpel and Nelson (2016) provided details on the prevalence, trends and water quality aspects of water supply intermittency.

In Ghana, reports show that access to safe drinking water is improving in Ghana. Notwithstanding progress, GWCL currently only meets the demands of about 60% of urban and peri-urban residents (JMP, 2013). Peloso and Morinville(2014) reported that due to the inadequacy of water resources to allow for equal distribution throughout the urban region, GWCL has implemented a rationing schedule, which directs water flows to certain areas of the city on select days (Adank et al., 2011). Some areas are reported to receive water supplies once a week or not at all, while other areas may be serviced as often as seven days a week (Morinville, 2012)

2.2 Causes of intermittent Water Supply

Billions of people over the world have limited or intermittent access to improved water supplies. Intermittent services are often linked to environmental degradation, population growth exceeding the rate of daily water demand and infrastructural development. (Thompson, 2001). Intermittent access to improved urban water

supplies is a large and expanding global problem. Considerable integrated water resources management (IWRM) work has focused on redressing causes of scarce water resources with efforts typically focused at trans-boundary, national, basin, or water utility scales (Fisher et al., 2005; Scott et al., 2003; Wilchfort& Lund, 1997; Wolf & Murakami, 1995).

Causes of intermittent water supply may be temporal or permeant. In developed countries, water supply intermittency may be caused by temporal events such as droughts, pollution accidents, earthquakes and maintenance (Solgi et al., 2013). In such situations, water supply is restored immediately the causal factors causing the problem are over or addressed. Temporal intermittent water supply mostly affects some part of the system and not the entire water distribution network. However, if it due to droughts and raw water intake points are affected, then the whole distribution system will be affected. In some countries such as Ghana, intermittent may be seen as a management strategy to ensure that various water users are served by rationing the water. In such situation the intermittency may called full-time intermittency because water rationing, and reduced duration of supply are norms for the whole system and reverting to continuous supply is not obvious (Simukonda, Farmani, &Butler, 2018).

Various authors have attributed the cause of intermittent water supply to various factors which have been broadly grouped by Simukonda et al. (2018) into poor governance, demographic and economic dynamics, unplanned extensions of water supply systems, poor system maintenance and operation, limited skilled manpower, poor electricity supply, hydrological regime change and lack of customer awareness as the root cause. Poor governance exists in the absence of principles such as participatory decision-making, the rule of law, responsive institutions, equity, transparency and accountability (Rogers & Hall, 2003). This type of governance is

linked to poor water supply in almost all developing countries (McIntosh, 2003) because it diminishes funding to infrastructure development and operation (Totsuka, Trifunovi, &Vairavamoorth, 2004; Dahasahasra, 2007; Bakker et al., 2008; van der Bruggen, Borghgraef, &Vinckier, 2010). It also contributes to water scarcity in countries or service areas (Ioris 2012; Giglioli &Swyngedouw, 2008), allow for political interference which affects management and operations water supply systems (Mckenzie& Ray, 2009).

Population growth and urbanization raise concerns about provision of social amenities both in developed and developing countries (Buchberger et al., 2008). However, populations in developing countries are growing rapidly resulting in increased water demand for domestic, industrial and other economic activities (Lehmann, 2010; Klingel, 2012). These situations ultimately require expansion in water supply infrastructure to meet the water demand and may create water scarcity due to limited sources of raw water and treatment capacity of available headwork's. Seetharam and Bridges (2005) and Le Blanc (2008) point to the fact that increased population in urban centers in lead to high demands for water and sanitation services beyond the existing infrastructure capacity which may create the need for intermittency or rationing of water supply services. Industrial activities to boost economic fortunes of countries may put pressure on water supply systems since more water would be needed for production at the same time creating effluents that could potentially pollute available water sources (Nachiyunde et al., 2013; Bao& Fang, 2012).

Climate change effect drives through many aspect of human life and water supply is not an exception. The hydrological system has been changing due to climate and current evidence shows that it will increase occurrences of extreme droughts and floods in various regions of the world (IPCC 2007; Commission of the European

Communities 2007). Droughts affect surface water bodies and aquifers which are the main sources for water supply to communities (Charalambous, 2012; Miyan, 2015). Inter-governmental Panel on Climate Change (IPCC) (2014) indicated how climate change continue to affect water supply systems and advises on how actors in the sector could work toward a resilience system to meet water supply demands.

Poor system management and operation has many aspects almost all of which relate to database management. Poor data management makes revenue collection inefficient (Chan, 2009; Biswas &Tortajada, 2010), tariffs setting difficult (Lehmann, 2010) and proper analysis of the state and performance of water supply infrastructure unattainable (Klingel, 2012). Suitable tariffs are very critical for water supply systems to ensure efficient water resources allocation, water affordability and utility sustainability through full cost recovery (Lehmann, 2010; Nauges & Whittington, 2016). The state and performance of WSS infrastructure depends on the infrastructure maintenance regime. According to International Monetary Fund (2015) poor infrastructure maintenance is a common but acute problem in developing countries. Poor maintenance plan and repair works schedules contribute to increasing WSS operation and maintenance costs and lead to increasing leakages (Buchberger et al., 2008; Catalano, Genco, &Vignetti, 2013). This mainly due to poor water sector institutions, lack of financial resources due to poor revenue collection, inappropriate data management systems and inadequate knowledge of water consumers.

Human resource with the requisite skill-sets are very key in delivery potable water to consumers but such skilled staff are limited in developing countries which affects water distribution systems. This reflects in how planning, management and operation of the system is done (Government of India 2009). Sometime, those with the capacity are sidelined due to political interferences and other factors. Managing limited water

resources efficiently by reducing water losses is data and technology intensive. However, management of databases is poor plus technical skills and uses of technology are low in developing countries (Farley & Liemberger, 2005). This is attributed to a lack of know-how, demotivated staff and failure to recognize the importance of functional databases (Klingel, 2012). Lack of the necessary technical and managerial skills to improved water services delivery to match the rapid population growth and urbanisation in developing countries, is well known (Myers, 2003; Blair, 2005; Cohen 2006; Government of India, 2009; Franceys &Jalakam, 2010). But solutions to this problem are rare because capacity building plans, though common, lack details on what skills or capacities need to be developed.

Extension of water distribution network or system is important because many residential areas in the urban and peri-urban areas do not have access to safe drinking water, since they are not connected to the main water distribution systems. The need for these extensions is reflected both in the Millennium Development Goals (Danilenko et al., 2014) and Sustainable Development Goals (United Nations General Assembly 2015) to ensure improved access to quality water. In an efficiently managed water supply system, expansion of water distribution system is used as a major indicator Thus, in developing countries, WDS extension is one of utilities' performance indicators (Chitonge, 2011; Danilenko et al., 2014). Extension is hardly done, sometime it is done without informed planning or any planning at all as utility databases are poorly managed (Klingel, 2012) and networks are extended to new areas after they are developed. This because the approach for service delivery is the demand driven approach and therefore, service beneficiaries would have to request for water supply services and pay for the cost of extension. Where distributions lines are non-existing, such areas are cut off from the system until there is political will to

invest in expansion.

Electricity supply is critical to water utilities for pumping. This complicates matters because poor electricity and water supply have many causal factors in common (Meier 1990).

Electricity supply for powering pumping at the pumping stations and headworks is fundamental in efficient water supply. Where water pressures are low, booster pumps are used to support the distribution. Power rationing affect water supply system by depriving the system of power to pump water into transmission lines. This may be due to the cost of generating energy which is either hydro or thermal dependent. In those that depend on fossil fuels, electricity generation is affected by their local availability and quality, imported fuel prices, the mix of fuels and efficiency of technologies used (Eberhard et al., 2011; International Energy Agency, 2015). Sometimes, headworks are built with standby generators to provide power for supply but such facilities are expensive to operate and maintain efficiently.

Lack of awareness affects water consumers as well as utilities. Consumers are affected by the poor water supply services which have become normal and therefore, they have developed coping mechanisms (McIntosh, 2003; Biswas & Tortajada, 2010). Consumers are mostly affected by any tariff increment and agitate in some cases to register their displeasure since some of them feel water should be supplied for free and be available every time and also it would not lead to any substantial improvement in service delivery (Hunter, Macdonald &Carter, 2010). Utilities are affected through challenges of implementing water pricing as a cost covering and water conservation measure (Lehmann, 2010), through consumers' unwillingness to pay water bills (Chan, 2009; Biswas &Tortajada, 2010) and cooperate with improvement measures such as conversion to continuous supply status (Franceys

&Jalakam, 2010), and through vandalism and water theft. Since many people in developing countries have lived with poor water supply services all along, imagining and demanding for better supply conditions is difficult without extensive awareness campaigns to influence perception of levels of service, water consumption trends and cooperation with improvement measures by utilities.

2.3 Addressing the Challenge of Intermittent Water Supply

The starting point is to identify a wide variety of actions that increase supplies, improve qualities, decrease demand, or alter demand timing to improve system performance. Upgrading the infrastructure to provide continuous water supply is an initial option for improving intermittent supply systems. This option is usually hard to achieve. Moreover, if transition conditions are not feasible, it must be recognized that supply will always be intermittent. Consequently, more proactive management tools that minimize the negative effects caused by this type of supply are required.

This paradigm enables improving the living conditions of people who dwell in intermittently supplied areas, and achieves predictable intermittent supply systems Many urban areas of the developing world, piped water is supplied only intermittently, as valves direct water to different parts of the water distribution system at different times. The flow is transient, and may transition between free-surface and pressurized, resulting in complex dynamical features with important consequences for water suppliers and users. Here, we develop a computational model of transition, transient pipe flow in a network, accounting for a wide variety of realistic boundary conditions. We validate the model against several published data sets, and demonstrate its use on a real pipe network. The model is extended to consider several optimization problems motivated by realistic scenarios.

We demonstrate how to infer water flow in a small pipe network from a single pressure sensor, and show how to control water inflow to minimize damaging. In supply system improvement perspectives, network sectorization is a fundamental step. Sectors are also important in transition processes to continuous supply and crucial for intermittent supply system management that aims to improve supply equity. Moreover, sectorization under an intermittent-supply based perspective may be useful for vulnerable continuous supply systems.

The first is to develop approaches and tools for analyzing and designing intermittent supply systems (Vairavamoorthy, Gorantiwar, &Pathirana, 2008). This option targets problems associated with intermittent operation of systems designed to operate continuously. The second is that of converting to continuous supply. This aims at over- coming all water supply intermittent problems. From the second option's perspective, intermittent WSSs are failed systems and any recourse through intermittent mode should be viewed as intermediate and transitory while efforts are being made towards achieving continuous supply status (Myers,2003; McIntosh, 2003; Klingel&Nestmann, 2013).

(Bolivia) had to become temporarily intermittent due to insufficient water in its supply sources. The joint WHO/UNICEF monitoring programme of Millennium Development Goals identify future priorities to be addressed coverage post-2015 Sustainable Development Goals Water is element of sustainable development. The sustainable development goal 6 emphasized eradication of unsafe and intermittent globally by the year 2030. The 2015 Ghana Millennium Development Goals (MDGs) Report is the sixth and final report in the biennial MDG Reports series. The report was published in 2015 and it examines progress made since 2000 towards attainment of all the goals and their targets, and draws some lessons from the implementation and

monitoring of the MDGs. Out of the 21 targets and 60 official indicators adopted globally for monitoring the MDGs, Ghana has, however, adopted a more nationally relevant set of 17 targets and 36 indicators. By presenting MDG experiences, the report is a forerunner to the adoption and implementation of the next global development agenda, the Sustainable Development Goals (SDGs).

2.4 Development of Treated Water Supply in Koforidua

Until 1938 there were no public treated water supplies in the Koforidua area. The town relied on rainwater cisterns and shallow wells; and the surrounding rural area depended on shallow wells and on the River Densu and a number of personnial tributaries. In 1938 intakes were constructed on two of the tributaries of River Densu, the Suhien and Okomeng streams, and gravity mains, a treatment works, a service reservoir, and a distribution system were constructed at the same time. By 1951 the demand far exceeded the reliable yield of these streams and a weir and intake were constructed on the River Densu at Bebianiaha, dome three miles south-west of Koforidua. A diesel-powered pumping station, 9 inches rising main, and a new treatment works to treat 0.3 mgd were constructed and put into service in 1954. A large raw water tank was constructed at the same time, into which delivery from the three water sources was retained and both are still in use to the present day. In 1962 a third pumping set was installed at the pumping station. A laying of a new 9 inches pipe, parallel to the existing main from the junction of the Okomeng and Suhien mains to the treatment works, was completed in July 1963. At the settling tanks and filters had been designed on conservative ratings, the treatment woks have been able to satisfactorily treat the throughput up to the present, now some 700, 000 gallons per day. Progressive extensions to the distribution system have been made. As the

distribution system consist mainly of asbestos cement pipes, deterioration in carrying capacity has been negligible, and distribution system appears to have been generally adequate. A supply of piped-water from Koforidua system was made available to Asokore in 1957and extended to Oyoko in February 1962.

2.5 The Present Water Supply System in Koforidua Municipality

Koforidua water supply system at present receives its water from Densu River waterworks at Bebianiaha, and from springs located at the headwaters of the Okomeng and Suhien rivers. Additional waters within the vicinity of Koforidua at Bokono, and several low yielding boreholes. The Densu River exhibits large seasonal as well as annual fluctuations in discharge. At times the river tends to dry out for several months, as happened in February-May 1983. Consequently, Koforidua suffers from acute water shortage during dry spells2. The spring flow at the Okomeng and Suhien Rivers, although more regular than the Densu flow, may also diminish drastically as was reported in 1983.Even though the New Juaben Municipality has varied water sources and systems including piped systems, boreholes and hand dug wells, flow of water has been hugely irregular, inadequate and unreliable.

2.6 Effects of Intermittent Water Supply on Consumers

Previous research has shown interrelationships between the water service delivery failures and adverse life impacts on the consumers using the water (Subbaramanet al., 2015). The water quality is mostly affected in cases where there is intermittent water supply which has far-reaching implications for disease vectors, and human morbidity and mortality. Within the literature, this issue has the attention of the public health sector (Galiatsi et al., 2016).Moreover, where households store the water in their own

storage facility, management of such systems are poor and create water quality problems that can threaten public health (Hashwa&Tokajian, (2004).

CHAPTER THREE

METHODOLOGY

This study contains the methodology utilized for the research was as follow: Research Design, Population of the study, Sampling techniques and sample size and data collection techniques.

3.1 Study Area

The study areas are locating in the New Juaben Municipality. Koforidua is the Regional Capital as well as the Municipality seat for the New Juaben. It houses the ministerial and regional offices, banks and commerce agencies as well as the largest market in the area for agricultural and other commodities and numerous workshops producing and selling agricultural tools and implements. The key sectors of the Municipal economy are, the service sector which constitutes 39.9 percent, industrial manufacturing and processing 26.7 percent, agriculture 26.1 percent and other socio-economic activities constitutes 7.3 percent. While majority of industrial establishments are found in the central business area of the Municipality, agricultural production is carried out in the small settlements and the peri-urban localities (GSS, 2014).

In 2010 the Population and Housing census report put the figure at 183,727 with a growth rate of 2.6%. According to the 2010 Population and Housing Census report, males constitute 48.3 percent of the population and female represents 51.7 percent. About 93.3 percent of the population lives in urban localities. In 2017, the Population was estimated at 217,389. The municipality is predominantly urban.The service sector is the fastest growing economic sector in the Municipality employing 39.9 percent of the population. A large number of small and medium scale service enterprises have

sprung up in the Municipality over the past decade mostly in the area of ICT and other business set-ups such as restaurants, hotels, hair-dressing salons, repair shops (mechanics, electricians, sprayers etc.), spare parts sales, drug/chemical stores, pharmacies, supermarkets, drinking spots, photo studios and communication centres. There exist other service providers like the banking, telecommunication and postal services (GSS, 2014).

3.2 Research Design

Research design specifies the methods and procedures used to gather information needed to structure and solve the research problem. It outlines the kind of information to collected, from what sources, and by what procedures. A good research design ensures that the information obtained is relevant to the research problem, and that it is collected by objectives and economical procedures (Smith & Gerald, 2010). This study adopted both qualitative and quantitative (mixed approach) research approaches with descriptive design. This appropriate for the study in order to address the research problem since quantitative data from the service beneficiaries and qualitative data from manager of the water supply system were needed for the study.

3.3 Target Population

The population identified for the research included service beneficiaries of the Water Company such as food vendors, managers of Sachet water producers, manager of Intravenous Company Industry, owners of small scale businesses (eg. Chop Bar Operators, Koko sellers, Hair dressers), household heads of the residential areas, and those responsible for water management for some institutions (eg. SDA Hospital, St. Joseph Hospital, Tertiary Institutions) and staff of GWCL as the service provider.

3.4 Sample Techniques

The researcher will adopt purposive sampling technique in selecting respondents. According to Kumekpor (2002) in purposive sampling, the units of the sample are selected not by a random procedure, but they are intentionally picked for study because of their characteristics or because they satisfy certain qualities which are not randomly distributed in the universe, but they are typical or they exhibit most of the characteristics of interest to the study‖. Kumar (1999) explains that the main consideration in the adoption of purposive sampling lies with the judgement of the researcher as to who can provide the best information to achieve the objectives of the study.

3.5 Data Collection Tools

The researcher used the following data collection tools for the study. The data collection tools involved questionnaire survey and interview guide.

3.5.1 Questionnaire Survey

A standardized interviewed questionnaire comprising closed ended questions was designed to solicit information from respondents. Close-ended question was used because Glasow (2005) has indicated, close-ended questions were easy for respondents to answer and it also helps researcher to analyze the data easily. The purpose of designing this survey instrument was to solicit information required to address the overall research questions. The questionnaire consisted of 19 questions covering main subject areas. The questions were simple and not misleading and could allow an analysis to be carried out on the results of the responses.

3.5.2 Interview Guide

The interview guide was carefully constructed in order to obtain responses that could information relevant for understanding the causes of intermittent water supply in the study area.

3.6 Data Collection Method

The questionnaires were administered through the researcher assisted approach.It allowed respondents to complete the questions as the researcher provided explanation to make it clear in cases where respondents had difficulties. The data collection using the questionnaire was completed within 7 days. The process of distribution and collection of the questionnaires in person was taken for two reasons. First, to make sure that the questionnaires gets to the intended recipients and secondly, to help improve the response rate. The interview guide was used for interviewing the heads of treatment plants of Ghana Water Company Limited, and the operations manager within the Municipality. Interviews were conducted in English and recorded by writing; hence there was no need for transcribing and translation.

3.7 Data Analysis and Presentation

The questionnaires were screened and examined for missing values in order to get maximum focus and fair approach for the analysis. The data was coded after the cleansing to facilitate categorization and analysis by transforming the data into suitable format for computer-aided analysis. Descriptive statistics including frequency tables and simple percentages were computed. This analysis was done using Statistical Package for Social Sciences (SPSS) software version 16. The results were displayed in Tables and charts to facilitate the interpretation, analysis and discussions if the findings. Interview responses were integrated into the quantitative data where

necessary and the rest were presented in narration for to provide answers to the research questions. This was estimated by using:

3.8 Ethical consideration

The study considered the need to protect the dignity and privacy of respondents. The consent of was sought from management of the selected service beneficiaries and

Water demand (Qm^3/d) = Estimated population for 2019 * average water

Ghana Water Company Limited. Respondents consent was also sought before data collection. The privacy of respondents was assured and adhered to.

CHAPTER FOUR

RESULTS ANDDISCUSSIONS

The chapter contains the results of the data collected in the form of results and discusses the findings of the study. The chapter covers the socio-demographic information of respondents and the specific objectives of the study as headings.

4.1 Socio-Demographic Information of Respondents

Both sexes were fairly represented in the study with the males being slightly higher (61.9%) than the females (38.1%) as shown in Table 1. Though, traditionally women use more water in the house, at the institutional level men have been uncharged of water management. The age distribution shows (Table 1) that most of the respondents are matured (31 years and above) and understand the issue of water rationing and therefore their contributions are important for the study.

Table 1: Sex and age distribution of respondents

Sex	Frequency	Percent
Males	65	61.9
Females	40	38.1
Total	**105**	**100**
	Age (years)	
20 years and below	1	1.0
21-30	12	11.4
31-40	40	38.1
41-50	38	36.2
Above 51	14	13.3
Total	**105**	**100**

Source; Field Survey, 2019

Table 2 shows the number of years has been operating their business. Out of the 105 respondents, 40 respondents selected the category of 1-5 years and 5 respondents selected 16-20 years. Table 2 shows most of the respondents have early years of business operation with a few of the respondents having operated their business for a longer period

Table 2: Number of years operating your business

Years of operation	Frequency	Percent
1-5	40	38.1
6-10	26	24.8
11-15	7	6.7
16-20	5	4.8
Above 20	9	8.6
Total	**105**	**100.0**

Source Field Survey, 2019

4.2 Capacity of the GWCL Water Treatment Plants in the Municipality

From the interview conducted with the head of the treatment head works, it came up that the Municipality is served by one treatment head works located at Bokorno in the Eastern region, in the Upper Manya-Krobo Municipality. However, there are two water intake sources that feed the treatment plant with a total volume of 19,200 m^3 of water per day for treatment. These intake points are located at Densuano where water is taken from the River Densu which is about 24 km away from the treatment plant and the second intake sources is from the River Volta located at Bokorno where the head works is located. It came up that from the intake point to the head works is about

8.4km whiles the distance from the head works to Koforidua which is the New Juaben Municipal capital is 25 km. The Engineer gave the volume of raw water contributed by each of the intake points as 5000 m3 and 14,200 m3 from River Densu and River Volta intake points respectively. The capacity of the plant is therefore, 19,200m^3 per day, and the plant is operating at full capacity.

Densu and Volta Lake Sources

River Densu, one of the sources of water supply to the Koforidua Urban Area, takes its source from Apedwa hills, a town near Suhum. It flows from Apedwa through the Akim forest area to Akwadum, a small town in the New Juaben District, about 9 kilometres away from Koforidua. The river flows to a little village called Obuotumpan – in the Suhum district about 6 kilometres from Koforidua – where abridge has been constructed on it. It should be noted that, this river is not perennial; and it easily dries up in the harmattan. Before the river flows to Koforidua at the water pumping station at Densuagya (Bebianiha), all the inhabitants at the village along the river banks use the river as their source of water. One clear instance is that the river banks have been exposed to the weather leading to rapid evapo-transpiration. People have also felled all the trees which provide shade for the river. Koforidua and its spreding towns are experiencing deforestation because trees have been felled for use as firewood. River Birim at Bunso remains as it is during the dry season whiles river Densu dries up completely. This situation also adds up to the water shortage problem in the New Juaben Traditional Area. The treatment filter house about 7.5 liters per hour.

Okomeng-Source (Gravity Flow)

The Okomeng stream like River Densu is also a source of water to Koforidua Municipality. However, unlike the Densu, the Okomeng's source is from a spring, although it is more regular than the Densu flow. It takes its source from rocks in the Koforidua-Kwahu scrap. It flows through the farming lands in Asokore through Effiduase in the New JuabenTraditional Area. It flows through Nyamekrom, a small village about 4 kilometres from Koforidua and finally Densuagya where it joins the River Densu. The Ghana water company limited had piped the Okomrng stream direct from source to the raw water tank at the treatment works. It is needless to say that Okomeng is a great relief to the inhabitants of Koforidua during dry spells when Densu dry up completely during the 1983 water crisis.

Suhien-Sources (Gravity Flow)

The Suhien stream like the Okomeng also provides water supply to the G.W.C.L treatment works. Both the Okomeng and Suhien are the main sources of water supply and the Densuriver serves as a supplement. The Suhienriver is also from a spring which takes its source from Suhein hills, a small town in the New Juaben Koforidua district. The river flows through the small spreading towns along the Koforidua-Tafo road notably Jumapo, Oyoko, and flows through the lands in the outskirt of Asokore heading towards Akwadum. The river flows under a bridge on the Koforidua Suhum road and meets its confluence with river Densu at Suhienso. Like Okomeng stream, the Suhien stream named after the Suhien town, is also piped by GWCL to its raw water tank direct from source. Because its supply is through gravity, the Suhien in addition to Okomeng have helped the Koforidua inhabitants during the dry season in particular when the Densu River gets dried up.

Water delivery for domestic and industrial purposes is supplemented by rain harvesting, rivers, streams and dugouts. Most of these sources are unsafe and expose the people to water-related diseases such as diarrhea, typhoid fever, guinea worm and schistosomiasis. The problem has been aggravated by a high population growth rate and a seemingly lack of capacity on the part of the responsible agency, the Ghana Water Company, to keep pace with the rate of demand. The River Densu is the main source that supplies water for treatment and delivery to the municipality and satellite communities. Rainwater harvesting is carried out basically at household level and in few institutions even though the option is viable in.

4.3 Analysis of population water demand and treated water supplied by GWCL

The amount of water pumped by the Ghana Water Company Limited from the treatment headworks to serve the municipality is about 18, 200m^3 per day. This means the quantity of water delivered from the intake point to the treatment plant has reduced after the treatment. However, the population of the municipality is estimated at 217,389 based on the Ghana Statistical Service's projection for 2017 (GSS, 2017). Since the population of the Municipality was projected to have been growing at the rate of 2.6%, it implies that the population witnessed an increase of to about 5,652 in 2018 and 5,799 in 2019. Therefore, the total population for this study is the population at the end of 2019, which is estimated at 228,840.

The water demand which is the quantity of water expected to use by each individual in the community per day which varies from urban and rural communities. Ghana water company which supply water to urban communities normally usesdomestic water demand per person per day of 60ltrs as the standard for planning water supply. Water demand (Qm^3/d) for a community per day is therefore a product of the

individual water demand (qm^3/d) per day and the estimated population. For the New Juaben Municipality the water demand can be estimated as follows:

Water demand (Qm^3/d) = Estimated population for 2019 * average water demand (qm^3/d)

Qm^3/d = 228,840 * 60 l/day

Qm^3/d = 13,730,400 l/day

Qm^3/d = 13,730.4

Assuming that industrial and domestic water demand is the same, then it implies that the water demand for the municipality is 13.7304m^3/d. However, the company has been pumping about 18,200m^3 of water into the municipality which is about 4.469.6 m^3 more than the water demand of the municipality. The results imply that the Company has enough capacity to meet the average water demand of the population in the New Juaben Municipality and therefore, some other factors may be responsible for the intermittent water supply.

The average water coverage is 49 per cent.According to the Head of the distribution section of the corporation; they do not deliberately close the taps in the course of the distribution of piped-borne water to consumers. The supply of water is by means of gravity. Under normal circumstances, service can be operated for 24 hours without interruption but because of shortfalls, the corporation cannot meet consumer demand. During the night when leakages get worse, the service reservoir is shut down at 10p.m to allow water to build up until 3 a.m. at full capacity the service reservoir reaches 3600mm (280, 000 gallons) of water and the taps are opened until the morning. Flow of water during the day is 2 feet at the service reservoir and not all areas get water. Places like Betom, Ridge (residential areas), Effiduase and Okorase which are on a hill are victims of irregular supply of water. Also schools like S.D.A training College

at Asokore, Ghana Secondary school, Effiduase and the central and St. Joseph's hospitals have high level tanks for the supply of water.

The company also has some problems with regards to the distribution of water to the Koforidua Township. Firstly, consumers do not pay their bill in time. That leads to lack of money to purchase spare parts for the distribution system such as pipes and waste-tap for the public stand-pipes. Secondly, there is much loss of water through leakages caused by faulty valves. This causes the lines to burst at times. Moreover, people throw rubbish on the pipelines. Finally, heavy rainfalls have exposed the distribution lines to the mercy of the scorching sun. According to the Regional manager, the company is now remetring the public stand pipes. This has been put under the supervision of the C.D.Rs at the various suburbs in the town. The C.D.Rs would be billed monthly and charged with the collection of money from any consumer who fetches water from the stand pipes. However, consumers who have their own pipes in their houses are exempted from this exercise because bills are sent to them monthly. The exercise of revenue collection by C.D.Rs has been started at Asamankese in the Eastern Region. In Koforidua, the company wants to start from Asokore.

4.3.1 Pumping Capacity

Densu intake pumps 180m³ per hours. Volta lake pumps 180m³ per hour. The Floating intake pumps 850m³ per hour. (The floating pumps activated when there is change in river levels). There is an intermediate pump station that pumps the treated water to its final destination. The final treated water pumps about 412.26m³ per hour while the intermediate pumps about 426m³ per hour. The pump head is 112.26m.

4.4 Perception of Consumers on Causes and effects of Intermittent Water Supply

The output displayed in Table 3 displays the sources of water of the respondents. All 105 people responded. 61.9% of the respondents get water mainly from Ghana Water Company Limited, 9.5% get water from the borehole, 4.8% of the respondents get their water from hand dug well. However, 13.4% combined GWCL and borehole, 5.8% of the respondents get water from both GWCL and hand dug well and 5.0% of the respondent obtain water from GWCL, streams and the Densuriver.

Table 3: Sources of water used by respondents

Sources of water	Frequency	Percent
GWCL	65	61.9
Borehole	10	9.5
Hand dug well	5	4.8
GWCL & BOREHOLE	14	13.4
GWCL & STREAM	1	1.0
GWCL and hand dug well	6	5.8
GWCL and stream, Densu river	4	4.0
Total	**105**	**100.0**

Source Field Survey, 2019

Table 4 displays the responds to the question 'of any experience of intermittent water supply**.** All 105 respondents answered the questions. 42.9% of the respondents said that they do experience intermittent water supply, 17.1% said they don't experience

intermittent water supply while 19.0% of the respondent experience intermittent water supply sometimes.

Table 4: Do you experience intermittent water supply

Responses	Frequency	Percent
Yes	45	42.9
No	18	17.1
Sometimes	20	19.0
Total	**105**	**100.0**

Source Field Survey, 2019

Table 5 shows the results for how frequent the consumers experience intermittent water supply. Out of a total of 81 valid respondents, majority 58 (71.6%) do not experience intermittent water supply quite often, 9.9% experienced intermittent water supply daily and weekly, while 8.6% of the respondents experienced it monthly. Which shows that most of the respondents do not experience intermittent water supply for over a month?

Table 5: Frequency of consumers experiencing intermittent water supply

Responses	Frequency	Percent
Daily	8	9.9
Weekly	8	9.9
Monthly	7	8.6
Not quite often	58	71.6
Total	**81**	**100.0**

Source Field Survey, 2019

Table 6 shows the distribution of how respondents meet their daily water demand as expected. Out of the 103 respondents 57.3% selected "Yes", they do meet their daily water demand as expected and 41.7% of the respondents selected "No" others had several reasons why they do not meet their daily water demand expected.

Table 6: Do you meet your daily water demand as expected

Responses	Frequency	Percent
Yes	59	57.3
No	43	41.7
Not often	1	1.0
Total	**103**	**100.0**

Source Field Survey, 2019

Table 7 shows the causes of the intermittent water supply. It was found that 10.8% out of the 93 respondents agreed that population growth is the reason why water supply is intermittent, 20.4% of the respondents said it was as a result of leakages,15.1% said it

was because of old water supply network. While half (50.5%) said that all of the above contribute to the intermittent water supply

Table 7: Causes of intermittent water supply

Responses	Frequency	Percent
Population Growth	10	10.8
Leakages	19	20.4
Old water supply network	14	15.1
All of the above	47	50.5
electricity	1	1.1
population growth and leakages	2	2.1
Total	**93**	**100.0**

Source Field Survey, 2019

Table 8 shows the distance between houses or businesses of respondents to water sources. Out of the 101 respondents, 42 (41.6%) respondents selected house connection and the second highest recorded was 1-10m with 22 (21.7%) respondents selecting that category

Table 8: Distance between the house or business to water source

Distances	Frequency	Percent
House connection	42	41.6
1-10m and 10-30m	1	1.0
1-10m	22	21.7
10-30m	7	6.9
Above 30	14	13.9
house connection and 1-10m	13	12.9
house connection and 10-30m	1	1.0
house connection and above 30m	1	1.0
Total	**101**	**100.0**

Source Field Survey, 2019

Table 9 shows if respondents experience any form of water leakages. Out of the 103 respondents, 42 (40.7%) respondents selected Sometimes which shows that some water leakages do occur and also sometimes does not occur, followed by No with a frequency of 39 (37.9%) and 22 (21.4%) respondents responded to Yes. Concluding to the fact that the respondents do experience water leakages

Table 9: Consumers experiences water leakages

Responses	Frequency	Percent
Yes	22	21.4
No	39	37.9
Sometimes	42	40.7
Total	**103**	**100.0**

Source Field Survey, 2019

Table 10 shows the causes of water leakages within the municipality from the consumers' perspective. Out of the 37 respondents, only 37 (35.2%) responded to the item. It is clear that highest recorded cause was 12 (32.4%) who indicated old pipes and bad network, 9 representing 24.3% attributed the cause of intermittent water supply to illegal connection by other people which is not an authorised act followed by poor water network with 9(24.3%) respondents pointing that cause due to leakages from pipes that were exposed and got burst.

Table 10: Causes of water leakages

Ccauses of water leakages	**Frequency**	**Percent**
Illegal connection	9	24.3
Leakage due to exposed pipe lines	9	24.3
Old pipes and bad network	12	32.4
poor maintenance	6	5.7
seasonal changes	1	1.0
Total	**37**	**100.0**

Source Field Survey, 2019

Table 11 shows the distribution of water quality from the Ghana Water Company Limited. Three categories were created under this section. Out of the 105 respondents 73 of them responded to the item with 44 (60.3%) respondents selecting Sometimes, 16 (21.9%) of the respondents selected No and 13 (17.8%) of the respondents selected Yes which shows they sometimes get quality water from the Ghana Water Company Limited. This means that the quality of water supplied have been changing from consumers' perspective, implying that the quality is not reliable.

Table 11: GWCL supplying quality water to consumers

Responses	Frequency	Percent
Yes	13	17.8
No	16	21.9
Sometimes	44	60.3
Total	**73**	**100.0**

Source Field Survey, 2019

Table 12 shows the usage of storage tanks by respondents. Over half of the respondent selected "Yes" with a percentage of (61.8%) and (38.2%) of the respondents selected "No" showing they do not have any form of storage tanks. This means most of the respondents have storage facilities in their houses or premises to store water for use when water supplied by the company is not flowing.

Table 12: Households with storage tanks

Responses	Frequency	Percent
Yes	63	61.8
No	39	38.2
Total	102	100.0

Source Field Survey, 2019

Table 13 shows the capacity of storage tanks in litres and m^3. Out of the 105 respondents, the biggest storage capacity of storage tank was above 20,000 litres tank with 15 (30.6%) respondents and 15 (30.6%) of the respondents had tanks with capacity 1000 litres to 10,000 liters. However, two (1.5%) of the respondents could not indicate the sizes of their water storage tanks.

Table 13: Capacity of storage tanks

Capacity of storage tanks (litres)	Frequency	Percent
Below 1000	11	22.4
1000 – 10,000	15	30.6
10,100-20,000	6	12.2
Above 20,000	15	30.6
Do not know the size	2	1.5
Total	**49**	**100.0**

Source Field Survey, 2019

Table 14 shows how long water serves respondents. Out of the 105 respondents the questionnaires were administered to 14 of the respondents responded to 1 Day and followed by 2 Day having a frequency of 11. The highest month which water served by respondent was one and a half month with 1 respondent. From Table 12 assumptions can be made that water serves a daily purpose by most of the respondents

Table 14: Length of days water from the reserve tank serve

Responses (days)	Frequency	Percent
Less than a week	33	13.3
1 - 2 weeks	7	2.0
3 -4 weeks	3	1.0
Above 1 month 5 weeks	6	1.0
Total	**49**	**100.0**

Source Field Survey, 2019

Table 15 shows the distribution if water is supplied by tankers to respondents. Out of 105 respondents, over half respondent to No and 36 respondents responded to Yes. Table 15 shows that most of the respondents are not supplied with water from tankers which means respondents depend in the categories created under the types of water sources

Table 15: Consumers access water from water supply tankers

Responses	Frequency	Percent
Yes	36	34.3
No	62	59.0
Total	105	100.0

Source Field Survey, 2019

Table 16 shows the distribution if water intermittent affects the economic activities of respondent. Out of the 97 respondents, two main categories were identified over half of the respondent respondents said Yes contributing to 54 (55.7%) respondents and 43 (43.3%) respondents agreed to No showing most of the respondents were affected by water intermittent.

Table 16: Intermittent water supply can affect economic activities

Responses	**Frequency**	**Percent**
Yes	54	55.7
NO	43	43.3
Total	**97**	**100.0**

Source Field Survey, 2019

Table 17 describes how respondents are affected by intermittent water supply system in the New Juaben Municipality. Out of the 105 respondents only 46 of them responded to the item with the highest recorded problems faced by water intermittent was 26.1% which shows income problems and a number of problems recorded such as lateness to work and school and also extra cost of money to fetch water from well when there's any shortage and other problems faced by the respondents.

Table 17: How intermittent water supply affect consumers

Effects on consumers	Frequency	Percent
Affects over 5% of income	12	26.1
Affect daily business activity and waste time	8	17.4
Causes lateness to work and school	7	15.2
Low economic income	11	23.9
It slows down work	3	6.5
Increase cost of water	5	10.9
Total	**46**	**100.0**

Source Field Survey, 2019

Table 18 shows the record of any experience from water sanitation diseases. This question shows any diseases associated with water sanitation. Out of the 105 respondents, slightly over half of the respondents the questionnaires were administered to responded No making 86.9% of the total and 13.1% of the respondents responded to Yes showing they have experienced water sanitation disease. From Table 12 conclusion can be made that most of the respondents are not affected by any water sanitation disease.

Table 18: Do you experience any water sanitation disease?

Responses	Frequency	Percent
Yes	11	13.1
No	73	86.9
Total	84	100.0

Source Field Survey, 2019.

Table 19 shows the type of water sanitation diseases. From the Table (19) three (3) types of diseases were covered. Out of the 105 respondents, most of the respondents didn't respond to any associated water sanitation diseases. The highest recorded water sanitation disease was Diahorrea and the least recorded disease was Typhoid and other respondents responded having two of the types of diseases mentioned. Concluding it shows most of the respondents do not get affected by water sanitation diseases

Table19: Types water and sanitation related diseases

Responses	Frequency	Percent
Typhoid	1	1.0
Diahorrea	5	4.8
Cholera	4	3.8
All of the above	3	2.9
cholera and dysentry	1	1.0
Diahorrea and cholera	4	4.0
itching	1	1.0
typhoid and diahorrea	4	3.9
Total	**105**	**100.0**

Source Field Survey, 2019

CHAPTER FIVE

SUMMARY, CONCLUSION AND RECOMMENDATIONS

This chapter contains the summary of the study, conclusion and recommendations as well as limitations encountered during the study.

5.1 Summary

This study into investigation of intermittent water supply in the New Juaben Municipality has highlighted such factors and maintenance practices that have attributing to the intermittent water supply in the Municipality. It was estimated during the study that, Ghana Water Company Limited loses 5,157m³ of water daily which is approximate to GH¢ 978,798.60 annually. Also, 42 .9% of the residents experienced intermittent water supply regularly while 19.0% experienced intermittent water supply sometimes. 56.2%.Respondents claimed they depend on alternative water sources eg, Water Supply Tankers, Boreholes etc. to enable them meet their daily water demands. However, they spent over 9% of their annual income on water supply that makes the cost of living very high. 84.8% respondents indicated that they also depends on other water sources due to the water quality emanated from heavy down pour, power failure and illegal connections in the Municipality.

44.8% respondents attributed the causes of intermittent water supply to population growth, leakages, obsolete networks and illegal connections. New Juaben Municipality being the Eastern Regional cosmopolitan Capital and serves as internal migration pull center because of educational institutions especially current free Senior High School Programme, industries, institutions, and other small scale business operators in the Municipality. The implications of the intermittent supply are many and complex, leading to adverse impacts upon society, along various dimensions:

Intermittent Water Supply service costs more than continuous service. Intermittent hours of water supply force customers to rely on black-markets or informal vendors, often serving higher-income citizens, thereby exacerbating inequalities among users. Intermittent Water Supply service costs more than continuous service, and users bear the brunt of having to pay more to access water services via alternative routes. It also weakens the social contract between governments and their communities when water utilities fail to deliver basic water services.

5.2 Conclusion

Achieving a paradigm shift from intermittent water supply to continuous supply is only possible by changing the way we manage water today. The study has shown that Ghana Water Company Limited in the New Juaben Municipality has one water treatment headworks with capacity of 19,200m^3 per day. The head works receives a total of 19,200m^3 of raw water from two intake points which are from River Volta and River Densu. These two main sources are to ensure continuous raw water supply for treatment throughout the year. The quantity of water supplied from the head works have been found to be 18,200m3 per day whiles the daily water demand for the Municipality is about 13,730.4m3 which is less than the water supplied by the Ghana water company Limited. Intermittent water supply in the municipality is not based on the quantity of water available for supply but other factors such as failure in the network distribution, burst in distribution lines, electricity cut-offs, illegal connection and lack of funds to expand and change the old pipe networks. Most of the consumers have adapted to the intermittent water supply by installing water storage tanks of different to store water when it is available for use when water is not being supplied. These tanks have their limits or capacities and can serve the consumers for different

time duration. It was found that some storage could last for a month while others are just for two days.

5.3 Recommendation

From the findings of the study on the causes of intermittent water supply in the New Juaben Municipality, the under listed are recommended to increase the universal access to water supply in the New Juaben Municipality.

For Ghana Water Company Limited

1. Since water losses was a major issue, it is important for the Ghana Water Company Limited to invest in technology to detect leakages, improved maintenance schedule, engage community members to report water leakages and acts promptly to the reports of citizens after validation of issues reported. This should help reduce the rate of water losses and improve water availability for consumers.
2. The company should carry out regular expansion and replacement of existing old water supply system or network to help improve access to potable water by reducing leakages attributable to pipe burst and bad distribution network.
3. Considering the rate of growth of the Municipality, it's important that the company develops propose and implement network expansion projects to increase the capacity of the head works for the Municipality.
4. Since consumers have been receiving water with varied qualities, it is important for the GWCL to check all its distribution system and ensure good treatment of their distribution lines to prevent water contamination and possible outbreak of water borne diseases among the consumers.

5. Effort should be made by the GWCL to inform consumers on time whenever there are challenges with the water supply system so they can have an alternative plans to access water readily since most of them indicated that it affected their businesses, made them go to school and work late as well as affected their economic fortunes.

For the New Juaben Muncipal Assembly

6. The Municipal Assembly should assist the GWCL to prepare well define spatial planning layout for water distribution network to avoid the constant conflicts with other municipal development services which often leads to cutting of pipelines and rendering some areas non-functional and contributing to water rationing.

For further studies

For further research, it is recommended that:

7. A study to examine the outlets responsible for the Water loses so that masseurs could be recommended to address them.
8. Since not much studies have been done on the water quality delivered at the consumers' tap, it is recommended that a study to assess the quality of the water delivered by the water distribution networks in the municipality be done to help identify where quality deterioration occurs for redress.

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APPENDIX-1

(WATER COVERAGE/LOSES ANALYSIS)

WATER COVERAGE ANALYSIS

1. Population - 217,389 (Population and Housing Census-2017)
2. Water pumped to Municipality per day – 18,200m³(GWCL-Koforidua)
3. Domestic water demand per person per day – 60ltrs.(Planning Standards for Water Supply)
4. Water demand daily - 217,389*60 = 13043340ltrs.
5. 13043340/1000 = 13,043.34m³
6. Daily Water Pumped – 18,200-13,043.34 = **5,157m³**

WATER LOSES PER DAY

1. Water pump per day – 18,200m³ (Source, GWCL-Koforidua)
2. Water loses per day – 5,157m³ (Source, GWCL-Koforidua)
3. Cost per cubic - Gh¢ 5.20 (Source, GWCL-Koforidua)
4. Cost of water loses daily– 5,157*5.20 = Gh¢26,816.40
5. Annual loses = 365days*26,816.40 = Gh¢ 978,798.60

APPENDIX-2

(QUESTIONAIRES SAMPLES)

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INTERVIEW GUIDE

RESPONSE 1

RESIDENTS-NEW JUABEN MUNICIPALITY,KOFORIDUA

This research questionnaire forms part of a project work for MA International Development Studies of a dissertation work on "intermittent water supply at Koforidua in the New Juabeng Municipality". I would be very grateful if you could please spend some 15 minutes to answer the questions. Any information given will be treated with strict confidentiality.

Background of Respondents;

1. **Location……**

Please answer the following questions by ticking [√] the appropriate box.

2. **Sex of respondents.**
   (a) Male
   (b) Female
3. **Age of respondents**
   (a) 20 years and below
   (b) 21-30 years
   (c) 31-40 years
   (d) 41-50 years
   (e) above 51 years
4. **How many years you started business operation?**

(a.)1-5 ☐

(b.)6-10 ☐

(c.) 11-15 ☐

(d.)16-20 ☐

(e.) Above 20 ☐

5. What type of water source are you using?

(a.)GWCL ☐

(b.) Borehole ☐

(c.) Stream ☐

(d.) Hand dug well ☐

(e.) Other please specify,……

6. Do you experience intermittent water supply? a) Yes b) No c) Sometimes

7. If yes, how frequent do you experience intermittent water supply?

(a.)Daily ☐

(b.)Weekly ☐

(c.) Monthly ☐

(d.)Not quite often ☐

(e.) Others, please specify……..

8. Did you meet your daily water demand as expected?

(a.)Yes ☐

(b.)No ☐

(c.) If No explain,

9. What are the causes of the intermittent water supply in your view? (select as many as applicable)

(a.)Population Growth ☐

(b.)Leakages ☐

(c.) Old water supply network ☐

(d.) Other please specify,……..

10. What is the distance between your house or business centre to the water source?

(a.) House connections ☐

(b.) 1-10m ☐

(c.) 10-30m

(d.) Above 30m ☐

(e.) Others, please specify,……..

11. Do you experience frequent leakages?

(a.) Yes ☐ **(b.) No** ☐ **(c) Sometimes** ☐

12. If yes, give the causes……

13. Do you have water quality problem with water supplied by GWCL?
(a) Yes (b) No (c) Sometimes

14. Do you use home storage tanks?

(a.) Yes ☐ **(b.) No** ☐

15. What is the capacity of the storage tank?……

16. How long does is serve you when full?……

17. Do you sometimes buy water from other water supply tankers or trucks?

Yes b) No

18. Does the intermittent affect your economic activities?

☐ **(a.) Yes** ☐ **(b.) No**

19. If yes, how does it affect you?……
……
……

20. Do you experience water and Sanitation related diseases sometimes?

(a.) Yes ☐ **(b.) No** ☐

21. What type of water and sanitation related disease have you experienced in the last six months?

(a) Typhoid (b) diarrhea (c) cholera (d)dysentery

.....

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INTERVIEW GUIDE

RESPONSE 2

GHANA WATER COMPANY LIMITED –NEW JUABEN MUNICIPALITY,KOFORIDUA

1. What are the raw water intake sources for your operation?

Ans: **Black Volta/Densu**

2. How many treatment plants are you operating for water supply to the municipality?

Ans: **1 (Bokorno)**

3. What are the types and capacities of your treatment plants?

Ans: **Conventional (19,200m^3/ day)**

4. Describe the components of each treatment plant and their water storage capacities.
5. Do you experience water losses regularly? (No/**Yes**) if yes what are the causes?
6. What is the breakdown of your water losses for the past five years
7. What is the accounting for these losses?

Ans: **Maintenance, illegal connection, population.**

8. Are the bulk meters functioning? (**Yes**/No)
9. If No explain why …….
10. What quantities are supplied to the municipality on daily basis? Any data to back this?

Ans: **18,200m^3/day**

11. Do you have raw water quality challenges? (**Yes**/No) if yes explain the causes:**Downpour at upstream**
12. What about treated water quality challenges? **Sometimes**
13. Any complaints from your clients or consumer? **Sometimes**
14. Do you pump water regularly? (**Yes**/No) if no explain the reason
15. Do you have pant maintenance plan? (**Yes**/No)
16. If No explain why?
17. If yes, describe the plan?

Ans; **Routine maintenance plan**

18. How often do you carry out the maintenance?

Ans: **Periodically**

19. Do you keep records of the maintenance performance? (**Yes**/No) if no explain why
20. What are the sources of electricity energy for your pumping stations?

Ans: **National Grid - ECG**

21. What is your client base in the municipality?
22. What is the extent of your service coverage in the municipality for the past five years?
23. What is the Present Coverage?

Ans: **49%**

24. What plans exist for future expansion and maintenance of the current coverage?

Ans; **Extension to peri-urban areas**

25. Do seasonal changes affect the raw water intake sources? (**Yes**/No)
26. What accounts for intermittent water supply in the municipality?

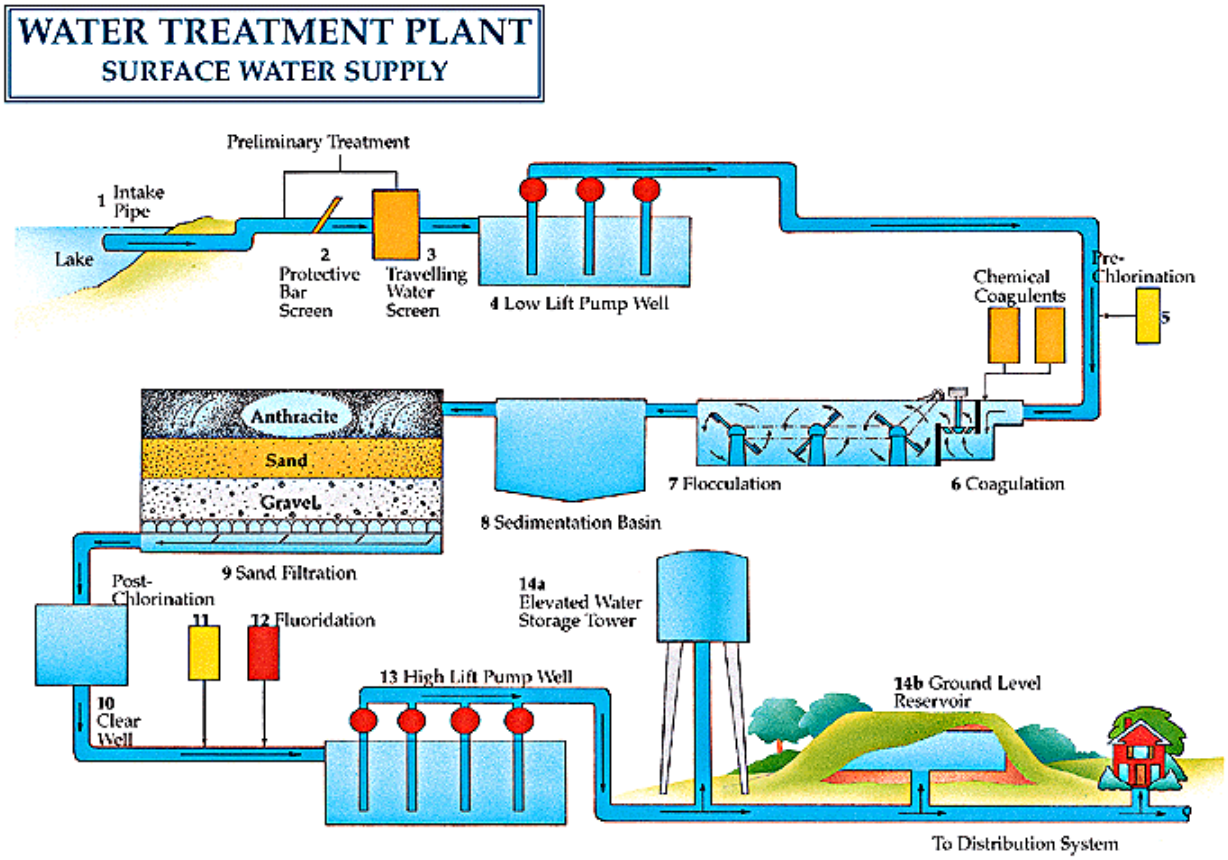
Ans; **Population, leakages, illegal connection, power failings**

27. What can the municipal assembly do to help improve water supply in the municipality?

Ans: **Extendible action to mistake in farming activities as the intake source**

28. Do you have other comments to make?

Surface Water Treatment Plant – Flow Diagram Conventional Method



1 Intake Crib

Raw water from a surface water lake or reservoir is drawn into the plant through intake structures. Large debris like logs are prevented from entering and zebra mussel control is performed at the intake.

2 & 3 Screens

Smaller debris like fish, vegetation and garbage are removed from the raw water by protective bar and traveling screens before the water enters the low lift pumps.

4 Low Lift Pump Well

These pumps lift the water to flow through the treatment processes by gravity.

5 Pre-oxidation & Primary Disinfection

Disinfectants or other oxidants are added to disinfect or control tastes and odours. The specific processes used are determined by the chemical and biological raw water characteristics.

5 Coagulation

Coagulants, rapidly add electrochemical charges that attract the small particles in water to clump together as a "floc". This initial charge neutralization process allows the formed floc to agglomerate but remain suspended.

6 Flocculation

By slower mixing, turbulence causes the flocculated water to form larger floc particles that become cohesive and increase in mass. This visible floc is kept in suspension until large enough to settle under the influence of gravity.

7 Sedimentation

Flocculated water is applied to large volume tanks where the flow speed slows down and the dense floc settles. Settled floc is removed and treated as a waste product that is discharged to the sewer system.

8 Media Gravity Filtration

Relatively floc free, settled water flows through a media filter by gravity. Filter media are made from layers of anthracite or granular activated carbon and sand. Gravel or synthetic materials support the media. Physical straining removes the remaining floc. Filters are periodically backwashed to clean off accumulated floc and other trapped impurities.

9 Clear Well

Filtered water in the clear well is used to backwash filters and kept in storage to ensure that disinfectants are in contact with the water long enough to inactivate disease causing organisms.

10 Secondary Disinfection

Supplemental chlorine is added to maintain disinfection concentrations while the water is pumped through the distribution system. The purpose is to ensure minimum residual disinfectant levels at the farthest points of the system.

11 Fluoridation

A process where silicofluoride compounds are added to treated drinking water to artificially raise the fluoride concentration to within a specified range; for example between 0.5 to 0.8 mg/L (ppm). Fluoridation is an optional public health dental policy.

12 High Lift Pump Well

Treat drinking water is pumped through large pressure pumps to other pumping stations, reservoirs or points of supply within the local distribution system.

13 Elevated Water Storage Towers and Ground Level Reservoirs

Water distributed to water towers and storage reservoirs ensures stable water pressure. An adequate supply of water is maintained to meet peak water demands or emergencies such as fires, water main breaks, and power outages and pump failures.

14 Distribution System

Distribution systems are comprised of large pipes known as trunk mains to deliver drinking water. Smaller diameter branch mains feed individual streets. Service connections to branch mains deliver water into residences. Pumping stations are used to increase pressure and to maintain adequate supply flows.