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Water Demand and Bacteriological Content of Public Water Systems in Abeokuta, Nigeria

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ABSTRACT

Water demand in Abeokuta, Nigeria and bacteriological content of public water supplied by the Ogun State Water Corporation, major water supplier in Abeokuta; is assessed in this paper. The water demand of the population was estimated for ten years based on the 2006 National Population Census result, using the geometric projection method. Forty sampling locations were also randomly selected in the city of Abeokuta. Water samples were collected - during the rainy and dry season. The samples were analyzed for total and faecal coliform count using the Most Probable Number method. The presence of Escherichia coli was detected in 39 of a total of 80 samples collected in both seasons. Water demand ranges from 2.01 x 10^7 m^3 - 2.48 x 10^7 m^3 per year. However, the current volume of water supplied, about 82 million litres per day (2.99 x 10^7 m^3 per year), that is when the public utility is in operation is only sufficient to meet the current water demand of the population. The paper argued the need for urgent expansion of the water scheme to adequately meet the present and future water needs of the population and by extension the targets of the Millennium Development Goals by 2015. The paper concludes on the need for periodic monitoring of the state of water from the distribution pipe network from source to the point of use, as well as the water quality parameters that are necessary to ensure the safety of water.

Introduction

The importance of water to the existence of life cannot be overemphasised. Water, beside food, air and vectors, is the route of transmission of many infectious diseases. Water constitutes 70 % of the total earth surface, about 98 % of which is saltwater leaving only 2% as fresh water (Olawuni, 2007). Eighty – seven per cent of the freshwater is locked up in glaciers; the rest in soils, living things and atmosphere. Consequently, with an estimated 1,360 million km^3 of water on the earth and only 4 million km^3 (0.3 %) is available for human consumption (Wilson, 1990), the fundamental fact remains that man's water needs depends largely on rivers, streams and groundwater (Awomeso et al., 2010).

Continuous increase in the world population translates to increase in water demand (Heydari et al., 2013) thereby recurrently depleting the world's supply of freshwater. The increasing demand leads to the search for water from every available source be it wells, streams, lakes, ponds and rivers both in rural and the urban area with little consideration for the quality status of the water that is being obtained.

Water is generally accepted as potable when it is free from disease producing micro organisms and chemical substances that are dangerous to health (Lamikanra, 1999). Akali et al., (2014) and Mara and Evans (2011) affirmed that access to reliable and clean water supply is a key determinant of human health. Diseases contacted through drinking water kills about 5 million children annually, makes 1/6th of the world population sick (WHO, 2004) and accounts for death of 600 children per day in West Africa (Quenum, 2003). The prevalence of water related diseases is further magnified through water scarcity, which constitutes a significant limiting factor for sustainable development (Aderibigbe et al., 2008 and Gleitsmann et al., 2007).

WHO and UNICEF estimates that 17 % of the world population lacks access to water resources, where access is defined as the availability of a minimum of 20 litres of water per capita per day from a reliable water source that is within a distance of 1km (Abaje, et al., 2009 and Bates, et al., 2008). However, 20 litres per capita per day remains a far cry from the 75 litres per capita per day necessary for protection against household diseases and 50 litres per capita per day necessary for basic family sanitation recommended by WHO, although individual consumption is known to vary widely across the globe (Abaje, et al., 2009 and THD, 2007). In acknowledgement of the problems, the Millennium Development Goals are targeted to reduce by half the proportion of people without access to safe drinking water and sanitation by 2015 (UN, 2003). However, with months away to 2015, access to potable water and basic sanitation is far from being achieved in Nigeria (Ekemenah, 2014.)

Public water supply in Abeokuta (the study area) is provided by the Ogun State Water Corporation through the Arakanga Water Scheme. Raw water for this purpose is abstracted from Ogun River, which has tributaries like Oyan, Ofiki and Opeki Rivers, resulting in an estimated 5.64 x 10^{12} litres/year for Ogun River. The Scheme has a pumping capacity of 103.68 million litres per day and the actual current capacity when operational is about 82 million litres per day (Ufoegbune et al., 2009; Shittu et al., 2013; Awoyinfa, 2014).

Public water supply in Abeokuta is not adequate. In recent past, water shortages had been a recurrent dilemma as progressive decline in accessibility and reliability of supply is observed. However, events took a new turn from 2011 when an improvement in the frequency of supply was observed (Awoyinfa, 2014). Nevertheless, the issue of quality, quantity and coverage remains a concern. A sizable section of Abeokuta city remains un-connected and un-served by the public water

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system while many sections that are previously served are now disconnected due to disrepair and poor maintenance of the existing distribution network. Hence, domestic water supply is barely met let alone the supply for agriculture, commercial and industrial uses.

Consequently, the population are forced to rely on various alternative sources especially the self – supply system (hand dug wells and/or boreholes) as a coping strategy (Oluwasanya, et al., 2011; Carter et al. 2005); putting a clause on the question of accessibility (Clasen and Bastable, 2003; Amori and Makinde, 2012).

This paper reviews the need for adequate water supply by estimating the current water demand in Abeokuta metropolis. The paper also assesses the bacteriological content of the available public water supply using total and faecal coliform as indicator parameters. Abeokuta (Figure 1) is located between Latitude $7^0$5'N and $7^0$20'N and Longitude $3^0$17'E and $3^0$20'E. Human population of the city is estimated at 449, 088 (National Population Census, 2009) and an approximate population density of 392 persons per square kilometre. Abeokuta has a tropical climate with two distinct seasons – wet (April – October) and dry (November - March). The mean annual temperature and rainfall are estimated at 28^0C and 1,270 mm respectively while the estimated mean annual potential evaporation is 1,100 mm. The study area has a dendritic drainage pattern and the geology is Pre-Cambrian Basement Complex (Idowu et al., 2007).

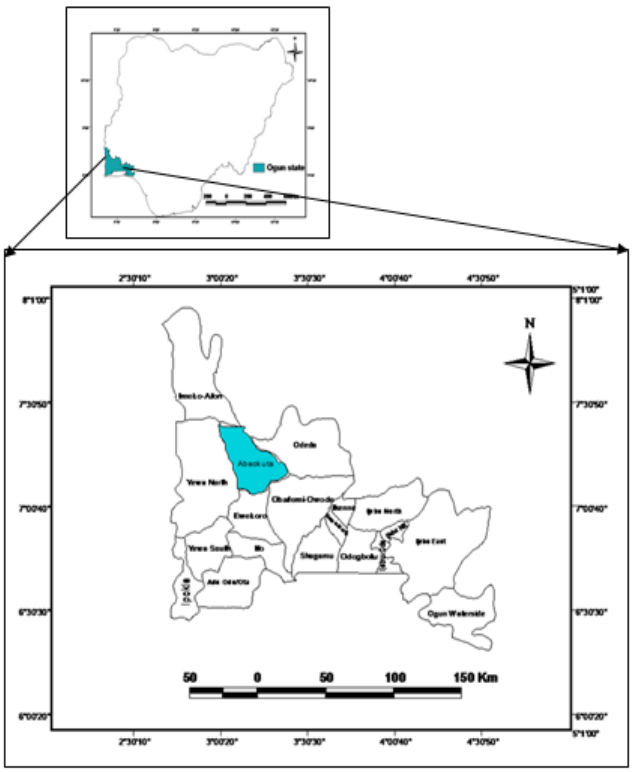

Figure 1. Map of Ogun state showing Abeokuta city, Nigeria (Insert is map of Nigeria)

Methodology

With the aid of the network distribution map of the study area obtained from the Ogun State Water Corporation, water samples were collected from 40 randomly selected public taps across the city using the stratified random sampling method (Anderson et al., 2010). Water samples were collected twice from each sampling location (once each during the rainy and dry season). The samples were collected using sterilised sample bottles to avoid contamination of the water by the container. They were then placed in an ice box, taken to the laboratory and analysed for total and faecal coliform count.

The population of Abeokuta was estimated using geometric projection method (Akali et al., 2014):

$$P_f = P_i \left(1 + {}^{r}/_{100}\right)^n$$

Where,

P_f = Final projected population

P_i = Original population before projection

r = Growth rate

n = Interval (in years)

An annual growth rate of 2.33 % for Nigeria (United Nations Population Division, 2008; Idowu et al., 2013) was used in estimating the population for the years under review (2006 - 2016). The estimated population was then used in computing the water demand for the ten year interval. Water demand estimation required population census result (National Population Census, 2009), the 2.33 % per annum growth rate for Nigeria (United Nations Population Division, 2008) and domestic water requirement of 120 litres per capita per day recommended for urban areas (Federal Ministry of Water Resources, 2000). The census result obtained in 2006 was multiplied with 2.33 % to obtain the estimated population increment for the next year. The water demand for the annual population was determined by multiplying the population with 120 litres per capita per day, multiplied by 365 days.

Results and Discussions

Water demand

The values of the domestic water demand of the population for the years 2006 to 2016 under review ranged from 2.01 x 10^7 m^3 per year and 2.48 x 10^7 m^3 per year (Table 1). At 82 million litres per day (2.99 x 10^7 m^3 per year all things being equal) the water supply by the water scheme per year can still meet the annual domestic water demand of the population till 2016 (Table 1). However, other sectors such as institutions (schools, hospitals, among others), commercial and industry, fire service and horticulture still require an estimated 20 %, 30 %, 7.5 %, and 7.5 % respectively of the total domestic water demand of the population (Idowu et al., 2013). Therefore, all the aforementioned sectors put together will be left to share the balance volume of between 5.1 x 10^6 m^3 – 9.8 x 10^6 m^3 per year for the years under review as against the actual required volume of 1.31 x 10^7 m^3 – 1.61 x 10^7 m^3 per year.

Ultimately, the non-domestic water needs will also require more water as population increment remains constant. In all, considering the total annual water demand for both domestic and other sectors, 82 million litres per day is grossly inadequate for the study area. Also responsible for insufficient water delivery are irregular power supply, leakages along distribution lines and poor network coverage.

Bacteriological quality

A total of 39 samples indicated the presence of *Escherichia coli* for both seasons; 20 samples during the rainy season and 19 samples in the dry season. The bacterial count per 100ml during the rainy and dry season ranged between 100 counts per 100ml and 400 counts per 100ml as well as between 100 counts per 100ml and 200 counts per 100ml respectively. The values of bacteria count detected in the samples collected during the rainy season are higher than the samples collected in the dry season. While some sampling locations that recorded the presence of bacteria during the rainy season did not record any during the dry season. The result could be attributed to entry of runoff into the distribution network through leakages; runoff, which is absent during the dry season (Egwari and Aboaba, 2002).

Table 1. Estimates of population and water demand in Abeokuta, Nigeria

Year	Population	Total annual domestic water demand (x 10^7 m^3)	Total annual water demand for other sectors (x 10^7 m^3)	Total annual water demand (domestic and other sectors) (x 10^7 m^3)
2006	449,088			
2007	459,552	2.01	1.31	3.32
2008	470,260	2.06	1.31	3.32
2009	481,217	2.11	1.34	3.40
2010	492,429	2.15	1.37	3.48
2011	503,903	2.20	1.43	3.63
2012	515,644	2.26	1.47	3.73
2013	527,658	2.31	1.50	3.81
2014	539,952	2.36	1.54	3.90
2015	552,532	2.42	1.57	3.99
2016	565,406	2.48	1.61	4.09

Although rainfall may not singularly influence the bacteriological quality of public water supply; rainfall may play a leading role in dirty localities with decaying distribution pipelines. It should be noted that the presence of *Escherichia coli* in any water indicates faecal contamination (Egwari and Aboaba, 2002; SON 2007; American Public Health Association (APHA), 2005; Zamberlan da Silva, et al., 2008).

Adequacy of water supply systems and the MDG

Adequate and safe drinking water supply remains a key prerequisite for a healthy life (Fawell and Nieuwenhuijsen, 2003). Abeokuta, a consistently growing city will continue to experience a steady influx of people from surrounding peri – urban and rural areas and by extension overstretch the available water supply. The problem is further magnified as an estimated half of the present population of Abeokuta are not served with treated public water (Oluwasanya et al., 2011); consequently, increasing population is a source of worry. Therefore, there is the urgent need to address the issue of providing adequate water supply.

With an annual flow of 5.64 x 10^{12} litres, Ogun River has sufficient raw water to meet the water demand for the city of Abeokuta if adequately utilized. However, the current capacity of the water treatment plant and the operational capacity of the scheme among other factors makes constant water supply in Abeokuta inadequate. There is the need for expansion of the water scheme to meet the water demand of the present population if the targets of the Millennium Development Goals are to be achieved by 2015 and beyond.

Contamination of public water supply system: a growing concern

Since the famous Soho, London cholera outbreak of 1854, the concept of contamination of pipe distributed water has continued to gain prominence in cities across the world. Contamination of drinking water resulting in water related diseases remains the most significant aspect of drinking water quality. Subsequently, the discovery of *Escherichia coli* in about 49% of the previously treated tap water samples collected give an indication of the need for monitoring of the water distribution pipes across the distribution network to the point of use. The occurrence of *Escherichia coli* in the distribution network is a strong indication of the possible presence of enteric pathogens such as *Salmonella typhi, Vibro cholerae, and Aeromonas hydrophilia* (Shittu et al., 2013).

Previous studies have shown that the presence of pathogens in drinking water supply of surface water origin can be attributed to inadequacies in water treatment systems and poor public hygiene practices (WHO, 2004; Chan et al., 2007; Shittu et al., 2013). The presence of pathogens in distribution networks referred to as pathogen intrusion (López-Jiménez et al., 2010) can be attributed to the occurrence of leakages along the distribution network (Egwari and Aboaba, 2002). Periodic monitoring of the bacteriological quality of the water is strongly advised to address the issue of the presence of harmful water related disease causing bacteria in the distribution network. Water safety plans, which is a comprehensive risk assessment and management plan from catchment to point of use of the public water supply scheme is also highly recommended.

Conclusion

This paper has revealed the problem of inadequacy in quantity and the poor quality of public water supply in Abeokuta, Nigeria. The risks associated with inadequate water supply and consumption of poor quality cannot be overemphasized. Coverage area, leakages along distribution network and quality of pipe distributed water are fundamental issues that need to be addressed. Close attention should be paid to post – production quality of pipe distributed water and the adoption of source – to – point of use assessment of tap water quality is advised. Overhaul of the distribution network is encouraged for the detection of leaking pipes and maintenance of the entire system.

Improvement in the pumping capacity of the Arakanga Water Scheme is recommended as the scheme is still functioning below its 26 years old design capacity. Expansion of the present coverage of the network is also suggested to improve accessibility. Finally, the adoption of Water Safety Plans is recommended to assess the water supply system.

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