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WATER QUALITY AND SOCIO – ECONOMIC APPRAISAL OF PUBLIC WATER SUPPLY IN ABEOKUTA, SOUTH WEST, NIGERIA

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Abstract

Water quality and the perception of residents towards the supply of portable water in Abeokuta were assessed in this study. Forty sampling locations were randomly selected using purposive sampling method. Water samples were collected from sampling locations (public - taps) along the pipe – distribution network from water distribution source to point of use twice: rainy and dry season. Water samples were subjected to the following physical and chemical analysis: pH, EC, TDS, total alkalinity, calcium, magnesium, sodium, potassium, chloride, nitrate, sulphate, bicarbonate, cadmium, lead, chromium and aluminium. Questionnaire were distributed in the study area through the stratified random sampling method using the network distribution map obtained from the Ogun State Water Corporation as guide. With the exception of bicarbonate, cadmium, lead and chromium, all physical and chemical parameters tested were present in the water samples collected. Fifty – one per cent of the respondents were females, while 75% of them were students. Sixty – eight per cent of the respondents attested that the quality of the water supplied was unsatisfactory. Seventy – seven per cent of the respondents attested that the water supplied did not meet their daily demand, hence the reliance on water from alternative water sources. It is suggested that issues of quality, inadequate water supply and coverage area should be addressed speedily.

Keywords: *Calcium, aluminium, quality, potable water, distribution network*

INTRODUCTION

Problems and constraints due to population growth in potable water provision for human survival has recently been a major theme in the discussions on water (Awomeso et al., 2009). Potable water, clean environment and proper hygiene play key roles in ensuring a healthy population, their growth and development as well as their survival. Hunter et al.(2010) attests that1 billion people in developing countries lack access to an improved drinking water supply; unsafe water and inadequate sanitation and hygiene are largely responsible for 88% of the 4 billion annual cases of diarrheal disease. Water-related diseases kill 5 million people a year, mostly children, around the world (Ahuja, 2013).

Inadequate water supply and basic sanitation has its attendant economic implications (Odjegba *et al.*, 2015). Aladejana and Talabi (2013) assert the importance of potable water supply in poverty alleviation and socio – economic development. The World Health Organization (WHO) estimated that in Africa, access to improved basic water and sanitation will result in saving more than US$11 billion in medical treatment cost per year. In Nigeria, all levels of government: Federal, State and Local Governments are responsible for providing water supply to the populace. Although the country boasts of adequate water resources which include rivers, streams, lakes, wetlands and groundwater that serve as sources of water for a large portion of the population in some areas, public water supply facilities are limited. Water scarcity is a common phenomenon in many towns and cities across the length and breadth of the country. Therefore, water from hand dug wells, boreholes, ponds, streams, rivers etc.; as well as from private water vendors serve as alternative sources, subjected to immediate use without prior treatment of any kind.

In Ogun State, Ogun State Water Corporation provides potable water to the populace through water schemes located in various towns across the state. In Abeokuta the state capital, the Corporation operates the Abeokuta Water Scheme (located at Arakanga and commonly called the Arakanga Water Scheme) responsible for providing potable water for the city. 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); an amount grossly inadequate to meet the total water demand of the entire city. Inadequate potable water supply in Abeokuta therefore is a recurrent dilemma with a progressive decline in accessibility and reliability of supply; a phenomenon linked to the continuous population growth and expansion (Odjegba *et al.*, 2014). Consequently, this paper assessed the water quality and socio – economic appraisal of public water supply in Abeokuta.

METHODOLOGY

Description of study area

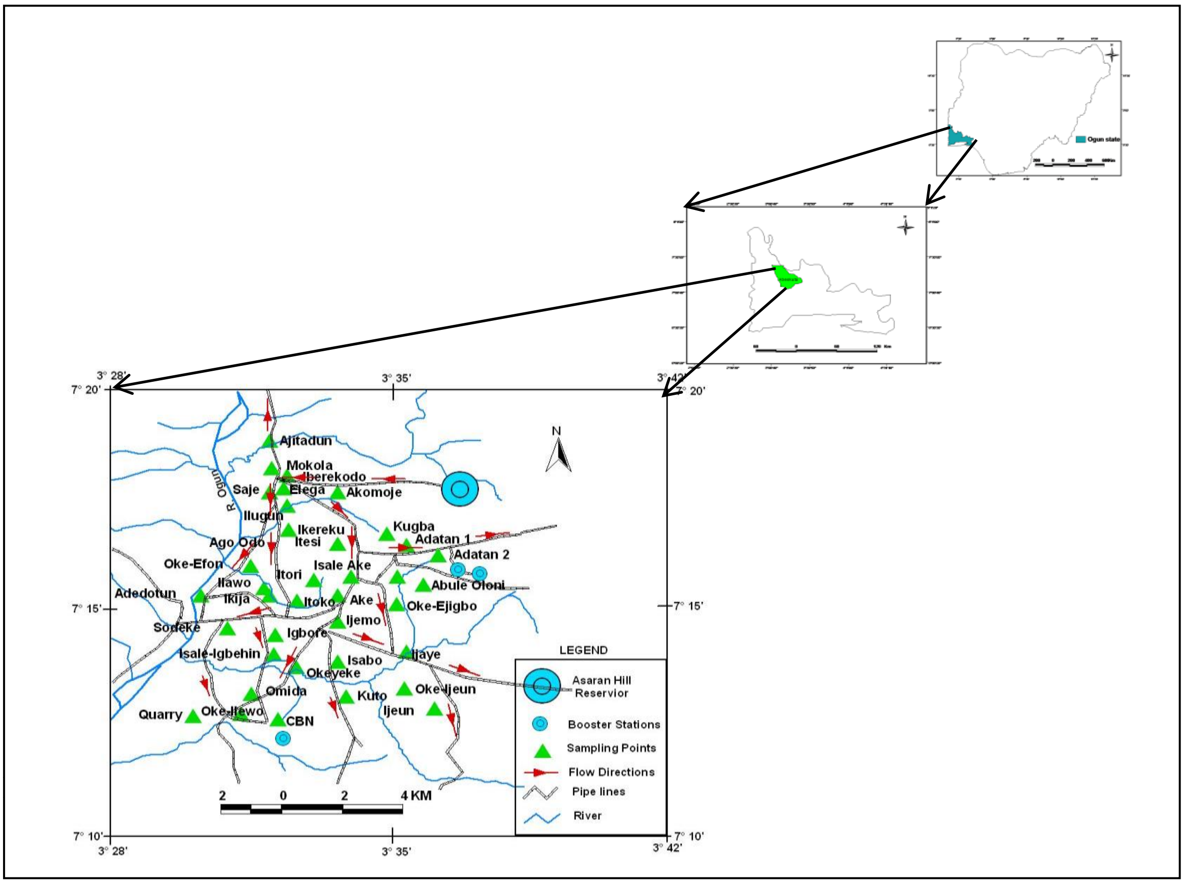
Abeokuta, the capital of Ogun State, Southwest Nigeria, (Figure 1) is situated within the rainforest belt of the tropics lying between latitude 7°06' and 7°13' North and longitude 3°15' and 3°25' East. It occupies a geographical area of 1256 sqkm with a population of about 1,950,860 inhabitants according to 2006 Nigerian population census. The city is about 100km north of Lagos and 80km Southwest of Ibadan, the Oyo State capital.

Water sample collection and analysis

Forty sampling locations (public taps) were randomly selected across Abeokuta using the purposive sampling method (Gledhill *et al.*, 2008; Adejuwon and Mbuk, 2011). A total of 80 water samples were collected from taps across the sampling locations during the rainy and dry season. The water samples were tested for the presence of physical and chemical parameters; pH, EC, TDS, total alkalinity, calcium, magnesium, sodium, potassium, chloride, nitrate, sulphate, bicarbonate, cadmium, lead, chromium and aluminium using standard methods.

Questionnaire distribution

The questionnaires were distributed across Abeokuta with the aid of a network distribution map of Abeokuta obtained from the Ogun State Water Corporation. The questionnaires were distributed using the stratified random sampling and interviewer administered method (Aderibigbe *et al.*, 2008). The information obtained ranged from the bio data of respondents to adequacy and frequency of water supply, water quality, effect of consumption on health of consumers among others. Standard measurements (Aderibigbe *et al.*, 2008), were described to respondents in other to estimate the volume of water used for various purposes. The questionnaires were analysed via descriptive statistics using SPSS 15.0; involving the use of percentages, frequencies and measure of central tendencies.



RESULTS AND DISCUSSION

The result of the physical and chemical analysis is presented in Tables 1 and 2. The result of pH during rainy and dry season ranged from 5.63 to 7.46 and 6.23 to 7.2 respectively, and recorded mean values of 7.16 and 6.66 respectively; both of which fell within the allowable limits of the Nigerian Standard for Drinking Water Quality (SON) 2007, the WHO drinking water standards 2006 and USEPA standards of 2012. However, the minimum value of 5.63 recorded during the rainy season was below the minimum allowable limit of 6.5 set by SON (2007), WHO (2013) and USEPA (2012). A pH of 5.63 indicates that the water sample collected is acidic. This decrease in pH values could be due to the exposure of water to carbon dioxide and increase in temperature (WHO, 2003 and Brian, 2014). Nonetheless, pH is a primary water quality standard and has no direct human impact (WHO, 2003; SON, 2007) as it is the case with chemical parameters; although Howard (2002) asserts that the pH of water is critical to chlorination. Howard (2002) states further that the effect of pH on chlorination (in the case of water treatment) is that high pH (alkaline) leads to increased chlorine reaction such that the chlorine concentration is expended on restoring the alkaline pH of the water to neutral state.

Electrical conductivity (EC) results indicated a range of values of 111 µS/cm to 202 µS/cm and 106 µS/cm to 178 µS/cm in both seasons and average values of 124.63 µS/cm and 139.7 µS/cm respectively and fell within the SON (2007) allowable limit of 1000 µS/cm. EC is a measure of the ability of water to conduct an electric current and is dependent on the concentration of ions in the water (Ballance, 1996). The result of total dissolved solids (TDS) ranged between 55 to 101 and 53 – 89 in both seasons and average values of 62.1 and 70.18 respectively fell within the SON (2007) and USEPA (2012) allowable limit of 500 mg/l. An elevated TDS concentration is not a health hazard, as TDS concentration is a secondary drinking water standard and is more of an aesthetic rather than a health hazard (SON, 2007; Orewole et al., 2007).

Total alkalinity, calcium and magnesium each recorded mean values of 8.5. 26.15 and 15.1 respectively during the rainy season and 8.23, 26.18 and 19.5 during the dry season; the range of values for the rainy season were 6 to 30, 10 to 36 and 12 to 32 respectively, while 6 to 11, 20 to 36 and 2 to 8 were recorded during the dry season. The mean values of total alkalinity recorded for both seasons fell within the allowable limit of 100 mg/l by W.H.O (2006). The alkalinity of water is simply the ability of water to neutralize acid. The total alkalinity of any water sample is the amount of strong acid needed to neutralize its alkalinity (Ballance, 1996). Ballance (1996) further established that the alkalinity of some waters is due to bicarbonates of calcium and magnesium. Calcium in the two seasons recorded values that were within the allowable limit of 50 mg/l (WHO, 2006; Orewole et al., 2007) for both seasons. However, the range of values of magnesium for both seasons was outrageously higher than the 0.2 mg/l set by SON (2007). Although magnesium and calcium are major contributors to water hardness, calcium and magnesium are essential elements needed in good quantity by the human body (Frantisek, 2003; WHO, 2009).There is no health-based drinking were standards for K (Nkono and Asubiojo, 1998).

Sodium, potassium and chloride recorded mean values of 5.23, 1.4 and 0.133 respectively during the rainy season and 4.25, 1.5 and 0.34 during the dry season; the range of values for the rainy season include 6 to 40, 0 to 6 and 0.009 to 0.223, while 2 to 8, 1 to 3 and 0.009 to 4.23 were recorded during the dry season. Nitrate recorded mean values of 15.98 and 17.05 for both seasons and a range of values of 12 to 43 and 7 to 28 respectively. The range of values for Sodium for the two seasons was within the maximum allowable limit of 200 mg/l set by SON (2007). Chloride and Nitrate values were within the allowable limits of 250 mg/l and 50 mg/l (SON, 2007) respectively. The health implication associated with high concentrations of NO_3, especially in young children, is the blue baby syndrome, which can cause death in the children (Orewole et al., 2007). Large concentrations of Chloride increase the corrosiveness of water and, in combination with sodium, give water a salty taste (Driscoll *et al.,* 2002).

Sulphate and aluminium each recorded mean values of 231.58 and 0.15 during the rainy season and 278.72 and 0.078 during the dry season; the range of values for the rainy season were 1.17 to 344.15 and 0.02 to 0.6, while 95.28 to 378.39 and 0.017 to 0.19 were recorded during the dry season. However, sulphate and aluminium values for both seasons were considerably higher than the 100mg/l (SON, 2007) and 250mg/l (USEPA, 2014). High sulphate concentrations, though not a significant health hazard, can cause scale formation and may be associated with a bitter taste in water that can have a laxative effect on humans and young livestock (Orewole et al., 2007; Barbooti *et al.,* 2010). The health implication of high aluminium intake is potential neuro-degenerative disorders (SON, 2007). The high occurrence of sulphate and aluminium could be attributed to the use of Aluminium Sulphate ($AlSO_4$) used as in water treatment (Srinivasan *et al.,* 1999). Bicarbonate, cadmium, lead and chromium were not detected in the water samples.

Responses from the Questionnaires

The responses from the questionnaire are presented in Tables 3 and 4. The bulk of the respondents (79%) were within the age range of 16 – 25 years, while 75% of them were students. This group constitutes young people in the post – primary as well as post – secondary level of education.

With 77% of the total respondents answering 'NO' to the adequacy of water supplied, it is very clear that the time that should be used in doing homework and after school studying is used in search of water from alternative sources. This would have a long term effect on the future productivity of the state, nation and the world as a whole because, this age group constitutes a section of the population that 'feeds' the labour force with manpower. Time wasted in search of water could be diverted to more creative things such as taking extra classes, learning a trade and other beneficial extra – curricular activities. This conforms to the findings of Aderibigbe et al. (2008) that other productive activities will probably be abandoned for fetching water, which will subsequently lead to less productivity, reduced earning power, hunger and possibly poverty.

51% of the respondents were females and 49% were males, that more of the respondents being females attest to the fact that females (women and girls) are more involved in the search for water to meet the water needs than males (UNICEF Nigeria, 2010, Osei-Asare, 2004, Amao and Omonona, 2010). A total 39% of the respondents reside in flats, 30% in face to face apartments, 16% in bungalows and 15% in single apartments.

68% of the respondents attested that the quality of the water supplied was unsatisfactory while the quantity of water supplied did not meet the water demand of 77% of the respondents, indicating two key water issues: quantity and quality. Gbadebo and Akinhanmi (2010) indicate that irregularity (inadequate quantity) remains the core problem of public water supply in Abeokuta metropolis. Inadequate quantity resulting in reliance on water from alternative sources (such as wells, boreholes, rivers and burst pipes) as a coping strategy has its consequences (Aderibigbe et al., 2008; Alabi – Aganaba and Osagbemi, 2005; Engelman and Leroy, 1993; Ajibade, 1999 and Rottier and Ince, 2003). However, poor coverage area is another problem that exists (Odjegba *et al.,* 2015).

CONCLUSION AND RECOMMENDATION

A sudden drop in pH along the distribution network is an indication of lapses in water distribution. If a drop in pH is due to the occurrence of CO_2 and increased temperature then the network pipe is probably exposed around the sampling point that recorded 5.63 pH. Hence, periodic infrastructural maintenance should be of top priority to the management of the Ogun State Water Corporation. Particular attention should be paid to the state of the distribution system and pipe leakages should be addressed promptly. High concentrations of sulphate and aluminium in the water samples call for caution in the use of chemicals in water treatment. Strict measures should be applied in dosing of chemicals, while personnel in charge of chemical applications in the water treatment plant should be adequately supervised.

Furthermore, attestation of majority of the respondents to poor quality of water supplied and inadequate quantity clearly unveils two potential consequences: incidence of water related diseases and loss of time/energy. Dependence on water from questionable alternative water supply sources can result in the prevalence of water related diseases (leading to diversion of funds for treatment), as well as the wasting of the quality time and energy in searching for water.

A large of the respondents predominantly, children and adult were involved in the sourcing and search for water, an issue that can undermine economic growth. Consequently, there is the need for water to be made available to every household at least 100m from the house so as to reduce the time and energy spent on searching for water.

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Table 1: Result of physical and chemical analysis for the rainy season

Parameter	Mean	Range	Standard Deviation	CV*	SON (2007)	WHO (2006)	USEPA (2012)
pH	7.16	5.63 – 7.46	0.28207	3.94	6.5 – 8.5	6.5 – 8.5	6.5 – 8.5
EC	124.63	111 – 202	13.88	11.14	1000 mg/l	-	-
TDS	62.1	55 – 101	6.96	11.21	500 mg/l	-	500mg/l
Total Alkalinity	8.5	6 – 30	4.57	53.76	-	100 mg/l	-
Calcium	26.15	10 – 36	4.80	18.36	-	-	-
Magnesium	15.1	6 – 40	6.78	44.90	0.2 mg/l	-	-
Sodium	5.23	2 – 11	2.52	48.18	200 mg/l	-	-
Potassium	1.4	0 – 6	1.06	75.71	-	-	-
Chloride	0.133	0.009 – 0.223	4.60	3458.65	250mg/l	-	250mg/l
Nitrate	15.98	12 – 43	0.04	0.25	50mg/l	50mg/l	10mg/l
Sulphate	231.58	1.17 – 344.15	72.24	31.19	100mg/l	-	250mg/l
Bicarbonate	--	-	-	-	-		-
Cadmium	-	-	-	-	0.003mg/l	0.003mg/l	0.005mg/l
Lead	-	-	-	-	0.01mg/l	0.01mg/l	0.015mg/l
Chromium	-	-	-	-	0.05mg/l	0.05mg/l	0.1mg/l
Aluminium	0.15	0.02 – 0.6	0.11	73.33	0.2mg/l	-	0.05mg/l to 0.2mg/l

***CV: Coefficient of Variation**

Table 2: Result of physical and chemical analysis for the dry season

Parameter	Mean	Range	Standard Deviation	CV*	SON (2007)	WHO (2006)	USEPA (2012)
pH	6.66	6.23 – 7.2	0.2364	3.55	6.5 – 8.5	6.5 – 8.5	6.5 – 8.5
EC	139.7	106 – 178	19.03	13.62	1000 mg/l	-	-
TDS	70.18	53 – 89	9.57	13.63	500 mg/l	-	500mg/l
Total Alkalinity	8.23	6 -11	1.69	20.53	-	100 mg/l	-
Calcium	26.18	20 – 36	4.85	18.53	-	-	-
Magnesium	19.5	12 – 32	4.14	21.23	0.2 mg/l	-	-
Sodium	4.25	2 – 8	1.55	36.47	200 mg/l	-	-
Potassium	1.5	1 – 3	0.60	40.00	-	-	-
Chloride	0.34	0.009 – 4.23	7.01	2061.76	250mg/l	-	250mg/l
Nitrate	17.05	7 – 28	0.77	4.62	50mg/l	50mg/l	10mg/l
Sulphate	278.72	95.28 – 378.39	56.02	20.10	100mg/l	-	250mg/l
Bicarbonate	--	-	-	-	-		-
Cadmium	-	-	-	-	0.003mg/l	0.003mg/l	0.005mg/l
Lead	-	-	-	-	0.01mg/l	0.01mg/l	0.015mg/l
Chromium	-	-	-	-	0.05mg/l	0.05mg/l	0.1mg/l
Aluminium	0.078	0.017 – 0.19	0.05	64.10	0.2mg/l	-	0.05mg/l to 0.2mg/l

***CV: Coefficient of Variation**

Table 3: Socio – demographic characteristic of respondents in the study area

Variables	Frequency	Percentage
Age Range		
6 -15	2	(1)
16 – 25	158	(79)
26 – 35	24	(12)
36 – 45	5	(3)
46 – 55	5	(3)
>56	3	(2)
Sex		
Male	98	(49)
Female	102	(51)
Occupation		
Civil servant	7	(4)
Private sector	22	(11)
Self – employed	6	(3)
Artisan	2	(1)
Unemployed	2	(1)
Retiree	2	(1)
Student	159	(79)
Household size		
Single member	82	(42)
Married couple	10	(5)
2 – 5 member	52	(26)
>5 member	54	(27)
House type		
Single apartment	29	(15)
Flat	77	(39)
Bungalow	31	(16)
Face to Face	60	(30)

Table 4: Water demand and quality in the study area

Variables	Frequency	Percentage
Water supply meets demand		
Yes	46	(23)
No	154	(77)
Water Quality		
Satisfactory	63	(32)
Unsatisfactory	136	(68)