



Rapid Assessment of the Water Chemistry of Public Water Supply in Abeokuta, South-West Nigeria

*¹ODJEGBA, EE; ¹BANKOLE, AO; ¹SADIQ, AY; ²BUSARI, IO; ¹LAYI-ADIGUN, BO

¹Department of Water Resources Management and Agrometeorology, Federal University of Agriculture, Abeokuta, Ogun State, Nigeria

²Department of Biological, Geological and Environmental Sciences, University of Bologna, Italy

*Corresponding Author Email: odjegbaee@funaab.edu.ng

Abstract: The study examined the water supply situation in Abeokuta, with emphasis on the quality of water distributed by the Ogun State Water Corporation from the treatment plant of the Abeokuta Water Scheme. Water samples were collected from standpipes (taps) across the city randomly selected using the stratified random sampling method and was analysed for physical and chemical parameters: pH, total dissolved solids (TDS), electrical conductivity (EC), total alkalinity, total hardness, calcium, magnesium, potassium, sodium, nitrate, bicarbonate, sulphate and chloride. The result of the physical and chemical parameters was subjected to statistical analyses using the multivariate t-test. The result of the treated water was further compared with the result of the analyses of raw water obtained from the source of water used in the treatment plant.

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Increased rural-urban migration, conditioned by the quest for greener pastures has continuously stretched the barely sufficient urban amenities – especially water supply. In low-income countries particularly in Sub-Saharan Africa, residents in urban areas mostly result to self-supply and communal water supply systems as coping strategy (Hadipuro *et al.*, 2013; Sutton and Butterworth, 2021). For instance, a World Health Organization 2019 report indicated that only 57% of the population in Sub-Saharan Africa had access to improved, fully functional, readily available, easily accessible and safe water supply (WHO, 2019). In the race towards SDG 2030, affordable, accessible

and safe water is still a challenge (Ahmad, 2017). In Nigeria, water is still not accessible to a large percentage of the population in adequate quantity and quality. A 2020 joint report of Nigeria's Federal Ministry of Water Resources, National Bureau of Statistics and United Nations Children's Fund (UNICEF) indicates that 68% of the country's population lacks access to basic water supply service. The provision of water supply for public consumption and use in Nigeria is the constitutional responsibility of the Federal, State and Local Governments (Balogun and Redina, 2019).

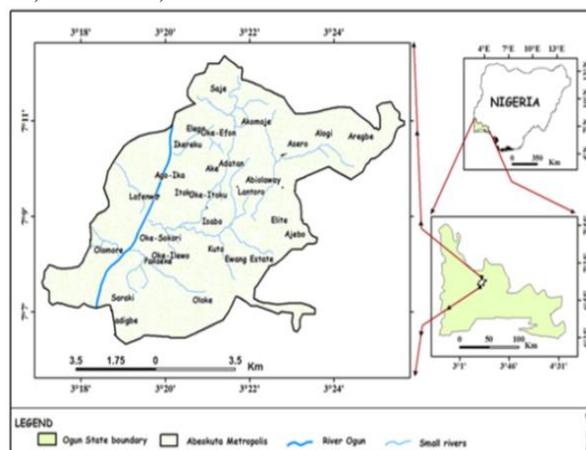


Fig 1: Map of Ogun State, Nigeria showing Abeokuta city. (Sadiq *et al.*, 2020)

*Corresponding Author Email: odjegbaee@funaab.edu.ng

All the 36 states including the Federal Capital Territory have Water Boards/Corporations or Public Utilities Boards that manage their public water utilities. Public utilities are functional across Nigeria; however, coverage and reliability are some of the many concerns (Akoteyon, 2019). Studies have also shown that water quality challenges have plagued public water systems (Akpor and Muchie, 2011, Odjegba *et al.*, 2015, Balogun *et al.*, 2017, Akoteyon, 2019). The focus of this study to assess the quality of public water supplied to Abeokuta city by the Ogun State Water Corporation and the effectiveness of the treatment process. Abeokuta is the capital of Ogun State. Public water supply is provided by the Ogun State Water Corporation through the Abeokuta Water Scheme. The source of water for the treatment plant at the Abeokuta Water Scheme is the Ogun River. Abeokuta city (Figure 1), lies between latitude $7^{\circ} 5' N$ and $7^{\circ} 20' N$ and longitude $3^{\circ} 17' E - 3^{\circ} 20' E$. It is easily accessible from Lagos, the industrial capital of Nigeria and the nation's major seaport.

The study area has a tropical climate, with distinct wet season (April-October) and dry season (November-March), and it is controlled by the prevailing south-west monsoon-wind reaching the land from the limit of Gulf of Guinea and the dry continental north - east wind (Harmattan) originating from the Sahara Desert. The wet season has two peak regimes, which are separated by the August break. The mean annual rainfall and temperature are about 1,270 mm and $28^{\circ}C$ respectively while the estimated mean annual potential evaporation is 1,100 mm.

MATERIALS AND METHOD

The Rapid Assessment of Drinking Water Quality (RADWQ) was used (Ince *et al.*, 2004). The sampling approach was used to select 40 sampling locations across Abeokuta city. Water samples were collected from public taps across the city. Water samples were analysed for physical and chemical parameters: pH, total dissolved solids (TDS), electrical conductivity (EC), total alkalinity, total hardness, calcium, magnesium, potassium, sodium, nitrate, bicarbonate, sulphate and chloride. The results of physical and chemical parameters for the tap water were compared with result of the analyses of raw water obtained from the source of water for treatment. This was done to ascertain the effectiveness of the water treatment process. Both results were further compared with the World Health Organisation (WHO), 2017 Guidelines for Drinking Water Quality. Result of the physical and chemical parameters was subjected to multivariate statistical analyses using *t* - test.

RESULTS AND DISCUSSION

The result of the physical and chemical parameters (Table 1) showed a pH range of 5.63 – 7.44 with a mean of 6.91 ± 0.36 . When compared with World Health Organisation (WHO) and Standards Organisation of Nigeria (SON) standards for drinking water quality (6.5 – 8.5), the pH values for 11 samples were found to be below 6.5, an indication that the water is acidic. Diverse factors are responsible for low pH in drinking water. Dirisu *et al.* (2016) reports that carbon-dioxide and sodium carbonate create low pH. Dirisu *et al.* (2016) stated further that organic matter decomposition leads to the release of carbon dioxide which combines with water to form carbonic acid, a weak acid that leads to low pH. However, pH as a primary standard parameter has no health implication (WHO, 2017). The EC and TDS values ranged from $106 \mu S/cm - 202 \mu S/cm$ with a mean of $132.10 \pm 18.23 \mu S/cm$, and between 53 mg/L and 101 mg/L with a mean of $66.07 \pm 9.19 mg/L$ respectively. The range of values for EC and TDS fell within the SON acceptable limit of 1000 $\mu S/cm$ and 500 mg/L respectively. EC is the measure of the capacity water to conduct electricity, while TDS is defined by the presence of inorganic salts and organic matter in water (Rusydi, 2018). EC has no direct human health impact, although, high concentrations could decrease the aesthetic value of water (Rahmanian *et al.*, 2015) Elevated TDS concentration may result in laxative or constipation effects (Meride and Ayenew, 2016). Total alkalinity and total hardness had values ranging from 6 mg/L – 30 mg/L with a mean of $8.34 \pm 3.50 mg/L$ and 16 mg/L – 66 mg/L with a mean of $43.39 \pm 7.24 mg/L$ respectively and they both fell within the allowable limit of 150 mg/L set by SON and 100 mg/L by WHO respectively. Consumption of water with high hardness value can lead to gastrointestinal irritation (Alam *et al.*, 2017). Alkalinity and hardness are collective used in predicting the corrosivity and scale formation of water in distribution networks (Boyd *et al.*, 2016). The results of sodium indicated that it had values ranging from 2 mg/L – 11 mg/L with a mean of $4.74 \pm 2.13 mg/L$, while that of Mg was between 6 mg/L – 40 mg/L with a mean of $17.30 \pm 6 mg/L$ respectively. Sodium ion values were below the maximum acceptable limit of 200 mg/L set by SON, while the values for magnesium were outrageously higher than the 0.2 mg/L and 0.4 mg/L set by SON and WHO respectively. Sodium is used for maintaining osmolarity, homeostasis and physiological functions in humans, though for hypertensive patients sodium concentration of 20 mg/L in water is recommended (Freije *et al.*, 2019). Although its values were very high, magnesium is an essential element needed in good quantity by the human body (Chellan and Sadler,

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2015). The recommended dietary amount of magnesium is 6 mg/kg per day (Gröber *et al.*, 2015). Therefore, for individuals with borderline magnesium deficiency, waterborne magnesium could make an

important contribution to their total intake. A lack of magnesium leads to a decrease in the concentration of intracellular potassium and an increase in calcium levels (Cunha *et al.*, 2012).

Table 1: Physical and chemical composition of the water samples

Parameters	Treated water			Standards	
	Range	Mean	Standard Deviation	(WHO, 2017)	SON (2007)
pH	5.63 – 7.44	6.91	0.36	6.5 – 8.5	6.5 – 8.5
EC	106 - 202	132.10	18.23	-	1000 mg/L
TDS	53 - 101	66.07	9.19	-	500 mg/L
Total alkalinity	6 - 30	8.34	3.50	100 mg/L	-
Total hardness	16 – 66	43.39	7.24	-	150 mg/L
Ca	10 - 36	26.37	4.80	50 mg/L	-
Na	6 – 40	4.74	6	-	200 mg/L
Mg	2 – 11	17.3	2.13	0.4 mg/L	0.2 mg/L
K	0 – 6	1.38	0.83	-	-
Cl	7 – 43	16.53	0.55	250 mg/L	250 mg/L
NO ₃	0.01 – 4.23	0.23	5.90	50 mg/L	50 mg/L
SO ₄	1.17 – 378.39	253.87	72.48	500 mg/L	100 mg/L

Calcium values ranged from 10 mg/L – 36 mg/L with a mean of 26.37 ± 4.80 mg/L while potassium values ranged from 0 mg/L – 6 mg/L with a mean of 1.38 ± 0.83 mg/L. Calcium deficiency in humans can cause rickets, reduced blood clotting, while elevated calcium levels can lead to cardiovascular diseases (Meride and Ayenew, 2016). The low values recorded for K may be due to the fact that regular sources of K ions in surface and ground water are absent in piped water (Orewole *et al.*, 2007); there is however, no health-based drinking water standards for K (Ling *et al.*, 2019; Arega, 2020). Results of anions indicated that bicarbonate was not detected in any of the water samples, while SO₄ recorded a range of values between 1.17 mg/L and 378.39 mg/L with a mean of 253.87 ± 72.48 mg/L. However, they were below the WHO limits of 500 mg/L. High sulphate concentrations 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). The high occurrence of sulphate is attributed to the Aluminium Sulphate (AlSO₄) used as a coagulant in water treatment. Very low concentrations were recorded for nitrate, with values ranging from 0.01 mg/L - 4.23 mg/L and a mean of 0.23 ± 0.55 mg/L. Chloride values ranged from 12 mg/L – 43 mg/L with a mean of 16.53 ± 5.90 mg/L. Nitrate and Chloride ions recorded values within the acceptable limits of 50 mg/L and 250 mg/L respectively (WHO, 2017). The health implication associated with high concentrations of NO₃, especially in young children, is the blue baby syndrome, which can cause death in the children (Meride and Ayenew, 2016).

Critical observation of the variation in the values of parameters analysed between the values obtained from the water sample collected at the water treatment plant and the various values obtained at the other sampling points, indicated 6 locations having pH values lower than that obtained at the treatment plant, which could be attributed to sulphur and amino acid compounds from human and animal excreta (Adekunle *et al.*, 2007). Also, total hardness values were high at four locations; could be attributed to a variety of dissolved polyvalent metallic ions, predominantly calcium and magnesium cations. Three locations had potassium values higher than that recorded at the treatment plant; however, K is important for human body functions like, blood pressure regulation and heart protection (Meride and Ayenew, 2016). Nitrate values for two locations were equally higher than that obtained at the water treatment plant. The major sources of nitrate pollution are domestic waste, industrial waste, sewage, sludge (Eddy and Ekop, 2007; Meride and Ayenew, 2016) which can only get into the distribution network through leaks in the pipes (Casillas *et al.*, 2015). Chloride values higher than that obtained at the treatment plant is attributed to the presence increased electrolytes (Adekunle *et al.*, 2007). The comparison between the result of raw and treated water is presented in Table 2. Seven out of the 13 parameters tested in the treated water were also tested in the raw water result. These include pH, EC, TDS, total hardness, calcium, magnesium, and chloride. The average raw water value for pH was 7.12, while that of treated water was 6.91. Raw water had an average EC value of 73.88 μ S/cm while that of the treated water was 132.10 μ S/cm. The result of total hardness indicated an average value of 19.93 mg/L for raw

water, while that of treated water was 43.39 mg/L. The average raw water value for calcium indicated an average value of 14 mg/L, while that of treated water was 26.37 mg/L. The average raw water value for

magnesium was 5.68 mg/L while that of treated water was 17.3 mg/L. The average raw water value for chloride was 31.25 mg/L while that of treated water was 16.53 mg/L.

Table 2: Comparison of values of raw and treated water

Parameters	Raw water		Treated water		Standards	
	Range	Average	Range	Average	WHO	SON
pH	7.01-7.39	7.12	5.63 – 7.44	6.91	6.5 – 8.5	6.5 – 8.5
EC	25.2 – 142.9	73.88	106 - 202	132.10	-	1000 mg/L
TDS	10.2 - 90	32.98	53 - 101	66.07	-	500 mg/L
Total alkalinity	-	-	6 - 30	8.34	100 mg/L	-
Total hardness	8 – 42	19.93	16 – 66	43.39	-	150 mg/L
Ca	4 - 23	14.00	10 - 36	26.37	50 mg/L	-
Na	-	-	6 – 40	4.74	-	200 mg/L
Mg	1 - 19	5.68	2 – 11	17.3	0.4 mg/L	0.2 mg/L
K	-	-	0 – 6	1.38	-	-
Cl	18 - 48	31.25	7 – 43	16.53	250 mg/L	250 mg/L
NO ₃	-	-	0.01 – 4.23	0.23	50 mg/L	50 mg/L
SO ₄	-	-	1.17 – 378.39	253.87	500 mg/L	100 mg/L

Except for pH, all the other six parameters (EC, TDS, total hardness, calcium, magnesium, and chloride) had their average raw water values lower than that of the treated water. The average pH value for the raw water at 7.12, which is almost neutral to alkaline, agrees with the report of Jaji *et al.* (2007). The fact that the average values for the other six parameters were higher for the treated water than the raw water can be attributed to the addition of water treatment chemicals such as calcium hypochlorite and aluminium chloride in the water treatment process. The result of the statistical analyses indicated that at $p \leq 0.05$, the water samples is adjudged to have met the required Standards Organisation of Nigeria (SON)/WHO standards and is therefore fit for consumption.

Conclusion: The study assessed the quality of the pipe distributed water supplied to Abeokuta city and the effectiveness of the water treatment process. Except for magnesium, all other parameters were within the acceptable limits of the water quality standards used. However, a drop in pH from the value obtained at the treatment plant while some other parameters experienced increment was observed. It is therefore imperative to note that these variations can only be due to the entrance of foreign matter into the distribution network at some point away from the treatment plant.

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