Physico-Chemical Quality Of Drinking Water From Various Sources In Abia State, Nigeria

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ABSTRACT
The majority of Nigerians lack access to a safe drinking water source, making sustainable and equitable access to safe drinking water a challenge. The current study was designed to evaluate the physicochemical quality of drinking water from various sources in 24 randomly selected communities throughout Abia State, Nigeria. These communities were selected from 8 Local Government Areas within the 3 senatorial zones of Abia State. Using sterile universal containers, water samples were collected from the major drinking water sources in the selected communities. On-site evaluation of the pH, electrical conductivity (EC), total dissolved solids (TDS) and temperature of the water samples was carried out using a HI9813-6 pH/EC/TDS/Temperature meter. The pH values of the water samples from all sampled communities ranged between 4.1 and 5.9, and the acidic pH levels of the water samples were not within the Nigerian Industrial Standard's (NIS) approved range of 6.5 - 8.5. Furthermore, the water sources in the selected communities were found to have ambient temperatures ranging from 25.8 - 31.8°C. The average electrical conductivity (0.04 µS/cm) and total dissolved solids (36.4 mg/L) of water samples from all senatorial zones studied were both within acceptable limits of 1000 µS/cm and 500 mg/L respectively. Although the other parameters (temperature, EC and TDS) evaluated in this study were within acceptable limits for drinking water physicochemical quality, this study emphasizes the importance of effective water treatment, safe distribution to households, and continuous monitoring and quality assessment of drinking water sources in Nigeria.

Keyword: Drinking water; Abia water, boreholes, tube wells, total dissolved solid

INTRODUCTION

Water is essential for human existence, and its importance for individual and national health and the well-being cannot be underestimated. Water that is safe and easily accessible is important for public health, whether it is used for drinking, domestic use, food production, or recreation. Improved water supply and sanitation, as well as better management of water resources, can boost countries' economic growth and contribute significantly to poverty reduction (Ince et al., 2010, WHO, 2022).

Despite a generous endowment of both surface and underground water capable of meeting demand, only 19% of Nigeria's population has access to safe drinking water. This is due to Nigeria's economic water scarcity. This economic water scarcity reflects the country's inability to protect and/or use water sources for socioeconomic development and environmental sustainability (Jones, 2019).

Tube wells, boreholes, and dug wells are some of the most common sources of drinking water in Nigeria. The sources of drinking water may change with the seasons. During the dry season, for example, it is more common to obtain drinking water from tanker trucks and water vendors, from bottles, or from the surface. During the rainy season, however, rainwater collection is far more popular (Sasu, 2022). Both surface water and groundwater are used as water sources in Nigerian urban areas. Treatment plants, distribution systems, elevated tanks, piped systems, house connections, yard taps, and public standpipes are all required in urban systems. Water supplies in semi-urban areas are primarily based on mechanized boreholes and overhead tanks, as well as piping with yard taps and public standpipes. Boreholes with hand pumps and protected wells are the most common rural water sources, though rainwater harvesting and natural springs are also used (Ince et al., 2010). The state and local governments bear primary responsibility for municipal and domestic water supply in Nigeria. To meet these targets, however, the federal government frequently intervenes to increase access (WHO, 2015).

The vast majority of health-related water quality issues are caused by microbial (bacterial, viral, protozoan, or other biological) contamination. However, chemical contamination of water resources may cause a significant number of serious health concerns. Water's chemical and physical qualities may influence consumer acceptance. Turbidity, color, taste, and odor, whether natural or man-made, influence consumer perceptions and behavior (WHO, 1997; WHO, 2011). Studies evaluating the quality of drinking water in Nigeria are on a continuum (Oyelakin et al., 2020; Ibrahim et al., 2020; Olowe et al., 2016; Foka et al., 2018; Ince et al., 2010). This is critical for highlighting the dangers of unsafe drinking water that are available and proliferating in both urban and rural communities, as well as boosting consumer confidence in safe water sources.

This current study was undertaken to assess the physico-chemical quality of drinking water from several sources in 24 randomly-selected communities across Abia State, Nigeria. The water sources included in this study were bore-holes, rivers, springs, streams, lakes and rain water collected in reservoirs.

MATERIALS AND METHODS

Study location

Water samples were collected from 24 randomly-selected communities in 8 Local Government Areas (LGAs) within the 3 senatorial zones of Abia State. The senatorial zones are Abia North (Arochukwu and Ohafia LGAs), Abia Central (Osisioma, Umuahia North and Umuahia South LGAs), and Abia South (Aba North, Aba South and Obingwa LGAs).

Sample Collection

Using sterile universal containers, water samples were collected from the major drinking water sources in the selected communities. The drinking water sources include: rivers, streams, springs, lakes, bore-holes, and rain water reservoirs.

Determination of pH, Electrical Conductivity, Total Dissolved Solids, and Temperature of the Water Samples

On-site evaluation of the pH, electrical conductivity (EC), total dissolved solids (TDS) and temperature of the water samples was carried out using a 4-parameter hand-held digital portable HI9813-6 pH/EC/TDS/Temperature meter (Hanna Instruments, USA). The probe was inserted into the water sample and the readings for pH, EC, TDS and temperature were observed.

Measurements of each sample were made in duplicates and the mean values were recorded.

Data Analysis

Data were presented as mean values and standard deviation (SD) of mean.

RESULTS

The drinking water sources of the various sample locations, which include communities, LGAs, and senatorial zones, are presented in Table 1. The results of on-site physicochemical analysis of water samples collected from selected communities in Abia State, Nigeria, are shown in Table 2. Table 3 provides a summary of the overall results of the on-site physico-chemical analysis of water samples collected from various locations within the three senatorial zones under consideration.

The pH values of the water samples from all sampled communities ranged between 4.1 and 5.9. Water samples from Eziukwu, a community in Aba South LGA and Abia South senatorial zone had the lowest mean pH of 4.1. The highest mean pH of 5.9 was recorded for Umuda Isingwu of Umuahia South LGA and Abia Central senatorial zone (Table 2).

Water samples from Abia South senatorial zone were the most acidic of the three senatorial zones sampled, with the lowest mean pH value of 4.49. The overall mean pH of the water samples across all senatorial zones was found to be 5.1 (Table 3).

Other physico-chemical properties studied include electrical conductivity (EC), total dissolved solids (TDS) and temperature. The water sources in the selected communities were found to have ambient temperatures ranging from 25.8 to 31.8^{o}C (Table 2). The water samples from all senatorial zones of Abia State under study had an average electrical conductivity of 0.04 µS/cm and total dissolved solids of 36.4 mg/L (Table 3).

Table 1: Various Sample Locations and their Drinking Water Sources

Senatorial zones	LGAs	Communities	Drinking Water Sources
Abia North	Arochukwu	Obichie Ihechiowa	Spring, stream, borehole, lake, rain water
		Ebuma Ututu	Spring, stream
		Amuvi Arochukwu	Stream, borehole
	Ohafia	Okagwe/Elu Ohafia	Spring, stream, borehole, rain water
		Amaeke-Etiti Abiriba	Stream, borehole, rain water
		Agbaja Nkporo	Stream, borehole, rain water
Abia Central	Osisioma	Obekwesu	Stream, borehole
		Umuobo	River, borehole
		Ekearo	Stream, borehole
	Umuahia North	Apumini	Stream, borehole
		Olokoro	Stream, borehole
		Ekenobizi	Stream, borehole
	Umuahia South	Umuda Isingwu	Stream, borehole
		Ibeku	Borehole rain water
		Isieke	Stream, borehole
Abia South	Aba North	Umuola	Borehole
		Ehere	River, borehole
		Osusu	Borehole
	Aba South	Eziukwu	Borehole
		Umuobasi	Borehole

	Okporala	Borehole
Obingwa	Obikabia	Borehole
	Mgboko	Stream, borehole
	Ohanze	Stream, borehole

Table 2: Physico-chemical Analysis of Water Samples from the Selected Communities of Abia State, Nigeria

Communities	**pH**		**EC** (µS/cm)		**TDS** (mg/L)		**T(ºC)**	
	mean	**SD**	**Mean**	**SD**	**mean**	**SD**	**mean**	**SD**
Obichie Ihechiowa	5.7	0.26	0.04	0.04	38.17	39.50	26.9	0.45
Ebuma Ututu	5.8	0.10	0.10	0.08	79.50	54.50	26.6	0.65
Amuvi Arochukwu	4.7	0.64	0.01	0.01	19.67	5.56	30.1	2.22
Okagwe/Elu Ohafia	4.8	0.44	0.01	0.01	5.77	7.47	31.5	3.51
Amaeke-Etiti Abiriba	5.6	1.08	0.07	0.05	44.00	58.90	27.4	0.84
Agbaja Nkporo	5.5	0.53	0.01	0.01	15.40	6.42	26.6	1.15
Obekwesu	4.8	0.85	0.01	0.01	9.25	1.30	28.0	0.20
Umuobo	5.5	0.35	0.01	0.01	17.50	6.50	26.6	0.40
Ekearo	5.7	0.55	0.02	0.01	8.75	2.77	26.6	0.20
Apumini	5.4	0.87	0.03	0.01	41.25	19.25	27.0	0.70
Olokoro	4.9	0.65	0.05	0.04	39.00	33.00	27.0	0.20
Ekenobizi	5.7	0.30	0.01	0.01	14.50	7.50	27.7	0.40
Umuda Isingwu	5.9	0.29	0.07	0.03	58.00	27.30	28.0	0.25
Ibeku	5.2	0.70	0.02	0.01	16.50	14.50	27.1	0.71
Isieke	5.8	0.80	0.01	0.01	11.50	9.50	26.3	0.10
Umuola	4.5	0.05	0.02	0.00	10.00	0.00	26.0	0.00
Ehere	4.6	0.60	0.07	0.08	58.50	53.44	26.9	1.21
Osusu	4.2	0.00	0.05	0.00	41.50	3.00	25.8	0.00
Eziukwu	4.1	0.48	0.26	0.21	213.00	118.36	27.5	1.23
Umuobasi	4.4	0.00	0.00	0.00	11.00	0.00	28.3	0.00
Okporala	4.2	0.00	0.03	0.00	31.00	0.00	27.5	0.00
Obikabia	4.8	0.00	0.00	0.00	6.00	0.00	26.6	0.00
Mgboko	4.8	0.55	0.04	0.02	32.50	9.50	26.8	0.00
Ohanze	5.1	0.60	0.03	0.01	10.00	8.00	31.8	3.95

Table 3: Summary of On-site Physico-chemical Analysis of Water Samples from Different locations of the Study Area

Parameters	**Approved Standard†**	**Abia North**		**Abia Central**		**Abia South**		**Total**	
		Mean	**SD**	**Mean**	**SD**	**Mean**	**SD**	**Mean**	**SD**
pH	6.5 -8.5	5.12	0.950	5.45	0.737	4.49	0.550	5.1	0.79
EC (µS/cm)	1000	0.03	0.053	0.03	0.030	0.09	0.140	0.04	0.08
TDS (mg/L)	500 mg/L	24.58	39.858	25.97	24.527	70.97	99.087	36.4	60.68
Temperature (ºC)	Ambient	28.66	4.521	27.16	0.820	27.44	2.260	28.18	2.65

†(NIS, 2015)

DISCUSSION

Sustainable Development Goal target 6.1 calls for universal and equitable access to safe and affordable drinking water. This sustainable and equitable access to safe drinking water remains a challenge in Nigeria, with the majority of Nigerians lacking access to a safe drinking water source. Although it is estimated that approximately 70% of Nigerians have access to basic water services, more than half of these water sources are contaminated, and the average Nigerian only has access to nine litres of water per day for general use. At the current rate, the country will miss the SDG targets for people's access to water unless all stakeholders show a strong commitment and take appropriate action (UNICEF, 2021; WHO, 2022).

The health concerns associated with drinking water chemical constituents stem from their ability to cause adverse health effects after prolonged exposure. Aside from massive accidental contamination of a drinking-water supply, some water chemical constituents can cause health problems with a single exposure. Chemicals from pesticides and fertilizers that end up in water may increase the risk of cancer and reproductive problems, as well as impair eye, liver, kidney, and other body functions. Furthermore, in many of these incidents, the water becomes unfit to drink due to an unacceptable taste, odor, and appearance (WHO, 2011; WQA, 2022). The WHO has recommended on-site testing for some water physicochemical quality indicators that may change rapidly during transport and storage. The organization also stated that on-site testing is important for assessing parameters where laboratory support is lacking or where transportation issues would make conventional sampling and analysis difficult or impossible (WHO, 1997).

The physicochemical quality of water sources in selected communities in Abia State, Nigeria, was assessed in terms of pH, total dissolved solids, electrical conductivity, and temperature, and the results are discussed below.

pH

The pH of the water samples from all of the communities studied ranged between 4.1 and 5.9. Water samples from Abia South senatorial zone were the most acidic of the three senatorial zones sampled, with the lowest mean pH value of 4.49. Water samples from Eziukwu, a community in Aba South LGA, and Abia South senatorial zone had the lowest mean pH of 4.1. The acidic pH of the water samples (mean pH value: 5.1) were not within the Nigerian Industrial Standard (NIS) approved range of 6.5 - 8.5 (NIS, 2015) (see Tables 2 and 3).

pH is a measurement of the activity of the hydrogen atom, which is a good representation of the acidity or alkalinity of the water. The standard pH scale ranges from 0 to 14, with 7 representing neutral. pH values ranging from 6.5 to 7.5 are considered near neutral, values less than 6.5 are considered acidic, and values greater than 7.5 are classified as basic or alkaline. Although pH has no direct impact on consumers, it is one of the most important operational water quality parameters because a change in the pH of water can have a variety of consequences. Because the pH of water is related to its potential corrosivity, water with a pH less than 6.5 can leach metal ions such as iron, manganese, copper, lead, and zinc from plumbing fixtures and pipes. As a result, this can be quite dangerous (WHO, 2011; SDWF, 2017; Clune and Cravotta, 2019).

There are assumptions that the low pH values found in the majority of wells and springs are due to carbon dioxide saturation in the groundwater, or that the physicochemical nature of the soil at sampling sites influences the final pH of the samples (Yasin et al., 2015; Byamukama et al, 1999).

Ince et al. (2010) provided a general overview of water quality in Nigeria. They stated that, while groundwater quality in Nigeria is better than surface water in terms of health criteria, much of the groundwater is corrosive, and some areas have iron, nitrate, or fluoride concentrations above WHO guideline values. They recommended that due to the corrosive nature of Nigerian groundwater, water supply equipment be made of stainless steel or plastic (Ince et al., 2010).

The World Health Organization (WHO) has not proposed a health-based guideline value for pH. However, the WHO recommends that the pH of water entering the distribution system be controlled to minimize corrosion of water mains and pipes in household water systems, as failure to minimize corrosion can result in contamination of drinking water and adverse effects on its taste and appearance (WHO, 2011).

Total Dissolved Solids

Total dissolved solids (TDS) are regarded as indicators of the general nature of water quality (Yasin et al., 2015). TDS is the term used to describe the inorganic salts and trace amounts of organic matter found in water. The main constituents are usually calcium, magnesium, sodium, and potassium cations, as well as carbonates, hydrogen carbonates, chlorides, sulfates, and nitrate anions. TDS in water supplies is typically derived from natural sources, sewage, urban and agricultural runoff, and industrial wastewater. TDS concentrations in natural sources have been found to range from less than 30 mg/L to as much as 6000 mg/L, depending on mineral solubilities in different geological regions (WHO, 2003).

In this study, the average total dissolved solids concentration in water samples from all senatorial zones of Abia State, Nigeria, was determined to be 36.4 mg/L. This value was within the acceptable range of <500 mg/L, according to the NIS guidelines (NIS, 2015) (Table 3).

TDS levels in drinking water may have an impact on its palatability and acceptability among consumers. The presence of high levels of TDS in water may be objectionable to consumers due to the resulting taste and excessive scaling in water pipes, heaters, boilers, and household appliances. Water with extremely low TDS concentrations may also be unpalatable to consumers due to its flat and insipid taste. Although the WHO has not proposed a health-based guideline value for TDS, the organization states that the palatability of water with a total dissolved solids (TDS) level of less than about 600 mg/L is generally considered to be good, as drinking water becomes significantly and increasingly unpalatable at TDS levels greater than about 1000 mg/L (WHO, 2003; WHO, 2011).

While TDS may be considered only an aesthetic and technical factor, a high concentration of TDS indicates that harmful contaminants such as iron, manganese, sulfate, bromide, and arsenic may be present in the water. This is especially true when excessive dissolved solids are introduced into the water as a result of human pollution, such as runoff and wastewater discharges (SDWF, 2017). In areas where the TDS content of the water supply is extremely high, the WHO recommends that the individual constituents be identified and the local public health authorities consulted (WHO, 2003).

Electrical conductivity

Electrical conductivity (or conductivity), which is the ability of water to to allow the passage of electric current, can be considered a proxy indicator of dissolved solids (a conductivity of 1400 S/cm is equivalent to 1000 g/l of dissolved solids) and is thus an indicator of the taste and salinity of the water. Electrical conductivity (EC) is measured on a scale from 0 to 50,000 uS/cm. Microsiemens per centimeter (uS/cm) is the unit of measurement for EC. The conductivity of freshwater is typically between 0 and 1,500 uS/cm, while that of seawater is around 50,000 uS/cm (MRCCC, 2007; Ince et al., 2010).

Pure water is a good insulator rather than a good conductor of electric current. An increase in ion concentration enhances water's electrical conductivity. In general, EC is determined by the amount of dissolved solids in water (Meride and Ayenew, 2016).

In the current study, water samples from the three senatorial zones of Abia State, Nigeria, had an average EC value of 0.04 µS/cm (Table 3). According to the NIS guidelines, this EC value is within acceptable limits of <1000 µS/cm (NIS, 2015).

Although high conductivity values pose little direct health risk, they are associated with poor-tasting water as well as customer dissatisfaction and complaints. Conductivity changes over time or high conductivity values can both indicate that the water has become contaminated (e.g. from saline intrusion, faecal pollution, or nitrate pollution). The contamination can cause corrosion in rising mains and pipes over time (Ince et al., 2010).

Temperature

The various water sources in the selected communities of Abia State, Nigeria evaluated in this current study were found to have ambient temperatures ranging from 25.8 to 31.8^{o}C (Table 2). The temperature of the water samples were within ambient temperatures for the region and considered normal.

Temperature has an impact on the physical, chemical, microbiological, and biochemical properties of water. This, in turn, has an impact on treatment efficacy and water quality, and can lead to issues with health-based contaminants and/or aesthetics (Health Canada, 2021). In terms of taste and consumer acceptance, cool water is generally preferred over warm water. Temperature has an effect on the levels of a variety of other inorganic constituents and chemical contaminants that may affect taste. High water temperatures promote the growth of microorganisms and may exacerbate problems with taste, odor, color, and corrosion (WHO, 2011).

CONCLUSION

The assessment revealed that the water sources in the study areas had low pH that were not within recommended range. More research is needed to determine the causes of the acidic water. Although a majority of the parameters evaluated in this study (temperature, electrical conductivity and total dissolved solids) were within acceptable limits for physicochemical quality of drinking water, this study emphasizes the need for continuous monitoring and quality assessment of drinking water sources in Nigeria.

CONFLICT OF INTEREST

The authors declare no conflict of interests.

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