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PHYSICOCHEMICAL ASSESSMENT OF A LOCAL DRINKING WATER SOURCE IN NGUGO, IKEDURU LOCAL GOVERNMENT AREA, IMO STATE, NIGERIA

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ABSTRACT
Population growth, industrialization and agriculture are increasingly and adversely impacting on freshwater bodies, thereby putting a strain on available drinking water sources especially in the rural areas. Physicochemical parameters of Mbaa Stream, Ngugo, Ikeduru Local Government Area of Imo State was assessed to determine its suitability for drinking and other domestic uses. The study was carried in 3 stations between April and June 2017 using standard analytical methods. A total of 9 parameters (pH, temperature, total dissolved solids, dissolved oxygen, biochemical oxygen demand, nitrate, alkalinity and electrical conductivity) were assessed. The values recorded were as follows: pH (5.4 - 5.9), temperature (27.0 - 31.0 ºC), total dissolved solids (4.8 - 24.7 mg/l), electrical conductivity (10.5 - 49.0 µS/cm), dissolved oxygen (6.6 - 8.0 mg/l), biochemical oxygen demand (2.4 - 3.5 mg/l), nitrate (3.7- 32.0 mg/l) and alkalinity (4.1 and 28.0 mg/l). The study showed that all the parameters assessed were within acceptable limits except pH. The physicochemical parameters were influenced by geology, season and anthropogenic factors. Based on pH and health issues associated with prolong intake of acidic waters, the water is not fit for human consumption.

KEYWORDS: *Stream, Physicochemical, Health, Drinking water*

INTRODUCTION
Due to population growth, increasing industrialization, agriculture and their associated adverse impacts on freshwater bodies, enormous pressure is put on available drinking water sources particularly in the rural areas. For the sustenance of life on earth, water is very necessary and in satisfactory condition (adequate, safe and accessible) too for all (WHO, 2017). The quality of water is of great concern because it is directly associated with human welfare (Singh *et al*., 2014). Regrettably, most water users are not aware of the health risks associated with the exposure to certain contaminants in water (Ostan *et al.,* 2007). The suitability of the water for any purpose is more important than the sources of water for that purpose (Hyeladi and Nwagilari, 2014). Common sources of drinking water in the rural areas include surfacewater (lakes, rivers, streams, springs, etc.) and

groundwater (boreholes and wells) (McMurry and Fay, 2004; Mendine, 2005). The streams, rivers, reservoirs and lakes which serve as sources of drinking water are also used as sites for liquid and solid wastes disposal (Ibiene *et al*., 2012; Anyanwu and Ihediwah, 2015). Water can be a threat to public health when the chemical constituents or pollutants exceed certain standards or thresholds (Celiker *et al*., 2014). In order to have a safe drinking water, there is need that the quality of the water be assessed and monitored (Bekele *et al*., 2019). Drinking water qualities are assessed by comparing the water samples with drinking water quality guidelines or standards (Anyanwu and Emeka, 2019; Anyanwu and Nwachukwu, 2020). These guidelines and standards provide for the protection of human health by ensuring that clean and safe water is available for human consumption (WHO, 2017). Mbaa stream is the main source of water for the domestic and social needs of Ngugo people especially during the dry season. A number of studies have been carried out on Otamiri River where Mbaa discharges (Iwuoha *et al*., 2012; Adebayo *et al.,* 2016; Obiyor *et al*., 2017) but none on this very important drinking water source. Hence, the aim of this study is to assess aspects of the physicochemical properties of Mbaa Stream, Ngugo to determine its suitability for drinking and other domestic uses.

MATERIALS AND METHODS

Study Area and Sampling Stations

Ngugo is a community in Ikeduru Local Government Area of Imo State, South-Eastern Nigeria (Fig. 1). It is located in Latitude 5°35′0″N and Longitude 7°9′0″E. Mbaa stream is the major natural source of drinking water in Ngugo. It took its source from Mbano, flow through Obollo community in the northern part of Ngugo and through the boundary between Ngugo and Ikembara (East of Ngugo) and discharges into Otamiri River, Owerri, Imo State. Three stations were selected along the stream for this study. Minimal activities were observed in the stream because of the onset of wet season. Station A was upstream and reference station; women were observed processing African Breadfruit (*Treculia africana Decne*) and extraction of water drinking for and other domestic uses. Station B was midstream and about 300 metres downstream of station A. Station B witnessed the highest level of human activities which includes bathing, swimming, washing and extraction of water for drinking and other domestic uses. Station C was about 250 metres downstream of station B; no activities were observed during the study.

Samples Collection and Analyses

Water samples were collected from Mbaa Stream, Ngugo, monthly between April and June 2017. The samples were collected with 1-litre water sampler, stored in sterilized 1litre plastic bottles and then taken to the laboratory for analysis. Some physicochemical parameters – pH and Temperature (Jenway 550 Portable pH meter), Total Dissolved Solids, and electrical conductivity (HACH CO. 150 TDS/Conductivity meter) were determined *in-situ* while Dissolved Oxygen, Biochemical Oxygen Demand, Nitrate, Alkalinity were determined in the laboratory using standards methods described by American Public Health Association (APHA) (2005).

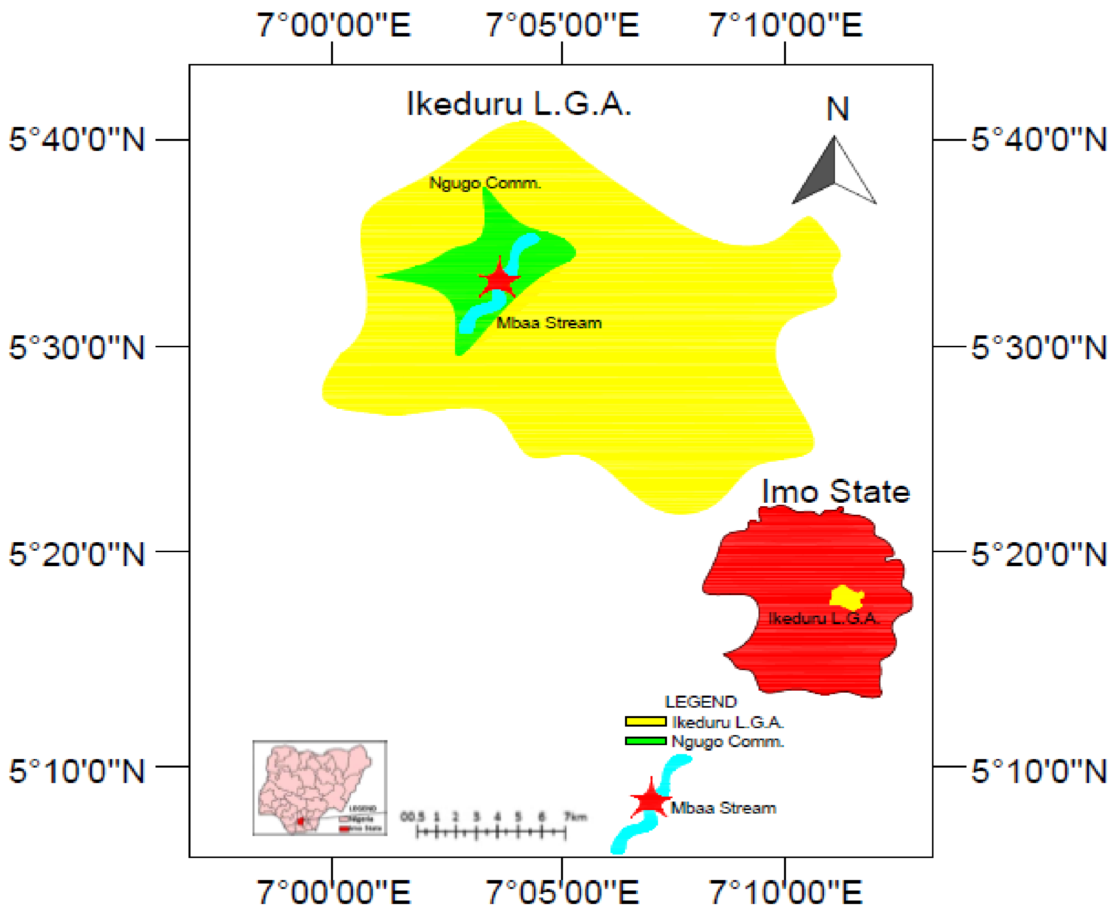

Fig. 1: Map of Ngugo Community, Ikeduru LGA, Imo State, Nigeria showing the

Data Analyses

The data were summarised using Descriptive Statistic Package of Microsoft Excel while one-way ANOVA was used to test for statistical differences among the stations and Tukey's pairwise comparisons test was performed to determine the location of significant difference ($P<0.05$).

RESULTS

The result of the physiochemical parameters are summarised in Table 1. The pH was acidic with values ranging between 5.4 and 5.9. The lowest and highest values were recorded in stations B and C respectively in April 2017 before the onset of wet season. There was no significant difference ($P>0.05$) in the pH values. The pH values were lower than the acceptable range set by SON (2015).

Temperature values ranged between 27.0 and 31.0℃. The lowest and highest values were recorded in stations C and A respectively both in May and June 2017. Station A was significantly different ($P<0.05$) from stations B and C. SON (2015) recommended ambient temperature for drinking water. Total dissolved solids (TDS) ranged between 4.8 and 24.7 mg/l. The lowest and highest were recorded in May and April 2017 in station C. High TDS values were recorded in all the stations in April 2017 before the onset of the wet season.

There was no significant difference (P>0.05) and all the values were lower than 500 mg/l set by SON (2015). Electrical conductivity (EC) followed the same trend with TDS; ranging between 10.5 and 49.0 mg/l. The lowest and highest were recorded in stations B and C respectively in May and April 2017. High EC values were recorded in all the stations in April 2017 before the onset of the wet season. There was no significant difference (P>0.05) and all the values were lower than 1000 mg/l set by SON (2015). Dissolved Oxygen (DO) values ranged between 6.6 and 8.0 mg/l. The lowest and highest were recorded in stations C and A respectively in May and June 2017. High DO values were recorded in all the stations in June 2017 and there was no significant difference (P>0.05). Though there is no guidance value for DO in drinking water in Nigeria; the values recorded were high. Biochemical Oxygen Demand (BOD) values ranged from 2.4 to 3.5 mg/l. The lowest and highest were recorded in station B in June and May 2017. There was no significant difference (P>0.05) in the values of BOD among the stations. There is also no guidance value for BOD in drinking water in Nigeria. The nitrate values ranged from 3.7 to 32.0 mg/l. The lowest value was recorded in station B in June 2017 while the highest was recorded in station C in April 2017. Station C was significantly (P<0.05) higher than the others. All the values were within the limit (50 mg/l) set by SON (2015) though values recorded in April and May 2017 for station C were close to the limit. Alkalinity values ranged between 4.1 and 28.0 mg/l. The lowest value was recorded in station C in June 2017 while the highest values were recorded in stations A and B in April 2017. Relatively low values were recorded in station C throughout the study. There was no significant (P>0.05) difference among the stations. The mean values were low though there is no guidance value for alkalinity in drinking water in Nigeria.

Table 1: Summary of the physicochemical Parameters evaluated in Mbaa Stream, Ngugo

Parameters	**Station A**	**Station B**	**Station C**	P-Value	**SON 2015**
pH	5.8±0.03 (5.7 – 5.8)	5.7±0.13 (5.4 – 5.8)	5.8±0.09 (5.6 – 5.9)	P>0.05	6.5 – 8.5
Temperature (ºC)	30.7±0.33[a] (30.0 – 31.0)	28.3±0.33[b] (28.0 – 29.0)	27.3±0.33[b] (27.0 – 28.0)	P<0.05	Ambient
TDS (mg/l)	11.5±6.18 (5.2 – 23.9)	11.5±5.93 (5.4 – 23.4)	11.5±6.36 (4.8 – 27.4)	P>0.05	500
EC (µs/cm)	23.2±12.38 (10.7 – 48.0)	22.9±12.05 (10.5 – 47.0)	24.2±12.42 (11.0 – 49.0)	P>0.05	1000
DO (mg/l)	7.3±0.38 (6.7 – 8.0)	7.1±0.19 (6.9 – 7.5)	7.1±0.40 (6.6 – 7.9)	P>0.05	-
BOD (mg/l)	3.1±0.09 (3.0 – 3.3)	3.1±0.34 (2.4 – 3.5)	3.1±0.15 (2.9 – 3.4)	P>0.05	-
Nitrate (mg/l)	4.9±0.24[a] (4.4 – 5.2)	4.3±0.33[a] (3.7 – 4.8)	21.5±6.89[b] (8.5 – 32.0)	P<0.05	50
Alkalinity (mg/l)	19.7±6.44 (7.0 – 28.0)	18.5±5.80 (8.0 – 28.0)	4.5±0.21 (4.1 – 4.8)	P>0.05	-

DISCUSSION

The pH values were low and acidic which could be attributed both geogenic (Nwankwo and Igboekwe 2011; Anyanwu and Umeham 2020a) and anthropogenic influences. Umunnakwe and Nnaji (2015) and Adebayo *et al.* (2016) recorded pH values of similar ranges in Nworie and Otamiri Rivers respectively in Owerri, southeast Nigeria. The lowest value recorded in station B in April 2017 before the onset of rains could be attributed to anthropogenic impact. Higher anthropogenic activities are associated with dry season because of increased use of waterbodies for most domestic activities during the period (Anyanwu and Umeham, 2020a &b). Radojevic and Bashkin (1999) associated extremes of pH with water pollution. Continuous consumption of water with low pH could lead to a condition known as acidosis (Ogundipe and Obinna, 2008), affect mucous membrane (Narasimha *et al*. 2011). Some of the health problems associated with drinking of acidic water includes vomiting, diarrhea, kidney disease, liver disease, stomach cramps, and nausea. Others include corrosion of teeth and bone problems due no retention of calcium (Reid, 2019).

The water temperatures were moderate and were influenced by season and sampling times. Studies have shown that air temperatures strongly influence the water temperatures (Park *et al*., 2016; Hassan *et al*., 2017; Gossiaux *et al*., 2019). Station A was significantly higher which could be attributed to the openness of the station. Cloud cover and abundant vegetation cover contribute to lower air temperatures (Falayi and Rabiu, 2011). Temperature has a significant effect on the flavour of water; optimum taste is obtained at a temperature that is 20 to 25 ºC cooler than body temperature (Osaka Municipal Waterworks Bureau, 2011). Cool water is more satisfying than warm water and increased water temperature boosts the growth of microorganisms and may also impact on taste, odour and colour (WHO, 2017). Total dissolved solids and electrical conductivity were low and within the respective limits. High values were recorded for both parameters in all the stations in April 2017. This could be attributed to season; higher evapotranspiration rates associated with high atmospheric temperatures and low precipitation results in concentration and higher values in the dry season (Atobatele and Olutona, 2013; Etesin *et al*., 2013; Houssou *et al*., 2017).

There is no guidance value for dissolved oxygen in drinking water in Nigeria; the high values recorded indicated that the water was well aerated. High DO values were recorded in all the stations in June 2017; turbulences and increased flow rate of river water during the wet season could be responsible (Ugwu and Wakawa, 2012).

Biochemical Oxygen Demand (BOD) values were low indicating low organic pollution. The more organic materials present in the water, the higher the BOD values will be (Omer, 2019). There is also no guidance value for BOD in drinking water in Nigeria. The lowest value recorded in station B in June 2017 could be due to dilution by rainwater (Atobatele and Olutona, 2013, Etesin *et al*., 2013, Houssou *et al*., 2017) while the highest recorded in the same station in May 2017 could be due to anthropogenic impacts and the effect of early rains. After a period of dryness (dry season), a rainfall event can greatly alter the physicochemical characteristics of a water body by bringing substantial amounts of pollutants through runoffs (Park *et al*., 2011; Zhou *et al*., 2015; Corbari *et al*., 2016; Zhang *et al*., 2016).

All the nitrate values were within the limit; though values recorded in April and May 2017 for station C were close to the limit. This cannot be explained because no activities were observed in the station during the study but anthropogenic and seasonal influences cannot be ruled out. Chapman and Kimstach (1996) reported that nitrate values is often less than 1 mg/l in surface waters but could increase to 5 mg/l due to anthropogenic influences. The lowest value was recorded in station B in June 2017 could be attributed to rainfall dilution. High concentrations of nitrate in surface water can degrade the water quality through the stimulation of the rapid growth of the algae (Tchobanoglous *et al*., 2003). Nitrate level in excess of 50 mg/L in drinking water results in immediate and serious health threat to infants (WHO, 2017). A disease condition known as blue baby or methemoglobinemia will occur when the nitrate ions react with blood hemoglobin and thereby reduce the blood's ability to hold oxygen (WHO, 2017).

Alkalinity values were low though there is no guidance value for alkalinity in drinking water in Nigeria. This is an indication of low buffering capacity of the stream to pH change (Omer, 2019). The lowest value recorded in station C in June 2017 could be due to dilution while the highest values recorded in stations A and B in April 2017 could be due concentration arising from high temperature and low precipitation (Atobatele and Olutona, 2013, Etesin *et al*., 2013, Houssou *et al*., 2017).

CONCLUSION

All the physicochemical parameters evaluated for the purpose of determining the suitability of Mbaa stream water for drinking were within acceptable limits except pH. The prolonged consumption of acidic waters by a large population and its health consequences is of great public health implication that cannot be quantified and neglected, hence enlightenment programme is recommended while use of alternative sources of drinking water like boreholes are encouraged. The physicochemical parameters were influenced by geology, season and anthropogenic factors.

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