An Appraisal of borehole Water Quality Index in Selected Areas within Owerri Metropolis, Imo State, Southeastern Nigeria.

Abstract

Borehole water is one of the major sources of potable water in most developing countries of the world. Therefore, it becomes imperative to evaluate the continuing portability of theses sources of water to the populace. The present study was undertaken to appraise the water quality of selected boreholes in Owerri Metropolis using the water quality index (WQI) method. Samples were collected from five different locations under stringent protocols. The water samples were analyzed for selected physicochemical properties and compared with WHO permissible limits and American Public Health Association. Results showed that the assayed parameters were within WHO permissible limits except Turbidity in Locations 2, 3 and 4. Water quality index ranged from 24.91 to 70.06. This study revealed that the investigated borehole waters are mostly portable and can be consumed. Nonetheless, the sources identified to be of poor quality should be treated before consumption.

Keywords: Water, Quality, Owerri, WHO.

Introduction

Water is one of the most abundant and essential resources of man, and occupies about 70% of earth's surface [1]. About 97% of this volume of earth's surface water is contained in the oceans, 21% in polar ice and glaciers, 0.3-0.8% underground, 0.009% in inland freshwaters such as lakes, while 0.00009% is contained in rivers [2]. According to [3], more than 97% of earth's water is in the oceans and ice caps, and glaciers account for another 2%. Also, the ocean comprises 97%, while 3% of the earth's water is fresh [4].

Water in its pure state is acclaimed key to health and the general contention is that water is more basic than all other essential things to life [5]. Man requires a regular and accessible supply of water which forms a major component of the protoplasm and provides an essential requirement for vital physiological and biochemical processes [2]. Man can go without food for twenty eight days, but only three days without water, and two third of a person's water consumption per day is through food while one third is obtained through drinking [6].

Basic household water requirements have been suggested at 50 litres per person per day excluding water to gardens [1]. [3] reported that since the water we drink provides for cell function and its volume requirements, the decrease in our daily water intake affects the efficiency of cells and other body activities. In addition to human consumption and health requirements, water is also needed in agriculture, industrial, recreational and other purposes. Water is also considered a purifier in most religions [7]. Though all these needs are important, water for human consumption and sanitation is considered to be of greater social and economic importance since health of the population influences all other activities. According to [8], environmental water usage includes artificial wet lands, artificial lakes intended to create wildlife habitat, fish ladders around dams and water releases from reservoirs to help fish spawn.

Apart from the essential role played by water in supporting human life, it also has, if polluted, a great potential for transmitting a wide variety of diseases. According to [9] in most developing countries like Nigeria where dangerous and highly toxic industrial and domestic wastes are disposed of by dumping them on the earth; into rivers and streams with total disregard for aquatic lives and rural dwellers, water becomes an important medium for the transmission of enteric diseases in most communities. Poisonous chemicals are known to percolate the layers of the earth and terminate in ground waters thereby constituting public health hazards [1]. For instance, a recent study by [11] reported that In Owerri West Local Government Area of Imo State, certain anthropogenic activity like the improper waste disposal can contribute to ground water pollution. This area suffers from non-provision of potable water supply. The inhabitants are therefore depending largely on private borehole water supply which is of doubtful quality [11].

World’s population cannot be sustained without access to safe water [10]. The water supply systems and drinking water inaccessibility in the developing countries is a global concern which calls for immediate action. Currently, 884 million people in the world especially in developing regions still do not get their drinking water from improved sources [12]. Providing quality drinking water to all citizens of the world who are deprived access to water will serve as the breaking point of poverty alleviation in most developing countries especially in Nigeria, where substantial amount of national budgets are used to treat preventable waterborne diseases [12].

Drinking contaminated water can cause various diseases such as typhoid, dysentery and diarrhea [13]. Accordingly, 2.2 million people die each year from diseases related to drinking contaminated water [13]. Diarrhea alone claims the lives of nearly 6,000 children a day in developing countries of Africa. According to the World Health Organization [14], drinking water is not available to 75-80 percent of the citizens living in rural areas of many developing countries like Nigeria. It is also observed that one out of every four persons in the world especially in developing countries suffer from some type of water borne disease or the other. These observations readily highlight the magnitude of the world water problem [15].

The water quality index approach essentially seeks to turn complex water quality data into information understandable and useable by the public [16]. Although, the concept of water quality index is not yet widely used in Nigeria, [17] has used it to assess the level of pollution of River Niger while [18] also applied it to determine the susceptibility of water resources to atmospheric pollutant due to petroleum exploitation.

However, there appears to be paucity of information on the water quality index of borehole water in Imo state. Hence, the present study aimed at appraising the Water Quality Index of selected borehole water collected from various locations in Owerri, Imo state.

Description of Study Area

Study area is Owerri Metropolis. Its metropolitan class informed its selection (Okere, Abu and Ndukwu, 2018). A typical representation of an urban area (Ogwueleka, 2009, Okere *et al.*, 2018) lying on coordinates 5°28'3.59''N, 7°02'06.0E on a land spanning over 550 km2 and comprising of three Local Government areas of the twenty-seven Local Government Areas in Imo State, namely Owerri West, Owerri municipal and Owerri North (Okere *et al.*, 2018). It is the commercial, entertainment and administrative Centre of Imo State. According to National Population Commission of Nigeria (2007) in the extraordinary gazette of 2006 census dated May 15, 2007, the population was 401,873 with female and male population of 190,575 and 211,298 respectively (NPC, 2007; Okere *et al.*, 2018). Owerri is bordered by the Otamiri River to the east and the Nworie River to the south. Its mean annual temperature ranges from 25 - 30°C and mean annual rainfall range of 2500-3500mm.

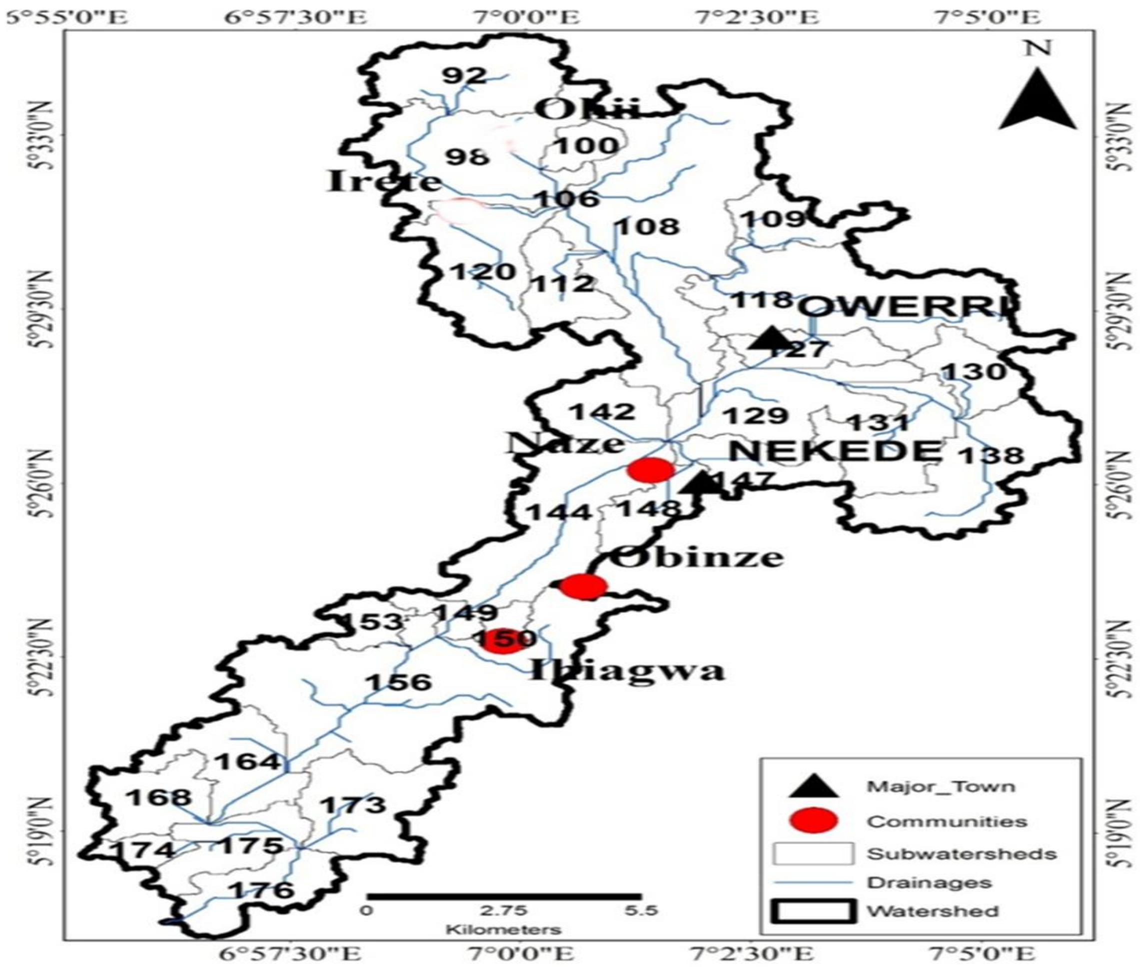

Figure 1: Map of the study area

Sample Collection

Water samples were collected from five different locations within Nekede, Ihiagwa, and Obinze (**Figure 1**). Samples were collected aseptically using a pre-cleaned 2 liter plastic polyethylene bottles, coded properly and transported to the laboratory for further analysis. All sampling protocols such as preservation and transportation of water samples were congruent with the standard prescribed by the American Public Health Association (APHA, 2002).

Sampling and Analysis

Samples were subjected to physiochemical analysis of the following parameters: pH, DO, TSS, TDS, BOD, Calcium, Hardness, Magnesium, Alkalinity, Nitrate, Sulphate, Total chlorine, Manganese, Turbidity, Conductivity following the procedure described by [18]. Result obtained from the analysis was compared with WHO permissible limits for drinking water and The Nigerian Standard for Drinking Water Quality.

Estimation of Water Quality Index from the Various Locations

The WQI approach as formulated by Horton (1965) is an index used in assessing the quality of water to the public [19]. It is an unambiguous tool that enables the integration of the water parameters, which are deemed important to the quality of the water accordingly. In this study, the WQI, which is calculated using the weighted arithmetic index method [20] was adopted to determine the portability of borehole water collected from the study areas.

Water Quality Index Calculation

The Water Quality Index (WQI) was calculated using the Weighted Arithmetic Index method. The quality rating scale for each parameter was calculated by using this expression:

$$WQI = \Sigma\, QnWn / \Sigma\, Wn$$

Where,

Qn = Quality rating of nth water quality parameter.

Wn = Unit weight of nth water quality parameter.

Quality Rating (Qn)

The quality rating (q_n) is calculated using the expression given in Equation (2).

$$Q_n = [(V_n - V_{id}) / (S_n - V_{id})] \times 100$$

Where,

V_n = Estimated value of nth water quality parameter at a given sample location.

V_{id} = Ideal value for nth parameter in pure water. V_{id} for pH = 7 and 0 for all other parameters.

S_n = Standard permissible value of nth water quality parameter.

Unit Weight (W_n)

The unit weight (W_n) is calculated using the expression given in Equation (3).

$$W_n = K / S_n$$

Where,

S_n = Standard permissible value of nth water quality parameter.

K = Constant of proportionality and it is calculated by using the expression given in Equation (4).

$$k = [1 / (\Sigma\, 1/ S_n = 1, 2 \ldots n)]$$

Table 1: Water quality rating

Water quality index level	Water Quality status	Grade
0-25	Excellent water Quality	A
26-50	Good water Quality	B
51-75	Poor water Quality	C
76-100	Very poor water Quality	D
>100	Unsuitable for Drinking	E

Source: (Brown *et al*, 1972; Chatterjee & Raziuddin, 2007; Imneisi & Aydin, 2016; Tyagi, Sharma, Singh, & Dobhal, 2013).

Table 2: Drinking water quality standards for selected parameters according to WHO and NIS

Parameters	Agency	Standards	Relative weight (Wn)
Turbidity	WHO	5.0	0.1931124
pH (mg/L)	WHO	6.5-8.5	0.12069525
TDS (mg/L)	WHO	500	0.001931124
EC	WHO	500	0.001931124
TH (mg/L)	WHO	500	0.001931124
Mg (mg/L)	NIS	20	0.0482781
Ca (mg/L)	WHO	75	0.01287416
Nitrates	WHO	50	0.01931124
Sulphate	NIS	100	0.00965562
Phosphate	WHO	5	0.1931124
Chloride	WHO	250	0.003862248
DO	WHO	>5	0.1931124
BOD	WHO	5	0.1931124

Source: Ibrahim *et al.* (2020)

Results and Discussion

Physicochemical properties of water samples collected from sampling locations is presented in Table 1. Results obtained showed that the pH values of water samples ranged between 6.6 to 8.4

across the locations which were below the WHO permissible limit of 6.5- 8.5. This implied that the water samples were normal with respect to pH values from all the locations under study. According to [3], pH is an important water quality parameter used to assess status of water because of its significance on health and environment. A pH value of less than 6.5 inhibits the human body from the intake of vitamins and minerals and when it exceeds 8.5 the water becomes caustic and irritating [10]. The results obtained in this study are in consonant with those reported by [20-23].

Results obtained for DO for all locations ranged from 4.90 to 0.6 and within the minimum required DO permissible concentrations in drinking water as set by WHO. This is in agreement with findings of [24] but contrasts with the opinion of [25].

The Total Dissolved Solids (TDS) provide a rough indication of the overall suitability of water. The palatability of water with a total dissolved solids (TDS) level of less than about 500 mg/L is generally considered to be good. Drinking water becomes significantly and increasingly unsafe at TDS levels greater than about 250 mg/l (WHO, 2011). The total dissolved solids (TDS) of all water samples were within WHO standard of 250 mg/L.

Also, the results obtained for BOD from locations all fell below the maximum permissible limit stipulated by WHO. BOD is a function of the amount of organic matter present in a particular water environment [3]. Hence the value of BOD is an indication of the amount of oxygen required by microorganisms present in the water environment to decompose the organic matter in it [27]. Consequently, a higher BOD value would indicate a higher amount of polluting biodegradables in water which invariably would require higher amounts of DO for its stabilization [16].

Calcium content of water samples ranged from 2.9 to 0.88 mg/l. similarly, the values were below 75 mg/L recommended by WHO. Calcium rich water is recommendable for drinking several times a day because it has the capacity to provide supplemental calcium and aids adequate hydration, however, it has an inhibitory effect on parathyroid hormone secretion and bone resorption causing stunted growth [28]. [23] and [20] also reported on the ability of excess calcium concentrations to retard growth. The presence of calcium and magnesium in groundwater is linked to the leaching of geologic materials such as limestone, dolomites, gypsum and anhydrites; although calcium ions are also derived from cation exchange process [29].

Total hardness in water is primarily due to the excess of Ca, Mg and Fe salts [30]. It is an important water quality parameter whether the water is intended for domestic, industrial or agricultural purpose. Hard water has been linked to, in addition to impacts stated by [31], have tendency to influence mortality, in particular, cardiovascular mortality in addition to reproductive failure, cancer and Alzheimer's disease [21]. Total hardness recorded for this study in all locations lie within the permissible limits of 500 mg/L stipulated by WHO. These results are consistent with similar studies [32].

Magnesium, mg/l, Alkalinity , Nitrate mg/l, Sulphate, mg/l , Total chlorine, mg/l , Manganese, mg/l values across the locations were below WHO permissible limits of 500, 250, 100, 50, 100, 250 and 0.2 mg/L respectively. Sulphate values observed fall below the WHO stipulated level of 200 mg/l. High levels of sulphate lead to dehydration and diarrhea especially in children [22]. The presence of sulphate in drinking-water can cause noticeable taste and very high levels might cause a laxative effect in unaccustomed consumers [33].

Nitrate was detected in the groundwater sample, but they were detected in traces in rainwater samples. Natural level of nitrate in groundwater is increased by municipal and industrial wastewater including leachate from sewage sludge disposal [13] and sanitary landfills. High nitrate concentrations have detrimental effects on infants less than 3.6 months of age. Nitrate toxicity comes from the body's natural breakdown of nitrate to nitrite. This leads to "blue baby disease" which threatens the oxygen carrying capacity of the blood around the body [17]. Nitrate is an essential ingredient of plant nutrition. It is, however regarded as an indicator of pollution in public water supply [12]. The findings are in agreement with the works of [33; 11; 21].

Turbidity in water refers to its degree of cloudiness or clarity. It relates to the ability of water to allow or impede the penetration of light due to the scattering effect of suspended particulate matter in the water. This suspended particulate matter may include clay, silt, fine organic and inorganic matter, or microorganisms [34]. For groundwater supplies, if turbidity is greater than 1 NTU, it is important to determine whether there is a potential risk for such water to cause health problems. Consequently, ground waters with turbidity greater than 1 NTU should be sampled for bacteria and nitrate (World Health Organization, 2017). The WHO standard for turbidity concerning portability of water is a value of not more than 5 NTU. The turbidity from L1 and L5 (3.55 and 1.78 NTU) was within WHO standard of 5NTU. However, the turbidity values from L2 (9.43), L3 (6.31) and L4 (10.58) were above the WHO standard. Turbidity in water is caused by suspended particles or colloidal matter that obstructs light transmission through the water (WHO, 2012). It may be caused by inorganic or organic matter or a combination of the two. High turbidity values observed could be an indication of possible sources of microbial contamination (WHO, 2012). Results obtained for turbidity in groundwater by this study is in agreement with [34]. Conductivity of the water samples ranged from 24.7 to 3.7.

Table 3. Physicochemical Analysis of Water from Different Locations In Owerri.

Parameters	**L1**	**L2**	**L3**	**L4**	**L5**	**WHO**
pH	7.1	8.4	7.9	6.6	6.9	8.5
DO (mg/l)	4.90	0.6	2.9	2.9	3.1	5
TSS (mg/l)	113	199	78	91	112	250
TDS mg/l	10.21	8.48	3.72	13.45	57.01	250
BOD	1.8	0.7	1.5	1.3	0.6	5
Calcium, mg/l	2.9	1.89	0.88	1.82	0.99	75
Hardness	1.82	0.39	0.81	1.03	0.04	500
Magnesium, mg/l	0.1	0.00	0.03	0.05	0.10	250
Alkalinity	99	83	101	21	71	100
Nitrate mg/l	85.3	77.7	44	16	33.7	50
Sulphate, mg/l	432.4	457.1	499.8	501.3	218.9	100
Total chlorine, mg/l	0.33	0.43	0.15	0.31	0.27	250
Manganese, mg/l	0.01	0.11	0.08	0.03	0.05	0.2
Turbidity	3.55	9.43	6.31	10.58	1.78	5
Conductivity	24.7	19.29	8.9	3.7	16.9	100

LEGEND: WHO= World Health Organisation

Summary of calculated water indices (WQI) from all the study locations is shown in Table 3. Results obtained indicated that WQI for location L1 fall within 0-25 water quality rating suggesting that the water the location is “excellent water quality. Water quality from location 2 fall within 26-50 which implies “Good water quality”. However, locations L3 and L4 recorded values within the range of 51-75 indicating that water from these sources are “poor water quality”, while location 5 recorded “Good water quality”. The high concentrations for Turbidity could be responsible for the higher WQI obtained for locations L3 and L4. This is in consonant with the report of [35].

Table 4. Summary of water quality status based on computed WQI from all the locations

Locations	WQI Values	Grade	Remarks
L1	24.91	A	Excellent water Quality
L2	47.11	B	Good water Quality
L3	70.06	C	Poor water Quality
L4	69.81	C	Poor water Quality
L5	43.12	B	Good water Quality

Conclusion

An appraisal of water quality index from selected boreholes in Owerri was carried in this study. Physicochemical parameters were analyzed and compared with WHO permissible limits. All parameters assayed were within WHO permissible limits except for turbidity at locations 2, 3 and 4 that were above WHO limit. Water quality index from the various locations showed that the quality of borehole water from the locations ranged from poor quality to excellent water quality. Anthropogenic activities within these areas should be monitored to avoid further contamination of the boreholes through runoff. The bacteriological analysis of water from these sources should be carried out to ascertain the bacterial load of these water sources.

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