Assessment of Groundwater Quality in Isiala-Ngwa North L.G.A of Abia State, Nigeria

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Abstract
This research work sought to assess the quality of selected groundwater samples from Isiala Ngwa North LGA of Abia State, using the water quality index (WQI) technique. Analysis of ten (10) water samples from hand dug wells was carried out for their physio-chemical properties. The parameters used for calculating the water quality index include the following: pH, hardness, total dissolved solid, calcium, fluoride, iron, potassium, sulphate, nitrate and carbonate. High levels of nitrite and pH were observed as clear evidence of physical and chemical pollution. Low pH values of 2.92 - 6.49 were obtained from water samples which were below 6.5-8.5 as recommended by WHO. Similarly, high nitrite concentrations of 3.02mg/L - 4.22mg/L were observed which were again higher than WHO acceptable limits of 3.0mg/L. It is expected that increased and/or continued combined environmental interventions, through public health education by community based health workers, awareness and sensitization campaigns on the sustainable use of inorganic fertilizer may improve groundwater integrity. Therefore the researchers recommend that government should also install more water filtration plants to provide safe drinking water for all in the area, sewer drains should be kept away from water supply drains to avoid waste water leaching in ground water and that regular monitoring of ground water quality should be practiced in all areas.

Keywords: *groundwater, water quality index, portability, physico - chemical, parameters.*

1. Introduction

Water is an essential natural resource for sustainability of life on earth. Humans may survive for several weeks without food, but barely few days without water because constant supply of water is needed to replenish the fluids lost through normal physiological activities, such as respiration, perspiration, and urination, (Bai and Lung, 2005). Though the hydrosphere is estimated to contain about 1.38 billion Km^3, only about 2.5% of the water, existing as fresh water in rivers, streams springs and aquifers, is available for human use; the remaining 97.5% is locked up in seas and oceans (Tebbut, 2003; Itah and Akpan, 2006). The geological constraints limit accessibility of many human communities to water that is adequate in terms of quantity, quality and sustainability.

Lack of adequate supply of potable water is a critical challenge in developing countries such as Nigeria. Potable water, also called drinking water in reference to its intended use, is defined as water which is fit for consumption by humans and other animals (Afobede and Oladejo, 2003). The usual source of drinking water is the streams, rivers, wells and boreholes which are mostly untreated and associated with various health risks (Cabelli, 2003). Paucity of infrastructure for effective treatment and distribution of water accounts for the incidence of high morbidity and mortality rate associated with water borne diseases in developing countries

(Droppo *et al.*, 2009). One of the targets of the millennium development goals (MDG) in terms of healthy living for the masses can be achieved through the supply of safe and convenient water (Smith et al., 2007). The quality of water influences the health status of any populace, hence, analysis of water for physical, biological and chemical properties including trace element contents is very important for public health studies.

2. Materials and Methods

Data for the study was generated from primary source. Data from the primary source include the result of laboratory analysis and the instrumentation that was carried out on collected samples to determine quality parameters. Groundwater samples were obtained from 10 locations. The physical properties examined include pH, electric conductivity, total dissolved solid while the chemical properties include; nitrogen oxide (NO_2), manganese (Mn), hardness, total suspended solid, zinc (Zn), iron (Fe), copper (Cu), alkalinity, turbidity and colour. The properties and methods of analysis are presented in Table 1. The description of water samples collected from HDWs in 10 communities are presented in Table 2 and the values of physical and chemical properties of water sample in Isiala Ngwa North are presented in Table 4.

Table 1: Water quality properties, methods of determination and equipment.

S/N	Properties	Equipment/Method
1.	pH	pH meter
2.	EC	EC meter
3.	Total Dissolved Salt (TDS)	TDS meter
4.	Turbidity	Turbidity meter
5.	Total Suspended Solids (TSS)	Quantitative analysis
6.	Alkalinity	Titration
7.	Hardness	Titration
8.	Colour	Colorimeter
9.	Copper (Cu)	Spectrophotometer
10.	Nitrogen oxide (NO_2)	Spectrophotometer
11.	Manganese (Mn)	Spectrophotometer
12.	Zinc (Zn)	Spectrophotometer
13.	Iron (Fe)	Spectrophotometer

Table 2: Description of Water samples collected from HDWs in 10 communities of Isiala-Ngwa North

S/N	Hand Dug Wells Location	Wells Location
1.	HDW 1	Amasa-Ntigha (Umuekpe)
2.	HDW 2	Nsulu (Umuosu)
3.	HDW 3	Nsulu (Ezial-Nsulu)
4.	HDW 4	Amapu-Ntigha (Umuobia)
5.	HDW 5	Amasa-Ntigha (Egbelu)
6.	HDW 6	Amapu-Ntigha (Umunka)
7.	HDW 7	Ihie (Umuode)
8.	HDW 8	Ihie (Amaogwugwu)
9.	HDW 9	Umuoha (Amapu)
10.	HDW 10	Ama-Asa (Ohuhu)

2.1 Sample Collection

The samples were taken to the laboratory for relevant physio-chemical analyses. The longitude, latitude and elevation of all the sampling locations were also recorded using a Global Positioning System (GPS). The static water level, total depth and water column of each hand dug well were equally measured using meter tape. The water samples were in turn analyzed for thirteen major parameters.

2.2 Physio-Chemical Analysis

The analysis of various physio-chemical parameters analyzed namely pH, total alkalinity, chlorides, sulphate, nitrate, total hardness, calcium, magnesium, electrical conductivity, dissolved oxygen, biochemical oxygen demand, total dissolved solids and total suspended solids were carried. The results were then matched and compared with WHO standards.

pH of water

The pH of pure water refers to the measure of hydrogen ions concentration in water. It ranges from 0 to 14. In general, water with a pH of 7 is considered neutral while lower than 7 is referred to as acidic and a pH greater than 7 is known as basic. Normally, water pH ranges from 6 to 8.5. It is noticed that water with low pH tends to be toxic and with high degree of pH it is turned into bitter taste.

Electrical Conductivity (EC)

Pure water is not a good conductor of electric current rather a good insulator. Increase in ions concentration enhances the electrical conductivity of water. Generally, the amount of dissolved solids in water determines the electrical conductivity. Electrical conductivity (EC) actually measures the ionic process of a solution that enables it to transmit current. According to WHO standards EC value should not exceeded 400 µS/cm

Total Dissolved Solids (TDS)

Water has the ability to dissolve a wide range of inorganic and some organic minerals or salts such as potassium, calcium, sodium, bicarbonates, chlorides, magnesium, sulfates etc. These minerals produced unwanted taste and diluted color in appearance of water. There is no agreement that has been developed on negative or positive effects of water that exceeds the WHO standard limit of 1,000 ppm. Total dissolved solids (TDS) in drinking water originates in many ways from sewage to urban industrial wastewater etc. Therefore, TDS test is considered a means to determine the general quality of the water.

Hardness

Hard water is characterized with high mineral contents that are usually not harmful for humans. It is often measured as calcium carbonate ($CaCO_3$) because it consist mainly calcium and carbonates the most dissolved ions in hard water. According to World Health Organization (WHO) hardness of water should be 500 mg/l.

Alkalinity

Alkalinity is the presence of one or more ions in water including hydroxides, carbonates and bicarbonates. It can be defined as the capacity to neutralize acid. Moderate concentration of alkalinity is desirable in most water supplies to stable the corrosive effects of acidity. However, excessive quantities may cause a number of problems. The WHO standards pegged the alkalinity only in terms of total dissolved solids (TDS) of 500 mg/l.

Magnesium (Mg)
Magnesium is the 8th most abundant element on earth crust and natural constituent of water. It is essential for proper functioning of living organisms and found in minerals like dolomite, magnesite etc. Human body contains about 25g of magnesium (60% in bones and 40% in muscles and tissues). According to WHO standards the permissible range of magnesium in water should be 150 mg/l.

Calcium (Ca)
Calcium is 5th most abundant element on the earth crust and is very important for human cell physiology and bones. About 95% calcium in human body stored in bones and teeth. The high deficiency of calcium in humans may cause rickets, poor blood clotting, bones fracture etc. and the exceeding limit of calcium produced cardiovascular diseases. According to WHO (1996) standards its permissible range in drinking water is 75 mg/l whereas PSQCA (2002) established the limit of 200 mg/l.

Nitrate (NO_2)
Nitrate one of the most important diseases causing parameter of water quality particularly blue baby syndrome in infants. The sources of nitrate are nitrogen cycle, industrial waste, nitrogenous fertilizers etc. The WHO allows maximum permissible limit of nitrate in drinking

2.3 Determination of Water Quality Index (WQI)
In determining water quality index, the significance of the different water quality parameters depends on the intended use. This research work seeks to evaluate water quality criteria based on the demands for portability. The ten parameters selected for this study are shown in the first column of table 3. The second column presents the drinking water standards for the parameters, while the third column gives the unit weights (w_i). The pH has been assigned the weight of total dissolved solid because they are both secondary pollutants. The water quality index (WQI) can be calculated.

Table 3: Water quality parameters with their WHO/Nigerian standards and unit weights.

Parameter (P_i)	**Standard (S_i)**	**Unit weight (W_i)**
pH	6.5 -8.5	0.001
Total dissolved solid	1000	0.001
Calcium	200	0.005
Fluoride	1.5	0.667
Iron	0.3	3.33
Nitrate	50	0.02
Potassium	100	0.01
Sulphate	400	0.0025
Carbonate	250	0.004
Total hardness	500	0.002

Unit weight of the *i*th parameter (W_i) can be calculated as follows:

Table 4: Physical and Chemical Properties of Water Samples in Isiala Ngwa North LGA of Abia State

Hand dug well No.	pH	(EC) $\mu s/cm$	TDS (Mg/l)	TSS (Mg/l)	Hardness (Mg/l $CaCO_3$)	Turbidity (FAU)	Colour (ptCo)	Alkalinity (Mg/l $CaCO_3$)	(Fe) (Mg/l)	Zn (Mg/l)	Mn (Mg/l)	Cu (Mg/l)	NO_2 (Mg/l)
HDW 1	6.58	80.28	56.88	Nil	2.47	2	2	71	ND	0.19	0.01	ND	4.22
HDW 2	5.61	34.10	25.40	Nil	1.70	2	1	81	ND	0.15	ND	ND	3.02
HDW 3	2.92	54.37	39.17	Nil	3.33	3	2	74	ND	0.05	ND	ND	3.27
HDW 4	6.08	104.18	71.18	Nil	2.34	3	1	64	ND	0.26	ND	ND	Nil
HDW 5	5.53	46.92	32.42	Nil	1.94	4	2	48	ND	0.07	ND	ND	Nil
HDW 6	6.91	76.46	40.56	Nil	1.38	1	1	39	ND	0.09	ND	ND	Nil
HDW 7	6.27	18.50	14.10	Nil	2.23	3	1	120	ND	0.21	ND	ND	3.56
HDW 8	5.57	18.38	14.68	Nil	2.68	2	1	84	ND	0.05	0.03	ND	3.20
HDW 9	6.40	42.28	27.18	Nil	1.14	4	2	60	ND	0.45	ND	ND	Nil
HDW 10	5.81	36.65	18.15	Nil	3.50	1	1	85	ND	0.26	ND	ND	Nil
WHO Standards	**6.5-8.5**	**1000**	**1000**	**N/A**	**100-500**	**5**	**15**	**500**	**3**	**5**	**0.5**	**1.00**	**3.00**

FAU = Formazin Attenuation Units, $\mu s/cm$ = Micro second per centimetre, **Mg/l** = Milligram per litre, **ptCO** = Platinum-Cobalt Scale

3. Results and Discussion

3.1 Results

The result of the analysis shows that the pH values range between 2.92 and 6.91. Five boreholes namely HDW2, HDW3, HDW5, HDW8 and HDW10 were observed to be below WHO standards for drinking water (6.5-8.5), this makes the well water to be acidic. The electrical conductivity values obtained ranged from 18.38 $\mu s/cm$ to 104.18 $\mu s/cm$ this result shows conformity with the WHO standards.

Total Dissolved Solids (TDS) of water sample ranges between 18.15mg/L and 71.18mg/L, the Total Suspended Solids (TSS) analysis shows no trace of total suspended solids. The values for water hardness ranges between 1.14mg/L and 3.50mg/L, turbidity; 1FAU and 4FAU, colour; 1 and 2ptCO, alkalinity; 39mg/L and 120mg/L, Total Iron (Fe); nil, Zinc (Zn); 0.05mg/L and 0.45mg/L, Manganese (Mn); was 0.01 and 0.03mg/L in HDW1 and HDW8 water samples respectively, while others showed no detection, Copper (Cu); not detected, Nitrite (NO_2); high values above WHO standards except in five of the groundwater samples. This observation may have been influenced by pit latrines and farm lands where fertilizer containing inorganic Nitrogen, Phosphorous and Potassium (NPK) were used and sited close to the boreholes. The high concentration of NO_2 observed in the result may be connected to inorganic fertilizers used during intense farming. When there is excessive rainfall, NO_2 is leached below the plants roots and pollute groundwater. NO_2 is highly leachable and readily moves with water through the soil profile.

3.2 Discussion

In the cause of this research work two properties - pH and nitrite as shown in Tables 4 were observed to be at variance with the World Health Organization (WHO) standards. This may have some health effects on short or prolonged consumption of water from these sources. Low pH in groundwater can allow toxic chemicals to become mobile and available for uptake by aquatic plants and animals. Heavy metals and base cations are mobilized by increasing acidity in soil and groundwater. Potential soil metals of concern in connection with human health are cadmium and aluminum. However, when acidic groundwater is fed into pipe systems other metals such as lead and copper can be elevated to a toxic level. This is capable of producing conditions that are toxic to aquatic life and more, water with high level of acidity can corrode household plumbing and their associated systems. Many investigations however show that a sharp increase in the concentration of most metals occurs when the pH drops by 5.25 according to Jordan *et al*., 2004.

Another biological effect of nitrite in humans is its involvement in the oxidation of normal haemoglobin to methaemoglobin, which is unable to transport oxygen to the tissues. The reduced oxygen transport becomes clinically manifest when methaemoglobin concentrations reach 10% of that of haemoglobin and above. This condition is called methaemoglobin anemia, cyanosis and at higher concentrations asphyseia. Infants under 3 months of age and pregnant women are more susceptible to methaemoglobin formation.

4. Conclusion and Recommendations

4.1 Conclusion

In this study, high level of nitrite and low pH were observed as clear evidence of physical and chemical pollution. Low pH values of 2.92 - 6.49 were obtained from water samples which were below 6.5-8.5 as recommended by WHO. Similarly, high nitrite concentrations of 3.02mg/L4.22mg/L were observed which were again higher than WHO acceptable limits of 3.0mg/L. It is expected that increased and/or continued combined environmental interventions, through public health education by community based health workers, awareness and sensitization campaigns on the sustainable use of inorganic fertilizer may improve groundwater integrity. However, sodium carbonate should be used as a purifier for acidic groundwater and again, wells located within 50 meters from pollution source should be abandoned and future wells should be constructed beyond 250 meters from pollution source.

4.2 Recommendations

The following recommendations were proffered by the researchers which include;

i. That regular monitoring of ground water quality should be practiced in all areas of Isiala-Ngwa North Local Government Area.

ii. Government should also install more water filtration plants to provide safe drinking water for all in the area.

iii. Sewer drains should be kept away from water supply drains to avoid waste water leaching in ground water.

iv. Sanitary conditions should be improved on regular basis.

v. Also awareness campaign of ground water diseases and importance of safe water for human health should be rekindled.

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