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Spatial Analysis of the Quality of Groundwater Supply: Evidence from Abia State

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Abstract The importance of potable water has been documented by many researchers. However, one major challenge in Nigeria is the ability for both rural and urban areas to access a clean water supply. This study examined the spatial analysis of the quality of groundwater supply in selected urban centres of Abia State. To achieve this, 13 borehole water samples were collected using purposive sampling technique. The parameters tested include; Temperature (°C), pH value, Electrical conductivity (µs), Total suspended solids (mg/l), Biological Oxygen demand (BOD),Turbidity (NTU), Sulphate (So_4), Chloride (Cl), Nitrate (No_3), Potassium (K), Sodium (Na), Calcium (Ca), Magnesium (Mg), Zinc (Zn), Iron (Fe) Copper (Cu) and Lead (Pb). The results of the water samples were compared with the WHO quality standards. The analyses revealed that the quality of water supply is inadequate. For instance, temperature in all the sampled sites ranged from 27.1°C - 29.7°C which is above the WHO value of 26.6°C, while the pH values (5.79 - 6.81) were lower than the WHO value of 7 – 8.5, indicating mildly acidic. Similarly, electrical conductivity, total suspended solids, biological oxygen demand, sulphate, nitrate, and chloride values were all below the WHO values. All the hypotheses were tested using analysis of variance. It was observed that significant variations exist between Ohafia and Umuahia, Ohafia and Aba, but no significant difference exists between Umuahia and Aba. Thus, the null hypothesis (H_0) was accepted in all, that “there are no significant variations in the physicochemical content as regards the sampling points in the zones. The study recommends amongst others that water should be boiled before use, or through the use of alum, water guard, or through disinfection with the use of chlorine.

Keywords: *groundwater, quality, Abia State*

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1. Introduction

Water is a precious resource which is essential for life and is ranked next to air as a basic necessity of man. Writers such as Chima, Nkemdirim and Iroegbu [4] have documented the importance of this resource as a precious and most commonly used resource. Ekop [6,7] emphasizes the importance of water in the socio-economic development of any area and stressed that its total absence, inadequacy or poor quality has a direct effect on the health of the people and the environment.

The issue of potable water supply in urban areas is very critical especially in Africa. A study by the United Nations [23] shows an average annual urban growth rate of 5% each year since 1980s, and that by 2030, half of the continents’ population is projected to live in cities. This urban growth has been accompanied by an increasing documented rise in abject urban poverty, characterized by city residents who lack quality housing, access to potable water and adequate sanitation, and other municipal services and infrastructures [22].

Potable water supply in Nigeria, like in other developing countries is facing serious challenges [3,8]. It is not surprising that the studies of Clasen, Schmidt, Rabie, Roberts, Cairncross [5], Hallar, Hutton, Bartram [9], and Hutton, Bartram [11] noted that water borne or water-related diseases such as diarrhea, Cholera, typhoid, malaria, hepatitis and more are linked to an estimated 80% of illnesses in developing countries. This condition explains why diarrhea is the leading cause of childhood death in parts of the world especially in developing countries where sanitation and access to potable water is not widespread [24,25].

The responsibility of providing potable water in Abia State rests solely on the shoulders of the State Water Board. But all it has to show for this is an array of abandoned projects and obsolete equipments that have become monuments, a situation which has resulted in one of either total absence or gross inadequacy of potable water supply. This state of affair in which most existing water supply projects are abandoned is very disturbing and unacceptable because water security is not only for human consumption but provides a take-off ladder for the economic development of any region.

Thus, the inability of the Water Boards to cope with the increasing demand for potable water supply has paved way for increased contribution of groundwater to total water use in the study areas. Shallow wells have become very important sources of water supply for domestic use due to general inadequacy and unreliability of pipe borne water. Groundwater is liable to pollution through geo-chemical processes such as release of gaseous materials by volcanic eruption, rock weathering, formation and permeation, through rocks and soils. According to Ekpo [6], the effect of a polluted groundwater through any of these processes remains for a long time and this calls for quality assessment from time to time. The attendant effects on groundwater exploitation on human health are critical especially regarding the quality of the water being supplied from various sources.

The literature reviewed shows the following studies; Akaninyene and Atser [2] studies the quality of public water supply in Makurdi urban. Ekop [7] studies pollution assessment of public water supply in Calabar urban. Ocheri, Mile and Oklo [15] carried out a study on groundwater contamination in Makurdi town, Benue state. Aimiuwu [1] investigates the impact of socio-environmental characteristics on quality of potable water development and sustainability in Benin-City. Ijioma and Ogwuegbu [12], studies policy-oriented water pollution impact assessment; illustrations from Aba River. Umeham and Elekwa [21] studied the hydrobiological status of Ngwui, Ikwu and Eme streams in Umuahia North, Abia state. Going by this, this study will be the first extensive work on the topic in Abia state.

What is missing is gap left with each of the works cited. For instance; Akaninyene and Atser [2] and Ekop [7] emphasize only on public water supply and demand in Makurdi and calabar leaving the private water provider. While the work of Ubogu and Rimamson [20] is just a literature review of access to potable water, while that of Aimiuwu [1] only looks at the broad impacts of socio-environmental characteristics on quality of potable water development. This study also isolated the private sector. Although the studies of Ijioma and Ogwuegbu [12] and that of Umeham and Elekwa [21] are also based in Abia state, their focus is in the areas of policies and surface water as against this study that is focused on groundwater.

2. Hypotheses

a. There are no significant differences in the physicochemical contents among the various zones (Ohafia vs Umuahia, Ohafia vs Aba, and Umuahia vs Aba).

b. There are variations in the physicochemical content as regards the sampling points in Ohafia zone

c. There are variations in the physicochemical content as regards the sampling points in Umuahia zone

d. There are variations in the physicochemical content as regards the Sampling points in Aba zone.

3. Geography of the Area:

Abia State lies within approximately latitudes 4°40′ and 6°14′ north, and longitudes 7°10′ and 8° east, and shares common boundaries with Enugu State in the North and Ebonyi State in the northeast; to the west is Imo State, and to the northwest is Anambra State. To the south and southwest, it shares borders with Rivers State; and to the east and southeast with Cross River and Akwa Ibom States respectively. The State covers an area of about 5,243.7sq.km which is approximately 5.8 percent of the total land area of Nigeria. With its capital at Umuahia, it has seventeen local government areas (LGAs).

In terms of relief, Abia State lies generally on a flat and low-lying land, generally less than 120m above sea level. Geologically, there are nine main geological formations from south to north. These include: the Benin formation (Coastal Plain Sand); the Bende-Ameki Group - Eocene (Clay, clayey and shale); the Nkporo Shale Group - Upper Senionian (Shale and mudstone); the Nsukka formation (Upper Coal Measures), the Igali sandstone (False-bedded Sandstone), the Eze-Aku Shale Group and the Asu River Group [13].

Abia State falls within the sub equatorial climatic zone with clearly marked dry season and double maxima rainfall in August and September. Relative humidity is usually high throughout the year. It varies considerably between the rainy and the dry seasons. The rainy months often have an average relative humidity of 80-90 percent while the dry months have an average relative humidity of 50-70 percent. The average monthly sunshine hours of the area are 4.8. The mean monthly evapotranspiration is 136mm (Abia State official website). The soils of Abia State fall within the broad group of ferrallitic soils of the coastal plain sand and escarpment [13]. The vegetation is ordinarily considered part of tropical rain forest which is the dominant natural vegetation in most parts of southern Nigeria.

The national census of Nigeria carried out in 2006 puts the provisional population of Abia State at 2,845,380 while its projection to 2015 is 3,652,627. There was thus an increase of 807,247 people over a period of 9 years. The high population of the study area could have some implications for the potable water supply situation. It could lead to potable water supply shortages as a very high population will be depending on one of either total absence or gross inadequacy of the potable water by the water Board. On the other hand, the high population of the area could be used to develop potable water supply projects through proper planning and implementation. Table 1 shows the three selected urban centres for the study.

Table 1. The study areas with their geographical co-ordinates.

Zone	Urban Centres	Latitude/Longitude
Abia North	Ohafia	05°37’0’’N , 07°50’0’’E
Abia Central	Umuahia North	05°32’06’’N, 07°29’52’’E
Abia South	Aba South	05°06′12″N, 07°21′24″E

Source: Researcher’s fieldwork.

4. Method of Study

This study adopted the sample survey method which involves direct observation, collection of water samples and laboratory analysis of the water samples amongst others. It employed both qualitative and quantitative approaches in data collection and analysis. An eight-day reconnaissance survey of the study environment which was conducted from 14th – 21st of June, 2015 actually aroused the interest of the researchers in this study. The water samples from boreholes for physicochemical analyses were collected from thirteen sampling points from 12th – 13th November, 2015 between 10am to 2pm daily. Three (3) water samples were collected from Ohafia zone, five (5) water samples each from Umuahia and Aba zones respectively. Points for borehole water sampling were based on purposive sampling. This was to ascertain the quality aspect of the water supplied to the urban population. The pilot and reconnaissance survey helped the researchers on this judgment as we were familiar with the relevant characteristics of the population. Points were chosen where greater number of the people obtains their water for domestic use while some were based on preference for a particular source irrespective of the distance to be covered.

Before the tap water samples were collected, cotton wool soaked in 70 per cent ethanol was used to sterilize the nozzle of the tap and the tap was allowed to run for two-three minutes. The water samples were collected in sterilized (sterilizing agent 5% HNO_3) 1 litre plastic container, rinsed with the water to be collected and then filled with the water samples. As soon as each of the 1-litre plastic cans was filled to the brim to avoid air bubbles, the cap was used to seal it firmly. The samples (SPL) were labeled as SPL 1, SPL 2, SPL 3, etc to show the different points for the analysis of physicochemical parameters. Plate 1 shows how the water samples were labeled.

Plate 1.

The samples were kept in a cooler box containing ice, before being sent to the Central Services Laboratory of the National Root Crop Research Institute, Umudike (NRCRIU) within two (2) hours for the analysis.

The water quality parameters selected for the study are; Temperature (°C), pH value, Electrical conductivity (µs), Total suspended solids (mg/l), Biological Oxygen demand (BOD),Turbidity (NTU), Sulphate (So_4), Chloride (Cl), Nitrate (No_3), Potassium (K), Sodium (Na), Calcium (Ca), Magnesium (Mg), Zinc (Zn), Iron (Fe) Copper (Cu) and Lead (Pb).These seventeen parameters were tested to ascertain the quality status of the groundwater unlike in some other works where few parameters were tested.

The physicochemical characteristics of the water samples were analyzed using various analytical methods. For instance, unstable pH, temperature and DO parameters were measured in-situ, with an ATI-Orion pH meter, thermometer and probe and meter respectively; while turbidity and TSS were respectively measured with a 214 A turbidity meter and photometric methods at wavelength of 810nm. Chloride, calcium and magnesium were determined through Argent metric titration method, EDTA titration method and calculation method respectively. Sulphate and Nitrate were determined with the aid of turbid and Brucine methods. Heavy metals such as Iron (Fe), lead (Pb) and zinc (Zn), etc were determined with the aid of the Atomic Absorption Spectrophotometer (AAS) respectively at 248, 283 and 213.9 nm wavelengths. The results were compared with the WHO thresholds for potable water supply.

In addition to these, simple statistical techniques like percentages and means were used as tools for comparison while tables were used to show the relationship of variables for easy analysis. Other statistical tool employed in testing the hypotheses is the analysis of variance (ANOVA).

5. Results and Discussion

5.1. Interpretation of Results of Physicochemical Analysis

Temperature

The analysis of the physical properties shows that in Ohafia area, temperature varied from 29.4°C in SPL 1, 29.7°C in SPL 2 to 28.2°C in SPL 3 for the sampled locations. The mean value of temperature is above the WHO recommended maximum concentration of 26.6°C and within the WHO maximum permissible concentration of 30°C. In Umuahia, temperature varied from 27.5°C in SPL 5 to 29.2°C in SPL 7, which falls within the WHO maximum permissible concentration. In Aba, water temperature ranges between 27.1°C in SPL 11 and 29.5°C in SPL 10. This falls within the WHO standard for drinking water. Generally, it was observed that there are spatial variations in temperature as 1°C variation is big in regards to temperature. The temperatures did not vary much because they are found within the same climatic condition.

Table 2. Results of Physicochemical Laboratory analysis of water samples from 12th – 13th November, 2015

Water quality Parameters	OHAFIA ZONE 12th November, 2015				UMUAHIA ZONE 12th November, 2015				ABA ZONE 13th November, 2015					WHO STD.
	SPL 1	SPL 2	SPL 3	SPL 4	SPL 5	SPL 6	SPL 7	SPL 8	SPL 9	SPL 10	SPL 11	SPL 12	SPL 13	
Temperature (°C)	29.4	29.7	28.2	28.0	27.5	29.0	29.2	27.8	28.6	29.5	27.1	27.5	28.2	26.6
pH	5.80	6.0	5.89	5.79	6.30	6.81	6.20	5.87	6.20	6.11	5.90	6.80	5.86	7.0-8.5
Electrical conductivity	2.3	2.5	3.1	2.4	2.1	2.7	2.2	3.0	2.85	2.72	3.10	2.9	2.47	50
Total suspended solids (TSS)	30.9	33.0	33.5	35.0	38.2	28.3	35.4	27.5	39.0	39.2	20.6	37.5	36.1	50
Biological O_2 demand (BOD)	1.02	1.02	1.01	1.04	1.03	1.07	1.02	1.09	1.08	1.03	1.01	1.02	2.00	3
Turbidity (NTU)	0.012	0.019	0.004	0.014	0.009	0.011	0.017	0.006	0.012	0.012	0.007	0.011	0.009	5
Sulphate (SO_4)	9.10	11.4	11.0	17.5	15.0	20.0	14.3	11.3	13.9	19.5	21.2	23.0	24.0	200
Chloride	15.96	25.5	22.3	19.6	28.7	38.3	22.3	28.7	31.9	25.5	38.3	28.7	25.4	200
Nitrate (NO_3)	0.64	0.02	0.38	0.56	0.45	0.23	0.60	0.07	0.02	0.17	0.02	0.04	0.31	50
Potassium (K)	1.65	1.70	0.80	1.45	1.60	2.50	1.90	1.80	2.10	2.80	1.80	3.40	1.70	1.0
Sodium (Na)	3.80	2.30	2.60	2.40	2.30	4.50	2.80	3.60	2.90	1.80	2.40	2.80	3.90	100
Calcium (Ca)	20.40	16.3	24.1	22.0	28.2	28.1	40.1	24.1	28.1	36.1	16.0	18.1	28.1	75
Magnesium (Mg)	12.32	9.72	7.36	19.8	21.0	16.1	18.5	9.72	11.1	13.6	9.72	7.30	16.1	50-150
Zinc (Zn)	0.01	0.01	0.04	0.19	0.14	0.04	0.03	0.03	0.13	0.21	0.01	0.07	0.17	5.0
iron (Fe)	0.01	0.01	0.02	1.00	0.0	0.0	0.21	0.1	0.12	0.04	0.01	0.27	0.14	0.3-1.0
Copper (Cu)	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	1.0
lead (Pb)	0.02	0.04	0.03	0.04	0.06	0.01	0.01	0.05	0.02	0.01	0.04	0.05	0.08	0.05

Units of measurement: Temperature (°C), Conductivity (µs/cm), Turbidity (NTU), All other units (mg/l). SPL = Sampling Locations.

Since temperature is a standard physical characteristic that is important in the consideration of the chemical properties of water, it therefore becomes necessary that the temperature of the water should be ascertained since high temperature is known to increase the toxicity of some toxic substances such as ammonia, reduce the concentration of dissolved oxygen, increase water acidity and influence the activities of some bacteria.

pH value

In Ohafia, the pH for all the samples varied from 5.80 in SPL 1 to 5.89 in SPL 3.Thus, the pH for the samples is below the WHO water quality standards and therefore have mildly acidic tendency. For Umuahia zone, the pH ranged between 5.79 in SPL 4 to 6.81 in SPL 6, which fall below the WHO values of 7 – 8.5. Therefore, the pH of the samples for Umuahia zone is mildly acidic. In Aba, the pH of the sampled sites ranged between 5.86 in SPL 13 to 6.80 in SPL 12. In all for Aba zone, the water samples were found to be mildly acidic as they are below the recommended water quality standards. The pH of a water body is very important because it may affect the solubility and toxicity of metals in the aquatic system, which may have adverse effects on human health. The water becomes acidic if its pH is less than 7, and becomes alkaline if above 7. In all ramifications, the pH of all the samples was lower than 7-8.5 and therefore have acidic tendency. This observation is in tandem with Holden and Green's (1960) assertion that alkaline waters are not typical of Africa. This range also conforms to the records of Nwadiaro, Oranusi and Umeham (1982) for Eastern Nigeria waters.

Electrical conductivity (EC)

The analyses of chemical properties indicate that in Ohafia, electrical conductivity (EC) range from 2.3µs/cm in SPL 1 to 3.1µs/cm in SPL 3. All values for electrical conductivity in Ohafia were below the WHO stipulated standard of 50µs/cm. In Umuahia, EC ranges from 2.1µs/cm in SPL 5 to 3.0µs/cm in SPL 9, and this falls below the recommended standards for drinking water. In Aba, EC ranges between 2.47µs/cm in SPL13 to 3.10µs/cm in SPL11. This is lower when compared to WHO standard. On the whole, EC concentrations in all the samples were very much lower than the WHO value of 50µs/cm.

Electrical conductivity is an index of the total ionic content of water, and therefore indicates the freshness or otherwise of the water [16]. Higher conductivity is attributed to the concentration of ions coupled with increased mineralization of organic matter [17]. It therefore becomes necessary that EC should be measured to give a good estimate of the dissolved solids content of the water.

Total suspended solids (TSS)

The total suspended solids in Ohafia area varied between 30.9mg/l in SPL 1 and 30.0mg/l in SPL 2. Therefore, the samples are lower than the recommended standards for drinking water. In Umuahia, the values ranged from 27.5mg/l in SPL 8 to 38.2mg/l in SPL 5, and is within the WHO recommended permissible level. In Aba, the samples varied between 20.6mg/l in SPL 11 to 39.2mg/l in SPL 10. In all, results for all the sampled sites were low when compared with the WHO standard of 50mg/l and therefore the water is good for domestic purposes.

Biological oxygen demand (BOD)

The five-day biochemical oxygen demand (BOD_5) value for Ohafia area varied between 1.01mg/l in SPL 3 and 1.02mg/l in SPLs 1 and 2. All samples are lower than the WHO minimum values of 3mg/l. In Umuahia, BOD values falls within 1.02mg/l in SPL 7 to 1.09mg/l in SPL 8, also below the recommended water quality standard. For Aba area, the samples varied between 1.01mg/l in SPL 11 and 2.0mg/l in SPL 13. In all, the five-day biochemical oxygen demand (BOD_5) value which is an index of gross or indiscriminate pollution had lower values when compared with the WHO minimum values for BOD (3mg/l). BOD is a measure of the consumption of oxygen by micro-organisms in the oxidation of organic matter. Thus, a high BOD indicates a high concentration of organic matter usually from waste water discharges. BOD of safe drinking water must be nil. If BOD of water is zero, it means that no oxygen is required and thus no organic matter content.

Turbidity

The results of the laboratory analysis for Ohafia area shows turbidity (NTU) ranges between 0.004NTU in SPL 3 and 0.013NTU in SPL 1. In Umuahia, values ranged from 0.006NTU in SPL 8 to 0.017 in SPL 7 while in Aba, it ranged from 0.007NTU in SPL 11 to 0.012NTU in SPLs 9 and 10. In all, turbidity levels in all the sampled locations conformed to WHO standard for domestic uses and were within the permissible levels. Since turbidity has an inverse relationship with transparency, the very low turbidity is indicative of high biological production. The probable reason for the low turbidity values is the low water table, which leads to high depths of most of the boreholes. Thus, low turbidity is not known to interfere with disinfection and cannot facilitate microbial growth. Measurement of turbidity is important because it is one of the visual factors affecting consumer acceptance of water.

5.2. Analysis of Elemental Contents

Sulphate, Chloride, Nitrate, Potassium, Sodium, Calcium

Elemental analyses were done to determine the contents of sulphate, chloride, nitrate, potassium, sodium, calcium, magnesium, zinc, iron, copper and lead in the samples.

Sulphate (S0$_4$)

The laboratory test results indicate that in Ohafia area, the concentration of sulphate ranges between 9.10mg/l in SPL 1 to 11.0mg/l in SPL 3 in the three sampled sites. The readings of all the sampled sites were found to be below WHO standards of 200mg/l. In Umuahia, all the sampled sites were below the recommended standard and varied between 11.3mg/l in SPL 8 to 20.0mg/l in SPL 6 for the five sampled sites. For Aba area, the five sampled sites ranged between 13.9mg/l in SPL 9 to 24.0mg/l in SPL 13. In summary, the contents of sulphate in all the sampled sites, falls below the WHO quality standards.

Chloride (Cl)

Chloride concentrations in the sampled sites in Ohafia varied between 15.96mg/l in SPL 1 and 22.3mg/l in SPL 3. In Umuahia, the five sampled sites varied between 19.6mg/l in SPL 4 and 22.3mg/l in SPL 7. In Aba area, the five sampled sites ranged from 25.4mg/l in SPL 13 to 38.3mg/l in SPL 11. Generally, for chloride concentrations in all the sampled areas, the values are relatively low, occurring below WHO standard of 200mg/l. It was observed that the low concentration of chlorides could be associated with the low level of total dissolved solids (TDS) and this indicates the nature of groundwater, which is fresh. Chlorides, most often occurring in the NaCl common salt form, are found in brackish water bodies contaminated by sea water or in groundwater aquifers with high salt content are indicative of sewage pollution from other chloride compounds.

Nitrate (NO_3)

Nitrate content of the sampled locations were low when compared with the WHO standards of 50mg/l. In Ohafia zone, the sampled sites concentration was found to occur from a range of 0.02mg/l in SPL 2 to 0.38mg/l in SPL 3. In Umuahia, the contents of the five sampled sites varied between 0.07mg/l in SPL 8 and 0.60mg/l in SPL 7. For Aba, the contents of the five sampled sites ranged from 0.02mg/l in SPLs 9 and 10 to 0.31mg/l in SPL 15. All the sites had values less than the WHO standard as stated above. Nitrates, in excessive amount contributes to the illness known as methemogbinemia and therefore has to be ascertained in water required for drinking purposes.

Potassium (K)

The contents of potassium in Ohafia varied between the lowest value of 0.80mg/l in SPL 3 and the highest value of 1.70mg/l in SPL 2. Apart from SPL 3 with a value of 0.80mg/l, all other sites had values above the WHO desirable limit of 1.0mg/l. In Umuahia, the contents of potassium for the five sites had the lowest value of 1.45mg/l in SPL 4 and the highest value of 2.50mg/l in SPL 6. In Aba, the sites had values ranging from 1.70mg/l in SPL 13 to 3.40mg/l in SPL 12. In summary, the contents of potassium in all the study areas apart from SPL 3 (Ohafia zone) had values which exceeded the WHO desirable limit of 1.0mg/l. Therefore, these sites are polluted by potassium.

Sodium (Na)

Sodium concentration in Ohafia varied between 2.30mg/l in SPL 2 to 3.80mg/l in SPL 1 for the three sampled sites. The five sampled sites in Umuahia ranged from 2.30mg/l in SPL 5 to 4.50mg/l in SPL 6. In Aba, the five sampled locations had the lowest value of 1.80mg/l in SPL10 and the highest value of 3.90mg/l in SPL 13. The content of sodium in all these sampled sites in the study areas were less than WHO standard of 100mg/l.

Calcium (Ca)

In Ohafia, calcium ranged between 16.3mg/l in SPL 2 to 20.40mg/l in SPL 1 for the sampled sites. In Umuahia, the five sampled sites had the lowest value of 22.0mg/l in

SPL 4 and the highest value of 40.1mg/l in SPL 7. In Aba, the lowest value of 16.0mg/l was found in SPL 11 and the highest value of 36.1mg/l was found in SPL 10. In all for the study areas, the values for calcium were low when compared with WHO standards of 75mg/l.

5.3. Magnesium, Zinc, Iron, Lead

The concentrations of heavy metals in drinking water supply is of crucial importance to health and water providers all over the world because of its health impacts if they should exceed the acceptable thresholds provided by the WHO. The likely health impacts of excessive concentrations of heavy metals above the WHO standards include neurological disorder, cancer, mental development in infants, and interference with vitamin D metabolism, central and peripheral nervous systems amongst other impacts [18].

Magnesium (Mg)

The magnesium contents in Ohafia for the sampled sites ranged between 7.36mg/l in SPL 3 to 12.32mg/l in SPL 1. For Umuahia, the highest value of 21.0mg/l for magnesium was found in SPL 5 while the lowest value of 9.72mg/l was found in SPL 8. In Aba, the values ranged between 7.30mg/l in SPL 12 to 13.6mg/l in SPL 10. In all the sampled sites, the values were all lower when compared with the WHO standards of 50mg/l. High concentration of calcium and magnesium determine the hardness of water. If bicarbonates and carbonates of Ca and Mg are present in water, the water is rendered hard temporary and this hardness can be removed by boiling or by adding lime to the water.

Zinc (Zn)

Values for zinc in Ohafia ranged from 0.01mg/l in SPLs 1 and 2 to 0.04mg/l in SPL 3. In Umuahia, values ranged from 0.03mg/l in SPLs 7 and 8 to 0.19mg/l in SPL 4. For Aba, contents of zinc varied between 0.01mg/l in SPL 11 to 0.21mg/l in SPL 10. However, these results were lower when compared with WHO standard of 5.0mg/l for zinc (Zn). These values indicate that the water samples are free from zinc pollution.

Iron (Fe)

The lowest value for iron in Ohafia is 0.01mg/l in SPLs 1 and 2 while the highest value of 0.02mg/l was found in SPL 3. In Umuahia, samples (SPL 5 and SPL 6) had a zero value where iron was not detected at all in the samples. The lowest value of 0.1mg/l was found in SPL 8 while the highest value of 1.0mg/l was found in SPL 4. In Aba, values ranged between 0.01mg/l in SPL 11 and 0.27mg/l in SPL 12. Apart from SPLs 5 and 6 that had a zero value for iron, all other values were within the WHO permissible levels of 0.3mg/l. The presence of more than 0.3ppm of iron in water will result in the staining of plumbing fixture and laundry and even smaller amounts may be troublesome.

Lead (Pb)

The content of lead was found to be highest with a value of 0.04mg/l in SPL 2 for Ohafia while its lowest value of 0.02mg/l was found in SPL 1. In Umuahia, values ranged from 0.01mg/l in SPLs 6 and 7 to 0.06mg/l in SPL 5. This implies that SPL 5 had a value above WHO highest desirable level. In Aba, the contents of lead varied from 0.01mg/l in SPL 10 to 0.08mg/l in SPL 13. The concentrations of lead in two locations were found to be above the WHO highest desirable level of 0.05mg/l. These locations are SPL 5 (Umuahia zone) with a value of 0.06mg/l and SPL 13 (Aba zone) with a value of 0.08mg/l. Other two locations, SPL 8 (Umuahia zone) and SPL 12 (Aba zone) were found to have the same values of 0.05mg/l which is the highest desirable level for WHO. The consumption of the affected water without adequate treatment may lead to serious health implications. The indiscriminate dumping of all sorts of metals and the location of the boreholes where the water samples were collected could be responsible for the observed lead concentrations in some of the water samples in the study area.

6. Significance of the Water Quality Parameters Documented

The primary objective of the water quality parameters tested is to ensure that water required for domestic uses particularly for drinking is of good physical quality, free from unpleasant taste or ordour and containing nothing which might be detrimental to health. It should be free from turbidity and excessive or toxic chemical compounds. Harmful micro-organisms and radio-activity must be absent.

The concentrations of heavy metals in drinking water supply is of crucial importance to health and water providers all over the world because of its health impacts if they should exceed the acceptable thresholds provided by the WHO. The likely health impacts of excessive concentrations of heavy metals above the WHO standards include neurological disorder, cancer, mental development in infants, and interference with vitamin D metabolism, central and peripheral nervous systems amongst other impacts [19]. The concentration of heavy metals calls for concern and therefore pertinent to ascertain the levels of metals in drinking waters so as to forestall harm to both human and aquatic life.

7. Test of Hypotheses

To test for hypothesis 1, Table 2 (physicochemical results) was subjected to statistical analysis. Analysis of Variance for the physicochemical analysis as regards zones (Table 3) and pairwise comparisons of the zones (Table 4) were computed.

1. H_0: There are no significant differences in the physicochemical results among the various zones

   H_1: There are significant differences in the physicochemical results among the various zones

General Linear Model: Y3 versus ZONE

Table 3. Analysis of variance for the Physicochemical Analysis as regards Zones

Source of variation	DF	Adj SS	Adj MS	F	p-value	Decision
Zone	2	2695.3	2695.3	9.84	0.000	Highly significant
Error	205	28083.4	28083.4			
Total	207	30778.8				

Table 4. Pairwise comparisons of the Zones

Vendor	Mean difference	T-value	P-value	Significance
Ohafia vs Umuahia	-7.168	-3.355	0.0027	Highly significant
Ohafia vs Aba	-9.321	-4.362	0.0001	Highly significant
Umuahia vs Aba	-2.153	-1.163	0.4765	Not significant

From the analysis (Table 4), it was discovered that significant differences exist between Ohafia and Umuahia, Ohafia and Aba, but no significant difference exists between Umuahia and Aba. The reason for Umuahia and Aba not being significant could be that both have similar and/or the same characteristics. Thus, the alternate hypothesis (H_1) is accepted for Ohafia and Umuahia; Ohafia and Aba, that "there are significant differences in the physicochemical contents among the various zones. But for Umuahia and Aba, the null hypothesis (H_0) is accepted.

To ascertain if there are significant variations in the physicochemical content as regards the sampling points in the three zones, analysis of variance was employed.

For Ohafia zone, hypothesis 2 was tested (Table 5).

2. H_0: There are no significant variations in the physicochemical content as regards the sampling points in Ohafia zone

   H_1: There are variations in the physicochemical content as regards the sampling points in Ohafia zone

Table 5. Analysis of variance for the Physicochemical Analysis in Ohafia Zone subject to the sampling points

Source of variation	DF	Adj SS	Adj MS	F	p-value	Decision
Sampling points	2	39.7	19.8	0.11	0.900	Not significant
Error	45	8427.1	187.3			
Total	47	8466.8				

Here p-value = 0.900 > 0.05, thus, the null hypothesis was accepted and the alternate hypothesis (H_1) rejected. The conclusion is that; there are no significant variations in the physicochemical contents (result of the analysis) as regards the sampling points in Ohafia zone.

For Umuahia zone, hypothesis 3 was tested (Table 6).

3. H_0: There are no significant variations in the physicochemical content as regards the sampling points in Umuahia zone

   H_1: There are variations in the physicochemical content as regards the sampling points in Umuahia zone

Table 6. Analysis of variance for the Physicochemical Analysis in Umuahia Zone subject to the sampling points

Source of variation	DF	Adj SS	Adj MS	F	p-value	Decision
Sampling points	4	39.7	39.7	0.24	0.928	Not significant
Error	75	134.1	134.1			
Total	79	11589.9				

Here p-value = 0.928 > 0.05, we therefore have no evidence to reject the null hypothesis. Therefore, there are no significant variations in the physicochemical content as regards the sampling points in Umuahia zone.

For Aba zone, hypothesis 4 was tested (Table 7).

4. H_0 There are no significant variations in the physicochemical content as regards the sampling points in Aba zone

   H_1 There are variations in the physicochemical content as regards the sampling points in Aba zone

Table 7. Analysis of variance for the Physicochemical Analysis in Aba Zone subject to the sampling points

Source of variation	DF	Adj SS	Adj MS	F	p-value	Decision
Sampling points	4	31.7	31.7	0.08	0.989	Not significant
Error	75	7860.9	7860.9			
Total	79	7892.6				

Here p-value = 0.989 > 0.05, we therefore have no evidence to reject the null hypothesis.

In all ramifications, Analyses of Variance for the physicochemical analysis in the three zones subject to the sampling points were found "not significant". Thus, the null hypothesis (H_0) was accepted in all, that "there are no significant variations in the physicochemical content as regards the sampling points in the zones.

8. Recommendations

1. There should be periodic re-examination of the quality of groundwater supply sources.
2. Consumers should boil their water before use or through the use of alum, water guard or through disinfection with the use of chlorine.
3. Maximum distance should be put between the borehole point and the nearest septic tank/cesspool. This will help to stall contamination or pollution.

9. Conclusion

In conclusion, the level of concentration of various elements in water is a measure of groundwater quality, and variation in concentration also means changes in the water quality. Spatial differences in groundwater quality were also observed as the analysis confirmed the water quality variability among the sampled sites. Though the spatial variability in water quality as indicated by its physical and chemical properties are very minimal, the near uniformity elemental concentration could be as a result of homogenous geographical, environmental and socio-cultural activities in the study area. Though, these variations are minimal and negligible, they could contribute with time to the deterioration of the drinking water quality if not immediately handled.

References

[1] Aimiuwu, D. O. (2008). Impact of Socio- Environmental Characteristics on Quality of Potable Water Development and Sustainability: A Case Study of Benin-City. 50th Annual Conference, Association of Nigerian Geographers (ANG); August 25th-28th, University of Calabar.

[2] Akaninyene, M. and Atser, J. (2000). "Demand and supply relationship and quality of public water supply system in Makurdi, A sub-humid tropical city of central Nigeria" in Adinna, E.N.; Ekpo, O.B. and Attah, V.I. (eds.), *Environmental Pollution and Management in the Tropics*, Enugu: Snaap Press Ltd, 350-356.

[3] Alayande, A.W. (2005). Water Demand Management: Paper presented at a workshop titled *"Urban water supply facilities maintenance course."* held at National Water Resource Institute, Kaduna, November 7-18, 2005.

[4] Chima, G.N., Nkemdirim, V.U. and Iroegbu, A.N. (2009). Water Demand and Supply in Umuahia Urban-Abia State: Critical study. *Knowledge Review* 18 (1) 9-15.

[5] Clasen, T; Schmidt, W.P; Rabie, T; Roberts, I. & Cairncross, S. (2007). Interventions to improve water quality for preventing diarrhea: a systematic review and Meta-analysis. *British Medical Journal* 334: 782-785.

[6] Ekop, O.B. (1994). "Spatial variations in quality and quantity of Public Water Supply in Calabar Municipality, Nigeria" *Nigeria Journal of Technical Education* 11:107-125.

[7] Ekop, O.B. (2003). Pollution Assessment of Public Water Supply in Calabar urban Nigeria. In Adinna, E.N.; Ekpo, O.B. & Attah, V.I.(eds.).*Environmental Pollution and Management in the Tropic. 337* -349. nugu: Snaap Press Ltd.

[8] Emoabino, I.U. and Alayande, A.W. (2006). "Water Demand Management:Problems and Prospects of Implementation in Nigeria". *Proceedings of International Congress on River Basin Management*, 154-159.

[9] Haller, L; Hutton G; and Bartram, J. (2007). Estimating the costs and benefits of water and sanitation improvements at global level. *J Water Health* 5:467-480.

[10] Holden, M.J. and Green, J. (1960). The hydrology and plankton of river Sokoto, *journal of animal ecology*; 29: 65-84.

[11] Hutton, G. and Bartram, J. (2008). Global costs of attaining the millennium Development Goal for water supply and sanitation. *Bull World Health Organ* 86:13-19.

[12] Ijioma, M.A. and Ogwuegbu, M.O.C. (1999). Policy-Oriented Water Pollution Impact Assessment: Illustrations from Aba River, Abia State; in A.I. Kalu(ed), *A Journal on the Environment* 3(1): 23-28.

[13] Ijioma, M.A. (2000). *Nigeria: Giant in the Tropics: Survey of states* in Mamman, A.B; Oyebanji, J.O. and Petters, S.W. (eds), Abuja, 2:3-13.

[14] Nwadiaro, C.S., Oranusi, N.A. and Umeham, S.N. (1982). Preliminary survey of the drinking water quality of some areas in Imo and Rivers States. *Proceeding of the 3rd National conference on water pollution* held at the Nigerian Agip Oil Co. Hq., Port-harcourt, 15-22.

[15] Ocheri, M. I. Mile, Y. and Oklo, A. (2008). Nitrate Contamination of Shallow Wells in Makurdi Urban area of Benue State. 50th Annual Conference Book of Proceedings; association of Nigerian Geographers (ANG); 25th-28th August, 2008.

[16] Obgeibu, A. E. and Victor, R. (1995). Hydrological studies of water bodies in the Okomu forest reserves (Santuary) in Southern Nigeria. 2 physico-chemical hydrology. Tropical Freshwater Biology, 4: 83-100.

[17] Petr, T. (1983). The Purari- tropical Environment of a High Rainfall River Basin. W. junk. The Hague.

[18] Standards Organization of Nigeria (2007). Nigeria standard for drinking water quality, ICS 13.060.20: Nigeria Industrial Standard Manual, NIS 554: 2007.

[19] Seeling, B; Derickson, R and Bergsrud, F (1992) Treatment systems for household water supplies: Iron and manganese removal,"1992 [Online]. Available: http://www.ag.ndsu.edu/pubs/h2oqual/watSystem/ae1030w.htm Accessed January 1, 2004.

[20] Ubogu, A. E. and Rimomson, A. M. (2008). An Overview of Access to Potable Water Supply in Jema'a L.G.A. of Kaduna State, Nigeria. 50th Annual Conference, Association of Nigerian Geographers (ANG) 25th-28th August, 2008.

[21] Umeham, S.N and Elekwa, I. (2005). "The Hydro-Biological status of Ngwui, Ikwu and Eme streams in Umuahia North LGA, Abia State, Nigeria". In E.I.C. Agwu, M.A. Ijioma and I.U. Kalu (2005) (eds) *Journal of the Environment.* 1(1) Dec.2005, ISSN Heritage Projects Publishers, Owerri, Nigeria. 31-36.

[22] UN-Habitat (2003). *The Challenge of the slums*: Global Report on Human settlements. London.

[23] UN (2005). *World Urbanization Prospects:* The 2005 Revision. Department of Economics and Social Affairs. Population Division.

[24] WHO (2006a). *Health and the MDGs: background.* http://www.who.int/mdg/background/en/index.html. Accessed May 21, 2010

[25] WHO (2006b). *Typhoid and Paratyphoid enteric fevers.* http://www.who.int/water sanitation health/disease/typhoid. Accessed August, 2012.