

Physico-Chemical and Heavy Metals Quality Assessment of Borehole Water in Different Residential Areas of Uyo Metropolis: A Case Study of G.R.A. and Low Income Residential Areas

Akpabio, J. J¹, Ekpo, F. E²

¹ Federal Polytechnic, Ukana, P. M. B. 2014, Ikot Ekpene, Akwa Ibom State, Nigeria

² Department of Biological Sciences Akwa Ibom State University, P. M. B. 1167, Uyo, Akwa Ibom State, Nigeria

Abstract: *Physico-chemical and heavy metals analyses of borehole water samples from four residential areas in Uyo Metropolis, Akwa Ibom State, Nigeria was carried out to ascertain the level of borehole water quality. The water samples were collected from Ewet and Shelter Afrique Housing Estates which are Government Residential Areas (GRA) and low income residential areas of Ikpa Road and Abak Road. The GRA are occupied by politician, senior civil servants while Ikpa Road and Abak Road residential areas are occupied by junior civil servants, students and petty traders. The parameters determined included: colour, odour, turbidity, temperature, pH, conductivity, alkalinity, Dissolved oxygen (DO), total dissolved solids (TDS), Nitrate, Chloride, Calcium and heavy metals such as Iron, Zinc, Manganese, Chromium, Lead and Cadmium using conventional equipment and standard laboratory procedures. Results obtained in borehole water collected from low income residential areas (Ikpa Road and Abak Road), showed traceable pollution that were above the World Health Organization (WHO) and National Agency for Food and Drug Administration Control (NAFDAC) limits for consumption. This results indicating toxic pollution in borehole water collected from Ikpa and Abak Roads residential areas. Heavy metals concentrations observed in borehole water from low income residential areas were above the WHO permissible level. This may be attributed to poor sanitary conditions and indiscriminate dumping of wastes in their environment. The results showed that borehole water in low income residential areas (Ikpa and Abak Road) in Uyo metropolis were strongly polluted and require urgent attention and high levels of treatment before use.*

Keywords: Borehole water quality, GRA, low income residential area, Uyo metropolis.

1. Introduction

Water is and has always been mankind's precious resource. It is recognized as the key environmental issue of the 21st century and a key to poverty alleviation (Hoffman, 2003). About 99% of the water on the planet earth is not suitable for human consumption and most of the water potential for drinking and domestic purposes is stored in groundwater (Walter, 2003). According to Macy *et al.*, (2007), water and sanitation are environmental health challenges facing developing countries. Lack of access to safe water and inadequate sanitation has an impact on individuals, households, communities and the countries. Where there is no clean water and proper sanitation in a community, millions of people suffer devastating diseases and millions of children die (Plate *et al.*, 2007). Diseases associated with unsafe water and inadequate sanitation affects poor people greatly. The gaps between the rich and the poor are attributed to the fact that environmental interventions have neglected sanitary needs. Interventions in water supply, sanitation and hygiene are the primary drivers of public health. They contribute greatly in the control of many diseases (Wordstone *et al.*, 2008). There is a link between poverty and water supply, for improvement of people's lives is not complete until there is provision of reliable, safe water supply. Most people living in low income residential areas in Uyo are poverty stricken and do not have water security. They mainly rely on borehole water source for their daily needs. This borehole water source is under threat of pollution from large increase in municipal and industrial waste disposal and also due to improper sanitation. Such pollution

impact has remained unmeasured and ignored over the years in low income residential areas in Uyo metropolis. The borehole water is used without treatment resulting in water being contaminated by leachate from the surrounding environment thereby posing serious health risk to the people (WHO, 2000). However, this study aims at examining the borehole water quality in four different residential areas in Uyo metropolis (Ewet and Shelter Afrique Housing Estate) which are occupied by politicians, senior civil servants and successful businessmen while (Ikpa Road and Abak Road) residential areas are occupied by students, junior civil servant and petty traders.

Study Area

The study was conducted in four different residential areas in Uyo Metropolis. The residential areas were Ewet Housing Estate, Shelter Afrique Housing Estate, Ikpa Road residential area and Abak Road residential area. Ewet Housing Estate and Shelter Afrique Housing Estate are Government Residential Areas that are occupied by politicians, senior civil servants, successful businessmen and senior citizens, while Ikpa Road residential area and Abak Road residential area are low income residential areas that are mainly occupied by the students, junior civil servants, petty traders, artisans and the poor people. Uyo is the capital city of Akwa Ibom State, and also the Local Government Council Headquarter. Water problems in Uyo metropolis range from scarcity and contamination of surface and underground water because of rapid development and industrialization. The high cost of treated bottled and sachet

water in Uyo metropolis, made the majority of the people especially those living in low income residential areas to rely on borehole water for their domestic and drinking purposes. Borehole water serves as the major source of domestic and drinking water in the study area. The water is under threat of pollution due to urbanization and industrialization that resulted from increase in municipal and industrial solid wastes.

2. Materials and Methods

Sample Collection and Preparation

At each of the four residential areas studied (Ewet, Shelter Afrique, Ikpa Road and Abak Road), four boreholes were randomly selected for water collection. The samples water was collected in triplicates from each borehole using white polyethylene bottles. The bottles were rinsed with water to be sampled prior to collection. Sufficient air spaces were left in all bottles except those for Dissolve Oxygen (DO) determination to allow for expansion of the water at increased temperature. In all cases, sampling bottles were used directly by holding the bottles horizontally and allowing the water to flow in gently, the bottles were gradually raised until it is sufficient. The pH was determined using the Hanna microprocessor pH meter. It was standardized with a buffer solution of pH range between 7.0. The temperature was determined in-situ at the site of sample collection using a mobile thermometer. This was done by dipping the thermometer into the sample and recording the stable reading. The Dissolved Oxygen (DO) was determined by using the Winkler's Method (Ademoroti, 1996). The conductivity, Total Dissolved Solid (TDS) and salinity were determined in the laboratory using the Jenway Conductimeter model MC METTLER TOLEDO. The chloride was determined by argentometric method, and nitrate (NO_3) by UV spectrophotometric method (APHA, 1992). The Total Solids (TS), Dissolved Solids (DS) and Suspended Solids (SS) were determined gravimetrically (Ademoroti, 1996). Heavy metals in the borehole water samples were determined by atomic absorption spectrophotometry (ASS) (Unicam 919 model) (Skoog and West, 1980).

3. Results and Discussion

The results of the physico-chemical properties of borehole water samples collected from different residential areas in Uyo, Akwa Ibom State of Nigeria is presented in table 1. The presence of colour and odour in water samples collected from low income residential areas (Ikpa Road and Abak Road) were an indication of pollution and confirmed leachates infiltration into the borehole (Ogedengbe and Akinbile 2007). Potable water must be colourless, odourless, tasteless and free from objectionable and pathogenic organisms (WHO 2004). The temperatures ranged of borehole water samples in Ikpa Road and Abak Road residential areas were (29.6°C and 29.4°C) respectively while the temperature recorded in Ewet and Shelter Afrique Housing Estate were (26.8°C and 27.2°C) respectively. The high temperature in borehole water samples recorded in low income residential areas (Ikpa Road and Abak Road) signified presence of active micro organisms which resulted

in the temperature increase. The high temperature values observed in low income residential areas were above the acceptable range of 26.5°C to 27.5°C WHO and NAFDAC standard for drinking and domestic water, hence indicating the presence of foreign bodies in the water samples. Similar results were reported by (Opeyee *et al.* 2001) in their studies of water pollution in low income residential area of Ogun State, Nigeria. Pollution from municipal wastes and septic tanks in low income residential areas (Ikpa Road and Abak Road) may also be responsible for the high values for temperature in the water samples analyzed. The turbidity readings of the borehole water samples collected from low income residential areas (Ikpa Road and Abak Road) were above the WHO (1985) standards of 5.0 NTU. Presence of suspended particles and other materials are usually responsible for high turbidity values. The high turbidity values in borehole water observed in Ikpa Road and Abak Road residential areas may be an indication of irregular washing and treatment of the water tanks in the areas especially as those borehole are used for commercial purposes. Adesina (2001) also reported that high turbidity values in borehole water may be caused by unlined well. However, it is sometime observed that soil particles may have found their way into the wells from the unstable side walls thereby increasing turbidity of the water. The observed turbidity values of borehole water obtained from Ewet and Shelter Afrique Housing Estates fall within the recommended standards of 5.0 NTU (WHO, 2004). The pH values observed for the water samples obtained from Ikpa Road and Abak Road residential areas were (5.55 and 5.70) respectively. The pH values recorded in Ewet and Shelter Afrique Housing Estates were 6.84 and 6.90. The pH values in low income residential areas were below the permissible levels of 6.50-8.50 recommended by NAFDAC and WHO

All borehole water samples collected in Uyo metropolis had no trace of alkalinity, alkalinity in water gives unpalatable taste (Goel, 2006). The chloride contents were 71.3mg/l for Ikpa Road and 85.3mg/L in Abak Road residential areas. In Ewet and Shelter Afrique Housing Estates the chloride contents were 72.3mg/l and 78.0mg/l respectively. The chloride contents in all the borehole water analyzed in Uyo metropolis were lower than the standards of WHO (250mg/L). Udoessien (2009) reported that high chlorine concentration gives an undesirable salty taste to water. Conductivity values in low income residential areas of Ikpa Road and Abak Road were $340.50 \mu\text{S}/\text{cm}$ and $400.00 \mu\text{S}/\text{cm}$ while the Ewet and Shelter Afrique Housing Estate recorded $250.65 \mu\text{S}/\text{cm}$ and $270.30 \mu\text{S}/\text{cm}$. These values were below the maximum standards of domestic and drinking water of $1000 \mu\text{S}/\text{cm}$ (WHO, 2000).

All the borehole water collected from Uyo Metropolis had low values for total hardness ($10.00\text{mg}/\text{l}$ - $23.00\text{mg}/\text{L}$). The result was in line with work of Akpan (2004) for total hardness of borehole water in Uyo, Akwa Ibom State, Nigeria.

Total Solid values in borehole water obtained in Ewet and Shelter Afrique Housing Estate were $125.0\text{mg}/\text{L}$ and $175.0\text{mg}/\text{L}$, these values were lower than the maximum value allowed by NAFDAC and WHO of $500\text{mg}/\text{L}$ while the

values recorded in low income residential areas off Ikpa Road 640.0mg/l and Abak Road 620.0mg/l were above the acceptable standards (WHO, 2000). Presences of solid particles in water indicate contamination (Goel, 2006). Nwosu and Ogueke (2004) observed that presence of solids may be as a result of poor sanitation. The high values of total solid recorded in low income residential areas may be as result of indiscriminate dumping of wastes and poor sanitary conditions in the environment. The concentrations of nitrate in borehole water samples in low income residential areas off Ikpa Road and Abak Road were 11.4 mg/l and 11.9mg/l respectively while 9.7mg/l and 9.5mg/l were observed in Ewet and Shelter Afrique Housing Estates. Nitrate is the most highly oxidized form of nitrogen compounds and it is commonly present in surface and ground waters because it is the end product of the aerobic decomposition of organic nitrogenous matter. The high values of nitrate observed in low income residential areas in Uyo metropolis may be attributed to poor management of solid wastes in these residential areas. Nitrates are relatively short-lived because they are quickly used by plants and bacteria. In man nitrates react directly with hemoglobin in human blood to produce methemoglobin which destroys the ability of blood cells to transport oxygen. This condition is specially serious in babies under three months of age as it causes a condition known as methemoglobinemia or "blue baby" disease (Walter, 2003). Nitrate is a major ingredient in farm fertilizer and necessary for crop production. After rainfall, varying quantities of nitrate are washed from farmland into nearby waterways and also to groundwater table through infiltration, percolation and seepage. Nitrates also get into waterways from leaking septic tanks, leachate from landfills, manure from livestock animal wastes.

The concentrations of Dissolved Oxygen (DO) in low income residential area (Ikpa Road and Abak Road) were 12.4mg /L and 12.0mg/l. The high value of DO recorded in low income residential areas in Uyo Metropolis showed that the borehole water samples in these areas were unsafe for consumption. The higher DO value is an indication of oxygen depletion which also inferred the presence of pollutants that use up the oxygen in water. The DO values observed in Ewet and Shelter Afrique Housing Estate were 7.5mg/l and 8.0mg/l respectively. Though the values are not up to maximum permissible level of WHO by showing traces of pollutants in the borehole water. But there are evidences of water being treated on regular basis in the area. The results also showed an effective quality control system and a high level of sanitation in the areas.

Table 2 showed heavy metals concentrations in borehole water samples collected in four different residential areas in Uyo Metropolis, Akwa Ibom State. The heavy metals were iron, lead, zinc, manganese, chromium and cadmium. The presence of some of these metals in high concentration was an indication that the borehole water is polluted especially in the low income residential areas. The pollution may be due to sitting of borehole close to septic tanks, indiscriminate

dumping of wastes, leachate from municipal and industrial wastes and other materials with certain degree of toxicity. WHO (2004) recommended a value of 0.1mg/l as tolerable level for manganese, above 0.5mg/l will impair potability. Though not detected in all the residential areas studied, it is reported that its excessive concentrations in water could result in taste and precipitation problems (Ekpo, 2012). The concentration of iron and lead in water samples collected from Ikpa Road and Abak Road residential areas were (2.3mg/l and 1.4mg/l) (2.6mg/l and 1.7mg/l) respectively. The high concentration of these metals in the low income residential areas was a clear indication of presence of toxic wastes in the area. The maximum permissible of iron content in drinking water is 0.3mg/L (NAFDAC, 2008) above which the water is unsafe for consumption. Lead must not be more than 0.01 mg/L as the water becomes poisonous if present in higher concentration. These values were higher than the desired concentrations for drinking water hence unfit for use as potable water. Shyamala *et al.* (2001) observed that formation of goiter in adults in Kenya was as a result of consumption of water with quantity of iron above the specified values. The concentrations of zinc in Ewet, Shelter Afrique, Ikpa Road and Abak Road residential areas were 2.9 mg/l, 2.4 mg/l, 3.7 mg/l and 4.3 mg/l respectively. The concentrations of zinc in these areas were not up to the maximum permissible level of drinking water. This indicates that there were traces of pollution the water samples collected from Uyo metropolis. The zinc contamination observed in borehole water in Uyo metropolis may be as a result of wastes containing zinc metals which were used in the areas, decomposed and found its way into the water table. The presence of chromium and cadmium in the borehole water samples in Uyo metropolis suggest pollution and a clear indication of the danger pose to consumers.

4. Conclusion

Assessment of water quality is an important factor for assessment of pollution levels in an environment. This study revealed that borehole water in low income residential areas of Ikpa Road and Abak Road is not suitable for drinking and use for domestic purposes while borehole water from Ewet and Shelter Afrique Housing Estates is suitable for drinking and use for other domestic purposes. As the results of borehole water collected from Ewet and Shelter Afrique Housing Estate is near WHO standards. Regular assessment of both physico-chemical and microbial analysis of borehole water in the low income residential areas should be carried out as this would be helpful in early detection of pollutants. Water quality studies should be given a priority, be integrated into development plans and be conducted on a regular basis to assess risks of contamination in water sources. Indiscriminate dumping of refuse should be discouraged and government should provide proper method of waste disposal.

Table 1: Mean values of Physico-chemical parameters of borehole water samples collected in four residential areas of Uyo Metropolis

Physico-chemical Parameters	Ewet Housing Estate	Shelter Africk Housing Estate	Ikpa Road Residential Areas	AbakRoad Residential Areas	WHO Standard	NAFDAC
Temperature (°C)	26.8	27.2	29.6	29.4	25-27	25-27
pH	6.84	6.90	6.21	5.92	6.5-8.5	6.5-8.5
Colour (TCU)	Unobjectionable	unobjectionable	objectionable	objectionable	objectionable	objectionable
Odour	3.00	2.70	4.00	4.50	3.00	3.00
Turbidity (NTU)	4.8	5.0	6.3	6.7	5.00	5.00
Total Dissolved Solid (mg/l)	125.0	175.0	640	620	500	500
Dissolve Oxygen (mg/l)	7.50	8.00	12.40	12.00	10	10
Biological Oxygen Demand (mg/l)	0.001	0.001	1.50	1.35	0	0
Calcium (mg/l)	70.00	65.00	73.00	74.50	75	75
Nitrate NO ₃ (mg/l)	9.70	9.50	12.40	11.90	10	10
Chloride (mg/l)	72.30	78.00	71.30	85.30	100	100

Table 2: Mean values of heavy metals concentrations in borehole water samples collected in four residential areas of Uyo Metropolis

Heavy metals	Ewet Housing Estate	Shelter Africk Housing Estate	Ikpa Road Residential Areas	Abak Road Residential Areas	WHO Standard	NAFDAC Standard
Iron (mg/l)	0.5	0.40	1.30	1.60	0.3	0.3
Manganese (mg/l)	0.04	0.06	1.00	0.10	0.05	0.05
Zinc (mg/l)	2.9	2.40	2.10	1.30	5.0	5.0
Chromium (mg/l)	0.50	0.70	1.00	1.05	0.05	0.05
Cadmium (mg/l)	0.007	0.006	0.10	0.09	0.005	0.005
Lead (mg/l)	0.02	0.01	0.07	0.05	0.01	0.01
Copper (mg/l)	0.04	0.05	0.10	0.08	0.05	1.0
Nickel (mg/l)	ND	ND	ND	ND	0.001	0.001

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