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Physicochemical properties and heavy metal content of selected water sources in Ishiagu, Ebonyi State- Nigeria

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Abstract

The physicochemical properties and heavy metal content of selected water sources within two kilometers from a quarry site in Ishiagu was investigated using standard methods. Biochemical oxygen demand, chemical oxygen demand, total dissolved solids and nitrate were above the World Health Organization (WHO) permissible limits for drinking water at the quarry site and one kilometer from the quarry site. Total hardness, chloride and fluoride were above the WHO permissible limits at the quarry site. A higher concentration above WHO specification, were also observed in phosphate and conductivity in all the samples. The metals (Aluminum, Cadmium, Iron, Zinc, Lead, Calcium and Magnesium) occurred above WHO permissible limits for drinking water in all the samples but, lead was not detected in the sample collected two kilometers away from the quarry site. Sodium, potassium, manganese and copper were above the WHO permissible limits in samples collected from the quarry site. These results indicate that the water sources were contaminated and unfit for human consumption. Communities within the area require alternative sources of potable water for drinking and domestic purposes.

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Introduction

Water is of considerable importance in nature, particularly essential for man's existence hence, the need for the provision of potable water in any community. Water is the most widespread natural resource and may be regarded as the second most important necessity of man (Baptist, 1980). Water of good drinking quality is of basic importance to human physiology and man's continual existence depends very much on its availability (Lamikanra, 1999).

Due to inability of governments to meet the ever-increasing water demand, people resort to groundwater sources such as shallow wells and boreholes as alternative water resources (LAWMA, 2000). In the cities pipe borne water is available but, some rural dwellers in some communities rely basically on hand-dug wells for potable water supply as the streams usually dry in dry seasons (Adekunle *et al*., 2007).

Before now, groundwater had been considered as uncontaminated but, presently either these water sources are under threat from pollution as a result of human life style manifested by the low level of hygiene practiced by the developing nations or leaching from solid rocks, industrial and agricultural practices (Akujieze *et al*., 2003, Ikem *et al*., 2002) . The quality of groundwater may also be affected by the characteristics of the media through which the water passes on its way to groundwater zone of saturation (Raji and Alagbe, 1997).

Ishiagu is a community where quarry sites and lead/zinc mines are located and every family has their well for source of potable water during dry season because the streams within the area usually dry at this period. There are literatures on physicochemical studies on polluted water sources (Akubugwo *et al*., 2007, Singh *et al*., 2009, Abulude, 2007, Agbaire and Obi, 2009) but, much work have not been done on the quality of hand dug wells in Ishiagu. This study attempts to determine the physicochemical characteristics and heavy metal content of the water sources in Ishiagu.

Materials and methods

Sampling sites

Ishiagu is located at Ivo Local Government Area of Ebonyi State and the area experience dry season between October and April of every year. The settlers are predominantly peasant farmers and the major industrial activities sited in the area are Lead/Zinc mines and quarry sites. The rural folks in the area depend on hand-dug wells for the sources of water for drinking and domestic purposes during dry season.

For this study water samples were collected at SETRACO quarry site (Sample A), 1 kilometer from the quarry site (Sample B) and 2 kilometers from the quarry site (Sample C).

Sample collection and analysis

The samples were collected at the three different sampling points with 2000ml plastic containers. The portion of the water sample for metal analysis were treated with 1ml of Hydrochloric acid (HCl) in 500ml sample to arrest microbial activities while those for non-metal analysis were freshly refrigerated in a cooler packed with, ice blocks to avoid microbial action affecting their concentration.

The physicochemical properties of the water samples were determined according to standard methods. The physicochemical properties determined include pH, Colour, Temperature, Total alkalinity, Turbidity, Conductivity, Total hardness, Total Dissolved Solids (TDS), Total Suspended Solids (TSS), Dissolved Oxygen (DO), Biochemical Oxygen Demand (BOD) and Chemical Oxygen Demand (COD).

The heavy metal concentration were estimated using Atomic Absorption Spectrophotometric (AAS) method after acid digestion, sodium and potassium were determined with flame photometer using direct aspiration method (APHA,1998). The data generated

were compared with World Health Organization (WHO, 2003) standards for drinking water.

Data analysis

Statistical analysis were carried out using analysis of variance (ANOVA) and means were compared for significance with the Duncan's Multiple Range Test at P<0.05 (Sokal and Rholf, 1969)

Results

The result in table 1 shows the physicochemical properties of water sources at Ishiagu compared with the World Health Organization (WHO, 2003) standards for drinking water. The well water at Ishiagu quarry site (Sample A) were found to have low total alkalinity value (36.67±1.53mg/l) followed by 209.67±0.58mg/l at about 2km from the quarry site (sample C) and then 335.00±1.00mg/l at about 1km from the quarry site (sample B). The sample A was slightly acidic (pH 6.43 ± 0.06) while sample B and sample C had pH of 7.67±0.06 and 7.40 ±0.00 respectively.

Table 1. Physicochemical properties of water sources in Ishiagu.

Parameters	Sample A	Sample B	Sample C	WHO
Total Alkalinity (mg/l)	36.67±1.53^{a}	335.00±1.00^{c}	209.67±0.58^{b}	600
pH	6.43±0.06^{a}	7.67 ±0.06^{c}	7.40±0.00^{b}	6.5 – 8.5
Temperature (^{o}C)	29.27 ±0.058^{a}	30.90±0.00^{c}	30.03 ±0.06^{b}	25 – 30
Colour (Pt.CO)	5.00±0.00^{a}	2.00±0.00^{a}	3.00 ±0.00^{a}	15
Conductivity (μS/CM)	9700.00±0.00^{c}	863.33±2.52^{b}	576.67±1.15^{a}	250
DO mg/l	22.10±1.13^{a}	21.65±1.87^{a}	21.50±0.43^{a}	7.5
BOD mg/l	20.74±2.22^{c}	8.39±1.87^{b}	2.48±0.43^{a}	2.0-6.0
COD mg/l	112.00±8.00^{c}	7.60±0.82^{b}	2.48±0.43^{a}	7.5
TDS mg/l	4083.33±28.87^{c}	550.00±50.00^{b}	26.67±28.87^{a}	250-500
TSS mg/l	100.00±0.00^{c}	66.67±28.87^{b}	33.33±28.87^{a}	-
Total hardness (mg/l)	1963.33±20.82^{c}	35.33±11.55^{a}	400.64±9.06^{b}	150 – 500
Turbidity (NTU)	Nil	Nil	Nil	5.0

The values were expressed as mean ± SD (n=3). Values in the same row, bearing difference superscript letters differ significantly (P<0.05). Sample A = Water samples fetched from well at Ishiagu quarry site; Sample B = Water samples fetched from well at a distance of 1km from Ishiagu quarry site; Sample C = Water samples fetched from well at a distance of 2km from Ishiagu quarry site.

Table 2. Concentration of non-metallic ions in the water samples at Ishiagu measured in milligram per litre (mg/l).

Parameters	Sample A	Sample B	Sample C	WHO
Fluoride	10.20±1.00^{c}	0.93±0.01^{b}	0.04±0.00^{a}	1.5
Phosphate	5.07±0.28^{a}	34.27±0.08^{b}	39.12±0.08^{c}	5.0
Sulphate	278.22±0.69^{c}	208.72±1.16^{b}	99.69±1.25^{a}	500.0
Chloride	697.56±18.62^{c}	225.83±18.62^{b}	145.17±16.13^{a}	250.0
Nitrate	86.59±0.06^{c}	10.75±0.03^{b}	4.56±0.02^{a}	10.0

The values were expressed as the mean ±SD (n=3). Values in the same row, bearing different superscripts differ significantly (P<0.05). Sample A = Water samples fetched from well at Ishiagu quarry site; Sample B = Water samples fetched from well at a distance of 1km from Ishiagu quarry site; Sample C = Water samples fetched from well at a distance of 2km from Ishiagu quarry site.

Table 3. Concentration of metals in the water samples at Ishiagu measured in milligram per litre (mg/l).

Parameters	Sample A	Sample B	Sample C	WHO
Aluminum	2.27 ± 0.01^{c}	0.407 ±0.01^{b}	0.37 ±0.03^{a}	0.2
Cadmium	0.53 ± 0.01^{c}	0.07 ±0.01^{b}	0.03 ±0.01^{a}	0.003
Copper	15.21 ± 0.01^{c}	1.71 ±0.01^{b}	0.84 ±0.02^{a}	2.0
Chromium	3.65 ±0.03^{c}	0.54±0.02^{b}	0.07 ±0.01^{a}	0.05
Iron	566.00 ±0.20^{c}	5.47 ±0.03^{b}	2.12 ±0.01^{a}	0.3
Manganese	5.86 ± 0.01^{c}	0.19 ±0.01^{b}	0.08 ±0.01^{a}	0.5
Lead	3.11 ±0.01^{c}	0.26 ±0.01^{b}	ND^{a}	0.01
Zinc	217.55±0.51^{c}	56.21±0.06^{b}	10.56±0.01^{a}	3.0
Potassium	39.50±0.10^{c}	14.40±0.01^{b}	3.87±0.01^{a}	-
Sodium	245.77 ±0.35^{c}	25.20 ±0.40^{b}	11.70 ±0.26^{a}	200.0
Magnesium	173.00 ±1.00^{c}	35.67 ±0.58^{b}	125.00±1.00^{a}	50.0
Calcium	945.00±1.00^{c}	126.33±1.53^{b}	82.33±0.58^{a}	75.0

The values were expressed as the mean ±SD. (n=3). Values in the same row, bearing different superscript letters differ significantly (P<0.05). Sample A = Water samples fetched from well at Ishiagu quarry site; Sample B = Water samples fetched from well at a distance of 1km from Ishiagu quarry site; Sample C = Water samples fetched from well at a distance of 2km from Ishiagu quarry site; ND = Not Detected

The temperature ranged from 29.27±0.058^{o}C in sample A to 30.90±0.00^{o}C in sample B. A highest conductivity value of 9700.00±0.00 µS/CM was observed in sample A followed by sample B and C. Biochemical Oxygen Demand (BOD), Dissolved Oxygen (DO), Chemical Oxygen Demand (COD), Total Dissolved Solid (TDS), Total Suspended Solid (TSS) had the highest concentration at sample A followed by sample B and then sample C. total hardness was higher in sample A followed by sample C and in sample B the total hardness was observed to be low.

Table 2 shows the non-metallic concentration of potable water sources in Ishiagu compared with World Health Organization standard for drinking water. Fluoride, sulphate, chloride and nitrate decreased in concentration from the quarry site down to a distance of 2km from the quarry site while only phosphate was found to increase in concentration from the quarry site to a distance of 2km from the quarry site. Fluoride and chloride were higher than WHO standard only at sample A and only nitrate was higher in both sample A and sample B. Sulphate was observed to be within the standard in all the samples and phosphate above the standard in all the samples.

Table 3 shows the heavy metal concentration of potable water sources in Ishiagu compared with WHO standard. The heavy metals were higher in sample A followed by sample B and then sample C, but lead was not detected at sample C as reported in Table 3. Other minerals such as potassium, sodium and calcium followed the same trend with the heavy metals except magnesium which was observed higher in sample C (125.00 ± 1.00mg/l) than sample B (35.67 ± 0.58mg/l).

Discussion

The Biochemical Oxygen Demand (BOD) and Chemical Oxygen Demand (COD) were observed to have a marked high value at the quarry site and 1km from the quarry site which may be attributed to organic, inorganic and oxygen demanding pollutants present in the water sources (Amadi *et al.*, 2006., Oladiji *et al.*, 2004., Akan *et al.*, 2008). High values of BOD and COD (Oladiji *et al.*, 2004, Adekunle *et al.*, 2007, Singh *et al.*, 2008) shows that the water samples are polluted.

Another evidence of pollution is the high level of Total Dissolved Solids (TDS) and Total Suspended Solids (TSS) and this indicate materials carried in suspended form (Amadi *et al*., 2006). Low level of total solids shows good quality river waters, while very high value of TDS confirm the observed high conductivity value of the potable water samples. The above result agrees with the reports of other researchers (Amadi *et al*., 2006, Adekunle *et al*., 2007) in polluted water samples.

The high conductivity level of the potable water samples indicate electrolyte contaminants but, do not give information of a specific chemical (Adekunle *et al*., 2007). The high conductivity level may also explain the high level of total hardness which may be due to the appreciable high concentration of calcium and magnesium in the potable water sources. Calcium and magnesium have been reported to be consistent with total hardness (Abulude *et al*., 2007). Very high level of total hardness makes water unfit for domestic use.

The high level of calcium, magnesium, Aluminum, potassium and sodium may be attributed to natural processes such as weathering of rocks, erosion, human activities like mining, quarrying, farming, calcium laden dust and leaching of rocks (Akubugwo *et al*., 2007.,Singh, 2008.,Umeham and Elekwa, 2005).

The heavy metals examined in the study showed a decrease from the quarry site down to 2km from the quarry site and this may be correlated with the dusts from the quarry sites, which settled at the bottom of the well as they are carried by the wind and dissociation from bedrocks through which the water flows (Adepelumi *et al*., 2001). It may also be due to anthropogenic influence such as small-scale entrepreneur activities which include open-air solid waste combustion, mining, quarrying, gas stations and smoke from automobile (Adepelumi *et al*., 2001, Adekunle *et al*., 2007). High level of heavy metals leads to increase serum liver enzymes, kidney function parameters and reduction in haemoglobin level packed cell volume and Red Blood Cells (Ikem *et al*., 2002, Vinodhini and Narayanan, 2009, Agbafor *et al*., 2007).

The high level of non-metallic ion such as nitrate, chloride, phosphate and fluoride of the potable waters may be traced to dissociation of their metallic compounds, oxidation of other forms of the compounds, high degree organic pollution, and type of minerals in the bedrock, eutrophication, agricultural activities and use of detergents (Goel *et al*., 1980, Osibanjo and Adie, 2007). Nitrate concentration above 10mg/l is dangerous to pregnant women and poses a serious health threat to infants less than three to six months of age because of its ability to cause methaemoglobinaemia or blue baby syndrome in which blood loses its ability to carry sufficient oxygen (Burkart and Kolpin, 1993) while high fluoride level in drinking water may lead to reduction in total erythrocyte, haemoglobin percentage, haematocrit value, protein content and then fluorosis (Sharma, 2004). This implies that the potable water in Ishiagu is polluted with organic and inorganic substances and therefore unfit for drinking at its present state.

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