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Short Communication

QUALITY ASSESSMENT OF SELECTED GROUNDWATER SAMPLES IN AMIKE – ABA, ABAKALIKI EBONYI STATE, NIGERIA

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ABSTRACT

The quality of selected groundwater (borehole) samples in Amike – Aba, were assessed for physicochemical parameters, trace metals and bacteriological tests for a period of seven weeks following standard water sampling and analysis procedures. The results of the physicochemical parameters showed the range 6.38 – 6.44 for pH, 26.20 – 26.35 for temperature, 0.20 – 0.25 mg/L O_2 for BOD_5, 10.87 – 12.98 µS/cm for conductivity, 32.16 – 34.87 mg/L for total hardness and 4.00 – 6.00 TCU for colour. The result of the bacteriological analysis showed that the total heterotrophic bacteria count (THBC) of the samples ranged from $2.4 \times 10^2 – 4.2 \times 10^3$ CFU/mL. The total coliform count also ranged from 280 – 540 MPN/100 mL. The study revealed the presence of *Escherichia coli*, *Proteus sp.*, *Psedomonas aeuginosa*, *Enterobacter aerogenes*, *Streptococcus faecalis* and *Bacillus sp*. in the water samples. The results of the trace metals showed the range (in mg/L) 0.223 – 0.273 for Fe, 0.048 – 0.059 for Cr, 0.0081 – 0.099 for Pb, 0.032 – 0.040 for Cu, 0.021 – 0.024 for Mn and 0.097 – 0.143 for Mg. Compared with World Health Organization limits and Nigerian Standard for Drinking Water Quality, the results revealed the groundwater samples are facing various hydrological stress and possible contamination which could change the quality of the groundwater in the near future.

Keywords: Groundwater, quality assessment, trace metals, coliforms, physicochemical parameters.

INTRODUCTION

Groundwater exists below the surface of the ground in the spaces between particles of rock or soil, or in the crevices and cracks in rocks, usually within 100 meters of the surface of the Earth (SGS, 2012). It plays an important role in both private and public water supplies all over the world (Pradhan and Pirasteh, 2011; Ibeh and Okplenye, 2005). This is because groundwater forms a major part of freshwater use globally (SGS, 2012). Also in most developing countries today, groundwater remains the only source of potable water supply, giving rise to high numbers of boreholes and wells. Again, it is likely that many people in developing countries have preferences for boreholes to other sources of water supply. This is also in line with view of World Health Organisation (WHO) that boreholes are resistant to many forms of natural and manmade disasters (except in cases of high magnitude earthquake), and the narrow opening at the top of the borehole often prevents contamination of the water source or damage to the pump components below ground (WHO, 2011).

However, in spite of the seemingly availability of water, the challenge of ensuring usable water in sufficient quantities remains a primary issue in most developing countries (Amangabara and Ejenma, 2012). The reasons for this are enormous. First, groundwater contains a variety of constituents such as microorganisms, gases, inorganic and organic materials, etc at different concentrations (Sundaram *et al*., 2009; SGS, 2012) which may constitute undesirable pollutant when they are not within WHO guidelines for drinking water (Nkamare *et al*., 2012). Anthropogenic contamination of the water even at the source is the second issue. For example, water contamination with trace metals can be related to polluted water infiltrating through soil, rock and eventually reaching the groundwater (Oladipo *et al*., 2011). Also, exposure of water to hostile environmental factors over a long period of time such as extreme sunlight, high temperature, segmentation, biological action, etc. tend to introduce either bacteria or viruses into the water (Okonkwo *et al*., 2012). Finally, water is an excellent solvent which tends to dissolve the minerals in the geological system. The greater part of the soluble constituents in groundwater comes from soluble minerals in soils and sedimentary rocks (Sundaram *et al*., 2009). According to Pradhan and Pirasteh (2011), the chemical nature of the ground water is influenced by several factors such as chemical weathering of the country rocks and interaction with the country rocks.

Abakaliki is a rapidly developing urban city where public water supply is nearly absent or in short supply especially

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in the suburb areas such as Amike – Aba. This has made groundwater (borehole) as a major source of water supply in the area for domestic use and for drinking. It is also pertinent to note that Abakaliki and Ebonyi State in general was before now one of the Guinea worm endemic areas of the country (Ekpo, 1990) and incidences of waterborne diseases such as cholera, dysentry, typhoid fever etc. are common. The recent upsurge in population in the area due to its current status as a State capital has given rise to unprofessional engaging in building/ construction of houses and sinking of boreholes without recourse to standard sanitary specifications (e.g. The WHO recommends that boreholes should be located at least 30 km away from latrines and 17m from septic tanks (Ibeh and Okplenye, 2005). Cases of some boreholes located close or adjacent to septic tanks/soak aways abound leading to contamination through underground seepages.

The quality assessment of groundwater samples in Amike – Aba has not been reported. There is also the need for regular monitoring and assessment of drinking water sources. This is because monitoring provides data on groundwater quantity and quality and it is an integral aspect of groundwater management (Sundaram *et al*., 2009).

The aim of this work is to estimate the presence of some of the parameters that are implicated in water pollution and ascertain their levels if present and compare their levels with that of WHO standard and Nigeria Industrial standards (NIS 554, 2007) for drinking water where applicable.

MATERIALS AND METHODS

The Study Area

Ebonyi State, South-East Nigeria, is an agrarian State with high mineral deposits. Abakaliki is on lat. 6.21N and long. 8.07E (Collins-Longman, 1981) and area falls within the climatic region of Southern Eastern Nigeria where the rainy season spans from April to October and the dry season from October to April (Ezeh and Ugwu, 2007). The average annual rainfall of the study area is about 1500mm with actual surface temperature (seasonal temperature) of between 24-36^{0}C during dry season and about 18 ^{0}C during the rainy season (Ezeh and Ugwu, 2007; Collins-Longman, 1981).

Sampling Protocols and Analysis

In order to avoid contamination, all glassware, high-density polyethylene (HDPE) storage bottles for reagent solutions and plastic items were acid cleaned following a standard procedure. All items for collecting and storing samples and reagents were first washed with distilled water, soaked in a 10% HCl solution for at least 24h (Prior and Johnes, 2002) and rinsed three times with distilled water. The washed items were dried and stored in zip locked polyethylene bags. However, the glass containers for microbial analysis were further sterilized using a hot air oven at 37^{0}C for 1h. All metallic wares were autoclaved at 121^{0}C for 15minutes.

The water samples were collected thrice-a-week for a period of seven weeks. Water samples were randomly collected in sterile, wide mouthed containers (*ca.* 1 litre) with cap. The water was allowed to run from the tap for about three minutes. The containers were completely filled with water and capped to prevent spillage. The samples for metal analysis were spiked with 1 mL of concentrated nitric acid. All the samples were protected from direct sunlight and transported to the laboratory in an ice-pack. The samples were kept in the refrigerator at 4^{0}C and analyses within one hour of collection and maximum of 24h. However, pH, temperature, dissolved oxygen; conductivity and turbidity were carried out *in-situ* at the sampling sites using probes (see Table 1).

The metallic contents of the samples were determined using atomic absorption spectroscopy (AAS) (Perkin-Elmer Buck Scientific VGP 210) according to standard procedures (Mendham *et al*., 2004). The Total Heterotrophic Bacteria Count (THBC) was carried out by the standard plate count procedures as described by (Benson, 2011) using plate count agar. Plates were incubated at 35^{0}C for 24h. The Total Coliform Count (TCC) was determined using the Most Probable Number (MPN) method (Benson, 2011) while morphological, physicological and biochemical characteristic method was used for identification of the bacterial species according to the scheme of (Holt *et al*., 1994).

RESULTS AND DISCUSSION

The results of the physicochemical parameters are presented in table 2 which was compared with standards for drinking water. The parameters were within the acceptable limits and present the water samples as potable. The pH of the samples was not too acidic and was slightly stable over the range (6.38 – 6.44). Hence, the pH was not influenced by treatment breakdowns or other accidental spills which affect groundwater (Sundaram *et al*., 2009). The temperature range also had little impact on the levels of inorganic constituents and chemical contaminants (see Tables 4 and 5) and the range of the water temperature which was not high did not increase problems related to taste, odour and color. The fairly stable temperature observed (26.20 – 26.35^{0}C) is not surprising since ground water is stored underground it has a relatively constant temperature throughout the year (Sundaram *et al*., 2009). Although the temperature and ionic compositions of water significantly affects the electrical conductivity of water, the values recorded were far below the acceptable standard (1000µS/cm) which

Table 1. Physicochemical parameters and method of determination.

Physicochemical parameters	Instrument/Method
pH	pH – 201 Lutron (Taiwan)
Conductivity	Lutron WA 300 Conductivity meter (Taiwan)
Dissolved Oxygen	Lutron 5509 DO meter (Taiwan)
Colour	Laser Beam Spectrometer DR 3000 HACH (USA)
Temperature	Portable digital multi-stem thermometer (Model – ST -9269)
Turbidity	Turbidimeter
BOD	Titration
Total Hardness	Titration

Table 2. Mean variation of the physicochemical properties (± standard error, SE) of the samples compared with the WHO standards (n = 7).

Parameter/unit	Range	Mean ± SE	Standard
pH	6.38 – 6.44	6.39 ± 0.015	6.5 – 8.5[a,b]
Temperature (^{0}C)	26.20 – 26.35	26.30 ± 0.028	Ambient[a]
BOD_5 (mg/L O_2)	0.20 – 0.25	0.23 ± 0.013	< 3.0[a]
Conductivity (μS/cm)	10.87 – 12.98	11.89 ± 0.346	1000[a]
Total hardness (mg/L)	32.16 – 34.87	33.34 ± 0.542	150[a]
Turbidity (NTU)*	0.00 – 0.00	0.00 ± 0.00	5[a,b]
Colour (TCU)*	4.00 – 6.00	4.80 ± 0.374	15.0[a]

[a]Nigerian Standard for Drinking Water Quality (Nigerian Industrial Standard NIS 554:2007) (Standard Organisation of Nigeria (SON), 2007), [b]Guidelines for Drinking-water Quality (WHO, 2011).
*NTU = nephelometric turbidity unit, TCU = true colour units

Table 3. Total heterotrophic bacterial count (THBC) (CFU/mL) and total coliform count (TCC) (MPN/100 mL) (n = 7).

S. NO.	Sample code	Range of THB count (CFU/mL)	Mean THB count (CFU/mL)	Range of total coliform (MPN/100 mL)	Mean total coliform (MPN/100 mL)
1	S – A	$2.4 \times 10^3 – 3.1 \times 10^3$	2.8×10^3	350 – 390	380
2	S – B	$3.9 \times 10^3 – 4.5 \times 10^3$	4.2×10^3	520 – 560	540
3	S – C	$1.1 \times 10^3 – 1.8 \times 10^3$	1.4×10^3	250 – 300	280
4	S – D	$2.2 \times 10^2 – 2.6 \times 10^2$	2.4×10^2	330 – 350	340
5	S – E	$3.6 \times 10^3 – 4.3 \times 10^3$	4.2×10^3	440 – 460	440

*MPN = Most probable number

implied little or no contributions of the parameters to its elevation. The water samples were not hard (32.16 – 34.87mg/L) or turbid and significantly had no visible coloration (4.00 – 6.00 TCU).

The result of the bacteriological test is presented in table 3. Samples S – B and S – E had the highest THBC of 4.2×10^3 CFU/mL respectively while sample S – D had the lowest count of 2.4×10^2 CFU/mL. The result of the TCC showed that sample S – B had the highest count of 540 while S – C had the least count of 280. The presence of coliforms in the water samples indicates inadequate treatment and contamination (WHO, 2008). Bacterial species isolated included *Escherichia coli*, *Proteus sp.*, *Psedomonas aeuginosa*, *Enterobacter aerogenes*, *Streptococcus faecalis* and *Bacillus sp*. The presence of *E. coli* indicates that the groundwater samples are contaminated with faecal matter (WHO, 2008; Madigan *et al*., 2000). As observed by Uzoigwe and Agwa (2012), who also observed high total coliform in the water samples analyzed, the presence of these indicator organisms in drinking water sources provides an indication of water-borne problems and direct threat to human health and should be viewed as a matter of serious concern.

The results of the chemical constituents (metals) of the groundwater samples are presented in tables 4 and 5. Table 4 shows the mean concentration (mg/L) of the metals per sample while table 5 shows the range of the metals in the samples compared to standards. The concentrations of these metals (Fe, Cr, Pb, Cu, Mn and

Table 4. Mean concentration (mg/L) of trace metals (± standard error, SE) of the samples compared with the WHO standards (n = 7).

Parameter/sample	S – A	S – B	S – C	S – D	S – E
Fe	0.254 ± 0.001	0.022 ± 0.001	0.223 ± 0.000	0.273 ± 0.001	0.226 ± 0.000
Cr	0.048 ± 0.001	0.051 ± 0.002	0.052 ± 0.001	0.049 ± 0.003	0.059 ± 0.001
Pb	0.091 ± 0.001	0.096 ± 0.000	0.099 ± 0.001	0.081 ± 0.001	0.082 ± 0.002
Cu	0.040 ± 0.002	0.032 ± 0.001	0.033 ± 0.001	0.029 ± 0.001	0.036 ± 0.001
Mn	0.024 ± 0.002	0.025 ± 0.001	0.021 ± 0.001	0.024 ± 0.001	0.023 ± 0.000
Mg	0.014 ± 0.001	0.097 ± 0.001	0.099 ± 0.001	0.114 ± 0.002	0.126 ± 0.003

Table 5. Mean concentration (mg/L) of trace metals of the samples compared with the WHO standards (n = 7).

Parameter	Range	Mean	Standard
Fe	0.223 – 0.273	0.240	0.03[a]
Cr	0.048 – 0.059	0.052	0.05[a,b]
Pb	0.0081 – 0.099	0.089	0.01[a,b]
Cu	0.032 – 0.040	0.034	2[b]
Mn	0.021 – 0.024	0.023	0.2[a]
Mg	0.097 – 0.143	0.119	0.2[a]

[a]Nigerian Standard for Drinking Water Quality (Nigerian Industrial Standard NIS 554:2007) (Standard Organisation of Nigeria (SON), 2007)
[b]Guidelines for Drinking-water Quality (WHO, 2011)

Mg) are relatively within the limits of the standards. The high concentrations of Pb, almost close to the NIS and WHO standards, could be attributed to geology of the area since Abakaliki is one of the well known lead-zinc mineralized districts in Africa (Hutchison and Meema, 1987). The relatively high concentration of Fe is probable from the soil geochemistry and abundance of the metal in the soil. The concentrations of Cr may have contributions from waste water discharges, seepages and from soil geochemistry. The concentrations of Mn from the study probably from rocks and aquifers since Mn occur in rocks and soils and are widespread in the environment (Krauskopf and Bird, 1995). The relative low concentrations of Mg compared to standard are also reflected in the hardness of water.

CONCLUSION

This work assessed the quality of selected groundwater (borehole) samples in Amike – Aba, for physicochemical parameters, trace metals and bacteriological tests for a period of seven weeks following standard water sampling and analysis procedures. Compared with World Health Organization limits and Nigerian Standard for Drinking Water Quality, the results revealed the groundwater samples are facing various hydrological stress and possible contamination which could change the quality of the groundwater in the near future.

Generally, the results of this study, except for the bacteriological tests, are not indicative of high pollution of the potable water sources and require caution in the interpretation of the results. Based on the result of the bacteriological analysis, it is recommended that the groundwater (borehole) in Amike – Aba be treated to disinfect contaminating microorganisms and to reduce the bioload. However, to meet the millennium development goal of potable water supply, efforts are required to improve water supply, sanitation coverage and it is important to regularly assess the pollution risks to groundwater posed by improper on-site sanitation systems.

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