Comparative assessment of the physicochemical and heavy metal contents of borehole and sachet water consumed in Aba metropolis, Abia State

ABSTRACT

Studies were carried out to comparatively assess the physicochemical and heavy metal levels of borehole and sachet water consumed in Aba metropolis, Abia State, following the standard analytical procedures and instrumentation. The pH, hardness, turbidity, electrical conductivity, chloride, sulphate and total dissolved solids with mean values of 7.9, 98.6 mg/l, 2.72 NTU, 104.55 μS/cm, 47.82 mg/l, 20.12 mg/l and 45.11 mg/l for borehole water samples and 7.3, 84.10 mg/l, 1.06 NTU, 72.30 μS/cm, 35.20 mg/l, 13.90 mg/l and 28.14 mg/l for sachet water samples, respectively were within the WHO guidelines for a safe drinking water. The levels of nitrate with mean values of 0.81 and 0.56 mg/l for borehole and sachet water samples, respectively were above the WHO recommended permissible limits thus suggesting public health concern. The order of decrease of the heavy metal concentration in the borehole and sachet water samples were, Zn > Cu > Pb > Cd. However, Pb and Cd were present at toxic levels in the water samples consumed in Aba metropolis. Statistical analysis of the physicochemical and heavy metal levels of the borehole and sachet water samples showed significance at p < 0.05.

Key words: Physicochemical parameters, heavy metals, borehole water and sachet water.

INTRODUCTION

Water plays a significant role in maintaining the human health and welfare. Water is an essential component of life and is regarded as a universal solvent (Oyem et al., 2004; Umedum et al., 2013). It is used for washing, cooking, agricultural and even for industrial activities. Water could be obtained from ground water and surface sources. The ground water sources include boreholes and hand dug wells, while surface water sources include rivers, streams and lakes (Oko et al., 2017). Water is a natural chemical substance which consists of the elements, hydrogen and oxygen in the ratio of 2:1. It is indispensable for man's existence on earth as about two-thirds of the human body consists of water and requires between one to seven (1-7) liters of water per day for its appropriate functioning to avoid dehydration (Okonkwo et al., 2011; Mbaenyi-Nwaoha and Egbeuche, 2012). Broadly, the demand for water by man can be divided into three major categories: domestic, industrial and agriculture (Jidauna et al., 2014).

The quality of water depends on its physical, chemical and biological characteristic, which determines utility for different purposes. Water quality and sustainability for use is determined by its taste, odour, colour and concentration of organic and inorganic matters (Rahmaian et al., 2005). Water for human consumption is referred to as potable or drinking water and should be of safe quality, which entails that it does not present any significant health risk over life...
time consumption (WHO, 2006)

Although water is the most common and important chemical compound on earth, only 2.6% of global water is fresh water and consequently available as potential drinking water. Although water is essential for life, it also remains an important source of disease transmission and a major cause of mortality in developing countries because of limitations in access and quality (Mbah and Muhammed, 2015).

Pollution of water bodies are usually caused by chemical and microbial contaminants which leads to water-borne infections and diseases (USEPA, 2001). Improper dispersal of industrial effluents which is the most common in major African urban and rural centres has led to heavy contamination of available fresh water sources, reducing the volume of safe agriculture, domestic, irrigation and drinking water.

Contamination of water sources often emerge from leaching of rocks, industrial and agrochemical discharges which are washed into them especially during the raining season (Lawal and Londip, 2011). The extent of pollution depends on the rainfall pattern, depth of water table from the source of contamination and soil properties such as permeability, composition of its recharge components, as well as geology and hydrology of the area (Sunit and Gupta, 1997). These contaminants can affect the clarity and chemical constituents of the water sources. Essentially, they can distort the quality of the water and even add odour thereby impacting negatively on economic activities (Uzairu et al., 2014).

The contaminants can be categorized as microorganisms, inorganic, organics, radio nuclides and disinfectants (Rahmanian et al., 2015). The inorganic chemicals hold a greater portion as contaminants in drinking water as compared with organic chemicals (Batayneh et al., 2012). According to reports, drinking water fact sheets, contaminated drinking water can transmit diseases such as diarrhea, cholera, dysentery, typhoid and polio and also, contaminated drinking water is estimated to cause 502,000 diarrheal deaths annually (WHO, 2011). One major contaminant of water sources from the environment is heavy metal. Heavy metals such as mercury, lead, arsenic and cadmium are harmful and even essential ones such as copper, zinc and nickel can be toxic at high concentrations in biological systems (Igbunedion and Oguze, 2016).

The presence of these elements in the environment has been linked with toxicity in man and aquatic organisms. This becomes visible after bioaccumulation over a long period of time since heavy metals cannot be degraded (Ndeda and Manohar, 2014). Diseases related to the heart, kidney and blood have been associated with areas polluted with heavy metals and most importantly inhalation of arsenic, lead and cadmium has been closely linked with lung and skin cancer (Egbe and Alumanya, 2016).

Therefore, guidelines and legislation have it that water suitable for drinking should contain heavy metals and physicochemical in low amounts to avoid being a public health concern. It therefore became imperative to comparatively evaluate the physicochemical and heavy metals in borehole and sachet waters consumed in Aba metropolis, Abia State, hence this research.

MATERIALS AND METHODS

Sample collection:

Thirty (30) of water samples were collected from ten (10) selected boreholes located within Aba metropolis. Thirty (30) sachet water samples comprising six different brands were purchased from water vendors within the metropolis. The samples were collected in pre-cleaned plastic jars.

Physicochemical parameters determinants

pH of the water samples was determined using a pH meter. Electrical conductivity using a conductivity meter, nitrates was determined by a calorimeter using DR 2000 spectrometer, sulphates and hardness were determined by titrimetry, chlorine by argentometry, turbidity by a turbidity meter, while total dissolved solids was determined by gravimetric method (APHA, 2000).

Heavy metal analysis

The water samples (100ml) was measured and transferred into a beaker and concentrated HNO₃ (5 ml) was added. It was warmed slowly and allowed to evaporate to 20 ml in a fume cupboard. Few drops of Concentrated HNO₃ was added and then heated until a light coloured, clear solution was observed. The beaker wall was then washed with de-ionized water and then filtered. The filtrate was transferred to a 100 ml volumetric flask, allowed to cool and made-up to mark with de-ionized water (APHA, 2000). Four metals (Cu, Zn, Pb and Cd) were analyzed from the sample digest with UNICAM 969 atomic absorption spectrometer after calibration with appropriate standards.

Statistical analysis

The data obtained were expressed in means and standard deviation and subjected to one way analysis of variance
RESULTS AND DISCUSSION

pH

The pH serves as an index to denote the extent of pollution by acidic or basic wastes. The mean pH values of the borehole and sachet water samples consumed within Aba metropolis were 7.9 and 7.3, respectively. The result indicates that the water samples were slightly alkaline. The pH in the borehole and sachet water samples consumed by the people differed significantly at p < 0.05. Both water samples had pH values within the WHO recommended limits for a safe drinking water (WHO, 2011).

Hardness

Hardness of water is the capacity of water to react with soap and is from one of the important properties of water from the utility point of view for different purposes (Dandwate, 2012). Table 1 shows that 98.6 and 84.1 mg/l were the mean levels of hardness for borehole and sachet water samples, respectively. The levels of hardness in borehole water samples was found to be significantly higher than the sachet water samples consumed by people living within the metropolis. The mean levels of the hardness of the water samples met the WHO recommended permissible limits. According to WHO (2011), water hardness is not considered to be of the major health concern at all levels in drinking water though it may affect its aesthetic acceptability. The results of this study for water hardness was lower than 441.23 mg/l reported by Okoro et al. (2017) for borehole water sources in Nsukka Urban area in Enugu State.

Turbidity

According to Dandwate (2012), turbidity in water is the reduction of transparency due to the presence of particulate matter such as clay or slit, finely divided organic matter etc. According to WHO (2011), turbidity is not necessarily a treat to health but can have a negative impact on consumer acceptability as a result of visible cloudiness and can be of an indicator of possible presence of contaminants that would be of concern to health when of high values. Table 1 shows that the mean levels of turbidity in the borehole and sachet water samples were 2.72 and 1.06 NTU, respectively. The mean values of turbidity in the water samples showed significant difference at p < 0.05. The mean levels of turbidity in the water samples were within recommended limits. Oko et al. (2017) obtained a higher turbidity value of 5.70 NTU in well water samples in Wukari local government area of Taraba State than reported in this study.

Electrical conductivity

Electrical conductivity is a measure of waters ability to conduct an electric current and is related to the amount of dissolved minerals in the water, but does not give an indication of which element is present (Adewoye et al., 2003). It is related to the total concentration of ionized substances in water. The more salts dissolve in water, the stronger the current flow and the higher the electrical conductivity. Table 1 shows that the mean values of electrical conductivity in the borehole and sachet water samples were 104.55 and 72.30 μS/cm, respectively. The levels of electrical conductivity in the water samples were within the recommended limits. The result of this study indicates that borehole water has a significantly high value of electrical conductivity than sachet water. The result is an indication of the presence of higher gravity of dissolved salts in the borehole water samples than it is in sachet water samples. The presence of high levels of impurities such as dissolved salts in water can render water unfit for drinking.

Nitrate

Table 1 shows that the mean levels of nitrate in the borehole and sachet water samples consumed by people living in Aba metropolis were 0.81 and 0.56 mg/l, respectively. The levels of nitrate in the studied water samples were above the recommended limits and therefore of public health concern. Borehole water samples contain significantly higher levels of nitrate than sachet water samples. According to Mwegha and Kihampa (2010) and Singh et al. (2010), the presence of nitrate in water indicates the presence of fully oxidized matter and is attributed mainly to anthropogenic activities such as run-off water from agricultural lands, discharge of household, municipal sewage from market places and other effluents containing nitrogen sources. Exposure to high levels of nitrate in water has been implicated in organ failure and some form of cancer in the body (Singh et al., 2010).

Chloride

The mean levels of chloride in borehole and sachet water samples were 47.32 and 35.20 mg/l, respectively as shown
in Table 1. The levels of chloride in the water samples were within the recommended limits for a safe drinking water. Research has shown that the sources of chloride in water were mainly through industrial waste discharges and domestic wastes etc. (Umadevi et al., 2010).

WHO (2011) stated that the presence of excess residual chlorine in water has adverse health effects such as cell damage which could result to cancerous diseases.

### Sulphate

Table 1 shows that the mean levels of sulphate in the borehole and sachet water samples were 20.12 and 13.90 mg/l, respectively. Research has shown that anthropogenic activities such as fertilizer application, pesticides and industrial effluent discharges are main sources of sulphate to water bodies (Umadevi et al., 2010). The levels of sulphate in the water samples met the recommended permissible limits for a safe drinking water.

According to Mahananda et al. (2010), high concentration of sulphate in drinking water has been associated with laxative effect when consumed with calcium and magnesium, the two most common constituents of hardness. Bhatia (2000) reported that people accustomed to drinking water with elevated high level of sulphate can experiences diarrhea, dehydration and gastro-intestinal irritation. Also high concentration of sulphate with sodium and magnesium in drinking water has been associated with respiratory illnesses (Umadevi et al., 2010).

### Total dissolved solids

Total dissolved solids indicates salinity behaviour of ground and surface water (Dandwate, 2012). The total dissolved solids of water are mainly due to vegetable decay, evaporation, disposal of effluents and chemical weathering of rocks. Umadevi et al. (2010) reported that high values of total dissolved solids in water may be attributed to the leaching of industrial effluents or back water intrusion. Table 1 shows that the mean values of total dissolved solids in the borehole and sachet water samples were 45.11 and 28.14 mg/l, respectively and significantly differ at p < 0.05. The levels of total dissolved solids in the water samples met the WHO requirement for a safe drinking water.

### Copper

Copper is an essential element required for biochemical processes in the body in trace amounts. Table 2 and Figure 1 show that the mean levels of copper in the borehole and sachet water samples were 0.43 and 0.62 ppm, respectively. The mean concentration of copper in the sachet samples was found to be significantly higher than the borehole water samples. The mean levels of copper in the water samples met the WHO guidelines.

According the Chukwu et al. (2008), copper in excess could impact a bitter taste to water and promote the corrosion of galvanized iron and steel fittings. Contamination of drinking water with high level of copper may lead to chronic anemia, liver and kidney damage (Acharya et al., 2008).

### Zinc

Zinc is one of the most important trace elements that play a vital role in the physiological and metabolic process of many organisms. It plays an important role in protein synthesis (Ademoye et al., 2013). Zinc occurs in small amounts in almost all igneous rocks.

Table 2 shows that the mean levels of zinc in the borehole and sachet waters samples were 1.51 and 0.97 ppm, respectively. The mean concentrations of Zinc in the borehole and sachet water samples differs significantly (p<0.05) and within the recommended limits for a drinking water.
Table 2: Mean levels of heavy metals in borehole and sachet water consumed by people living within Aba metropolis, Abia State.

<table>
<thead>
<tr>
<th>Metal</th>
<th>Borehole water sample</th>
<th>Sachet water sample</th>
<th>F-test P value</th>
<th>WHO STD</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cu</td>
<td>0.43 ± 0.03</td>
<td>0.62 ± 0.14</td>
<td>0.02</td>
<td>2</td>
</tr>
<tr>
<td>Zn</td>
<td>1.51 ± 0.26</td>
<td>0.97 ± 2.20</td>
<td>0.01</td>
<td>10</td>
</tr>
<tr>
<td>Pb</td>
<td>0.12 ± 0.02</td>
<td>0.05 ± 0.01</td>
<td>0.01</td>
<td>0.05</td>
</tr>
<tr>
<td>Cd</td>
<td>0.09 ± 0.03</td>
<td>0.04 ± 0.02</td>
<td>0.02</td>
<td>0.05</td>
</tr>
</tbody>
</table>

Figure 1: Bar chart representation of the mean levels of heavy metals in the borehole and sachet water consumed within Aba metropolis, Abia State.

Water quality. Too little quantities in the body can cause problems while high concentrations of it have been associated with harmful health effects (vomiting, nausea, epigastric pain and diarrhea) (Singh et al., 2010). The mean levels of zinc obtained in the water samples in this study was higher than 0.36 ppm reported by Adewoye et al., (2013) in hand dug wells in Gambari, Ogbomoso, Oyo State.

Lead

Lead is the most recognized toxic environmental pollutant. Toxic levels of lead in man are associated with encephalopathy seizures and mental retardation (Gregoriadou et al., 2001). Lead is an important pediatric heavy metal poison and it affects bones, brain, blood, kidneys and thyroid gland on exposure (Singh et al., 2010). Lead absorption is enhanced by deficiencies of iron, calcium and zinc. Table 2 shows that the mean levels of lead in the borehole and sachet water samples were 0.12 and 0.05 ppm, respectively. The levels of lead significantly differ in the studied borehole and sachet water samples. The mean levels of lead in the water samples were above the WHO recommended limits for a safe drinking water. Oko et al. (2017) obtained a higher mean value of 0.14 ppm for lead in ground water samples in Wukari local government area of Taraba State, which compared very well with the values of the metal in borehole water samples reported in this study.
Cadmium

Cadmium enters into the environment when it is discharged as a by-product of the refining of zinc (Durub et al., 2007). Cadmium interferes with enzymatic processes involving re-absorption of proteins in the kidney. It is almost absent in human and animal body at birth, however, accumulates with age (Maharpawar, 2015). Organs such as the liver, placenta, kidneys, lungs, brain and bones can be affected by cadmium exposure. Table 2 shows that the mean levels of cadmium in the water samples were 0.07 and 0.05 ppm, respectively. Significant difference was observed for the levels of cadmium in the borehole and sachet water samples at 5% level of confidence. The borehole water samples were found to contain the metal at above the WHO recommended limit for a safe drinking water.

Conclusion

Seven out of the eight studied physiochemical parameters (pH, hardness, electrical conductivity, turbidity, chlorine, sulphate and total dissolved solids) were present at non-toxic levels in the borehole and sachet water samples consumed in Aba metropolis. The levels of nitrate were at toxic levels in the water samples which suggest public health concerns. Of the four heavy metals (Cu, Zn, Pb and Cd) investigated in the water samples, Pb and Cd were present at levels, which suggests public health concern considering the toxicity effects associated with prolonged exposure to these metals. The levels of the physiochemical parameters and heavy metals in the borehole and sachet water samples consumed in Aba metropolis were statistically significant (p < 0.05).

REFERENCES


