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Evaluation of selected physico-chemical properties and heavy metal content of Ebonyi River for domestic use in Abakaliki southeastern Nigeria

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Abstract

This study evaluated the selected physico-chemical properties and heavy metals content of Ebonyi River in Abakaliki southeastern Nigeria. Four replicate water samples were collected from the following sites in Ebonyi River– A. Site near road construction activities, B. Site near automobile repair activities, C. Site near agricultural activities and D. Site near residential houses in August 2017 while Ivy bottle water (E) was used as control. These water samples were used for the determination of conductivity, colour, dissolved solids, suspended solids, total solids, total hardness, odour, pH, nitrate, zinc, cadmium, aluminum, and lead concentration in these areas of different activities. The data collected was analysed using ANOVA for CRD and treatment differences among means was dictated using fisher`s least significant differences. Similarly, the data obtained was compared with World Health Organization standards for domestic water qualities. The results showed significant ($p < 0.05$) increase among the sites of different activities than control with regard to total dissolved solids, total suspended solids, conductivity, nitrate, total hardness, zinc and lead. While cadmium and aluminum were absent in both the control and the sites of different activities in Ebonyi River studied. On the other hand there was non-significant ($p < 0.05$) changes in pH and total solids in all the water samples studied. Colour and odour were observed colourless and odourless, respectively in the areas of different activities studied in Ebonyi River. Among all the parameters studied, the concentration of nitrate, zinc and lead in the sites of different activities in Ebonyi River were above the standard for domestic water uses.

Keywords: Contamination; Impurity; Standard; Treatment; Water Quality

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1. Introduction

Water quality is defined as the chemical, physical and biological characteristics of water, usually in respect to its suitability for a designated use. As we all know, water has many uses, such as for recreation, drinking, fisheries, agriculture and industry. Each of these designated uses has different defined chemical, physical and biological standards necessary to support that use. According to Maybeck et al. (1989) water is vital for the existence of all living organisms, but this value resource is increasingly being threatened by human activities as human population increases in the earth. Water using for domestic activities must contain other impurities apart from hydrogen and oxygen in recommended standard. These impurities (such as total solids, total suspended solids, total dissolved solids, sewage release, and nutrients loading) reduce qualities of water when they are above the recommended standard (Njoku et al., 2017a).

Njoku and Ngene (2015) showed that the sources of the water in the study areas mostly affected by the anthropogenic activities are streams, pond, lakes, seas, underground water and rivers. Apart from human activities, natural tragedy such as floods, erosions and volcanoes can reduce the quality of water and make it unfit for domestic usage (Ezenwaji et al., 2014). Similarly, Njoku and Ngene (2015) revealed that these activities coupled with atmospheric factors affect the suitability of water for any purpose. The rural communities in developing countries, particularly in Abakaliki the study area depend largely on surface water and other water bodies for their water consumption and such rivers constitute health hazard because of anthropogenic activities and indiscriminate disposal of untreated sewage and surface run-off into them.

Ebonyi River had its source from River Benue and passes through all the three zones in Ebonyi state, bounded by many communities in that state and opens into Cross River that empties its water into the Atlantic Ocean. This river provides domestic and drinking water to more than 50% indigene of Ebonyi state. Apart from provision of water to the people for domestic and drinking uses, it is also a source of fish and other aquatic animal productions, facility for tourism and transportation and source of water for irrigation. The main objective of the study was to evaluate selected physico-chemical properties and heavy metal content of Ebonyi River for domestic use.

2. Materials and methods

2.1. Study area

The study was carried out at Ebonyi River in Ababkaliki Ebonyi State southeastern Nigeria. Ebonyi River is one of the major sources of water for different uses for Ebonyi people.Abakaliki lies at latitude $6^0$15'N and longitude $8^0$5'E in the derived savannah of southern Nigeria. The two distinct seasons within the zone are rainy season which lasts from April to October and dry season which lasts from November to March. The minimum and maximum temperatures of the area are 27^0C and 31^0C, respectively. The relative humidity of the area is between 60 to 80 percent. The area has an annual rainfall range of 1500 – 2000mm and the soil of the area belongs to the order Ultisol classified as typic Haplustult.

2.2. Selection of experimental site

After the preliminary survey of the study area, the following sites of Ebonyi River were selected:

A. Site near road construction activities;
B. Site near auto mobile repair activities;
C. Site near agriculture activities;
D. Site near residential houses and
E. Bottle water (Control)

2.3. Sampling methods

Four replicate water samples were collected from each site using clean empty cans, labeled and taking to laboratory for analysis. Temperature measurements were taken in-situ using a mercury-in-glass thermometer by dipping the thermometer into the river and the reading was taken after the temperature stabilized.

2.4. Laboratory analysis

2.4.1. Determination of physical parameters

Bhagure (2010) methods were used to determine total suspended solids, total solids and total dissolved solids. The colour of the samples was determined in terms of percentage transmittance of light as described by Hossain et al. (2001). The conductivity of the sample was determined using SANXIN SX723 conductivity meter as described by Hossain et al. (2001).The colour of the water samples was determined with the aid of a Lovibond. 30ml of distilled water (control) was poured into a test-tube and placed in the centre of the lovibond holes and then matched with disc of different colour range. It was done same way with the rest of the samples and results were compared with the control.The threshold odour number (TON) is determined by diluting a sample of the odourous water with free water until the least definitely perceptible odour is achieved. A series of dilutions with increasing concentration is prepared in glass bottles and the headspace is saturated with the odour. The testing takes place by presenting the odourous mixtures for the panelists together with blanks (odour free water). The panelists smell the headspace in each bottle and declare “odour” or “no odour” in each bottle. When all panelists have detected the odours in to succeeding dilution steps the average threshold is calculated.

2.4.2. Determination of chemical parameters

The water pH was determined using pH meter (Jung, 2001). Nitrate (NO^{-}_{3}) was determined using turbidimetric method as described by (Jung, 2001). Total hardness was determined using estimation method described by Jung (2001).

2.4.3. Determination of heavy metals

Heavy metals (Cd, Zn, Pb and Al) were determined by digesting the sample in a fume cupboard and reading transmittance of light using Atomic Absorption Spectrophotometer model (American Public Health Association, 1998).

2.5. Data analysis

The data collected was analyzed using analysis of variance for CRD and treatment differences among means was dictated using Fisher's lest significant difference (SAS Institute Inc., 1999). Similarly, the data obtained was compared with World Health Organization (WHO) Standards for domestic water qualities.

3. Results and discussion

3.1. Selected physical properties of Ebonyi River

Table 1. Selected Physical Properties of Ebonyi River Studied

Site	TS (mgL^{-1})	TDS (mgL^{-1})	TSS (mgL^{-1})	Colour	Odour	Conductivity (μ/cm^3)
A	7.75	8.00	0.25	Colourless	Odourless	80.00
B	14.25	15.00	0.75	Colourless	Odourless	150.00
C	16.92	22.00	5.08	Colourless	Odourless	220.00
D	18.70	23.00	4.30	Colourles	Odourless	230.00
E	7.00	7.00	0.00	Colourless	Odourless	70.00
FLSD (P<0.05)	NS	0.056	0.56	0.00	0.00	1.39
Standard	500	500	150	50		500

Where: A. Site near road construction activities; B. Site near auto mobile repair activities; C. Site near agriculture activities; D. Site near residential houses; E. Bottle water (Control; TS = Total solids, TDS = Total dissolved solids and TSS = Total suspended solids.Standard according to Alloways (1996)

Table 1 shows the selected physical properties of Ebonyi River studied. There was a significant (P<0.05) changes among the different water samples studied with respect to total suspended solid, total dissolved solid and conductivity,whereas total solid, colour and odour shows non-significant changes. Control (E) recorded, the lowest total suspended solid value of $7.00mgl^{-1}$. This observed total suspended solid in control

was lower than A, B, C, and D by 1,7,10, and12%, respectively. The order of increase in total dissolved solid was E<A<B<C<D. The lowest total solid of 0.00mgl^{-1} was observed in control whereas total solid in sites of different activities in Ebonyi River ranged between 0.25 – 5.08mgl^{-1}. The higher total suspended solid, total dissolved solid and total solid in sites of different activities in Ebonyi River than control maybe attributed to debris, particulate matter and impurities that contaminated these sites from the activities carried out in the area. Njoku et al. (2017b) on their study of water qualities as affected by Rice mill processing wastes in Abakaliki south eastern Nigeria observed higher total suspended solid, total dissolved and total solid in areas nearer rice mill wastes than the control which is a support of these study. Similarly, Njoku et al. (2017a) also support of this study.

3.2. Selected chemical properties of Ebonyi River

Selected chemical properties of Ebonyi River studied are as shown in Table 2.There was a significant ($p<0.05$) changes among the difference water samplesstudied with regard to nitrate concentration and total hardness whereas pH showed non-significant ($p < 0.05$) changes , however, the order of increase in pH was B=D<A<C<E. The lowest total hardness of 0.00 mgl^{-1} was observed in control whereas total hardness in site of different activities in Ebonyi River ranged between 72.00 – 203.00 mgl^{-1}. Control (E) recorded the lowest nitrate concentration value of 25.98 Mgl^{-1}. This observed nitrate in control was lower than A,B,C,and D by 7,10,13,and 15%, respectively. The higher pH, nitrate and total hardness concentration in sites of different activities in Ebonyi River than control may be attributed to impurities and particulate matter that contaminated these sites from the activities carried out in the area. Njoku et al. (2015) on their evaluation of water sources in Abakaliki southeastern Nigeria for domestic uses observed higher pH, nitrate and total hardness concentration in other sites than the control which is in support of this study. Similarly, the observed nitrates in all the sites of different activities in Ebonyi River were above the standard (Alloways, 1996).

3.3. Selected heavy metal contents of Ebonyi River

Table 3 showed the selected heavy metals concentration of Ebonyi River studied. There was a significant ($p<0.05$) changes among the different sites studied with respect to zinc and lead whereas Cadmium and Aluminum were absent in all the water samples studied.

Zinc was absent in control (E) whereas zinc concentration in site of different activities in Ebonyi River ranged between 45.766 – 238.637 mgl^{-1}.The order increase in lead concentration was E<A<D<C<B. The higher zinc and lead concentration recorded in sites of different activities in Ebonyi River than control maybe attributed to impurities that contaminated these sites from activities carried out in the area. Similarly, the concentration of zinc and lead were higher than standard recommended by Alloways (1996). Njoku (2015) on their effect of waste dumpsites on water and air qualities in Abakaliki southeastern Nigeria observed higher zinc and lead concentration in other sites than control which is in support of this study.

Table 2. Selected Chemical Properties of Ebonyi River

Site	Ph	Nitrate (mgL^{-1})	Total hardness (mgL^{-1})
A	6.50	32.56	72.00
B	6.20	35.93	135.00
C	6.70	38.87	203.00
D	6.20	40.52	200.00
E	7.00	5.98	0.00
FLSD (P<0.05)	NS	2.96	3.19
Standard	6.5-8.5	10	500

Where: A. Site near road construction activities; B. Site near auto mobile repair activities; C. Site near agriculture activities; D. Site near residential houses; E. Bottle water (Control).Standard according to Alloways (1996)

Table 3. Selected Heavy Metal Contents of Ebonyi River Studied (mgL^{-1})

Site	Cadmium	Zinc	Lead	Aluminum
A	0.00	45.766	0.025	0.00
B	0.00	686.649	0.086	0.00
C	0.00	238.637	0.083	0.00
D	0.00	215.754	0.052	0.00
E	0.00	0.00	0.003	0.00
FLSD (P<0.05)	0.00	0.057	0.018	0.00
Standard	0.003	3.00	0.01	0.2

Where: A. Site near road construction activities; B. Site near auto mobile repair activities; C. Site near agriculture activities; D. Site near residential houses; E. Bottle water (Control.Standard according to Alloways (1996)

4. Conclusion

The result showed that among all parameters studied in water from the sites of different activities of Ebonyi River that only nitrate, zinc and lead were higher than the recommended standard. Similarly, the concentration of all parameters including nitrate, zinc and lead observed in control were within the

recommended standard. This higher concentration of nitrate, zinc and lead than the recommended standard make Ebonyi River unfit for domestic uses. Using this water for domestic uses will result to ill heath associated with these parameters when they are more than the recommended standard. Therefore, this work recommended the treatment of water from Ebonyi River before usage to prevent health hazard associated from using water polluted by nitrate, zinc and lead.

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