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ABSTRACT

The water qualities of three rivers (Asu, Ebonyi and Cross) were evaluated for these physicochemical parameters: transparency, flow rate, depth, temperature, conductivity, total dissolved solid (TDS), pH, dissolved oxygen (DO), phosphate (PO₄⁻) and nitrate (NO₃⁻) for 12 months (August 2014 – July 2015). The results showed variations in the water quality parameters among the rivers. Temperature, conductivity and TDS were highest in Asu River with mean values of 30.23 °C, 88 µS/cm and 42.58 mg/L, respectively. The mean values of pH varied from 7.0 to 6.56 with the highest value (7.0) recorded in Ebonyi River and the lowest value (6.56) recorded in Mid-cross River. The mean value of DO was highest (5.8 m/L) in Mid-cross River and lowest (4.9 mg/L) in Asu River. The lowest mean values of transparency, flow rate and depth were recorded in Asu River, the highest (0.5 m) mean value of transparency was recorded in Mid-cross River while the highest mean value (1.48 m) of Flow rate was recorded in Ebonyi River. Variations in the mean value of nutrient in the water showed that PO₄⁻ (0.28 mg/L) and NO₃⁻ (0.40 mg/L) were the highest in Asu River. The lowest PO₄⁻ was recorded in Ebonyi River (0.17 mg/L) while the lowest NO₃⁻ value was recorded in the Mid-Cross River. Variations in Temperature, DO, Flow rate and PO₄⁻ were not significantly different (P > 0.05) while conductivity, TDS and transparency were significantly different (P < 0.05). The results of most water parameters recorded are within the recommended limits of set standards for rivers.

Keywords: Water Quality, Physicochemistry, Aquaculture, Three Rivers, Acceptable Limit.

INTRODUCTION

Speaking chemically, natural water is not pure, but partly contaminated or influenced by natural and artificial conditions such as geographical soil conditions, sources of aquifers, climate conditions and anthropogenic sources (Narayanan, 2007). These anthropogenic sources include: agricultural chemicals which are washed into rivers through runoff, burning of biomes also contributes to the atmospheric deposition of nutrients into freshwater system, thus promoting the formation and growth of algae that lead to eutrophication. Mike and Michael, (2004) also identified some factors that determined the health of a river ecosystem such as discharge, the physical structure of the channel and riparian zone, channel management like macrophytes cutting and dredging, level of exploitation (fishing) and the presence of physical barriers to connectivity. In the same vein, urbanization, industrialization, acid rain, nature of the water bed also alter the stream/river environment and the aquatic organisms by changing their habitat structure, water quality and biotic interaction (Karr and Chu, 1999).

The need for water quality could be determined in different ways either for drinking, other domestic uses, industrial, agricultural, irrigation or fish farming. However, the maintenance of aquatic ecosystem is totally dependent on the physicochemical properties and biological diversity (Verkatesharaju et al; 2010). The level of physicochemical parameters of water will determine the purpose with which the water could be best used for with little or no treatments. Variability in physicochemical parameters is responsible for the distribution of organisms in different freshwater habitat according to their adaptation, which allow them to survive in a specific habitat (Jeffries and Mills, 1990). Major shift in the stream bed composition and processes can alter species distribution, productivity and even change the production of green house gases (Palmer et al, 1997). Temperature, dissolved oxygen (DO), carbon (iv) oxide (CO₂), pH, conductivity, total dissolved solid (TDS), transparency and current among others and their regular and irregular fluctuations in water have been identified as a determinants in riverine fish ecology (Blober, 2000).
The search for good domestic water has been man’s utmost concern since the beginning of civilization and thus, scarcity of clean freshwater is one of the world most pressing environmental problems; therefore, in search of domestic water which includes the water needs for families for drinking, cooking, sanitation/hygiene etc (Bustanmante et al.; 2004), rural community dwellers in the river front depend on the rivers/streams as a source of water for their domestic and other uses. This could be as a result of uneasy access and high cost of harnessing underground water.

Water resources challenges have long existed in sub-Sahara Africa, but their impacts have been amplified by recent trend such as increasing urbanization, economic growth, maritime trade and climate change. These challenges highlight the fact that the quantity and quality of water available is being reduced at a warping speed (Any, 2013). Most countries in sub-Sahara Africa lack organizational frameworks to achieve sustainable water management. Good water quality management is largely based on the basic information on water sources and physicochemical parameters. Thus, this research work is aimed at evaluating the quality of some selected rivers in Ebonyi State and compares their physicochemical parameters with set standard limits in other to determine their fitness for domestic use and fish farming. The result obtained from this study would provide accurate and precise information for background level of physicochemical parameters in the Study Rivers thus, contributing to the effective monitoring of public health, environmental quality and the health of the organisms inhabiting the river ecosystem.

MATERIALS AND METHODS

Study Area

The study areas are Ebonyi, Asu and Mid-cross Rivers all in Ebonyi State, Nigeria. Asu River is located in Akpoha and flows through agricultural farmlands where rice, yams, vegetables and other cereal crops are farmed in commercial quantity with herbicide and pesticide. The collection points in this river were at latitude 6° 03' 44.00" N, longitude 8° 00' 36.38"E and latitude 6° 03' 15.16" N, longitude 8° 00' 36.37" E. The collection points in Ebonyi River were at latitude 6° 18 ' 38.35 " N, longitude 8° 06 ' 46.99 " E and latitude 6° 18 ' 22.94 " N, longitude 8° 08 ' 51' 51.77 " E. It is located in Abakaliki and flows beside mechanic village and rice mill. Mid-cross River is the largest among the three rivers and flows through the commercial city of Afikpo (Ndibe) where abattoirs are common. The collection points were at latitude 5 50 ' 01.58 " N, longitude 7 55 ' 54.59 " E and latitude 5 50 ' 14.08 " N longitude 7 56 ' 07.88 " E

The rivers lie within the Southern Guinea savanna zone. They are tributaries to Cross River basin and are connected to Atlantic Ocean through the same river basin. In general, all the rivers are relatively broad, flow slowly and changes seasonally in width and depth with arrays of hydrological regime that characterized most rivers in the region. These rivers support a lot of agricultural activities such as fishing, cultivation of root crops along the river bank and within the watershed. Sand mining, trading (mainly on aquatic food items), car wash, domestic activities such as washing of cloths, kitchen utensils and bathing are also common activities within the rivers. There are rainy and dry season that influence the activities within the rivers and their banks. Some parts of the water bodies are often fringed with macrophytes like Imperata cylindrica, Eupatorium odoratum etc; and along the river banks are tree plants like Elias guinensis, Vitex doniana etc.

Sample Collection

Surface water samples were collected monthly from the study sites at two designated points between 10.00AM – 1.00PM from August 2014 – July 2015. Unstable parameters such as temperature and pH were determined in situ with Hanna instrument (HI96107). The transparency, flow rate, depth were measured in situ also. Improvised secchi disc with black and white band was used to determined transparency, while flow rate was determined in situ as distance/time (d/t) using cork, stop watch and line. The depth was measured by lowering a calibrated stick into the river; the sub-merged was noted and recorded in metre (M). Conductivity and TDS were determined using Hanna conductivity and TDS metre model HI 9880I, respectively. DO was fixed in BOD bottle in situ and determined in Applied Biology Laboratory using Winkler’s methods. Finally, nitrate and phosphate were determined using spectronic 20D machine according to AOAC (2003).

Data Analysis

Data obtained were subjected to one way analysis of variance (ANOVA) and values were considered significant at p < 0.05. Tables were generated using excel spreadsheet and simple mean and standard deviation were also calculated.
Table 1: Mean values and Standard Deviations of Physicochemical Parameters of Three Selected Rivers in Ebonyi State and Set Standards for Domestic Use and Aquaculture

| River       | Parameter    | Asu River | Ebonyi River | Mid-cross River | NSDWQ  | FEPA    | SON  | DU | AQ | FEPA    | SON  | DU | AQ |
|-------------|--------------|-----------|--------------|-----------------|--------|---------|------|-----|----|---------|------|----|----|
|             |              |          |              |                 | DU     | AQ      | DU   | AQ  |    | DU      | AQ   |    |    |
| Temperature | °C           | 30.23±2.6  | 30.03±2.13   | 26.68±2.66      | Ambient | < 25    | 27   | Ambient | Ambient | 25-30 | < 35 |
| Conductivity | µs/cm       | 88±7.33    | 51.67±9.09   | 66.56±13.37     | 1000   | NS      | SN   | 1000 | 1000 | 500-100 | 500  | 500 |
| TDS mg/l    |              | 42.58±7.32 | 27.42±5.4   | 35±10.02        | 500    | 2000    | 500  | 500 | 100 | 500-100 | 500  | 500 |
| pH          |              | 6.6±0.62   | 7.0±0.46    | 6.59±0.42       | 6.5-8.5 | 6-9     | 6.5-8.5 | 6.5-8.5 | 6.5-8.5 | 6.5-8.5 | 6.5-8.5 |
| DO mg/l     |              | 4.9±1.38   | 5.60±1.34   | 5.8±2.1         | NS     | NS      | 8-10 | NS | NS | 14      | 4-6   |    |    |
| Transparency | m           | 0.26±0.16  | 0.49±0.34   | 0.5±0.1         | 5      | NS      | NS   | 5   | NS | 5       |      |    |    |
| Flow rate m/s |          | 1.80±0.88  | 1.83±0.91   | 1.48±0.82       | NS     | NS      | NS   | NS | NS | NS      |      |    |    |
| Depth m     |              | 4.50±3.19  | 3.40±2.70   | 4.55±2.56       | NS     | NS      | NS   | NS | NS | NS      |      |    |    |
| P0₄ mg/l    |              | 0.28±0.25  | 0.17±0.11   | 0.21±0.16       | NS     | NS      | NS   | NS | NS | 6.5     |      |    |    |
| NO₃ mg/l    |              | 0.4±0.21   | 0.14±0.16   | 0.10±0.14       | 0.2    | 20      | 20   | 50 | NS | 50      |      |    |    |

Values with Different Superscript are Significantly Different (P < 0.05) while the same are not Significantly Different (P > 0.05) Nigeria Standard for Drinking Water Quality (NSDWQ), Federal Environmental Protection Agency (FEPA), Standard Organization of Nigeria, World Health Organization (WHO), Domestic use (DU), Aquaculture (AQ) and Not Stated (NS)
Fig 1. Monthly Variations in the Major Physicochemical Parameters of Asu, Ebonyi and Mid-Cross River
RESULTS

The monthly variations in the major physicochemical parameters are presented in Figures i-x while the mean values of physicochemical parameters of the study sites and set standards are presented in Table 1. The graphs showed no observable pattern of variations among the rivers; however, some parameters like temperature, transparency, flow rate, depth and nutrients fluctuated seasonally. A total of ten (10) different physicochemical parameters were analyzed. The analysis showed that highest mean temperature of 30.23±2.6°C was recorded in Asu River while the lowest mean temperature of 26.68±2.13°C was recorded in Ebonyi River. The highest mean values of conductivity (88.00 ± 7.33 µs/cm) and TDS (42.58±7.32 m/l) were recorded in Asu River while the lowest values were recorded in Ebonyi River (fig. 1). The mean pH value of 7.0 ± 0.46 was observed in Ebonyi River while the mean value of 6.59±0.42 was observed in Mid-cross River. Mean DO level of 5.8±2.1 m/L was obtained in Mid-cross River while 4.9±1.38 mg/L was obtained in Asu River. The highest (0.5± 0.1 m) and lowest (0.26± 0.16 m) mean transparencies were recorded in mid-Cross River and Asu River, respectively. The lowest flow rate of 1.48±0.82 m/s was determined in Mid-cross River while the highest mean value of 1.83 m/s was determined in Ebonyi River. The mean values of Depths ranged from 3.40±2.70 m in Ebonyi River to 4.55±2.5m in Mid-cross River (fig. 1). The mean values of nutrients recovered in the rivers showed that PO4 3- (0.28± 0.25 m/L) and NO3 3- (0.4± 0.21 m/L) were highest in Asu River and PO4 3- (0.17±0.11 mg/L) was lowest in Ebonyi River while NO3 3- (0.10± 0.14mg/l) was lowest in mid-Cross River. Significant variation (P < 0.05) were observed in mean values of conductivity, TDS, pH, transparency, depth and nitrate, while variations in the mean values of DO, temperature, flow rate and phosphate were not significant (P > 0.05) between the rivers (Table 1).

DISCUSSION

The differences in the monthly variations of major physicochemical parameters of the Study Rivers and seasonal fluctuations could be linked to difference anthropogenic activities within the study sites, specific geographical soil sediments and variable weather patterns of the area. The mean value of temperature in this work is above the report of Agbaire et al; (2015) in Abaraka Delta State, Nigeria but in tandem with the work of Taiwo et al; (2012) in his study on Nigeria surface waters. The results are above the standards of NSDWQ; (2007), SON; (2007) FEPA, (1991) for domestic use and aquaculture. However, the result is within the recommended limit of WHO; (2009) for Domestic use and aquaculture. Differences in temperature could be due to the function of the climate condition at a particular geographical location and period of sampling. Vegetations along the river bank could also play a significant role in influencing the temperature of aquatic ecosystem. Water temperature is an important parameter which influences the onset of fish spawn, aquatic vegetation growth and biological demand of oxygen in rivers (Keremah et al; 2014). Changes in temperature could affect the metabolism and physiology of fishes and its productivity.

The mean conductivity recovered in this work is within the permissible limits of set standards (NSDWQ; 2007, WHO; 2004, FEPA; 1991 and SON; 2007) for domestic use and aquaculture. The total load of salts in water is directly related to its conductivity which in-turn dependant on the ionic concentration and water temperature (Deline; 1992). Report proves that high value of conductivity is an indication of water pollution (Solomon et al; 2013), this however, may be as a result of high concentrations of cations and anions which alter the chemistry of the aquatic ecosystem. However, Sikoki and Veen, (2004) have reported that fishes differ in their ability to maintain osmotic pressure, therefore the optimum conductivity for fish production differ from one species to another. The mean total dissolved solid (TDS) values in this work are consistent with the work of some researchers like Mulongaibalu et al; (2014) in Ishasha River and Lake Edward, East Africa and Osagie; (2010) on water bodies around Benin City, Nigeria. The recorded values are also within the recommended limits of set standards (NSDWQ; 2007, WHO; 2004, FEPA; 1991, SON, 2007). This consistencies in the TDS values could be linked to relatively same geological drainage, atmospheric precipitation, water balance (evaporation–precipitation) and moderate concentrations of the ions in the surface runoff (Singh et al; 2010). Research report agrees that extremely low concentration of TDS may be unacceptable because of its flat insipid taste (WHO; 1996).

The average value recorded for water pH in this study is optimum for fish productivity and this agreed with the report of Bhatnagar and Devi, (2013). It compared very well with the result of Agbaire (2015), and also within the national and international standards (FEPA; 1991, WHO; 2009, SON; 2007, NSDWQ; 2007). This is an indication of balance between photosynthesis and respiration in the Study Rivers. Decomposable organic matters which add carbon (iv) oxide, that lower pH, must have been high in the study rivers (Craig and Louis, 2008). The pH may not have direct effect on man, but its indirect action in the physiological process cannot be ignored (NSDWQ, 2007). The results of the recorded values of DO in this work are below the permissible limit of FEPA for aquaculture and WHO for domestic use, however, it is within the WHO; (2004) limit for aquaculture. These values are also below the report of other similar researchers (Muhibbu-Din et al; 2011, Ezeribe et al; 2012). DO is a measure of the amount of...
gaseous oxygen in an aqueous solution, its concentration in water tend to decrease as temperature of the water increases (Eze and Ogbaran; 2010). This could be the reason for its low concentration levels in the Study Rivers, as temperature of the rivers were quite high. DO is known to affect such attributes as growth, survival, distribution, behavior and physiology of aquatic organism.

The values of transparency recorded in this work are lower than that recorded by Okogwu and Nwani (2009). These differences could be attributed to different bottom sediments of organic matters and localized activities. Sampling period could also be a factor for the differences in transparency. When transparency is reduced, it is often associated with high level of disease causing microorganism, such as bacteria and other parasites (Shittu et al; 2008). The transparency of a river system measures it ability to transmit light that restricts light penetration into the water and limit photosynthesis (Bhatnagar and Devi; 2013). Particles in water are usually affected by factors such as clay particles, pigments caused by deposition of organic matter, dispersion of plankton organisms, particulate organic matter etc. Variations in the flow rate among the rivers were not significant (P < 0.05), this could be attributed to the same rainfall patterns within the region, also, the roughness of river channel and accumulation of sediment can influence water flow rate. The flow rate of a river is capable of influencing other physicochemical parameters such as transparency, DO and TDS, thereby regulating the biological productivity and diversity. The water depth was significant between Ebonyi and Mid-cross River; however, the variations between Asu and Ebonyi River, Asu and Mid-cross River were not significant (P > 0.05). The mean values of the water depth were higher than the recorded result of similar researchers (Muhibbu-Din, et al; 2011). These differences could be as a result of localized activities such as sand mining and fishing. Sediment accumulation and size of river are also factors.

The nutrients levels of these rivers were low and not consistence with the work of Turkura et al; (2012) in Mada River, Nasarawa Nigeria. However, the values are within the standard limits of WHO; 2004, FEPA; 1991, and SON; 2007 (Table 1) for domestic use and aquaculture but exceed the recommended limit of NSDWQ; (2007). Jaji et al; (2007) states that low amount of nitrate is an indication of unpolluted natural waters. The low concentration of this nutrient indicates its low level in the watershed. Excess nutrient (NO_3^-) may not be harmful to fish (Abgaire, et al; 2015), however, high accumulation of these nutrients could lead to eutrophication which in turn pollute water bodies. Nitrate indicates the presence of fully oxidized organic matter and excess level of it can cause methemoglobinemia as blue baby disease, though it does not pose a direct threat to older children and adults, but do indicate the possible presence of other more serious residential or agricultural contaminations such as bacteria or pesticides (Robert, 2006).

CONCLUSION

This work has presented the levels of physicochemical parameters in the Study Rivers. The results showed that most of the parameters determined did not exceed the permissible limit of set standards. However, some parameters that deviated from set standards such as DO, temperature and PO_4^- can be improved by treatment. Meanwhile, these rivers investigated were in general fit for aquaculture but need an adequate treatment method before these water sources are consumed in order to avoid epidemic of water relate diseases. It is worthy to note that lack of good water quality from the authorities or managers may drive consumers to alternative, potentially less safe sources.

COMPETING INTEREST

No competing interest among the authors.

AUTHORS’ CONTRIBUTIONS

The research design was written by Ani Chijioke in collaboration with Nwonumara Godwin Nkwuda (phone 08062394068, ngnkwuda@gmail.com). The sample collection from Asu River was done by Ani Chijioke, Mid-Cross River collected by Nwinyimagu Amaechi Joshua (phone NO: 07032658075, amaechijn@gmail.com) and Ebonyi River collected by Nwonumara Godwin Nkwuda. Analysis of water sample in the Laboratory was done by Nwani Christopher Didiguwu (phone NO: 08037509910, Email: didigwunwani@yahoo.com) and Okogwu Okechukwu Iduma (phone NO: 07062145074, Email: okeyokoguw@gmail.com) took charge of statistical analysis and data interpretation.

Related literatures was sourced by Ani Chijioke who also compiled the whole work into an article which was read by all the co-authors and made necessary imputes and corrections
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