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Research Article

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Environmental Impact Assessment of Anthropogenic Activities on Water Quality of River Benue of Nigeria

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Abstract Water pollution has been a major problem in the global context. In this study, Physico-chemical and biological properties of River Benue were assessed to evaluate the impact of industrial effluents, domestic sewage and other anthropogenic activities on the water quality of the river. Samples were taken in three replicates at different locations that are representative of the water source in Makurdi. Analysis of the Physico-chemical and biological parameters shows that the mean values for turbidity, colour, total suspended solids, total dissolved solids, total solids, nitrates, nitrite, ammonia, copper, phosphorus, iron and total coliform were relatively higher at station 2 (industrial area), followed by station 3 (settlement area) as compared to station 1(reference point) ($S_2>S_3>S_1$). Temperature was found to be 26℃ at station 1. Both station 2 and 3 had the temperature of 29℃. Narrow fluctuations in pH were observed across the sampled stations. Both station 1 and 3 had pH of 7.4. Station 2 had 7.6. Dissolved oxygen was observed to be lower at station 2 and 3 (3.0mg/L). Station 1 had 4.0mg/L. These results indicate the gradual pollution of the river water due to anthropogenic activities. Environmental protection of the river water is therefore necessary to minimize or avoid further pollution of the river for the good health of the populace.

Keywords Physico-chemical, total coliform, anthropogenic activities, water quality, pollution

Introduction

Water is one of the fundamental and essential natural resource, needed for all vital life processes. It makes up 50-97% of the weight of all plants and animals. In humans, about 70% of body weight is water [1]. Water is abundant in nature occupying 71% of the earth surface [2]. The importance of water in our environment cannot be overemphasized. Besides domestic use, water is also a vital resource for agriculture, hydropower generation, manufacturing, transportation and many other human activities [1]. Despite its importance, water is the mostly mismanaged natural resource in the world [3].

Natural waters occurring in the environment are not chemically pure waters. No form of water is completely pure except it has undergone some series of analytical process [3]. Apart from naturally occurring compounds which pollutes water and brings about physico-chemical transformation as a result of water contact with soil, rocks or atmosphere due to circulation in the environment, biological process and human anthropogenic activities also contribute significantly to changes in natural water composition. Many different organic or inorganic compounds have been introduced into natural waters from external sources such as drainage and factory pollution as a result of man's activities. The water collects and transports these dissolved or insoluble organic and inorganic compounds to various places. Water pollution has been a major problem in the global context [5].

Although waste disposal is of major concern in most urban areas, pollution of water bodies is increasing steadily due to rapid population growth, industrial proliferation, urbanization and wide sphere anthropogenic human activities [6]. The formulation and implementation of waste disposal management schemes does not match the rapid rate of development in urban areas. Settlements in urban areas are being developed without proper plan leading to poor waste disposal systems. Consequently, the waste not properly disposed reaches the nearby water sources and may contribute greatly to the poor quality of the water [7]. With the prevailing hard economic situation and the zeal to make more profit, most of the industrial wastes are still been released into the environment untreated or partially treated. Some industries do not have well established waste treatment facilities and simply adopt the use of substandard treatment methods that partially treat the waste and in some instances, forego the waste treatment process [5]. Wastes from these industries are directly or indirectly discharged into the nearby water bodies, resulting in an increase in pollutant loads which declines water quality [6].

Unrestrained release of heavy metals via discharge of industrial effluents, sewage and agro-chemicals into water resources renders it unfit for human use and has adverse effect on aquatic life, crippling the natural biotic organisms to extinction [8]. Toxic substances may also accumulate in aquatic life which is one of our important sources of food. Drinking of such polluted water or consumption of its aquatic life threatens human public health [9]. Many people contact different diseases due to consumption of contaminated water. The transmission of infectious diseases via contaminated water continues to be a risk and a major burden to human public health. Interventions to improve the quality of drinking water therefore provide significant benefits to health [10].

Water quality is determined according to its physical, chemical and biological parameters, and this has special significance especially in terms of protecting public health [11]. Coliforms are found in sewage, treated effluents and all natural waters subject to animal faecal contamination and decomposed plant materials. Their use in assessing water quality is therefore considered acceptable for routine purposes [12]. The potential health consequences of microbial contamination of water are such that its control must always be of paramount importance and must never be compromised [10].

According to [1], most people in urban cities of developing countries have access to piped water; however, several others still rely on borehole and river water for domestic use. Due to lack of analytical equipment and knowledge, many people drink water the way it comes to them without ascertaining the purity of such water. The supply of piped water by the Benue State Water Board to residents in Makurdi and other parts of the State has never been efficient. Consequently, most parts of the town of Makurdi rely on hand dug wells to meet their daily domestic water needs and some others take water directly from River Benue for drinking [12]. Unfortunately, industries and settlements are now located on the bank of River Benue and there is sparse information on the water quality of River Benue leading most people to use it without adequate treatment. Access to safe drinking water is essential to health, a basic human right and a component of effective policy for health protection. The importance of water sanitation and hygiene for health and development has been reflected in the outcomes of a series of international policy forums [9].

Water quality of River Benue was therefore assessed to determine the extent of pollution due to input of industrial wastes, domestic sewage and other anthropogenic activities thereby generating an important information to the general public and appropriate authorities to take proper action in preventing pollution of the environment for the good health of the populace and to provide it consumers with basic information.

Materials and Methods

Study Area

The Benue River previously known as the Chadda River or Tchadda is a major tributary of the Niger River which is the longest in West Africa [11]. The Benue River is the second largest river in Nigeria and is approximately 1,400 kilometers [11-12]. The river rises in the Adamawa Plateau of Northern Cameroon, from where it flows west through the town of Garoua and Lagdo Reservoir into Nigeria south of the Mandara mountains and through Jimeta Ibi and Makurdi before meeting the Niger at Lokoja [12]. River Benue is an important route of transportation in the regions through which it flows. Makurdi; an urban town lies between latitude $7^0$45’ and 7^0 52’N and longitude 8^0 35’ and 8^0 41’E with two seasons, the wet and the dry season [12]. Benue River flooded in 2012 during the rainy season.

Sample Collection

Samples were taken in three replicates at three different locations that are representative of the water source in Makurdi. Samples collected in a labeled clean and sterile 500ml bottles were immediately placed in a lightproof insulated box containing melting ice to ensure rapid cooling. Bottles used for sample collection were first rinsed with the appropriate sample before the final collection. Samples were then transported to the laboratory of the Benue State Water Board Makurdi for analysis. The time between sample collection and analysis was within 6 hours.

Station 1 (upstream): This site was selected in a quiet environment without much anthropogenic activities to serve as reference point.

Station 2 (midstream): This site was selected in an industrial area. A number of anthropogenic activities known to cause pollution were observed. Refuse were dumped indiscriminately and industrial effluents from these industries were directly and indirectly discharged into the river. Animals were seen grazing and wallowing in the industrial effluents. Evidence of farming and transportation activities was also observed.

Station 3 (downstream): This site was selected in a settlement and residential area. Sewage generated from old and new colonies were discharged near the river. Farming, cattle grazing, fishing and transportation activities were also observed.

Sample Analysis

Parameters with extremely low stability such as temperature, pH and turbidity were tested on the site. Other parameters were analyzed in the laboratory of the Benue State Water Board Makurdi. The three replicates of sample collected at each station were analyzed and the mean value for each physico-chemical parameter was taken.

Determination of Physico-chemical Parameters

Physico-chemical parameters were determined using standard methods for the examination of water and waste water. Methods used for the determination of the parameters were as follows;

pH: pH Meter
Turbidity: Nephalometric Turbidity Tube
Temperature: Thermometer
Dissolved Oxygen (DO): Iodometric Method
Colour: Platinum – Cobalt Standard Method
Total Suspended Solid (TSS): Photometric Method also called Non-filterable Residue
Total Dissolved Solid (TDS): Gravimetric Method
Total Solid (TS): Summation of TSS and TDS
Iron: TPTZ Method (Powder Pillows)
Copper: Bicinchoninate Method
Ammonia: Salicylate Method
Nitrates: Cadmium Reduction Method (Powder Pillows)
Nitrite: Diazotization Method (Powder Pillows)
Phosphorus: PhosVer 3 (Ascorbic Acid) Method (Powder Pillows)
Chlorides: Argentometric Method

Determination of Total Coliform

Total coliform was determined using the multiple - tube fermentation technique also referred to as the Most Probable Number (MPN). Separate analyses were conducted on five portions of each of three serial dilutions of a water sample. 1ml each of 10^{-3} dilution aliquot was added aseptically to 5 tubes containing 10ml of single strength sterile medium (lactose broth). This was shaken gently to mix the sample with the single strength medium and placed in a rack. Small inverted glass tubes (Durham tubes) were inserted into the test tubes to facilitate the detection of gas production and then incubated. The number of positive reactions was recorded after 48 hours. Growth in the medium which indicates a positive result was confirmed by visible turbidity and/or a colour change. The MPN index was determined by comparing the pattern of positive results with statistical tables.

Results

Variations in the physico-chemical parameters of the replicates in station 1, 2 and 3 are depicted in table 1. Table 2 shows the mean values of the variations in the physico-chemical parameters and the result of total coliform in all the selected stations.

Table 1: Variations in the physico-chemical parameters of the replicates in the sampled stations

Parameter / Unit	Station 1			Station 2			Station 3		
	R_1	**R_2**	**R_3**	**R_1**	**R_2**	**R_3**	**R_1**	**R_2**	**R_3**
Temperature (^{0}C)	26.5	26.8	26.0	28.8	28.0	29.5	28.6	29.0	28.0
Turbidity (NTU)	8.4	8.1	8.5	21.1	21.4	21.5	12.3	12.5	12.2
Colour (Pt/co)	214	216	213	452	453	452	239	238	240
pH	7.4	7.5	7.2	7.6	7.8	7.6	7.4	7.4	7.5
DO (mg/L)	3.5	3.8	3.6	2.8	2.5	2.6	3.0	3.0	2.8
TSS (mg/L)	55	56	55	95	94	96	69	69	68
TDS (mg/L)	50	50	51	187	188	187	49	50	49
TS (mg/L)	105	106	106	282	282	283	118	119	117
Chlorides (mg/L)	35.5	35.0	35.5	35.0	36.0	35.0	35.5	36.0	34.5
Nitrates (mg/L)	3.4	3.2	3.5	5.8	6.0	5.5	4.1	4.5	4.0
Nitrite (mg/L)	0.02	0.03	0.02	0.04	0.04	0.04	0.03	0.04	0.03
Ammonia (mg/L)	0.05	0.06	0.08	0.11	0.15	0.10	0.07	0.08	0.07
Copper (mg/L)	0.37	0.36	0.37	0.77	0.75	0.80	0.46	0.45	0.50
Phosphorus(mg/L)	0.67	0.68	0.70	0.96	0.95	1.00	0.71	0.80	0.74
Iron (mg/L)	0.33	0.35	0.32	0.61	0.66	0.65	0.44	0.40	0.45

Table 2: Mean values of the variations in the physico-chemical parameters and the result of total coliform in the sampled stations

Parameter (Unit)	Station 1	Station 2	Station 3	WHO permissible limits
Temperature (^{0}C)	26	29	29	25 – 36
Turbidity (NTU)	8	21	12	5
Colour (Pt/co)(TCU)	214	452	239	1 – 5
pH	7.4	7.6	7.4	6.5 – 8.5
DO (mg/L)	4	3	3	NA
TSS (mg/L)	55	95	69	500
TDS (mg/L)	50	187	49	1000
TS (mg/L)	106	282	118	1000
Chlorides (mg/L)	35	35	35	200 – 250
Nitrates (mg/L)	3	6	4	50
Nitrite (mg/L)	0.02	0.04	0.03	10
Ammonia (mg/L)	0.06	0.1	0.07	NA
Copper (mg/L)	0.4	0.8	0.5	1.0
Phosphorus (mg/L)	0.7	1.0	0.8	1.0
Iron (mg/L)	0.33	0.64	0.43	0.30
Total coliform (cfu/ml)	120	210	180	0.00

Key: NA – Not Available

Discussion

Mean values of the physico-chemical parameters and the result of the total coliform fluctuated across the selected stations. Mean temperature value at station 1 was determined to be 26^{0}C. Station 2 and 3 had 29^{0}C. Increase in temperature at station 2 and 3 may be attributed to inflow of industrial effluents and domestic sewage. However, temperature does not influence hygienic value of water [13]. Turbidity which measures the relative clarity or cloudiness of water varied greatly across the selected stations. Station 1 had 8NTU, station 2 21NTU and station 3 12NTU (S_2>S_3>S_1). High turbidity observed at station 2 followed by station 3 as compared to station 1 may be caused by the presence of plankton, soluble coloured compounds e.g. iron, microscopic organisms including bacterial and other pathogens as well as suspensions from sewage disposal. Excess turbidity leads to fewer photosynthetic organisms available to serve as food sources for many invertebrates. As a result, overall invertebrate numbers may decline which may then lead to a fish population decline [13]. The colour of the river was generally high. However, higher colour was observed at station 2 (452Pt/co) followed by station 3 (239Pt/co). Station 1 had 214Pt/co. The general high colour of the river may be due to the presence of coloured decomposed organic materials and metals such as iron and copper. Colour observed to be higher at station 2 followed by station 3 can be attributed to the presence of highly coloured industrial wastes and domestic sewage resulting from anthropogenic activities. This is an indication of toxicity and may stain textiles and fixtures [2]. Total suspended solid was found to be 55mg/L at station 1, 95mg/L at station 2 and 69mg/L at station 3($S_2>S_3>S_1$). Higher suspended solids observed at station 2 followed by station 3 may be caused by plankton growth or waste water indicating possible hazardous contamination. Total dissolved solids and total solids were also found to higher at station 2.

Narrow fluctuations in pH were observed. Both station 1 and 3 had pH of 7.4 and station 2 had pH of 7.6. This shows the ability of the river to neutralize acid due to the geological characteristics of the bottom of the water body which may contain basic compounds. This pH indicates the existence of biological life as most of them thrive in a quite narrow and critical pH range. In too acidic or basic waters biological life is extinct [13]. Dissolved oxygen was 4.0mg/L at station 1. Station 2 and 3 had 3.0mg/L. Decrease in oxygen concentration at station 2 and 3 may be due to turbidity caused largely by organic particles, increase in temperature or decomposition of organic matter by aerobic microorganisms. Prolonged exposure to this low dissolved oxygen levels may not directly kill an organism but rather increases its susceptibility to other environmental stresses [13]. Uniform mean value for chlorides at all the sampled stations which was found to be 35mg/L indicates its natural occurrence, penetrating into the water from the soil and natural layers of salt. Pollution from anthropogenic sources had no or little effect on the chlorides composition of the water body. The mean value of nitrates was found to be higher in station 2 (6mg/L) followed by station 3 which had 4mg/L. Station 1 had 3mg/L. The presence of nitrates in all the sampled stations indicates its natural occurrence in the river water as a result of plant or animal material decomposition. However, its higher values at station 2 followed by station 3 is due to human activities such as disposal of industrial and domestic sewage as well as use of agricultural fertilizers and manure. The level of nitrite in the river water was generally low. Station 1 had 0.02mg/L, station 2 0.04mg/L, station 3 0.03mg/L. This may be due to its less stability. Nitrite is less stable than nitrates and generally, due to chemical and biochemical factors it is oxidized to nitrates or undergoes reduction to ammonia in fairly short time [13]. The little increase in station 2 and 3 may be as a result of the presence of organic or inorganic substances. The level of ammonia was higher at station 2 (0.1mg/L) followed by station 3 (0.07mg/L). Station 1 had 0.05mg/L. Ammonia observed in the river water can be a product of decomposition of plant and animal matter or due to chemical or biochemical reduction of nitrate and nitrite. Higher values observed at station 2 may be an indication of pollution originating from soil as a result of use of ammonia rich fertilizers and sewage. Copper was established to be higher at station 2 (0.8mg/L). Station 3 had 0.5mg/L and station 1 had 0.4mg/L. Although the level of copper in the river water was low, higher levels observed at station 2 followed by station 3 may be as a result of corrosion of the copper pipes or fittings which are widely used in household plumbing and industries. Phosphorus was found to be 1.0mg/L at station 2, 0.8mg/L at station 3 and 0.7mg/L at station 1. Higher levels of phosphorus at station 2 may be due to fertilizer runoff from agricultural human activity, industrial wastes and decay of organic matter. Phosphorus is not harmful in clean waters but it is an algal nutrient often contributing to excessive algal growth and eutrophication [13]. Iron was determined to be 0.64mg/L at station 2, 0.43mg/L at station 3 and 0.33mg/L at station 1. The main source of iron in the river water may be from erosion of minerals from rocks and soil. Increase in station 2 may be attributed to sewage and corrosion of pipelines discharging the industrial wastes into the river.

Total coliform was observed to be high at all the sampled stations but higher at station 2 (210MPNindex/100ml). Station 3 had 180MPNindex/100ml and station 1 had 120MPNindex/100ml. High levels of coliform indicate the presence of pollution from disease causing (pathogenic) organisms and decomposed plant materials. This shows the presence of water-borne organisms that could potentially cause disease. Higher levels at station 2 followed by station 3 may be evidence of water pollution with sewage containing faeces of humans or other warm blooded animals.

The mean values for temperature, pH, total suspended solid, total dissolved solid, total solid, chlorides, nitrates, copper and phosphorus in all the sampled stations were within the WHO standard for drinking water. However, the mean values for turbidity, colour, iron and total coliform in all the sampled stations were above the WHO permissible limits for drinking water as shown in table 2.

Conclusion

The river water showed some level of deterioration in water quality. Analysis of the results obtained indicates the gradual pollution of the river water due to anthropogenic activities. As compared to WHO standard for drinking water, the river water is not suitable for domestic use or human consumption unless treated. Legislation on environmental protection of the river water with strict compliance and monitoring is therefore considered necessary in order to minimize or avoid further pollution of the water for the good health of the populace.

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