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Assessment of Physicochemical Characteristics and Heavy Metals Concentration in Freshwater from Jega River, Kebbi State, Nigeria

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Abstract**—**This study was conducted to determine the physicochemical characteristics and heavy metal concentration (Cadmium (Cd), Copper (Cu), Iron (Fe), Lead (Pb) and Zinc (Zn)) in freshwater from Jega river. 30 water samples were collected in two 1-liter sterile plastic containers from three designated sampling points, namely; Station A (before the bridge; upstream), Station B (at the bridge where human activities such as washing of cars, motorbike, clothes, bathing and other household materials are concentrated), Station C (after the bridge; downstream) fortnightly, between March and July 2014. Results indicated that the highest pH mean value of 7.08 ± 1.12 was observed in station C, the highest conductivity with the mean 58.75 ± 7.87 µs/cm was observed at station A, the highest mean value of the water total hardness was observed at station A (54 ± 16.11 mg/L), the highest mean value of nitrate deposit was observed in station A (1.66 ± 1.33 mg/L), the highest mean value of alkalinity was observed at station B (51.33 ± 6.66 mg/L) and the highest mean (39.56 ± 3.24 mg/L) of total dissolved solids was observed at station A. The highest concentration mean value of Fe was observed in station C (65.33 ± 4.50 mg/L), the highest concentrations of Cd was observed in station C (0.99 ± 0.36 mg/L), the mean value of 2.13 ± 1.99 mg/L was the highest concentration of Zn observed in station B, the concentration of Pb was not detected (ND) and the highest concentration of Cu with the mean value of 0.43 ± 0.16 mg/L was observed in station B, while the lowest concentration was observed at station C (0.27 ± 0.26 mg/L). Statistical analysis shows no significant difference (P > 0.05) among the sampling stations for both the physicochemical characteristics and heavy metal concentrations. The results were found to be within the internationally acceptable standard limits.

Keywords **—**Assessment, freshwater, heavy metal concentration, physicochemical.

I. Introduction

HEAVY metals are members of loosely defined sub-set of elements that exhibit metallic properties with high density and toxicity. They include transition metals, metalloids, lanthanides and actinides and occur naturally as they are components of the lithosphere released into the environment through volcanism, soil erosion, dissolution of water-soluble salts and weathering of rocks [1]. Living organisms require trace amount of some heavy metals such as Zn, Cobalt, Strontium, and Cu for normal growth and metabolism, but excess levels of these metals can be detrimental to the living organisms [2].

Though heavy metals are natural trace components of the aquatic environment, industrial wastes, geochemical structures, agricultural and mining activities have increased their levels which affect the physiochemical characteristics of the water, sediment and biological components [3], [4]. The agricultural drainage water containing pesticides and fertilizers and effluents of industrial activities and runoffs in addition to sewage effluents supply the water bodies and sediment with huge quantities of inorganic anions and heavy metals. Hence, aquatic pollution can have major impacts on the physicochemical parameters of the river such as pH, total dissolved solids, temperature and hardness of water [4], [5].

Natural factors like erosion, agricultural activities; and anthropogenic activities like dumping wastes, washing of cars, bathing and washing of clothes along rivers can contribute to larger problem of river pollution. This can seriously damage water bodies and cause health hazards to fish, people and animals. These activities had been observed to be concentrated at the river bank of Jega River probably due to its proximity to the town. Thus, there are possibilities of the presence of abundant heavy metals in the water body.

Jega River serves as a major source of portable drinking water to both the inhabitants of the community and domestic animals, and other human activities such as, fishing, washing of clothes, household materials, car washing, blocks industry, dyeing and bathing. However, there is no adequate waste disposal and control of effluent discharges emanating from such activities into the receiving river. This could be a potential cause of water contamination. Furthermore, there are little or no available documented records of the status of the physicochemical and heavy metal concentrations of the water in Jega River. Thus, studying the presence of some heavy metals like Pb, Cu, Fe, Zn and Cd in Jega River is imperative, to ascertain its ability to sustain the aquatic animal therein and humans who depend on the river for daily activities.

II. Materials and Methods

A. Study Area

The samples for the study were obtained from Jega River, Kebbi State, Nigeria. Jega River is a subsidiary of the River Niger in Nigeria with all year round flow of water. Since the river runs along Jega township, Jega and surrounding

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communities are known for their agricultural activities in the dry season principally under irrigation. Other activities around the river include dyeing, car washing, laundry and other domestic activities that directly or indirectly discharge untreated effluents in to the river.

B. Water Sample Collection

Water samples were collected as described by [6], in two 1-liter sterile plastic containers from three designated sampling points in Jega River (fortnightly) between March and July 2014. Three locations were marked for sample collection, namely; Station A (before the bridge; upstream), Station B (at the bridge where human activities such as dyeing, car washing and laundry), and Station C (after the bridge; downstream). Figs. 1-3 show the pictorial presentation of the sampling stations.

Fig. 1 Station A: Upstream, mostly consist of agricultural activities

Fig. 2 Station B: At the bridge (domestic and industrial activities discharge untreated effluent into the receiving stream)

Fig. 3 Station C: Downstream (mostly preoccupied with agricultural activities and waste disposal)

The sampling bottles were pre-conditioned with 5% nitric acid and later rinsed thoroughly with distilled de-ionized water. At each sampling site, the polyethylene sampling bottles were rinsed at least three times before sampling was done. Pre-cleaned polyethylene sampling bottles were immersed about 10 cm below the water surface. Two samples of about 0.5 L of the water were taken at each sampling site. Samples were acidified with 10% HNO_3, placed in an ice bath and brought to the laboratory for analysis of physicochemical characteristics and heavy metal concentrations as illustrated in Fig. 4.

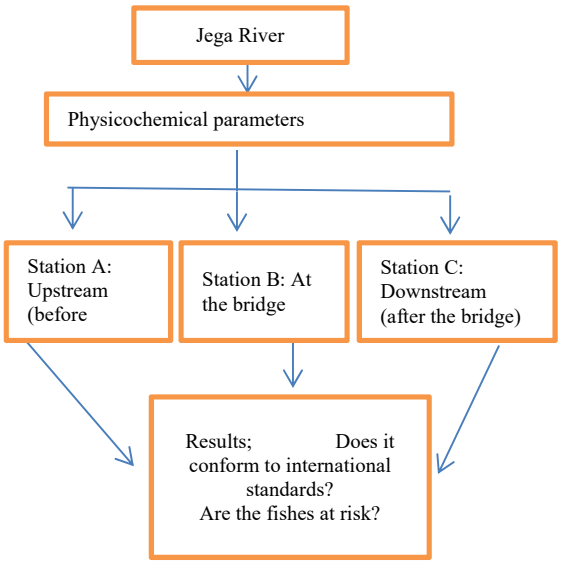

Fig. 4 Conceptual framework of the study

C. Physicochemical Analysis

Some physicochemical parameters of water from Jega River, such as pH, conductivity, total hardness, alkalinity, nitrate (NO_3), phosphate (PO_4) and total dissolved solid (TDS) were determined using standard procedures.

The hydrogen concentration (pH) of the water samples was determined with pH meter at room temperature. The pH meter was first standardized with buffer solution of pH 4.0 and 9.0 before taking readings of the samples. The probe of the pH meter was then inserted into the water sample and the readings were recorded.

The alkalinity of the water sample was determined by taking 50 ml of water sample in a clean conical flask and 2 drops of methyl orange indicator was added and shaken until yellow color was observed. This was titrated with 0.02 N sulphuric acid (H_2SO_4) until the color of the solution changed from yellow to orang. The total alkalinity was calculated as:

$$\text{Total Alkalinity} = \frac{\text{Vol.}(H_2SO_4)\times\text{Mol.}(H_2SO_4)\times 1000}{\text{M1 of water sample}} \quad (1)$$

where M1= One litre of water sample.

To determine total hardness, 1 ml of ammonium chloride buffer solution was added to 50 ml of water and 3 drops of eriochrome black-T indicator was added. The resultant wine color solution was titrated with 0.01 N EDTA (Ethylene-diamine-tetraethanoic acid) until a blue color was observed.

Total hardness was calculated as:

$$CaCO_3 = \frac{\text{Vol.EDTA} \times N \times 1000}{\text{Vol.of sample}} \quad (2)$$

Conductivity meter was used to measure the conductivity of the water sample and reading express in micro-ohms/cm. The probe of the motor was rinsed very well and then inserted into the water sample and the readings were record.

For NO_3 determination, 50 ml of water sample was evaporated to dryness and 2 ml of H_2SO_4 was added to the residue after cooling and mixed quickly. 15 ml of distilled water was added to the mixture (residue and H_2SO_4) and then 15 ml of NaOH was added. A yellowish colour was observed which indicate the presence of NO_3. The absorbance was read on spectrophotometer at 420 nm and the calibration curve was drawn and concentration was extrapolated from the curve. NO_3 was calculated with;

$$NO_3\ (mg/l) = \frac{\text{reading from curve} \times 1000 \times D}{\text{M1 of water sample}} \quad (3)$$

where: D = is the dilution factor, M1= One litre of water sample.

D. Heavy Metal Analysis in Water

Acid mixture (HNO_3 + HCl_4) at (1:1), and wet oxidation, also called wet digestion, were used for the detection of heavy metals in the water samples. 1 ml of water sample was weighed into a conical flask and 20 ml of the acid mixture was added and then transferred into a hotplate. The mixture was heated gently until the digest became clear. The digest material was cooled and diluted into 100 ml with distilled water in a standard flask and will be analysed for heavy metals using Atomic Absorption Spectrophotometer (AAS), [4]. Each of the metals will be determined at specific wavelength.

III. Result and Discussion

A. Physicochemical Parameters

Table I shows the physicochemical parameters of Jega River. The highest pH mean value of 7.08 ± 1.12 was observed in station C, while the lowest mean, 6.71 ± 1.23, was observed in station B. The highest conductivity (58.75 ± 7.87µs/cm) was observed at station A, while the lowest mean value (51.23 ± 6.43 µs/cm) was observed in station C. The highest mean value of the water total hardness was observed at station A (54± 16.11 mg/L), while lowest mean value (42± 1.00 mg/L) was observed at station B. The highest mean value of NO_3 deposit was observed in station A (1.66 ± 1.33 mg/L) while the lowest mean value (1.00 ± 0.55 mg/L) was observed at station B. The highest mean value of alkalinity was observed at station B (51.33 ± 6.66 mg/L), while the lowest mean value for alkalinity was observed at station A (44.57 ± 5.41 mg/L). The highest TDS (39.56 ± 3.24 mg/L) was observed at station A, while the lowest mean value (34.56 ± 1.35 mg/L) was observed at station B. Statistical analysis showed no significant difference (P>0.05).

TABLE I
PHYSICOCHEMICAL QUALITIES OF WATER FROM JEGA RIVER

ST	pH	Cond. (µs/cm)	TH (mg/L)	NO_3 mg/L	Alk. (mg/L)	TDS mg/L
A	6.82 ±0.91	58.75 ±7.87	54 ±16.11	1.15 ±0.85	44.57 ±5.41	39.56 ±3.24
B	6.71 ±1.23	54.23 ±2.23	42 ± 1.00	1.00 ±0.55	51.33 ±6.66	34.56 ±1.18
C	7.08 ±1.12	51.23 ± 6.43	52 ±2.03	1.66 ± 1.33	47.57 ± 5.41	36.56 ± 1.35

ST = Stations, Cond. = conductivity , TH = Total Hardness, Alk. = Alkalinity

B. Concentration of Heavy Metals in Water from Jega River

The highest concentration mean value of Fe was observed in station C (65.33± 4.50 mg/L), while the lowest mean value was observed at station A (41.67 ± 19.34 mg/L). The highest mean concentration of Cd was observed in station C (0.99 ± 0.36 mg/L) while the lowest concentration was observed in station A (0.89 ± 0.15 mg/L). The mean value of 2.13 ± 1.99 mg/L was the highest concentration of Zn observed in station B, while the lowest mean value was observed at station A (1.88 ± 1.44 mg/L). The concentration of Pb was ND. The highest concentration of Cu with the mean value of 0.43 ± 0.16 mg/L was observed in station B, while the lowest concentration was observed at station C (0.27 ± 0.26 mg/L). Statistical analysis shows no significant difference (P>0.05) as shown in Table II

TABLE II
HEAVY METALS OF WATER FROM RIVER JEGA

ST.	Fe, mg/L	Cd, mg/L	Pb, mg/L	Zn, mg/L	Cu, mg/L
A	41.67±8.34	0.63±0.15	ND	1.88±1.44	0.85 ±0.13
B	51.33±6.23	0.55±0.20	ND	2.13±1.99	0.73 ±0.16
C	65.33±4.50	0.41±0.32	ND	1.90±1.47	0.53 ±0.26

ST. = Stations

C. Discussion

From the results, Fe recorded the highest mean concentration (65.33 mg/l) which is higher than standards. The relatively high concentrations of Fe could probably be due to continuous introduction of anthropological activities and rock particles into the pond since rocks were reported to be very good sources of mineral elements [7]. Despite that Zn has a high concentration in the Jega River (2.13 mg/l), it was still found to be within the standard limit of [8]-[10] which are; 3 mg/l.3 mg/l and 5 mg/l respectively, thereby making it not to serve as a threat to lives. Pb (0.000 mg/l) was completely absent in all the samples analysed. Abundance of heavy metals in the river was probably due to rock weathering, and also surface runoffs from agricultural lands containing agronomic chemicals such as fertilizers, herbicides fungicides etc. that are being washed into the river.

IV. Conclusion

The study concluded that heavy metals were detected in freshwater from Jega River pointing to the fact that the river itself contains these heavy metals. Pb was ND in the study. However apart from Fe, all other concentrations are all within acceptable limits for human consumption.

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