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Bioaccumulation of Trace Metals in Fish from Issiet River, Uruan, Nigeria

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Abstract: Environmental problems associated with water pollution are great. Obviously, the problems are connected to the damages done to the aquatic environment as a result of anthropogenic activities. Anthropogenic activities could have serious detrimental effects in the aquatic environment. These could go a long way in affecting the suitability of water and aquatic organisms from such an environment for human use. Levels of Pb, Ni, Fe, Cu, Co and Cd were evaluated in fish (*Brycinus nurse*) in order to assess the bioaccumulation of the trace metals in the fish with the view to ascertain the suitability of the fish from Issiet River in Uruan, Nigeria, for human consumption, The levels of the trace metals were also evaluated in water and sediment. Dry and wet seasons' samples were collected and digested according to standard methods and analysed using Unicam 939/935 atomic absorption spectrophotometer. Physicochemical properties were also quantified in water samples using standard procedures. The results revealed variable levels of the investigated parameters in the samples. Trace metals levels in fish ranged from 0.0031±0.00 mg/kg Cd to 0.298±0.01 mg/kg Fe for the two seasons. The trace metals levels in fish, water and sediment were below the permissible limits stipulated by WHO and USEPA. Bioaccumulation factor analysis of trace metals in fish revealed the range: 1.15 of Cd to 3.06 of Ni from water for the two seasons and 0.23 of Cd to 1.11 of Pb from sediment. In conclusion, the analysed fish, water and sediment contained variable levels of the investigated trace metals. Their levels in the fish were below the limits that could cause toxicity in human consuming the fish, at the time of the study. Periodic analyses of the investigated trace metals in the river are highly recommended for the purpose of documentation and monitory.

Keywords: Bioaccumulation, Trace Metals, AAS, Fish, Issiet River, Uruan, Nigeria

1. Introduction

Water is a vital substance in all parts of the environment. Due to its uniqueness, water could be said to be critical in the sustenance of life and human existence [1]. Water is a universal solvent which is important and essential to humans and other living things. Water dissolves soluble substances present in an aquatic environment. This alters the physicochemical parameters of the water in such an environment [2]. Indeed water pollution is one of the most serious environmental problems in the world today [3, 4]. Pollutants resulting from human activities have negatively impacted our natural water bodies. Human health and welfare, food security, industrial development and the ecosystem on which man depends are all at risk unless water and land resources are managed in a more ecologically appropriate

manner than they have been in the past [5]. River water supports many life forms, provides recreation and fishing to the community, and it may also be used for drinking purposes and irrigation. River water has been used as recipient of toxic and solid waste from domestic, industrial and agricultural runoff [1]. Many of these solid wastes are water-borne which are either floating in water or adsorbed on the sediment [4-6]. The extent of pollution of any water body depends on the quality and quantity of wastes and effluents discharged into the water as well as other factors prevalent in the water [1, 4, 5].

Pollutants or contaminants in the aquatic environment that pose serious threat include hydrocarbons, sewage, pesticides, and trace metals. Trace metals and pesticides that originated from land based sources, are of particular concern to the marine environment because they exhibit both toxicity and persistence and are known to bioaccumulate in the food chain [7, 4].

Protection of water sources against all forms of contaminations which continually threatened the terrestrial and aquatic ecosystems due to increasing inputs of untreated wastes and chemical agents that are capable of causing damages to the environment are of great concern [7, 4, 5]. River waters are quite vulnerable to pollution because they are naturally open, easily accessible, and substantially used in agricultural, industrial, and municipal processes [8, 4, 5]. The most often polluted environmental phases are the aquatic systems. This is due to the fact that contaminants in the air, soil or on land ultimately end up in the aquatic systems via local precipitation, water runoff and leaching of rocks and solid wastes [4, 5]. Indeed, toxic trace metals are the most common environmental contaminants that affect the aquatic systems [4, 5]. The presence of trace metals in aquatic systems can provoke serious environmental issues because of their persistence in the environment, as well as their bioavailability and toxicity to aquatic organisms and their ability to be incorporated into the food chain [9, 4, 5].

Contamination of river system by trace metals is a major global concern and their determinations have received great attention for monitoring environmental pollution. Sediment is an important sink for trace metals [10]. Sediment has a large capacity to retain trace metals from various sources and the trace metals may be immobilized within the sediment by processes such as adsorption, flocculation and precipitation [11].

Trace metals are non-biodegradable and persist in the environment and may become concentrated up in the food chain [12]. This can lead to enhance levels in the liver and muscle tissues of fish [13]. According to Udosen [3], the toxicity of metal or its compounds in water depends on many interrelated factors, and various equilibrium conditions that may be prevalent in water in relation to organism present. The author gave the factors as: The form of the metal in the environment, which governs its availability for bioaccumulation; the presence of other metals whose influence may range from additive increase in toxicity on one hand to antagonistic effects on the other. According to the author, one metal may by its presence facilitate the toxic effect of another metal, in addition to exerting its own effect. Adding that, this could result in combined toxicity that is greater than the toxicity of the individual metals. He pointed out that, silver and copper, mercury and copper, copper and zinc have been shown to exhibit this synergic effect. Udosen [3], mentioned other factors to include: environmental factors such as temperature, salinity, pH, dissolved oxygen and light which could influence toxicity by changing the type of the metal species and the physiological stress on the organisms; the condition of the organism (phase of cycle, age, sex, nutritional state); general adaptability to conditions in the environment by shell closure or immunity to metal toxicity as well as hardness of water. Water is considered hard when it contains calcium and magnesium compounds. Similarly, if a large amount of other metallic ions ($Fe^{2+,}$ Al^{3+}, Mn^{2+}, Sr^{2+}, and Zn^{2+}) are present, the water is considered hard [3].

It had been established that although many metals are essential for animals' tissues metabolism, the ranges between beneficial and toxic levels are very small; and that there is an increasing concern about the health effect in humans due to continuous consumption of food contaminated with trace metals, and that the extent of this contamination depends on several complex factors, some of which are the specific metabolic and homeostatic mechanism operating in the type of food and tissue considered [11].

Trace metals found in an aquatic environment can come from natural and anthropogenic sources. Such sources include geological minerals, wind-blown silicate dust and volcanic emissions. Human activities such as mining, industrialization and sewage treatment discharges as well as discharges of electronic wastes (computers, printers, photocopy machines, television sets, mobile phones and metallic toys) and discharges of agricultural wastes are some of the few examples of man-made sources which contribute to the increased levels of trace metals in aquatic environment [3, 5]. Some researchers have pointed out that, in Nigeria, especially among the rural settlements, where safe and suitable potable water supply for drinking and other uses are lacking, the people depend on rivers, streams, ponds, lakes, shallow hand-dug wells for their water needs and also depend on aquatic animals which are capable of bio-accumulating pollutants like trace metals, for food. They added that, pollution of the aquatic environments could pose serious threat to man [14, 4, 5].

Issiet River in Uruan, Akwa Ibom State serves as a local river port with regular fishing, transportation and lumbering activities. Indeed, communities within the vicinity of the river depend directly on the Issiet River for recreational activities as well as for food. Erosion, lumbering and agricultural activities and of course domestic sewage discharges could lead to a wide scale contamination of the river. A polluted or contaminated aquatic environment could impacts negatively on living organisms that exist there. This could go a long way in impacting negatively on humans that depend on the river for their livelihood. Information on bioaccumulation of trace metals in fish from Issiet River is

inadequate or not available at all. Data obtained from this study will provide information on the bioaccumulation of trace metals in fish from the river and current levels of the investigated trace metals in fish and also provide the potential health risk of eating fish caught from the river. The information obtained will serve as a baseline data on the state of the Issiet River and enable both government and private organizations on pollution control to take necessary actions. So, there is every need for this study which is aim at determining the bioaccumulation of trace metals in fish from Issiet River, Uruan, Nigeria, with the view to ascertain the suitability of the fish for human consumption in terms of trace metals contamination.

2. Materials and Methods

2.1. Study Area

This study was conducted in Issiet River in Uruan, Akwa Ibom State, Nigeria. The area has geographical coordinates of 4°57'0" North and 8° 1' 0" East. Ishiet River is a continuation of Ikpa River with its estuary at Nwaniba, beyond which it joins the Cross River as part of its braided section. The vicinity of the river is within a typical rain forest zone that is characterized by distinct dry and wet seasons. The wet season sometimes begin in April and is often characterized by heavy storms of short duration. Sometimes strong winds that destroy crops and building occur. The annual average rainfall of the area is about 2,168 mm. The dry season which normally lasts between three and five months from November to March is often influenced by the hot North- East trade winds blowing from the Sahara desert. The mean annual temperature of the area is 26°C with high relative humidity. The location of the study area is shown in Figure 1.

2.2. Samples Collection

Water, fish (*Brycinus nurse*) and sediment samples were collected between the months of January and March 2019 for the dry season samples and June and August 2019 for wet season samples. Samples were collected from three (3) locations designated as stations 1, 2 and 3, representing downstream, midstream and upstream, respectively. Water and sediment samples were collected according to the methods described by [1, 3, 4, 5]. Water samples for trace metal analysis were collected in nitric acid pre-rinsed (1L) containers and 5 mL of concentrated nitric (HNO_3) acid added immediately to minimize chemisorption. Water samples for Dissolved oxygen (DO) and biochemical oxygen demand (BOD) determinations were collected in amber bottles. In the field, the bottles were pre-rinsed with the water from the respective sampling sites. Each mouth of the sample bottles was dipped against the flow direction to avoid trapping of air bubbles in the bottles. Sufficient air spaces were left in all the bottles (except those for DO determination) to allow for expansion of water when the temperature increases. Sediment samples were collected at a depth of about 25 m using Van Veen grab sampler at three different points and made into composite samples. The sediment samples collected were stored in 1L plastic containers.

Fish (*Brycinus nurse*) samples were collected by means of locally prepared fish traps. These traps were placed inside the water (one per sampling site) at dusk and were inspected at dawn the following day. Medium- sized fish samples were selected from the total catch early in the morning, and were stored in a locally made aquarium.

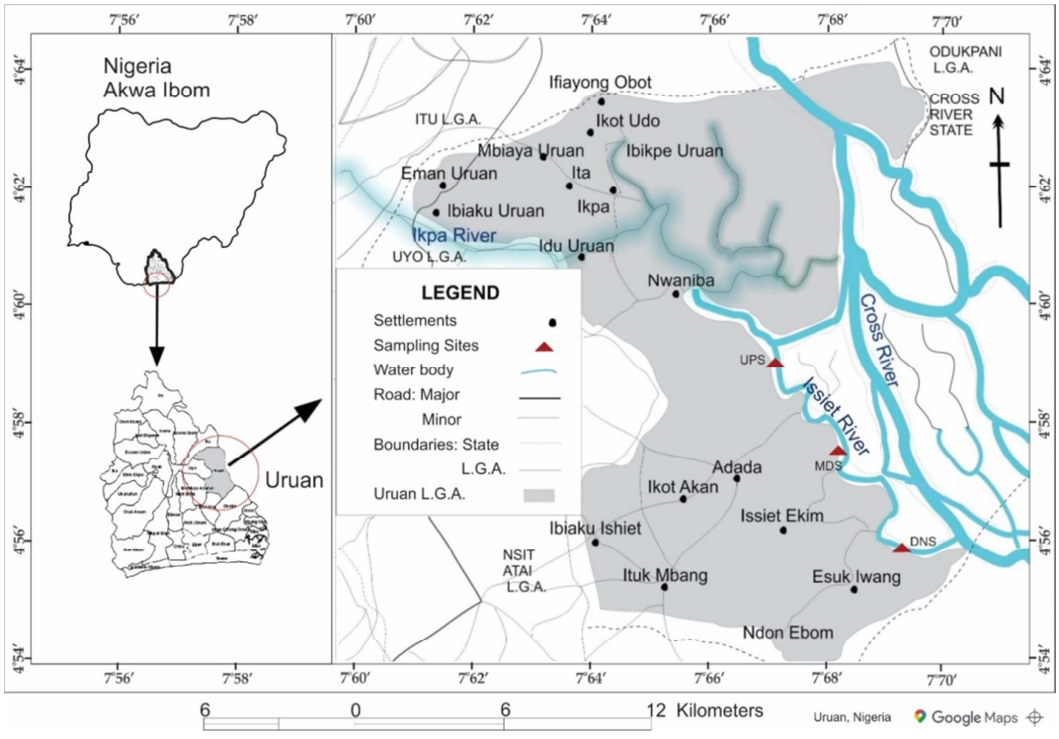

Figure 1. *The study area.*

2.3. Samples Preparation

Sediment samples were prepared according to the method described by [3-5]. The samples were air-dried and ground using porcelain mortar and pestle. The texturally equivalent petite fractions of the sediment were separated after grinding by sieving through a 2.00 mm mesh sieve. For each of the finely dried and ground sediment, 20 g were kept in an air-tight plastic bottle prior to digestion. Fish samples were washed with distilled water to remove dirt and other loosely held particles. They were then descaled, gutted and decapitated using stainless steel kitchen knife. The decapitated fish samples were filleted on both sides, placed in a porcelain crucible and dried in an oven. The dried muscles of fish samples were blended into a powder using an electric blender. The powdered fish samples were stored in a well-labeled plastic bag before digestion.

2.4. Digestion of Sediment Samples

Digestions of sediment samples were done according to the method described by [3, 4]. From each of the finely ground sediment samples, exactly 1.0 g was digested in a mixture of nitric acid (HNO_3) and perchloric acid ($HClO_4$) in the ratio of 3: 2 in a crucible and refluxed on a hot plate placed inside the fume hood at 110 ^oC and was allowed to heat for 45 minutes till the mixture became clear. After heating, the resultant solutions and the undigested portion of the sediments were filtered using a filter paper. The filtrate was put in a volumetric flask and made up to 20 cm^3 with deionized water. All the digested samples were stored in plastic bottles with plastic covers and labeled appropriately for trace metals analyses.

2.5. Digestion of Fish Samples

Digestions of fish samples were done according to the method described by [15, 5]. Each of the fish was dried in an oven at 80 °C for 24 h and homogenised to powder form. Two (2) g of the powdered sample were taken in a beaker; 6 mL HNO_3, 2 mL perchloric acid and 30 mL distilled water added and stirred. The beaker was heated, allowed to cool and the content filtered and made up to 50 mL with distilled water in a 50 mL volumetric flask.

2.6. Determination of Trace Metals in the Water, Fish and Sediment Samples

The digest solutions of the water, fish and sediment samples were prepared by measuring 10 mL of each of the samples into 250 mL crucibles. The samples were digested with aqua regia reagent (HCl and HNO_3), in the ratio of 3: 1 at 130°C using electric hotplate for 30 minutes. Each of the filtrate was made up to 100 mL with distilled water in 100 mL volumetric flasks after filtration. Standard solutions of the trace metals to be analysed were prepared. Atomic absorption spectrophotometer (AAS) (model: varian spectra 100, Australia.) was set with power on for ten minutes. The standard metal solutions were injected to calibrate the AAS using acetylene gas. An aliquot of the digest solutions were injected and the concentrations obtained from the AAS.

Note: The standard solutions of the trace metals analysed were prepared as follows:

Cadmium: Cadmium metal (0.100 g) was dissolved in 4 mL of conc. HNO_3 and 8 mL of the conc. HNO_3 was then added and diluted with deionized water to $1dm^3$.

Lead: Lead (II) trioxonitrate (V) {Pb $(NO_3)_2$} (1.5980 g) was weighed and dissolved in 50 mL nitric acid and the solution diluted to 1 dm^3 with deionized water.

Nickel: Nickel metal (4.953 g) was dissolved in 50 mL of 5M HNO_3 and diluted to 1 dm^3 with deionized water. *Iron*: Iron metal (7.022 g) was dissolved in 50 mL of 0.1M H_2SO_4 and diluted to $1dm^3$ with deionized water. *Cobalt*: Cobalt metal (5.0 g) was dissolved in 50 mL of 0.1M HNO_3. The solution was diluted to $1dm^3$ with deionized water.

Copper: Copper metal (1.965g) was dissolved in 50 mL of 1 M HCl and diluted to 1 dm^3 with ionized water.

2.7. Bioaccumulation Factors (BAF)

The bioaccumulation of the trace metals in fish was quantified from bioaccumulation factor (BAF) which is the ratio of the level of each of the trace metals in fish to the level of the trace metal in water or in sediment as modified by [16] according to Equation 1 or Equation 2.

$$BAF = \frac{C_F}{C_W} \quad (1)$$

$$BAF = \frac{C_F}{C_S} \quad (2)$$

Where: C_F = Level of trace metal in fish, C_W = Level of trace metal in water, C_S = Level of trace metal in sediment.

2.8. Physicochemical Parameters Determination in the Water Samples

The physicochemical parameters of the water samples were determined by standard procedures described by [17, 18, 4]. All field meters and equipment were checked and calibrated according to the manufacturer's specifications. The pH meter was calibrated using buffers of pH 4.0, 7.0 and 10.0. Total Dissolved Solid (TDS) meter was calibrated using the potassium chloride solution provided by the manufacturer. *In situ* measurements for some of the parameters pH, and temperature (°C) were measured using WTW pH Electrode SenTix 41. While electrical conductivity (EC) and TDS was determined by using a C0150 conductivity meter.

Dissolved oxygen (DO) in the water sample was determined by the Winkler's method. The biochemical oxygen demand (BOD) determination was done by keeping the water samples in an incubator in the dark for five days, after which the DO test was repeated and the BOD calculated by taking the difference between the initial and final concentrations of oxygen present after incubation as shown in Equation 3.

$$BOD_5\,(mg/l) = DO\ (initial) - DO\ (final) \quad (3)$$

Where: A = volume of $AgNO_3$ used for titrating the sample, B = volume of $AgNO_3$ used for titrating the blank and M = Molarity of $AgNO_3$.

Nitrite determination was done by measuring 10 m L of the water sample into a 25 mL conical flask and 1 mL of sulphanylamide solution added and allowed to stand for 2 – 8 minutes. An exact volume of 1 m L of 1-naphthylethylene diamine reagent was added to the mixture and allowed to stand for about 20 minutes and then made up to the 25 mL mark with deionised water. The absorbance was read at 543 nm using Jenway 7305 visible spectrometer. Nitrate determination was done by measuring 10 mL of the water sample into a 25 mL conical flask and 2 mL of bruccine reagent added and followed with the addition of 10 m L concentrated H_2SO_4, mixed for about 30 seconds and allowed to stand for 20 minutes and then made up to the 25 mL mark with deionised water. The absorbance was read at 420 nm using jenway 7305 visible spectrometer. The Bruccine reagent was prepared by dissolving 1.0 g of bruccine sulpahte and 0.1 g of sulphanilic acid in 70 mL of hot distilled water and 3 cm^3 concentration HCl added and the volume made up to 100 mL with distilled water.

Sulphate determination was done by the Gelatin method by measuring 10 mL of the water sample into a 25 mL conical flask and 1 mL of gelatin-$BaCl_2$ reagent added. The sulphate was precipitated out as $BaSO_4$ and the volume made up to the 25 mL mark with deionised water. The absorbance was read at 420 nm using jenway 7305 visible spectrometer.

Phosphate determination was done by the molybdenum blue method by measuring 30 mL of the water sample into a 25 mL conical flask and 3 mL of molybdenum blue reagent added and the volume made up to the 25 cm^3 mark with deionised water. The absorbance was read at 885 nm using jenway 7305 visible spectrometer.

2.9. Quality Control

Quality control of the analytical data was guaranteed through the implementation of laboratory quality assurance and laboratory methods, including the use of standard operating procedures, calibrations with standards and analyses with reagent blanks. Samples were analysed in triplicates, all chemicals and reagents used were of analytical grade.

2.10. Statistical Analyses

The data generated in this study were subjected to descriptive statistical analysis using statistical package for social sciences (SPSS).

3. Results and Discussion

3.1. Levels of Trace Metals in Water, Fish and Sediment Samples

The results of the levels of the investigated trace metals in water, fish and sediment samples analysed in this study are as presented in Tables 1 to 3. The levels of the trace metals in water are presented in Table 1. Those in fish are presented in Table 2. Those in sediment are presented in Table 3.

Table 1. *Trace metals levels (mg/L) in water from Issiet River during dry and wet seasons.*

Metals	Dry Season				Wet Season			
	UPS	MDS	DNS	Mean±SD	UPS	MDS	DNS	Mean±SD
Cd	0.003	0.005	0.003	0.003±0.00	0.003	0.005	0.007	0.005±0.00
Fe	1.270	1.700	1.390	1.45±0.22	1.390	1.810	1.320	1.51±0.27
Ni	0.025	0.032	0.023	0.03±0.00	0.031	0.036	0.028	0.03±0.00
Cu	0.070	0.067	0.052	0.06±0.01	0.080	0.092	0.062	0.08±0.02
Pb	0.006	0.007	0.003	0.005±0.00	0.005	0.005	0.002	0.004±0.00
Co	0.033	0.018	0.021	0.02±0.01	0.021	0.023	0.019	0.02±0.00

UPS = Upstream; MDS = Midstream; DNS = Downstream

Table 2. *Trace metal levels (mg/kg) in fish from Issiet River during dry and wet seasons.*

Metals	Dry Season				Wet Season			
	UPS	MDS	DNS	Mean±SD	UPS	MDS	DNS	Mean±SD
Cd	0.0021	0.0038	0.0035	0.0031±0.00	0.0019	0.0026	0.0029	0.0025±0.00
Fe	0.310	0.320	0.321	0.32±0.06	0.291	0.304	0.301	0.298±0.01
Ni	0.112	0.114	0.112	0.11±0.00	0.071	0.082	0.089	0.08±0.01
Cu	0.163	0.166	0.160	0.16±0.03	0.130	0.154	0.121	0.14±0.02
Pb	0.008	0.008	0.008	0.008±0.00	0.005	0.008	0.012	0.01±0.00
Co	0.033	0.033	0.030	0.03±0.00	0.030	0.028	0.032	0.03±0.00

UPS = Upstream; MDS = Midstream; DNS = Downstream

Table 3. *Trace metal levels (mg/kg) in sediment from Issiet River during dry and wet seasons.*

Metals	Dry Season				Wet Season			
	UPS	MDS	DNS	Mean±SD	UPS	MDS	DNS	Mean±SD
Cd	0.003	0.004	0.004	0.0035±0.00	0.0026	0.0025	0.0027	0.002±0.00
Fe	0.510	0.520	0.501	0.512±0.01	0.351	0.451	0.402	0.401±0.05

Metals	Dry Season				Wet Season			
	UPS	MDS	DNS	Mean±SD	UPS	MDS	DNS	Mean±SD
Ni	0.100	0.194	0.108	0.13±0.05	0.210	0.159	0.099	0.156±0.06
Cu	0.206	0.271	0.200	0.23±0.04	0.197	0.168	0.211	0.192±0.02
Pb	0.005	0.029	0.029	0.02±0.01	0.006	0.017	0.032	0.018±0.01
Co	0.073	0.079	0.042	0.06±0.02	0.069	0.074	0.052	0.065±0.01

UPS = Upstream; MDS = Midstream; DNS = Downstream

From Table 1, the mean levels of the investigated trace metals in water samples from the three stations during the dry season ranged from 0.003 ± 0.00 mg/L Cd to 1.45 ± 0.22 mg/L Fe, and those in samples obtained during the wet season ranged from 0.005 ± 0.00 mg/L Cd to 1.51 ± 0.27 mg/L Fe. In Table 2, the mean levels of the investigated trace metals in fish during the dry season ranged from 0.0031 ± 0.00 mg/kg Cd to 0.32 ± 0.06 mg/kg Fe, and those in samples obtained during the wet season ranged from 0.0025 ± 0.00 mg/kg Cd to 0.298 ± 0.01mg/kg Fe. According to Table 3, the mean levels of the investigated trace metals in sediment samples obtained during the dry season ranged from 0.0035 ± 0.00 mg/kg Cd to 0.512 ± 0.01 mg/kg Fe, and those in samples obtained during the wet season ranged from 0.002 ± 0.00 mg/kg Cd to 0.401± 0.05 mg/kg Fe. A clustered column chart comparing the levels of the trace metals in the different media for the two seasons is presented in Figure 2.

3.2. Bioaccumulation Factor (BAF) of Trace Metals in Fish

The generated BAF of trace metals from water to fish are presented in Table 4 and that generated from sediment to fish are as presented in Table 5. From Table 4, the highest BAF values of 3.06 and 2.67 in fish from water in the dry and wet seasons, respectively, were recorded for Ni. The lowest BAF value of 1.15 was recorded for Cd in the dry season. From Table 5, the BAF values in fish from sediment, ranged from 0.23 Cd to 1.11 Pb in the wet season. The BAFs of the investigated trace metals in the river were mostly higher in the wet season compared to the dry season. These could be attributed to higher activities and feeding regimes by the fish. [19, 5] noted that these tend to lower oxygen affinity of the blood of the fish and increase the rates of feeding of the fish and of course, pollutants accumulation. The rate of accumulation of trace metals in an organism depends on the ability of the organism to eliminate the trace metals and the levels of the trace metals in the surrounding [20, 5].

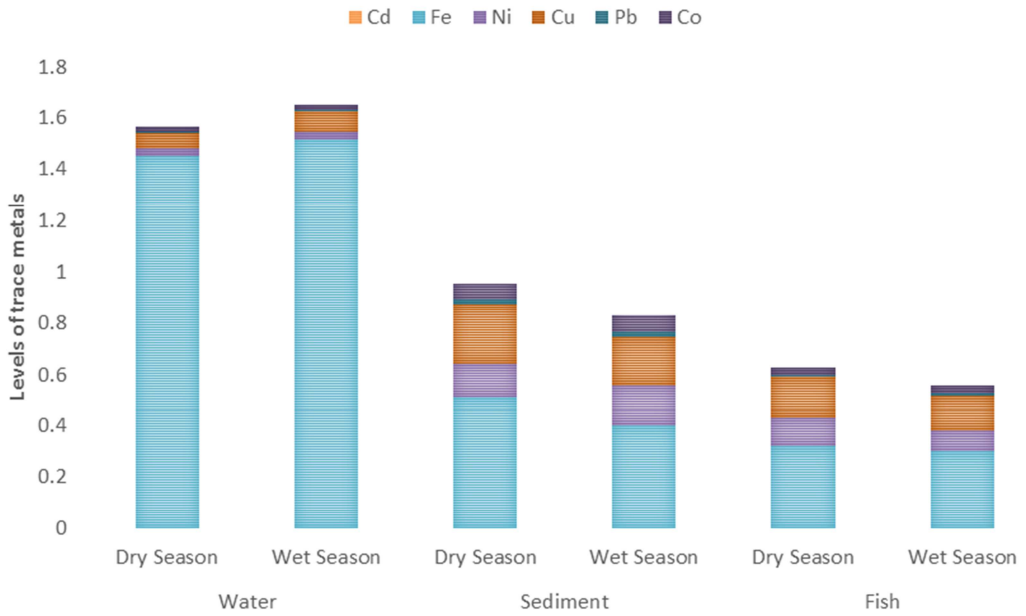

Figure 2. *Levels of trace metals in the different media for the two seasons.*

Table 4. *BAF of trace metals from water to fish.*

Metals	Dry Season			Wet Season		
	Level in fish	Level in water	BAF	Level in fish	Level in water	BAF
Cd	0.83	0.72	1.15	0.65	0.37	1.76
Fe	3.17	1.810	1.75	2.99	1.45	2.06
Ni	0.11	0.036	3.06	0.08	0.03	2.67
Cu	0.16	0.092	1.74	0.14	0.06	2.33
Pb	0.01	0.004	2.50	0.02	0.01	2.00
Co	0.03	0.023	1.30	0.03	0.02	1.50

Table 5. *BAF of trace metals from sediment to fish.*

Metals	Dry Season			Wet Season		
	Level in fish	Level in sediment	BAF	Level in fish	Level in sediment	BAF
Cd	0.83	3.14	0.26	0.65	2.850	0.23
Fe	3.17	5.10	0.62	2.99	4.750	0.63
Ni	0.11	0.13	0.85	0.08	0.156	0.51
Cu	0.16	0.23	0.70	0.14	0.192	0.73
Pb	0.01	0.02	0.50	0.02	0.018	1.11
Co	0.03	0.06	0.50	0.03	0.065	0.46

The levels of trace metals in an aquatic or terrestrial environment and their accumulation in organisms could affect the survival of aquatic organisms in the environment thereby leading to the toxic index of consumption of the aquatic organisms by humans [21, 5]. Cr is considered an essential trace nutrient and a vital component of glucose factor, but its toxicity damages the liver, lungs and causes organ haemorrhages [22, 5]. The results obtained for the levels of trace metals investigated in water, fish and sediment samples in this study are comparable to those reported by Addo et al, Uwah et al [23, 5] in samples obtained from Kpeshie Lagoon, Accra and Atabong River, Nigeria, respectively.

Studies have shown that the presence of Pb in any compartment of the aquatic ecosystem indicates contamination and that Pb is a toxic trace metal with no metabolic benefits to humans and aquatic biota [24]. The concentration levels of Pb obtained from samples analysed in this study were in agreement with those reported by Dan et al [25] and Uwah et al [5] from Qua Iboe River Estuary, Nigeria and Atabong River, Nigeria, respectively.

Table 6. *Physicochemical parameters of water samples during dry and wet seasons.*

Parameters	Dry Season				Wet Season			
	UPS	MDS	DNS	Mean±SD	UPS	MDS	DNS	Mean±SD
Temp (ºC)	30.00	30.00	29.00	29.67±0.58	29.50	29.00	30.12	29.54±0.56
pH	6.20	6.10	6.10	6.13±0.06	6.20	6.26	6.10	6.19±0.08
TDS (mg/L)	802.00	852.00	885.00	846.33±41.8	800.80	831.50	840.00	824.10±20.6
EC (µscm-1)	180.55	189.22	193.41	187.73±6.56	179.20	185.90	188.21	184.44±4.68
DO (mg/L)	3.50	3.50	3.60	3.53±0.06	3.48	3.52	3.70	3.57±0.12
BOD (mg/L)	2.02	2.03	2.04	2.03±0.01	2.20	2.08	2.13	2.14±0.06
Nitrate (mg/L)	3.03	3.17	3.86	3.35±0.44	2.80	2.91	3.04	2.92±0.12
Sulphate (mg/L)	11.23	14.25	17.50	14.33±3.14	12.52	16.05	18.90	15.82±3.20
Phosphate (mg/L)	3.20	3.26	3.42	3.30±0.11	3.61	3.50	3.75	3.62±0.13
Nitrite (mg/L)	1.11	1.13	1.19	1.14±0.04	1.15	1.16	1.12	1.14±0.02

Upstream = UPS; Midstream = MDS and Downstream = DNS

3.3. Levels of Physicochemical Parameters in the Water Samples

The results of the investigated physicochemical parameters in the water samples analysed in this study are as presented in Tables 6. Studies have revealed that, the toxicity level of a given biota is dependent on both the pollution sources of the biota and the physicochemical properties of the given environment [26, 4, 5]. As presented in Table 6, temperature ranged from 29.00 to 30.12°C across the sampling stations in both the dry and wet seasons, with the mean values of 29.67±0.58 and 29.54±0.56°C, for dry and wet seasons, respectively. Studies have revealed that temperature is an important factor which influences the chemical and biological characteristics of aquatic system [5]. Different aquatic organisms show different behavioural changes at different temperatures, so, knowing the temperature of a water body is important is very important. In water, temperature range of 25 to 30°C is favourable for survival of aquatic organisms [27, 5]. The hydrogen ions concentration (pH) in the water gave the mean values of 6.13±0.06 and 6.19±0.08, for dry and wet seasons, respectively. Studies have revealed that pH has implication on the bioavailability of trace metals in an aquatic body. According to report, high or low pH levels of a river is capable of affecting the aquatic lives and alter the toxicity of pollutants in one form or the other in the river [28, 5].

The mean EC values in the water were 187.73±6.56 and 184.44±4.68 μscm^{-1}, for dry and wet seasons, respectively. EC is the ability of an aqueous solution to carry electric current. It gives information on all dissolved ions in the solution. The EC values of the water were higher in the dry season when compared with those of the wet season in this study. This could be attributed to reduction in the volume of water during the dry season as a result of a decrease in volume of water due to evaporation and precipitation. It could also be as a result of anthropogenic activities like farming, which involves the application of fertilizers to farmlands which are later leached into the river during the rains. These EC values were below the WHO guideline limit of 1500 μscm^{-1}.

The mean TDS values in the water were 846.33±41.8 and 824.10±20.6 mg/L, for dry and wet seasons, respectively. TDS are common indicators of water pollution. The TDS values reported in this study were above the permissible level of less than 10, as stipulated by [29]. This could be attributed

to storm water runoff and anthropogenic activities like sand mining, constantly going on in the river as well as atmospheric particles deposits. According to FEPA [30], TDS can be influenced by the pH of the water body, and noted that changes in the pH could affect the solubility of the suspended matter. The TDS results reported in this study were in agreement with those reported by [30, 5].

The reported DO mean values in this study were 3.53±0.06 for mg/L for dry season and 3.57±0.12 mg/L for wet season. Those of BOD were 2.03±0.01 mg/L for dry season and 2.14±0.06 mg/L for wet season. The DO level in water indicates the potential for the oxidation of organic matter in the water which entails the ability of the water to support aquatic life [31, 5]. The reported DO levels in this study were below the permissible limits of 8-10 mg/L stipulated by [29]. These DO levels, as reported in this study could be attributed to high influx of domestic and agricultural wastes from surface run-offs. Do levels in systems where the rate of respiration and organic decomposition are high, are lower than in systems where the rate of photosynthesis is high [28, 5]. BOD is an important parameter of water which indicates the state of fresh water bodies [32, 5]. BOD is the amount of oxygen required to break down a contaminant, biologically. As reported in this study, BOD values were comparable with those reported by Abdo and El-Nasharty [32] and Uwah et al [5] in Ismailia Canal, Egypt and Atabong River, Nigeria, respectively. These values were below the WHO limits of 10 mg/L.

Nitrate, nitrite, sulphate and phosphate mean levels in the water investigated in this study were 3.35± 0.44, 1.14±0.04, 14.33±3.14 and 3.30 ± 0.11 mg/L, respectively, for the dry season and 2.92±0.12, 1.14±0.02, 15.82±3.20 and 3.62±0.13 mg/L, respectively for the wet season. These values were in relations with those reported by Uwah et al [5] from Atabong River, Nigeria.

4. Conclusion

Based on the analyses and results, it can be concluded that the water, fish and sediment of Issiet River in Uruan, Akwa Ibom State, Nigeria, investigated in this study contained variable levels of the analysed trace metals in the samples collected during dry and wet seasons. These could be attributed to all kinds of human activities (including agricultural activities) in the vicinity of the river and excessive water run-off during wet seasons, which resulted to the leaching of various kinds of wastes into the river. However, the levels of the investigated trace metals in the water, fish and sediment samples were below the permissible limits stipulated by WHO. Bioaccumulation factor analysis of the trace metals in fish revealed the range: 1.15 of Cd to 3.06 of Ni from water for the two seasons and 0.23 of Cd to 1.11 of Pb from sediment. The levels of the trace metals in the fish were below the limits that could cause toxicity in human consuming the fish at the time of the study. Periodic analyses of the investigated trace metals and others in the river are highly recommended for the purpose of documentation and monitory.

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