An Assessment of Some Heavy Metals in Sediment of Otamiri River, Imo State, South-Eastern Nigeria

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Abstract

An assessment of some Heavy Metals in Sediment of Otamiri River, Imo State, South-Eastern Nigeria was conducted between the months of August to October, 2015. Water samples were collected from four sampling stations established along the river channel for 3 months (fortnightly). Physic-chemical parameters were analyzed following conventional field and standard laboratory techniques. Temperature range between 24.25°C - 30.50°C, Hydrogen ion mean concentration value of 7.01 ± 0.19 ppm was obtained, CO_2 recorded a mean value of 3.41 ± 0.19 ppm, Total Hardness recorded a mean value of 35.59 ± 1.09 ppm, Ammonia recorded a mean value of 1.36 ± 0.11 ppm, Dissolved Oxygen recorded a mean value of 4.61 ± 0.26 ppm, and mean value of 4.63 ± 0.12 ppm was observed in Biochemical Oxygen Demand. Nickel concentration ranged between 2.16 - 4.21 ppm, Lead range 0.71 - 6.01 ppm, Chromium range between 1.63 - 11.067, Chromium range between 0.74 - 3.61, and Copper concentration range between 0.94 - 10.36. All the parameters measured were significantly different at $p < 0.05$ except pH, Nitrate, and Nickel throughout the sampling period.

Keywords

Physico-Chemical Parameters, Heavy Metals, Otamiri River

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1. Introduction

Heavy metals are classified as metallic elements that have relatively high atomic weight and are poisonous at low concentrations [1]. They are natural components of the earth crust and cannot be degraded or destroyed [2]. Heavy metals are one of the most serious pollutants in our natural environments due to their toxicity, persistence and bio accumulation problems [3]. Trace metals in natural waters and their corresponding sediments have become a significant topic of concern for scientists and engineers in various fields associated with water quality, as well as a concern of general public. Direct toxicity to man and aquatic life and indirect toxicity through accumulation of metals in aquatic food chain are at the focus of their concern [4]. They gain access into aquatic ecosystem through anthropogenic sources ranging from domestic waste, sewages, industrial effluents, fertilizer applications, pesticides, oil spillage, mine effluents and obnoxious fishing method and get distributed in the water [2] [5] [6].

The activity of trace metals in aquatic systems and their impact on aquatic life vary depending upon the metal [7]. Of major importance in this regard is the ability of metals to associate with other dissolved and suspended components. Most significant among these associations is the interaction between metals and organic species, which originate naturally from process such as vegetative decay or result from pollution through organic discharge from municipal and industrial sources that have a reasonable affinity and capacity to bind to metals [8] [1]. Hence, protecting sediment quality becomes an important part of restoring and monitoring the biological integrity of water as well as protecting aquatic life, wildlife and general health [9].

Sediments, being an integral component of aquatic ecosystem, provide habitat, feeding, spawning and rearing areas for many aquatic organisms [10], and Otamiri River, Imo State Nigeria, serving the surrounding populace for several usages such as drinking, cooking, fishing, washing, sand dredging and irrigation. It equally serves as a major recipient of several arrays of anthropogenic pollutants arising from industrial, agricultural and domestics inputs, thus the need to investigate the likely effect of these pollutants in the river.

2. Materials and Methods

2.1. Study Area Description

Otamiri River is one of the main rivers in Imo state, Nigeria. The river takes its name from "Otamiri", a deity who owns all the water that are called by its name, and who is often the dominating god of Mban houses [11]. It islocated on latitude 5˚23'N and 5˚30'N, and Longitude 6˚58'E and 7˚04'E. The river runs south from Egbu pass Owerri and through Nekede, Ihiagwa, Eziobodo, Obowuumuisu, Mgbirichi and Umuagwo to Ozuzu in Etche Local Government Area of Rivers state from where it flows to the Atlantic Ocean. The length of the river from its source to its confluence at Emeabiam with Uramiriukwa River is 30 km [11]. The Otamiri watershed covers about 10,000 km^2 with annual rainfall of 2250 - 2500 mm. The watershed is mostly covered by depleted rain forest vegetation, with mean temperature of 27˚C throughout the year [11]. The Otamiri is joined by the Nworie River at Nekede in Owerri, a river about 9.2 km in length.

Otamiri River is subject to intensive human and industrial activities and is used as a source of drinking water by some of the surrounding communities when the public water system fails. Most of the wastes from Owerri are dumped at the Avu landfall in Owerri west on the Port-Harcourt highway, which creates a high concentration of phosphate and nitrate in the Otamiri River [8].

2.2. Sampling Design and Sampling Station

Four (4) sampling station were selected for study on Otamiri river. The sampling stations were selected based on their proximity to the different effluents discharge point and the different human activities around the river while water sampling for physico-chemical parameters and sediment samplings for heavy metals was carried fortnightly for three months (August-October, 2015) within 08:00-12:00 hours on sampling days.

2.3. Sample Collection

Surface water samples for chemical parameters were collected from all sampling stations in plastic bottles and transported to the Department of Fisheries and Aquaculture Technology laboratory, Federal University of Technology, Owerri for analysis.

Water sample for dissolved oxygen was collected in 250 ml glass sampling bottles. The bottles were filled with water and cork under water, making sure that no air bubble was trapped in the bottle. The bottles were then carefully open and fix with 2 ml each of freshly prepare Winkler's solutions A and B, from Department of Fisheries and Aquaculture Technology accordingly, as described by [12] and transported to the laboratory for analysis.

Likewise, water sample for Biochemical Oxygen Demand (BOD) was collected in 250 ml Amber sampling bottle and incubated in a dark polythene bag and transportation to the laboratory. The sample was latter fixed after 120 hrs (5 days) with 2 ml each of Winkler's Solution A and B respectively as described by [12].

Also, sediment from each sampling station was hauled in a pre-labeled polythene bags and transported to the laboratory for analysis.

2.4. Sample Analysis

Analysis was done in two stages: field analysis and laboratory analysis. The fieldwork involved *in situ* measurements and Laboratory analysis of the chemical parameters were carried out in the Department of Fisheries and Aquaculture Technology Laboratory, Federal University of Technology Owerri, Imo State.

Water temperature was measured with mercury-in-glass thermometer, which was immersed into the water and allowed to assume the water temperature before reading, while still in the water in other to avoid interference with ambient temperature and recorded in degree Celsius (˚C).

Also, transparency was measured on the field using Secchi-disc as described by. The disc was lowered into the water. The visibility point of the disc was measured thereafter with a meter rule and recorded in meter (m).

Likewise, water current was determined with the aid of a floater, meter rule and stop watch.

pH was determined using a pH meter (Jenway; Model-3505). The glasses electrode of the meter was immersed in the water and values off.

Nitrate (NO$_3$)

This was determined by colorimetric method [12] using a UV/VIS/ Spectrophotometer (Jenway; model-6850).

DO, BOD and COD were measured by titration method [12],while other chemical parameters were determine using Lamotte Fresh Water test kit, model AQ/2-3, code 3633-03.

2.5. Analysis of the Heavy Metals

The heavy metal compositions of the water samples were determined with BUCK Atomic Absorption Spectrophotometer (AAS) model 210VGP.

2.6. Statistics Analysis

Bivariate and multivariate statistics as provided by the SPSS Version 22.0 (PEC, 2008) was used in the analysis of the data on the physic-chemical parameters. The determination of spatial variance equality (homogeneity) in the means of the physic-chemical parameters was made with one-way analysis of variance (ANOVA). Further mean separation was made with the Duncan Multiple Range Test.

3. Result

The results of the analyzed physico-chemical parameters in water and sediments are shown in **Table 1**, Descriptive statistics of physicochemical parameters and trace metal concentration are shown in **Table 2**.

4. Discussion

The physico-chemical parameters of Otamiri River, Imo State, South-Eastern Nigeria, like any other aquatic ecosystem, is prone to ecological imbalances resulting from both natural and anthropogenic impacts arising from man's quest for the exploitation of natural resources for sustainability and livelihood.

The differences observed in the physic-chemical parameters across the different sampling stations of the river could be responsible for the recorded variations in the concentrations of the heavy metal in the sediments [13]-[16].

The trace metal concentrations are higher in all the locations were found to be far above the World Health Organization (WHO) and Federal Ministry of Environment (FMEN) recommended level in water. The heavy

Table 1. Spatial variations in Physico-chemical parameters of Otamiri River between Augustand October 2015 using Duncan multiple range test (DMRT) (P < 0.05).

PARAMETERS/Stations	FUTO STATION	UMUAGWO STATION	EZIOBODO STATION	EGBU STATION	WHO/FME STANDARD (mg/L) 2003
Temperature (°C)	30.50 ± 2.646^a	24.25 ± 2.217^b	29.25 ± 2.217^a	25.75 ± 3.775^a	20 - 30
pH	6.75 ± 0.646^a	7.10 ± 0.141^a	7.18 ± 0.171^a	7.0 ± 0.365^a	6.5 - 8.5
CO_2 (mg/L)	3.43 ± 0.568^a	3.65 ± 0.342^a	2.25 ± 0.30^b	4.3 ± 0.258^b	-
Nitrate (mg/L)	0.10 ± 0.071^a	0.07 ± 0.021^b	0.09 ± 0.018^a	0.18 ± 0.096^a	0.50
Total Hardness (mg/L)	34.25 ± 2.568^a	42.65 ± 1.746^b	29.08 ± 2.442^b	36.4 ± 1.811^a	150
Ammonia (mg/L)	0.975 ± 0.171^a	1.40 ± 0.183^b	1.93 ± 0.222^b	1.13 ± 0.299^a	<0.4
Dissolved Oxygen (mg/L)	4.25 ± 0.646^a	4.53 ± 0.538^a	6.23 ± 0.532^b	3.45 ± 0.30^a	>4.0
Biochemical Oxygen Demand (mg/L)	4.478 ± 0.374^a	2.96 ± 0.162^a	4.945 ± 0.108^a	6.14 ± 0.235^a	40
Chemical Oxygen Demand (mg/L)	30.99 ± 0.337^a	40.76 ± 0.577^a	20.81 ± 0.565^a	19.98 ± 0.473^a	40
Chloride (mg/L)	1.70 ± 0.279^a	4.68 ± 0.300^b	2.20 ± 0.78^a	4.79 ± 0.222^b	250
Nickel (mg/L)	4.21 ± 0.832^a	3.40 ± 1.39^b	2.16 ± 0.840^b	3.99 ± 0.176^a	0.02
Lead (mg/L)	6.02 ± 1.48^a	0.71 ± 0.233^b	3.61 ± 0.736^b	0.997 ± 0.568^b	0.01
Chromium (mg/L)	1.63 ± 0.685^a	2.43 ± 0.596^a	5.78 ± 1.171^b	11.07 ± 0.441^b	0.05
Cadmium (mg/L)	3.61 ± 1.00^a	3.13 ± 0.978^a	0.74 ± 0.213^b	1.01 ± 0.71^b	0.003
Copper (mg/L)	10.36 ± 2.25^a	6.79 ± 1.154^b	1.25 ± 0.983^b	0.94 ± 0.329^b	2.00

Means with different superscript along the same row are significantly different (p < 0.05); N.B. Values with the same superscripts are not significantly different.

Table 2. Descriptive statistics of the physicochemical parameters of Otamiri river between august and October, 2015, Owerri, Imo state.

Parameters	Min. Value	Max. Value	Mean	Standard Error
Temperature (°C)	24.25	30.50	27.44	1.394
pH	6.75	7.175	7.01	0.194
CO_2 (mg/L)	2.25	4.3	3.41	0.193
Nitrite (mg/L)	0.065	0.175	0.108	0.031
Total Hardness (mg/L)	29.075	42.65	35.59	1.087
Ammonia (mg/L)	0.975	1.925	1.36	0.112
Dissolved Oxygen (DO) (mg/L)	3.45	6.225	4.61	0.260
Biochemical Oxygen Demand (BOD) (mg/L)	2.955	6.135	4.63	0.121
Chemical Oxygen Demand (COD) (mg/L)	19.975	40.758	28.14	0.249
Chloride (mg/L)	1.695	4.785	3.34	0.125
Nickel (mg/L)	2.1617	4.205	3.44	0.458
Lead (mg/L)	0.7133	6.0167	2.84	0.440
Chromium (mg/L)	1.63	11.067	5.23	0.387
Cadmium (mg/L)	0.74	3.6067	2.12	0.396
Copper (mg/L)	0.942	10.363	4.84	0.683

metal contents were higher in the sediment because they were enriched directly from the weathering profile and retained by clay particles in the soil. Near absence of the metals in the water could be their inability to remain in solution. [17] stated that water contamination prevents its use for human consumption. Generally, the source of these pollutants could be ranging from industrial to agricultural and domestic sources. Apparently, lentic zones such as these ponds could serve as brooding grounds for aquatic organisms and elevated contaminations with these recalcitrant pollutants could expose the organisms, especially juveniles, to toxicity. Therefore, when eva-

luating pollution and the quality of aquatic systems, it is important to take into consideration possible contamination by sediments deposited around ponds, apart from detecting contaminants that do not remain soluble after launched in water column [18]. The presence of trace metals and other inorganic elements in relatively high concentrations in water from sampled locations is not unusual as presence of some chemical elements such as ammonia and nitrate in higher concentrations above World Health Organization (WHO) recommended level have been reported by [19]. The abnormally high levels of heavy metals in the surface water of sampled locations is of great concern and calls for urgent attention if the inhabitants are to be protected against the chronic effects of the abnormal levels of the chemicals. The nickel, lead and cadmium concentration are high in some locations and this can be affiliated with faecal dumps, sand dredging and prolonged physical activities. Trace elements may come from natural weathering and erosion, or many other individual pollution sources. Dumping of degradable and non-degradable refuse into Otamiri River is the norm rather than an exception.

5. Conclusion and Recommendation

The present study shows heavy metal contamination levels and physico-chemical characteristics of Otamiri River between August and October 2015, with the sediments of the four stations shown in heavy metals concentrations.

From the analysis made from these assessments, chromium and copper took the lead of the heavy metals. It is clear that the concentrations of all the metals showed pronounced levels of pollution. The study therefore indicates the significant increase in the levels of the metals with sediments.

The result of this study proved that the activities within the various stations might have been responsible for the elevated levels of all the metals in the sediments samples.

The levels of most metals in the sediment were higher than the sediment guideline limit. This trend should not be allowed to continue to reduce risk of induced heavy metal contamination of the food web in these study environments.

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