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Evaluation of Seasonal Variations in Heavy Metal Concentration of Fish Pond Waters and Sediments in Umudike, Southeastern Nigeria

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Abstract

In this study, water and sediment samples collected randomly from fish ponds of Michael Okpara University of Agriculture Umudike, Abia State, Nigeria for a period of nine months (January to September, 2012), were analyzed for Fe, Cu, Zn and Pb concentrations. The results obtained revealed that the variation in the concentrations are more in the dry season than the rainy season, this could be attributed to the tidal water current and higher evapotranspiration of water during dry season that may lead to efficient sedimentation of these metals. Fe was found to be the most abundant metal in both the sediment and water of the pond, while Pb recorded the lowest values with traces in some months. The metals distribution pattern of the pond clearly indicate the source of the metals to be natural sources to the pond as well as other agricultural activities around fish pond. However, the values obtained from the water and sediments were within the acceptable limits of WHO standards for domestic and agricultural activities.

Keywords: Heavy Metals, Sediments, Water, Fish Pond, Seasonal Variations.

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Introduction

Heavy metals are usually present in natural waters (ground and surface) through some natural processes, such as chemical weathering of rocks and soil leaching. These processes are largely influenced by environment, climate, and biological factors. Most heavy metals have a great ecological role in the management of sustainable environment due to their toxicity and bioaccumulation behavior (Funtua, *et al*., 2007). These exist as suspended colloids and therefore undergo a global ecological cycle in which natural water and sediments are the main pathways (Horsfaall, *et al*., 1999). The accumulation of these heavy metals in water sediments and plankton is most often an indication of water pollutions. Heavy metals are considered persistent contaminants due to their toxic properties when their concentrations in aquatic system pass beyond certain levels; they create several problems for both human beings and marine organisms. Water is a ubiquitous chemical substances that is essential for the survival of all forms of life. It is an important aspect of our daily life. As population increases and higher standards of living are pursued and consequently attained, the need for increased water resources management and protections becomes greater desirable. Industrial water consumption increase resulting from the increased diversification of economic activities such as fish farming.

Sediments provides habitat for many aquatic repository of many persistent chemicals that are introduced into surface waters. They exist mainly at the bottom of water column and play a major role in the pollution scheme of the river systems by heavy metals (Forstner, 1996).Some of these pollutants are directly discharged by plants, municipal sewage treatment plant and agro- chemicals. The water sediments are basic components of our environment. They play important role in influencing pollution of surface waters as they provide nutrients for living organisms. Most chemicals and waste materials including organic chemicals and heavy metals accumulate in the sediments. The accumulation of these materials is usually in several magnitudes, higher in the sediments than in overlying water. This is because of long-term release of low concentration of chemicals into water resulting in elevated concentration in the sediments (Oti*et al.,* 2001). Similarly, the heavy metals depict the quality of the water system which helps to detect the presence of contaminants that do not remain soluble after discharge into surface water. Moreover, sediments act as carriers to heavy metals and possible sources of pollution because heavy metals cannot be fixed by the sediments and can be released back to the surface water column by changes in environmental conditions (Funtua, *et al*., 2007). Thus the analysis for heavy metals will enable us to detect pollution that is beyond water analysis (Funtua, *et al*., 2007).

Presently, the fish pond of Michael Okpara University of Agriculture, Umudike is used in rearing fishes for production and table uses. However, the water from the ponds is being discharged from time to time into streams and canals. It is used in the production of vegetables and nursery trees. The health implication of these heavy metals in water and sediments is the microbial population which is the most effective means to biodegrade hydrocarbon pollutants in contaminated sediments cannot have any impact on the heavy metals; hence these materials find their ways into the aquatic organisms as well as the irrigated plants (Lawal, *et al.,* 2004). There is therefore a serious need to understand the levels of these materials in the waters and sediments of the pond so as to have a clear picture of the safety of both pond inhabitants and that of the users of the water and organisms from the ponds.

The result would be useful to the environmentalists, Aquaculturists and horticulturists who use the waters of the pond to raise nursery and the chemists.

Since there are two distinct seasons in southeastern Nigeria, the rainy season and the dry season, and the major source of water to the pond is through the rivers and canal, there is a need to investigate the movements of these heavy metals in the ponds. This will enable the authorities to plan for a sustainable management of our water resources for sound environment and health substance.

Materials and Methods

Michael Okpara University of Agriculture where the study was carried out is in Umudike, southeastern Nigeria.Umudike lies between latitudes $5^0$27"and $5^0$32"N and longitude $7^0$32" and $7^0$35" E. The climate is the equatorial type, with an average annual precipitation of 2164mm (Table 1). There are two distinct seasons: the rainy season which starts in March and ends in October. The dry season starts in November and end in Marchthe subsequent year (NRCRI Metrological Center, 2011). There are two peaks in rainfall in the months of June/July and September. The mean daily humidity during the day could be as low as 45% during the peak of the harmathan wind and above 70% during the wet season. Most dams and ponds lost water during the harmathan period. Water is being supplied through reservoir and this higher accumulation of some non-bio-remedial substances. The vegetation is the tropical rain forest (white, 1983), with secondary forest that is tending towards derived savanna (Okpala, 2008).

The main source of water to the pond is from the Ehimmiri stream, Umuahia. The stream passed through the National Root Crops ResearchInstitute farm to a constructed dam into the Michael Okpara University of Agriculture Research Center. Other sources are water tributaries draining from Olokoro into the river basins as well as rain floods and direct rainfalls. Water and sediment samples were collected randomly from the ponds for nine months at a distance of 50 meter apart from each sampling point. The samples were collected in January, February March and April for the dry season period and June, July, August and September. The sediments were allowed to drain off water in a calico bag and finally dried in the dehumidifier for about 48 hours. The dried sediment sample was crushed and sieved through a 2mm sieve and stored for the analysis of the heavy metals.

20ml of the water sample was measured into a conical flask and evaporated to dampness. 0.2g of the sediments was also weighed into a conical flask. 3ml of an extraction mixture (H_2S0_4 – Selenium-Salycyclicacid)was added to the sample, covered with a watch glass and allowed to stand for about 16 hours. The sample was placed on a hot plate and heated at 20˚C for 2 hours.5ml of $HClO_4$ was then added to the sample and heated at 60˚C until a profuseperchloric fumes

were observed. The sample was then removed from the hot plate, dissolved in distilled water then filtered paper into a No. 42 Whatman filter paper into a 50ml volumetric flask and made up to the mark. The following heavy metals: zinc, lead, iron, copper and chromium were determined using the UNICAM 969 Atomic Absorption Spectrophotometer (AAS) method (Norozamsky*et al.,* 1983).

Results and Discussion

The results of the mean monthly variation in the concentration of the heavy metals of the sediments are shown in Table 2, while the percentage variations of these heavy metals are also displayed in Figure 1. The results showed that the concentration of Zn in the sediment had a range of 0.35 – 2.25 mg/100g, with its peak of 2.25 mg in March. However, the peak did not go beyond the World Health Organization standard in Table 4 (WHO 2004). During the period of the study the concentration of Zn was slightly higher in the months of January to April and lower during the rainy season. The variations in the concentration of Cu, Pb, and Fe were 0.35 – 0.95 mg/100g, 0.03 – 0.38mg/100g and 3.13 – 5.63mg/100g respectively. Pb concentrations was traces in April, May and December and higher in June. The values of Cu, Pb, Fe were also low compared with the standards of WHO (Ano and Okwunoduru, 2008). The concentration of Fe is greater than Zn, Cu and Pb in the sediments. These confirm an earlier assertion made by Fostner and Wittman, (1979). The Fe is ubiquitous in all fresh water environments and often reaches significantly higher in water and sediments than other trace metals. The variations of Zn and Cu were 70% between July and August while Pb and Fe concentration did not have significant variations among the months (Fig 2.1, Table 2).

The results of the variations in the water sample is shown in Table 3, Zn had a range of 0.038 – 0.15mgl^{-1}. The magnitude of the concentration of Zn in the water is March >April>Jan >Feb >June >May >August > July > Sept. The overall mean value of Zn across the periods is 0.09±0.04mgl^{-1} which is also within the acceptable limits of WHO for domestic water. Cu ranges between 0.64– 0.04±0.20mgl^{-1}. The concentration of Cu is at its peak in September and least in July. The mean levels of Cu concentration in water was found to be 0.115mgl^{-1}. Cu has a low solubility potentials in aqueous solution, it is usually absorbed by water- borne suspended solids which later move down to the underlying sediments. Pb and Fe were found to be in the range of 0.003 – 0.095$mgl^{-1}$and 0.26 – 2.46 mgl^{-1}respectively. Pb was virtually trace in the months of September. Similarly the variations of Fe concentration during the months did not significantly vary except in September when the concentration was at its peak (2.48mgl^{-1}).The magnitude of the concentration is September> March >May >February> August>January> July > April > June>. Fe level in the sediments is more than in the water (Table 3)

Conclusion and Recommendations

From the results obtained from the analysis of the sediments and waters of the pond, there were higher concentrations of the heavy metals (Zn, Cu, Pb and Fe.) in the sediments than the waters. The variations observed were that during the rainy season most of the metals appeared to be moved by the water current and more concentrated in the dry seasons in both the sediments and water. Among the metals detected, Pb had the lowest concentration while Fe was more abundant across the period of the study. However the levels of these heavy metals did not exceed the WHO standards for domestic and agricultural tolerable standards. This explains the acceptability and survival of Aquatic life and agricultural practices of the fish pond in Michael Okpara University of Agriculture Umudike (Table 4).

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Tables

Table 1: Weather Data of the Study Area (2009 -2011)

			Jan	Feb	Mar	Apr	May	Jun	July	Aug	Sept	Oct	Nov	Dec	Total
2008	**Rainfall**	Amt	13.4	0	168.4	219.8	373.5	352.3	310.2	327.4	404.0	211	6.9	8.6	2395.6
		Days	2	0	8	16	18	19	20	22	20	13	2	1	141
	Temp	min	20	21	23	23	23	23	22	22	23	23	24	22	378
		max	31.0	35	34	32	32	30	29	29	30	31	32	33	269
	RH	0900	53.0	510	75.0	800	830	84.0	88.0	86.0	87.0	81.0	80.0	68.0	916
		1500	36.0	26.0	56.0	63.0	67.0	73.0	75.0	77.0	74.0	70.0	61.0	49.0	727
	Sunshine	hrs	5	4	5.9	3.7	5.8	4.3	3.0	3.3	3.3	5.7	6.2	61	56.3
2009	**Rainfall**	Amt	62.80	62.8	47.8	100.5	416.2	236.7	306.3	287.4	2.5.5	311.1	23.7	0.0	2068.8
		Days	2	4	4	12	15	14	18	19	18	14	7	0	127
	Temp	Min	23.0	24.0	24.0	23.0	23.0	23.0	22.0	23.0	22.0	23.0	22.0	23.0	275
		Max	33.0	34.0	34.0	33.0	33.0	31.0	30.0	29.0	30.0	31.0	32.0	34.0	384.0
	RH	0900	74.0	79.0	78	78	80	83.0	37.0	88.0	86.0	82.0	74.0	78.0	917.0
		1500	49	55	56	162	70	72.0	78.0	78.0	72.0	72.0	58.0	53.0	775.0
	Sunshine	hrs	3.1	4.7	4.3	3.5	46	32	2.0	1.3	2.7	3.8	5.1	4.80	43.10
			Jan	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**July**	**Aug**	**Sept**	**Oct**	**Nov**	**Dec**	**Total**
2010	**Rainfall**	Amt	0.0	78.2	34.7	126.0	213.5	459.0	276.9	420.7	309.3	349.2	78.2	4.6	2350.0
		Days	0	5	4	10	13	18	16	19	19	21	6	1	113
	Temp	Min	23.0	24.0	24.0	24.0	24.0	24.0	23.0	23.0	23.0	23.0	23.0	22.0	280.0
		Max	35.0	35.0	34.0	34.0	32.0	30.0	30	30.0	30.0	31.0	31.0	33.0	385.0
	RH	0900	72.0	73.0	77.0	76.0	84.0	87.0	86.0	86.0	85.0	82.0	75.0	78.0	961.0
		1500	45.0	50.0	53.0	59.0	70.0	77.0	75.0	77.0	72.0	76.0	59.0	45.0	758.0
	Sunshine	hrs	6.4	6.3	3.9	6.1	5.0	3.5	3.4	2.2	2.9	2.9	4.1	49	51.0
2011	**Rainfall**	amt	0.00	60.8	111.4	105.0	347.7	339.5	236.5	345.1	424.7	242.8	12.0	9.6	2.35.9
		Days	0	4	8	8	15	13	22	24	23	11	3	1	132
	Temp	Min	20.0	23.0	24.0	23.0	23.0	22.0	23.0	23.0	23.0	23.0	23.0	21.0	272.0
		Max	33.0	33.0	34.0	33.0	32.0	30.0	30.0	29.0	30.0	30.0	31.0	33.0	378.0
	RH	0900	62.0	82.0	80.0	80.0	82.0	81.0	87.0	91.0	90.0	85.0	80.0	64.0	964.0
		1500	40.0	59.0	60.0	65.0	73.0	76.0	79.0	82.0	79.0	75.0	59.0	40.0	787.0
	Sunshine	hrs	5.4	4.7	6.10	4.6	3.8	3.0	2.10	1.5	2.4	4.5	6.6	7.0	517.0

R/F = Rainfall (mm); Temp = Temperature (°C); RH = Relative humidity (%);S/S = Sunshine (hours)

Table 2: Mean Monthly variations of heavy metals concentration in the sediments of the pond.

Months	**Zn**	**Cu**	**Pb**	**Fe**
Jan	2.13	0.8	0.03	5.2
Feb	2.15	0.63	0.05	5.63
Mar	2.25	0.45	0.25	4.88
April	1.88	0.65	0.00	4.45
May	1.40	0.95	0.00	4.15
June	1.23	0.55	0.38	3.95
July	0.35	0.35	0.95	3.15
August	0.95	0.43	0.03	3.60
September	1.1	0.38	0.00	3.13
Mean ±SD	**1.15±0.65**	**0.58±0.20**	**0.09±0.13**	**4.24±0.88**

Table 3: Mean monthly variations of heavy metals concentration in the water of the pond.

Months	**Zn**	**Cu**	**Pb**	**Fe**
Jan	0.12	0.04	0.003	0.29
Feb	0.09	0.06	0.003	0.32
March	0.15	0.05	0	0.51
April	0.13	0.09	0	0.27
May	0.07	0.06	0	0.34
June	0.08	0.04	0	0.26
July	0.05	0.03	0	0.28
August	0.05	0.04	0	0.31
September	0.04	0.64	0.095	2.46
Mean ±SD	**0.09±0.04**	**0.11±0.20**	**0.011±0.03**	**0.56±0.72**

Figures

Figure 1: Percentage monthly Variation in the heavy metal concentration of the sediments

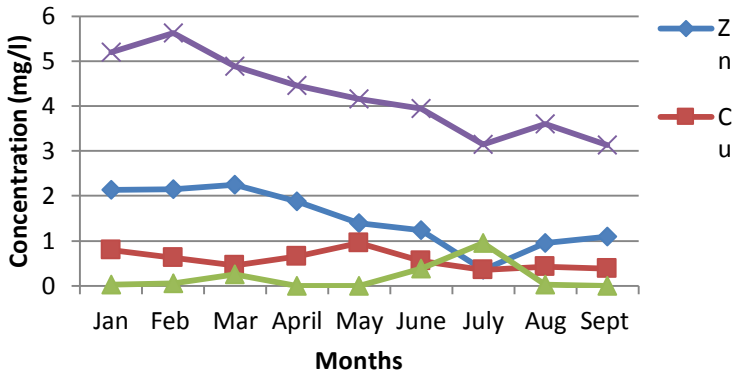

Figure 2: Percentage Variation in the heavy metal concentration of the pond water