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Analysis of heavy metal and anion contents in Ata/Ehimiri Stream in South-South region of Nigeria

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ABSTRACT

The research was conducted to determine the levels of heavy metal and anion of water samples from Ata/Ehimiri stream within a watershed ecosystem in the South-South region of Nigeria. A single factor experiment in randomized complete block design (RCBD) with three replications was used to study the heavy metal contents of the stream water samples collected at 100m apart within four watershed points. Water samples were collected in duplicates from the different sampling locations using white tamper proof plastic bottles and were analysed using Fisher's LSD method. Determination of heavy metals and anions of the water sample of the Ata/Ehimiri Stream revealed that Cadmium **(**Cd) contents of the study locations ranged from 0.001-0.003ppm while chromium (Cr) contents ranged from 0.001-0.008ppm. Contents of Fe, Cl^-, NO_3^-, SO_4^-, PO_4^- and Pb also indicated lower concentrations. The contents of the surface water samples in the study locations were low and are found to be within the regulatory limits which indicate that the water is free from pollution and is safe for human and livestock consumption.

Keywords: Heavy metals, contents, Ata/Ehimiri stream, watershed, water sample, levels

INTRODUCTION

Water is essential to living things and it enhances their daily activities. Water covers about 70% of the Earth surface and only 1% of it is available to human for drinking (Magombo and Kasamu, (2016). Moe (2006) stated that about 783 million people globally lack access to water supply while 2.5 million people lack adequate sanitation; and about 6 to 8 people die annually from consequences and water related illnesses, inadequate sanitation and poor hygiene practices. Toxic Substances (heavy metals, oil and petroleum products) may enter surface waters either dissolved in runoff or attached to sediment or organic materials and may also enter groundwater through soil infiltration (Udoessien, 2013). Organic materials (natural or synthetic) may enter surface waters dissolved or suspended in runoff.

Watershed is the drainage basin, river basin, catchment or drainage divide, or the corridor of a river /stream (Bisong, 2001). Rivers and river systems are complex and intimately connected to and also affected by the characteristics of their surrounding watershed, the land that water flows over and under on its way to the river (Ejizu *et al*., 2014). According to Anderson (1999), water quality goals help to minimize the long-term cumulative export of phosphorus, nitrogen and turbidity in the waters. The goals also aim at providing a safe supply of water for present and future generations and maintaining tributary water quality as high as possible.

Water quality problems are diagnosed by linking the cause of the resource problem to its source and then estimating the pollutant load, if possible (OEPA, 2015).

Moreover, a monitoring program and reliable estimation of quality of the surface water are necessary, as the, physical and biological composition of surface water are the prime factors of which the suitability of water, domestic, industrial or agricultural purposes depend (Adesakin *et el.,* 2017). OEPA (2015) stated that many times diagnosis is complicated by multiple sources linked to several pollutants like, sediment/siltation (sand, silt, and clay), cropland and forestry activities, pasture, stream banks, construction roads, mining operations, gullies, livestock operations and other land-disturbing activities. Sediments may destroy fish habitat by: (a) blanketing spawning and feeding areas, (b) eliminating certain food organisms, (c) causing gill abrasion and fin rot, and (d) reducing sunlight penetration, thereby impairing photosynthesis.

It is certain that some metals are introduced into water bodies either by natural phenomenon or through anthropogenic activities. Stream water can be polluted with Cd through leaching, flooding and erosion as well as an event of environmental pollution and natural disasters respectively (WHO, 1993; Nan *et al*., 2002). According to Udousoro and Umoren (2014), as water quality issues become more serious and widespread, the need for water quality monitoring as an important of health promotion strategy in the developing countries cannot be overemphasized. Nutrients and toxic substances attached to sediment particles may enter aquatic food chains, cause fish toxicity problems, impair recreational uses or degrade the water as a drinking water source.

However, everal studies have been carried out on the concentration of heavy metals in water samples from various water bodies in south-south region of Nigeria. These includes water samples from headstream and downstream of Amaogwugwu river, Ohuhu-Umuahia Abia State (Eze *et al.,* (2014), Igwi Stream in Abia State (Ogwu, *et al*., 2014), Ikoli Creek (Ogambe *et al*., 2015), Kolo Creek, Bayelsa State, Niger Delta region of Nigeria (Ogambe *et al*., 2016) and Seiyaboh *et al.* (2017), This study therefore, analysed the levels of heavy metal contents and anion in water samples from Ata/ Ehimiri Stream within watershed ecosystem in Abia State, South - South region of Nigeria.

MATERIALS AND METHODS

Study Area

This study was carried out in Ata/Ehimiri Stream watershed in Umudike in Ikwuano Local Government Area, Abia State. Ata Stream is a tributary of Ehimiri Stream that flows from Lodu-Ibeku through Umudike to join the Akwa Ibom River. The study area Umudike lies within the humid lowland rainforest on latitude 5^0 29'N and longitude 7^0 33'E. It is on an altitude of 122m above sea level. The mean annual climatic data of Umudike are as follows: maximum and minimum temperature, 32^0C and 23^0C respectively; rainfall, 2238mm; relative humidity, 65-80% (Source: Meteorological Station, National Roots Crop Research Institute (NRCRI), Umudike in 2012).

Experimental Design

A single factor experiment in randomized complete block design (RCBD) with three replications was used to study the heavy metal contents of the Ata/ Ehimiri Stream. Water samples collected at 100m apart within the four watershed points. Heavy metals and anion of the water sample analyzed are chromium (Cr), cadmium (Cd), iron (Fe), lead (Pb), cobalt (Co), chloride (Cl^-), sulphates (SO^{-2}_4), nitrates (NO^-_3), and phosphates (PO_4^{-3}).

Method of Data Collection

The study employs the method of water samples and treatment by (Ademoroti, 1996). Water

samples were collected in duplicates from four different sampling locations within the watershed ecosystem (Fish Farm, Raphia Palm plantation site, College of Veterinary Medicine (CVM)) and bridges at the National Root Crop Research Institution (NRCRI) using white tamper proof plastic bottles. The bottles were rinsed and filled with the samples water with sufficient air spaces in the bottles to allow for expansion of the water at increased temperature. The temperature of the different water samples were determined *in situ* by dropping the mercury-in-glass Celsius thermometer (0^o C - 100^oC) for about five minutes until a steady temperature was observed. pH paper was immersed in the water sampled and colour change was observed and compared with a standard. This was confirmed using a pH-meter (each model) standardized before use with a standard buffer solution of pH 4.0 (potassium hydrogen phthalate, 0.05M) and pH 9.2 (Borax buffer, 0.01M). The water samples collected for analysis were preserved in the laboratory in order to prevent or retard the chemical and biological changes that could inevitably occur once the samples are removed from their sources and were stored in a refrigerator at 4^0C- a temperature where bacteria are inactive in order to ensure the accuracy for acidity and alkalinity determinations which was used for elemental and anionic determinations.

Determination of Heavy Metals

Heavy Metals were determination using (AOAC, 1984) method Atomic Absorption Spectrometry (AAS). (Unicam) and (FEP) (Gallenkamp model) at the soils and water laboratory in University of Uyo, Akwa Ibom State to determine the Cu, Pb, Cd, Fe, and Co, contents of the Ata/ Ehimiri stream water. The analyses were carried out by direct aspiration of water samples into flame analyzer. Before determination of any metal in the sample, a calibration curve of the metal was prepared using aliquots from standard stock solutions of the metal or salt of the metals in preparing the working standards. From the calibration curves, the cones of the metals in the samples were determined. Alternatively, the cones of the metals in the samples were directly related to the cone of the calibration curve. The cone of the metal was multiplied by the dilution factor. The stock solutions were usually of 1000mg/l.

Determination of anions

Determination of anions (Chloride (Cl^-), Sulphates (SO^-_4), Nitrates (NO^-_3), and Phosphates (PO_4^{-3}) were carried out using the model by (Ademoroti, 1996). A 10ml water sample was transferred into different 25ml standard flasks and 2ml of bromine reagent was added 10ml of conc. H_2SO_4 was also added rapidly and it was mixed for about 30 second and allowed to stand for 5 minutes. The flasks were in cold water for about 5 minutes and then made up to volume with deionized water. The absorbance was read at 470nm with Unicam 8626 UV/VIS spectrophotometer. For $PO4^{-3}$, 25ml of each water sample was measured into 50ml volumetric flasks. 10ml of Vanadatemolybdate reagent was added and diluted to the volume with deionized water. A reagent blank was prepared by making up 20ml of reagent to volume in a 50ml volumetric flask. The solutions were mixed and allowed to stand for about 10 minutes for colour development. The absorbance was read at 470nm with Unicam 8625UV/VIS spectrometer. For SO_4^-**,** 10ml of each water sample was measured into different 25ml volumetric flasks 10ml of deionized water was added. 1ml of gelatin $BaCl_2$ reagent was also added in each case and mixed thoroughly, then allowed to stand for about 30 minutes. The absorbance was read at 420nm with Unicam 8625UV/VIS spectrometer.

Data Analysis

The heavy metals/anion properties of water samples were statistically analyzed using Fisher's LSD at $P \leq 0.05$ (Steel and Torrie, 1980) and Alika (2006).

RESULTS

Heavy Metal and Anion Contents of Water Samples

The results of the analysis of heavy metal and anion contents of Cd, Co, Cr, Fe, Pb, PO_4, NO^-_3, SO_4, and Cl in water samples of Ata/ Ehimiri Stream in Umudike, Nigeria are presented in Table 1. It could be seen in the table that no significant differences existed between the Cadmium (Cd) contents of the surface water at the watershed zones of the Fish Farm, Raphia Palm plantation site, NRCRI and College of Veterinary Medicine (CVM). Lower lead content of 0.01 – 0.02 was observed in the samples, Cobalt (Co) content in the NRCRI location had significantly the highest Co content while the Fish Farm site had the least Co content. . The result also showed that Content of Chromate (Cr)**,** in the water samples from NRCRI study locations had significantly the highest Cr content (0.008 mg/l), Raphia palm plantation had (0.001 mg/l**)** and College of Veterinary Medicine had (0.001 mg/l**)** while Fish Farm study sites had the least ($p \leq 0.005$) Cr content. The table revealed that Iron in the College of Veterinary Medicine (CVM) and the Fish Farm study locations had significantly the highest and least Fe content respectively.

Table 1 also shows the level of some anion SO_4^-, NO_3^-, PO_4^- and Cl contents in the surface water of Ata/Ehimiri Stream. NRCRI and the College of Veterinary Medicine watershed zone had significantly the highest and least SO_4^- contents respectively in the surface water of the study area. Summary of the SO_4^- contents of the study sites are significantly as follows; NRCRI> Fish Farm> College of Veterinary Medicine > Raphia Palm plantation watershed zones. Nitrate (NO_3^-) contents in NRCRI study locations had significantly the highest (17.89 mg/l) and the Fish Farm the least (6.20 mg/l) NO_3^- Summary of NO_3^- contents of the stream surface water at the study sites are significantly as follows: NRCRI > Fish Farm> College of Veterinary Medicine >Raphia Palm plantation zones. Phosphate (PO_4^-) contents in the NRCRI and the Raphia Palm plantation study sites had significantly the highest (12.72 mg/l) and least (4.12 mg/l) PO_4^- contents in the stream/river. Cl found in surface water at the NRCRI/ Raphia Palm plantation zone had significantly the highest Cl content (8.52mg/l) while the Fish Farm zone had the least ($p \leq 0.05$) Cl content (5.68 mg/l). Fe contents in College of Veterinary Medicine (CVM) and the Fish Farm study locations had significantly the highest (2.34 mg/l) and least (0.94 mg/l) Fe content respectively in the surface water samples.

Table 1: Heavy metal and anion contents of water samples in four study locations in Ata/ Ehimiri Stream watersheds in Umudike, Nigeria

	Heavy metals					Anions			
Study	**Cd**	**Co**	**Cr**	**Fe**	**Pb**	**PO_4**	**NO_3**	**SO_4**	**Cl**
Locations	(mg l^{-1})	(mg l^{-1})	(mg l^{-1})	(mg l^{-1})	(mg l^{-1})	(mg l^{-1})	(mg l^{-1})	(mg l^{-1})	(mg l^{-1})
NRCRI, Umudike	0.001	0.013	0.008	1.13	0.02	12.72	17.89	315.60	8.52
CVM, MOUAU	0.001	0.010	0.001	2.34	0.01	5.29	8.47	192.90	6.98
Fish Farm, MOUAU	0.003	0.007	0.004	0.94	0.02	8.68	13.04	235.10	5.68
Raphia palm, MOUAU	0.002	0.008	0.001	1.18	0.01	4.12	6.20	176.30	8.52
F-LSD	NS	0.004	0.002	0.12	NS	0.56	1.18	17.74	0.45

NRCRI= National Root Crops Research Institute.
MOUAU =Michael Okpara University of Agriculture Umudike.
CVM= College Of Veterinary Medicine, Michael Okpara University of Agriculture, Umudike.

DISCUSSION

The analysis of heavy metals and anion contents of water samples from Ata/Ehimiri Stream in four study locations revealed that, Cadmium Cd contents of the study locations had significantly low ranged from 0.001-0.003ppm. This is in line with the acceptable range of 0.01-2.00ppm for agricultural land (Tucker *et al*., 2005). The Chromium (Cr) contents in water samples of the study locations ranged from 0.001-0.008ppm and are within the acceptable range for human use. Chromium (Cr) is very medicinal and critical in the metabolism of insulin, glucose, lipids and amino acids (Sharma *et al*., 2005). It is useful in the prevention of mild diabetes in humans (Sharma *et al*., 2005).

The Fe content of the surface water of Ata/ Ehimiri Stream at the four study locations was significantly higher than other metals. This implies that the nature of it abundance on earth supersedes others. Despite the fact that Fe had higher metal contents among others, the levels were lower than the ranges reported by Green and Heyes (2000) and Vecere *et al*., (1999). There was no significant difference between the Pb contents of the surface water in the watershed zones of the Fish Farm, Raphia Palm plantation, NRCRI and College of Veterinary Medicine (CVM).

The study also revealed lower concentration of NO_3^- and PO_4^-. This indicates low problems of eutrophication as indices of pollution (Goldman *et al*., 1973). Low contents of the surface water samples in the study locations are within the recommendedstandard by WHO (2006). It also indicates that the water is free from pollution (Custodis and Llamas, 1983). However, the analysis of heavy metal contents in the study area revealed low range of heavy metal contents in water samples from the study area. The reason for the low range of heavy metal contents could be that Ata/Ehimiri Stream in Abia State is not expose to anthropogenic activities that causes water pollution such as oil production effluent which is commonly known to be the most source of water pollution in South-South

region of Nigeria. The result corroborates with the study of Owamah, (2013) which stated that concentration of heavy metals from the non-petroleum impacted river is lower than the value of petroleum-impacted river were higher than the heavy metals environment

CONCLUSION

The level of heavy metals and anion contents of water samples collected from Ata/ Ehimiri stream watersheds in Umudike, Ngeria has been determined and were found to be within the specific range limits standard recommended by World Health Organization for drinking. The watershed is considered to be free from pollution, safe for human and livestock consumption and it is therefore recommended that appropriate government bodies provides necessary action to protect and conserve the watershed ecosystem for sustainable use.

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