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Evaluation of Heavy Metals Contaminants in Sediments of Aba River, Aba Abia State-Nigeria.

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Abstract: Heavy metal concentrations of sediments in Aba River, Abia State, Nigeria have been studied. Samples of sediments were collected from five different locations along the profile of the river. The samples were prepared in the laboratory according to standard methods, and the analysis was done using Atomic Absorption Spectrophotometer (AAS). The various concentration levels of heavy metals such as: Cr, Cu, Cd, Zn, Ni, Fe, Mn and Pb were determined in the River sediments. The results of analysis showed that the mean concentration of metals were, Cr 463 mg / kg), Fe (6,2940.0 mg /kg),Cd (412 mg /kg),Ni (138 mg /kg), Pb (1,280 mg / kg), Mn (3,070.0 mg /kg), Zn (3,106.0 mg / kg) and Cu (526.0 mg / kg).The results of the analysis indicated that the levels Cr, Fe, Cd, Ni, Pb, and Mn across all the sample stations were above the WHO standards, while the level of Zn exceeded the WHO standard only at the Abattoir and DSAR stations. Also, the level of Cu at the Abattoir station exceeded the WHO standard. The observed levels of the heavy metals in Aba River are mainly due to anthropogenic effects. There seems to be imminent danger to the living organisms in the environment since the observed high levels do pose environmental contamination risk.

Keywords: Heavy metals, Pollution, Aba River, Sediments.

INTRODUCTION

One of the major recent environmental concerns that has received increasing attention over the last few decades because of its adverse effects is the pollution of river sediments with chemical contaminants[1, 2]. Sediments are organic and inorganic materials derived from weathering processes of sand, clay, silt and other soil particles that settle at the bottom or bank of a water body[3, 4]. They are rich in minerals and serve as habitat and major nutrient sources for aquatic organisms[5, 6]. Sediments also mediate the uptake, storage, release and transfer of these nutrient elements between environmental compartments[7]. In aquatic monitoring, sediments can be classified as deposited or suspended. Deposited sediments are those found on the bed of a river or lake while suspended sediments are found in the water column where they are being transported by water movements. A number of processes such as erosion, transport and deposition mutually interact along the river and influence the sedimentary content of the river[8, 9].

Sediments have been negatively identified as the ultimate sink of contaminants in the aquatic systems. These contaminants which mostly occur as trace metals or heavy metals adsorb onto suspended particles and eventually settle to the sediments[10]. However, if particles of sediments are ingested or the chemicals are otherwise released, the toxicants enter the food web, shellfish, fish, and other organisms which tend to bioaccumulate these toxicants thereby threatening larger consumers including human.[11, 12]. Anthropogenic sources such as increased population, urbanization, exploration and exploitation of natural resources, industrial activities and agricultural practices have been recognized as causal factors influencing the generation and accumulation of heavy metals in sediments in aquatic environments[13, 14].

The implication is the detrimental effect on organisms that thrive on sediments resulting in death, reduced growth and lower species diversity[14]. It is also important to mention here that analysis of sediments provides information on the impact of distant human activity on aquatic life[15, 16]. Therefore, the assessment of the impact of the contamination of river sediments by heavy metals has become essential as they influence the ground and surface waters, plants, animals and humans[17, 18]. Aba is the commercial nerve centre of Eastern Nigeria. It has a freshwater river within its metropolis popularly known as Aba River. It provides recreation, used for industrial purposes, fishing and also supports different forms of life. The enrichment of heavy metals in Aba River has been reported by previous researchers[19.] The contamination of this river by heavy metals from non-point sources has become one of the greatest challenges confronting the residents. Apart from the chemical contaminants from public gutters that run straight into the river, it also receives wastes from sources including: airborne supply of emissions from automobiles in the vicinity of the river, domestic effluents from public eateries and discharges from industries located along the river course. Run-offs from these sources empty into the river from various points and have consequently increased the heavy metal concentrations on the water sediments[20]. However, the overall objective of this research work was to examine the extent to which each the of heavy metals such as Cr, Cu, Cd, Zn, Ni, Fe, Mn and Pb affect sediments of Aba River with a view of creating environmental awareness to the government and the public on the present state of the river.

MATERIALS AND METHODS

2.1 Location of Study Area: Aba River is a tributary of Imo River and is the major river that passes through Aba town and flows through the Azumiri River to the Atlantic Ocean (**Figure 1**). It is located on

Longitude 7º 19'E to 23'E and latitude 5º 10'N in Aba, Abia state, Nigeria. The area has a land mass of 198km^2. The commercial and industrial city of Aba is located in close proximity to the river. The areas of interest in this research study were stations along the course of the river that channel their waste into the river.

2.2. Climate and Vegetation: The study area falls within the humid tropical rainforest climate. The average rainfall for the area is about 2285 mm and falls from March to November with a relative humidity of 80% and mean[21] temperature of 27 ºC. Most parts of the area are flooded during the rainy season due to poor drainage system and construction. The dry season in the area is from November to March and is characterized by dry, cold and windy weather, with little or no rainfall[21]. The temperature is highest in December and lowest in February due to the harmattan.

SEDIMENT SAMPLING AND CHEMICAL ANALYSIS

Five sampling stations were established along the Aba River course in order to give a comprehensive idea of overall quality of the river sediments. The samples were taken on a monthly interval visit to the stations for a period of eight months (June 2014 - January 2015). The stations which include; Upstream Aba River (USAR), Petterson Zechonis (PZ), Nigerian Breweries (NBL), Abattoir (ABT) and Downstream Aba River (DSAR) with a distance of 2.0km from each station were analyzed.

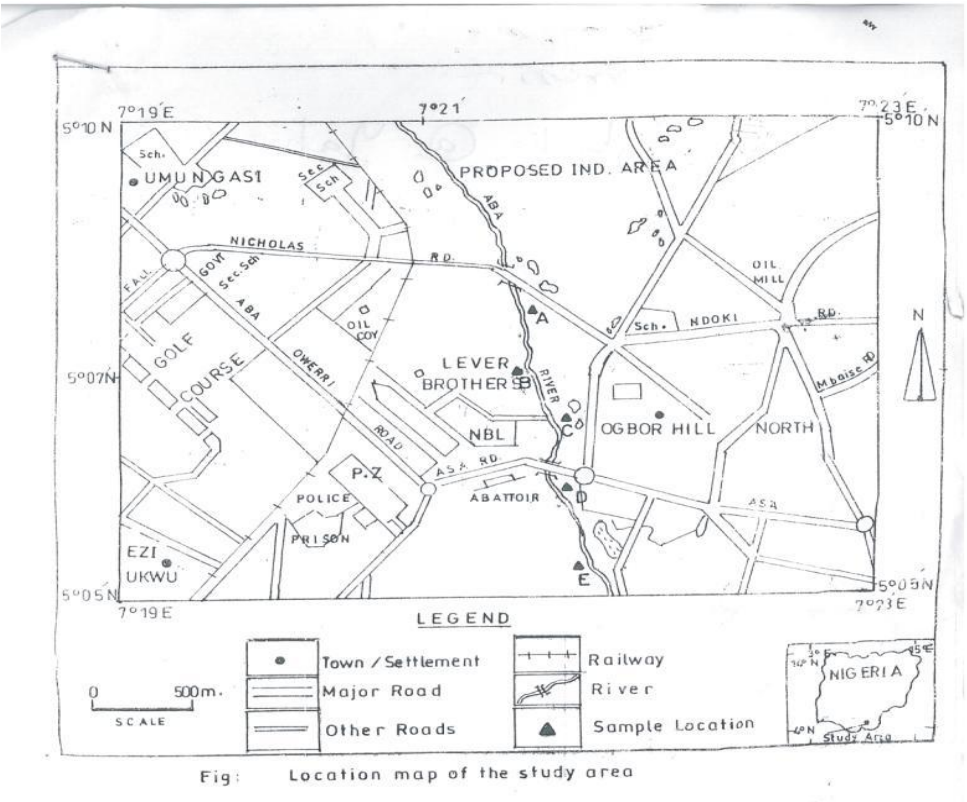

Fig: Location map of the study area

Fig.1: location map of study area.

At each sampling station, samples were collected from the bottom sediments using ekman grab. Eight sample replications were collected from each station and the findings were represented by the average replicated samples. The samples were taken to the laboratory, dried at 105 ^{0}C; ground, sieved and about 10g of the finest dried grains were digested with a mixture of Conc.H_2O_2 and HNO_3, and preserved in the refrigerator for subsequent analysis for the levels of Cr, Cu, Cd, Zn, Ni, Fe, Mn and Pb. The concentrations of these heavy metals were determined in mg/kg .**Fig 1**

RESULTS AND DISCUSSION

The results of the analysis showed the presence of eight heavy metals; Cr, Cu, Cd, Zn, Ni, Fe, Mn and Pb in sediments of Aba River in different levels of concentration as shown in **Table 1**. The maximum concentration of chromium (Cr), 1.84 mg /g was obtained in August 2014 at the NBL station, while the minimum concentration level of 0.013 mg /g was obtained at DSAR. The maximum level of 4.482 mg /g for copper was obtained at ABT in the month of August to September while the mean concentration of 0.057 mg / g was obtained in the month of October to November at USAR. The maximum concentration level of cadmium in the river was obtained with a value of 0.098 mg / g in June to July 2014 while the minimum level was obtained at DSAR between Augusts to September with a value of 0.008 mg / g. The maximum concentration of Fe in the river was obtained at the NBL location in the Aug-Sep 2014 period with a value of 77.27 mg / g while the minimum value was 20. 27 mg / g was obtained at Abattoir in Aug-sep 2014. The maximum level of zinc (Zn) in the Aba River was obtained at the Abattoir in June-July, 2014 with a value of 7.624 mg / g while the minimum value of Zn was obtained in the month of October –November, 2014 at USAR. The maximum concentration of Nickel (Ni) in Aba River was obtained at NBL in June-July, 2014 period with a value of 0.304 mg / g while the minimum concentration was obtained at DSAR with a value of 0.046 mg / g in Oct-Nov, 2014. The maximum concentration of Lead (Pb) was obtained at ABT with a value of 5.33 mg /g in Aug-Sept, 2014 while the minimum value was obtained at PZ in June-July, 2014 with a value of 0.04 mg / g. The maximum concentration of Manganese (Mn) was obtained in Abattoir (ABT) in Aug-Sept, 2014 with a value of 13.274 mg /g while the minimum concentration gave a value of 0.047 mg / g was recorded at NBL station in the month of Oct-Nov, 2014.

However, a sum total of eight heavy metals were determined in sediments of Aba River. The levels of heavy metals vary from one sampling station to another. This could be specifically attributed to the effect of human activities that are peculiar to each of the four stations analyzed (**Table 2-3**). Again, the observed levels of each of the heavy metals are a reflection of the turbulence flow pattern within the river.

More so, the sources of heavy metals in Aba river are traceable to refuse dumps, farm lands public gutters and effluents from Nigerian Bottling Company, PZ company, Abattoir and other non-point sources[22] These variations therefore indicated the relative abundance of these metal pollutants in the sample stations. Heavy metals such as Cr, Cu, Cd, Zn, Ni, Fe, Mn and Pb are present in various forms of domestic waste and metals from the detergents in laundry waste waters discharged and drained into the rivers could scale up the level of metal concentration in sediment of Aba River[22]. Farming activities with agrochemicals could be an additional factor to river pollution since run-off water from agricultural lands empty into Aba River[23]. Furthermore, the use of pesticides and artificial fertilizers could further increase the crude content of, Fe, Cr, and Mn in the soil while erosion would take off the top soil leading to mineral dissolution into water sediments[9]

A good number of scientific evidence have revealed that traces of chemicals in river sediments may be as a result of the irrepressible need of pesticides, organochlorine and organophosphate fertilizers to boost crop yield[9, 21] . Hence, the observed levels of heavy metals found in Aba River sediment could be as a result of extensive cultivation of food crops at the alluvial banks of the river thereby leading to the loading of the river sediments with metals.

Heavy metals such as Zn, Fe, Cr and Mn are notable indicators of contamination from anthropogenic activities; therefore detection of these metals in Aba River indicates contamination of the river by human activities[20].

Table 1: Statistical summary of Heavy metals in sediments of Aba River

Elements (mg/g)	Mean USAR	Mean PZ	Mean NBL	Mean ABT	Mean DSAR	Max.	Min.	Mean	SD	CV (%)	WHO
Chromium(Cr)	0.754	0.369	0.647	0.351	0.203	0.754	0.203	0.463	0.228	49.244	0.05
Copper (Cu)	0.103	0.102	0.268	1.926	0.233	1.926	0.102	0.526	0.786	149.43	1.00
Cadmium (Cd)	0.071	0.024	0.070	0.023	0.016	0.071	0.023	0.041	0.027	65.854	0.003
Iron(Fe)	60.951	59.90	72.13	52.746	68.961	72.130	59.904	62.94	7.711	12.258	0.3
Zinc (Zn)	0.9035	1.15	3.137	5.197	5.140	5.197	0.904	3.106	2.073	66.742	5.00
Nickel (Ni)	0.2617	0.110	0.155	0.074	0.091	0.262	0.074	0.138	0.075	54.348	0.02
Lead(Pb)	0.27	0.090	1.335	3.400	1.305	3.40	0.090	1.280	1.317	1*2.891	0.05
Manganese (Mn)	1.7567	0.814	3.205	6.355	3.219	6.355	0.814	3.070	2.100	68.4*4	0.5

Table 2 shows the comparison of the levels of heavy metals concentration in sediment of Aba River with WHO standards at different sampled stations. The existing WHO (2008) guideline for chromium (Cr) is 0.05mg/g and the value at USAR was 0.74 mg /g, PZ (0.369 mg / g), NBL (0.647 mg / g), ABT (0.351 mg /g) and DSAR (0.203 mg / g). The levels of concentration of Iron (Fe) in the sediments at USAR was 60.9509 mg / g, PZ (59.9037 mg / g),NBL(72.13 mg / g), ABT (52.7963 ppm) and DSAR(68.961 mg /g) while the WHO standard is 0.3 ppm. Also, the level of concentration of zinc in the sediment at USAR was 0.9037, PZ (1.1544 mg / g), NBL (3.1374 mg / g), ABT (5.1963 mg /g) and DSAR (5.1398 mg /g) while WHO set standard is 5.0 ppm. The concentration level of copper in the Aba river at USAR was 0.103, PZ (0.102 mg / g), NBL(0.268 mg / g), ABT (1.9257 mg / g) and DSAR (0.2327 mg / g) while the WHO set standard is 1.0 mg /g. The cadmium level at USAR was 0.071 mg /g, PZ (0.024 mg / g), NBL (0.07 mg / g), ABT (0.0233 mg / g) and DSAR (0.0153 mg / g). The WHO standard for Cd is 0.003 ppm. The level of Nickel (Ni) at USAR is 0.2617 mg /g, PZ (0.110 mg /g), NBL (0.1553 mg /g), ABT (0.074 mg /g) and DSAR (0.091mg/g). The WHO standard for Ni is 0.02 mg/g. The concentration of lead (Pb) in the sediment at USAR was 0.27 mg / g, PZ (0.09 mg / g), NBL (1.335 mg / g), ABT (3.4 mg /g) and DSAR (1.305 mg /g) while the WHO set standard is 0.05 mg /g. The manganese (Mn) level at USAR

is 1.7567 mg /g, PZ (0.8143 mg /g), NBL (3.2042 mg /g), ABT (6.355 mg /g) and DSAR (3.2187 mg /g) while the WHO standard for Manganese is 0.5 mg /g.

Table 2: Comparison of the observed values of heavy metals in the sediments of Aba River with World Health Organization (WHO) standard

Elements(mg/g)	Mean	WHO STANDARD
Chromium(Cr)	0.463	0.05
Copper(Cu)	0.526	1.0
Cadmium(Cd)	0.041	0.003
Iron(Fe)	62.94	0.3
Zinc(Zn)	3.106	5.0
Nickel(Ni)	0.138	0.02
Lead(Pb)	1.280	0.05
Manganese(Mn)	3.070	0.5

Table 3: Location, Description of activities and sediment type

Site/Location	Code	Activity/Establishment	Sediments
Upstream	USAR	Fruits and vegetable farming, fish factory, Car washing, gas station, sewage disposal, Bus park, Seepage, Garages etc	Silty sand
Petterson Zochonis Industries PLC	PZ	Industrial waste water discharge, Solid waste dumpsite, recreational activities etc	Sand
Nigeria Breweries Limited	NBL	Industrial waste water, dotted solid waste dumpsite, residential, commercial activities.	Sand
Abbatoir	ABT	Animal dung, Commercial, waste water, Vehicular emission	Sand/Clay
Downstream	DSAR	Dyeing of textile materials, residential buildings, vehicular emissions,	Silty sand

It was observed that Aba River sediments are polluted with the analyzed heavy metal pollutants at various levels of concentration. The result of the analysis therefore shows that the sediments are becoming increasingly contaminated by metal pollutants indicating that there could be problem of bioaccumulation on plants that rely on the sediment for supply of nutrients[5].

However, the results reveal that that apart from the levels of Zn that is exceeded the limit at ABT and DSAR, and Cu that exceeded only at ABT; all other heavy metals were above the WHO standard at all the stations. Heavy metals are generally known to be carcinogenic to humans because of their bioaccumulation characteristics[24].

CONCLUSION

The study has established that the heavy metals; Cr, Cu, Cd, Zn, Ni, Fe, Mn and Pb were present in the sediments of Aba river to varying degrees of concentration. It is suspected that the the levels of concentrations of these metals will continue to increase in Aba river since most the metals are likely to be from human activities within the catchment area and river banks. The study revealed that the Aba river sediment is becoming polluted because of the observed high levels of these heavy metals. The contamination of the water sediment by these chemical elements has direct consequences on the lives of the consumers on the long run owing to the fact that heavy metals have been associated with many human ailments.

RECOMMENDATIONS

From the results and conclusion Government and its agencies should put in place environmental laws that can help save ABA River from excessive pollution.

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