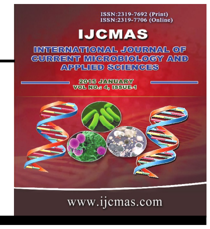

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Original Research Article

Heavy Metal Concentrations in Aquatic Macrophytes of Aba River, Abia State, Nigeria

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A B S T R A C T

An investigation of the levels of heavy metals in macrophytes of Aba River, Abia state, Nigeria was done in June 2014 in order to determine the pollution status of the River and the possibility of bioaccumulation and magnification on other living tissues in the food chain. This is of grave public health importance.Heavy metals were investigated in macrophyte tissues (leaf, stem and root) from Five (5) sampling stations with distinct land uses. Macrophyte samples were collected in triplicates for laboratory analysis. A total of 15 samples were collected. Collected samples were analyzed for the heavy metals copper (Cu), cadmium (Cd), chromium (Cr), lead (Pb) and nickel (Ni)using standard techniques. Data were subjected to statistical analysis using the SPSS®descriptive software. Results from the study indicate that different concentrations of heavy metals were found in plant tissues (leaf, stem and root). Concentration of heavy metals showed that root> stem> leaf in most stations. Correlationanalyses reveal that concentrations of Cu in leaves were negatively correlated with concentration in stem. Cd concentration in stem was also positively correlated with that in root.Pb concentration in leaves was also negatively correlated with concentration in root. Ni concentration in stem showed positive correlation with that in root. Analysis of Variance (ANOVA) showed that there is a significant difference ($P<0.05$) between lead concentration in leaves and root. Sinceplants are crucial in the food chain thereis an urgent need for Government to monitor all receiving waters and provide a regulatory framework. Our findings indicate that if nothing isdone, it may portend danger in the future.

Keywords

Heavy metals, Concentrations, macrophytes, Aba River

Introduction

Aquatic macrophytes are floating plants with or without well-defined structures such as leaves, stems and roots. They range from vascular plants such as sea grasses to algae.

They differ greatly from phytoplanktons which are microscopic and do not have differentiated body parts. Macrophytes constitute an important part of fresh water ecology and are also widely touted and disliked for their ability to impede smooth water navigation.

They are also important in providing habitat and nursery area for commercially and recreationally important fish species, and provide protection against shoreline erosion.

They constitute an important part of animal feed especially for water fowls and are recently employed as detoxifiers in water purification plants. Due to their remarkable ability to absorb toxins, their use as animal feed is a growing concern to researchersworldwide. Trace metals constitute some of the most hazardous substances if consumed in quantities above tolerable limits. Specifically, trace metals over-load results in the death of sediment-dwelling organisms, fish and produce cancer-like growth along with tumors as a result of bioaccumulation and bio-magnification (Hendricks, et al. 1985).

The tendency for pollutants especially heavy metals to bio-magnify in living tissues is a disturbing truth. Aba River situated at the very nerve Centre of the highly commercialized and industrialized city of Aba in Nigeria, possesses lots of macrophytes and therefore exposed to this threat. Lots of pollutants from chemical plants, automobile repair shops, cosmetic houses, abattoirs and detergents find its way into the River.

Heavy metals introduced by human activities into aquatic ecosystems have become the subject of wide spread concern. Exceeding the tolerable limits they become potentially toxic (Pocock, et al, 1994, Koller et al, 2003).

This paper is a study of the aquatic macrophytes in the River, as to ascertain the levels of select heavy metals in the plants and also to see which part of the plant is most culpable in absorbing it. This information will serve both for purposes of ensuring stricter control regarding pollution of our waters and may serve useful purposes of using macrophytes in the oil industry for detoxifying waste waters before disposal into the environment.

Materials and Methods

Collection of Samples

Macrophyte samples were collected from each station by simply pulling the plants. Samples were labeled according to stations, put in transparent polyvinyl chloride (PVC) plastic bags and then transported to the laboratory for analysis.

Laboratory analysis

Samples were oven dried and 2.0gm of oven dried plant specimens was put into a washed 250ml Erlenmeyer flask and 8ml of Perchloric acid, 50ml concentrated Nitric acid and 4ml concentrated sulphuric acid added to the sample under a fume hood.

The mixture was heated gently first for 15 minutes and then heated strongly for 45 minutes. After cooling, 40-50ml of distilled water was added to the mixture to provide a medium for the metals. The mixture was heated again for a minute and allowed to cool and then filtered into a 100ml Pyrex volumetric flask using a Whatman No.42 filter paper.

The filtrate was then analyzed for heavy metals using the Atomic Absorption Spectrometer (AAS) and readings obtained as electronic red light displays on the front of the spectrometer. Each metal was detected and differentiated by the degree of light absorption or penetrance on it.

Data analysis

Arithmetic means and standard deviations were calculated for all heavy metals in plant tissues. Regression analysis was employed using the SPSS® tool pack in order to determine the correlation between heavy metals in plant tissues (leaf, stem and root). Analysis of variance was employed at the 95% confidence level to determine the degree of significance in interaction of heavy metals inmacrophyte tissues between stations and between macrophyte tissues (leaf, stem, and root).

Result and Discussion

The results for the analysis of Heavy metals in macrophytes of Aba River are represented in Tables 1 – 4.

The concentrations of the heavy metalsin the different macrophyte tissues are captured in tables 3.2 – 3.4. The concentrations of all the heavy metals were appreciable exceptCr which showed non-detectable values in plant tissues. This low concentration of Cr can be explained by the fact that Cr is considered as a metal with low biogeochemical mobility which reduces its availability and toxicity potential (Abel, 1989).

Ni showed low but significant bioavailability compared with the metals sampled in the River,despite the favourable activities adjacent to the River. Although Ni is widely available to aquatic ecosystem through a variety of anthropogenic sources such as household waste waters and other inputs, one reason for this trend may be the fact that a lot of Ni released into the environment ends up in soils or sediments where it is strongly attached to particles containing iron and magnesium; thus the concentration of Ni in the water of rivers and lakes is very low with the average concentration usually less than 10 parts of Ni in a billion parts of water (Registry, A,. 2011). This also explains why the concentrations of the metals investigated had the highest concentrations in root than in the stems and leaves.Another reason for the significant concentration of Ni may be as a result of bio-concentration and magnification, which can lead to toxic levels of these metals in organisms even when the exposure level is low (Ezeronye and Ubalua, 2005)

Pb levels in Aba River were significantly high in all stations. This could be traced to the urban and industrial waste and high petrol-lead used by vehicles in Nigeria (Arah, 1995). The study also observed differential rates of absorption of the heavy metals in the different plant tissues. This may be due in part to the fact that bioaccumulation in biota is essentially dependent on the chemical effect of the metal, its tendency to bind to particular materials and on the lipid content and composition of the biological tissues (Bower, 1979).

This kind of differential rate of absorption has also been observed in previous studies in the Niger Delta of Nigeria.Differential rate of absorption of heavy metals in leaf, stem, and root of bitter leaf and okro plants exposed to metal polluted soils was observed by Gbaruku and Friday (2007).

Uptake of metal ions is an essential part of plant nutrition although different plant types react differently to the presence or absence of heavy metals. Several heavy metals such as Cu, Mn, Zn, Fe, and Ni play important roles in enzyme induction and reaction membrane function and isozyme activity.

The response of Plants to high concentration of metals varies across a broad spectrum from toxic reaction to tolerance; some plants are obligate metallophytes with a physiological requirement for elevated metal contents in soils (Nedelkoska and Doran, 2000).

Plant species and varieties vary in their capacity for heavy metal accumulation. Zinc uptake and accumulation for instance by shoots and roots varied with Zn levels in the growth media and vegetable types (Long et al, 2003). Ni et al (2002) observed that Cd concentration (accumulation) in various plant parts of the Chinese cabbage, winter greens and celery in shoots and roots varied with both different Cd levels and type of vegetable. In this study, the concentration of heavy metals in the different plant tissues (leaf, stem and root) across study stations shows no fixed trend. As Aba River is made up ofmacrophytes of differential species and varieties, the findings of this work may be in agreement with the findings of Ni et al, 2002; Long et al, 2003 which explains the trendless observed.

Investigation of heavy metals contained in aquatic biota is an accepted practice for determining the pollution status and ecosystem integrity of water bodies. In this study, the approach has been to take a cursory glance at heavy metals in macrophyte tissues (Roots, Stems, and Leaves). However, it is clear that the measurement of chemical, physicaloreven biological parameters alone without considering the temporal and spatial variations within the system cannot be a conclusive index for determining the integrity or health of the aquatic ecosystem.

In this study, the presence of heavy metals have been shown to be more abundant in the river catchments where there are industrial activities and pollution inducing practices adjacent to the river. Heavy metals have been shown to be more abundant in roots than in stems and leaves tissues. Therefore the findings from this study should help us with decisions regarding the use of macrophytes for both animal feed and other industrial uses. It will also guide government in the planning, decision making and the enactment of land use ordinances, regarding land use patterns in coastal catchments. This study provides that impetus for action.

Aba River despite its strategic positioning and significance is relatively understudied and scarcely cited in scientific literature. It is suggested that more research need be done on the pollution status of the river so as to create a pool of vital and citableinformation on the river and its catchments.

Finally, it is recommended that in addition to a pollution control regime, a yearly environmental audit be carried out on the river so as to ascertain and monitor its ecological health in time and space.

Table.1 Location of sample stations in Aba River

Station	Longitude	Latitude	Elevation (Ft)	Description/ Notable features
1	$50^0$06'28.2''N	$70^0$23'10.9''E	8.0	Housing quarters (up-stream)
2	$50^0$06'29.4''N	$70^0$22'10.2''E	20.0	Industrial/chemical plants.
3	$50^0$05'30.7''N	$70^0$21'11.0''E	36.0	Automobile workshop
4	$50^0$04'36.9''N	$70^0$20'9.0''E	13.0	Refuse dump.
5	$50^0$03'45.5''N	$70^0$19'9.2''E	60.0	Furniture shops (Down-stream)

Table.2 Concentration of Heavy Metals in Leaf of Macrophytes of Aba River

Metals(ug/l)	1	2	3	4	5
Cu	7.0^{a}±1.0	0.3^{b}±0.06	6.8^{a}±2.0	4.7^{c}± 0.6	ND
Cd	4.6^{a}±0.5	5.0^{ac}±1.0	6.0^{b}±0.4	5.5^{c}±1.0	5.0^{ac}±0.6
Cr	ND	ND	ND	ND	ND
Pb	7.2^{a}±0.6	8.0^{b}± 1.4	8.8^{d}± 1.2	6.6^{c}± 2.0	8.8^{d}± 3.0
Ni	3.5^{a}± 0.9	3.6^{ac}±. 1.2	3.5.^{a}± 1.7	3.2^{b}±1.2	38.1^{c}±1.0

Mean ± SD. SD – Standard Deviation.
Means with the same letter superscripts along the same column are not significantly different.
ND – Not detected.

Table.3 Concentration of Heavy Metals in Stem of Aba River

Metals(ug/l)	1	2	3	4	5
Cu	1.2^{a}±0.2	18.4^{b}±3.1	1.0^{a}±0.4	3.5^{c}±0.1	1.0^{a}±1.3
Cd	4.0^{a}±0.6	6.6^{b}±1.0	4.2^{a}±0.8	7.5^{c}±1.3	6.0^{b}±1.0
Cr	ND	ND	ND	ND	ND
Pb	5.0^{a}±0.8	10.0^{b}±0.82	6.8^{c}±1.1	10.8^{d}±2.0	9.8^{b}±1.0
Ni	3.5.^{a}±1.0	4.3^{b}±1.2	3.2^{c}±1.2	3.8^{d}±1.6	4.2^{b}±1.4

Mean ± SD.SD – Standard Deviation.
Means with the same letter superscripts on the same column are not significantly different.
ND – Not detected

Table.4 Concentration of Heavy metals in Roots of Aba River

Metals(ug/l)	1	2	3	4	5
Cu	40.0^{a}±1.2	28.0^{b}±1.6	3.0^{c}±0.5	30.0^{b}±2.0	11.5^{d}±1.4
Cd	6.6^{a}±2.0	7.0^{b}±1.8	5.5^{c}±1.3	7.2^{b}±0.6	6.6^{a}±1.0
Cr	ND	ND	ND	ND	ND
Pb	13.0^{a}±3.0	12.0^{b}±1.0	8.8^{c}±2.0	13.2^{a}±3.0	11.8^{b}±1.2
Ni	4.50^{a}±1.0	5.0.0^{b}±1.3	3.80^{c}±1.1	4.0^{c}±1.6	5.50^{d}±1.4

Mean ± SD. SD – Standard Deviation.
Means with the same letter superscripts on the same column are not significantly different.
ND – Not Detected.

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