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Pistia Stratiotes Distribution in Njaba River: An Implication of Heavy Metals in Surface Water and Sediments

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Abstract
The study assessed the effect of heavy metals on the species of higher aquatic plant, *Pistia strtiotes*, in Njaba River, Imo State, Nigeria. Water and higher aquatic plants sample were collected from three stream points (upstream, midstream and downstream) along the course of the River for six months. The following metals were measured: concentration of manganese, Zinc, Iron, Copper, Chromium, Cadmium, Nickel, Lead, Mercury, Arsenic and pH value. Metal pollution index was also used to determine the effect of heavy metals on phytoplankton population. At the end of the study, Nickel, Iron, Cadmium, Lead, Manganese, Arsenic, Mercury, Chromium and Copper concentrations were higher than the permissible value of NSDWQ, 2007 (Nigerian Standard for Drinking Water Quality). The result also revealed that *Pistia stratiotes* were found more on the midstream (32) and downstream (17) while (3) were found on the upstream. This means that upstream contains more of the heavy metals and so supports little existence of higher plants.

Keywords: *Pistia stratiotes,* Distribution, Njaba River, Heavy Metals, Surface Water, Sediments.

Introduction
Pistia stratiotes (Water Lettuce) is a beautiful medicinal aquatic plant which grows in large numbers. It is found floating on lakes, lazy streams and on stagnant water which is rich in lime. The leaves are arranged in whorls, fanlike and contain numerous soft hairs. Attached to the reverse side of the tract is a fleshy inflorescence. It grows abundantly in tropical countries. Its medicinal use

include: to treat abnormal accumulation of liquid in cellular tissue; bladder complaints, kidney disease, diabetes, anaemia and dysentery; as a laxative and softer of inflamed parts; promotes the flow of urine; treatment of piles, tumors, boils, and chronic skin diseases; remedy for infectious venereal diseases.

The leaves are used in infusion for treatment of abnormal accumulation of liquid s in cellular tissue, bladder complaints, diabetes, blood in urine, anaemia and dysentery. The root is used as a laxative, softens inflamed parts and promotes the flow of urine. The pounded leaves are used as a poultice for piles, tumors and boils. Mixed with coconut oil, the juice of the leaves is recommended for chronic skin diseases. The powdered dry leaves, mixed with a little honey, make a remedy for infectious venereal disease, taken in doses of 3 to 4 teaspoons a day.

One of the greatest challenges of Water source analysts, Hydrologist and Environmental managers has been the problem of surface water pollution in Nigeria. Industrial, urbanization and domestic activities have contributed immensely to increasing scale of pollution of rivers, lakes and other water bodies. Rivers or lakes are very important aspects of surface water resources of the earth. Water pollution also exists on a global scale. Not enough water is available to dispose of the diverse substances continuously. Despite the implementation of ever-improving methods of sewage treatment throughout the world, lakes, streams, and groundwater are becoming increasingly polluted. Household detergents, which contain phosphate, may flow into oligotrophic lakes and lead to their eutrophication. This leads to an overgrowth of algae and a rapid deterioration of water quality.

The entry of contaminations into the environment due to human and natural activities is one of the most important issues facing today's communities. Human activities through production of a variety of compounds and chemicals have introduced some unwanted pollutants, many of which of cause serious problems and risks to the environment and for man himself. As municipal, industrial and agricultural waste enters the water, biological and chemical contaminants including heavy metals also enter water resources. Although most of these metals are essential as micronutrients, their high concentration in the food chain can cause toxicity and environmental impacts and also can endanger aquatic ecosystems. Heavy metals as the name implies are an important class of pollutants which can produce considerable harm to the environment when they are above certain concentration. These elements can be reached into the surface water or ground water, taken up by plants, and can bond semi-permanently with soil components such as clay or organic matter, which later affect human health. Heavy metals are significant environmental pollutants; their toxicity is a problem of increasing significance for ecological, evolutionary, nutritional and environmental reasons.

Heavy metals like Copper, Nickel and Iron are regarded as essential metals because they play important roles in biological systems while Lead and Cadmium are non essential metals, as they are toxic even in trace amounts (Fernandes *et al.,* 2013). These essential metals can also produce toxic effects when the metal intake is excessively elevated. Heavy metals are taken into biological system via inhalation, ingestion and skin absorption. If they enter and accumulate in the body tissue faster than the body's detoxification pathways can dispose of them, a gradual build-up of these toxins will occur and result in toxicity (Prusty, 2014). Moreover, high concentration of exposure is not necessarily required to produce a state of toxicity in the body tissue as low concentration of exposure can also reach toxic levels. Aquatic life as well as humans can be protected from the toxic effects if heavy metals through regular monitoring of water bodies. However, several Rivers in Nigeria have not been adequately assessed for heavy metals content and the distribution of plankton population especially *Pistia stratiotes* that is an essential medicinal aquatic plant. Thus, the main aim of the study was to access the effect of heavy metals on the biological and ecological status of Njaba River in Imo State, Nigeria. The specific objectives include: (a) to investigate the amount of heavy metals in Njaba River and (b) to determine the effect of heavy metals on the distribution and population of *Pistia stratiotes* in Njaba River.

MATERIALS AND METHODS

Study Area

The experiment was conducted at Njaba River in Imo State, Nigeria. it lies between latitude 4^0 40^1 N to 6^0 30^1 N and longitude 5^0 00^1 E to 7^0 30^1 N. The climate is typical of the tropical rainforest zone and having rainfall almost the year round. Temperature ranges between 24^0C and 38^0C. Highest humidity is up to 90% during wet season while values as low as 40% could be recorded at the peak of the dry season.

Sample Collection

Local canoe was used for transportation in the Lake; plankton net of 55µm mesh size was hauled horizontally along the Lake for 5 minutes at each sampling location, according to the methods of Grant (2012). The resultant concentrated plankton samples was later transferred to plastic containers, which was fixed and preserved in 4% formalin solution according to Boney (2013) and Anene (2013) at the field. In the laboratory, with the use of a wide-mouthed pipette, 1ml of the plankton subsample was withdrawn from the field samples that was homogenized by inverting the containers few times, and was placed on a sedge-wick rafter counting chamber and was observed by direct microscopy. Keys provided by Jeje and Fernando (2016) were used for species identification. Counts was made and their averages taken and then expressed as cells/ml of water.

Heavy Metal Analysis

Principles of Atomic Absorption Spectrophotometer were carried out using the Emission Spectroscopy (AAS) method.

Reagent(s)

1000mg/l stock solution of each of the metals to be analyzed was prepared. For each of the metals, a working solution or sub-stock solution of 100mg/l was prepared using dilution factor formulae:

$C_1V_1 = C_2V_2$
Where C_1 = Conc. of the Stock solution (1000mg/l); C_2 = Conc. of the working solution (100mg/l); V_1 = Volume of the stock (unknown); V_2 = Volume of the working solution (100ml).
Hence, 10ml of each of the stock solution were diluted to mark in a 100ml volumetric flask, respectively.
Plant Digestion for heavy Metal Analysis (Wet Digestion Method)
5 gram of the sample was digested in 250ml conical flask by adding 30ml of aqua regia and heated on a hot plate until the volume remains about 7ml - 12ml. The digest was filtered using what-man filter paper and the volume made up to the mark in a 100ml volumetric flask, and was then stored in a plastic container for AAS analysis.
Water Digest for Heavy Metal Analysis
50ml of water sample was digested in 250ml conical flask by adding 10ml of aqua regia (Conc. HNO_3, HCl, HF in ratio 3:2:1), and heated on a hot plate until volume remains about 7ml - 12ml. The digest was filtered using what-man filter paper into a 50ml volumetric flask and the volume was made up to the mark using distilled de-ionized water, and then stored in a plastic container for AAS analysis.

Statistical Analysis

The MS Excel 2007 and SPSS version 17.0 software packages were used in the analysis of data. Means of the plankton taxa were made with the single factor analysis of variance (Anova). Diversity Index was also determined.

RESULTS

Analysis of Njaba River

Analysis of Njaba River in Imo State was carried out and the result of the analyzed water contained in Table 1. The varied values of the heavy metals with their means are pH, Iron, Manganes, Zinc, Copper, Chromium, Cadmium, Nickel, Lead, Mercury and Arsenic were all shown in Table 1.

Table 1: Statistical Summary of the Analyzed Water Samples

Parameters mg/I	Range	Mean	NSDWQ (2007)
pH	5.30 – 7.32	6.12	6.5 – 8.5
Fe	0.02 – 2.45	1.03	0.3
Mn	0.02 – 0.08	0.06	0.2
Zn	0.03 – 2.81	1.66	3.0
Cu	0.04 – 1.47	1.03	1.0
Cr	0.03 – 0.15	0.08	0.05
Cd	0.002 – 0.024	0.02	0.003
Ni	0.02 – 0.12	0.08	0.02
Pb	0.02 – 0.11	0.03	0.01
Hg	0.002 – 0.004	0.002	0.001
As	0.002 – 0.044	0.022	0.01

NSDWQ – Nigerian Standard for Drinking Water Quality.

Metal Pollution Index
The results of the computed Metal Pollution Index are shown in Table 2.

Table 2: Calculated Heavy Metal Pollution Index of Njaba River

Parameters (mg/l)	HMPI value	Rating
Arsenic	2.11	Moderately polluted
Cadmium	3.34	Moderately polluted
Chromium	1.41	Moderately polluted
Copper	1.03	Moderately polluted
Iron	3.42	Moderately polluted
Lead	3.01	Moderately polluted
Manganese	2.51	Moderately polluted
Mercury	2.01	Moderately polluted
Nickel	3.51	Moderately polluted
Zinc	0.56	Lightly polluted

< 0.01 = Very Lightly polluted; 0.01 – 0.99 = Lightly polluted; 1.0 – 4.99 = Moderately polluted; 5.0 – 10.0 = Highly polluted; > 10.0 = Very Highly polluted.

Abundance of Higher Aquatic Plant in Njaba River
Table 3 below shows the abundance of higher aquatic plant in Njaba River. *Pistia stratiotes* and *Eichhornia crassipes* were the only higher plant observed.

Table 3: Abumdance of Higher Aquatic Plant in Njaba River

Plants	Upstream	Midstream	Downstream	Total	% Abundance
Pistia stratioles	2	20	10	32	61.54%
Eichhornia crassipes	1	12	7	20	38.46%
Total	3	32	17	52	

DISCUSSION
FAO (1992) noted that in natural aquatic ecosystem, metals occur in low concentration, normally at the nanogram to microgram per liter level. In recent times, however, the occurrence of metal contaminants especially the heavy metals in excess of natural loads has become a problem of increasing concern. This situation has risen as a result of the rapid growth of population, increased urbanization and expansion of industrial activities, exploration and exploitation of natural resources, extension of irrigation and other modern agricultural practices as well as the lack of environmental regulations.

Pistia stratiotes L is a common aquatic plant in many tropical countries. Its ability to absorb nutrients and other elements from the water has made it possible to use it for water purification purposes. *Pistia,* especially stems and leaves, have been successfully used as indicators of heavy metal pollution in tropical countries. The uptake of heavy metals in this plant is stronger in the roots than in the floating shoots. Metallothionein-like compounds have been found from roots of this species after Cadmium exposure (Gonzalez *et al.,* 2019).

From the study, it was observed that heavy metals are found more on the upstream than at the mid and downstream. *Pistia stratiotes* and *Eichhornia crassipes* are found more at the midstream than at the downstream. Lead is a toxic element that can be harmful to plants, although plants usually show ability to accumulate large amounts of lead without visible changes in their appearance or yield. In many plants, Lead accumulation can exceed several hundred times the threshold of maximum level permissible for human consumption. The introduction of Lead into the food chain may affect human health and thus, studies concerning Lead accumulation in vegetables have increasing importance (Adu *et al.,* 2018). However, the observed values of Lead were higher than the permissible limit. This result is in line with the findings of Umunnakwe and Aharanwa (2018) who reported Lead to exceed the permissible limit in Oguta lake.

Hoekman (2015) indicated that high Cadmium level in water when consumed may cause nausea, vomiting, diarrhea, muscle cramps, liver injury and renal failure. Cadmium values recorded in this study were above NSDWQ (2007) limit. Data obtained from this study revealed that Arsenic value was above NSDWQ (2007) permissible limit with the mean value of 0.022 mg/l. Arsenic toxicity depends on numerous interacting factors which makes effects difficult to estimate. The use of aquatic algae is often advocated for bioremediation of Arsenic contaminated waters as they absorb Arsenate and transform.

From the study, nickel concentration was high (0.08 mg/l) as against the recommended value of 0.02 mg/l (NSDWQ, 2007). Nickel is released into the air by power plants and trash incinerators. It will then settle to the ground or fall down after reactions with raindrops. High Nickel concentration in surface waters can diminish the growth rates of algae. Nickel is not known to accumulate in plants or animals. As a result Nickel will not biomagnified up to food chain in Oguta lake (Umunnakwe and Aharanwa, 2018). Heavy metals from weathered soils and rocks, mining and metallurgical releases and industrial emissions causes stress in water (Boari *et al.,* 2017; Adams, 2017), and this may expose microflora or microfauna, aquatic lives and humans who depend on such waters (Edor, 2017). Chromium is a key element in the metabolism of sugar in plants and animals and also regulates the rate of insulin molecules in transporting glucose into cells for glycolysis. High concentrations of Chromium and the other heavy metals were observed in the study. This situation is also reported by other studies at different places (Olatunji and Osibanjo, 2017). The result of this study is in contrast to the findings of other studies that reported Chromium below the recommended standard (Akintujoye *et al.,* 2018) and quite different from other studies that reported higher concentrations of Chromium beyond the recommended standard (Hong et al., 2019; Olatunji and Osibanjo, 2017).

Zinc was within the permissible limits (NSDWQ, 2007). The generally high values of Chromium and other heavy metals may be due to the fact that other factors other than seasons and anthropogenic activities are impacting on their concentration in the river. The high incidence of Iron is an indication of an increased disposal of Iron related effluents into the river. This may have come from the machineries and or equipment used in the timber industry. This result is in line with the result of other studies elsewhere that reported Iron in surface water beyond the acceptable limits (Akintujoye, *et al.,* 2018). However, this result is in contrast to the findings of other studies that reported Iron concentration in surface waters within the acceptable limit for drinking water quality (Abah *et al.,* 2018).

CONCLUSION

The results of the analysis revealed that Njaba River is slightly to moderately polluted by heavy metals. The reported level of heavy metals in the water poses a threat to plants and to the health of humans who depend directly on the water for domestic use. The study suggests that in the tropical condition many factors such as heavy metals govern the occurrence and abundance of higher aquatic plants especially, *Pistia stratiotes*, in upstream, midstream and downstream. A trend analysis of indicator groups revealing a typical response of higher aquatic plants in response to heavy metals. Thus, intensive investigation and experimental ecology of effects of heavy metal on higher aquatic plants found in upstream, midstream and downstream. *Pistia stratiotes* were found more on the midstream and downstream. This means that upstream contains more of the heavy metals and so supports little existence of higher plants (*Pistia stratiotes* and *Eichhornia crasspes*).

RECOMMENDATION

This study vindicate the essence of continuous monitoring of our water bodies as this will help to give vital information on the status of water bodies in Nigeria and to expedite remedial measure in the event of pollution.

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