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HEAVY METALS CONTAMINATION AND ACCUMULATION BY *LEMNA MINOR* (DUCKWEED) IN A POND ECOSYSTEM

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ABSTRACT

This study was carried out to assess the potential of *Lemna minor* as a Bioaccumulator of Heavy metals in a Pond Ecosystem. The analysis of heavy metal in plant and water samples were carried out using standard analytical methods. The result revealed the presence of cadmium, chromium, lead, cobalt and zinc. Their concentrations were as follows: 0.50±0.08mg/kg, 1.26±0.22mg/kg, 0.23±0,019mg/kg, 2.17±0.86mg/kg, 4.27±0.04mg/kg in plants; 1.67±0.05mg/L, 3.88±1.74mg/L, 2.14±0.06mg/L, 0.49±0.01mg/L, 7.21±1.76mg/L in water respectively. The difference between the heavy metal concentrations in plant and water samples was not statistically significant (P>0.05). From the data of this analysis in plant, chromium was higher than that of the World Health Organization Standard (W.H.O), while cadmium, lead and zinc were lower than the standard. In the water samples, cadmium was higher than the World Health Organization standard (W.H.O) while chromium, lead and zinc were lower than the standard. The results obtained showed that BCF of Cadmium, Chromium, Lead and Zinc were below 1. The BCF of Cobalt was 4.4 and this implies that *Lemna minor* is a hyperaccumulator of Cobalt.

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INTRODUCTION

Lemna minor (Duckweed) is an aquatic plant floating at the water surfaces. Duckweed grows fast and adapts easily to various aquatic conditions. They are most commonly found in ponds and wetlands. The small size of *Lemna*, its simple structure and rapid growth makes duckweed very suitable for toxicity tests [1]. It has been found to be useful in the treatment of wastewater to remove mineral and organic chemicals and radionuclides [2].

Rapid industrialization, urbanization and population in the last few decades have added huge loads of pollutants in the water resources [3]. Such unprecedented pollution in aquatic ecosystems need eco-friendly, cost-effective remediation technology. A large number of industries including textile, paper and pulp, printing, iron-steel, electroplating, coke, petroleum, pesticide, paint, and pharmaceutical consume large volumes of water and organic chemicals which differ in their composition and toxicity [3]. The discharge of effluents from these industrial units into different water bodies, resulting in water pollution, is a major concern, especially in developing countries. Water contamination is a major issue in developed nations, owing to the expansion of industry and new agriculture technology, which is mostly solved by developing waste water management techniques. However, a lack of technological expertise, a lack of environmental policy enforcement, and a lack of financial capital have created significant obstacles.

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Heavy metals are a major concern for numerous water contaminants due to their pervasive and bioaccumulative existence [4] [5]. Water is an essential component of mankind's substance, and as people become more conscious of the environment, marine environments, in particular, have piqued the interest of researchers all over the world. There is a clear need to develop a low-cost, environmentally friendly technology to remove contaminants, particularly heavy metals, and thus improve water quality. Phytoremediation seems to be a viable option. Lemna minor, a free-floating, fast-growing, nitrogen-fixing Pteridophyte, appears to be a promising candidate for heavy metal removal, disposal, and regeneration from contaminated aquatic ecosystems [6] [7].

Heavy metal contamination is causing significant environmental and health issues in areas where most construction practices are already reliant on water sources [8] [9]. Heavy metals are chemical elements that have a heavy atomic weight and have a density that is higher (at least five times) than water [9].

Aquatic macrophytes are photosynthetic species that are large enough to be seen by the naked eye in the water. Aquatic spermatophytes (flowering plants), pteridophytes (ferns), and bryophytes are all included (mosses, hornworts, liverworts).Aquatic macrophytes are ideally suited to waste-water management than terrestrial plants due to their quicker growth and greater biomass yield, as well as their higher pollutant uptake capacity and purification results due to direct interaction with polluted water [10]. They also affect the structural and functional aspects of aquatic ecosystems by changing water movement regimes (flow and wave impacts conditions), providing shelter and food for fish and aquatic invertebrates, and altering water quality by regulating oxygen balance, nutrient cycle, and heavy metal accumulation [11] [12].

Their potential to hyperaccumulate heavy metals makes them promising research candidates, especially for the treatment of industrial waste and sewage waste water [13].

Aquatic macrophytes' living and decaying biomass should be used to remove heavy metal toxins from aquatic environments [14]. The word "bioaccumulation" is characterized as the phenomenon of heavy metal absorption by living cells based on the state of biomass.

Due to its proliferative existence, research on *Lemna minor* may be fascinating and enlightening. Fast growth rate, high biomass yield, reasonably extensive root system, simple harvest, and tolerance to a wide variety of heavy metals are all characteristics of *Lemna*, making it an ideal plant for phytoremediation. Other promising areas of future study include the effect of heavy metal uptake on overall physiological/biochemical metabolism, as well as their regulation at the genetic level. Through a greater understanding of this symbiotic relationship, this eco-friendly mechanism can be put to good use in the field of phytoremediation. This research is aimed at evaluating heavy metal concentration in an urban pond and its corresponding uptake (bioaccumulation) in *Lemna minor*.

MATERIALS AND METHOD

Description of Sampling Site

The natural pond is located in University of Uyo Botanical Garden in University of Uyo Main Campus, Uyo LGA, Akwa Ibom State. It is located between latitude N 5°2’22 and longitude E 7°58’47. The continuous flow of water has created a unique natural habitat that supports a luxuriant growth of algae and other aquatic plants and animals. The pond collects water from rainfall and surface runoff. It covers an area of about 2 hectares and an estimated depth of about 4 meters. The average annual temperature is 26.4°C and average rainfall of 2509mm.

Collection of Samples

Plant (*Lemna minor*) and water samples were collected from University of Uyo Botanical Garden, located at University of Uyo Main Campus. The samples were collected by adaptive core sampling technique. The water was scooped and the plant were filtered using filter paper. The samples were stored in an air tight container and brought to the laboratory for analysis.

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Preparation of Samples

Samples were dried in a hot air oven at the temperature of 60^0c. After drying, it was ground to powder to reduce the particles size and increase surface area. 100ml of filtered water was later used for the analysis.

Digestion of Heavy Metals

One gram of dried plant sample was weighed into 150ml beaker and carried out in duplicate. Then 20ml of concentrated HNO_3 acid was added very carefully and allowed to stand for one hour, and then 15ml of HCL (Hydrogen chloride) was added. It was further digested in hot plate till mixture turned yellow while some fume came out from the beaker which indicates temperature of the digestion of the sample. The digest was allowed to cool and then some of distilled water was added and quantitatively filtered into $100cm^3$ volume of flask which was then transferred into a small rubber. The filtrate was collected in small rubber containers for determination of heavy metals using Atomic Absorption Spectrophotometer (A.A.S).

Determination of Heavy Metals Using Atomic Absorbtion Spectrophotometer [15]

The extract obtained from the digestion was taken for analysis using atomic absorption spectrophotometer. For analysis of the sample extract, the blank solution and stock solution were prepared. The blank solution was used to set the pointer to zero and the stock solution for the reading of the absorbance. The standard solution was also prepared for the pointing of standard. The concentrations of each element were concluded thus:

$$\frac{V_x \text{ X Com (mg/L)}}{\text{Mg}}$$

V_x = Volume
Mg = the mass of sample digested
Also
The absorbance observed for each of the stock solution (extract) = A_s X C_s
A_c = Absorbance obtain from the sample
C_s = Concentration of the stock sample (standard)
A_s = Absorbance of stock sample.
Agua regia method was used in the water sample.

Determination of Bioconcentration Factor

Bioconcentration factor (BCF) was calculated using the formula of Yadav *et al* (2009) as;

$$\text{Bioconcentration factor (BCF)} = \frac{\text{Average metal concentration in the whole plant (mg/kg)}}{\text{Metal concentration in the soil (mg/kg)}}$$

Statistical Analysis

The Independent Students t-Test was used to analyse and compare the data using Statistical Package for Social Science (SPSS) software version 25.

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RESULTS AND DISCUSSION

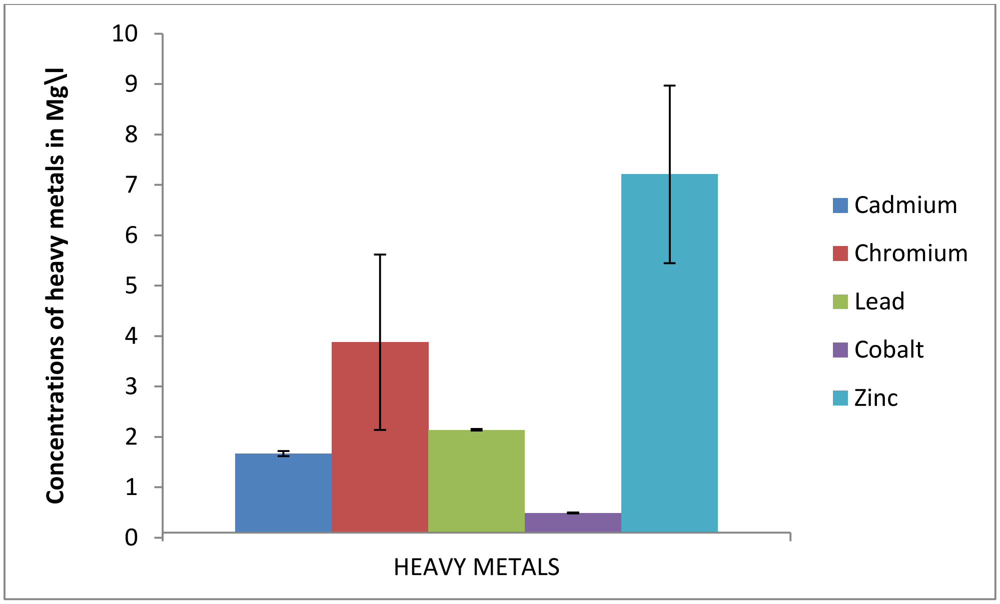

Figure 1: Heavy Metals Concentration in Water Samples

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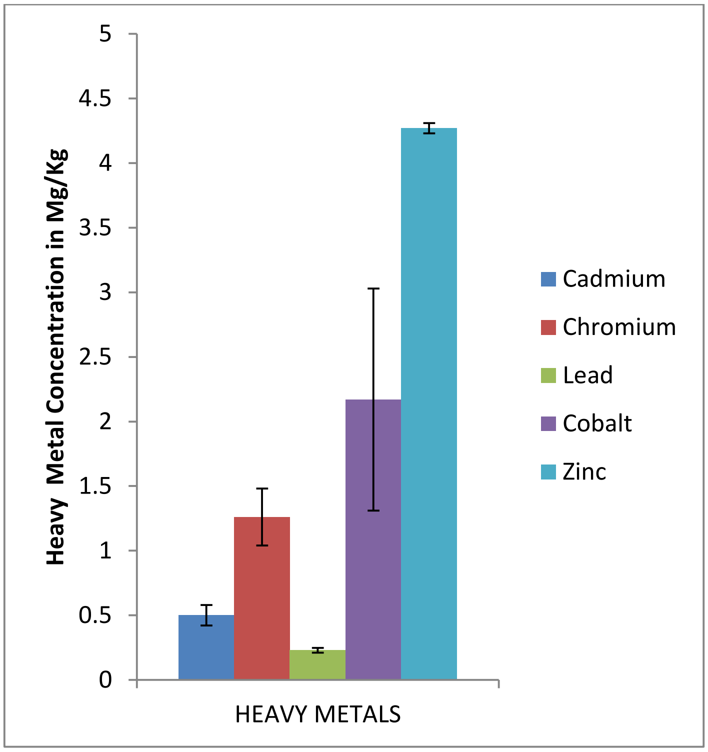

Figure 2: Heavy Metals Concentration in Plant Samples

TABLE 1: BIOCONCENTRATION FACTOR (BCF) OF HEAVY METALS IN *Lemna minor*

METALS	BCF
Cadmium	0.299
Chromiun	0.324
Lead	0.107
Cobalt	4.428
Zinc	0.592

The result obtain from the analysis of heavy metal in plant and water sample from a pond ecosystem in University of Uyo Botanical Garden revealed that Cadmuim, Chromium, Lead, Zinc, and Cobalt were present in the samples and their concentration were as follows; water sample: 1.67± 0.05mg/L, 3.88 ± 1.74mg/L, 2.14 ± 0.016mg/L, 0.49 ± 0.01mg/L, 7.21 ± 1.76mg/L respectively. Plant sample: 0.50 ± 0.08mg/kg, 1.26 ± 0.22mg/kg, 0.23 ± 0.019mg/kg, 2.17 ± 0.86mg/kg, 4.27 ±0.04mg/kg respectively.

Cadmium

Cadmium was 1.67 ± 0.05 for water sample and 0.50 ± 0.08 for plant sample comparing this result, cadmium concentration in water sample is higher than plant sample which is supposed to be so since the water is the main reservoir [15]. Comparing this with the World Health Organization (W.H.O) standard 0.3mg/L, 1mg/kg respectively, this indicates that the result is within the safe limit. This is in line with the work of Udosen *et al.*, [16] who had 0.64mg/kg of cadmium but lower than

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9.05mg/kg of cadmium reported by Monechot *et al*., [17]. There is need to prevent this trend since there is a high tendency of heavy metal to accumulate in the environment. Cadmium is a heavy metal naturally present in water. It is highly toxic to organism, having toxicity 2-20 times higher than many other heavy metals. Cadmium content in waste water has been dramatically increased from anthropogenic sources including oil spillage, agricultural application of fertilizer and sewage sludge [18].

Lead

Lead concentration was 2.14 ± 0.016mg/L in water sample and 0.23 ± 0.019 in plant sample, this result is lower than the World Health Organization Standard which is 5.0mg/L and 2.0mg/kg respectively, this indicates that lead concentration in plant is within a permissible limit. This is in accordance with the work of Monchot *et al.*, (2014). The presence of lead in both samples maybe due to activities especially industries that are concentrated in the area. The pollution of wasted by lead is a very serious problem, as lead is carcinogenic to man [19].

Cobalt

Cobalt concentration from the plant sample was 2.17 ± 0.86mg/kg and 0.49 ± 0.01mg/L in water sample, this result is almost in range with the result of cobalt from plant and water sample in Ekiti State reported by [20]. Cobalt is essential to the metabolism, also all animals. It is a key constituent of cobalamin, also known as vitamin B_{12}, the primary biological reservoir of cobalt as an uptake element [21].

Zinc

Zinc concentration from water sample was 7.21 ± 1.76mg/L and in plant sample, it was 3.27 ± 0.04mg/kg. This result is low when compared with the World Health Organization Standard (W.H.O) 5.0mg/kg, 5.0mg/L respectively. Presence of zinc may be due to motor vehicle emission sewage sludge application, smelting and scrap metal processing [22]. Zinc can be toxic to plant if present in more than very small quantity [23].

Chromium

Chromium concentration was 3.88±1.74mg/L in water sample and 1.26±0.22mg/kg in the plant sample. Chromium concentration in the plant sample was higher than that of the World Health Organization Standard (W.H.O). Toxic effects of Cr on plant growth and development include alterations in the germination process as well as in the growth of roots, stems and leaves, which may affect total dry matter production and yield. Cr also causes deleterious effects on plant physiological processes such as photosynthesis, water relations and mineral nutrition. Metabolic alterations by Cr exposure have also been described in plants either by a direct effect on enzymes or other metabolites or by its ability to generate reactive oxygen species which may cause oxidative stress.

Bioconcentration Factor (BCF)

The results obtained showed that BCF of Cadmium, Chromium, Lead and Zinc were below 1. This implies that *Lemna minor* is a not a good accumulator of these metals. The BCF of Cobalt was 4.4 and this implies that *Lemna minor* is a hyperaccumulator of Cobalt.

CONCLUSION

The heavy metal composition of plant and water sample from a Pond Ecosystem in University of Uyo Botanical Garden, Akwa Ibom State revealed that cadmium, zinc, chromium, cobalt and lead were present in both samples. In plant sample, chromium was higher than that of the World Health Organization Standard (W.H.O) while cadmium, lead and zinc were lower than the W.H.O Standard. In water sample, cadmium was higher than the W.H.O standard while zinc, lead and chromium were lower than the W.H.O standard. The results obtained suggested that *L.minor* is a hyperaccumulator of Cobalt.

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