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Determination of Heavy Metals in Water Hyacinth Plant (*Pontederiacrassipes*) fromOlogeRiver,Ojo Area, Lagos State, Nigeria

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Abstract
The water hyacinth plant, formerly classified as Eichhornia crassipes is now recognized as Pontederia crassipes, is known to absorb significant quantities of metals from aquatic environments through its stem, root, and leaf. This study is used to determine the concentrations of five heavy metals, such as iron (Fe), manganese (Mn), copper (Cu), zinc (Zn), and nickel (Ni), in water hyacinth samples collected from the Ojo River, Lagos. Sampling was conducted between December and March from a consistent location. The harvested plant materials root, stem, and leaf were prepared by weighing 5 g of each part, followed by digestion using aqua regia in a 3:1 ratio, heated on a hot plate for 20 minutes. The cooled and filtered extracts were analyzed via Atomic Absorption Spectroscopy (AAS) to determine the metal concentrations. Results indicated that Fe, Mn, Cu, Zn, and Ni were present in all parts (stem, root and leaf) of the plant samples, with concentrations in descending order: Fe > Mn > Cu > Zn > Ni. Mean concentrations (mg/L) were as follows: stems (211.76, 14.45, 10.49, 4.29, 1.21) mg/L, roots (224.97, 16.480, 11.76, 4.79, 1.25 mg/L, and leaves (194.61, 13.74, 8.83, 3.46, 1.11) mg/L. The concentrations of all the heavy metals analyzed did not fall within the acceptable limits set by the World Health Organization (WHO). In conclusion, the trend of heavy metal concentrations in the parts of the water hyacinth plant are root > leaf > stem and some studies underscore the potential of P. crassipes as a bioindicator for heavy metal pollution in aquatic ecosystems.

Keywords:
Ologe River, Water hyacinth plant, Heavy metals, Digestion, Atomic Absorption Spectroscopy

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I. Introduction

The Earth's crust naturally contains heavy metals. They have a relatively high density, can't be destroyed or reduced to nothing, and are dangerous or toxic even in small amounts. Mercury (Hg), cadmium (Cd), arsenic (As), chromium (Cr), thallium (Tl), and lead are a few examples of heavy metals (Pb). They sometimes make their way into our systems through things like food and water. Some heavy metals act as trace elements and are necessary to keep the body's metabolism running smoothly. However, they can cause toxicity in higher amounts. Assuming that weight and toxicity are connected, heavy metals also include metalloids like arsenic, which can cause toxicity at low exposure levels. [1]. Heavy metal poisoning may be brought on by contaminated drinking water (such as from lead pipes), high ambient air concentrations close to the source of the emission, or ingestion through the food chain. Because they have a propensity to bioaccumulate, heavy metals are hazardous. When a chemical's concentration in a biological organism rises over time relative to its concentration in the environment, this is referred to as bioaccumulation. Both manmade and natural processes can lead to heavy metal pollution. Agriculture, mining, and smelting industries have contaminated large regions of the planet, primarily in China, Japan, and Indonesia, with heavy metals like Cd, Cu, and In. [2]. Both natural and anthropogenic sources, such as industrial discharge, vehicle exhaust, and mining, emit these metals into the environment. Heavy metals are non-biodegradable and have a propensity to accumulate in living things, in contrast to organic contaminants. In fact, the majority of them have been linked to cancer in the past. Long-term and ongoing exposure to heavy metals is recognized to pose a number of negative health risks. Appropriate techniques must be created for their efficient removal from the environment because they are non-degradable and have a propensity to bioaccumulate. Aquatic plants have the capacity to actively and passively absorb large amounts of metals from water and sediment through a variety of organs, including roots, stems, and leaves. This makes these plants suitable for heavy metal alterations in the environment. [3]. Some of the sources of heavy metals in the environment include geogenic, industrial, agricultural, pharmaceutical, domestic effluents, and atmospheric sources. [4]. Low biomass accumulation, chlorosis, inhibition of growth and photosynthesis, altered water balance and nutrient assimilation, and senescence, which ultimately cause plant death, are all toxic effects of heavy metals on plants. [5]. Heavy metals exert toxicities in plants through four proposed mechanisms [6] such as: similarities with the cation nutrient resulting from the absorption at the root surface; for example, As and Cd compete with P and Zn, respectively, for their absorption. Heavy metals have several acute and chronic toxic effects on different organs in the human body [7] and this include gastrointestinal and kidney dysfunction, nervous system disorders, skin lesions, vascular damage, immune system dysfunction, birth defects, and cancer.The effects of heavy metals affect fishes and aquatic invertebrates include: reduction of the developmental growth, increase in developmental anomalies, and reduction of fish survival. Due to an exponential development in their use in many industrial, agricultural, residential, and technical applications, human exposure has significantly increased.[8]. Geogenic, industrial, agricultural, pharmaceutical, home effluents, and atmospheric sources are some of the sources of heavy metals in the environment that have been reported. [9]. Point source locations, including mines, foundries, smelters, and other metal-based industrial processes, are highly prevalent sources of environmental contamination. [8,9].Even though heavy metals are naturally occurring substances that are present throughout the earth's crust, most environmental pollution and human exposure are caused by anthropogenic activities such as metal mining and smelting, industrial production and use, domestic and agricultural use of metals, as well as production and use of metal-containing compounds. [10]. Additionally, metal corrosion, air deposition, soil erosion of metal ions and leaching of heavy metals, sediment re-suspension, and metal evaporation from water supplies to soil and groundwater can all contribute to environmental pollution. [11]It has also been claimed that natural events like weathering and volcanic eruptions greatly contribute to heavy metal contamination. (12) Industrial sources include plants that process metal in refineries, burn coal in power plants, burn oil, has nuclear power plants, use high-tension lines, and process plastics, textiles, microelectronics, wood preservation, and paper. [13]. Water hyacinth reproduces primarily by means of runners or stolons, which eventually form daughter plants. Each plant reproduces approximately thousands of seeds every year, and they can remain viable for more than 28 years [14]. Some water hyacinths can grow between 2 and 5 meters (7 and 16 feet) within the period of a day in some sites in Southeast Asia [15].The common water hyacinth (*Pontederia crassipes*) is vigorous growers and mats can double in size within one to two weeks in terms of plant count rather than size, and they are said to multiply more than a hundred folds in number, in a matter of 23 days [15].In its native range, these flowers are pollinated by long-tongued bees and they reproduces sexually and clonally. The invasiveness of the hyacinth is related to its ability to clone itself and large patches are likely to be part of the same genetic form. However, anthropogenic activities including deliberate deposition of water hyacinth in ponds and dams are largely to be blamed for the widespread [16]. Water hyacinths multiply into mats to eliminate the presence of fish, and choke waterways for boating and shipping. This effect was well-taking hold in the state of Louisiana by the turn of the 20th century [17]. The invasion of water hyacinth has a major impact on the rural people that it has affect on, especially those who depend on water bodies for their livelihoods, such as fishing and riparian communities [18]. Study reported by Dersseh et al. [19], that water hyacinth invasion has negative impacts on the hydrology and environment, resulting in subsequent socio-economic impacts, as it disrupts human daily activities and health. The increase in evapotranspiration compared to surface evaporation disrupts the hydrological water balance in the infected areas, which could disrupt local rainfall events. Reduced water flows in rivers due to water hyacinth blockages will promote sedimentation, deoxygenation and water quality deterioration. Weed canopies on lakes reduce sunlight penetration. This increases the water turbidity and reduces variability in temperatures, as well as other similar water quality concerns [21]. Consequently, all these events lead to a reduction in fish and other aquatic organism populations as their habitat becomes less habitable. Instead, the proliferation of disease vectors such as mosquitoes and snails will occur, as the plant hosts a variety of these species [22]. The aim of this study is to determine the presence and concentration of heavy metals in water hyacinth plants.

II. Materials And Methods

Sample Collection

The plant samples were collected from the OlogeRiver, Ojo, Lagos. The samples were taken at 8 am in two different seasons between the months of December 2021 - March 2022.

Methodology

The collected plant samples were air-dried for one week. Subsequently, the roots, stems, and leaves were ground separately into fine particles and sieved to ensure uniformity. For digestion, 5 g of each sieved sample was placed into a conical flask, and aqua regia (a mixture of hydrochloric acid and nitric acid in a 3:1 ratio) was added. The mixture was heated on a hot plate for 20 minutes to facilitate digestion and then allowed to cool. Distilled water was added to the cooled mixture, which was then filtered to obtain a final volume of 50 ml. The filtered solution was transferred into sample bottles for analysis. This process was repeated for three independent samples, and the prepared solutions were analyzed for heavy metal concentrations using Atomic Absorption Spectroscopy (AAS).

III. Results And Discussions

Heavy Metal Concentrations in Plant Parts

The presence and concentration of heavy metals such as iron (Fe), manganese (Mn), copper (Cu), zinc (Zn), and nickel (Ni) in water hyacinth (*Pontederia crassipes*) were quantified for the stem, root, and leaf across three samples. The results of the heavy metaluptake in the in the plant root, stem and leaf of the water hyacinthare presented in Figures 1–3.

The concentrations of the heavy metals determined from the water hyacinth (*Pontederia crassipes*) plant stem, root and leaves are Fe (224.97, 194.61, and 211.76) mg/L, Mn (16.48, 13.74, and 10.15) mg/L, Cu (11.76, 8.83, and 10.15) mg/L, Zn (4.79, 3.46, and 4.29) mg/L, and Ni (1.25, 1.11, and 1.21) mg/L.

Stem

The results of heavy metal uptake by the water hyacinth stem in Figure 1 revealed the bioaccumulation or uptake of the heavy metals are Fe (194.61 mg/L), Mn (13.74 mg/L), Cu (8.83 mg/L), Zn (3.46 mg/L) and Ni (1.11 mg/L). The trend of the heavy metal uptake by the water plant are Fe > Mn > Cu > Zn > Ni

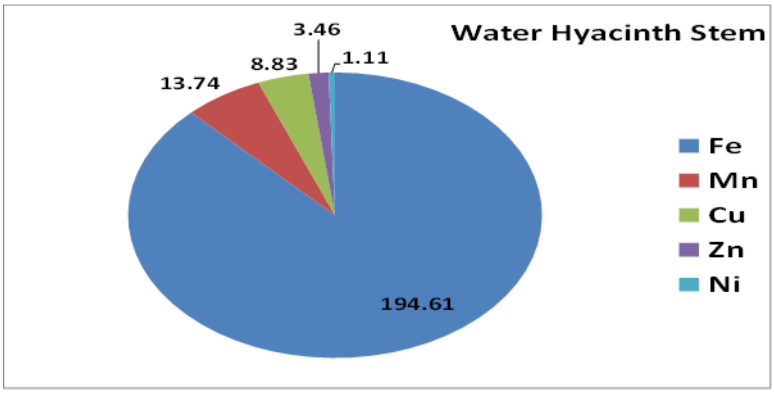

Figure 1: Concentration of heavy metals in water hyacinth plant stem

Root

The results of heavy metals uptake by the water hyacinth root in Figure 2 revealed the water plant bioaccumulation or uptake of the heavy metals are Fe (224.97 mg/L), Mn (16.48 mg/L), Cu (11.76 mg/L), Zn (4.79 mg/L) and Ni (1.25 mg/L). The trend of the heavy metal uptake by the water plant are Fe > Mn > Cu > Zn > Ni.

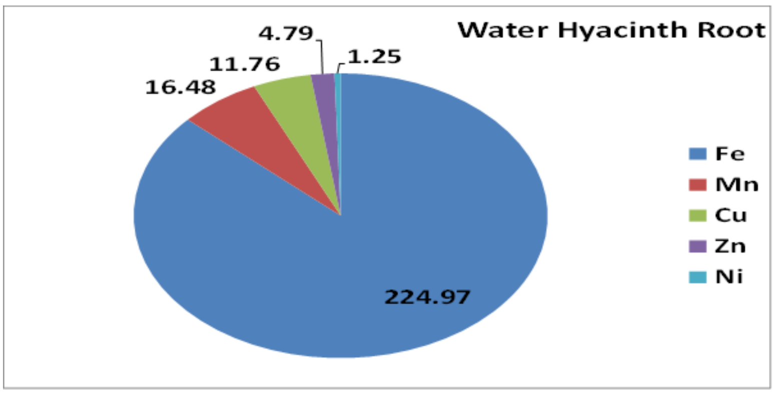

Figure 2: Concentration of heavy metals in water hyacinth plant root

Leaf

The results of heavy metals uptake by the water hyacinth root in Figure 3 revealed the water plant bioaccumulation or uptake of the heavy metals are Fe (211.76 mg/L), Mn (14.45 mg/L), Cu (10.15 mg/L), Zn (4.29 mg/L) and Ni (1.21 mg/L). The trend of the heavy metal uptake by the water plant are Fe > Mn > Cu > Zn > Ni.

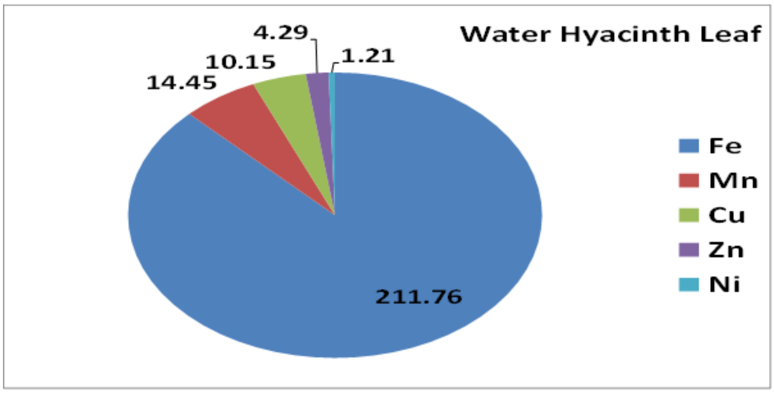

Figure 3: Concentration of heavy metals in water hyacinth plant leaves

Discussion

The results of heavy metal uptake in water hyacinth from Figures 1–3 indicated that Fe was consistently the most abundant metal across all the plant parts with mean concentrations ranging from 194.61 mg/L (stem), 224.97 mg/L (roots) and 211.76 mg/L (leaf), Mn was the second most accumulated metalfrom 13.74 mg/L (stem), 16.48 mg/L (roots) and 14.45 mg/L (leaf), followed by Cu, was the third most accumulated metal from 8.83 mg/L (stem), 11.76 mg/L (roots) and 10.15 mg/L Zn, was the fourth most accumulated metal from 3.46 mg/L (stem), 4.79 mg/L (roots) and 4.29 mg/L (leaf), and Ni was the fifth most accumulated metal from 1.11 mg/L (stem), 1.25 mg/L (roots) and 1.21 mg/L (leaf).The trend of heavy metal uptake in the different parts of the plant are root > leaf > stem and the uptake of the entire metals uptake is evident across all the plant parts samples as Fe > Mn > Cu > Zn > Ni. The results obtained in Figures 1–3, emphasizes on the variability in metal uptake by different plant parts revealedFe to have the highest metal uptake concentration in the roots, stem and leaf suggesting its preferential accumulation there. Conversely, the lower concentrations of Ni across all plant parts reflect the limited uptake or accumulation capacity of this metal by *P. crassipes*. There is a common trend of heavy metal uptake in each part of the plant revealed that the root > leaf > stem and the concentration of each metal (Fe, Mn, Cu, Zn and Ni) in each part revealed the same trend [22];[23]; [24].

IV. Conclusion

This study confirms the presence of heavy metals: iron (Fe), manganese (Mn), copper (Cu), zinc (Zn), and nickel (Ni) in the parts of the water hyacinth (*Pontederia crassipes*) plant, with iron being the most abundant metal across all plant parts. While iron plays essential biological roles, including its involvement in hemoglobin synthesis and hormone production, excessive accumulation poses significant health risks, such as liver and heart disease. These findings underscore the potential of *P. crassipes* as a bioindicator for heavy metal contamination and highlight the necessity of monitoring and managing iron levels in aquatic ecosystems to mitigate associated health and environmental impacts.

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