ASSESMENT OF HEAVY METALS IN THE SHOOTS AND ROOTS OF AQUATIC PLANTS AT OWENA RESERVIOR, ONDO STATE

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ABSTRACT
The balancing and functionality of aquatic ecosystems have shown to depend largely on various aquatic plants. Thus, this study seeks to assess the physico-chemical parameters of water, some heavy metals (Cd, Cu, Fe, Mn, Pb and Zn) in the root and shoot of some aquatic plants in Owena Reservoir so as to provide a baseline information on the pollution status of the aquatic plants in the reservoir. The samples were analyzed using standard methods. The result revealed the physico-chemical properties of water and heavy metals concentration in the aquatic plants to be within the recommended limit. However, there was significant difference (P<0.05) across the period, aquatic plants and parts. The order of bioaccumulation was; Ceratophyllum demersum > Saciolepis africana > Pistia stratiotes. Also, the metal accumulation followed the trend; Cd < Pb < Mn < Cu < Zn < Fe. The result of the study indicate that the study area and species was not polluted and conducive for optimum growth of aquatic organisms. However, proper monitoring of the aquatic environment is hereby recommended so as to avoid potential contamination and destruction of the aquatic flora and fauna.

Key words: *contamination, ecology, organisms, flora, fauna.*

INTRODUCTION

The contamination of the aquatic ecosystems with heavy metals has become a global menace with adverse effects on the aquatic flora and fauna. These metals (cadmium, chromium, copper, mercury, lead, nickel, zinc etc) are introduced into aquatic systems through extensive anthropogenic practices (automobile exhaust, discharge of wastewater and domestic effluents), agricultural activities (application of insecticides, soil erosion and run off), industrial activities (oil spills, mining, dredging, crude oil exploration etc), weathering of rocks and leaching, formation of ores (Jain, 2004).

Heavy metals bio-concentrate and bio-magnified along the food chain in the aquatic environment and accumulates in different ways being controlled by various mechanisms (Olawusi-Peters and Akinola, 2017). Heavy metals are also considered as trace elements because of their presence in trace concentrations (ppb range to less than 10ppm) in various environmental media (Kabata, 2001). However, when present at high concentrations, they impose severe damage to the physiological, biochemical and structural systems of aquatic plants and animals (Olawusi-Peters *et al.*, 2017).

Aquatic plants have often been considered as sinks for heavy metals in the aquatic environment (Xing *et al.*, 2013). Although, they play an important role in aquatic systems as they provide food and habitat to aquatic organisms, stabilize the sediments, improve water clarity and add diversity to the shallow areas of the water bodies, their ecological position in the niche enables them to absorb and bio-accumulate variable amount of different heavy metals pollutants. They also serve as an enriched source of food for pelagic organisms as they are in constant flux with the surface water column, and are important component of aquatic communities due to their roles in oxygen production, nutrient cycling, water quality control, habitat provision and shelter for aquatic life (Vardanyan and Ingole, 2006).

These plants reflect the toxicity of the water environment, and thus serve as a tool for the bio monitoring of contaminated waters (Cardwell *et al*., 2002). Ndimele and Jimoh, (2011) reported that heavy metals exceeding the carrying capacity of waters has caused many problems with regards to aquatic ecosystem balance. Aquatic plants can uptake large amounts of metals from water and/or sediment through active and passive absorption through different organs such as roots, stems, and leaves, making these plants suitable for heavy metal alterations in the aquatic environment (Harguinteguy *et al.,* 2014 and Cai *et al.,* 2018). Therefore, this study seeks to assess heavy metals (Cd, Cu, Fe, Mn, Pb and Zn) in the roots and shoots of widely distributed aquatic plants *Saciolepis africana*, *Ceratophyllum demersum* and *Pistia stratiotes* from Owena reservoir in Ondo state, Nigeria.

Study area

The study was carried out in Owena reservoir which is located across Owena River in Ifedore Local Government Area of Ondo-State (Figure 1). The reservoir is located at geographical coordinate between latitude 7° 15`north, longitude $5^0$ 5` east while the river is located at latitude 7^0 4` north, longitude $4^0$ 47` east in Western Nigeria (Fapohunda *et al*., 2007). The reservoir is about 300m long and 9m deep, with the capacity of approximately 600,000 m^3. It was primarily constructed as a source water supply and for anthropogenic and agricultural activities for the people. Some forest trees and wild grasses are the vegetation around the reservoir.

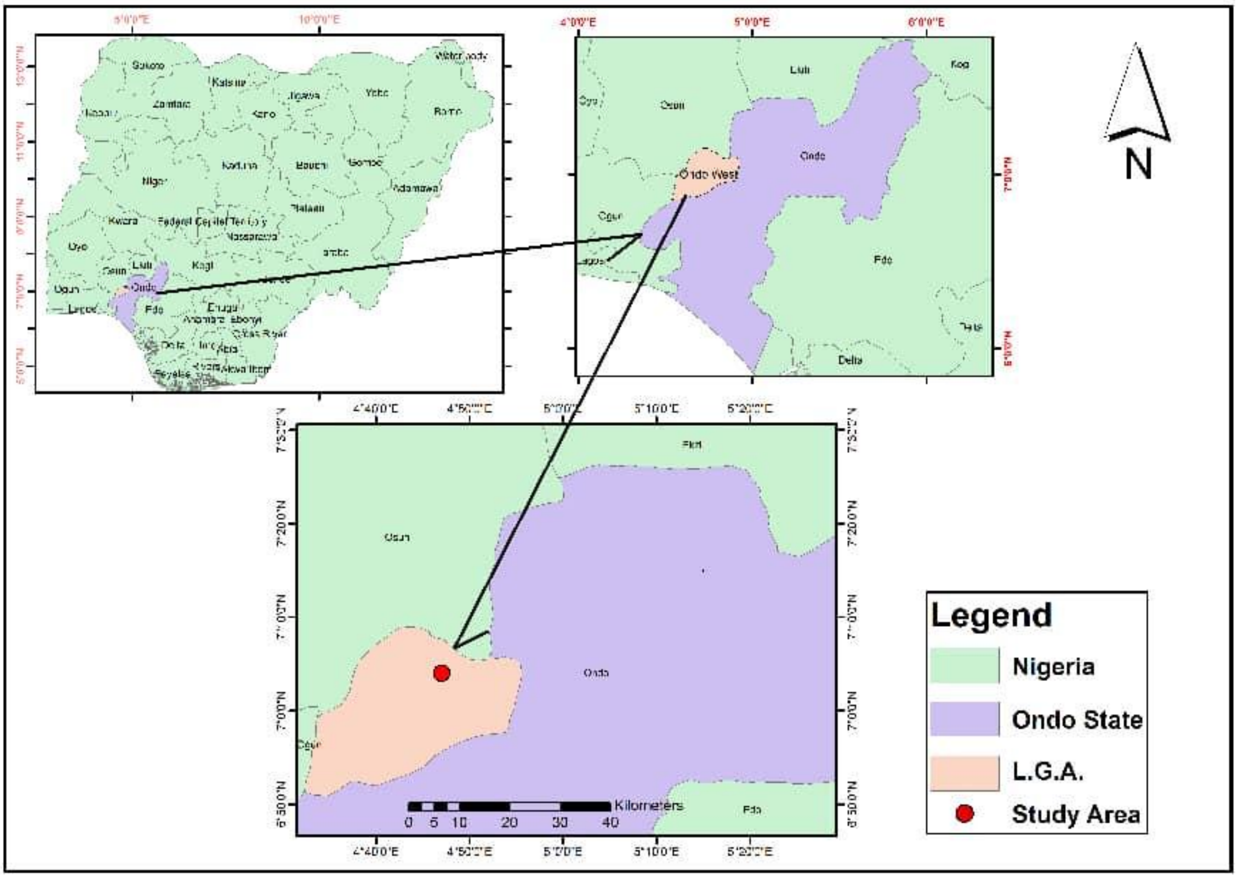

Figure 1: Map showing the study area

MATERIALS AND METHODS

Collection and Identification of samples

The samples (water and plants) were collected from the study area on monthly schedules between 8:00am to 10:00am from May to September 2017. Water samples were collected in triplicate at sub-surface level, using 250 ml sampling bottles, while the plants were collected from the root and then washed with deionized water and placed in polyethylene bags. The samples, were immediately transported to the laboratory and preserved at 4^{o}C for preliminary studies. The aquatic plants were identified to species levels and certified by taxonomists at Department of Crop, Soil and Pest Management, Federal University of Technology, Akure.

Determination of physico-chemical properties of water

Temperature: This was measured in degree Celsius (^{o}C) in-situ using mercury in glass thermometer.

Power of Hydrogen (pH): This was determined via Electrometric Method (Method No: 4500-H+B) using Hanna multi probe meter United Kingdom. The meter was calibrated using pH 4.0, 7.0 and 10.0 buffer solution. Sample pH was measured by inserting the probe in the sample and taking the corresponding readings on the digital meter.

Electrical Conductivity: EC was determined via Electrometric Method (Method No: -2510 B) using Hanna multi probe meter United Kingdom. The meter was calibrated using three-point calibration standards (1413, 12880 and 80000 µS/cm). Sample EC was measured by inserting the probe in the sample and taking the corresponding readings on the digital meter in (µS/cm).

Dissolved Oxygen (DO): DO (mg/l) was determined using Azide Modification (APHA, 1995). 200ml of samples was treated with 1ml Manganous sulphate and 1ml Alkali-Iodide solution, 1 ml sulphuric acid before titrating against 0.025 M Sodium thiosulphate using starch indicator.

Turbidity: Turbidity was measured using a spectro-photometer (HACH model DR/2010) using distilled water as a blank and read at a wavelength 860 nm.

Digestion of plant samples and determination of Heavy metals: Digestion process of plant samples was done according to AOAC, (1990). The root and shoot of the plants were oven dried at 90^{o}C for 48 hours and the ash contents were determined by heating at 550 °C for 1 hour. HCl and HNO_3 were used to digest the ashed samples.1g of dry matter was weighed into a 50 ml beaker. 10 ml mixture of H_2SO_4, $HClO_4$ and HNO_3 was then added to the dry matter. This process was done at a temperature of 90 °C until 4ml of the mixture was left in the beaker, and 10 ml of the mixture of acids was then added. The heavy metal concentrations in the plant organs were then determined using the Atomic Absorption spectrometer. Calibration solutions were prepared with 10 mg/l mix element standard stock solution (AccuTrace MES-21-1).

Data Analysis: The data obtained were subjected to multivariate analysis of variance to compare the species (P=0.05) and T. test to compare the concentration in the shoot and root (P=0.05), using Statistical Package for Social Sciences (SPSS) version 16.0.

RESULTS

Physico-chemical properties of water

The result of the physicochemical properties of water samples obtained in the study area is presented in Table 1. The physico-chemical parameters of water were significantly different ($p > 0.05$) across the sampling period. Water temperature varied from 27.00 to 28.65 °C with the highest value recorded in June and lowest in April. Turbidity ranged from 5.70 - 8.49 NTU, with lower values (5.70, 5.91 and 5.75) observed in May, June and July respectively and higher values (8.49, 8.77, 8.65) observed in July, August and September respectively. The electrical conductivity observed in the study ranged between 100.40 -103.00 µS cm^{-1} with the highest value recorded in May and lowest value in September. DO and pH ranged between (6.65 – 7.38 mg/l) and (6.20 – 6.83) respectively.

Table 1 - Physiochemical parameters of Owena reservoir

	April	May	June	July	August	September
Temperature (°C)	28.00±0.20^{a}	27.00±1.00^{a}	28.65±0.55^{a}	28.15±0.05^{a}	27.05±0.01^{a}	27.75±0.85^{a}
Turbidity (NTU)	5.70±0.12^{a}	5.91±0.04^{a}	5.75±0.05^{a}	8.49±0.16^{b}	8.77±0.20^{b}	8.65±0.15^{b}
Conductivity (µS cm^{-1})	102.30±0.10^{a}	103.00±0.40^{ab}	101.90±0.20^{b}	101.70±1.50^{b}	101.70±0.90^{b}	100.40±0.20^{bc}
DO (mgl^{-1})	6.65±0.02^{a}	6.71±0.11^{a}	6.60±0.10^{a}	7.01±0.01^{b}	7.38±0.03^{b}	7.36±0.08^{b}
pH	6.20±0.10^{a}	6.27±0.07^{a}	6.73±0.02^{a}	6.83±0.06^{a}	6.83±0.06^{a}	6.87±0.01^{a}

Heavy metal concentration in shoot and root of some aquatic plants

The mean concentration of heavy metals in the shoot and root of different plants species is presented in Table 2. The metals analyzed were significantly different across the parts and were below the WHO, (2015) permissible limit for aquatic plants in inland waters. The highest Cd (0.005±0.001) was found in the shoot of *Ceratophyllum demersum* while the lowest (0.002±0.001) was found in the root of *Pistia stratiotes.* Mn and Cu was highest in the root of *Ceratophyllum demersum* and lowest in the root of *Pistia stratiotes.* Pb was highest (0.108±0.148) and lowest (0.016±0.008) in the shoot and root of *Saciolepis africana* respectively. Fe and Zn concentration were highest in the root of *Ceratophyllum demersum.*

Table 2 -Mean concentration of heavy metals in shoot and root of plants species

	Saciolepis Africana		***Ceratophyllum demersum***		***Pistia stratiotes***		**WHO**
Metals	**Shoot**	**Root**	**Shoot**	**Root**	**Shoot**	**Root**	**(1996)**
Cd	0.004±0.001^{a}	0.003±0.0004^{b}	0.005±0.001^{a}	0.004±0.003^{b}	0.004±0.004^{a}	0.002±0.001^{b}	0.02
Mn	0.299±0.098^{a}	0.273±0.074^{ab}	0.263±0.143^{a}	0.399±0.216^{b}	0.215±0.222^{a}	0.205±0.061^{ab}	0.50
Cu	0.339±0.092^{a}	0.379±0.042^{ab}	0.389±0.010^{a}	0.445±0.042^{b}	0.298±0.284^{a}	0.293±0.034^{ab}	10.00
Pb	0.108±0.148^{a}	0.016±0.008^{b}	0.041±0.008^{a}	0.058±0.015^{ab}	0.038±0.037^{a}	0.071±0.019^{b}	2.00
Fe	0.890±0.608^{a}	0.787±0.818^{b}	1.820±1.037^{a}	2.025±1.488^{b}	1.267±1.522^{a}	0.546±0.295^{b}	20.00
Zn	0.2403±0.055^{a}	0.439±0.185^{b}	0.512±0.033^{a}	0.725±0.325^{b}	0.352±0.343^{a}	0.418±0.230^{b}	5.00

The trend of metal accumulation in the studied samples shows *C. demersum* > *S. africana* > *P. stratiotes* (Fig. 2 – Fig. 3). The metal accumulation also followed an increasing order Cd < Pb < Mn < Cu < Zn < Fe.

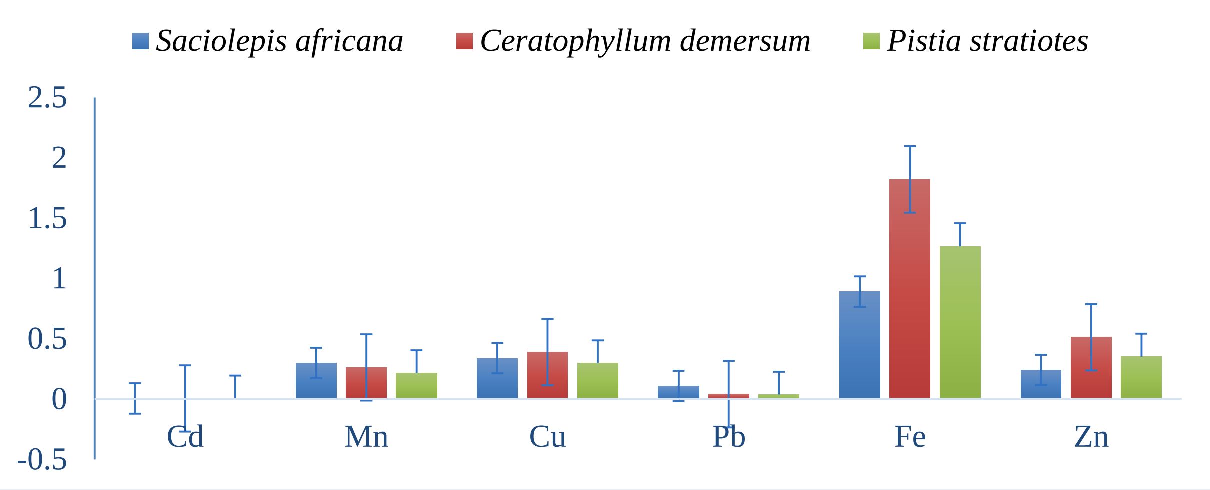

Figure 2: Heavy metals concentration in the shoot of some aquatic plants

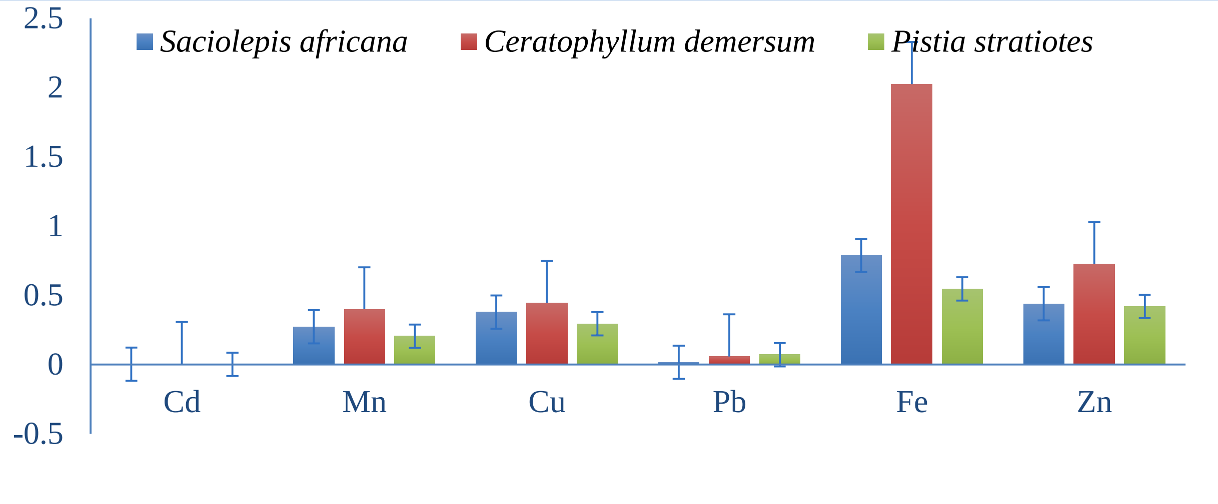

Figure 2: Heavy metals concentration in the root of some aquatic plants

Correlation of water quality parameters with heavy metal in root and shoot of plants species

The relationship between the physico-chemical properties of water and the heavy metal concentration in the root and shoot of the sampled aquatic plants showed positive and negative correlation with the metals both in the root and shoot of the aquatic species. Electrical conductivity was the most negatively correlated parameters with all the metals in the root and shoot when compared with the other parameters.

Table 3: Correlation of water quality parameters with heavy metal in root and shoot of plants species

	Metals	*Saciolepis africana*		*Ceratophyllum demersum*		*Pistia stratiotes*	
		Root	**Shoot**	**Root**	**Shoot**	**Root**	**Shoot**
Temperature (°C)	Cd	-0.0006	0.1498	0.2192	0.2732	0.7048	-0.0635
	Mn	0.7547	0.2474	0.422	-0.1509	0.2439	0.1241
	Cu	0.3737	0.7851	-0.4488	0.0746	0.1080	0.4311
	Pb	-0.1228	0.2992	0.1845	-0.5389	0.1929	0.4438
	Fe	0.5497	0.2909	0.3678	-0.9485	0.0968	-0.1698
	Zn	0.2254	0.4343	0.4856	0.1051	-0.5919	-06506
Turbidity (NTU)	Cd	0.1547	0.0881	0.2839	0.4019	-0.4183	0.1527
	Mn	0.1859	0.3172	-0.1571	-0.6765	0.5425	0.0292
	Cu	-0.2730	0.3780	0.7561	0.4568	0.0458	0.1796
	Pb	0.5571	0.5637	0.6283	0.6888	-0.4476	-0.1973
	Fe	-0.0594	0.6245	0.2030	0.3945	-0.2674	0.1500
	Zn	-0.1349	0.1540	0.0944	0.7581	0.0290	0.6882
Electrical Conductivity	Cd	-0.5447	-0.2172	-0.5771	-0.3926	0.0307	0.0271
	Mn	-0.6828	-0.7389	-0.3146	0.4388	-0.6923	0.0529
	Cu	0.3788	-0.6972	-0.2039	-0.6729	-0.1083	-0.2815

(µS cm^{-1})	Pb	-0.0884	-0.9585	-0.7193	-0.1588	0.1026	-0.1001
	Fe	-0.3017	-0.8732	-0.6561	0.2145	0.2461	0.1736
	Zn	0.0444	-0.5548	-0.3042	-0.8477	0.3422	-0.4569
Dissolved oxygen (mg/l)	Cd	0.3471	0.0196	0.3961	0.2653	-0.5149	0.0804
	Mn	0.1240	0.3889	-0.0556	-0.4427	0.4989	-0.0797
	Cu	-0.5030	0.1826	0.7349	0.5707	-0.0096	0.0697
	Pb	0.3769	0.5799	0.6140	0.6467	-0.3180	-0.2082
	Fe	-0.1512	0.6275	0.2427	0.5118	-0.2254	-0.0164
	Zn	-0.1584	0.0868	0.0490	0.7234	0.0349	0.8271
pH	Cd	0.1843	-0.0023	0.4102	0.2774	-0.4687	0.2544
	Mn	0.2502	0.3441	0.0201	-0.6593	0.4907	0.1373
	Cu	-0.4350	0.4573	0.7079	0.4731	-0.0841	0.3099
	Pb	0.3641	0.6684	0.7624	0.6883	-0.4821	-0.0291
	Fe	-0.1189	0.6476	0.2134	0.3443	-0.3732	0.0843
	Zn	-0.2665	0.1649	0.2126	0.7485	-0.0141	0.6615

DISCUSSION

Physico-chemical properties of water

The physico-chemical parameters of water were significantly different ($p>0.05$) across the sampling period. Water temperature falls within the FEPA, (1991) guideline range of 15-35 ºC for optimum growth, productivity, survival of freshwater ecosystems and distribution of the flora and fauna (Singh and Mathur, 2005). However, the seasonal changes in the parameters could pose a significant and uneven influence on the general metabolism and growth performance of aquatic organisms in the ecosystem. Turbidity values were higher than the WHO, (1984) permissible limit (5 NTU) for inland waters. Increase in turbidity could be attributed to heavy soil erosion and suspended solids from domestic seawage which deteriorate the quality of the water surface and harm aquatic life. These also could minimize the filter runs which allows pathogens to be more hazardous to aquatic life (Gupta *et al.,* 2017). The electrical conductivity observed in the study which could be adduced to water run offs (carrying and depositing a lot of decomposed organic matter), effluents discharge and high level of dissolved ions in the area. The DO concentrations were higher than the standard limit (4mg/l) for freshwater ecosystem, indicating a degree of pollution of the water media (WH0, 1984). This could be attributed to the large amount/ quantity of aquatic plants in the aquatic ecosystem, since submerged plants produce oxygen through photosynthesis. The water pH was also slightly acidic all through the period of study and could be as a result of sewage discharge, acid runoff, fossil fuel combustion from automobiles, and human-mediated activities in and around the study area. The result of this study shows the significant effect of variation in water quality on the biological productivity and quality of the ecosystem. This was in consonance with the report of Ayo and Arotupin, (2017) who worked on the microbial and physicochemical qualities of river Owena and observed similar parameters and adduced it to the pollutants from various human-mediated activities in the area.

Heavy metals concentration in the shoot and root of some aquatic plants

The lead adsorption capacity of *Ceratophyllum demersum*, *Saciolepis africana* and *Pistia stratiotes* were compared revealed that *C. demersum* had better adsorption capacity than the other plants. This suggest the potential of *C. demersum* to take up and accumulate the most. The result of this study was at variance with the report of Mohammad *et al.,* (2014) who worked on the rhizofiltration of heavy metals from eutrophic water using *Pistia stratiotes* in a controlled environment, and observed higher accumulation of *Pistia stratiotes* with heavy metals when compared to other conventional plants, stating it to be an excellent indicator of the pollution status of an environment with heavy metals. Different accumulation abilities of species have shown to depend on individual aquatic plants, groups and locations (Cardwell *et al.,* 2002), thus accounting for the higher accumulation in the other aquatic plants studied. The absorption and hyper accumulation of metals in harvestable root and shoot tissue from the growth substrate through phytoextraction process underlines the dominance of metal contaminants. Furthermore, there was little or no variation in the metal accumulation across the parts, thus signifying uniformity in the mode of bioaccumulation.

The observed increase in the concentration of Mn and Fe when compared with other metals could adduced to the disposal of industrial effluents as well as inflows from other rivers. This may result in nutrient imbalances of various plants, thus reducing the availability of rich nutrient for aquatic species that feeds on them in the ecosystem. The low levels of heavy metals concentration observed in the studied aquatic plants when compared with the recommended limit apparently indicates no pollution of the aquatic biotopes. This could be linked to the low level of anthropogenic and agricultural activities in the area and high metal removal rate of aquatic plants as they are used for the remediation of wastewater having high concentration of metals (Kao *et al.,* 2001). However, this may pose a potential threat to the aquatic environment and species if left unchecked.

The correlation analysis revealed the relationship and influence the physico-chemical properties of water had on the accumulation of metals by the aquatic plants. The analysis shows a positive relationship mostly, thus supporting that the aquatic environment is not polluted and conducive for the growth and survival of various aquatic organisms. However, effective measures and constant monitoring of the environment is hereby recommended for safeguard the aquatic lives and system from degradation and pollution.

CONCLUSION

The concentration of the heavy metals in the examined aquatic plants were generally below the permissible limit of WHO, (2015). It was observed that *Ceratophyllum demersum* bio accumulated the metals most when compared with the other species. There was also no significant difference in the metal accumulation across different parts. Hence, human-mediated activities in the study area should be monitored and regulated to the barest minimum to ensure maximum productivity of the water body and improve fish yield.

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