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Assessment of metals in sediments and Typha latifolia of Zobe Reservoir, Nigeria

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Abstract
This study evaluated the concentration of selected metals and their relationship in sediment and *Typha latifolia* from Zobe reservoir, Dutsinma, Nigeria. In the three-month study, the metals were assessed in samples of sediments and *T. latifolia* collected fortnightly from three sampling locations sited up-, mid- and downstream. Although lead was not detected in the sediments and *T. latifolia* samples, other metals were detected at relatively very low concentrations while iron had the highest concentration. The role of sediment as a sink for metals was evident in the relatively higher metal contents observed in the sediment samples. Significant correlative relationship between zinc and other metals in the sediments can be attributed to the sediment's role as metal reservoir while the positive correlation among the metals in *T. latifolia* could have resulted from the metals' roles as micronutrients. Significantly positive correlation between copper contents in sediments and *T. latifolia* samples can be attributed to the storage of the metals which is common to both sample types. With this, Zobe reservoir can be regarded as free from iron, copper, zinc and lead pollution. Continuous efforts to discourage waste disposal in the water body and its channels are important to preserve the reservoir.

Keywords
Bioaccumulation; aquatic macrophytes; Food safety; pollution; Zobe reservoir

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Contents

1. Introduction

The role of modern agricultural practices, urbanization and industrialization in releasing different waste types into land and aquatic environments has been highlighted in several studies. The rate of environmental pollution has been on the rise, which has led to an upsurge in the occurrence of different pollutants in these environments (Oladele et al., 2018). Incidence of pollution has been reported in most developed and developing countries, hence, environmental pollution has become a matter of global concern (Kennish, 2017; Abdelaal et al., 2021). Aquatic environments have become adversely affected by pollution, which has raised the low concentrations of naturally occurring chemicals to unimaginable levels as well as introduced new pollutants into some water bodies (Iji et al., 2014). Anthropogenic activities have been affirmed as a major contributor to the pollution of many freshwater ecosystems (Islam et al., 2014; Jenyo-Oni and Oladele, 2016; Oladele et al., 2018).

Metals, being a constituent of many industrial, agricultural and domestic wastes, have become an object of research over several decades due to their persistence in aquatic ecosystems and the highly toxic values they possess (Gheoghe et al., 2017). The adverse effects of metal accumulation on man, which include diseases of the brain, lungs, heart, kidney, liver, bones, and spinal cord among others, have been established in the literature while several studies are still ongoing to discover more hazardous impacts of this pollutant. The damaging impact of metals is not limited to man, studies have affirmed that high levels of metal accumulation in aquatic environments also compromise the health and stability of aquatic ecosystems and their biota (Bahobil et al., 2017; Omitoyin, 2018; Ajani, 2019). Among the biological components of freshwater ecosystems, aquatic macrophytes have displayed considerable capacities to accumulate metals (Núñez, et al., 2011; Bello et al., 2018; Eid et al., 2020). Due to this feature, they are being used for cleansing purposes and restoration of polluted water bodies, a process called phytoremediation. Aquatic macrophytes do assimilate and store pollutants in their tissues, as well as catalyse biochemical and chemical reactions around the rhizosphere which aids water purification (Jenssen et al., 1993; Jha et al., 2016). As a result of these and other features, these aquatic plants have been used as biological indicators to determine the pollution status of many aquatic environments. Besides the remediating function of aquatic macrophytes and their role as bioindicators, they are one of the transfer links for metals between the aquatic environment and man. Hence, the need to examine the metal contents of aquatic macrophytes, especially those that are utilized by man as food or medicinal products. *Typha latifolia* is one of such aquatic macrophytes.

Typha latifolia is a freshwater aquatic macrophyte utilised medicinally for its therapeutic functions (Channa et al., 2019). The medicinal properties of the plant are used in Northern Nigeria for the treatment of skin diseases, healing of sores and boils, cleaning of injury scars, and prevention of anaemia among others. Besides its medicinal value, the plant is used by livestock farmers as a forage crop for feeding ruminant animals such as cattle, goat and sheep. The usage of this aquatic macrophyte for the above highlighted and other uses has made the evaluation of its metal content pertinent.

Zobe reservoir is one of the freshwater reservoirs in Katsina State, North-western Nigeria. It was built primarily for the provision of potable water to Dutsinma town and surrounding communities. The water body has diverse socio-economic uses ranging from meeting the domestic need for potable water supply to providing water for crop irrigation, and livestock farming as well as supporting the livelihood of fishermen who fish the water (Gambo, 2019). The occurrence of domestic activities as well as the practice of crop and livestock farming within the vicinity of the water body, in addition to the likely deposition of domestic and agricultural wastes along the water channel, informed the choice of the metals assessed in this study. Since the evaluation of metal contents in sediments of a water body reveals the condition of the waterbody over an extended period (Singovszka et al., 2017; Duncan et al., 2018), assessment of metal content in sediments and T. latifolia, one of the widespread aquatic macrophytes in Zobe reservoir, will provide an insight to the pollution state of the reservoir for effective management. This will also help to determine the safety of the plant for human use. Therefore, the objective of this study was to evaluate the iron, copper, zinc and lead concentration in sediment and Typha latifolia from Zobe reservoir. The study also examined the relationship among these metals in the two sample types.

2. Materials and method

2.1 Study area

This study was conducted Zobe reservoir, a freshwater reservoir with "latitude 12°22'16"N and longitude 7°28'59"E", and located in Dutsin-Ma local government area of Katsina State, Nigeria. The reservoir has a water storage capacity of up 177 x 10^6 m^3 and covers a land area of about 4,500 hectares of land (Atalabi et al., 2018). The reservoir has two major tributaries namely Rivers Karaduwa and Gada, and is surrounded by rural communities whose major occupations are crop and livestock farming, and fishing.

2.2 Sample collection

Samples of sediments and *T. latifolia* were collected at two weeks interval over three months (April to July, 2021) from three sampling locations situated along the course of the water body. A sampling location was sited at the upstream, midstream and downstream sections of the water body, and was labelled with the name of the community or landmark closest to the sampling location. The up-, mid- and downstream sampling locations were named Garhi, Makera and Damgate, respectively.

Samples of sediment and *T. latifolia* were collected on sampling days between 6.30 and 9.30 hours using standard methods. A Van Veen grab was used for sediment sample collection from each sampling location while careful uproot of whole plant were carried out during *T. latifolia* collection. From each of the three sampling locations, three (3) subsamples were collected from different sampling points for each sample type and were made into a composite so as to ensure representative sampling per location. Labelled polyethylene bags, which were pretreated with 5% nitric acid and rinsed with distilled water, were used to transport sediment samples collected from each of the locations (Achionye-Nzeh and Isimaikaiye, 2010, Oladele et al., 2019) while the plant samples were thoroughly rinsed of sediment and other particulate materials with distilled water before being transported in labelled polyethylene bags to the laboratory.

2.3 Sample preparation and analysis

The sediment and plant samples were air-dried under room temperature, ground and sieved with 2mm mesh-sized sieve in preparation for sample digestion and metal content determination. Digestion of samples was done using the methods of Abou El-Anwar (2019), while atomic absorption spectrophotometer was used for determination of iron, copper, zinc and lead contents of each of the samples. Data obtained were analysed using SPSS statistical package, the mean concentration of each of the metals was presented with mean and standard deviation, while analysis of variance (ANOVA) and correlation were used to test the differences in mean concentration and determine the relationships which exist among the metals, respectively.

3. Results

The concentration of metals in samples of sediment and T. latifolia obtained from Zobe reservoir are presented in Tables 1 and 2, respectively. Besides the varying content of each metal among the locations, lead was not detected in either of the sediment or plant samples. Also, the tables show that the sediment samples had higher iron and copper contents, while zinc was of lower concentration.

Table 1. Metal concentration (mg/kg) in sediment samples

Location	Iron	Copper	Zinc	Lead
Garhi	5.408±0.798b	0.223±0.023b	0.117±0.012c	ND
Makera	4.478±1.422b	0.328±0.072a	0.237±0.126b	ND
Damgate	7.312±1.315a	0.372±0.031a	0.362±0.063a	ND
	5.733±1.662	0.308±0.078	0.283±0.129	-

ND: Not detected

Table 2. Metal concentration (mg/kg) in T. latifolia samples

Location	Iron	Copper	Zinc	Lead
Garhi	3.993±0.687a	0.247±0.012b	0.368±0.121a	ND
Makera	4.615±1.191a	0.302±0.016a	0.407±0.142a	ND
Damgate	3.353±1.539a	0.268±0.023b	0.403±0.198a	ND
	3.987±1.239	0.272±0.029	0.393±0.149	-

ND: Not detected

Table 1 reveals that the Damgate section of the reservoir had higher contents of iron (7.312±1.315 mg/kg), copper (0.372±0.031 mg/kg), and zinc (0.362 mg/kg) than the other locations. In fact, iron and zinc concentrations were significantly ($P < 0.05$) higher at the Damgate location whereas copper was detected at significantly ($P < 0.05$) lower levels at the Garhi end of the reservoir.

Furthermore, the metal content in the plant samples, presented in Table 2 shows that Makera had higher concentrations of all the metals. Although the iron and zinc concentrations were not significantly different among the three locations, the copper content in Makera (0.302±0.016 mg/kg) was significantly ($P < 0.05$) higher than those of Garhi (0.247±0.012 mg/kg) and Damgate (0.268±0.023 mg/kg) locations. The relationship between the metals in sediment and plant samples is presented in Tables 3 and 4, respectively. In these tables, each metal content was represented with the metal's chemical symbol (Fe, Cu and Zn) attached with the suffix -SD and -TL, respectively, for sediment and T. latifolia samples. It is noteworthy that the computation of the correlation coefficient of the relationship between lead and other metals could not be done due to non-detection of lead in both sample types.

Table 3 reveals that the relationship among the metals in the sediment samples was all positive while the relationship between zinc and other metals (0.520 and

Table 3. Correlation coefficients of metals in sediment samples

Specification		Fe-SD	Cu-SD	Zn-SD
Fe-SD	Pearson correlation	1	-	-
	Sig. (2-tailed)	-	-	-
Cu-SD	Pearson correlation	0.352	1	-
	Sig. (2-tailed)	0.152	-	-
Zn-SD	Pearson correlation	0.520*	0.558*	1
	Sig. (2-tailed)	0.027	0.016	-

*Correlation is significant at the 0.05 level (2-tailed).

Table 4. Correlation coefficients of metals in T. latifolia samples

Specification		Fe-TL	Cu-TL	Zn-TL
Fe-TL	Pearson correlation	1	-	-
	Sig. (2-tailed)	-	-	-
Cu-TL	Pearson correlation	0.074	1	-
	Sig. (2-tailed)	0.77	-	-
Zn-TL	Pearson correlation	0.303	0.144	1
	Sig. (2-tailed)	0.222	0.569	-

0.558) was significant at a 5% confidence level. Similarly, the relationship among the metals in the plant samples was all positively correlated (Table 4). Furthermore, Tables 5, 6 and 7 show the correlation coefficients of iron, copper and zinc, respectively, between the sediments and T. latifolia samples. As revealed in the tables, the iron contents in the sediment and plant samples were negatively correlated (-0.130) (Table 5), copper contents had a significantly positive correlation (0.481) at 5% confidence level (Table 6) while zinc had a 0.028 correlation coefficient between the two sample types (Table 7).

Table 5. Correlation coefficients of iron in samples of sediments and T. latifolia from Zobe reservoir

Specification		Fe-TL	Fe-SD
Fe-TL	Pearson correlation	1	-
	Sig. (2-tailed)	-	-
Fe-SD	Pearson correlation	-0.13	1
	Sig. (2-tailed)	0.608	-

Table 6. Correlation coefficients of copper in samples of sediment and T. latifolia from Zobe reservoir

Specification		Cu-TL	Cu-SD
Cu-TL	Pearson correlation	1	-
	Sig. (2-tailed)	-	-
Cu-SD	Pearson correlation	0.481*	1
	Sig. (2-tailed)	0.043	-

*Correlation is significant at the 0.05 level (2-tailed).

Table 7. Correlation coefficients of zinc in samples of sediment and T. latifolia from Zobe reservoir

Specification		Zn-TL	Zn-SD
Zn-TL	Pearson correlation	1	-
	Sig. (2-tailed)	-	-
Zn-SD	Pearson correlation	0.028	1
	Sig. (2-tailed)	0.911	-

4. Discussion

Non-detection of lead in sediment and plant samples from all the sampling locations shows that the reservoir is free of lead pollution. This may be attributed to relatively little or no entry of lead-containing wastes into the water body. Several studies, such as Islam et al. (2014), Oyebode (2015) as well as Jenyo-Oni and Oladele (2016) among others, have affirmed that human activities and waste deposition in aquatic environments are principal sources of metals and other pollutants in water bodies. Also, the detection of iron, copper and zinc in the sediment samples could have resulted from inflow of materials and/or wastes that contained these metals. However, relatively low concentrations of these metals may have indicated that the water body has received low levels of these metals over an extended period. Furthermore, quite low concentrations of copper and zinc, less than 0.5mg/kg, are similar to the findings of Jenyo-Oni and Oladele (2016) which reported less than 0.5mg/kg for metals such as lead, zinc, cobalt, chromium and cadmium in sediment samples from Lake Asejire, a freshwater Lake in Southwestern Nigeria.

The ferruginous characteristics of Nigerian soils (Olowu et al., 2010) may have been responsible for the higher concentration of iron in the sediment samples, when compared with other metals. Significantly lower metal contents recorded at Garhi pointed to the fact that domestic activities as well as crop and livestock farming within the vicinity of Makera and Damgate may have played important roles in slightly higher metal contents observed in these locations. A higher concentration of metals in the sediment samples, than what was observed in the plant samples, corroborates the fact that aquatic sediments serve as a sink for metals and other pollutants in water bodies (Lundy et al., 2017; Oladele et al., 2019).

The detection of iron, copper and zinc in *T. latifolia* samples, although at relatively low levels, may be attributed to their importance as trace nutrients required by the plant for various life processes. This is supported by the submission of Uchida (2000) which affirmed the role of these metals as essential elements required in minute quantities. Higher metal content in *T. latifolia* samples from Makera corroborates the submission that domestic activities as well as crop and livestock farming activities around Makera location play contributory roles to adding these metals to the water body. For usage as a medicinal plant, when compared with the recommended standards as reported by Adefarati et al. (2017), *T. latifolia* is safe for use, since the metal content of the plant is well below the recommended levels (Table 8) except for iron. The importance of iron an essential nutrient required for plant growth may have led to the concentration detected in the plant samples (Uchida, 2000).

Table 8. Comparison of metal contents (mg/kg) in *T. latifolia* samples with local and international standards

	Iron	Copper	Zinc	Lead
This study	3.987±1.239	0.272±0.029	0.393±0.149	-
*NAFDAC	3	40	50	2
*WHO/FAO	3	73	100	0.3

*NAFDAC and WHO/FAO maximum allowable limits.

The significantly positive association between zinc and other metals in the sediment samples may be attributed to the storage of zinc, among other metals, in aquatic sediments (Abou El-Anwar, 2019). The positive correlative relationship among the metals in *T. latifolia* samples could have resulted from their importance as mineral nutrients required for plant growth (Uchida, 2000). The negative correlation value between iron contents in sediment and T. latifolia samples may have pointed to the absorption and utilization of the metal in T. latifolia for biochemical reactions as against storage which only takes place in the sediment. The significantly positive correlative association observed between copper contents in sediment and *T. latifolia* samples may be attributed to the storage of the metal which is common to both sample types. Besides utilization, *T. latifolia* have the capacity to accumulate copper and other metals in its tissues (Jha et al., 2016), while sediment's role as a metal reservoir has been documented (Singovszka et al., 2017). Likewise, storage of zinc in both sediment and *T. latifolia* may have accounted for the positive correlation between the zinc content in both sample types.

5. Conclusion

Metal contents observed in sediments and Typha latifolia of Zobe reservoir are quite low. This is exemplified by non-detection of lead and relatively low levels of other metals in both sample types. The importance of underlying soil minerals was displayed in higher iron concentrations observed in the sediment samples while the essentiality of iron as a nutrient element accounted for a higher concentration of iron in the plant samples. Therefore, the water body can be referred to as free from iron, copper, zinc and lead pollution. Detection of iron, copper and zinc in both sample types affirmed their importance as biological indicators. Although the metals were detected at relatively low levels, their detection calls for adequate monitoring of the activities of communities surrounding the water body. Also, continuous efforts to discourage the disposal of wastes along the water channel should be carried out and sustained in order to preserve the water body from pollution. Further studies on the use of other biological indicators are recommended to buttress the pollution status of the reservoir.

6. Conflict of interest

The authors wish to express that there is no conflict of interest in the conduct of the research, data processing and manuscript preparation.

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