Frontiers in Health Informatics
ISSN-Online: 2676-7104
www.healthinformaticsjournal.com
2024; Vol 13: Issue 8
Open Access

Phytoremediation perspectives of five aquatic macrophytes for heavy metals removal from polluted pond in Kanyakumari district of Tamil Nadu

Jeba Nisha.J[1*] and Dr.Amaliya.N.K[2]
[1]Research Scholar, Department of Chemistry, Reg.No: 20213282032019, Women's Christian College, Nagercoil-629001, (Affiliated to Manonmaniam Sundaranar University, Abishekapatti, Tirunelveli-627012), Tamil Nadu, India.
[2]Assistant Professor, Department of Chemistry, Women's Christian College, Nagercoil-629001, Email: amaliya87@gmail.com (Affiliated to Manonmaniam Sundaranar University, Abishekapatti, Tirunelveli-627012), Tamilnadu, India.
[*]Address for Correspondance
Jeba Nisha.J,
Research Scholar,
Department of Chemistry,
Reg. No: 20213282032019,
Women's Christian College, Nagercoil-629001,
(Affiliated to Manonmaniam Sundaranar University,
Abishekapatti, Tirunelveli-627012), Tamil Nadu, India.
Email: jebanishahelan@gmail.com

Cite this paper as: Jeba Nisha.J and Dr.Amaliya.N.K (2024) Phytoremediation perspectives of five aquatic macrophytes for heavy metals removal from polluted pond in Kanyakumari district of Tamil Nadu. *Frontiers in Health Informatics, 13* (8), 2602-2607

Abstract

The current study stated the heavy metals accumulation potentials of five aquatic macrophytes (*Eichhornia crassipes, Pistia stratiotes, Lemna minor, Azolla pinnata* and *Hydrilla verticillata*) and pollution status of North Thamaraikulam pond in Kanyakumari district of Tamil Nadu. Concentration of five metals (Pb, Cr, Cd, Ni & As) were determined in the water and aboveground and belowground tissues of the selected macrophytes. Bioconcentration Factor (BCF) and Translocation Factor (TF) were calculated for each species.
Key words: heavy metals, accumulation, macrophytes, pollution, tissues

Introduction

Pond water pollution is a concerning issue that has gained global attention. Nowadays, with the development of society, no matter in industry or agriculture, wastewater pollution is extremely serious. This pollution occurs when pollutants, such as chemicals, nutrients, and waste, enter a pond or other bodies of water. These pollutants can come from various sources, including industrial discharges, agricultural runoff, and improper waste disposal. Therefore, it appears that decision-makers must take immediate action to decrease pollution and adopt suitable and sustainable remedial solutions. This is essential to preserve the quality of pond ecosystems and protect the health of organisms and humans who rely on these water sources.

Phytoremediation is a bioremediation method that uses the biodynamic potential of macrophytes to remove metals and other pollutants from the water and soil matrices through their organs. During phytoremediation, pollutants become non-toxic and are lost from the environment, participating in the physiological processes of plants and gradually transforming into biogenic elements, making their conversion to metals and gaseous compounds. Heavy metals are removed largely due to their accumulation in aquatic macrophytes and gradual depletion of their concentrations from the contaminated water.

Materials and Methods

Wastewater Sampling

The samples were collected using polypropylene cans during Summer 2023. The relevant details including the sampling date, sample name (code), sampling station's name (code), general environmental conditions such as the nature of the surrounding landscape, the state of the water flow, and general water conditions such as colour, odour, p^H were recorded.

Collection of plant samples

Plant samples were collected from different sites of nearby water source in Mylaudy. The stock of same sized young and healthy specimens (equal fresh weight was used for each plant type) of these aquatic macrophytes, and care was taken to maintain the samples pure and unadulterated during collection and handling. The plant samples were kept in clean, labelled plastic bags with the sample number, coordinates and scientific name of the plant. Plant samples were taken and cleaned with tap water to eliminate dirt particles.

Experimental procedure

Five species (*Eichhornia crassipes, Pistia stratiotes, Lemna minor, Azolla pinnata* and *Hydrilla verticillata*) have been screened out under laboratory conditions for acclimatization. The total length of experiments was 60 days. Heavy metals concentration was measured by AAS at 10 days interval (0,10,20,30,40,50 and 60 days). The concentration of heavy metals accumulation in shoot and roots were calculated after the completion of experiments.

Statistical Analysis

Pearson's correlation network analysis was done by using Origin pro software and this was analysis the linear relationship between the independent variables.

Result and Discussion

Removal Efficiency (%)

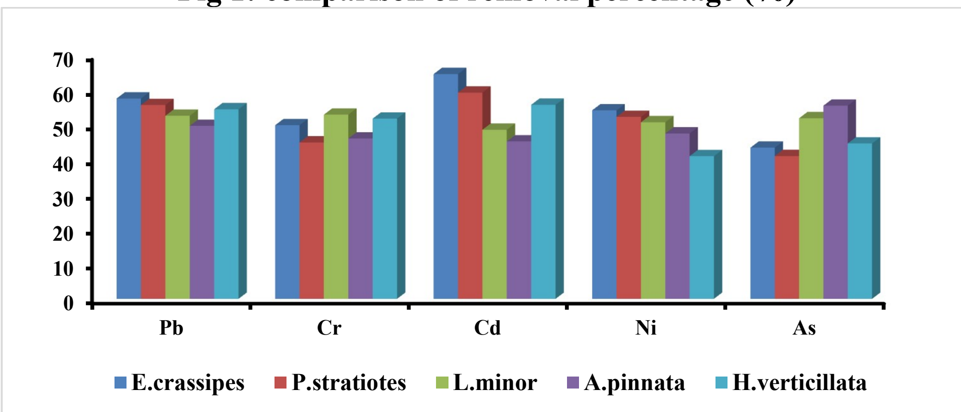
The removal percentage of metal ions by aquatic plants was determined by using initial metal concentrations of the treatment and the final concentrations at the end of the experiment (Mohamed *et al*., 2016).

$$\text{Removal percentage (\%)} = \frac{\text{Initial conc.of heavymetal in water} - \text{Final conc.of heavy metal in water}}{\text{Initial conc.of heavy metal in water}}$$

Table 1: Removal percentage of heavy metals

Macrophytes	Pb	Cr	Cd	Ni	As
E.crassipes	57.48	49.81	64.5	54.09	43.37
P.startiotes	55.61	44.87	59.17	52.2	40.96
L.minor	52.52	52.85	48.5	50.66	51.81
A.Pinnata	49.63	46	45.17	47.45	55.42
H.Verticillata	54.39	51.71	55.67	40.93	44.58

Fig 1: comparison of removal percentage (%)



Removing order for heavy metals

Lead (Pb): *E.crassipes > P.stratiotes > H.verticillata > L.minor > A.pinnata*
Chromium (Cr): *L.minor > H.verticillata > E.crassipes > A.pinnata > P.stratiotes*
Cadmium (Cd): *E.crassipes > P.stratiotes > H.verticillata > L.minor > A.pinnata*
Nickel (Ni): *E.crassipes > P.stratiotes > L.minor > A.pinnata > H.verticillata*
Arsenic (As): *A.pinnata > L,minor > H.verticillata > E.crassipes > P.stratiotes*

Removal order of aquatic macrophytes

E.crassipes: Cd > Pb > Ni > Cr > As
P.stratiotes: Cd > Pb > Cr > Ni > As
L.minor: Cr > Pb > As > Ni > Cd
A.pinnata: As > Pb > Ni > Cr > Cd
H.verticillata: Cd > Pb > Cr > As > Ni

Bioconcentration Factor (BCF)

Bioconcentration Factor serves as a vital blueprint for determining metal uptake effectiveness in aquatic plants, guiding phytoremediation strategies and enhancing wastewater treatment efficiency (Daud *et al.*, 2018). Bioconcentration factor is a useful parameter for assessing the potential of heavy metal accumulation (Alhaji *et al.*, 2020). It was calculated by dividing the heavy metal concentration in plant tissues at harvest by the initial concentration of the element in the external solution (Taiwo *et al.*, 2015).

$$\text{BCF} = \frac{\text{Concentration of metal in plant tissues}}{\text{Concentration of metal in Water}}$$

Bioconcentration Factor (BCF) shows all the five plants were hyper accumulator (Table 3).

Translocation Factor (TF)

Translocation Factor (TF) is a crucial metric for evaluating phytoremediation efficiency (Mojiri *et al*., 2013). Translocation Factor (TF) is defined as the ratio of metal concentration in the upper part to that in the roots. It shows the ability of the plant to transport metal ion in to the shoot tissues (Alhaji *et al*., 2020).

$$TF = \frac{heavy\ metal\ concentration\ in\ shoot\ (ppm)}{hea\quad metal\ concentration\ in\ root\ (ppm)}$$

Table 2 shows that the maximum absorption of metals is in roots followed by shoots for almost all the plant species (Root > Shoot).

Table 2: Concentration of heavy metals in plant tissues

Plant tissues	Pb	Cr	Cd	Ni	As
WH	0.2483	0.1843	0.0275	0.2985	0.91
WL	0.2055	0.1468	0.0265	0.2916	0.74
DW	0.1389	0.0716	0.0365	0.2511	1.15
AZ	0.1264	0.0546	0.0216	0.1864	1.24
HY	0.1546	0.0957	0.0338	0.1594	0.98
WHR	0.1588	0.0995	0.0155	0.1951	0.52
WLR	0.1293	0.0856	0.0144	0.1851	0.39
DWR	0.0786	0.0394	0.0225	0.1453	0.69
AZR	0.0695	0.0284	0.0112	0.0995	0.79
HYR	0.0934	0.0533	0.0202	0.0827	0.58
WHS	0.0895	0.0848	0.012	0.1034	0.39
WLS	0.0762	0.0612	0.0121	0.1065	0.35
DWS	0.0603	0.0322	0.014	0.1058	0.46
AZS	0.0569	0.0262	0.0104	0.0869	0.45
HYS	0.0612	0.0424	0.0136	0.0767	0.4

Roots accumulated the major part with only a small part translocated to the shoots (Saha *et al*., 2016). The difference in TF indicates the preferential accumulation / uptake and translocation of metals (Kumar *et al*., 2012). One of the reasons for higher accumulation factor in the plant roots may be due to their absorption to the surface of root tissue. The highest metals accumulations in the water hyacinth leaves were more accumulated because they are micro nutrients for plants.

Table 3: Bioconcentration Factor and Translocation Factor for macrophytes

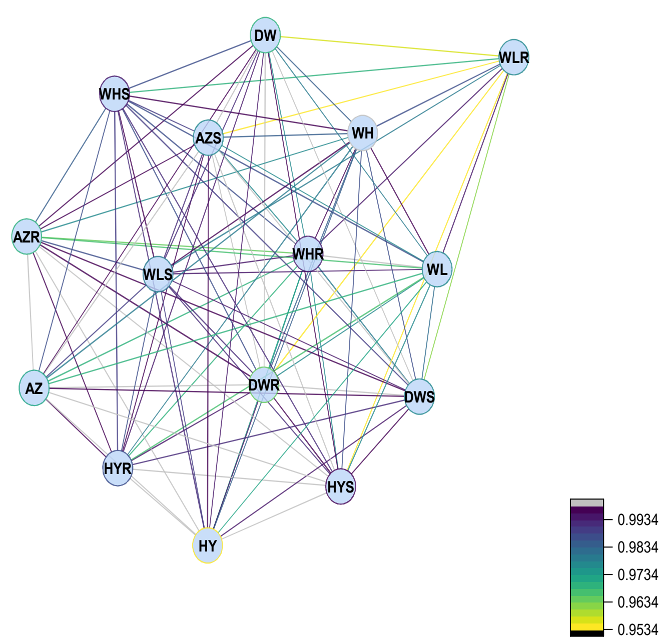
Macrophytes	Pb		Cr		Cd		Ni		As	
	BCF	TF	BCF	TF	BCF	TF	BCF	TF	BCF	TF
E.crassipes	2.32	0.53	3.07	0.69	1.05	0.69	1.71	0.46	1.21	0.74
P.stratiotes	1.92	0.6	2.45	0.92	1.01	0.92	1.67	0.59	0.99	0.89

L.minor	1.29	0.67	1.19	0.46	1.39	0.46	1.44	0.75	1.53	0.64
A.pinnata	1.18	0.88	0.91	0.88	0.82	0.88	1.07	0.93	1.65	0.56
H.verticillata	1.45	0.55	1.59	0.51	1.29	0.51	0.91	0.95	1.31	0.69

Pearson's Correlation Network

The Pearson correlation network is a statistical tool used to visualize and analyze relationships between variables (concentration of heavy metals in plant parts such as root, shoot and total plant). It's based on the Pearson correlation coefficient, which measures linear correlation between variables. In this network, Variables are represented as nodes, and edges connect variables with significant correlation. Fig 2 shows that the strong positive correlation between with each other because of the absorption of heavy metals in plant's parts are same in all macrophytes, and the color of the lines represents the correlation coefficient.

Fig 2: Pearson Correlation Network



WH-Water Hyacinth, WL- Water Lettuce, DW-Duckweed, AZ-Azolla pinnata, HY-Hydrilla verticillata, R-Root, S-Shoot

Conclusion

Phytoremediation of heavy metals from North Thamaraikulam pond water (polluted water) by five aquatic macrophytes was studied. Pearson's correlation network shows the linear relationship between the variable and shows strong positive correlation between eachother that shows the concentration of heavy metals were absorbed by plants in same manner. BCF and TF values indicates that the phytoremediators are hyper accumulator for all studied heavy metals and utilized as a cleaning agent for the polluted pond water.

Reference

Alhaji, SN, Umar, SA, Abdullah, AM, Kasimu, S & Aliyu, S 2020, 'Phytoremediation of Nickel, Lead, and Manganese in Simulated Waste Water Using Algae, Water Hyacinth and Water Lettuce', International Journal of Mineral Processing and Extractive Metallurgy, vol. 5, no. 2, pp. 30-36.

Daud, MK, Ali, S, Abbas, Z, Zaheer, IE, Riaz, MA, Malik, A, Rizwan, M, Rehman, MZ & Zhu, SJ 2018, 'Potential of Duckweed (Lemna minor) for the phytoremediation of Landfill Leachate', Journal of Chemistry, vol. 2018, Article ID 3951540, PP.1-9, https://doi.org/10.1155/2018/3951540

Kumar, N, Bauddh, K, Dwivedi, N, Barman, SC & Singh, DP 2012, 'Accumulation of metals in selected macrophytes grown in mixture of drain water and tannery effluent and their phytoremediation potential', Journal of Environmental Biology, vol. 33, pp. 923-927.

Mohamed, ER, Ahmed, MS, Tantawy, AA, Gomaa, NH & Mohmoud, HA 2016, 'Phytoremediation of Pb, Cd and Cu by an Aquatic Macrophyte *Azolla pinnata* from industrial wastewater in Egypt', Middle East Journal of Applied Science, vol. 6, no.1, pp. 27-39.

Mojiri, A, Aziz, HA, Zahed, MA, Aziz, SQ & Selamat, MRB 2013, 'Phytoremediation of Heavy Metals from Urban Waste Leachate by Sothern Cattail (Typha domingensis)', International Journal of Scientific Research in Environmental Sciences, vol. 1, no. 4, pp. 63-70.

Saha, P, Shinde, O & Sarkar, S 2016, 'Phytoremediation of industrial mines wastewater using water hyacinth', International Journal of Phytoremediation, vol. 19, no. 1, pp. 87-96.

Taiwo, IO, Babajide, SO, Taiwo, AA, Osunkiyes, AA, Akindele, OI & Sojobi, OA 2015, 'Phytoremediation of Heavy Metals (Cu, Zn, and Pb) Contaminated Water using Water Hyacinth (*Eichhornia Crassipes*)' IOSR Journal of Applied Chemistry, Vol. 5, no. 11, pp.65-72.