Nanotechnology Perceptions
ISSN 1660-6795
www.nano-ntp.com

Comparative Study Of The Phytoremediation Capacity Of Hydrilla Verticillata In Heavy Metal Contaminated Water

Jeba Nisha.J[1] , 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.

Hydrilla verticillata is used to remove heavy metals (Pb, Cr, Cd, Ni and As) in polluted water, and accumulation of it in the roots and shoots were examined. H.verticillata were cultured and harvested after 60 days. The aim of this study is to analyse removal efficiency (%) of heavy metals in water, and evaluating the uptake by H.verticillata, bioconcentration factor (BCF) and translocation factor (TF). The highest removal efficiency for H.verticillata was 64.5% for Cd. This plant showed heavy metal concentrations higher in the roots than shoots that suggesting the metals were bound in the root and partially transported to the shoot.

Key words: heavy metal, accumulation, removal, uptake, concentrations.

Introduction

Water is a fundamental component of life on Earth, and its importance cannot be overstated. It is indispensable for individual organisms and ecosystems alike. Pond serves as the vital source of fresh water required for irrigation, drinking. Pond water is a valuable resource that supports diverse ecosystems and provides various benefits to humans. In recent decades there has been a noticeable increase in industrial and domestic activities that produce unprocessed wastewater containing numerous spin-off elements of various origin known as metals. Most of the contaminants can be harmful to the aquatic life and human health.

Phytoremediation is a promising and sustainable approach for mitigating heavy metal contamination in aquatic environments. Aquatic plants have the ability to uptake, accumulate, and detoxify heavy metals through various mechanisms, such as phytoextraction, rhizofiltration, and phytostabilization. These processes involve the uptake of metals from water and sediment by plant roots, the translocation and accumulation of metals within plant tissues, and the immobilization of metals in the root zone. Moreover, aquatic plants can enhance the microbial activity in the rhizosphere, promoting the biodegradation and immobilization of heavy metals. As a result, phytoremediation offers a cost-effective and environmentally friendly solution for remediating heavy metal pollution in aquatic ecosystems. This research aims to explore the effectiveness of various aquatic plant species in phytoremediating heavy metals and to optimize the conditions for enhancing their remediation capacity.

Materials and Methods

Collection of Plants

Aquatic plants collected from the nearby water source and transported to the laboratory and it was washed with fresh tap water. Almost similar-sized plants were collected and used for the treatment.

Collection of Polluted water

Polluted water samples collected from Koduppaikuzhi pond located in the Kalkulam Thaluk in Kanyakumari district. The samples collected in a clean PVC can and transferred to the laboratory.

Experimental set up

The experimental set up for Hydrilla verticillata were conducted in clean container. 12l of water samples were taken in container. The experiment was conducted for a period of 60 days in the shady area. The concentrations of heavy metals were analysed by AAS for every 10 days (0,10,20, 30, 40, 50 and 60 days) intervals during the treatment period. At the end of the 60th day, the plants were harvested, washed, separated into shoots and roots and then digested which were then analysed for metal accumulation using Atomic Absorption Spectrometer (AAS).

Statistical Analysis

The analysis was carried out on independent replicants for every parameter. Response Surface Methodology (RSM), Central Composite Design (CCD) were employed in order to clarify the nature of the response surface in the experimental design and established through Design Expert Software.

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).

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

Utilizing Hydrilla verticillata as a phytoremediator, the mean reduction in Lead from 0.2195ppm to 0.0324ppm, Chromium from 0.0493 ppm to 0.0189 ppm, Cadmium from

0.0148 ppm to 0.0078 ppm, Nickel from 0.0994 ppm to 0.0609 ppm and Arsenic from 0.53 ppm to 0.2457 ppm in station-3.

The order of heavy metal removal percentage of polluted water by Hydrilla verticillata is Cd>Pb>As>Cr>Ni.

Heavy Metals	**Removal efficiency (%)**
Pb	63.09
Cr	47.29
Cd	64.5
Ni	38.73
As	52.83

Table-1: Removal efficiency for heavy metals

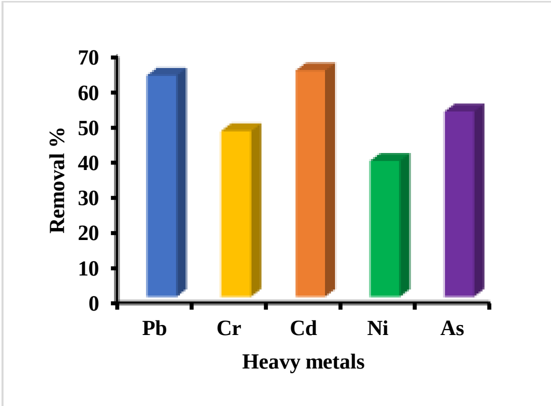
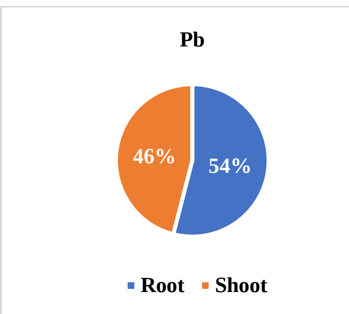
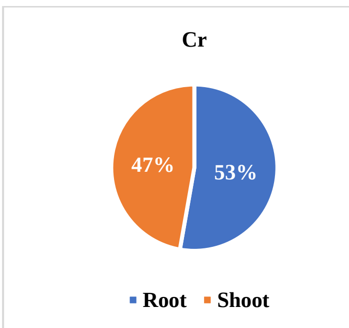


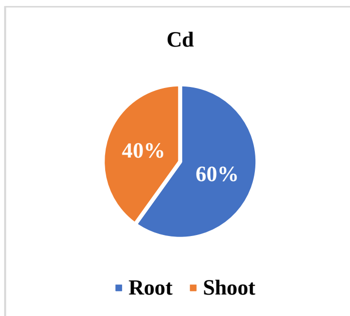
Fig-1: Comparision of Removal efficiency for heavy metal

Heavy metal accumulation in plant parts

Heavy metal accumulation in plant tissues denoted in fig-2. The bioaccumulation in plant root is higher than the shoot.







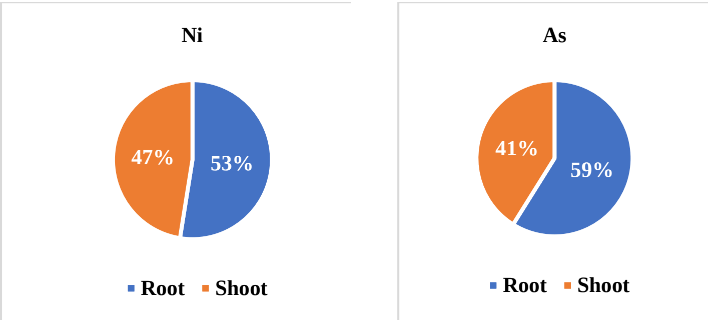


Fig-2: Comparision of heavy metal accumulation in plant tissues

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).

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

The order of Bioconcentration Factor for the bioaccumulation of heavy metals by phytoremediator is Cr>Pb>As>Cd>Ni.

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).

The order of Bioconcentration Factor for the bioaccumulation of heavy metals by Hydrilla verticillata is Cd>As>Pb>Cr>Ni.

Heavy metal	**BCF**	**TF**
Pb	1.44	0.54
Cr	1.53	0.94
Cd	1.26	0.94
Ni	0.86	0.96
As	1.38	0.7

Table-2: BCF & TF for H.verticillata

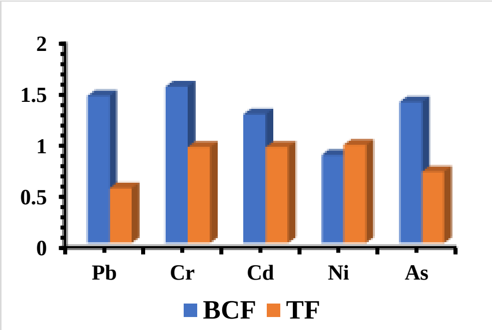


Fig-3: BCF & TF of heavy metals in plant

The data stated that the bioremediator (Hydrilla verticillata) is a hyper accumulator for all the heavy metals except Nickel. For Nickel, Hydrilla verticillata as a moderate accumulator.

Statistical Analysis

In this work, Central Compsite Design (CCD) and the Response Surface methodology (RSM) was used for analysing the correlation between the variables (heavy metal concentration and the time duration for remove the heavy metals) and the important process response (removal efficiency).

Std	Run	Factor1 Time (Days)	Factor 2 Concentration (ppm)	Pb Response 1
7	1	20	0.0552	37.13
4	2	30	0.0467	46.81
5	3	40	0.0405	53.87
6	4	50	0.0359	59.11
3	5	0	0.0878	0
2	6	60	0.0324	63.09
1	7	10	0.0681	22.44

Table-3: Experimental variables and results for Pb removal

Std	Run	Factor1 Time (Days)	Factor 2 Concentration (ppm)	Cr Response 1
1	1	0	0.0493	0
6	2	10	0.0374	24.14

3	3	20	0.0303	38.54
4	4	30	0.0262	46.86
5	5	40	0.0212	56.99
2	6	50	0.0192	61.05
7	7	60	0.0175	64.5

Table-4: Experimental variables and results for Cr removal

Std	**Run**	**Factor1 Time (Days)**	**Factor 2 Concentration (ppm)**	**Cd Response 1**
3	1	0	0.0148	0
1	2	10	0.0133	10.14
2	3	20	0.0121	18.24
6	4	30	0.011	25.68
5	5	40	0.0097	34.46
4	6	50	0.0087	41.22
7	7	60	0.0078	47.29

Table-5: Experimental variables and results for Cd removal

Std	**Run**	**Factor1 Time (Days)**	**Factor 2 Concentration (ppm)**	**Ni Response 1**
5	1	0	0.0994	0
3	2	10	0.0892	10.26
1	3	20	0.0826	16.9
2	4	30	0.0749	24.65
6	5	40	0.0698	29.78
7	6	50	0.0654	34.21
4	7	60	0.0609	38.73

Table-6: Experimental variables and results for Ni removal

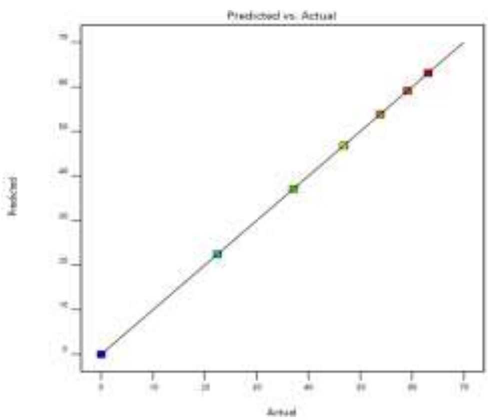
Std	Run	Factor1 Time (Days)	Factor 2 Concentration (ppm)	As Respons e 1
3	1	0	0.4	0
4	2	10	0.335	16.25
7	3	20	0.29	27.5
1	4	30	0.255	36.25
2	5	40	0.23	42.5
6	6	50	0.2067	48.33
5	7	60	0.1871	53.23

Table-7: Experimental variables and results for As removal

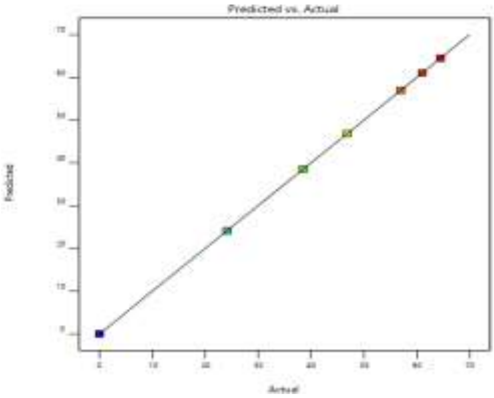
Predicted vs Actual values plot for heavy metal removal. It considerable model were achieve the best fit for the treatment.

Fig-4: The design expert statistical plots – predicted versus actual plot: a) Pb, b) Cr, c) Cd, d) Ni, e)As

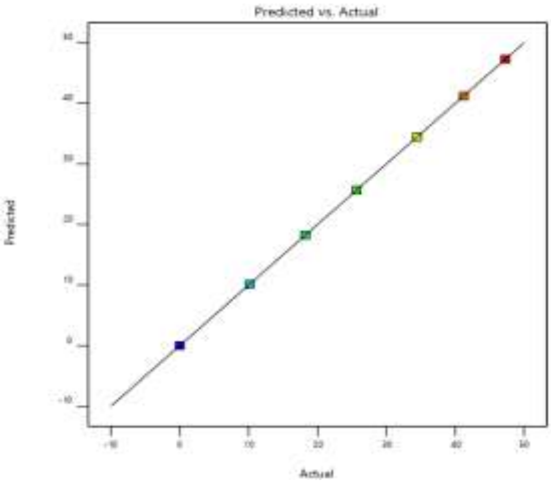
a) Pb



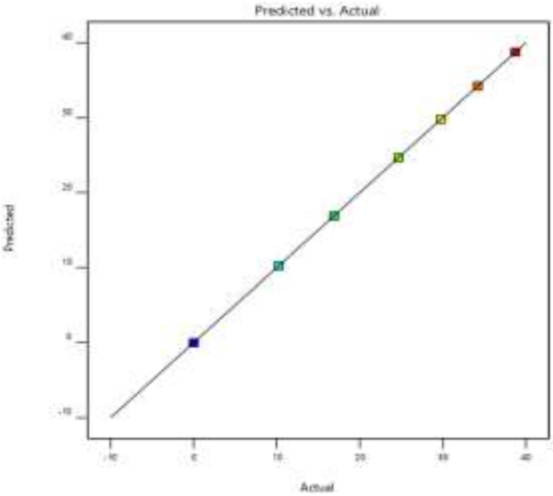
b) Cr


Predicted vs. Actual
Predicted
Actual

c) Cd


Predicted vs. Actual
Predicted
Actual

d) Ni



e) As

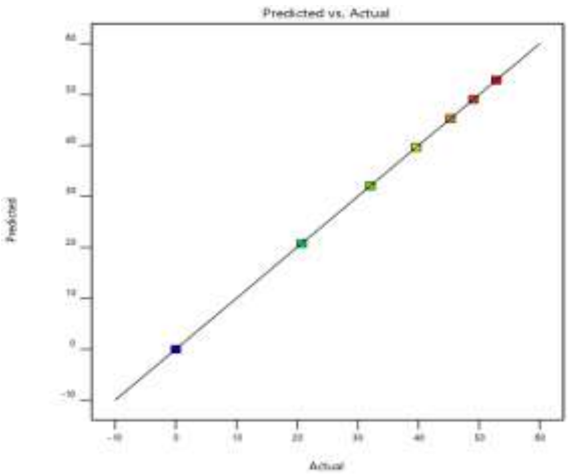
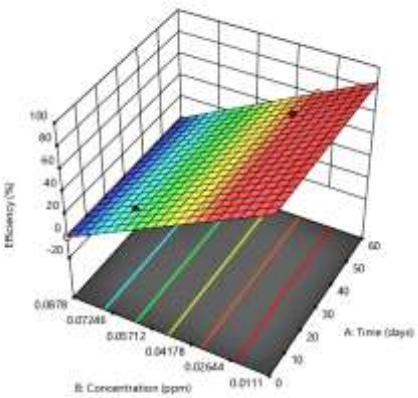
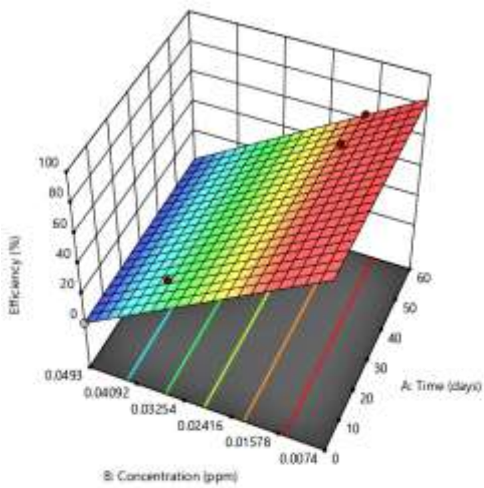


Fig-5: The 3-D surface plots of heavy metal removal: a) Pb, b) Cr, c) Cd, d) Ni, e)As

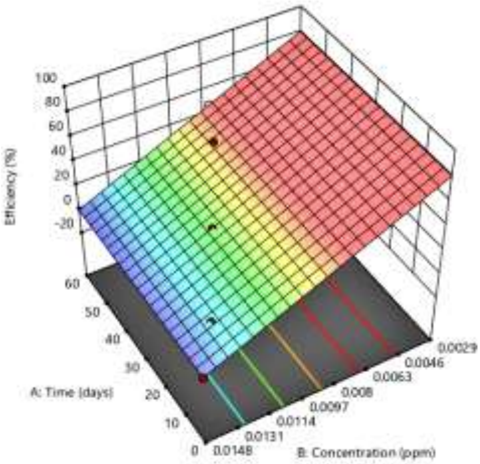
a) Pb


100
80
60
40
20
0
-20
Efficiency (%)
0.0878
0.07246
0.05712
0.04178
0.02644
0.0111
B: Concentration (ppm)
0
10
20
30
40
50
60
A: Time (days)

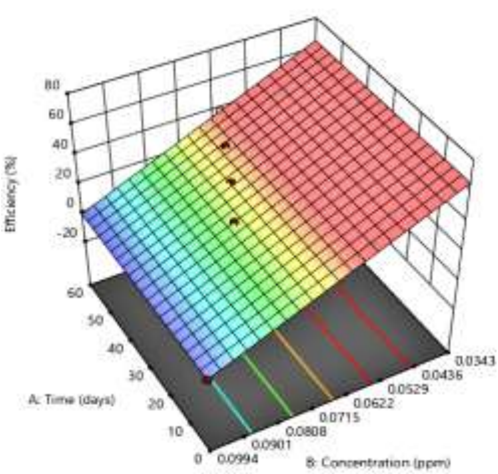
b) Cr


100
80
60
40
20
0
Efficiency (%)
0.0493
0.04092
0.03254
0.02416
0.01578
0.0074
B: Concentration (ppm)
0
10
20
30
40
50
60
A: Time (days)

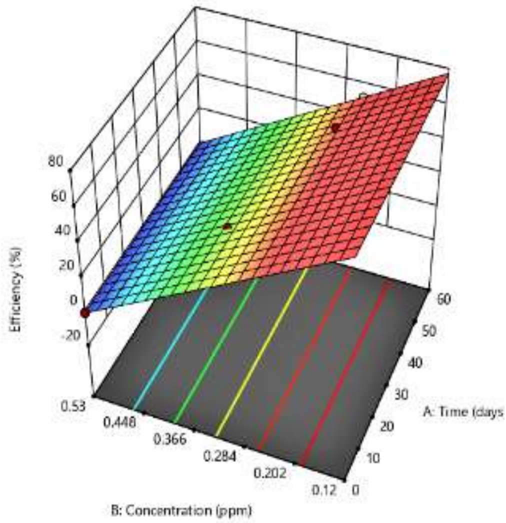
c) Cd


100
80
60
40
20
0
-20
Efficiency (%)
60
50
40
30
20
10
0
A: Time (days)
0.0029
0.0046
0.0063
0.008
0.0097
0.0114
0.0131
0.0148
B: Concentration (ppm)

d) Ni


80
60
40
20
0
-20
Efficiency (%)
60
50
40
30
20
10
0
A: Time (days)
0.0343
0.0436
0.0529
0.0622
0.0715
0.0808
0.0901
0.0994
B: Concentration (ppm)

e) As



Conclusion

Phytoremediation of heavy metals from Koduppaikuzhi pond water (polluted water) by Hydrilla verticillata was studied. Central composite Design (CCD) and Response Surface Methodology (RSM) were used in the design expert software. The factors were the time taking for phytoremediation and the time interval during the treatment; while removal efficiency of Hydrilla for heavy metals Pb, Cr, Cd, Ni and As. The removal percentage of heavy metals by Hydrilla is Cd>Pb>As>Cr>Ni. BCF and TF values indicates that the phytoremediator (Hydrilla verticillata) utilized as a cleaning agent for the polluted pond water.

References

1) 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.
2) 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
3) Alhaji, SN, Umar, SA, Abdullahi, SM, Kasimu, S & Aliju, S 2020, 'Phytoremediation of Nikel, Lead and Manganese in Simulated Waste Water Using Algae, Water Hyacinth and Water Lettuce' Int.J.Min.Process.Extract.Metallurgy., 5(2): pp.30-36.
4) 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.J.App.Chem., 5(11), pp.65-72.
5) 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.

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