Concurrent removal and accumulation of Fe^{2+}, Cd^{2+} and Cu^{2+} from waste water using aquatic macrophytes

Abida Begum

Department of chemistry, P.E.S School of Engineering, Hosur Road, Bangalore, India

Abstract

The metal bioaccumulation capability and effectiveness of eight aquatic macrophytes *Eicchornia crassipes* (water hyacinth), *Pistia stratiotes* (water lettuce), *Lemna major* (duckweed), *Ipomoea aquatica* (kang kong), *H.verticillata*, *Nymphaeae spp*. (water lilies), *Nelumbo nucifera* (lotus), *Nymphoides indica* were investigated for the removal of three heavy metals Fe(II), Cd(II) and Cu (II). These plants were grown at 2.0 mg/L concentrations of metals in laboratory experiment. Within a span of 6 days, the plants were capable of removing about 65- 95% of the selected heavy metals. The sorption process was very rapid for copper removal. Highest removal was observed on 6th day of experiment in all macrophytes. It was observed that macrophyte *Nymphoides indica* as the most efficient for the removal of selected heavy metals followed by *Nelumbo nucifera* (lotus), and *Nymphaeae spp*. (water lilies). The trend of the sorption is Fe (II) > Cd (II) > Cu (II). Results from analysis confirmed the accumulation of different metals within the plant and a corresponding decrease of metals in the water. Plants have accumulated heavy metals in its body without the production of any toxicity or reduction in growth. Selected plants shown a wide range of tolerance to all of the selected metals and therefore can be used for large scale removal of heavy metals from waste water

Keywords: Aquatic macrophytes, Biosorption, Heavy metals.

Introduction

Macrophytes are aquatic plants, growing in or near water that are either emergent, submerged or floating. Macrophytes are beneficial to lake because they provide food and settler for fish and aquatic invertebrates. They also produce oxygen, which helps in overall lake functioning, and provide food for some fish and other wildlife. Aquatic macrophytes are unchangeable biological filters and they carry out purification of the water bodies by accumulating issolved metals and toxins in their tissue. In view of their potential to entrap several toxic heavy metals. Aquatic macrophytes may be native to an area or they may have been imported (referred to as *non-native* or *exotic*). Most of aquatic macrophytes are vascular plants, meaning they contain a system of fluid-conducting tubes, much like human blood vessels.

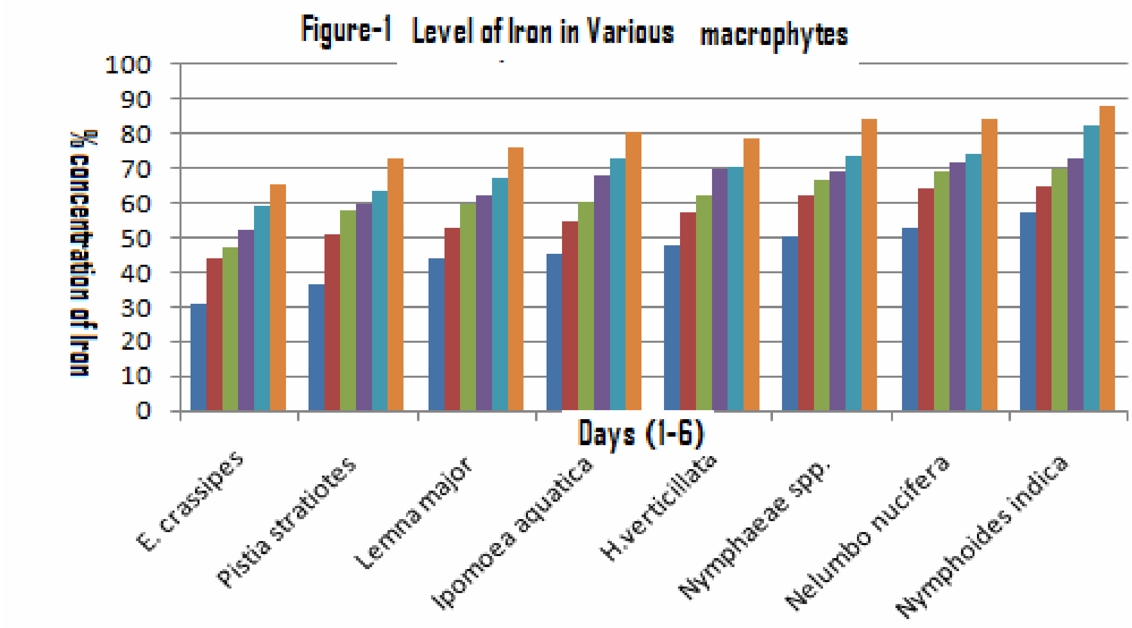
Aquatic macrophytes take up metals from the water, producing an internal concentration several fold greater than their surroundings. Many of the aquatic macrophytes found to be the potential scavengers of heavy metals from aquatic environment and are being used in wastewater renovation systems. Rapid industrialization and urbanization have resulted in elevated emission of toxic heavy metals entering the biosphere [1]. Activities such as mining and agriculture have polluted extensive areas throughout the world [2,3]. The release of heavy metals in biologically available forms by human activity, may damage or alter both natural and man-made ecosystems [4]. Heavy metal ions are essential micronutrients for plant metabolism but when present in excess, can become extremely toxic The aim of the present work is to investigate the performance of eight aquatic macrophytes *Eicchornia crassipes* (water hyacinth), *Pistia stratiotes* (water lettuce), *Lemna major* (duckweed), *Ipomoea aquatica* (kang kong), *H.verticillata*, *Nymphaeae spp*. (water lilies), *Nelumbo nucifera* (lotus), *Nymphoides indica* in the removal of selected heavy metals.

Results and Discussion

Table 1 and figure 1 show the final concentration of Iron remaining in water (mg/L) and biosrption of Iron by macrophtes (%) in seven species of macrophytes. The percentage bioabsorption of the elements in the plants increase according to this sequence: *Eicchornia crassipes (65%) > Pistia stratiotes* (73%)> *Lemna major (76%)> H.verticillata (78.5%)> Ipomoea aquatic(80.5%)> Nymphaeae spp (84 %) > Nelumbo nucifera(84.5) > Nymphoides indica (88%).*

Table-1 Biosorption of Iron by various macrophytes

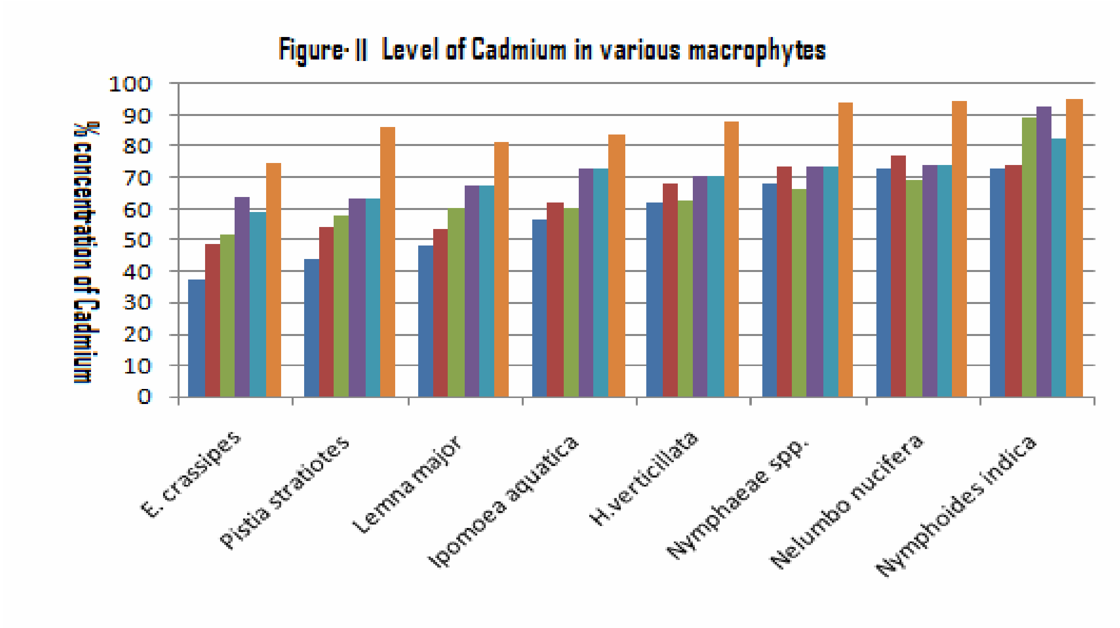
Macrophytes	***Concentration of Heavy metals/percentage removal***											
	Final Concentration of Iron remaining in water (mg/L)						Biosorption of iron by macrophytes (%)					
	No. Of Days											
	1	**2**	**3**	**4**	**5**	**6**	**1**	**2**	**3**	**4**	**5**	**6**
E. crassipes	1.38	1.12	1.06	0.96	0.82	0.69	31	44	47	52	59	65.5
Pistia stratiotes	1.27	0.98	0.84	0.81	0.73	0.54	36.5	51	58	59.5	63.5	73
Lemna major	1.12	0.94	0.8	0.75	0.65	0.48	44	53	60	62.5	67.5	76
I. aquatica	1.09	0.91	0.79	0.64	0.51	0.39	45.5	54.5	60.5	68	73	80.5
H.verticillata	1.05	0.86	0.75	0.61	0.59	0.43	47.5	57	62.5	69.5	70.5	78.5
Nymphaeae spp.	0.99	0.75	0.67	0.62	0.49	0.32	50.5	62.5	66.5	69	73.5	84
N. nucifera	0.94	0.72	0.62	0.56	0.45	0.31	53	64	69	72	74	84.5
Nymphoides indica	0.86	0.7	0.6	0.54	0.35	0.24	57	65	70	73	82.5	88



Biosorption of Cadmium by the selected macrophtes (Table -II and figure-II) is of the order *Eicchornia crassipes (74.5%) > Lemna major*(81.5%)*> Pistia stratiotes*(86%)*> Ipomoea aquatic(84%)> H.verticillata (88%)> > Nymphaeae spp (94 %) > Nelumbo nucifera(94.5) > Nymphoides indica (95.15%)*

Table-II Biosorption of Cadmium by various macrophytes

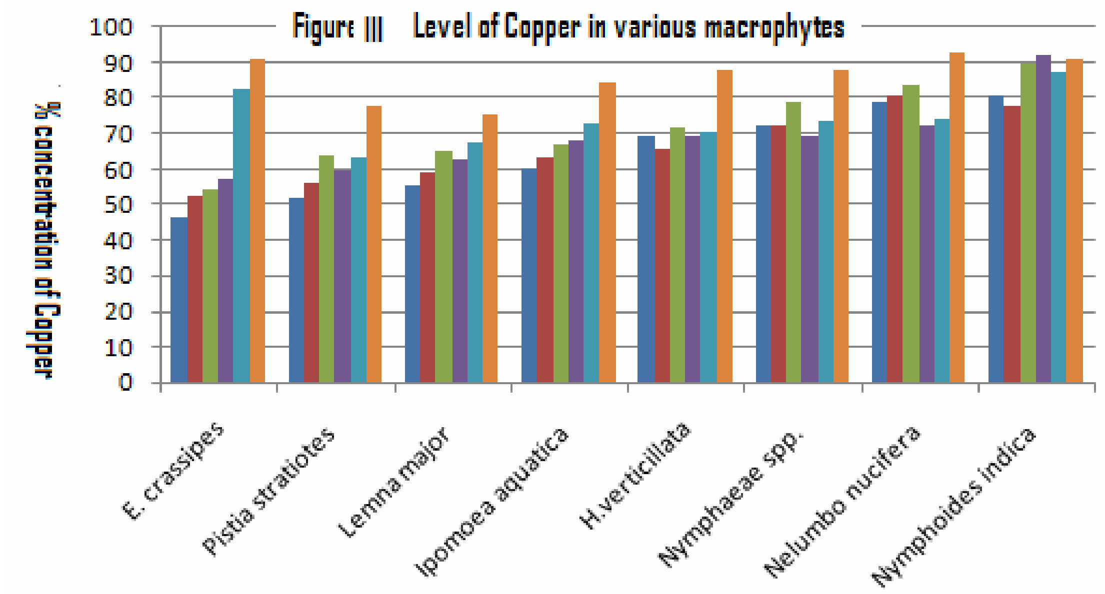
Macrophytes	***Concentration of Heavy metals/percentage removal***											
	Final Concentration of Iron remaining in water (mg/L)						Biosorption of iron by macrophytes (%)					
	No. Of Days											
	1	**2**	**3**	**4**	**5**	**6**	**1**	**2**	**3**	**4**	**5**	**6**
E. crassipes	1.25	1.03	0.96	0.86	0.72	0.51	37.5	48.5	52	57	64	74.5
Pistia stratiotes	1.12	0.91	0.76	0.54	0.44	0.28	44	54.5	58	59.5	63.5	86
Lemna major	1.04	0.93	0.75	0.63	0.54	0.37	48	53.5	60	62.5	67.5	81.5
I. aquatica	0.87	0.76	0.63	0.59	0.44	0.32	56.5	62	60.5	68	73	84
H.verticillata	0.76	0.64	0.58	0.47	0.38	0.24	62	68	62.5	69.5	70.5	88
Nymphaeae spp.	0.64	0.53	0.44	0.38	0.24	0.12	68	73.5	66.5	69	73.5	94
N. nucifera	0.54	0.46	0.34	0.27	0.18	0.11	73	77	69	72	74	94.5
Nymphoides indica	0.54	0.52	0.22	0.18	0.15	0.097	73	74	89	91	92.5	95.15



The result of biosorption study for the heavy metal Copper by the tested macrophtes shown in table-III and figure-III *was Lemna major (75.5%)> Pistia stratiotes (77.5%)> Ipomoea aquatic(84.5%)> H verticillata (88%)> Eicchornia crassipes (91%) > Nelumbo nucifera(91%) > Nymphaeae spp (93 %) > Nymphoides indica (95.15%).*

Table-III Biosorption of Copper by various macrophytes

Macrophytes	*Concentration of Heavy metals/percentage removal*											
	Final Concentration of Iron remaining in water (mg/L)						Biosorption of iron by macrophytes (%)					
	No. Of Days											
	1	**2**	**3**	**4**	**5**	**6**	**1**	**2**	**3**	**4**	**5**	**6**
E. crassipes	1.07	0.95	0.91	0.85	0.35	0.18	46.5	52.5	54.5	57.5	82.5	91
Pistia stratiotes	0.96	0.88	0.72	0.71	0.56	0.45	52	56	64	59.5	63.5	77.5
Lemna major	0.89	0.82	0.7	0.62	0.52	0.49	55.5	59	65	62.5	67.5	75.5
I. aquatica	0.79	0.73	0.66	0.54	0.48	0.31	60.5	63.5	67	68	73	84.5
H.verticillata	0.62	0.69	0.57	0.43	0.42	0.24	69	65.5	71.5	69.5	70.5	88
Nymphaeae spp.	0.56	0.55	0.42	0.39	0.39	0.24	72	72.5	79	69	73.5	88
N. nucifera	0.42	0.39	0.32	0.24	0.29	0.14	79	80.5	84	72	74	93
Nymphoides indica	0.39	0.44	0.21	0.16	0.25	0.18	80.5	78	89.5	92	87.5	91



Among all studied metals, the lowest Iron content was recorded in *E. Crassipes (65%)* while the greatest amount of Copper was observed in *Nymphoides indica* (95%). The concentration of individual metal also varies from species to species [6]. According to the previous studies macrophytes were grown for 4 weeks for the removal of toxicity, but toxicity tests that use macrophytes are only of 1 to 6 days duration. Certain macrophytes species are resistant to higher accumulation of Cu in a very short duration and, therefore, are considered excellent accumulators of copper.

Materials and Methods

Macrophytes were hand picked from the freshwater habitat. They were sorted species-wise out in the laboratory, rinsed with tap water to remove any epiphytes and insect larvae grown on plants. The plants were placed in plastic buckets with tap water under natural sunlight for one week to let them adapt to the new environment, then the plants of the same size were selected for further experiment [5]. A stock solution (1000 mg/L) each was prepared in distilled later with analytical grade Fe, Cu and Cd salts which was later diluted as required. The plants were maintained in tap water supplemented with 2 mg/L of Iron, Copper and Cadmium solution. Plants that were not exposed to metals served as controls. All experiments were performed in triplicate. The test durations were 1, 2, 3, 4, 5 and 6 days. Tap water was added daily to compensate for water loss through plant transpiration, sampling and evaporation. After each test duration, water was analyzed for metals accumulation by atomic absorption spectrophotometry.

Conclusion

This study demonstrates the use of aquatic macrophytes to remove Fe(II), Cd(II), and Cu(II) from solution. Selected macrophytes exhibits high potential for wastewater treatment because of its ubiquity, rapid growth rate, ease of harvest, wide range of temperature tolerance and extended growing and harvesting periods [7]. Therefore the aquatic macrophytes ***Nymphaeae spp. Nelumbo nucifera*** **and** ***Nymphoides indica*** (rate of accumulation of all the selected heavy metals was high) could be harvested in water systems to remove heavy metals effectively, and hence Indicates the potential of these plants for pollution monitoring of these metals.

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