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Zinc Uptake Potential of Eichhornia Crassipes at Various Concentrations

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Abstract: Eichhornia crassipes was exposed to the various concentrations of Zinc (Zn) and the potential of absorption at various concentrations and different time intervals was studied. It is observed that Zn absorption was higher at initial period of exposure and gradually reached to the saturation in all the concentrations. The absorption of Zn was higher at 1.5 ppm and above exposure concentrations. Relatively, the absorption was higher in roots as compared to absorption in shoots at all concentrations. The Transfer Factor (TF) was highest (0.32) for 0.5 ppm concentration after 25 days and (0.31) after 30 days. The study concluded that, Echhornia crassipes is capable to absorb Zn at any concentrations including higher concentrations of 1.5, 2.0 and 2.5 ppm and is tolerant macrophyte without any sign of ecotoxicity. Therefore, it may be used in "Phytoremediation Eco-technology" (Pollution remediating environmental technology) in constructed wetlands like floating wetland reactor systems for preventing the spread of zinc contamination.

Keywords: Constructed wetland, Eichhornia crassipes, Ecotoxicity, Metal concentrations, Metal Uptake, Phytoremediation, Water Pollution, Zn absorption.

I. INTRODUCTION

Pollution of water bodies due to toxic heavy metals in many regions has become a major environmental problem. Most of the conventional remediation approaches do not provide any acceptable solution to control and irradiate it. In recent years, there is a considerable interest for developing the cost effective and environment friendly technologies for the remediation of soil and wastewater polluted with toxic elements (Zayed et.al., 1998). Therefore, the wetland plants are being demonstrated and used successfully for the phytoremediation of toxic metals in natural and constructed wetlands. The study demonstrating the remediation potential by uptake of specific pollutant is of great interest in phytoremediation process. Hence, the present study was focused on the potential of water hyacinth (*Eichhornia crassipes*), for the removal of zinc (Zn).

Eichhornia crassipes is a free-floating aquatic macrophyte introduced externally and has since spread over, now commonly occurring in major water bodies in Maharashtra, reproducing both vegetative reproduction via ramets formed from auxillary buds on stolons, and sexually through seed production. Among the free-floating macrophyte species, the water hyacinth (*Eichhornia crassipes*) stands as a promising candidate for phytoremediation of polluted water thereby pollutant removal owing to its faster or rapid growth rate and extensive root system (Kumari and Tripathi, 2014; Olukaanni and Kokumo, 2013; Rezania et.al., 2013). The water hyacinth here functions as a horizontal trickling filter media. The submerged root system of water hyacinth provides physical support for the bio-film bacterial to growth. This reduces the pollutants (Dhote and Dixit, 2009). Even then, the construction of aquatic systems, mainly, the water hyacinth treatment process has not gained much popularity and public acceptance (Chang et.al., 2012). The specific pollutant absorption potentiality can help to promote the use of concerned macrophyte for removal of specific pollutant and hence present investigation was carried out to know the uptake potential by absorption with specificity of this plant for Zn.

II. MATERIALS AND METHODS

A. Experimental Procedures

E. crassipes macrophytes of same size were collected from a local water-body and rinsed with tap water to remove any epiphytes and insect larvae grown on plants. The plants were placed in plastic tubs 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. A stock solution (1000 mg/L) of zinc was prepared in distilled water with analytical grade $ZnSO_4.7H_2O$ which was later diluted as per experimental requirement. The plants were maintained in tap water supplemented with aqueous solutions having 0.5, 1, 1.5, 2 and 2.5 mg/L concentrations of Zn. Plants that were not exposed to Zn metal solution served as controls. All experiments were performed in triplicate. The total test durations were 0 days to 30 days with 5 days intervals for intermediate analysis. Tap water was added daily

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to compensate for water lost through plant transpiration, sampling and evaporation. The plant samples were harvested after each of the test durations at the interval of 5 days. They were separated into shoots and roots, and were analyzed for respective uptake potential of Zn accumulation.

The sampled plants were washed with tap water and rinsed with distilled water to wipe out any adhering substances. The root and body of plants were separated and slowly crushed, blended to homogenize and then dried in oven (60°C for 24 hrs). Then, the dried samples were pulverized and fine powder was obtained which was sieved (0.15 mm) following the procedure prescribed by Kalra (1998). Separately prepared powder of plant parts (shoots and roots) were directly digested with nitric and perchloric acid till a clear solution was obtained and then diluted to 50 ml with double distilled water (APHA, 1998) to make up the volume and Zinc (Zn) was determined by EDTA Complexometry-Back Titration method (Nicolaysen, 1941) and confirmed (Islam and Ahmed, 2013). The analysis procedure was confirmed by analyzing 2 blanks considering all laboratory and analytical conditions being equal. The translocation factor for Zn was determined using following formula;

$$\text{Translocation factor (TF)} = \text{MCS/MCR}$$

Where, MCS stands for Metal Concentration in Shoot and MCR stands for Metal Concentration in Root.

III. RESULTS AND DISCUSSION:

The *Eichhornia crassipes*, commonly known by its vernacular name Water hyacinth is a floating macrophyte whose appetite for nutrients and explosive growth rate has been put it to use in pollution remediation for cleaning up municipal and agriculture wastewaters (Gupta, 1980). It has been noticed that water hyacinth has quest for nutrients can be turned in a more useful direction. Water hyacinth has been investigated by many researchers (Tokunaga et.al., 1976; Pinto et.al., 1987; Fett et.al., 1994; Maine et.al., 2001) and shown to accumulate trace elements such as Ag, Pb, Cd and Zn. Their focus on suggesting water hyacinth use as a key step in wastewater recycling is due to the fact that it forms the central unit of a recycling engine driven by photosynthesis and therefore the process is sustainable, energy efficient and cost efficient under a wide variety of rural and urban conditions (Gijzen and Veenstra, 2000; Lu et.al., 2004). Therefore, the investigations have been carried out to demonstrate the phytoremediation potential of water hyacinth, *E. crassipes* upon its exposure to various concentrations at different times for the removal of Zn. The absorption of Zn recorded (Table 1) in the roots during the relative growth of *E. crassipes* when exposed to different concentrations of Zn on 5^{th}, 10^{th}, 15^{th}, 20^{th}, 25^{th} and 30^{th} days of exposure are shown in Figure 1. Zinc absorption in roots was found increased with the increase in exposure concentration and increase in exposure times. In all the experimental sets 1 to 6, the absorption rate was higher for first 5 days and the rate was relatively declined thereafter. Control set showed no change in the absorption which was due to non-availability of Zn in the water in control set. The absorption in all other sets having different Zn concentrations was observed. The absorption in roots was highest (2.38) after 30 days in the set 6 of experiment exposed to 2.5 ppm followed by set 5 having 2.0 ppm Zn concentration. There was very negligible difference in the absorption in 2.0 ppm (set 5) and 2.5 ppm (set 6) exposures after the absorption period of 25 days. The absorption continued till the end of experiment indicating that the plant has strong absorption affinity towards Zn and no saturation level reached within 30 days of exposure. There was no any sign of toxic effect on any plants indicating that the macrophyte is fully tolerant for all the test concentrations of Zn.

Table 1: Absorption potential in the Roots of Eichhornia crassipes exposed to various concentrations of Zinc at different time intervals.

Zinc conc. (ppm)	Exposure period (Days)						
0	0	5	10	15	20	25	30
0.0 (Set 1) Control	0.01	0.01	0.01	0.01	0.01	0.01	0.01
0.5 (Set 2)	0.01	0.15	0.25	0.42	0.56	0.68	0.79
1.0 (Set 3)	0.01	0.30	0.61	1.09	1.21	1.52	1.60
1.5 (Set 4)	0.01	0.93	1.45	1.76	2.05	2.37	2.37
2.0 (Set 5)	0.01	1.41	2.01	2.23	2.28	2.37	2.38
2.5 (Set 6)	0.01	1.72	2.21	2.24	2.28	2.37	2.38

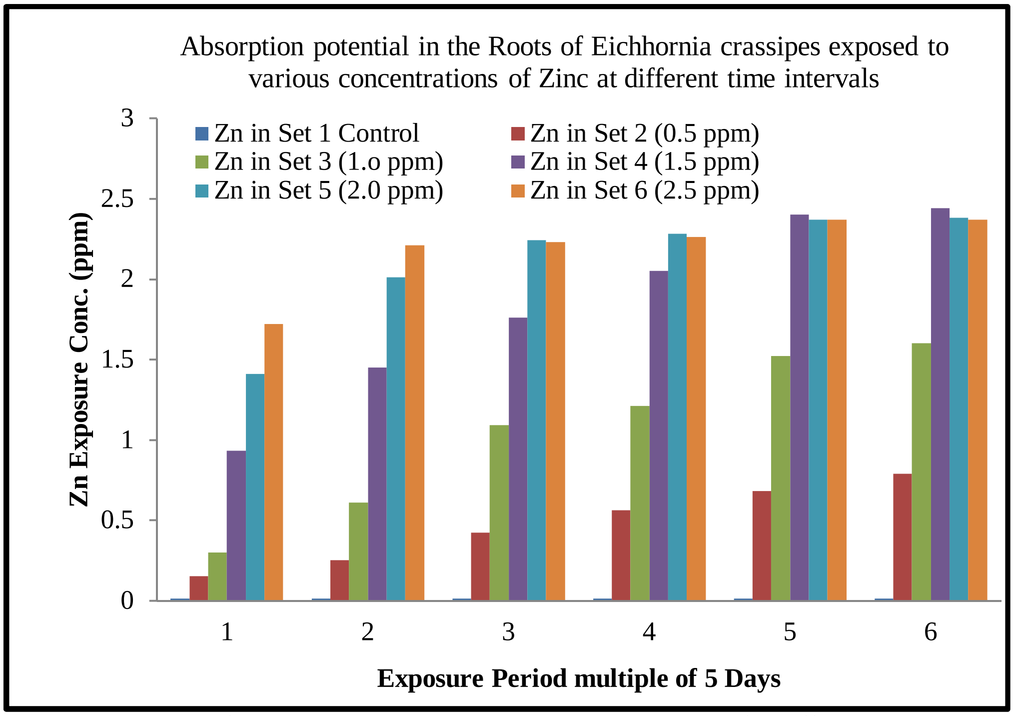

Figure 1: Zn absorption in the Roots of E. crassipes exposed to various concentrations for different times in Days multiple of 5.

The Zn accumulations by water hyacinth at different concentrations and exposure times in Roots and Shoots are separately shown in Fig 1 and Fig 2, respectively. In general, there were increases in metal accumulation in both, the shoots and roots with the increase in exposure times. The absorption and accumulation was relatively higher at higher concentrations of 1.5 ppm and above it. The rate of accumulation in shoots was higher for first 10 days. The Zn content in control (set 1) was below detectable limit and was recorded as nil. The rate of absorption and accumulation of Zn in shoots was found higher for higher exposure concentrations. There was no much difference in absorption and accumulation in set 5 (2.0 ppm) and set 6 (2.5 ppm) indicating that the absorption rates are saturated, without saturation in accumulation after 25 days. No any sign of eco-toxic effect was noticed in any of the experimental test sets which revealed that the macrophyte is fully tolerant for Zn at the all experimental test concentrations.

Table 2: Absorption potential in the Shoots of Eichhornia crassipes exposed to various concentrations of Zinc at different time intervals.

Zn Conc. ppm)	Exposure period (Days)						
0	0	5	10	15	20	25	30
0.0 (Set 1) Control	0.00	00	00	00	00	00	00
0.5 (Set 2)	0.01	0.01	0.03	0.07	0.13	0.22	0.23
1.0 (Set 3)	0.01	0.05	0.11	0.18	0.21	0.36	0.50
1.5 (Set 4)	0.01	0.08	0.18	0.25	0.45	0.53	0.58
2.0 (Set 5)	0.01	0.09	0.19	0.38	0.46	0.53	0.58
2.5 (Set 6)	0.01	0.10	0.19	0.39	0.47	0.53	0.58

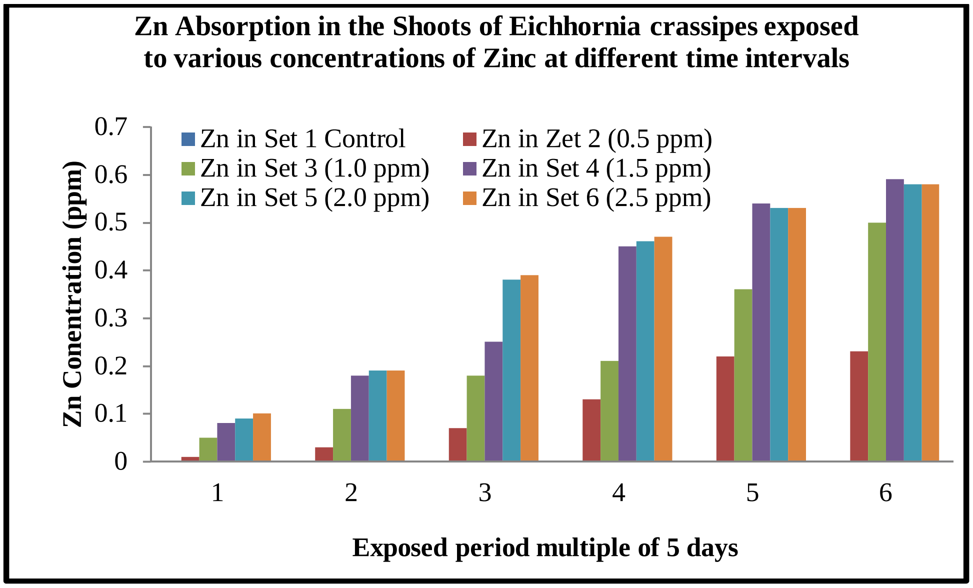

Figure 2: Zn absorption in the Shoots of E. crassipes exposed to various concentrations for different times in Days multiple of 5.

A plant's ability to translocate metals from the roots to the shoots is measured using the Transfer Factor-TF (Baker, 1981). The transfer factor greater than 1 ((TF > 1) signifies that the plant is effectively translocating the heavy metal from roots to the shoots (Baker and Brook, 1989). The Transfer Factor calculated for all the experimental sets indicated that no much effective translocation is taking place. On the other hand, there are no any signs of eco-toxicity which indicates that the plant can absorb and accumulated as well as survive even at the higher concentrations than the presently tested Zn concentrations which needs to be separately tested to determine higher tolerating concentrations.

Table 3: TF factor of Eichhornia crassipes exposed to various concentrations of zinc at different time intervals.

Zn Conc. ppm)	Transfer Factor upon Different Exposure periods (Days)						
0	0	5	10	15	20	25	30
1.0 (Set 1) Control	0.00	00	00	00	00	00	00
0.5 (Set 2)	1.00	0.67	0.12	0.17	0.23	0.32	0.29
1.0 (Set 3)	1.00	0.17	0.18	0.17	0.17	0.24	0.31
1.5 (Set 4)	1.00	0.09	0.12	0.14	0.22	0.23	0.24
2.0 (Set 5)	1.00	0.07	0.09	0.17	0.20	0.22	0.24
2.5 (Set 6)	1.00	0.08	0.09	0.17	0.21	0.22	0.24

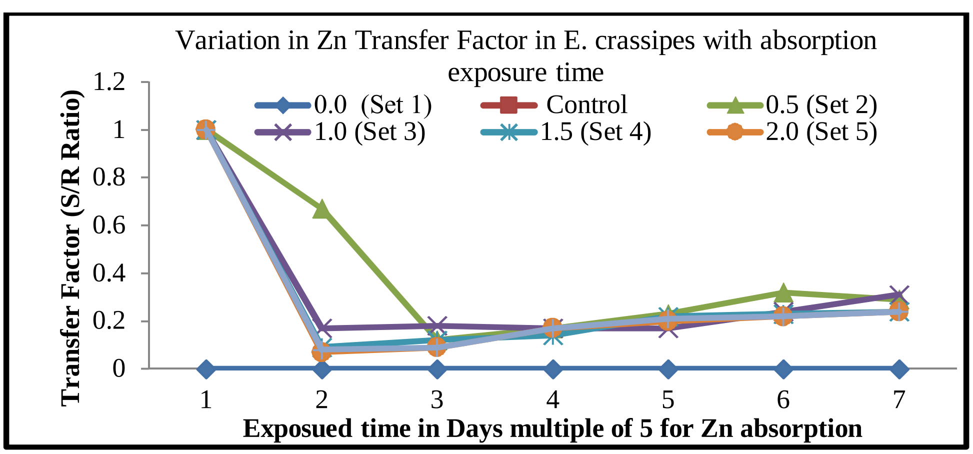

Fig. 3: Variation in Zn Transfer Factor (TF) in Echhornia crassipes with absorption time of exposure.

IV. CONCLUSION

The studies concluded that, *Echhornia crassipes* is capable to absorb Zn at any concentrations including higher concentrations of 1.5, 2.0 and 2.5 ppm and is tolerant macrophyte without any sign of ecotoxicity. Therefore, it may be used in "Phytoremediation Eco-technology" (Pollution remediating environmental technology) in constructed wetlands like floating wetland reactor systems to prevent the spread of zinc contamination from land to the aquatic environment.

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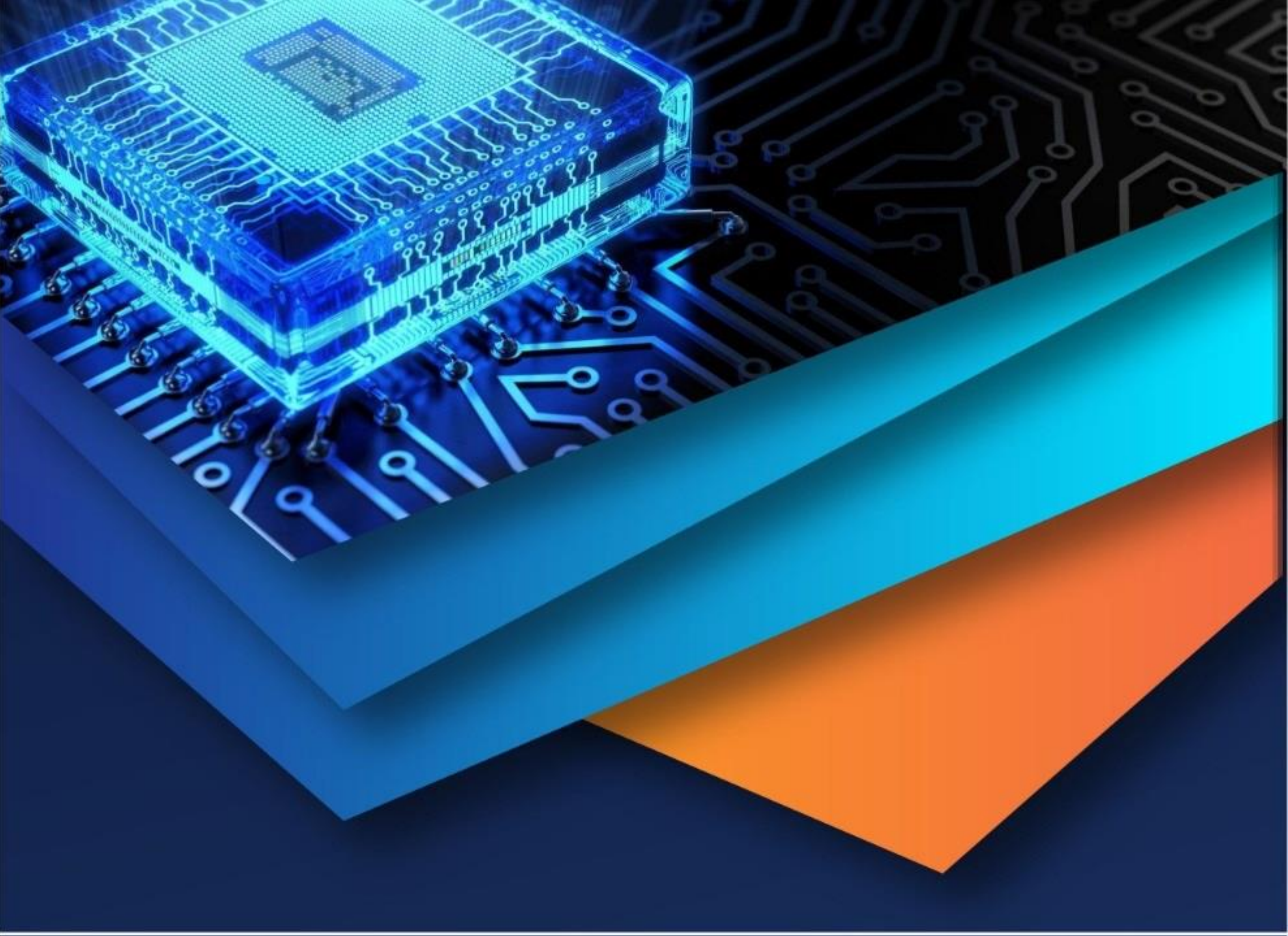

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