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Influence of *Eichhornia crassipes* for removing Zn from electroplating industry wastewater

D.Sivakumar*, M.Thiruvengadam, R.Monica Shruthi, K.Thaiyalnayagi, T.M.Modhini
Department of Civil Engineering, Vel Tech High Tech Dr.Rangarajan Dr.Sakunthala Engineering College, Chennai 600062, Tamil Nadu.
***Corresponding author: E-Mail; shri.sivakumar1974@gmail.com**

ABSTRACT

This study was focused on removal of Zinc (Zn) from electroplating industry wastewater using the method called bioremediation by *Eichhornia crassipes*. The experimental investigations have been carried out by using *Eichhornia crassipes* for conducted the sorption study with various nutrient dosage (10, 20, 30, 40, 50, 60 and 70 g), dilution ratio (2, 4, 6, 8, 10, 12 and 14) and pH (3, 4, 5, 6, 7, 8 and 9) and biomass (20, 40, 60, 80, 100, 120 and 140 g). The results showed that the maximum percentage removal of Zn in the electroplating industrial wastewater was obtained at the nutrient dosage of 60 g, dilution ratio of 10, pH of 8 and biomass 100 g. From the results, this study concluded that bioremediation by *Eichhornia crassipes* was effectively used for removing Zn from electroplating industry wastewater.

KEY WORDS: Flame Atomic Adsorption Spectrophotometer, Bioremediation, Electroplating Industry Wastewater, Constructed wetland.

1. INTRODUCTION

Among the various sources of surface water and groundwater contamination, the electroplating industry stands out as one of the most important, because it generates a considerable volume of wastewater containing high concentrations of metal ions and, often, high concentrations of organic matter. The surface water and groundwater is contaminated due to wastewater when it is not discharged properly (Sivakumar Durairaj, 2013c; Sivakumar, 2011). Wastewater generated from electroplating industry generally contains much higher concentrations of properties like total dissolved solids, suspended solids, phenols, chromium, chlorides, ammonia, and heavy metals, which must be controlled to an acceptable level before being discharged to the environment according to environmental regulations worldwide.

The suggested treatment methods for the removal of pollutants from electroplating industries are adsorption (Sivakumar and Shankar, 2012; Sivakumar, 2013b; Sivakumar, 2014c; Sivakumar, 2014f; Sivakumar, 2014g; Sivakumar, 2014k; Shankar, 2014a; Sivakumar and Nouri, 2015), ion exchange, chemical precipitation, bioremediation (Shankar, 2014b; Sivakumar, 2014d; Sivakumar, 2014e), constructed wetland (Sivakumar, 2015; Sivakumar, 2013a; Sivakumar, 2014h; Ingole and Bhole, 2003; Soltan and Rashed, 2003) and electro-dialysis (Sivakumar, 2014i; Sivakumar, 2014j) etc. In recent years, considerable attention has been focused on absorption process using aquatic plants because, it has more advances than over conventional treatment methods include: low cost; high efficiency; minimization of chemical and biological sludge. This can be achieved by using constructed wetland (Turker, 2014). Constructed wetlands are artificial wastewater treatment systems consisting of shallow ponds or channels which have been planted with aquatic plants and which rely upon natural microbial, biological, physical and chemical process to treat wastewater. The treatment systems of constructed wetlands are based on ecological systems found in natural wetlands. For the design and construction of treatment wetlands and the processes by which constructed wetlands can remove pollutants, it is important to have a basic understanding of how natural wetlands work. Thus, this study was conducted to remove Zn from electroplating industry wastewater using constructed wetland by aquatic macrophytes *Eichhornia crassipes*.

2. MATERIALSAND METHODS

2.1. Collection of *Eichhornia crassipes*: The aquatic macrophytes *Eichhornia crassipes* were collected from the Porur Lake, Chennai, which had no connection with any industry wastewater discharge points. The collected aquatic plants were washed with distilled water and weighed. Further, the aquatic macrophytes were initially subject to stabilization in small plastic tanks containing well water and the same were preserved for 15 days period. In addition, these plastic tanks were filled with gravel and wetland soil (collected from the Porur Lake) up to five inches in height and maintained at normal temperature.

2.2. Collection of Wastewater Sample: For the present study, the wastewater sample was collected from electroplating industry, Ambatore Industrial Estate, Chennai with the help of air tight sterilized bottles. Samples were taken to the Environmental Engineering Laboratory for analyzing the Zn from electroplating industry wastewater. The analysis was carried out for Zn in the electroplating industry wastewater using Flame Atomic Absorption Spectroscopy (FAAS) with the wavelength of 213.6 nm. The average initial concentration of Zn from electroplating industry wastewater is 138 mg/l respectively. It was found that the Zn concentration in wastewater from electroplating process varied in wide range depending on process details and working behaviors in the production step of each industry.

2.3. Sorption Experiments: For the experiments, the *Eichhornia crassipes*, which maintained in the plastic tanks were collected, cleaned and introduced in the experimental tanks (constructed wetland). The experimental tanks also a plastic tank as similar to plastic tank for preserving the *Eichhornia crassipes*. These experimental tanks were filled with electroplating industry wastewater of 1000 ml. Triplicate of each experimental setup was maintained. In order to reduce the Zn in a electroplating industry wastewater, the experimental setup (constructed wetland) was examined for a period of 7 days by 1 day interval by using aquatic macrophytes *Eichhornia crassipes* and conducted the sorption study with various nutrient dosage (10, 20, 30, 40, 50, 60 and 70 g), dilution ratio (2, 4, 6, 8, 10, 12 and 14), pH (3, 4, 5, 6, 7, 8 and 9) and biomass (20, 40, 60, 80, 100, 120 and 140 g). The nutrient used in this study was activated sludge which was collected from the municipal wastewater treatment plant, Chennai.

The dilution ratio was used such that 1 part of wastewater with various numbers of part of well water, thus, the ratio of 2, 4, 6, 8, 10, 12 and 14 represents these parts of well water mixed with raw wastewater. The pH was adjusted by using 0.1 M of NaOH and 0.1 M of HCl. The concentrations of the various parameters in an electroplating industry wastewater before and after treatment with *Eichhornia crassipes* were determined as per the standard procedure stipulated by APHA, AWWA and WEF (2005). The percent removals of Zn in the electroplating industry wastewater by *Eichhornia crassipes* was calculated by using the following formula:

$$\text{Percenrage Reduction} = \frac{(C_1 - C_2)}{C_1} x100$$

in which C_1 is concentration of the Zn in the electroplating industry wastewater before treatment with *Eichhornia crassipes* and C_2 is concentration of Zn in the electroplating industry wastewater after treatment with *Eichhornia crassipes*.

3. RESULTS AND DISCUSSIONS

The different process parameters like nutrient dosage, dilution ratio, pH, biomass against the contact time were selected for removing Zn from electroplating industry wastewater using constructed wetland by an aquatic plant *Eichhornia crassipes*.

3.1. Effect of Dilution Ratio: Fig.1 indicates the experimental investigations conducted by changing the dilution ratio from 2 to 14 (wastewater 1 : well water 2) with an increment of 2 using *Eichhornia crassipes*. The percentage reduction of Zn in an electroplating industry wastewater using *Eichhornia crassipes* against the different dilution ratios (Since, day 6 is the optimum contact time found from the study, the results obtained on the day 6 was presented and the results obtained by the day 1, 2, 3, 4, 5 and 7 were not presented in this study) with the optimum contact time of 6 days, nutrient dosage of 10 g, biomass of 40 g, and pH of 5 was presented (Fig.1).

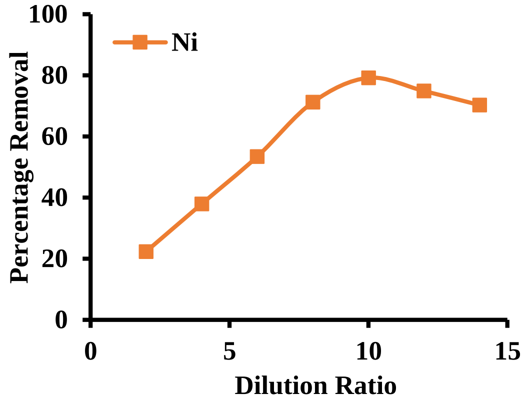

Fig.1 Removal of Ni by *Eichhornia crassipes* against Dilution Ratio

The results revealed that the percentage removal for Zn in an electroplating industry wastewater is low at the beginning and then increases with dilution ratio. This is because; diluted concentration of Zn in an electroplating industry wastewater was sorbed easily by the *Eichhornia crassipes* than high concentration electroplating industry wastewater. In other words, the active sites in the *Eichhornia crassipes* could not be sorbed the Zn ion from the electroplating industry wastewater, since, there is very strong bondage between the Zn ions at an elevated concentration and in later stage sorbent sites of *Eichhornia crassipes* could be effectively utilized. Up to dilution ratio of 10, the sorption of Zn in an electroplating industry wastewater by *Eichhornia crassipes* increased steadily. For the dilution ratio 12 and 14, the percentage removal results showed resembles of the results obtained for the dilution ratio 10. It is more likely that an even sufficient contact time available, Zn in the electroplating industry wastewater was sorbed on the active sites of Eichhornia *crassipes* completely for the dilution ratio 10, and hence, there was no difference in sorption on dilution ratio 12 and 14.

Similarly, the sorption of Zn in an electroplating industry wastewater on day 7, the removal percentage of Zn was similar to that of day 6, indicated that the maximum removal of Zn was completed on day 6 itself. Hence, the optimum dilution ratio found in this study for the maximum removal of Zn in an electroplating industry wastewater is 10. Further, the maximum sorption removal percentage of Zn in an electroplating industry wastewater by *Eichhornia crassipes* against dilution ratio of 10 was found to be 74.6 % (Fig.1).

3.2. Effect of pH: Fig.2 represents the experimental investigations conducted by changing the pH from 3 to 9 with an increment of 1 using *Eichhornia crassipes*. The percentage reduction of Zn in an electroplating industry wastewater using *Eichhornia crassipes* against pH (Since, day 6 is the optimum contact time found from the study, the results obtained on the day 6 was presented and the results obtained by the day 1, 2, 3, 4, 5 and 7 were not presented in this study) with an optimum contact time of 6 days, nutrient dosage of 10 g, biomass of 40 g, and an optimum dilution ratio of 10 was presented (Fig.2).

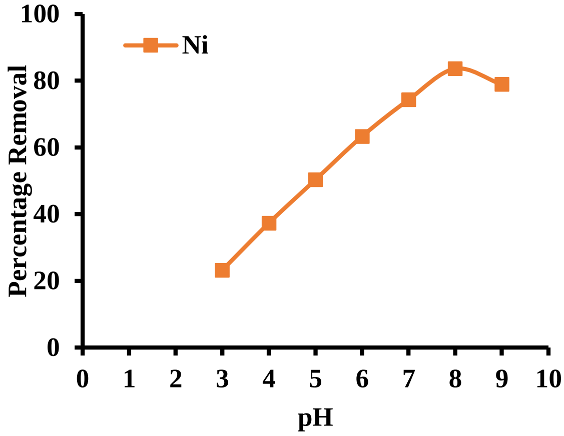

Fig.2 Removal of Ni by *Eichhornia crassipes* against pH

The results revealed that the percentage removal of Zn in an electroplating industry wastewater is low at the beginning and then high with pH increases. This is because, in a slight alkaline to alkaline condition, the Zn ion is coupled with various cations and anions present in the electroplating industry wastewater, can be easily sorbed by *Eichhornia crassipes* than in acidic condition. Up to pH of 8, the sorption of Zn in an electroplating industry wastewater by *Eichhornia crassipes* increased steadily and for the pH 9, the percentage removal results showed the resembles of the results obtained for the pH 8. Hence, the optimum pH found in this study for the maximum removal of Zn in an electroplating industry wastewater is 8.

The sorption of Zn in an electroplating industry wastewater on day 7 and for the pH 9, the removal percentage of Zn in an electroplating industry wastewater was not significant even the contact time and pH were higher, it is more likely that the sorption was completed for the contact time day 6 and for the pH 8, leading to lower specific uptake for the pH of 9 and for the contact time of 7 days. Thus, the maximum sorption removal percentage of Zn in an electroplating industry wastewater by *Eichhornia crassipes* against the optimum pH of 8 was found to be 78.2 % (Fig.2).

3.3. Effect of Nutrient Dosage: Fig.3 indicates the experimental investigations conducted by changing the nutrient dosage from 10 g to 70 g with an increment of 10 g using *Eichhornia crassipes*. The percentage reduction of Zn in an electroplating industry wastewater using *Eichhornia crassipes* against nutrient dosage (Since, day 6 is the optimum contact time found from the study, the results obtained on the day 6 was presented and the results obtained by the day 1, 2, 3, 4, 5 and 7 were not presented in this study) with an optimum contact time of 6 days, biomass of 40 g, optimum dilution ratio of 10 and an optimum pH of 8.

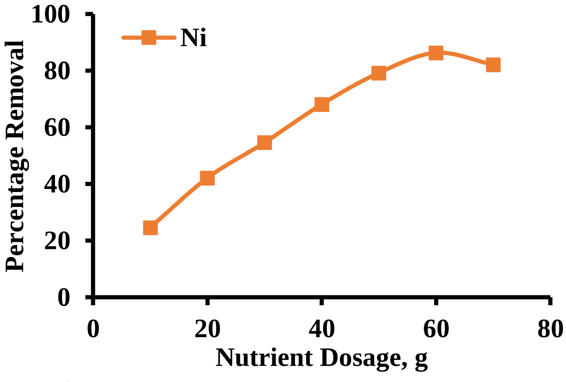

Fig.3 Removal of Ni by *Eichhornia crassipes* against Nutrient Dosage

The results revealed that the percentage removal of Zn is low by *Eichhornia crassipes* at the low dosage, and then increases with increased nutrient dosage. This is because, the supplied low nutrients are completely utilized by the portion of supplied biomass of 40 g and thereafter the supplied nutrient was completely taken by the *Eichhornia crassipes* for its growth. Up to nutrient dosage 60 g, the sorption of Zn in an electroplating industry wastewater increased steadily by *Eichhornia crassipes* and for the nutrient dosage of 70 g, the percentage removal results showed the resembles of the results obtained nutrient dosage 60 g. It is because, the maximum removal could be achieved for the nutrient dosage 60 g and hence, there was no change is difference of removal percentage for the nutrient dosage of 70 g by *Eichhornia crassipes.* Similarly, there was no difference in removal of Zn in an electroplating industry wastewater by *Eichhornia crassipes* for the day 7. Hence, the optimum nutrient dosage found in this study, for the maximum removal of Zn in an electroplating industry wastewater by *Eichhornia crassipes* is 60 g. Thus, the maximum sorption removal percentage of Zn in an electroplating industry wastewater by *Eichhornia crassipes* against nutrient dosage of 60 g was found to be 82.4 % (Fig.3).

3.4. Effect of Eichhornia crassipes Biomass: Fig.4 indicates the experimental investigations conducted by changing the *Eichhornia crassipes* biomass from 20 g to 140 g with an increment of 20 g. The percentage reduction of Zn in an electroplating industry wastewater using *Eichhornia crassipes* against biomass (Since, day 6 is the optimum contact time found from the study, the results obtained on the day 6 was presented and the results obtained by the day 1, 2, 3, 4, 5 and 7 were not presented in this study) with a contact time of 6 days, optimum dilution ratio of 10, optimum pH of 8 and optimum nutrient dosage of 60 g.

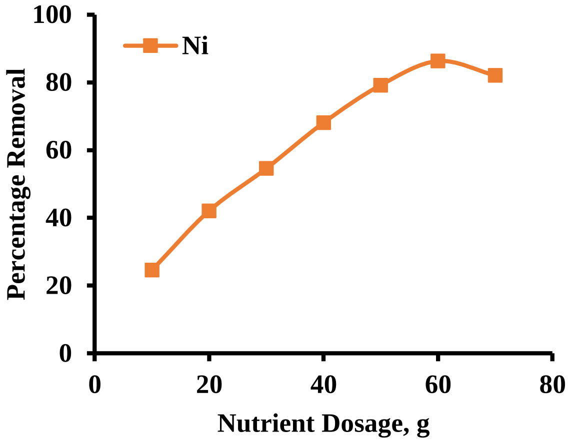

Fig.4 Removal of Ni by *Eichhornia crassipes* against Biomass

The results revealed that the percentage removal of Zn is low by *Eichhornia crassipes* at the low biomass, and then increases with increased biomass. This is because, the supplied low biomass is completely utilized for the removal of Zn in an electroplating industry wastewater, but still there was portion of Zn available for the less biomass condition, which may be sorbed by supplied higher *Eichhornia crassipes* biomass. Up to biomass of 100 g, the sorption of Zn in an electroplating industry wastewater increased steadily and for the biomass of 120 and 140 g, the percentage removal results showed the resembles of the results obtained biomass of 100 g. It is because, the maximum removal could be achieved for the biomass of 100 g and hence, there was no change is difference of removal percentage for the *Eichhornia crassipes* biomass of 120 and 140 g.

Similarly, there was no difference in removal of Zn in an electroplating industry wastewater by *Eichhornia crassipes* for the day 7. Hence, the optimum biomass found in this study, for the maximum removal of Zn in an electroplating industry wastewater by *Eichhornia crassipes* is 100 g. Further, the maximum sorption removal percentage of Zn in an electroplating industry wastewater by *Eichhornia crassipes* against the biomass of 100 g was found to be 85.3 % (Fig.4).

4. CONCLUSION

In the present study, the experiments were conducted to find out the suitability of *Eichhornia crassipes* for removing Zn in an electroplating industry wastewater. The ability of *Eichhornia crassipes* for removing Zn in an electroplating industry wastewater was done against various nutrient dosage, dilution ratio, biomass and pH against the optimum contact time of 6 days. The maximum percentage reduction of Zn in an electroplating industry wastewater by *Eichhornia crassipes* were obtained at an optimum nutrient dosage of 60 g, dilution ratio of 10, biomass of 100 g and pH of 8. The results of this study indicated that the maximum removal percentage of Zn in an electroplating industry wastewater was found to be 85.3 %. This study concluded that the aquatic macrophyte *Eichhornia crassipes* might be used as sorbents for removing Zn in an electroplating industry wastewater. Further, this study may extend to remove any pollutant in not only from electroplating industry wastewater, but also from any industry wastewater.

REFERENCES

APHA, AWWA, and WEF, Standard methods for the examination of water and wastewater, 20th edition, APHA Publication, Washington D.C, 2005.

Ingole N.W, and Bhole A.G, Removal of heavy metals from aqueous solution by water hyacinth (*Azolla Caroliniana*), J Water SRT – Aqua, 52, 2003, 119-128.

Shankar D, Sivakumar D, Thiruvengadam M, Manojkumar M, Colour removal in a textile industry wastewater using coconut coir pith, Pollution Research, 33, 2014a, 490–503.

Shankar D, Sivakumar D, Yuvashree R, Chromium (VI) removal from tannery industry wastewater using fungi species, Pollution Research, 33, 2014b, 505–510.

Sivakumar D, A study on contaminant migration of sugarcane effluent through porous soil medium, Int. J. Environ. Sci. Tech., 8, 2011, 593–604.

Sivakumar D, Balasundaram V, Venkatesan G, Saravanan S.P, Effect of tamarind kernel powder for treating dairy industry wastewater, Pollution Research, 33, 2014c, 519–523.

Sivakumar D, Gayathri G, Nishanthi R, Vijayabharathi V, Sudeshna Das, Kavitha R, Role of fungi species in colour removal from textile industry wastewater, International Journal of ChemTech Research, 6, 2014d, 4366–4372.

Sivakumar D, Hexavalent chromium removal in a tannery industry wastewater using rice husk silica, 1(4), 2015, 27-40.Soltan M.E, and Rashed M.N, Laboratory study on the survival of water hyacinth under several conditions of heavy metal concentrations, Adv. Environ Res., 7, 2003, 82- 91.

Sivakumar D, Kandaswamy A.N, Gomathi V, Rajeshwaran R and Murugan N, Bioremediation studies on reduction of heavy metals toxicity, Pollution Research, 33, 2014e, 553–558.

Sivakumar D, Murugan N, Rajeshwaran R, Shobana T, Soundarya C, Vanitha V.S, Role of rice husk silica powder for removing Cr(VI) in a tannery industry wastewater, International Journal of ChemTech Research, 6, 2014f, 4373–4378.

Sivakumar D, Nouri J, Removal of contaminants in a paper mill effluent by Azolla Caroliniana, 1(4), 2015, 297-304.

Sivakumar D, Role of low cost agro-based adsorbent to treat hospital wastewater, Pollution Research, 2014g, 33, 573–576.

Sivakumar D, Shankar D, Dhivya P, Balasubramanian K, Bioaccumulation study by lemna gibba lin., Pollution Research, 33, 2014h, 531–536.

Sivakumar D, Shankar D, Gomathi V and Nandakumaar A, Application of electro-dialysis on removal of heavy metals, Pollution Research, 33, 2014i, 627–637.

Sivakumar D, Shankar D, Kandaswamy A.N and Ammaiappan M, Role of electro-dialysis and electro-dialysis cum adsorption for chromium (VI) reduction, Pollution Research, 33, 2014j, 547–552.

Sivakumar D, Shankar D, Nithya S, Rajaganapathy J, Reduction of contaminants from leachate using *moringa oleifera*– A kinetic study, Pollution Research, 33, 2014k, 529-529.

Sivakumar D, Shankar D, Vijaya Prathima A.J.R, Valarmathi M, Constructed wetlands treatment of textile industry wastewater using aquatic macrophytes, International Journal of Environmental Science, 3, 2013a, 1223–1232.

Sivakumar Durairaj, Adsorption study on municipal solid waste leachate using moringa oleifera seed, Int. J. Environ. Sci. Technol., 10, 2013b, 113–124.

Sivakumar Durairaj, Experimental and analytical model studies on leachate volume computation from solid waste, Int. J. Environ. Sci. Tech., 10, 2013c, 903–916.

Sivakumar Durairaj, Shankar Durairaj, Colour removal from textile industry wastewater using low cost adsorbents, International Journal of Chemical, Environmental and Pharmaceutical Research, 3, 2012, 52–57.

Turker O.C, Vymazal J.V, Ture C, Constructed wetlands for boron removal: A review, Ecological Engineering, 64, 2014, 350-359.