

International Journal of Innovative Research in Science, Engineering and Technology

(A High Impact Factor, Monthly, Peer Reviewed Journal)

Visit: www.ijirset.com

Vol. 7, Issue 1, January 2018

Industrial Effluent Treatment by Phytoremediation

Joan Savitha¹, T.Vel Rajan²

P.G. Student, Department of Civil Engineering, Thiagarajar College of Engineering, Tiruparankundram,
Madurai, India¹

Professor, Department of Civil Engineering, Thiagarajar College of Engineering, Tiruparankundram, Madurai, India²

ABSTRACT:The drawback of conventional technologies for wastewater treatment have led to serious thinking on alternate, low cost, natural and energy saving technologies on water and wastewater treatment. Methods like phytoremediation which employs floating plants, constructed wetlands etc. for the treatment of wastewater will be a better alternative to the conventional technologies. Floating plants such as water hyacinth has a remarkable ability in treating the polluted water. Hence, the current study is focused on the treatment of industrial effluent using water hyacinth. The objective of the study is to determine the phytoremediation potential of water hyacinth on industrial effluent treatment. Batch study have been employed to find the pollutant reduction efficiency of water hyacinth. Removal efficiencies of about 90-100% was achieved for electroplating wastewater. Thus, water hyacinth is found to be an effective biological organism in removing pollutants in wastewater.

KEYWORDS:Heavy Metals, Phytoremediation, Electroplating wastewater, Water Hyacinth (Eichhorniacrassipes),Removal Efficiency.

I. INTRODUCTION

Water is the essential source of life on the earth as we need water in every walk of life on one side, on other side polluted water can be lethal for existing life. Water pollution is the contamination of water bodies (e.g. lakes, rivers, oceans, aquifers and groundwater). This form of environmental degradation occurs when pollutants are directly or indirectly discharged into water bodies without adequate treatment to remove harmful compounds. Various treatment methods have been employed to cleanup polluted sites. At present a wide range of phytotechnologies have emerged to prevent environmental degradation. Different physical and chemical methods used for this purpose suffer from serious limitations like high cost, intensive labour, alteration of soil properties and disturbance of soil native microflora. Phytoremediation is the name of a set of technologies that use plants to degrade, extract, or contain contaminants from soil and water. This topic has been the great deal of research over the last ten years.

Phytoremediation is the direct use of living green plants for in situ, or in place, removal, degradation, or containment of contaminants in soils, sludges, sediments, surface water and groundwater. The mobilization of heavy metals by man through extraction from ores and processing for different applications has led to the release of these elements into the environment. Since heavy metals are non-biodegradable, they accumulate in the environment. This contamination poses a risk to environmental and human health. Some heavy metals are carcinogenic, mutagenic, teratogenic and endocrine disruptors while others cause neurological and behavioral changes especially in children. Thus remediation of heavy metal pollution deserves due attention. Phytoremediation is a relatively recent technology and is perceived as cost-effective, efficient, novel, eco-friendly, and solar-driven technology with good public acceptance. Phytoremediation is an area of active current research. New efficient metal hyper accumulators are being explored for applications in phytoremediation and phytomining. Molecular tools are being used to better understand the mechanisms

International Journal of Innovative Research in Science, Engineering and Technology

(A High Impact Factor, Monthly, Peer Reviewed Journal)

Visit: www.ijirset.com

Vol. 7, Issue 1, January 2018

of metal uptake, translocation, sequestration and tolerance in plants. It presents great opportunity of using suitable plant species to clean up the environment.

II. LITERATURE REVIEW

Xiaomei Lu, et al (2004) stated toxic heavy metal pollution of water and soil is a major environmental problem, and most conventional remediation approaches do not provide acceptable solutions. Wetland plants were being used successfully for the phytoremediation of trace elements in natural and constructed wetlands. This study demonstrated the phytoremediation potential of water hyacinth (*Eichhorniacrassipes*), for the removal of cadmium (Cd) and zinc (Zn). The phytoaccumulation of heavy metals, Cd and Zn, by water hyacinth (*E. crassipes*), was studied. Water hyacinths were cultured in tap water, which was supplemented with 0.5, 1, 2 and 4 mg/L of Cd and 5, 10, 20, and 40 mg/L of Zn, and were separately harvested after 0, 4, 8 and 12 days. The experiment showed that both Cd and Zn had effects on plant relative growth. Removal of metals from solution was fast especially in the first four days. The accumulation of Cd and Zn in shoots and roots increased with the initial concentration and also with the passage of time. Plants treated with 4 mg/L of Cd accumulated the highest concentration of metal in roots (2044 mg/kg) and shoots (113.2 mg/kg) after 8 days; while those treated with 40 mg/L of Zn accumulated the highest concentration of metal in roots (9652.1 mg/kg) and shoots (1926.7 mg/kg) after 4 days. The maximum values of bioconcentration factor (BCF) for Cd and Zn were 622.3 and 788.9, respectively, suggesting that water hyacinth was a moderate accumulator of Cd and Zn and could be used to treat water contaminated with low Cd and Zn concentrations.

Shoa-Wei Liao, et al (2004) reported the ability of water hyacinth (*Eichhorniacrassipes*) to absorb and translocate cadmium (Cd), lead (Pb), copper (Cu), zinc (Zn), and nickel (Ni) was studied. Translocation ability was defined as the quantity of Cu, Pb, Cd, Ni, and Zn translocated in the plant's tissues, and was expressed as a root/shoot ratio. The ratio results were in the order of $Cu > Pb > Cd > Ni > Zn$. Water hyacinth plants had a high bio concentration of these trace elements when grown in water environments with low concentrations of the five elements. Generally, the concentration of these five elements in the roots was 3 to 15 times higher than those in the shoots. The concentrations in the root tissue were found in the order of $Cu > Zn > Ni > Pb > Cd$. The absorption capacity for water hyacinth was estimated at 0.24 kg/ha for Cd, 5.42 kg/ha for Pb, 21.62 kg/ha for Cu, 26.17 kg/ha for Zn, and 13.46 kg/ha for Ni. This study shows water hyacinth to be a promising candidate for phytoremediation of wastewater polluted with Cu, Pb, Zn, and Cd.

C.O. Akinbil, et al (2010) investigated water hyacinth and water lettuce (*Pistiastratiotes*) to determine their effectiveness in aquaculture wastewater treatment in Malaysia. Wastewater from fish farm in Semanggol Perak, Malaysia was sampled and the parameters determined included, the pH, turbidity, dissolved oxygen (DO), biochemical oxygen demand (BOD), nitrite, phosphate, nitrate (NO_3^-), nitrite, ammonia (NH_3), and total kjedahl nitrogen (TKN). Also, hydroponics system was set up and was added with fresh plants weights of 150 ± 20 grams *Eichhorniacrassipes* and 50 ± 10 grams *Pistiastratiotes* during the 30 days experiment. The phytoremediation treatment with *Eichhorniacrassipes* had pH ranging from 5.52 to 5.59 and from 4.45 to 5.5 while *Pistiastratiotes* had its pH value from 5.76 to 6.49 and from 6.24 to 7.07. Considerable percentage reduction was observed in all the parameters treated with the phytoremediators. Percentage reduction of turbidity for *Eichhorniacrassipes* were 85.26% and 87.05% while *Pistiastratiotes* were 92.70% and 93.69% respectively. Similar reductions were observed in COD, TKN, NO_3^- , NH_3 , and PO_4^{3-} . The capability of these plants in removing nutrients was established from the study.

Xiuxia Chen, et al (2010) investigated both live plants and dried state of water hyacinth were applied to a sequential treatment of swine wastewater for nitrogen and phosphorus reduction. In the facultative tank, the straw behaved as a kind of adsorbent toward phosphorus. The adsorption efficiency was about 36% upon saturation. At the same time, the water hyacinth straw in the facultative tank enhanced NH_3-N removal efficiency as well. However, no adsorption was evident. This study demonstrated an economically feasible means to apply water hyacinth phosphorus straw for the swine wastewater treatment. This study demonstrated a potential to recycle water hyacinth for an economical swine wastewater treatment. According to data contained herein, water hyacinth straw could be useful for waste removal. The material acted as a phosphorus adsorbent and the removal rate varied with the contact time. Compared with similar

International Journal of Innovative Research in Science, Engineering and Technology

(A High Impact Factor, Monthly, Peer Reviewed Journal)

Visit: www.ijirset.com

Vol. 7, Issue 1, January 2018

facilities, the present facultative tank with water hyacinth straws covering the water showed a much greater NH₃-N reduction efficiency. It is speculated that a similar result could be obtained on a large-scale operation, and the present system would be able to achieve WSP treatment effects with less land than the conventional design.

A. Mary Lissy P N., et.al (2010) reported water hyacinth is one of the aquatic plant species successfully used for wastewater treatment. It is very efficient in removing pollutants like suspended solids, BOD, organic matter, heavy metals and pathogens. The study conducted in this regard revealed how efficiently wastewater could be treated using the plant 'Water hyacinth'. The efficiency of waste water treatment was expressed in terms of the variation in pH, biochemical Oxygen Demand (BOD), total Dissolved Solids (TDS) and heavy metals before and after treatment. When the plants were collectively grown, the removal of pollutants from the water was very high. The experimental results have shown that about 65% removal of heavy metals could be achieved by water hyacinth. The plants have also got the capacity to convert the accumulated biomass into biogas. This system of treatment was cost effective since cost of installation and maintenance was very low. This system could be provided alone or together with other systems used for treating waste water. In conclusion, the present investigation demonstrated the feasibility of adopting a "sustainable" and eco-friendly approach to sewage waste water treatment using aquatic plant Eichhornia.

Abolanle S. Adekunle., et.al (2012) carried out a study using water hyacinth as a pollution monitor for the simultaneous removal of heavy metals such as copper (Cu), cadmium (Cd), iron (Fe), zinc (Zn), lead (Pb), chromium (Cr) and aluminium (Al). Effluents were collected from eight industries including paint, textiles, aluminium, galvanizing and battery industries situated in Lagos State, Nigeria. After cultivation of the plant for seven days in a plastic bowl containing each effluent, while sampling was carried out from the bowl everyday, the collected samples were analyzed for Pb, Fe, Zn, Cr and Cu at wavelengths 248.3, 213.7, 357.9 and 324.9 nm respectively using atomic absorption spectrophotometry. Aluminium was determined using UV spectrophotometry and potassium was determined using a flame photometer. The results of the analysis indicated that the range of the heavy metal in the effluents before the cleaning process were Pb (0.1 to 4.4 ppm), Cr (0.39 to 0.5 ppm), Cu (0.08 to 1.65 ppm), Zn (0.7 to 8.7 ppm), Fe (1.2 to 7.5 ppm), Al (0.15 to 1.05 ppm) and Ni (0.6 to 49.2 ppm) while Cd was not detected in none of the effluents. The values were higher than the Federal Ministry of Environment and the World Health Organization effluent limitation guidelines recommended levels. The cleaning experiment showed that water hyacinth has the ability to clean-up the effluents of their heavy metals content by removing about 70 to 90% of their initial concentrations within four to six days of the experimental set-up.

III. METHODOLOGY AND EXPERIMENTAL SETUP

Various types of floating plants like duckweed, water lettuce, pennywort, azolla, water hyacinth used for phytoremediation are analysed. Through the literature survey, it was found that water hyacinth plays a dominant role in treating wastewater. So, water hyacinth had been selected for treatment of electroplating wastewater in this study. Effluent samples were collected from M/S BSA Electroplating and Color coating industry in Madurai in 30L plastic bottles. The initial pH of the effluents was measured. Water hyacinth (*Eichhornia crassipes*) plants were collected from a Vellakal lake in Madurai District. After collection, they were rinsed with tap water to remove any epiphytes and insect larvae grown on plants. The plants were placed in tub with tap water without addition of any nutrient media under natural sunlight for 1 week to let them adapt to the new environment so that the plants can be able to survive for the experiments to be carried over. Then the plants of the same size were selected for the following experiments. To assess the phytoremediation capacity of *Eichhornia crassipes* in the removal of heavy metal pollutants, an experiment was conducted in the laboratory. The initial weight of test plants were taken after keeping them on a filter paper to remove excess water. About 300gm of water hyacinth was taken. The plants were then transferred and spread uniformly into a plastic trough having capacity of 20 litres containing waste water with dilution of 10% and 20%. The experimental setup was placed near window so that, the plant receives enough sunlight. The experiment was carried out for 6 days. After 6 days, treated water was re-taken for heavy metal analysis. *Eichhornia crassipes* was inoculated in waste water of different concentration: i) 10% wastewater and 90% tap water, ii) 20% wastewater and 80% tap water.

International Journal of Innovative Research in Science, Engineering and Technology

(A High Impact Factor, Monthly, Peer Reviewed Journal)

Visit: www.ijirset.com

Vol. 7, Issue 1, January 2018

The wastewater after treatment with water hyacinth are tested using Inductively Coupled Plasma Optically Emitted Spectroscopy (ICP-OES) equipment. Heavy metals analysed are Aluminium, Barium, Cadmium, Cobalt, Chromium, Copper, Potassium, Manganese, Molybdenum, Nickel, Lead, Selenium and Zinc. The below pictures shows the batch study conducted on electroplating wastewater and acclimatization made to adapt the plants to the laboratory condition.



(a)

(b)

(a) Batch study on electroplating wastewater (b) Acclimatization of the water hyacinth plants

IV. RESULTS AND DISCUSSION

Electroplating wastewater was analysed using ICP-OES for heavy metals viz. (Aluminium, Barium, Cadmium, Chromium, Copper, Phosphorous, Manganese, Nickel, Lead, Selenium, Zinc). It was found that the concentration of Barium, Cadmium, Copper, Phosphorous, Nickel, Lead, Selenium are insignificant. Hence, Aluminium, Chromium, Manganese and Zinc had been considered for the study.

Table 1 Characteristics of Electroplating Effluent

S.NO	PARAMETERS	CONCENTRATION (mg/L)
1	Zinc	19.17
2	Chromium	13.99
3	Manganese	1.38
4	Aluminium	0.65
5	Barium	0.39
6	Copper	0.28
7	Nickel	0.23
8	Molybdenum	0.06
9	Lead	0.03
10	Selenium	0.01

The above table explains about the initial concentration of various heavy metals present in the raw electroplating wastewater. Among the heavy metals observed, Zinc and Chromium has a higher concentration when compared to other parameters.

International Journal of Innovative Research in Science, Engineering and Technology

(A High Impact Factor, Monthly, Peer Reviewed Journal)

Visit: www.ijirset.com

Vol. 7, Issue 1, January 2018

Table 2 Results on 10% Electroplating Effluent

S.NO	PARAMETERS	CONCENTRATION OF 10% EFFLUENT (mg/L)	CONCENTRATION OF TREATED EFFLUENT(mg/L)	REMOVAL EFFICIENCY
1	Chromium	1.400	0.010	99.99%
2	Zinc	1.917	0.021	98.9%
3	Manganese	0.138	0.060	95.6%
4	Aluminium	0.065	0.040	93.8%

From the above table, it was shown that Chromium, Zinc, Manganese and Aluminium had removal efficiency of about 99.99%, 98.9%, 95.6%, 93.8% respectively on 10% dilution of electroplating wastewater using water hyacinth plant. It is concluded that Chromium shows the greater removal efficiency.

Table 3 Results on 20% Electroplating Effluent

S.NO	PARAMETERS	CONCENTRATION OF 20% EFFLUENT(mg/L)	CONCENTRATION OF TREATED EFFLUENT(mg/L)	REMOVAL EFFICIENCY
1	Zinc	3.834	0.020	98.9%
2	Chromium	2.800	0.010	99.9%
3	Manganese	0.276	0.010	99.2%
4	Aluminium	0.130	0.040	93.8%

In the case of 20% dilution of electroplating wastewater, it was shown that the removal efficiency of Zinc, Chromium, Manganese and Aluminium are 98.9%, 99.9%, 99.2% and 93.8% respectively. Among these heavy metals, it was found that chromium shows the best removal efficiency of about 99.9% with 10 and 20% dilution.

V. CONCLUSION

Water hyacinth proved to have the remarkable ability in treating industrial wastewater. It gave a removal efficiency of about 90 – 100% in heavy metals. Among the other aquatic plants, water hyacinth has been investigated extensively as wastewater purifier. But it cannot withstand high concentration of toxic elements in wastewater. So one can conclude that Phytoremediation technology is one of the important technologies, and when such technologies are merged with existing technologies they can be proved as efficient technologies.

REFERENCES

- [1] Orth H. M and Sapkota D. P., “ Upgrading a facultative pond by implanting water hyacinth” Wat. Res, Vol.No. 22, pp.1503-1511, 1988.
- [2] R. K. srivastav., S. K. Gupta., K.D.P. Nigam and P. Vasudevan., “Treatment of chromium and nickel in wastewater by using aquatic plants”, Wat. Res. Vol.No. 28, Issue No. 7, pp. 1631-1638, 1994.
- [3] Muramoto S and Oki Y., “ Removal of some heavy metals from polluted water by water hyacinth (Eichhorniacrassipes)”, Bull. envir. Contam.Toxic.Vol.No. 30, pp.170-177, 1983.
- [4] Zaranyika., M. F and T. Ndapwadza., “Uptake of Ni, Zn, Fe, Co, Cr, Pb, Cu and Cd by water hyacinth (Eichhorniacrassipes) in Mukuvisi and Manyame rivers, Zimbabwe.”, J. Environ. Sci. Health A, Vol.No.30, pp.157-169, 1995.
- [5] Kawai H., Uehara M. Y., Comes J. A., Jahnel M. C., Rossetto R., Alem P., Roberio M. D., Tinel, P. R and Gricco V. M., “Pilot-scale experiments in water hyacinth lagoons for waste treatment.”, Wat. Sci. Technol, Vol.no.19, pp.129-173, 1987.
- [6] McDonald R. C and Wolverton B.C., “Comparative study of wastewater lagoon with and without water hyacinth”, Econ. Bet, Vol.no.34, pp.101-110, 1980.

International Journal of Innovative Research in Science, Engineering and Technology

(A High Impact Factor, Monthly, Peer Reviewed Journal)

Visit: www.ijirset.com

Vol. 7, Issue 1, January 2018

- [7] Q. Mahmood., P. Zheng., E. Islam., Y. Hayat., M. J. Hassan., G. Jilani and R.C. Jin., “Lab Scale Studies on Water Hyacinth (Eichhorniacrassipes Marts Solms) for Biotreatment of Textile Wastewater”, Caspian J. Env. Sci., Vol.No. 3, Issue No.2, pp. 83-88, 2005.
- [8] Tripathi B. D and Shukla, S. C., “Biological treatment of wastewater by selected aquatic plants”, Environmental Pollution, Vol.No.69, pp.69-78, 1991.
- [9] Youngchulkimand Wan-joongkim., “Roles of water hyacinths and their roots for reducing algal concentration in the effluent from waste stabilization ponds”, Wat. Res, Vol.No. 34, Issue No. 13, pp. 3285±3294, 2000.
- [10] KasemChunkao., ChatriNimpee and KittichaiDuangmal., “The King’s initiative using Water hyacinth to remove heavy metals and plant nutrients from wastewater through BuengMakkasan in Bangkok, Thailand”, Ecological Engineering, Vol.No.39, pp.40- 52, 2012.
- [11] Chongrakpolprasert and Nawa raj khatiwada., “An integrated kinetic model for water hyacinth ponds used for wastewater treatment”, Water Resources, Vol.32, No.1, pp.179-185, 1998.
- [12] 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, Vol.No.7, pp.82- 91, 2003.