Removal of Metals using *Cucurbita pepo* (Pumpkin) as a Bio-coagulant

Punem Deepthi[1]*, C. Sarala[2], Khagga Mukkanti[3] and P. Sharath Kumar[4]
1. Centre for Environment, IST, JNTUH Kukatpally-085, Telangana, INDIA
2. Centre for Water Resources, IST, JNTUH, Kukatpally-085, Telangana, INDIA
3. Centre for Chemical Science and Technology, IST, JNTUH, Kukatpally-085, Telangana, INDIA
4. Telangana State Pollution Control Board, Hyderabad, Telangana, INDIA
*cindrella.deeps@gmail.com

Abstract

The water resources of the world are being polluted through various anthropogenic activities. The World Health Organization (WHO) roughly calculated that up to 80% of all disorders and sickness in the world is due to polluted water or lack of safe drinking water. Indian population is counting on the untreated surface water which is the root cause of their illness, as reports have established that 90% of human sickness in rural areas may be considered due to polluted water supply. Metals are toxic inorganic contaminants unlike the organic contaminants which can be degraded by microorganisms, where it makes compulsion for their removal from the water bodies. Due to the disadvantages of conventional treatment methods, there has been an extensive research for alternative eco-friendly methods to remove metals.

In the present study, the efficiency study of Cucurbita pepo (Pumpkin) is carried out for the removal of metals. The results concluded that Cucurbita pepo (Pumpkin) in the powdered form acts as a good bio-coagulant showing its best efficiency with 59% of nickel and 87.25% of iron removal. Use of bio-coagulants is approved for non-toxic, eco-friendly, simplified water treatment method for rural people depending on the contaminated drinking water.

Keywords: Bio-coagulant, *Cucurbita pepo* (Pumpkin), Non-toxic, Eco-friendly, Contaminated water, Metal removal, Rural people.

Introduction

Day to day, the increase in population, economic development and mainly because of anthropogenic actions, the water bodies are being polluted. Environmental pollution is currently one of the most important issues[13]. Among different known forms of pollution, water pollution is of major concern as water is vitally important.

Nevertheless, years of increased commercial and domestic activities resulted in the cause of huge amount of waste water containing toxic pollutants[1]. Most of the metal pollutants are introduced into the ecosystem as a result of various industrial operations such as mining, smelting, surface fishing industry, energy and fuel production, fertilizer, pesticides etc.[15] Among the chemical intensive industrial wastes, metals like Cd, Cr, Cu, Ni, As, Pb, Fe and Zn are the most hazardous due to their high solubility in the aquatic bodies. Metals from industrial wastes are of great concern as they produce chronic diseases in amphibious animals[14].

In general, many conventional methods for metal removal from aqueous solutions include Reverse osmosis[16], Chemical precipitation[10], Ion exchange[5], Solvent extraction[6], Electrodialysis[3], Coagulation and Flocculation[11], Microbial reduction[12] and Filtration[9] but the major concern is that these methods generate toxic sludge, require more man power , high expensive equipment and mainly these are not eco-friendly .

Besides, plant based bio-coagulants are biodegradable and are known to be safe for human health. The plant material extracts are used to treat water for domestic household from decades. In the present work, *Cucurbita pepo* (Pumpkin) was used as a bio-coagulant to treat the metals from aquatic bodies. The main objective of the study is to investigate the efficiency of locally available bio-coagulant to treat the metals which can be an alternative for chemical coagulants in the present scenario.

Material and Methods

Preparation of Bio- Coagulant: *Cucurbita pepo* (Pumpkin) was used as a bio-coagulant in the present research work. *Cucurbita pepo* (Pumpkin) was collected from Rythu market. The seeds are departed from the fruit and are dried under the sun for 3 to 5 days. The dried seeds (Fig. 1) are crushed by using the mortar and pestle into a fine powder. The fine powder (Fig. 2) is stored in air tightened packets and used for the experimental work.

The required dosage of seed powder is made into a paste which was mixed in a little quantity of water and stirred with a glass rod for 1 min to activate the coagulant properties of the seed.

Fig. 1: Dried seeds of *Cucurbita pepo*

Fig. 2: Fine powder

Preparation of Stock Solution: Stock solution of 1000ppm of nickel sulphate ($NiSO_4.6H_20$) and Ferrous sulphate ($FeSO_4.7H_20$) was prepared using distilled water. The required concentrations of 2ppm, 4ppm and 6ppm are produced from the prepared stock solution.

Fig. 3: Jar Apparatus

In the present work, the jar test apparatus (Fig. 3) was used to treat the samples with bio-coagulants. A set of beakers filled with 1000 ml of the sample with known concentrations of Ni^{+2} and Fe^{+2} were added to 1000 ml of deionised water to get the required concentrations of 2ppm, 4ppm and 6ppm. Various doses of bio-coagulant (0.5 gm/l, 1gm/l and 2 gm/L) were added to the sample and stirred at constant speed of 100 RPM, contact time of 30 minutes and pH neutral. After the contact time, the suspension was allowed to settle by varying settling time intervals (30, 60, 90 min.). Immediately after the required settling time periods the suspension was filtered using Whattmann filter paper no. 1. The metal concentrations in the treated samples were analyzed using AAS. A triplicate test was done to get the average of the results. The following equation is used to get the efficiency percentage removal of metal ions by bio-coagulant.

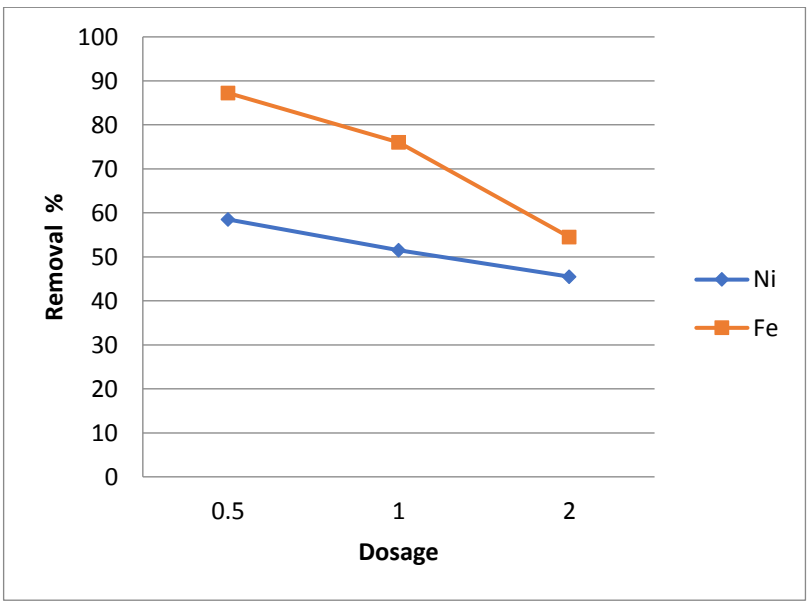
Percentage Removal = (Ci –Cf / Ci) X 100

where Ci and Cf are the initial and final metal ion concentrations respectively.

Results and Discussion

A lot of fluctuations occur during the treatment process. The parameters such as temperature, stirring time, pH, coagulant dosage, ionic strength and competition between metal ions have a notable effect on metal binding to adsorbent, the biomass also induces the treatment process; as the adsorbent dose increases, the number of adsorbent particles also increases and there is greater availability of sites for adsorption[2]. Bio-coagulant has not shown any alteration of water sample pH during the process and also after the treatment.

Effect of Bio-Coagulant Dosage: Bio-coagulant dosage is the most important parameter as it shows the capacity of a bio-coagulant for a given concentration of the adsorbate under required operating conditions. Graph 1 indicates the effect of bio-coagulant dosage on Ni^{+2} and Fe^{+2}. It is shown in the figure that the removal percentage decreases from 58.5% to 45.5% for nickel and from 87.25% to 54.5% for iron, with increase of bio-coagulant dosage from 0.5-2 grams, however no significant increase in the removal capacity was observed on further increasing the dosage of natural coagulant due to accomplishment of equilibrium between adsorbate and adsorbent at the operating conditions providing adsorbent incapable of further adsorption[7].



Graph 1: Effect of coagulant dosage on Ni^{+2} and Fe^{+2} by *Cucurbita pepo* (pumpkin)

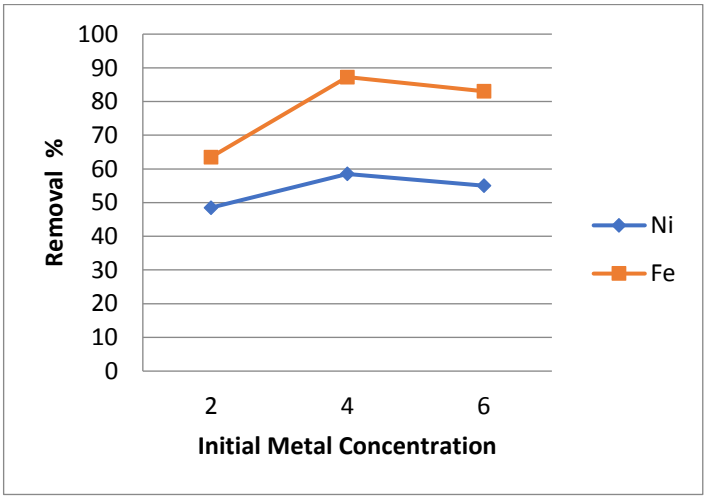
Effect of Initial Concentration: The effect of initial concentrations (2,4 and 6ppm) on treatment process (in terms of percentage removal) by *Cucurbita pepo* (Pumpkin) was studied as shown in graph 2. The pH of synthetic metal ion of the solution was kept neutral -7, the dosage of bio-coagulant (0.5gms, 1gms, 2gms) is added and kept for agitation time of 30 mins.

From the study, the *Cucurbibta pepo* had shown optimum efficiency removal of nickel and iron at 4ppm of metal concentration. it was shown that the percentage removal of nickel and iron increases with increase in initial concentration, further declined where bio-coagulant has not shown any change further and attained equilibrium with increase in the initial metal concentration. This may be explained as the number of active binding sites of adsorbent and competing of metal ions on the surface of adsorbent decreasing further adsorption of metal ions at higher concentrations, therefore more metal ions were left un-adsorbed in solution at further increase in concentration levels[8].

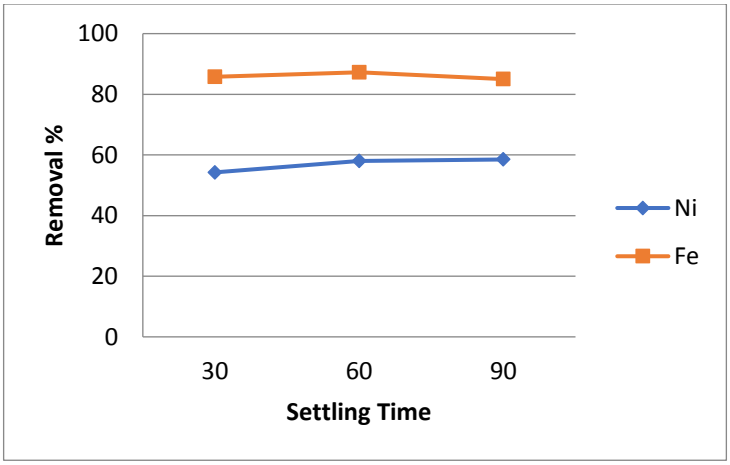
Effect of Settling time: The effect of different settling time (30, 60, 90 mins) on the efficiency of *Cucurbita pepo* (Pumpkin) was carried out by varying metal ion concentrations (2, 4, 6 mg/L), coagulant dosage (0.5gm, 1gm, 2 gms) and an optimum pH (7), agitation time (30 mins) throughout the study. The bio-coagulant had shown efficiency with 59% removal of nickel and 87.25% removal of iron at 90 and 60 mins respectively.

From the graph 3 it was shown that removal percentage of nickel and iron increased with increase in settling time and further increase in settling time had shown decline in the percentage removal and attained equilibrium after 90 mins of settling time. The decrease in the removal may be due to the disassociation of the coagulant and metal ions. A drastic removal of nickel is at 90 mins and iron is seen at 60 mins of settling time. The disassociation of proteins might occur at the 90mins of settling time which resulted in the decrease of the metal removal.

From the obtained results, it was investigated that the efficiency of bio-coagulants from plant material (seeds) in treating the metals from contaminated water provides an attainable, simple, eco-friendly, low-cost water treatment method for rural communities in India. *In vitro* studies using prepared water samples have shown that *Cucurbita pepo* seeds (Pumpkin) have more efficiency in treating and removing metals from contaminated water.



Graph 2: Effect of Initial Metal Concentration on Ni^{+2} and Fe^{+2} by *Cucurbita pepo* (Pumpkin)



Graph 3: Effect of Settling time on Ni^{+2} and Fe^{+2} by *Cucurbita pepo* (Pumpkin)

It was also observed that the bio-coagulant seed powder does not affect the pH of the water. Moreover, the efficiency of the seed powder at its finest size reduced the metal levels drastically. The more efficiency of the seed powder may be due to its vast total surface area, whereby most of the water-soluble proteins are at the solid-liquid interface during the extraction process[4]. This may increase the concentration of active coagulants in the extract, which improved the coagulation process.

Conclusion

Cucurbita pepo (Pumpkin) seeds are a high capacitate, economically viable, low cost bio-coagulant for the removal of nickel and iron. The efficiency of cucurbita pepo (pumpkin) for the removal of nickel and iron has been experimentally investigated. The bio-coagulant had shown 58.5% and 87.25% removal at optimum dosage of 0.5gms, metal concentration of 4ppm, 90 and 60mins of settling time for nickel and iron respectively. This study can conclude that cucurbita pepo is the favorable alternative of nickel and iron removal from water.

Acknowledgement

Authors sincerely thank the University Grand Commission under Rajiv Gandhi National Fellowship (UGC-RGNF) for funding and supporting financially for the completion of work.

References

1. Bhatnagar Amit and Minocha A.K., Conventional and non conventional adsorbents for removal of pollutants from water, *Indian Journal of Chemical Technology*, **13**, 203-217 **(2006)**

2. Cleide S.T. et al, Bioremediation of Waters Contaminated with Heavy Metals Using Moringa oleifera Seeds as Biosorbent, *Applied Bioremediation - Active and Passive Approaches*, http://dx.doi.org/10.5772/56157 **(2013)**

3. Delimi R., Boutemine N. and Benredjem Z., Removal of heavy metals from Water Rinsing of Plating Baths by Electrodialysis, E3S Web of Conferences, DOI: 10.1051/ e3sconf,25011 **(2013)**

4. Gassenschmidt U., Jany K.D. and Tauscher B., Isolation and characterization of a flocculating protein from *Moringa oleifera* Lam, *Biochem Biophys Acta*, **1243**, 477 – 481 **(1995)**

5. Gaikwad R.W., Sapkal V.S. and Sapkal R.S., Ion exchange system design for removal of heavy metals from acid mine drainage wastewater, *Acta Montanistica Slovaca Ročník*, **15**, 298-304 **(2010)**

6. Joanna Konczyk, Cezary Kozlowski and Wladyslaw Walkowiak, Lead(ii) removal from aqueous solutions by Solvent Extraction with Tetracarboxylresorcin [4]arene, *Physicochem. Probl. Miner. Process*, **49**, 213−222 **(2013)**

7. Kumar Rohit Raj, Kardham Abhishek, Arora Jyoti Kumar, Srivastava Man Mohan and Srivastava Shalini, Neural net work modeling for Ni removal from aqueous system using shelled moringa oliefera seed powder as an agricultural waste, *J. water Resource and Protection*, **2**, 331-338 **(2010)**

8. Kafia Shareef Surchi M., Agricultural Wastes as Low Cost Adsorbents for Pb Removal: Kinetics, Equilibrium and Thermodynamics, *International Journal of Chemistry*, **3**, 103-112 **(2010)**

9. Swaminathan Klamath, Nagappan Saravanan, Rajangam Padmavathi and Dharmalingam Sangeetha, Separation of Ni2+, Cu2+ and Cr6+ Metal Ions from Water by Complexation Micro Filtration Technique Using Synthetic Polymer Membranes, *Progress in Nanotechnology and Nanomaterials*, **2**, 47-54 **(2013)**

10. Mahmood Brbooti M., Balasim A. and Najah M., Removal of Heavy Metals Using Chemicals Precipitation, *Eng.& Tech. Journal*, **29(3)**, 595-612 **(2011)**

11. Johnson Pauline D., Girinathannair Padmanabhan, Ohlinger Kurt N., Ritchie Stephen, Teuber Leah and Kirby Jason, Enhanced Removal of Heavy Metals in Primary Treatment Using Coagulation and Flocculation, *Water Environment Research*, **80**, 472-479 **(2008)**

12. Ronald R.H., Cohen, Use of microbes for cost reduction of metal removal from metals and mining industry waste streams, *Journal of Cleaner Production*, **14**, 1146-1157 **(2006)**

13. Renge V.C., Khedkar S.V. and Pande Shraddha V., Removal of heavy metals from wastewater using low cost adsorbents: A Review, *Scientific Reviews & Chemical Communications*, **2**, 580-584 **(2012)**

14. Sabat Sasmita, Kavitha R.V., Shantha S.L., Nair Gopika, Ganesh Megha, Chandroth Niranjana and Krishna Murthy V., Biosorption; an ecofriendly technique for the removal of heavy metals, *Indian Journal of Applied Research*, **2**, 1-8 **(2012)**

15. Shi W., Becker J., Bischoff M., Turco R.F. and Konopka A.E., Association of Microbial Community Compositionand Activity with Lead, Chromium and Hydrocarbon Contamination, *Applied and Environmental Microbiology*, **68**, 3859-3866 **(2002)**

16. Tomáš Bakalár, Milan Búgel and Lucia Gajdošová, Heavy metal removal using reverse osmosis, *Acta Montanistica Slovaca Ročník*, **14**, 250-253 **(2009)**.

(Received 28th July 2020, accepted 25th September 2020)