ZINC REMOVAL BY USING LOW COST ADSORBENTS AND COMPARISON WITH ACTIVATED CARBON

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Abstract - *Heavy metal removal by adsorption process are the most common method used for treating contaminated water. The focus of this research was to determine if natural materials such as dry leaves and agricultural residues such as sugarcane bagasse might be used as low-cost adsorbents, as well as a 1:1 combination of both for zinc removal. Method used were Batch process with variables like time of contact, dosage and pH and column process with factors rate of flow and bed height. In batch process mixture of adsorbent gave good results with 84.68% removal where pH was an important factor which influenced the removal process of zinc. In the column process, bed height had a crucial effect, with dry leaves removing 98.63 % of zinc. After comparing it with commercially available activated carbon results from other researches done before it gives similar results.*

Key Words: *Zinc, Dry leaves, sugarcane bagasse, Mix ratio 1:1, Batch process, Column process.*

1. INTRODUCTION

Since water is important resource of the biosphere, it is polluted after being used in daily life leading to water pollution. One of major contaminant are heavy metals, considered as one of the potential contaminant after dye and are lethal even at low concentrations as non-biodegradable . Due to heavy metals being highly soluble in water environments, they are naturally absorbed by fishes and vegetables. When these metals are come in contact with human, they are probing into our body by water, food, air or absorption through skin leading to health problems [Himanshu Patel, 2020].

In environment one of the main source for pollution is Industrial wastewater. Therefore, monitoring heavy metal discharge to water bodies is very important. As per World Health Organization these 10 metals that are Ni, Mn, Zn, Co, Se, Ti, Cr, Cu, and Sb are of main public worry. These metals which are accessible from earth's crust layer in small concentration and originate in their metallic and elemental form with other inorganic materials like sulphate, oxide, carbonate, or rock. [Himanshu Patel, 2020].

Zinc is a beautiful bluish-white metal that belongs to group II B in periodic table. When heated between 110°C and 150°C, it is brittle and crystalline but ductile and pliable. It reacts readily with oxygen and other non-metals, as well as dilute acids, to produce hydrogen. Its uses are galvanization of steel, preparation of some alloys, manufacture of the negative plate in electrical batteries, as a pigment in cosmetics, plastics, wallpaper, printing inks, and photocopier paper etc., during manufacture of rubber used as a catalyst and in final product as a heat disperser. Also as it possess anti-oxidant properties it is used in single tablets for reducing early mature of the skin and muscles tissues of the human body [Charif Gakwisiri et al, .2012].

Now when zinc used in the above process the industrial discharge contains zinc as the pollutant present in large quantities .If this discharge is not purified satisfactorily and is discharged there can be many problems such as the deposition of zinc-polluted sludge on river banks [Charif Gakwisiri et al, .2012], it may lead to acidification of water, bio-magnification of food chain through bio accumulation in fish ,crops when consumed by human and animals, groundwater can get contaminated ,can be a risk to some of the plant species growth. Particularly in humans the essential zinc required is 10 to 20mg in the diet, more than this it leads to anaemia, damage the pancreas and decrease the levels of cholesterol.

For removal of the heavy metal pollutants from water number of process have been used such as precipitation, ozonation, ion exchange, electro dialysis, electrodeposition, adsorption and filtration. However, some of these methods use chemicals which are again a concern to public and these methods are costly [Salim.R and R. Abu el-halawa, 2002]. Thus to keep safety and economical methods in mind there is an increased interest towards adsorption process with low cost adsorbent for elimination of heavy metal from contaminated water. [Naba Kumar Mandal, 2014].

The adsorption process are been used in heavy metal removal for a extended time due to its advantage in removing the heavy metal contaminants present in small trace concentrations where other methods become inefficient , such as reverse osmosis, chemical precipitation [Tonni Agustiono Kurniawan et.al,2005]. Several research have been done on heavy metals removal where most of the adsorbent used is commercially available activated carbon. Heavy metal reduction with marketable activated carbon is efficient, with removal rates ranging from 45 to 70% in batch processes and 64 to 98 percent in column processes, however the high cost and loss during regeneration limit its use. As a result, in this investigation, commercial activated carbon was replaced with uncommon, low-cost, and locally accessible adsorbents. The extensive use of cost effective adsorbents for treatment of wastewater is due to their resident availability, technical viability, applicable in engineering and cost-efficiency. As a result, agricultural wastes or by-products from agriculture businesses are regarded low-value goods, such as banana peel, orange peel, lemon peel, mango peel, pomegranate peel, and other bio adsorbents that are readily accessible in local markets. Now, waste from the food and agriculture processing sectors, such as shells, seeds, and peels, is used as a bio adsorbent to extract heavy metals from wastewater. Many locally accessible wastes, such as leaves shed by trees and other naturally occurring trash, can also be used. The development of new actions for the treatment of wastewater based on raw materials which are of low-cost with high efficiency in pollutant removal are in need[Neetesh Kumar Dehariya, 2018]

Certain study such as Aydına et al. 2009, for removal of copper Lentil (LS), Wheat (WS), and Rice (RS) were used, Francisco et al. 2013 Sugar Cane Bagasse,used for removl of copper and zinc, Himanshu Patel 2020,neem leaf used to remove Pb,Cu,Cr,Zn,Ni and Cd have shown that low cost adsorbent give similar results as commercially available activated carbon.

The present study was conducted to evaluate the zinc removal potential of selected adsorbent that is dry leaves, sugarcane bagasse, and the both of these adsorbent in mixture of ratio1:1.the two process which were selected for the study was batch process and column process. The following factors were selected that is the effects of pH, contact time, adsorbent dose in batch process and in the column process the factors were bed height and flowrate. After the results were obtained they were analyzed for adsorption isotherms and also were compared with the activated carbon results from various researches done for zinc removal.

2. MATERIALS AND METHODOLOGY

The dry leaves are available in abundance. The dry leaves selected for removal of the zinc metal were collected from Shree Khantheshwara park Banshankari 3rd stage Bangalore. These dry leaves mainly are from trees sky fruit, gooseberry, and jackfruit. Another adsorbent sugarcane bagasse is the fibrous residue obtained after the crushing sugarcane stalks which is most abundant residue from agro-industries. Sugarcane bagasse was collected from road side juice hawker in Banshankari 3rd stage Bangalore.

2.2 ADSORBENT PREPARATION

The Dry leaves collected were dried for a period of three days and cleaned with distilled water and sun dried. Later leaves were grounded with the grinder, the powdered leaves was sieved (Indian standard sieve 300). This powder was then washed several times with distilled water to remove lighter materials and other impurities, afterwards the material was dried in sun and stored for experimental usage (Sohail Ayub et al, .2006).

Sugarcane bagasse collected, chopped into small bits and washed for with tap water then with distilled water to remove the dust and dirty, later wet sugarcane bagasse was sun dried .This was grind into powder, sieved (Indian standard sieve 300) and stored for experimental usage (Ahmad S et al, .2018).The zinc solution used for the study was prepared from $ZnSO4.7H2O$. 100ml of stock solution was used to make zinc solution of 1 litre, with a concentration 100 mg/l. The Dithizone method I is consider in zinc concentration determination and calibration curve was prepared for determining the unknown concentration of zinc mentioned in the"Standard Methods: for the examination of water and wastewater", 2017, p.225, 328.B.

2.3 METHOD USED FOR ADSORPTION PROCESS

Batch process and fixed column bed process were used for adsorption of zinc. The experiment was carried out in the Environmental Laboratory of Civil Engineering Department, UVCE, Bangalore University Jnanabharathi campus, 560056.

In the Batch Process, known amount of adsorbent is combined with the sample, agitated for a period of time, then filtered and tested for zinc content. The influence of contact duration, dose, and pH was investigated. [Sohail Ayub et al, .2006].

In Column process an uninterrupted flow of zinc solution was passed to the columns by gravity which contains the adsorbent selected and the discharge from the column are collected in a container below and analyzed for the zinc concentration. The effect of bed height and rate of flow were studied [Himanshu Patel 2020].

3. RESULTS AND DISCUSSION

The experimental data obtained during the adsorption studies were used to evaluate the effect of adsorbent dose, contact time and influence of pH in batch process, where flowrate, bed height in column process. The feasibility of an adsorbing system is determined by plotting adsorption isotherms. Batch and Column studies are compared for its removal efficiency.

Comparison of dry leaves, sugarcane bagasse and mixture in ratio 1:1 adsorbents

The investigations reveal that adsorbents surfaces (dry leaves, sugarcane bagasse and mixture in ratio 1:1) can be used as effective adsorbents for the Zn removal. Adsorption process the contact time has important role as the contact time increases the adsorption increases giving the adsorbent to adsorb the adsorbate on its surfaces as in Fig.-1 the mixture of ratio 1:1 shows higher removal compare to the dry leaves and sugarcane bagasse used separately.

Adsorption of zinc is highly pH dependent as in Fig. -3, the best results obtained for pH 4, 7, and 8. The increased amount of $H+$ ions present at low pH values, which in turn neutralise the negatively charged hydroxyl group (-OH) on the adsorbed surface, lowering the impediment to zinc ion diffusion, may be the explanation for the greater adsorption capacity seen at these pH values[15]. Reduced adsorption may be possible at lower pH due to an excess of OH- ions that obstruct the passage of positively charged zinc ions. The surface is active for the adsorption of cations at higher pH values due to the accumulation of OH ions [15]. Similar observations were recorded through the studies directed on dihydric phenol elimination on activated carbon by Mahesh, et al., (2013) and Sharma, et al., (2016) used sphagnum moss peat for the elimination of chromium and zinc.

It is has been detected that the % reduction increases with cumulative adsorbent dose. 2.5 g dose of adsorbents used was sufficient to adsorb zinc from the solution with initial concentration of 100 mg/l where dry leaves removed 57.84 %, sugarcane bagasse removed 28.18% and the mix ratio used removed 84.68 % of zinc Shown in Fig. -2. Similar results were reported by (Ayub, et al., 2013, Rao, et al., 2002; Bansal and Sharma, 2012; Kim and Joltech, 2015; Singh, et al., 2012; Mall, 2010). Because of the saturation of the adsorbent surface, zinc removal is rapid in the onset and substantially slower in the latter stages.

In column process rate of flow and bed height obtained were 1ml/min and 20cm respectively where decrease in flowrate and increase in the bed height gave good removal efficiency similar study carried out by Himanshu Patel, 2020.the removal efficiency in column process is seen to be in rage of 95 to 98 % for the adsorbents used but the mix of the dry leave san d sugarcane bagasse have a better removal.

The extent of removal depends on the adsorbent dose, contact time, pH and rate of flow and bed height. Mix of ratio 1:1 is found to be superior to dry leaves and sugarcane bagasse used separately, as shown in Fig.-1 to 9 for both the batch and column process with respect to the removal efficiency of the above metal. The removal efficiency ranges from 50% - 90% in both the batch and column process and in comparison column process gave better results as shown in Tab.-1.

Table-1: Comparing the Removal % of Zinc by Both Batch and Column Process

Adsorbent	Dry leaves	Sugarcane Bagasse	Mixture ratio 1:1
Batch process	57.96%	28.18%	84.68%
Column Process	98.63%	95.65%	95.99%

For all the adsorbents, the Freundlich, Langmuir and BET adsorption isotherms were plotted and the isotherms are given in the Fig. – 10, 11, 12. Hence it can be stated that the adsorption isotherm is represented more closely by Freundlich and BET adsorption isotherm for dry leaves sugarcane bagasse and mix ratio 1:1, while Langmuir adsorption isotherm for holds good only for mix ratio 1:1.Thus over all the mixture of both the adsorbent in ratio 1:1 follows all the three adsorption isotherms.

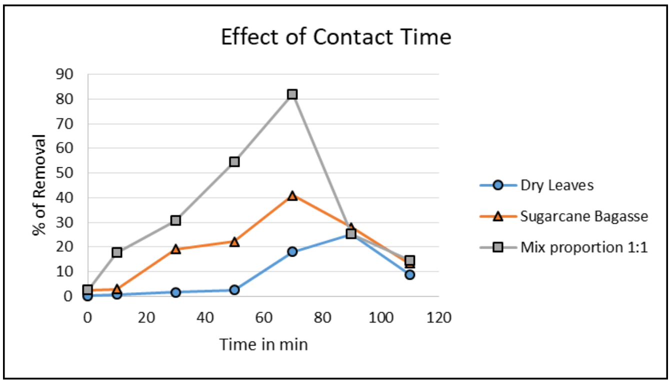

Figure -1: The Role of Contact Time Zinc Removal by Adsorbent: Dry Leaves, Sugarcane Bagasse and Mixed Ratio 1:1

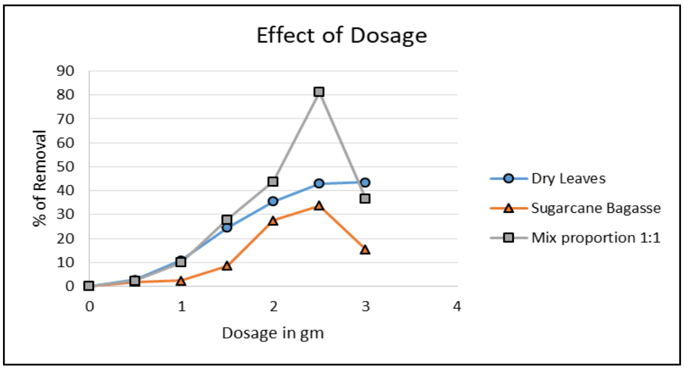

Figure -2: Effect of Dosage on Zinc Removal by Adsorbent: Dry Leaves, Sugarcane Bagasse and Mixed Ratio 1:1

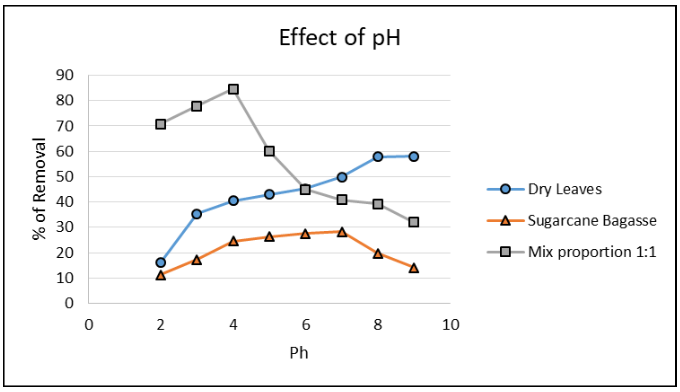

Figure -3: Effect of pH on Zinc Removal by Adsorbent: Dry Leaves, Sugarcane Bagasse and Mixed Ratio 1:1

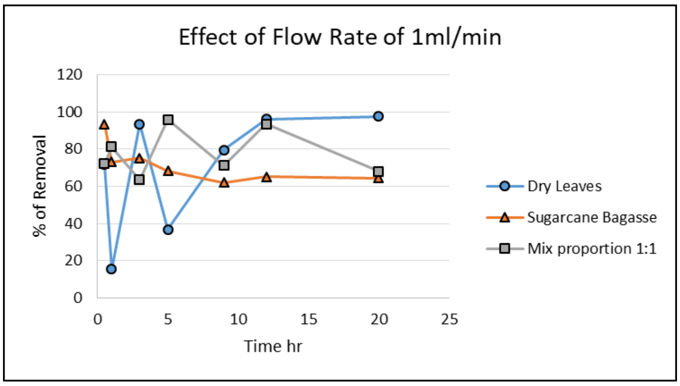

Figure -4: Effect of Flow Rate of 1ml/min on Zinc Removal by Adsorbent: Dry Leaves, Sugarcane Bagasse and Mixed Ratio 1:1

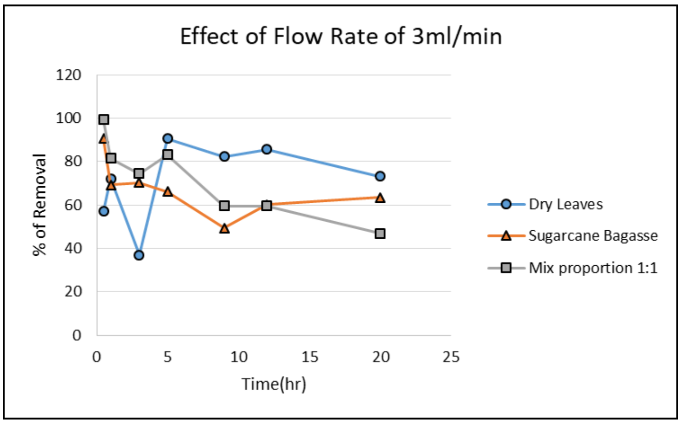

Figure -5: Effect of Flow Rate of 3ml/min on Zinc Removal by Adsorbent: Dry Leaves, Sugarcane Bagasse and Mixed Ratio 1:1

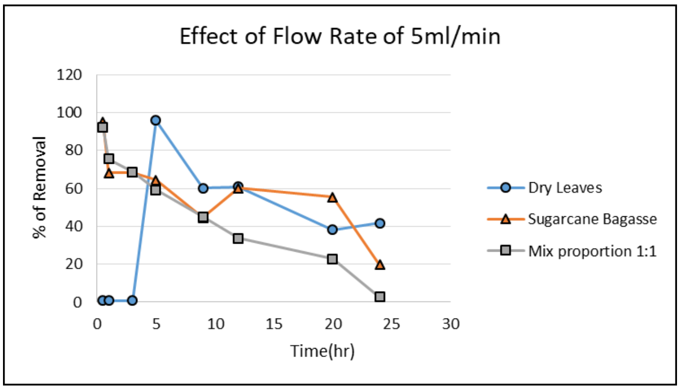

Figure -6: Effect of Flow Rate of 5ml/min on Zinc Removal by Adsorbent: Dry Leaves, Sugarcane Bagasse and Mixed Ratio 1:1

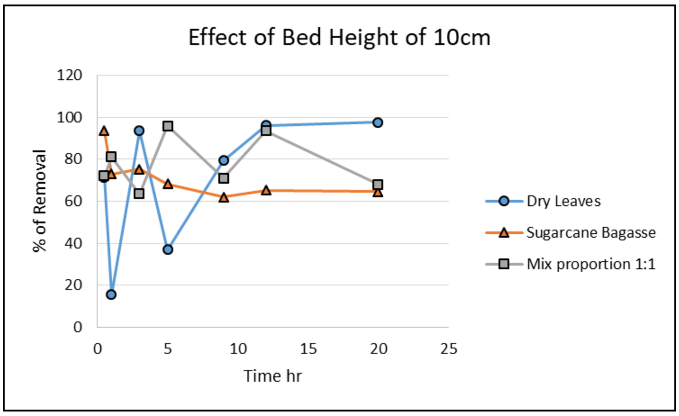

Figure -7: Effect of Bed Height of 10cm on Zinc Removal by Adsorbent: Dry Leaves, Sugarcane Bagasse and Mixed Ratio 1:1

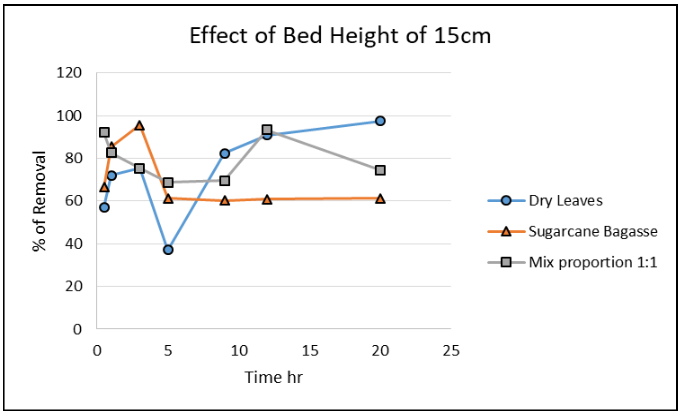

Figure -8: Effect of Bed Height of 15cm on Zinc Removal by Adsorbent: Dry Leaves, Sugarcane Bagasse and Mixed Ratio 1:1

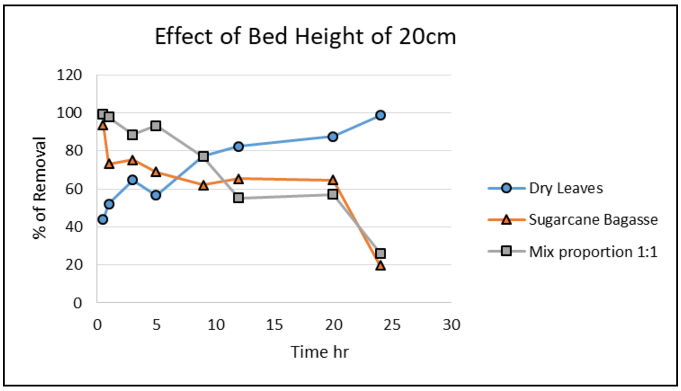

Figure -9: Effect of Bed Height of 20cm on Zinc Removal by Adsorbent: Dry Leaves, Sugarcane Bagasse and Mixed Ratio 1:1

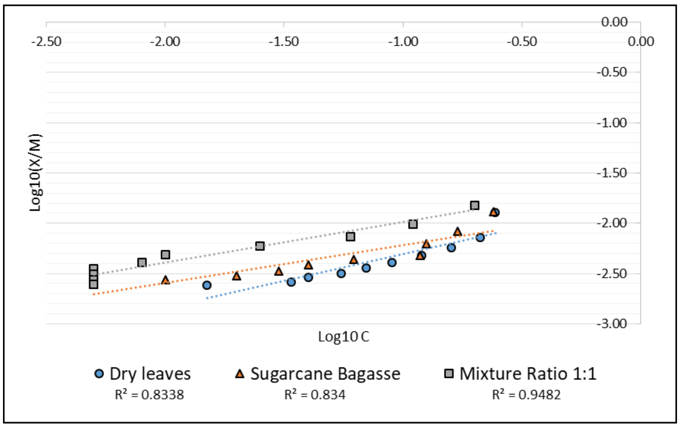

Figure -10: Freundlich Isotherm for the Adsorbents

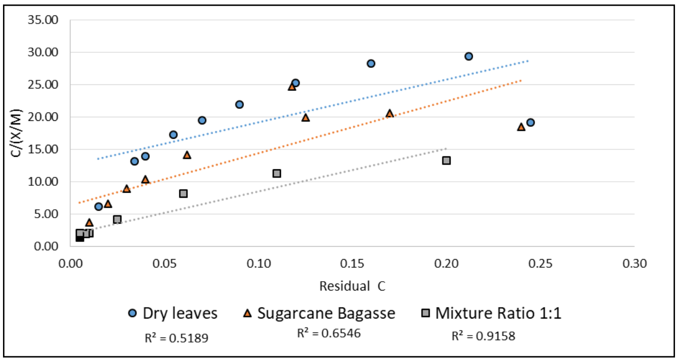

Figure -11: Langmuir Isotherm for the Adsorbents

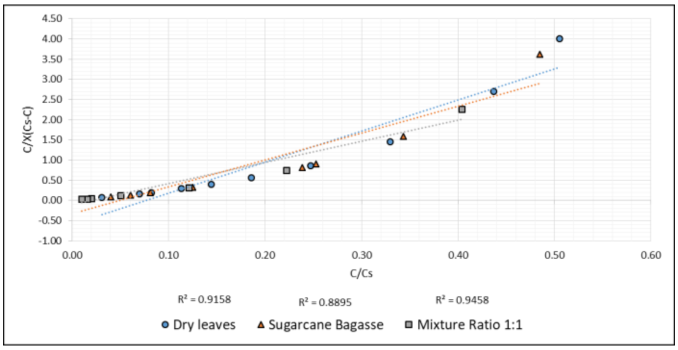

Figure -12: BET Isotherm for the Adsorbents

Table-2: Comparing with the Activated Carbon Results from Previous Research [17] [15] [5].

Adsorbent	Dry leaves	Sugarcane Bagasse	Mixture ratio 1:1	Activated Carbon
Batch process	57.96%	28.18%	84.68%	70%
Column Process	98.63%	95.65%	95.99%	98%

3. CONCLUSIONS

1. A simple and cost-effective treatment procedure is described for the heavy metal ions removal from zinc solution prepared for the study by adsorption onto dry leaves, sugarcane bagasse and the mixture of them in ratio 1:1.
2. The zinc uptake capacity of all the adsorbents investigated is found highly pH dependent and the best results.
3. The isotherm data obtained is more closely to Freundlich and BET adsorption isotherm for all the three adsorbent and only mixture of ratio 1:1 follows Langmuir adsorption isotherm.
4. Among the adsorbent used the mixture of ratio1:1 demonstrate a high adsorption capacity towards Zn ions in both the batch and column process conducted.
5. Since this method involves less capital cost and is highly efficient the regeneration of the leaves and the bagasse is not essential since they are a readily available material with a zero cost value. The results presented could be of value for the heavy metal ions reduction or removal from industrial effluents.

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