A Review on Removal of Cadmium in Waste Water using Various Low-Cost Adsorbents

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Abstract— Cadmium is an extremely toxic heavy metal and it is considered as a carcinogen. It is generally used in manufacturing of batteries and extensively used in cadmium electroplating and paint industries. The limit of cadmium in drinking water is 0.05 mg/l .Many methods are available for cadmium removal in waste water. One of the most effective methods is adsorption. This paper reviews the various types of adsorbents and its efficiency to remove cadmium.

Key words: Adsorption, Heavy Metals, Removal, Efficiency

I. INTRODUCTION

Toxic heavy metals pose a serious threat to human beings. Excessive release of heavy metals in to the environment is due to urbanization. It has posed a great problem worldwide. Heavy metals enter the food chain through water either drinking water or by crop irrigation. Cadmium is considered as a human carcinogen (group 1 [1]-according to international agency for research on cancer, Group 2a [2] [3]-according to environmental protection agency (EPA) and 1B carcinogen classified by European chemical agency). Cadmium is emitted from the sources such as smelting, metal plating, cadmium-nickel batteries, phosphate fertilizer and alloy industries. [4] The contaminated water can be treated by means of several methods such as adsorption, Biological methods, electro coagulation, electro dialysis, flotation, membrane separation, extraction.

Among various water purification and recycling technologies, adsorption is a fast, inexpensive and universal method. Various types of adsorbents are used for the removal of cadmium. The most common adsorbent used in waste water treatment is activated carbon .it has a strong affinity for binding organic substances even at low concentration. Activated carbon is expensive material the greater the quality of activated carbon the higher its cost. In recent years research has been focused on adsorbents whose cost is low and efficiency is high. Low cost adsorbents are derived from plant waste or a waste material. Various Nano metal oxides are in research for the efficiency of heavy metal removal.

II. LOW COST ADSORBENTS

1) Alcaligenes Eutrophus:
Alcaligenes eutrophus CH34 strains are able to promote bio mineralization .being biologically induced crystallization of heavy metals. Cadmium removal efficiency is 99% [7]

2) Algae:
In this paper fuccus vesiculosus and focus serratus were studied for the ability to remove cadmium from aqueous solutions. Metal sorption is rapid, 90%of the metal uptake completed within first 25 mins of contact [8]

3) Alginate Carriers:
Activated sludge immobilized on alginate carriers [9].It was proved that adsorption by alginate and alginate with PVA obeys a second–order rate law. It also shows high efficiency.

4) Alumino Silicates:
The adsorption efficiency of cadmium in three Mexican alumino silicates (two zeolites and one clay) was studied [10]. The sorption kinetics was described by second order Ritchie modified model.

5) Aragonite Shells:
Aragonite is a carbonate mineral. It is formed by biological and physical process from precipitation of marine and fresh water environment. Cadmium removal occurs by surface precipitation of otavite [11].Biogenic aragonite provides high efficiency for removing cadmium and other metals in polluted water.

6) Ascophyllum Nodosum:
Ascophyllum nodosum is a large brown alga. Kinetics of cadmium adsorption was relatively fast 90% of total adsorption takes place in less than one hour. [12]

7) Aspergillus Niger:
Aspergillus niger is a fungus and it is the most common species. The optimum ph for cadmium adsorption is reported as 4.0.the maximum uptake capacities of Cd ion is 15.50 mg/g at initial concentrations of 75 mg/l [13].

8) Bacillus Subtilis:
Bacillus subtilis is a gram positive bacterium that can be commonly found in soil and vegetation. Cadmium binds predominantly to phosphoryl ligands below pH 4.4[14].

9) Bagasse Fly Ash:
Bagasses remain after the extraction of juice in sugar cane. It is an industrial waste of sugar industry.90% removal of cadmium is possible in 60 min [15] .Adsorption process is endothermic in nature.

10) Bifurcaria Bifurcata:
Bifurcaria bifurcata is a gene of brown marine algae sea weeds. Kinetics for cadmium adsorption is relatively fast [16]. 90% of the total adsorption takes place in less than 1 hour.

11) Biofilm:
A biofilm is a group of microorganism in which cells stick to each other on surface. For this study biofilm covered granular activated carbon was used to study the removal efficiency of cadmium. It has been found that biofilm covered granular activated carbon is more efficient than granular activated carbon [17]

12) Biomass, Sargassum Waste:
Sargassum is a brown macro algae. The biomass from sargassum waste can be utilized in removal of cadmium in waste water. Waste biomass biosorbed 100% cd^{2+} ions from a 3 and 98 mg/l [18]

13) Biomass, Candida Utilis:
Candida utilis is a species of yeast and it is most commonly termed as torula.the cadmium sorption capacity of dried yeast biomass was perceptibly higher than that of the other tested adsorbents. Considering the sorption of the dried yeast biomass equal to 100 %, the cells in alginate reached 86 % while native cells showed only 42 % [20]

14) Calcite:
Calcite is a carbonate material. Calcite can be used for the removal of cadmium. Calcite is an effective inorganic adsorbent. Maximum adsorption capacities were determined as 18.52 mg/g cadmium [19]

15) Charcoal, Coconut Shell Activated:
Activated carbon is derived from waste coconut shells. Adsorption of cadmium increases with increase in pH value. Charcoal derived from coconut shell of 30 gm dose could remove 66% cadmium in waste water [21].

16) Cladosporium Resinae:
Cladosporium resinae is a fungi. The fungal biomass can be used to remove cadmium.it is a non-living biomass [22].

17) Clay, Mixed:
Mixed clay from different regions was used for this study. Cadmium removal was 85% in the pH range of 6 and 9[23].

18) Chitosan:
Chitosan is linear polysaccharides. It's made by treating shrimp and other crustacean shells with the alkali sodium hydroxide. Chitosan is an effective scavenger for heavy metals [40]. Adsorption capacity of 5.93 mg of cd2+/g of chitosan was achieved at a pH of 4.0-8.3.

19) Cobalt Nickel Solution:
Cobalt nickel solution is precipated with diisobutyldithiophosphinate. Organophosphorus reagent used for this purpose extract cadmium in preference to cobalt.it shows high efficiency [24].

20) Fuccus Spiralis:
Fuccus spiralis is a brown marine macro algae. Dried alga is used .Biosorption capacity of alga strongly depends on pH. Uptake is almost negligible at pH <=2 [25] .Biosorption is relatively fast with 90% of total adsorption takes place in less than one hour.

21) Juniper Fiber:
Juniper is a small dia underutilized ligno cellulosic material. Base treated juniper fiber is used for cadmium adsorption. Carboxylate ion present in juniper promotes cadmium sorption. Base treated juniper fiber could be an inexpensive and efficient sorbent for removing heavy metal [26].

22) Lathyrus Sativus Husk:
Husk of lathyrus sativus (HLS) was found to be most efficient (95% of the metal is removed).the process was very fast and more than 90% of the total adsorption takes place within 5 minutes and found to follow pseudo second order kinetics [27]

23) Leaves, plantanus orientalis:
Platanus orientalis leaves can be utilized in removal of cadmium. Maximum adsorption takes place in pH range of 7and 60 min contact time[39]

24) Light Weight Expanded Clay Aggregate (LECA):
Light weight expanded clay aggregate can be used as an effective adsorbent for cadmium removal. The maximum removal efficiency for cadmium removal is 89.7% [38] LECA is a low cost and available adsorbent to remove cadmium.

25) Manganese Dioxide:
Cadmium can be removed using the aqueous solution of manganese dioxide. Adsorption of cadmium on manganese dioxide depends on time, pH, composition and concentration of manganese dioxide solution [28].

26) Membrane, Hollow Fiber:
Best performance of cadmium removal can be yielded at pH of 4 and the initial concentration of 100 ppm gives the best removal [29].

27) Olive stones:
Olive stones are the byproduct obtained from olive oil production. For an initial concentration of 220 mg/ℓ, a maximum sorption capacity of 0.065 mmol/g for Cd (II) has been obtained [37].

28) Paecilomyces Variotti:
Paecilomyces variotti is a fungus. It has the tendency to absorb cadmium. Biosorption of cadmium by fungi shows greater efficiency. The fungal biomass can be used to remove cadmium [22].it is a non-living biomass.

29) Perlite:
Perlite is an amorphous volcanic glass that has a relatively high water content.it is an industrial mineral. Cadmium adsorption by perlite was rapid in first hour of reaction time and the optimum pH was found to be 6.0 [30].

30) Pine Cone, Ground:
Pine cone is a reproductive organ of pine tree.it has the tendency to remove cadmium. Main parameter in removal of cadmium by pine cone is initial cadmium concentration, particle size and pine cone mass [31].

31) Red mud:
Red mud, analuminum industry waste has been converted in to an inexpensive and efficient adsorbent. Removal of cadmium was almost complete at low concentration. Red mud also removes zinc ion [32]. Adsorption decreases with increase in temperature.

32) Sea Food Processing Waste:
Primary sludge from alum and lime coagulation of cuttlefish waste can be used in heavy metals processing. Adsorption capacity is 15.73 mg/g of cadmium [6].

33) Soils Bio Solids Amended:
Solids rich in bio solids have the tendency to remove cadmium in waste water. Decreasing the pH Increase the efficiency of cadmium removal [33]

34) Soybean Plants:
Soybean plant adsorb the cadmium on it root surfaces.it shows high efficiency on cadmium removal. Certain parameters influence the efficiency [34]

35) Tea Waste:
Tea waste can be used as an adsorbent for heavy metal removal.it also removes cadmium concentration in waste water. For 1.5 gram of tea waste the efficiency is about 77.2% [35]

36) Yeast Biomass:
Yeast biomass is an excellent source of proteins, nucleic acid and vitamins. It has the ability to remove cadmium if it is slightly modified [36] .Deactivated protonated yeast was converted in to sodium form and use4d for bio sorption.

37) Zeolites:
Zeolites are micro porous, alumino silicate materials used as commercial adsorbent and catalyst. For modified zeolite pellet the removal efficiency was more than 98% [37]

III. CONCLUSION

Low cost adsorbents show a high efficiency rather than conventional adsorbents. Low cost adsorbents are easily available in nature and a small modification in waste materials can change the material in to an efficient adsorbent. The above listed are some of the adsorbent used in the removal of cadmium in waste water. Results showed that low cost adsorbents can be fruitfully used for the removal of heavy metals in concentration of 20-50 mg/l and the removal percentage of heavy metals was dependent on the concentration of adsorbent and dose of low cost adsorbent. Commercial activated carbon of the cheapest variety cost about 84,200 INR. The adsorbent material listed above is easily available at a relatively cheap rate.so the use of low cost adsorbents for the removal of cadmium is fruitful.

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