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Removal of Hexavalent Chromium by Adsorption Using Natural Wastes-A Review

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Abstract

Heavy Metal recovery is one of the serious problem in this world. Many Industries were discharged their effluent into the water bodies (lakes, rivers etc.,) without any prior treatment. Tanneries are the type of industry which delivers the effluent with high concentration of Hexavalent Chromium (Cr^{6+}). It should directly affects the lungs and causes the cancer. The present study has reviewed the removal of Hexavalent Chromium (Cr^{6+}) from various natural adsorbents.

Keywords: Environmental pollution; Minerals; Industrial waste

Introduction

Environmental pollution particularly from heavy metals and minerals in waste water is one of the most serious problems in India. Due to extensive activities such as industrial operations, mining, agricultural processes and disposal of industrial waste materials, heavy metal concentrations have increased to hazardous levels. The presence of heavy metals in waste water is non-biodegradable, severely toxic, accumulates in nature and contaminates ground water and surface water posing serious threat to the living beings and the environment. Many treatment methods are available to treat the waste water from heavy metal concentration. Due to high reagent requirement Cost of the method, and some other disadvantages of all those methods, adsorption is the effective method to remove the concentration of heavy metal from wastewater.

Literature Review

Mango kernel

Mango kernel powder activated with Phosphoric Acid (H_3PO_4) as an adsorbent to remove the chromium from the industrial effluent [1]. The mango kernel powder activated with 40% of Phosphoric Acid (H_3PO_4) and carbonized at 600°C for one hour in an inert atmosphere. Then, he found that the maximum adsorption capacity of Chromium was 7.8 mg/g at the pH of 2 and the temperature of 35°C. Finally, he concluded that the Langmuir Adsorption Isotherm is represented the equilibrium data is good and the adsorption kinetics was represented in pseudo-second order relation.

Groundnut hull

The groundnut hulls as an adsorbent to remove the hexavalent chromium from aqueous solutions [2]. Two different kinds of Groundnut hulls was used, one is Unmodified Groundnut Hull (UGS) and another one is Modified Groundnut Hull (MGS). Then, He found that the maximum adsorption capacity of Chromium for UGS-90 mg/g and, for MGS-131 mg/g at the pH of 2 and the temperature of 28°C. The Isotherm data were analyzed by Langmuir and Freundlich isotherms and he found that the Freundlich model is better than the Langmuir isotherm model and the Adsorption kinetics followed by pseudo-second order relation.

Eucalyptus bark

Low cost biomaterials such as bagasse, rice husk, Eucalyptus Bark for removal of Chromium and Magnesium from industrial effluent [3]. He found that the maximum removal efficiency of chromium was observed at pH of 2 and the adsorption capacity was found to be 45 mg/g. Eucalyptus Bark is the most effective adsorbent which removes 99% of Hexavalent Chromium (Cr^{6+}) at concentration of 200 ppm. The Freundlich isotherm is represented a good equilibrium data and, finally he concluded that the Eucalyptus Bark is the best adsorbent for the removal of chromium from industrial effluent.

Neem leaf powder

Neem leaf powder as a low-cost adsorbent to remove the Hexavalent chromium from the aqueous solutions [4]. Neem leaves are the cheapest material and it is easily available in all areas. Here, 85% of chromium was removed at pH value 2 and it is taken as optimum range for further experiments. Batch adsorption process was used and this research work indicates that, the percentage of adsorption increased when we increase the adsorbent dosage and contact time.

Banana peels

The banana peels as an adsorbent [5]. Here, the banana peels were treated with 10% of Hydro Chloric Acid (HCL), and followed by alkaline hydrolysis with 10% of Sodium Hydroxide (NaOH) for washing purpose. This is called as Grafted Banana Peels (GBPs). The maximum adsorption capacity of chromium using this GBPs was 96% at the optimum pH value of 3. The adsorption data is fully fitted for Langmuir and Freundlich Isotherm models.

Sugarcane bagasse

Sugarcane Bagasse ash was used as an adsorbent to remove the chromium content from aqueous solutions [6]. Here, the sugarcane bagasse was treated with orthophosphoric acid and burn for 3 hours and that ash was used for heavy metal recovery. The maximum adsorption capacity of 100% achieved using this bagasse ash at the optimum pH range of less than 5. Finally, this research work concluded that the efficiency of chromium removal increased when the absorbent dosage increase [7].

Sugarcane leaf

Sugarcane Leaf was used as an adsorbent to remove the Copper, Lead and Chromium contents in industrial waste water [8]. Here, the sugarcane leaves were fine grained up to 5 mm thickness in size and that powder was uses as an adsorbent without adding any chemical reagents. Batch adsorption process was conducted and finally the chromium content removed almost 62% from waste water at the room temperature without any pH modification [9].

Aloe vera leaf

Aloe Vera Leaf used as an adsorbent in the form of powder without adding any chemical reagents [10]. Here, the chromium content was removed almost 60% at the optimum pH level of 2. Batch adsorption process was conducted and finally this work concluded that the aloe vera is best adsorbent and it has a possibility to adsorb the heavy metals from the waste water [11].

Green coconut shell

Green Coconut Shell was used as an adsorbent washed with orthophosphoric acid [12]. Hexavalent Chromium (Cr^6) was adsorbed greater that 90% for 10 mg/l solution [13]. Here the batch adsorption process were used and the temperature was maintained 10-80°C and the concentration was 10-100 mg/g. Langmuir and Freundlich isotherms were fitted for this work and the maximum adsorption capacity from equilibrium data is 22.96 mg/g.

Silica sand

Silica sand coated with groundwater was used as an adsorbent to remove the Hexavalent Chromium (Cr^{6+}) from synthetic wastewater [5]. Here, the adsorption capacity was 0.27 mg/g at the pH of 4 and also the ionic strength had improved the Cr^{6+} removal. Freundlich isotherm was fitted and its correlation between 298 K to 318 K. Finally concluded that, the silica sand is not had an ability to remove Cr^{6+} from aqueous solutions.

Aluminium Magnesium Mixed Hydroxide (AMH)

AMH was prepared by precipitation with a series of solutions with various Magnesium/Aluminium (Mg/Al) molar ratios [14]. Here, the saturated adsorption capacities of AMH for Cr^{6+} was 105.3 to 112 mg/g at the temperature varies from 20°C to 40°C. The optimum pH was ranged between 2.5 to 5. The adsorption was reached equilibrium within 150 min. Mg/Al molar ratio 3 was the largest adsorption efficiency because of the small average diameter. From this research, the AMH was the best adsorbent to remove the chromium from aqueous solutions.

Rye Husk (RH)

RH was used as an adsorbent to remove the Cr^{6+} from the aqueous solutions [15]. The maximum adsorption capacity of Cr^{6+} by using RH was 80% at the pH of 3 and then, the adsorption capacity of RH was 68% at the pH of 5. Here, Langmuir isotherm is fitted for equilibrium adsorption and the maximum concentration of Cr^{6+} was removed at 150 min.

Activated carbon and bentonite

Activated Carbon and Bentonite was used as adsorbents to remove Cr^{6+} from wastewater by batch adsorption process. The maximum adsorption capacity was reached at 120 min for both adsorbents during the temperature between 30°C to 40°C. The adsorption capacity was increased by increasing the dosage. Finally, this work concludes that the bentonite was an effective adsorbent compared to activated carbon to remove the chromium content in wastewater at the pH of 2 [16].

Bamboo

Bamboo was used as an adsorbent added with KOH and heated at 1073 K for 3 hours. Hexavalent chromium was removed up to 98.28% using this activated carbon bamboo adsorbent at the pH of 2. Freundlich isotherm was fitted for this work and the maximum equilibrium adsorption was carried out at the temperature of 298 and 318K within 20 minutes. Adsorption efficiency was 59.23 mg/g at 300 K [17].

Cucumis melo peels

Cucumis Melo Peels Activated Carbon was used as an adsorbent to remove the Hexavalent Chromium from aqueous solutions. The maximum adsorption capacity was reached at the pH of 3 and the maximum chromium removal was 98.10%. Here the adsorption isotherms Freundlich, Langmuir, Tempkin and Dubinin-Radushkevich were investigated from the results and the Dubinin-Radushkevich isotherm is not fitted compared to other isotherms. From this research, Cucumis Melo Peels had a nature to remove the chromium (VI) from the wastewater [18].

Tendu leaves

Tendu leaves from bidi industry was used as an adsorbent to remove the heavy metals from electro plating industrial effluent. The chromium was removed up to 99.5% by using this tendu leaves. The Langmuir isotherm was fitted in this research work and it shows the good efficiency at the pH of 5 and 7. From this work, the tendu leaves are the best adsorbent to remove the chromium from the industrial effluent [19,20].

Conclusion

Natural Waste Products were used as a low-cost adsorbents for the removal of Chromium (VI) from different kind forms of wastewater was studied in this paper. Many Natural waste products were given their efficiency in good level. But, compared to the above mentioned waste products, Sugarcane Bagasse Ash gives the complete removal efficiency of Chromium metal (100%) from the wastewater. Also, Tendu leaves are having 99.5% of removal efficiency to remove the chromium from wastewater. These are the natural waste products which is available in very low cost.

The concentration of heavy metal had been changed when we adjust the pH value from the wastewater. From this review, the heavy metal concentration mainly depends upon the pH value of waste water.

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