EXPERIMENTAL STUDY ON REMOVAL OF CHROMIUM IN WATER

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Abstract

In this investigation, locally available and inexpensive Mustard and Seemai Karuvelam were used as adsorbents, on that the mustard is used as biosorbent are used to remove chromium from synthetic wastewater. The removal of this metal ion from water in the batch method of adsorption have been studied and discussed. Adsorption kinetics study was also carried out and the material exhibits good adsorption capacity. Scanning Electronic Microscopic image was also used to understand the surface characteristics of adsorbent before and after adsorption studies. Effects of various factors such as pH, adsorbent dose, adsorbate initial concentration and time were analyzed. The initial concentrations of chromium were considered 10-30mgL^{-1} in batch method. The maximum chromium adsorbed was 100% in mustard and 97.64% in seemai karuvelam at Batch method. Batch method of adsorption studies indicated that the biosorbent and the adsorbent could be reused for removing heavy metals. Results of the laboratory experiments show that the performance of mustard and seemai karuvelam proves that they can effectively be used as low cost adsorbents for the removal of chromium from wastewater.

Keywords: *Locally available, inexpensive, mustard, seemai karuvelam, adsorbents, biosorbent, remove chromium, synthetic wastewater, metal ion, adsorption kinetics study, scanning electronic microscopic image , pH, adsorbent dose, adsorbate initial concentration, time, batch method.*

Introduction

Heavy metals have vast industrial applications due to their technological importance. As a result of inappropriate waste-disposal of industries, such as electroplating, leather tanning, wood processing and alloy preparation, significant amounts of chromium has been discharged into the environment. Chromium is the seventh most abundant element on earth and exists in several oxidation states. Chromium (Cr) is a naturally occurring element with atomic number 24 and atomic mass of 51.996 amu. The element belongs to the group of transition metals and in the oxidation state elementary presents an electronic configuration 4d5s1. The most prevalent forms of chromium in the natural environment are hexavalent and trivalent. Chromium is a naturally occurring element found in rocks, animals, plants, soil and in volcanic dust and gases. It exists in different oxidation states that range from +2 to +6. The most stable forms are Cr(VI) and Cr(III), although they significantly differ in biological, geochemical and toxicological properties. Trivalent chromium occurs naturally in the environment at a narrow concentration range and is considered to be less toxic than Cr(VI). Hexavalent chromium is used extensively in industrial processes such as electroplating, tanning, textile dyeing, corrosion inhibition and wood treatment, all of which produce discharge of chromium-containing effluents. The high

solubility of Cr(VI) makes it a hazardous contaminant of water and soil when discharged by industries that produce or utilize chromium. When it is released to the environment, Cr(VI) is a potential contaminant of groundwater that can participate in trophic transfer in food chains. The United States Environmental Protection Agency has identified Cr(VI) as one of the 17 chemicals posing the greatest threat to humans. The permissible limit for total chromium in drinking water is 0.05 mg/L (WHO 2004). Cr(VI) exposure in humans can induce allergies, irritations, eczema, ulceration, nasal and skin irritations, perforation of eardrum, respiratory track disorders and lung carcinoma. Moreover, Cr(VI) evidences the capability to accumulate in the placenta, damaging fetal development and it is a high carcinogenic agent. Cr(VI) pollution in the environment alters the structure of soil microbial communities, reducing microbial growth and related enzymatic activities, with a consequent persistence of organic matter in soils and accumulation of Cr(VI) . The toxic action of Cr(VI) is due to its capability to easily penetrate cellular membranes, and cell membrane damages caused by oxidative stress induced by Cr(VI) have been extensively reported, both in eukaryotic and prokaryotic cells, with effects such as loss of membrane integrity or inhibition of the electron transport chain. The chromium can be removed from water by several techniques, on that in this paper we are adopting "Batch Method of Adsorption".

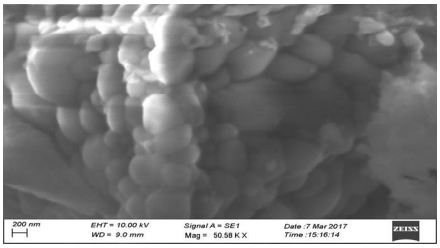
Materials and Methodology

Adsorbents

The adsorbents which have been used so economic and to reduce the waste that has been generated from it. But it must reduce the targeted element in very less time. The adsorbent that has been selected are satisfying all the required properties.

Mustard

It belongs to the family of Brassicaceae and having the scientific name of Brassica juncea. It is an edible gram which highly used in food at allcountries.In African, Pakistani, Bangladeshi, Italian ,Indian, Chinese, Japanese, Korean, and African-American are using this in their daily life in food. Cultivators of B. juncea are grown for their greens, and for the production of oilseed. The mustard condiment made from the seeds of the B. juncea is called brown mustard and is considered to be spicier than yellow mustard.



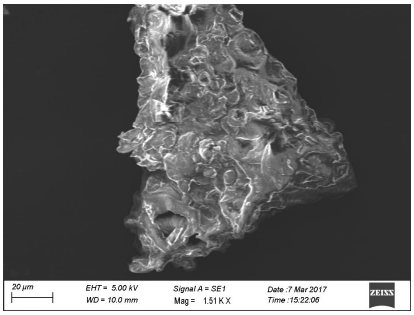
SEM image of the biosorbent Mustard

Seemai Karuvelam

It belongs to the family of Fabaceae and having the scientific name of Prosopis juliflora**.** The mesquite tree grows to a height of up to 12 meters (39 ft) and has a trunk with a diameter of up to 1.2 meters (3.9 ft). Its leaves are deciduous, bi-pinnate, light green, compounded with 12 to 20 leaflets. Flowers appear shortly after

leaf development. The flowers are in 5–10 cm long green-yellow cylindrical spikes, which occur in clusters of 2 to 5 at the ends of branches. Pods are 20 to 30 cm long and contain between 10 and 30 seeds per pod. A mature plant can produce hundreds of thousands of seeds. Seeds remain viable for up to 10 years. The tree reproduces by way of seeds, not vegetatively. Seeds are spread by cattle and other animals that consume the seed pods and spread the seeds in their droppings. Its roots are able to grow to a great depth in search of water: in 1960, they were discovered at a depth of 53 meters (175 feet) at an open-pit mine near Tucson, Arizona, putting them among the deepest known roots. The tree is said to have been introduced to Sri Lanka in the 19th century, where it is now known as vanni-andara, or katu-andara in Sinhala.

It is claimed that P.julifllora existed and was recognised even as a holy tree in ancient India, but this is most likely a confusion with Prosopis cineraria. The tree is believed to have existed in the Vanni and Mannar regions for a long time. This species has thorns in pairs at the nodes but thornless internodes. It may also be almost thornless.



SEM image for Seemai Karuvelam

A government order was issued to clean up all these mess at particular time for better avoidance of water scarcity. By this action all the plants are get cutoff. Hence it can be used as an adsorbent, the total plant is burnt and its ash is used.

Batch Method of Adsorption

By using Batch Method of Adsorption the chromium can be reduced easily. This method is chiefly employed to adsorb many chemical products and this method is widely used in all fields. In this method the adsorbent is put into a solution to adsorb the adsorbate from the solution. This process is carried out on various circumstances. A synthetic solution of chromium is prepared by adding 10mg of potassium dichromate in 1liter of water. Then it was sampled into 250ml for 10ppm at various pH likewise it was prepared for 20ppm at various pH. The pH of the synthetic solution is 6, hence the pH was adjusted to 2pH, 4pH, 6pH and 7pH. It can be done by adding 98% pure HCl for acidification and 96% pure NaOH for base. The adsorbents are finely crushed in a crucible and they are batched by 0.5g, 1g and 2g respectively. After batching is done the adsorbents are put into sample and they are mixed well. The samples are tested at 0 mins, 15 mins, 30 mins and 60 mins with the help of a U. V. Spectrophotometer. The values that are obtained from the display are noted carefully.

Data Analysis

According to the values that are obtained from the U.V. Spectrophotometer a simple calculation is done by using this formulae,

$$\text{Adsorption \%} = \frac{(C_0 - C_1) \times 100}{C_0}$$

C_0 – concentration of the synthetic solution without adsorbent

C_1 – concentration of the solution after adding adsorbent at different time interval

Result and Discussion

For the different concentration of adsorbents, sample's pH level and time variation the absorbance values that has been absorbed from the U.V.Spectrophotometer are noted and calculated according to the Adsorption % formula. The results are tabulated and graphs are drawn according to their values by taking time vs adsorption

Adsorption of Chromium in Biosorbent Mustard

Table 1.1, 10ppm of synthetic solution 0.5 gram biosorbent

	15 mins	30 mins	60 mins
2 pH	79.54	90.91	100
4 pH	67.69	23.07	86.15
6 pH	97.64	54.11	85.88
7 pH	97.64	61.17	71.70

From the above table 1.1, It is clearly noted that the, removal of chromium is maximum in 2pH & 7pH and minimum in 6pH & 4pH with respect to the time interval of 0, 15, 30 & 60 mins

Table: 1.2, 10ppm of synthetic solution 1 gram biosorbent

	15 mins	30 mins	60 mins
2 pH	63.63	36.36	45.45
4 pH	30.76	23.07	35.38
6 pH	28.82	32.81	60
7 pH	58.83	36.47	32.82

From the above table 1.2 .It is clearly noted that the, removal of chromium is maximum in 7pH & 2pH and minimum in 6pH & 4pH with respect to the time interval of 0, 15, 30 & 60mins.

Table: 1.3, 10ppm of synthetic solution 2 gram biosorbent

	15 mins	30 mins	60 mins
2 pH	58.82	32.94	15.92
4 pH	16.47	14.11	17.6
6 pH	26.15	38.46	83.07
7 pH	19.90	41.30	48.40

From the above table 1.3 .It is clearly noted that the, removal of chromium is maximum in 7pH & 6pH and minimum in 2pH & 4pH with respect to the time interval of 0, 15, 30 & 60 mins.

Table: 1.4, 20ppm of synthetic solution 0.5 gram biosorbent

	15 mins	30 mins	60 mins
2 pH	28.45	66.67	94.30
4 pH	56.85	13.04	86.95
6 pH	60.97	79.67	82.11
7 pH	67.47	57.72	56.09

From the above table 1.4.It is clearly noted that the, removal of chromium is maximum in 6pH & 2pH and minimum in 7pH & 4pH with respect to the time interval of 0, 15, 30 & 60mins.

Table: 1.5, 20ppm of synthetic solution 1 gram biosorbent

	15 mins	30 mins	60 mins
2 pH	56.94	59.72	77.7
4 pH	61.11	81.94	31.94
6 pH	17.39	30.04	82.68
7 pH	8.94	29.26	84.14

From the above table 1.5 .It is clearly noted that the, removal of chromium is maximum in 4pH & 2pH and minimum in 6pH & 7pH with respect to the time interval of 0, 15, 30 & 60mins.

Table: 1.6, 20ppm of synthetic solution 2 gram biosorbent

	15 mins	30 mins	60 mins
2 pH	84.72	93.05	97.82
4 pH	20.83	11.11	77.7
6 pH	79.51	26.81	6.50
7 pH	66.67	35.0	38.42

From the above table 1.6. It is clearly noted that the, removal of chromium is maximum in 2pH & 7pH and minimum in 6pH & 4pH with respect to the time interval of 0, 15, 30 & 60 mins.

Removal Data for Seemai Karuvelam

Table 2.1, 10ppm of synthetic solution 0.5 gram adsorbent

	15 mins	30 mins	60 mins
2 pH	30.08	36.58	44.71
4 pH	78.0	47.0	8.23
6 pH	21.41	20	3.52
7 pH	80	54.70	65.88

From the above table 2.1. It is clearly noted that the, removal of chromium is maximum in 6pH & 2pH and minimum in 7pH & 4pH with respect to the time interval of 0, 15, 30 & 60mins.

Table: 2.2, 10ppm of synthetic solution 1 gram adsorbent

	15 mins	30 mins	60 mins
2 pH	9.04	41.17	49.41
4 pH	5.88	17.05	92.94
6 pH	65.8	52.94	76.47
7 pH	37.6	22.35	97.64

From the above table 4.2.2, It is clearly noted that the, removal of chromium is maximum in 6pH & 2pH and minimum in 7pH & 4pH with respect to the time interval of 0, 15, 30 & 60mins

Table: 2.3, 10ppm of synthetic solution 2 gram adsorbent

	15 mins	30 mins	60 mins
2 pH	77.64	60	24.58
4 pH	0	0	70.45
6 pH	47.2	47.7	54.54
7 pH	6.15	20.61	73.84

From the above table 2.3, It is clearly noted that the, removal of chromium is maximum in 2pH & 6pH and minimum in 7pH & 4pH with respect to the time interval of 0, 15, 30 & 60 mins

Table: 2.4, 20ppm of synthetic solution 0.5 gram adsorbent

	30 mins	60 mins
2 pH	35.7	18.69
4 pH	30.08	77.23
6 pH	23.57	82.11
7 pH	36.58	53.69

From the above table 2.4, It is clearly noted that the, removal of chromium is maximum in 6pH & 4pH and minimum in 7pH & 2pH with respect to the time interval of 0, 30 & 60 mins.

Table 2.5, 20ppm of synthetic solution 1 gram adsorbent

	30 mins	60 mins
2 pH	14.63	43.90
4 pH	75.90	14.63
6 pH	40.56	80.48
7 pH	20.32	11.38

From the above table 2.5, It is clearly noted that the, removal of chromium is maximum in 4pH & 6pH and minimum in 2pH & 7pH with respect to the time interval of 0, 30 & 60mins

Table: 2.6, 20ppm of synthetic solution 2 gram adsorbent

	30 mins	60 mins
2 pH	37.39	19.44
4 pH	37.39	78.04
6 pH	33.33	72.35
7 pH	64.2	45.52

From the above table 4.2.6, It is clearly noted that the, removal of chromium is maximum in 7pH & 4pH and minimum in 6pH & 2pH with respect to the time interval of 0, 30 & 60mins.

Comparison of removal of chromium by the adsorbent and the biosorbent

By comparing the two adsorbents we can able to draw a graph which compares the removal of chromium in the synthetic solution.

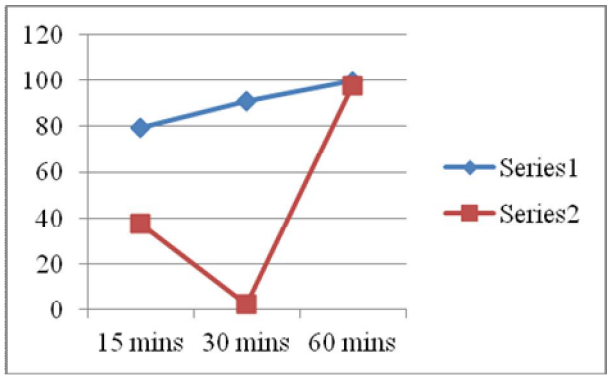


Fig: 3.1, comparative analysis of removal

Series 1: crushed mustard at 2pH at 0.5mg

Series 2: seemai karuvelam ash at 7pH at 1g

The Fig: 4.3.1, shows that the removal of chromium from the synthetic solution with the help of the biosorbent and adsorbent is compared and they shows that the adsorption, that was occurred in the biosorbent Crushed Mustard is 100% and the adsorbent Seemai Karuvelam's ash is 97.64%. Hence the Fig: 4.3.1 clearly shows that the biosorbent can effectively remove the chromium in the synthetic solution and it can be also employed to remove chromium in the waste water.

Conclusion

The removal performance of chromium from waste water using locally available and inexpensive mustard and seemai karuvelam is quite good. The maximum percentage of chromium that was removed by the bio-adsorbent crushed mustard is 100% in 0.5g and the adsorbent seemai karuvelam ash is 97.64% for 1g. On the other hand it is have to be clearly noted that the maximum removal of chromium is attained not only by the adsorbents but also by the action of pH concentration in it. It has to be noted that the in mustard is having the maximum removal in mustard was occur in 2pH and seemai karuvelam in 7pH. While taking these adsorbents into considerations the pH and the amount of chromium that have been dissolved in water. In view of all the findings, it may be concluded that these adsorbents are very useful, economic and quite rapid. Therefore these adsorbents could be successfully used for the removal of chromium from waste water and many other effluents.

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