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Experimental Study on Reduction of Chromium Content from Industrial Effluent using Banana Peel

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Abstract: Hazardous metal pollution in water is increasing in the present day due to the discharge of industrial effluents into aquatic environment that possess a potential threat to human health. Among these metals, hexavalent chromium which exists in many industrial wastewaters is considered highly toxic and need to be treated before its disposal. The chromium can be removed by various methods such as ionexchange, membrane separation, ultra-filtration, ion flotation, electro coagulation, sedimentation and reverse osmosis have been employed In the intervention of various ideas in this scientific world,various alternative measures are being taken up for the removal from the effluents without making the environment to be hazard, but they may not be economical. Hence, in this study an experiment is being carried out for the removal in an efficient and economical manner using Banana Peel. Banana peel a discarded agricultural waste was used as bioadsorbent through easy and environmental friendly processes for removal of Chromium (VI) from aqueous solution through bisorption. Bisorption of Chromium (VI) onto banana peel was carried out by considering the influencing parameters such as adsorbent dose, contact time and the initial chromium concentration in solution. On account of this, for different adsorbent particle sizes it is evident that using adsorbent size of 150µm gives maximum adsorption rate (98%) and further decreasing the adsorbent size gives the same rate, hence 150µm particle size will be efficient..From the present investigation, it is evident that the banana peel has proven to be a proficient biosorbent for the removal of Chromium (VI) from aqueous solution.
Keywords: Bisorption, Absorbance, Adsorption, Adsorbent, Longmuir Adsorption Isotherm, Biological Oxygen Demand, Chemical Oxygen Demand, Adsorbate.

Introduction:

Today's water environment is polluted in many ways due to the development and usage of various industries. Then the polluted water is treated and applicable for reuse. But while treating the waste water more steps are involved and high cost of work is done. Where the waste water treated and reused but the sludge produced during treatment is toxic and disposal is risk. Effluent from industries has various heavy metals present in it which causes toxicity in water. Thus, making it unfit for domestic purpose. The heavy metals are removed using various chemicals like silica activated carbon etc., and also using ion exchange process. These are not eco-friendly methods of treating water, which again leads to pollution while disposing them. To overcome the above process biosorbents is used which gives economical and efficient result. Hence, banana peel is being used as a biosorbent. There are several different kinds of chromium that differ in their effects upon organisms. Chromium enters the air, water and soil in the chromium (III) and chromium (VI) form through natural processes and human activities. Chromium (III) is an essential element for organisms that can disrupt the sugar metabolism and cause heart conditions, when the daily dose is too low. **Chromium (VI) is mainly toxic to organisms**. It can alter genetic materials and cause cancer. Chromium is not known to accumulate in the bodies of fish, but high concentrations of chromium, due to the disposal of metal products in surface waters, can damage the gills of fish that swim near the point of disposal. In animals chromium can cause respiratory problems, a lower ability to fight disease, birth defects, infertility and tumor formation.

Chromium is a heavy metal released from the effluent of industry. The chromium exists in various oxidation states[1,2] among which Trivalent and Hexavalent are toxic. There is a great difference between Chromium (III) and Chromium (VI) with respect to toxicological and environmental properties[2]. In general Chromium (III) is less toxic than Chromium (VI).Hexavalent chromium is a commonly used industrial metal, is a well-known human lung carcinogenic[2, 3,4]. Epidemiology and animal studies suggest that the particulate Chromium (VI) compounds, specifically the water insoluble compounds, are the more potent carcinogens; however, the carcinogenic mechanism remains unknown. The entry routes of chromium into the human body are inhalation, ingestion, and dermal absorption. Occupational exposure generally occurs through inhalation and dermal contact, whereas the general population is exposed most often by ingestion through chromium content in soil, food, and water[2, 4]. The chromium gets accumulated in water by the industrial effluent in to local water bodies. The various industries[1] discharge wastewater containing chromium are dye and pigment[5],wood preservative, metallurgy, synthetic ruby, catalysts ,refractory material. This chromium from the waste water can be removed by many methods such as Ion Adsorbent[7, 8], Membrane Filterexchange[7, 8], etc., the above methods are till today used but they are high cost and process involved is too tough. For example modified silica gel as adsorbent is high cost and reagents used for its reaction is highly expensive and toxic. So there is a need for alternative adsorbent overcoming its drawback. Agricultural and agro processing waste can be used as a low cost biosorption[7, 9] for removal of heavy metals in waste water, they include Banana Peel, rice husk, jackfruit peel, tea waste, orange peel etc. as biosorbent. Banana is a common fruit cultivated all over the world. The leading producer of banana is India and results lot of biomass waste from their peel. Therefore so many research and studies are going on to use banana peel as biosorbent. Banana peel has been used as an adsorbent to remove the metals copper and lead[12] from the waste water, which gave idea to use Banana peel as an adsorbent to remove the chromium. Already some paper is published to remove chromium from waste water[11, 13] and efficient result is achieved. In which the parameters initial metal ion concentration[11], concentration of adsorbent[10,11], Particle size and Langmuir adsorption isotherm[11]has been studied and analyzed. The amount of chromium present after the extraction sample is analyzed by the using Photo colorimeter Based on Ion-Pair Formation [14].

Experimental Investigations:

The experimental study was carried with the study of each materials that inhibiting the removal process that are hazard to the environment.

Materials Used:

Prepartion of Adsorbate

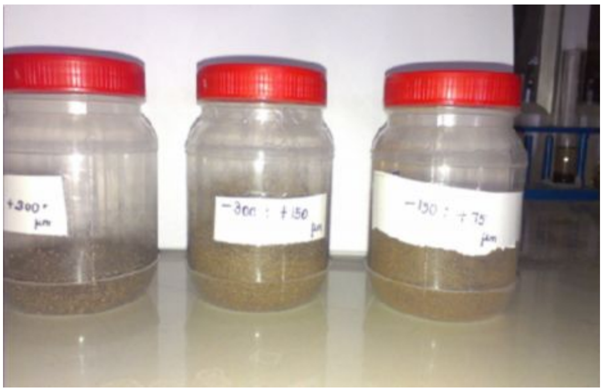
Standard chromium (VI) solution (1000 µg ml-1) was prepared by dissolving 2.829 g of K2Cr207 in 1000 ml distilled water. Suitable volume of this solution was diluted to obtain the working standard. Chromium (VI) solution (100 µg ml-1) is prepared by pipetting out 10 ml of Chromium (VI) 1000 µg ml-1 and diluting it with 100ml distilled water. The solution before dilution gives Yellowish orange colour.

Fig.1- Standard Chromium (VI) Solution (1000 mg/l)

Reagents Used

The reagents used in this Experimental studies are 15% NaCl, 0.1% Rhodamine 6G, Sulphuric acid, and Toluene and they are obtained as 15% of NaCl is prepared by diluting 150g of NaCl in 1000ml of distilled water, 0.1% of Rhodamine 6G is obtained by diluting 1g of Rhodamine 6G in 1000ml of distilled water.

PREPARATION OF ADSORBENT



Collect the raw banana peel and wash it with distilled water to remove foreign contaminates and cut the washed banana peel in pieces less than 1 cm and subjected to sunlight for 6days Finally, Grind the dried banana peel and sieve it using IS standard mesh i.e., 300 µm, 150 µm & 75 µm store the various sized banana peel in each container

Fig. 2- Banana Peel at different Sieve Sizes i.e., 300 µm, 150 µm & 75 µm

Analysis:

Adsorption Characteristics at Various Initial Conc. of Adsorbate, Conc. of Adsorbent & Particle Size

Table 1Absorbance at 540nm for Treated Sample of Various Initial Concentration

Conc. Of Banana Peel (gm)	Absorbance At 540nm Using Photo Colorimeter											
	300µm				150µm				75µm			
	Conc. 8mg/l	Conc. 6mg/l	Conc. 4mg/l	Conc. 2mg/l	Conc. 8mg/l	Conc. 6mg/l	Conc. 4mg/l	Conc. 2mg/l	Conc. 8mg/l	Conc. 6mg/l	Conc. 4mg/l	Conc. 2mg/l
0.5	0.12	0.18	0.18	0.18	0.09	0.12	0.06	0.14	0.08	0.10	0.05	0.10
1	0.05	0.10	0.03	0.07	0.03	0.05	0.05	0.06	0.02	0.08	0.03	0.08
1.5	0.04	0.03	0.03	0.03	0.03	0.04	0.03	0.04	0.02	0.05	0.02	0.05
2	0.03	0.03	0.03	0.03	0.02	0.03	0.02	0.04	0.02	0.04	0.03	0.04

Analysis of Final Conc. of Adsorbate at Different Initial Concentration

Table 2Final Concentration of Treated Sample at Various Adsorbent Size

Conc. Of Adsorbent (gm)	Final Concentration Of Adsorbate in mg/l											
	300µm				150µm				75µm			
	Conc. 8mg/l	Conc. 6mg/l	Conc. 4mg/l	Conc. 2mg/l	Conc. 8mg/l	Conc. 6mg/l	Conc. 4mg/l	Conc. 2mg/l	Conc. 8mg/l	Conc. 6mg/l	Conc. 4mg/l	Conc. 2mg/l
0.5	0.85	1.80	1.80	1.80	0.65	0.8	0.45	1.0	0.60	0.75	0.35	0.35
1	0.35	0.70	0.50	0.55	0.25	0.3	0.25	0.30	0.45	0.45	0.35	0.45
1.5	0.30	0.25	0.25	0.50	0.25	0.3	0.25	0.30	0.15	0.15	0.25	0.25
2	0.25	0.25	0.25	0.35	0.15	0.20	0.15	0.30	0.15	0.30	0.45	0.35

Efficiency of Adsorption of Chromium Metals at Different Conc. of Adsorbent

Table 3Efficiency of Adsorption of Chromium Metals at Different Conc. Of Adsorbent

Conc. Of Adsorbent (gm)	% Adsorption Of Chromium Metals											
	300µm				150µm				75µm			
	Conc. 8mg/l	Conc. 6mg/l	Conc. 4mg/l	Conc. 2mg/l	Conc. 8mg/l	Conc. 6mg/l	Conc. 4mg/l	Conc. 2mg/l	Conc. 8mg/l	Conc. 6mg/l	Conc. 4mg/l	Conc. 2mg/l
0.5	89.3	77.5	77.5	77.5	91.8	89.4	94.4	87.5	92.5	90.6	95.6	95.6
1	95.6	91.3	93.7	93.2	96.8	95.6	95.6	96.3	94.4	94.4	96.8	94.4
1.5	96.3	96.9	96.9	93.7	96.8	96.8	96.8	96.3	98.1	98.1	98.1	96.9
2	96.9	96.9	96.9	95.6	98.1	96.8	98.1	96.3	98.13	96.2	96.8	95.6

Study of Langmuirs Adsorption Isotherm

Adsorption isotherms studies were conducted by varying the Chromium (VI) concentration from 2-8mg/l in 100 ml of water with 1.5g of adsorbent dose at 150µm particle size.The applicability was judged with the correlation coefficient (R^2).

Table 3: langmuirs adsorption

S.No	Conc. (gm)	C_i (mg/l)	C_f (mg/l)
1	1.5	8	0.75
2	1.5	6	0.60
3	1.5	4	0.45
4	1.5	2	0.15

Langmuir equation can be linearized by the below equation

$$\frac{1}{qe} = \frac{1}{(b\,qm)Cf} + \frac{1}{qm}$$

Where, C_f is the equilibrium concentration in liquid phase (mg/l), q_m is the monolayer adsorption capacity (mg/l) and b is the Langmuir constant related to the free adsorption energy (l/mg).

Results and Discussions

Effect on Concentration of Adsorbent

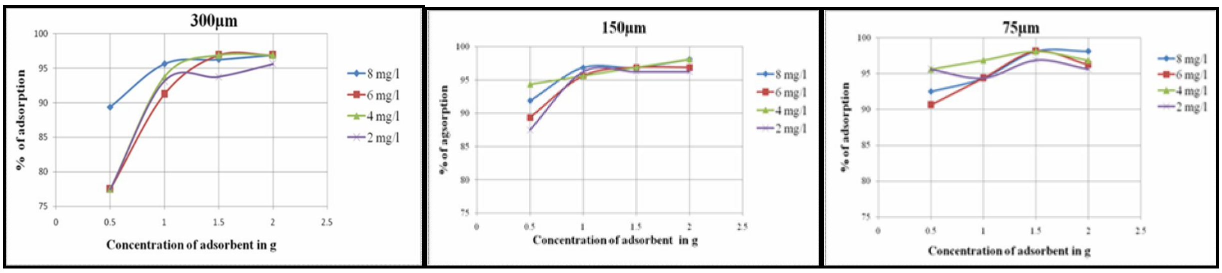


Fig. 3-Effect on Concentration of Adsorbent for various Particle Size

On investigation,highest Chromium (VI) removal while using the adsorbent size of 300µm, 150µm and 75µm were 96.25% and 93.75, 96.25 and 96.85, 96.88% and 98.13%,for the Chromium(VI) concentration of 2 and 8 mg/L respectively **at the adsorbent dose of 1.5g.Thereafter, the Chromium(VI) removal started to decline as the adsorbent mass were raised and then remained leveled.**

Effect of Initial Concentration of Adsorbate

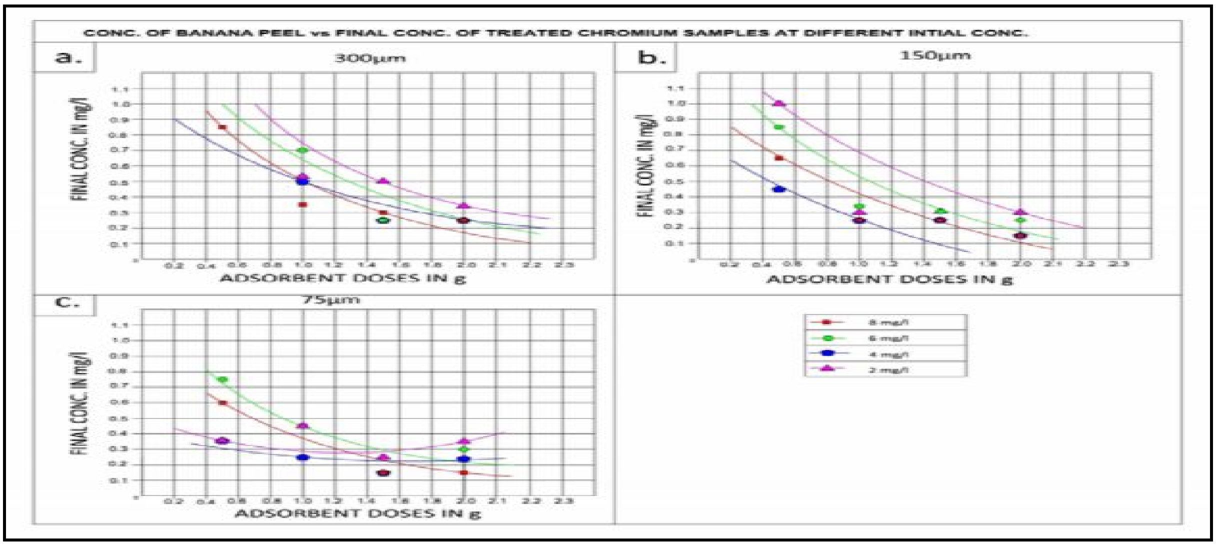


Fig. 4- Effect of initial concentration of adsorbate at three different Proportions

Effect of Particle Sizes

Batch experiments for the effects of particles on adsorption were conducted for three different particle sizes of 300µm, 150µm, and 75 µm at room temperature. Figure 5 indicates that the removal of chromium was increased from 96% to 98% by decreasing the particle sizes from 300µm to 75µm at a different concentration. This behavior can be attributed to the ***effective surface area increased as the particle size decreased***. The adsorption efficiency achieved by 150µm(98%) is equal 75µm(98%). Therefore 150µm gives more efficiency and it was used for further experiments.

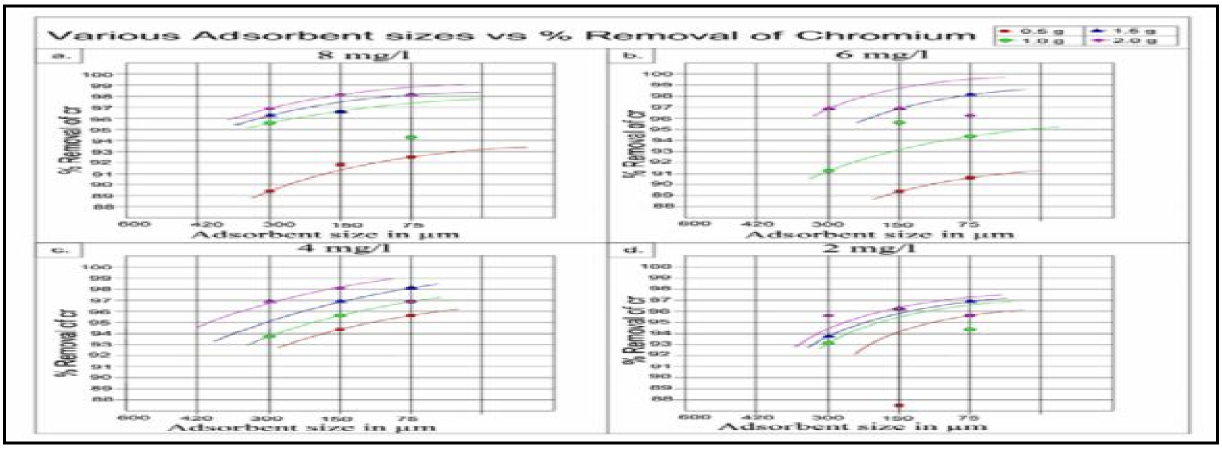


Fig. 5-Effect of particle sizes at different Concentrations

Effect on Langmuirs Adsorption Isotherm:

The Langmuir isotherm linear plot for chromium(VI) adsorption with regression coefficients are shown in figure 6 and table 4 maximum adsorption capacity 'q_m' was found at 1.05 mg/g for 1.5g of concentration of adsorbent .R^2 value of 0.965 suggest that Langmuir relationship for chromium(VI) onto banana peel. 'b' is the adsorption constant related to the affinity of binding sites (l/mg) and lower value of 'b' 0.865 l/g for 1.5g concentration of adsorbent indicate that the particles radius of banana peel were small toward adsorption. Separation factor R_L value is 0.126 reveals that Chromium (VI) adsorption onto banana peel is favorable.

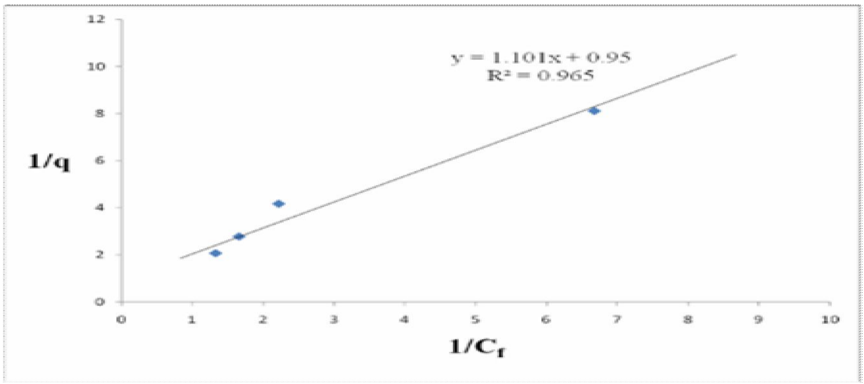
Adsorbent Dose (gm)	q_m(mg/l)	b(l/mg)	R_L	R^2
1.5	1.05	0.865	0.12	0.965

Slope = $1/q_m$ = 0.95

$q_m = 1.05$

$b = 0.865$

Separation factor, $R_L = \frac{1}{1+b\,ci} = 1.26$



Conclusion

The study of adsorption characteristics of chromium concentration up to 8mg/l is determined among which 1.5g of adsorbent dose gives a maximum adsorption rate (98%). Increasing the adsorbent dosage above 1.5g gives the same rate of adsorption and even gradual low rate of adsorption. For different adsorbent particle sizes it is evident that using adsorbent size of 150µm gives maximum adsorption rate (98%) and further decreasing the adsorbent size gives the same rate, hence 150µm particle size will be efficient. Adsorption of 95% of chromium occurred with 6 mg/L and 8 mg/l of Chromium (VI) concentration. On discussion with Langmuir and isotherm models, it showed a near linear relationship with R^2 value of 0.965. .From the present investigation, it is evident that the banana peel has proven to be a proficient biosorbent for the removal of Chromium (VI) from aqueous solution. It was found that the adsorption characteristic of this biosorbent was dependent on adsorbent dose, particle size and initial chromium concentration.This study can conclude that banana peel is found to be a favorable alternative for hexavalent chromium adsorption from water.

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References

1. Agency for Toxic Substances and Disease Registry Case Studies in Environmental Medicine (CSEM) Chromium Toxicity
2. A.L. Holmes, S.S. Wise, & J.P. Wise, Sr. Carcinogenicity of hexavalent chromium- Wise Laboratory of Environmental & Genetic Toxicology, Maine Center for Toxicology University of Southern Maine, 96 Falmouth St., Portland, ME 04104, USA
3. Edmund G. Brown Jr. Public Health Goal for Hexavalent Chromium (Cr VI) In Drinking Water-Pesticide and Environmental Toxicology Branch Office of Environmental Health Hazard Assessment California Environmental Protection Agency July 2011
4. Pollution Prevention and Abatement Handbook World Bank Group Effective July 1998-Dye Manufacturing
5. United Nations Industrial Development Organization Vienna, 2011.Introduction to Treatment of Tannery Effluents.
6. Rajvinder Kaur, Joginder Singh, Rajshree Khare and Amjad Ali. Biosorption the Possible Alternative to Existing Conventional Technologies for Sequestering Heavy Metal Ions from Aqueous Streams- Department of Chemistry, M.M.E.C, M.M.U, Mullana, Ambala, 133207 (India) School of Chemistry and Biochemistry, Thapar University, Patiala – 147004 (India)

7. Elisabeth L. Hawley, Rula A. Deeb, Michael C. Kavanaugh and James Jacobs R.G Treatment Technologies for Chromium (VI)
8. Thomas Anish Johnson, Niveta Jain, H C Joshi and Shiv Prasad. Agricultural And Agro Processing Wastes As Low Cost Adsorbents For Metal Removal From Waste Water-Journal Of Scientific And Industrial Research Vol. 67, September 2008
9. M.A.Hossain, Halo Ngo, W.S.Guo and T.V.Nguyen. Removal of Copper from Water by Adsorption onto Banana Peel as Bioadsorbent- School of Civil and Environmental Engineering, University of Technology Sydney, Australia
10. Ayeesha S Khanam and Usha N Murthy. Experimental Study on Biosorption of Cr (VI) from Water by Banana Peel Based Biosorbent- Department of Environmental Engineering, UVCE, Bangalore, and Karnataka, India.
11. Renata S. D. Castro et al Banana Peel Applied to the Solid Phase Extraction of Copper and Leadfrom River Water: Preconcentration of Metal Ions with a Fruit Waste-pubs.acs.org/IECR
12. Jamil R. Memon, Saima Q. Memon, Muhammad I. Bhanger and Muhammad Y. Khuhawar. Banana Peel: A Green and Economical Sorbent for Cr (III) Removal-Pak. J. Anal. Environ. Chem. Vol. 9, No. 1 (2008) 20 – 25
13. V.Maheswari and N. Balasubramanian. Spectrophotometric Determination of ChromiumBased on Ion-Pair Formation-Department o/Chemistry, Indian Institute ofTechllology, Madras 600 036, India
14. Topallar, Bayrak. Investigation Of Adsorption Isotherms Of Myristic, Palmitic And Stearic Acids On Rice Hull Ash-*Department Of Chemistry, Faculty Of Sciences And Letters, Trakya University, 22030 Edirne-Turkey* -Received 11.04.1997.

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