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Adsorption of Titanium Industry Effluent Contaminated with Chromium Using Bird Bone

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Abstract

Bird bone was used as adsorbent to remove chromium from Titanium industry effluent which was located in Trivandram. Laboratory experimental investigation was carried out to identify the binding of chromium ions by bird bone was found to be mainly influenced by pH, with maximum sorption 14.45 ± 0.98 ppm found in the effluent after adsorption at pH 7. The metal uptake by bird bone particles was maximum (13.35 ± 0.75 ppm) at room temperature and increasing temperatures decreased the Cr ion uptake.

Keywords: Biosorption; Bird bone particles; Chromium uptake; Titanium industry effluent.

Introduction

Biosorption utilizes biological materials to accumulate heavy metals from waste water or soil by either metabolically mediated or purely physico-chemical path ways of uptake. Heavy metals released into the environment by industrial activities tended to persist indefinitely, circulating and eventually accumulating through the food chain, becoming a serious threat to the threat to the environment [1]. Adsorptive removal of heavy metals from effluents was done by using activated carbon or activated alumina [2]. Adsorption has been found to be an efficient and inexpensive method for removing dyes, pigments, heavy metals and other colourants and for controlling the biochemical oxygen demand. Activated carbon, inorganic oxides, mineral and natural adsorbents have been extensively used as adsorbents to treat waste water [3]. Low cost biosorbents such as seaweeds, moulds, yeast, bacteria, crab shells, agricultural products such as wool, rice, straw, coconut husks, peat moss, exhausted coffee, waste tea leaves, walnut skin, coconut fibre, polymerized corn cob, melon seed husk, defatted rich bran, rice hulls, soy bean hulls and cotton seed hulls, wheat bran, hardwood sawdust, pea pod, cotton and mustard seed cakes, petiolar felt sheath of palm were tried [4,5].

Bone charcoal has traditionally been used in the sugar refining industry to remove colour from sugar solutions and it also used to adsorb radioisotopes of antimony from radioactive wastes [6,7]. Egg shells are a very reliable adsorbent due to its calcium carbonate content [8].

The main objective of the study was how efficient bird bone powder was in adsorbing heavy metal Cr at various different parameters such as pH and temperature.

Materials and Methods

Bird bone powder was employed as biosorbent for the removal of Cr from titanium industry effluents.

Preparation of biosorbent material.

Preparation of bone char

Bird bones collected from common fowls were boiled for 30 minutes and the meat attached to the bones was completely removed. The bone was crushed into small fragments in a mechanical crusher. After it was dried at 60°C in a hot air oven for 24 h, bone char was further powdered in an electric blender and sifted in a 80 mesh sieve (<180 µm).

Experimental design

The experimental was designed to analyze the adsorptive potential of cheap bioresource, capable of entrapping Cr and ion in the aquatic and semi aquatic media. The powdered adsorbents were mixed with the two different types of effluents (raw and treated effluent) in 5 different concentration of 1, 2, 3, 4 and 5 mg/l. The medium was separately maintained at six different pH levels (0.5, 2, 4, 7, 8 and 9). The adsorbent were thoroughly mixed with the toxicant solution and the mixture was agitated once in 2 h. The initial concentrations of Cr was estimated in the two different effluents. The treatment was run for a period of more than 60 days. The Cr content of the effluents was estimated after 60 days of interaction with the adsorbents. The difference between the initial and final metal levels indicated the quantity adsorbed by the bioresource used.

The effect of temperature on the adsorptive potential of the materials used was estimated at pH 7. For assessing the effect of temperature, the reaction mixtures were allowed to interact in a 250 ml Erhlen-Meyer flask. The flasks were placed inside separate incubators maintained at 42, 32 and 28°C. The experiments were continued for more than 60 days and the quantities of Cr was analysed in the treated effluent.

Estimation of heavy metal (Cr)

An Atomic Absorption Spectrophotometer (ELICO) model with Air-C2H2 flame type,with an average fuel flow rate between 0.8-4.0 L min-1 and the support gas flow rate between 13.5-17.5 L min-1 was used for sample analysis and operated as per the equipment manual .The single element hollow cathode lamps for respective metals were of ELICO Co.Ltd-L series. Calibration curves for various elements obtained from these standards were of first order reaction. The sample for Cr analysis was aspirated with the help of an Automatic sampler.

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Results and Discussion

Maximum amount of bird bone powder adsorbed chromium at pH 7 and at 5g of adsorbent used, 14.45 ± 0.98 ppm of chromium found in the raw titanium industry effluent (after sludge off). At pH 0.5, at 5 g bird bone powder, 39.66 ± 0.53 ppm of chromium was found in the effluent (Table 1).

Similarly in the case of Table 2, maximum adsorption of Cr found at pH 7 and 10.00 ± 0.89 ppm of Cr has left in the effluent after adsorption by the bird bone powder at the dosage of 5 g/l and 41.94 ± 0.82 ppm of Cr found in the effluent after adsorption at pH 0.5 at the dosage of 1 g/l.

The highest amount of chromium was adsorbed at the adsorbent concentration of 5 g/l temperature of 28°C and the concentration of chromium left in the effluent after adsorption was 20.28 ± 0.70, 18.41 ± 0.42, 15.78 ± 0.85, 14.32 ± 0.86 and 13.35 ± 0.75 ppm at the adsorbent concentration of 1,2,3,4 and 5 g/l (Table 2). The lowest amount of Cr adsorption occurred when temperature (42°C) was high (Table 3).

Highest adsorption was recorded at temperature (28°C) at the adsorbent dosage of 5 g/l as 8.83 ± 0.45 ppm (amount of Cr left in the effluent after adsorption) and lowest adsorption recorded at 42°C at the dosage of 1 g/l as 41.04 ± 0.38 ppm (amount of Cr left in the effluent after adsorption) Table 4.

Bird bone powder effectively adsorbed chromium from the titanium industry effluent. Higher dosages of the adsorbent removed more quantities of Cr compared to low dosages, indicating an additive effect. But the effectiveness of the adsorbent is more when administered in lower dosages. At pH 7, 1 g bird bone powder removed about 22.33 ppm of Cr while 5 g removed only 32.19 ppm, thus adsorption is not directly proportionate to the quantity of adsorbent used. Thus adsorption is not directly proportionate to the quantity of adsorbent used. The sites available for adsorption seemed to decrease when more quantities of the adsorbent are administered.

The pH influenced adsorption of Cr by bird bone powder. At acidic pH levels, the quantity of Cr adsorbed much less compared to neutral and alkaline pH levels. Thus pH plays a vital role in determining the quantity of Cr adsorbed from the medium by bird bone powder. The pH seemed to modify the adsorption potential of bird bone powder and the pH should be maintained at 7.0 to achieve maximum adsorption of Cr. Agarwal and Gupta [9] found out that animal bone charcoal acts as a low cost adsorbent for Cr(vi) from aqueous solution.

Zhu et al. [10] reported that fluorine removal efficiency increased from 21 to 95.80% with increase in adsorbent dose of 0 to 40 g/l of modified bone char. Olaniyi et al.[11] reported that at a particle size of about 355 μm of cow bone charcoal , maximum adsorption of 2.49

S. No	S.No	Amount (in g) of bird bone powder	Chromium in effluent (ppm)	Cr concentration (ppm) in effluent					
				pH					
				0.5	2	4	7	8	9
	1	1	46.64 ± 0.93	46.34 ± 0.58	40.03 ± 0.90	36.17 ± 0.89	24.31 ± 0.88 (-47.79)	34.82 ± 0.45	43.36 ± 0.61
	2	2		45.48 ± 0.65	37.31 ± 0.56	34.38 ± 0.62	22.42 ± 0.82 (-51.83)	32.19 ± 0.86	41.55 ± 0.39
	3	3		44.15 ± 0.53	37.30 ± 0.82	34.22 ± 0.50	20.49 ± 0.92 (-55.96)	29.80 ± 0.51	40.31 ± 0.88
	4	4		42.18 ± 0.92	34.27 ± 0.80	32.20 ± 0.85	17.47 ± 0.76 (-62.42)	28.05 ± 0.50	37.35 ± 1.02
	5	5		39.66 ± 0.53	33.83 ± 0.87	30.90 ± 0.56	14.45 ± 0.98 (-68.87)	25.50 ± 0.54	35.16 ± 0.75

Note: Percent decrease in Cr concentration in parentheses. Deviations significant at P ≤ 0.05 (t-test)

Table 1: Adsorption of Cr from raw titanium industry effluent (after sludge off) by bird bone powder at different pH levels.

S. No	Amount (in g) of bird bone powder	Chromium in effluent (ppm)	Cr concentration (ppm) in effluent					
			pH					
			0.5	2	4	7	8	9
1	1	43.46 ± 1.10	41.94 ± 0.82	34.52 ± 0.65	30.20 ± 0.88	18.83 ± 0.64 (-56.65)	27.73 ± 0.45	37.34 ± 0.89
2	2		40.28 ± 0.85	32.06 ± 0.74	28.30 ± 0.74	17.32 ± 0.81 (-60.12)	27.11 ± 0.75	36.30 ± 0.82
3	3		38.13 ± 0.51	30.88 ± 0.72	28.14 ± 0.59	14.29 ± 0.93 (-67.09)	24.84 ± 0.51	34.18 ± 0.82
4	4		36.25 ± 0.80	29.16 ± 0.82	26.22 ± 0.88	13.24 ± 0.67 (-69.51)	23.02 ± 0.81	32.27 ± 0.79
5	5		35.00 ± 0.41	24.26 ± 0.79	22.27 ± 0.96	10.00 ± 0.89 (-76.96)	20.00 ± 0.89	29.83 ± 1.07

Note: Percent decrease in Cr concentration in parentheses. Deviations significant at P ≤ 0.05 (t-test)

Table 2: Adsorption of Cr from treated titanium industry effluent (disposed) by bird bone powder at different pH levels.

S. No	Amount (in g) of bird bone powder	Chromium in effluent (ppm)	Cr concentration (ppm) in effluent		
			Temperature (°C)		
			28	32	42
1	1	46.64 ± 0.93	20.28 ± 0.70 (-56.41)	36.90 ± 0.67	45.50 ± 0.58
2	2		18.41 ± 0.42 (-60.41)	36.01 ± 0.67	44.20 ± 0.95
3	3		15.78 ± 0.85 (-66.04)	34.14 ± 0.48	41.72 ± 0.52
4	4		14.32 ± 0.86 (-60.41)	31.22 ± 0.79	40.38 ± 0.70
5	5		13.35 ± 0.75 (-71.24)	29.50 ± 0.67	37.62 ± 0.86

Note: Percent decrease in Cr concentration in parentheses. Deviations significant at P ≤ 0.05 (t-test)

Table 3: Adsorption of Cr from raw treated titanium industry effluent (after sludge off) at pH 7 by bird bone powder at different temperature levels.

S. No	Amount (in g) of bird bone powder	Chromium in effluent (ppm)	Cr concentration (ppm) in effluent		
			Temperature (°C)		
			28	32	42
1	1	43.46 ± 1.10	17.36 ± 0.67 (-60.03)	33.50 ± 0.60	41.04 ± 0.38
2	2		15.27 ± 0.85 (-64.84)	31.04 ± 1.07	40.27 ± 0.86
3	3		13.30 ± 0.64 (-69.37)	29.11 ± 0.53	37.67 ± 0.65
4	4		11.77 ± 0.48 (-72.89)	26.42 ± 0.83	35.44 ± 0.83
5	5		8.83 ± 0.45 (-79.65)	25.97 ± 0.96	34.31 ± 0.83

Note: Percent decrease in Cr concentration in parentheses. Deviations significant at P ≤ 0.05 (t-test)

Table 4: Adsorption of Cr from treated titanium industry effluent (disposed) at pH 7 by bird bone powder at different temperature levels.

chromium and 1.42 mg/g of lead was adsorbed from aqueous solution.

Chojnacka [12] and Chen et al. [13] pointed out that cow bone charcoal is used as a microporous adsorbent, metals penetrate easily in to these pores, when the ionic size becomes small. Han et al.[14] and Jain et al. [15] pointed out that different chemical functional groups such as carboxyl, hydroxyl and amide are responsible for biosorption of metal ions. These functional groups are the potential sites for adsorption and the uptake of metal depends on various factors such as abundance of sites, their accessibility and affinity between the adsorption site and metal.

Temperature was another significant factor determining adsorption of heavy metals .At higher temperatures (42°C), even 1 g of adsorbent adsorbent removed 55.1 percent of Cr from the titanium industry effluent at the ideal pH of 7.

Ibrahim et al. [16] studied the effect of maximum metal ion concentration for the adsorption capacity of chromium and lead at 30°C and here cowbone charcoal was used as an adsorbent. Olaniyi et al. [11] found that at 30°C, cow bone reported the effect of temperature for the removal of metals using an immobilized sorbent obtained from poultry waste.

References

1. Kuppusamy V, Jegan JR, Palanivelu K, Velan M (2004) Copper removal from aqueous solution by marine green alga. Electronic J Biotechnol, 7: 61-71.
2. Monser L and Adhoum N (2002) Modified activated carbon for the removal of copper, zinc, chromium, and cyanide from waste water. Separation and Purification Technology, 26: 137-146.
3. Alasheh S, Banat F, Aitah LA (2003) Adsorption of phenol using different types of activated bentonites. Separation and Purification Technology, 33: 1-10.
4. Iqbal M, Saeed A, Akhtar N (2002) Petiolar felt-shealth of palm, a new biosorbent for the removal of heavy metals from contaminated water. Biores Technol, 81: 153-155.
5. Saeed A, Iqba M, Akhtar MW (2002) Application of biowaste materials for the sorption of heavy metals in contaminated aqueous medimum. Pak J Sci Ind Res, 45: 206-211.
6. Gary UK, Kaur MP, Garg VK, Sud D (2007) Removal of hexavalent chromium from aqueous solution by agricultural waste biomass. J Hazard Mater, 40: 60-68.
7. Ofomaja AE, Ho YS (2007) Effect of pH on cadmium biosorption by coconut meal. Hazard. Mater, 139: 356-362.
8. Aimi NB, Norhafizah BA, Wong CS (2013) Removal of Cu from water by adsorption on chicken egg shell. International Journal of Engineering and Technology, 13: 1.
9. Agarwal A, Gupta PK (2015) Adsorption study of Cr(vi) from aqueous solution using animal bone charcoal. International Journal of Engineering Technology, Management and Applied Sciences, 3: 151-163.
10. Zhu H, Wang H, Wang G, Zhang K (2011) Removal of fluorine from water by the aluminum modified bone char. International Conference on Biology, Environment and Chemistry, 1: 455-457.
11. Olaniyi I, Moses S, Odoh R (2012) Adsorption study of Cr (VI) and Pb (II) from aqueous solution using animal charcoal derived from cow bone. Pelagia Research Library, 3: 648-657.
12. Chojnacka K (2005) Biosorption of Cr (III) ions by egg shells. Journal of Hazardous Materials, 121: 167-173.
13. Chen SB, Zhu YC, Ma YB, Mekay G (2006) Effect of bone char application on Pb contaminated soil. Environ. Pollut, 39: 433-439.
14. Han X, Wong YS, Wong MH, Tama NFY (2007) Biosorption and bioreduction of Cr (vi) by a microalgal isolate. J Hazard Mater, 146: 65-72.
15. Jain M, Garg VK, Kadirvelu K (2009) Chromium (VI) removal from aqueous system using H. annuus stem waste. J Hazard Mater, 162: 365-372.
16. Ibrahim O, Sunday M, Odoh R (2012) Adsorption Study of Cr (VI) and Pb (II) from aqueous solution using animal charcoal derived from cow bone. Pelagia Research Library, 3: 648-657.