

Removal of Aluminium from Metal Plating Industrial Waste Water by Different Column Chromatography Technique

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Abstract: Recently electroplating and metal working industries discharge huge quantities of heavy metals in their effluent. It is major problem to human health and aquatic life. Number of works has been done in copper, nickel, lead, zinc, Iron but in the adsorption of aluminium heavy metals work is very less. Precipitation, solvent extraction, membrane processing, and electrolytic methods are available for reducing the metals but it is high cost. So cheap and effective alternative method are used for the removal of heavy metals for reduce operating costs. The number of low cost adsorbents Zeolite, tea waste, rice husk, coconut husk and Sabina powder have been used for the removal of aluminium heavy metals.

Keywords: Aluminium waste water, rice husk, tea waste, coconut husk

1. Introduction

The term "heavy metal" is collectively applied to a group of metals (and metal-like elements) with density greater than 5 g/cm³ and atomic number above 20 (Raut et al., 2012). Removal of heavy metals from industrial wastewater is of primary importance. Water of high quality is essential to human life and water of acceptable quality is essential for agriculture, industrial, domestic and commercial uses. Electroplating industries discharge aqueous effluents containing relatively high levels of heavy metals, e.g., uranium, cadmium, mercury, nickel, Aluminium, chromium and copper. Untreated effluents from these manufacturing processes have an adverse impact on the environment. A specific problem associated with heavy metals in the environment is the accumulation in the food chain and persistence in the environment. Physical and chemical methods have been designed to remove metal ions from effluent, but in general, these methods are commercially impractical, either because of high operating cost or difficulty in treating the solid wastes generated.

Heavy metal pollution exists in many industrial wastewaters, such as metal plating facilities, mining operations, nuclear powerhouse, fertilizer industries, paints and pigments, municipal and storm water run-off, battery and tannery industries (Patterson, 1977). Some metals associated with these activities are as follows; lead, cadmium, copper, chromium etc. Heavy metals are not biodegradable and tend to accumulate into living organisms, causing various diseases and other problems. Lead and its compounds are found frequently in surface water, because it is a ubiquitous metal in the environment. The most widely used methods for removing metal ions are as follows; precipitation with chemical and electrochemical methods or sometimes using sulphides (Chen., 2004; Marani et al, 1995; Patterson, 1985). A major problem with this type of treatment is the disposal of the precipitated wastes. Ion exchange treatment which is the second most widely used method for metal ion removal does not present a sludge disposal problem and has the advantage of reclamation of Cu (II) (Petrus & Warchol,

2003). This method can reduce heavy metals to very low levels. However, ion exchange treatment does not appear to be economical. Activated carbon is also efficient for removal of trace elements from the waste water, but its high cost has prevented its wide usage.

The adsorption phenomenon has still been found economically appealing for the removal of toxic metals from wastewater by choosing some adsorbents under optimum operation conditions (some aquatic plants, agricultural by-products, sawdust, clay, zeolite) have the capacity to absorb and accumulate heavy metals. Cost comparisons are difficult to make due to the scarcity of consistent cost information. Although many experiments have been accomplished in the area of low-cost sorbents, a great deal of work is necessary to understand better low-cost adsorption processes and to demonstrate the technology.

In our study, a batch removal method was employed for the Aluminium metal uptake investigation by Column chromatography (Zeolite column, Activated agriculture waste column and Sabina washing powder column). Metal uptake analysis was done by atomic absorption spectrophotometer.

2. Materials and Method

2.1 Sample Collection

Metal effluents are collected from metal plating industry area in the Madurai district. In this study, Aluminium metal only was analyzed before and after treatment.

2.2 Preparation of adsorbents

1. Tea Waste

Simple procedure to prepare the adsorbent, firstly tea waste washed and then rinse with distilled water [Mahavi et al.,2005]. After drying in 100°C, it was ground and screened (using screen with mesh size 10). Prior to the experiments, removed other soluble dirtiness and colored components

from the T.W. by washing with distilled water for much times until a colorless solution of tea waste was spectrometrically observed at room temperature. Decolorized and cleaned tea waste was dried at room temperature for a few days by spreading on gauze (Malkoc and Nuhoglu 2007). The dried tea waste was sieved and stored in sealed polythene bags [Amarasinghe et al.,2007].

2. Rice Husk

Rice husk is agricultural waste mostly available in rural areas, collected their and grinding in grinders than sieved & washed with distilled water repeatedly for dirt and other particulate matter removal, then dried in hot oven at 100°C for 24 hours, then either directly used as an adsorbent or treated with H₂SO₄ and then washed again with distilled water for removing acidity, washing up to totally acidity are removed and then dried at 100°C for 12 hours then collected in air tight plastic bags and then used as an adsorbent [Ajmal et al.,2003].

3. Coconut Husk

Coconut easily available in all temple and religious places, collected them dried in hot oven at 80°C for 4 hours and then grinds in grinder in the powder form then sieved 120 mm sizes than washing with distilled water for dirt and other particulate matter removing, then again dried at 100°C for 24 hours then used as an adsorbent [Abad, 2002].

4. Zeolite Column

A zeolite chemical was purchased from the chemical company for this work as such but various percentages.

5. Sabina Washing Powder Column

Sabina washing power chemicals was purchased from the shop for this work as such (it is activated soil) but various percentages.

2.3 Various Factors Affecting Adsorption Capacity

pH:

For adsorption of heavy metal ions, pH is one of the most important environmental factors [Wahi et al., 2010]. The P^H value of solution strongly influences not only the site dissociation of the biomass surface, but also the solution chemistry of the heavy metals: hydrolysis, complexation by organic and Inorganic ligands, redox reactions, precipitation, the speciation and the adsorption availability of the heavy metals [Jalali,2002]. The adsorptive capacity of metal cations increases with increasing pH of the Sorption system, but not in a linear relationship. The percentage adsorption increases with pH to attain a maximum at pH 6 and thereafter it decreases with further increase in pH. We prepared the adsorbent materials at various pH levels. (5 to 8)

Temperature:

Temperature has also an influence on the adsorption of metal ions, but to a limited extent under a certain range of temperature, which indicates that ion exchange mechanism exists in adsorption to some extent. Adsorption process is usually not operated at high temperature because it will Increase the operational cost. It found that temperature (20–40°C) had Minor effect on the accumulation level of

aluminium by surface of wood ash in Suspension. Adsorption reactions are normally exothermic, so adsorption capacity increases with Decrease of temperature in the range of 20– 40°C.

Incubation time:

The adsorption process of heavy metal by activated agriculture waste usually completes rapidly for all metals. The adsorption of Metals aluminium by tea waste, rice husk, coconut husk is a rapid process and often reaches equilibrium within several hours. Then evaluate the adsorbent amount of single and binary compounds at various intervals of time (30 to 90 min).

Effect of Adsorbent Dosage:

In case of Aluminium ions, there is slight and gradual increase in percentage removal with increasing dose. It is apparent that the percent removal of heavy metals increases rapidly with increase in the dose of the adsorbents due to the greater availability of the exchangeable sites or surface area. Moreover, the percentage of metal ion adsorption on adsorbent is determined by the adsorption capacity of the adsorbent for metal ions.

Preparation of column

Burette or glass cylinder was used as column. The diameter of the cylinder is taken as 40cm and depth is 70 cm. The bin type is off circular fibered type with required number of holes for draining purpose. The filter adsorbents were taken as single and combined (equal part of two adsorbents) and filled up to 60cm. A depth of 10 cm was left for loading metal effluent water. A rectangular tray was placed below the bin for collection of treated effluent. The treated samples were analysed by atomic absorption spectroscopy.

Table 1: Comparison of heavy metal concentration (Aluminium) after treatment of various activated adsorbents at different pH (initial conc.of aluminium is 2250 µg/l)

S. No	Types of adsorbents	Conc. Of aluminium (µg/l) at Different pH			
		5	6	7	8
1	Saw dust	305.2	422.4	468.4	512.3
2	Rice husk	319.6	390.4	470.4	499.0
3	Coconut husk	348.9	360.1	422.0	440.0
4	Zeolite	419.1	488.6	538.6	584.6
5	Sabina powder	382.3	438.4	471.1	535.5

Table 2: Comparison of heavy metal concentration (Aluminium) (µg/l) after treatment of various activated adsorbents at different Temperature in constant pH 5 (initial conc.of aluminium is 2250 µg/l)

S. No	Types of activated adsorbent	Conc. Of aluminium (µg/l) at different temperature		
		30°C	40°C	50°C
1	Saw dust	318.4	348.9	362.0
2	Rice husk	336.6	373.4	318.3
3	Coconut husk	350.0	387.1	380.5
4	Zeolite	374.6	381.4	388.5
5	Sabina powder	390.7	415.0	411.8

Table 3: Comparison of heavy metal concentration (Aluminium) ($\mu\text{g/l}$) after treatment of various activated adsorbents at different incubation time (minutes) in constant pH 5 and 30°C (initial conc. of aluminium is $2250 \mu\text{g/l}$)

S.No	Types of activated adsorbent	Conc. Of aluminium ($\mu\text{g/l}$) at different incubation time		
		30	60	90
1	Saw dust	375.6	389.8	392.1
2	Rice husk	321.3	335.6	340.6
3	Coconut husk	376.8	350.9	354.3
4	Zeolite	378.3	376.4	375.3
5	Sabina powder	435.4	393.6	393.4

Table 4: shows that the concentration of aluminium after effluent treatment in constant pH 5 and temperature 60°C (initial conc. of aluminium is $2250 \mu\text{g/l}$)

S.No	Adsorbents	Conc. Of Aluminium ($\mu\text{g/l}$)
1	Saw dust+rice husk	235.5
2	Saw dust+coconut husk	328.0
3	Saw dust+zeolite	380.5
4	Saw dust+Sabina powder	345.4
5	Rice husk+coconut husk	247.0
6	Rice husk+zeolite	303.5
7	Rice husk+Sabina powder	240.0
8	coconut husk+zeolite	355.5
9	coconut husk+Sabina powder	392.5
10	Zeolite+Sabina powder	365.7
11	Saw dust+rice husk+coconut husk	238.5
12	Saw dust+rice husk+zeolite	249.0
13	Saw dust+rice husk+Sabina powder	237.6
14	Rice husk+coconut husk+zeolite	265.5
15	Rice husk+zeolite+Sabina powder	234.0
16	coconut husk+zeolite+Sabina powder	220.0
17	Saw dust+rice husk+coconut husk+zeolite	231.9
18	Saw dust+rice husk+coconut husk+Sabina powder	196.5
19	Rice husk+coconut husk+zeolite+Sabina powder	199.8
20	Saw dust+Rice husk+coconut husk+zeolite+Sabina powder	205.5

3. Results and Discussion

Aluminium as the third most abundant element of the earth and its wide distribution accounts for the presence of it in nearly all natural waters as soluble salt, a colloid or as insoluble compound. The permissible limit of Aluminium in drinking water is 0.05 mg/l as laid down by WHO/ICMR (Packham 1988, APHA, AWWA, WEF 1992). If its concentration exceeds the permissible limit it may be a cause of Alzheimer disease which is characterized by memory loss, formation of neuritic plaque, etc. (Mathur et al., 2008).

Table 1 shows that comparison of heavy metal concentration (Aluminium) after treatment of various activated adsorbents at different pH (initial conc. of aluminium is $2250 \mu\text{g/l}$). The maximum removals of at pH 6 were found to be nearly 88.8, 93.3 and 69%, respectively [58]. The maximum adsorption at pH 6 may be attributed to the partial hydrolysis of M^+ , resulting in the formation of MOH^+ and $\text{M}(\text{OH})_2$. $\text{M}(\text{OH})_2$ would be adsorbed to a greater extent on the non-polar adsorbent surface compare to MOH^+ . With increase of pH from 2 to 6, the metal exists as $\text{M}(\text{OH})_2$ in the medium and surface of adsorbent is minimum, leading to the enhancement of metal adsorption. At higher pH, that is,

above optimum pH of 6, increase in OH^- ions cause a decrease in adsorption of metal ions at adsorbent-adsorbate interface [Periyasamy and Namasivayam, 1993].

Table 2 shows that comparison of heavy metal concentration (Aluminium) ($\mu\text{g/l}$) after treatment of various activated adsorbents at different Temperature in constant pH 5 (initial concentration of aluminium is $2250 \mu\text{g/l}$). Ajmal et al., (2003) reported that maximum equilibrium adsorption capacity of various heavy metals for Pb (II), Ni(II), Co(II) and Cr(VI) ions by the wood ash was reached at temperature of 25°C . The decrease in capacity at higher temperature between 25 and 40°C revealed that the Processes of adsorption for these metal ions by ash are exothermic. The decrease of adsorption Capacity at higher temperature may be due to the damage of active binding sites in the biomass.

Studied the effect of contact time or incubation time on the adsorption of Aluminium onto Sabina powder, Initially the removal was very rapid in first 30 minutes, then adsorption rate gradually decreases and removal reaches equilibrium in around 90 minutes. The time required to reach equilibrium was dependent on initial concentration of aluminium. The percentage removal of zinc was increases with increase in contact time till equilibrium attained in 30 minutes [Wasewar, 2009]. It is observed that in all cases the percentage removal is comparatively lower for 24 h contact time, with increasing removal efficiencies at higher contact time. In case of Ni(II) and Cd(II) ions rise sharp rise in percentage removal with increasing contact time.

On other hand, percentage removal of Mn(II), Zn(II) and Cu (II) increases gradually with contact time, reaching nearly 100% removal only at around 72 h. It is evident from the results that the contact time required to attain equilibrium is dependent on the initial concentration of heavy metals. For the same concentration, the percentage removal of heavy metal increases with increase of contact time till equilibrium is attained. The optimal contact time to attain equilibrium with carbon aerogel was experimentally found to be about 48 h [Mishra et al., 2005]. The effects of the contact time on the amount of Cu^{2+} and Ni^{2+} adsorbed per unit of adsorbent at three different temperatures (30, 45, and 60°C). For Cu^{2+} and Ni^{2+} , a gradual increase in adsorption occurred upon increasing the contact time up to 120, 240 min, at which point the maximum values of adsorption were attained. Extending the contact time further had an insignificant effect on the amounts of the heavy metals adsorbed.

Table 4 shows that the concentration of aluminium after effluent treatment. Various combinations of the activated saw dust, rice husk and coconut husk with zeolite and Sabina powder were prepared in equal amount (Table 4). In this study, adsorptions of aluminum are varied from adsorbent to adsorbent combination in a standard pH, Temperature and incubation time. The maximum adsorption was occurred in the five combined materials because of all the materials activated and it has high adsorption capacity. Mathur et al., (2008) reported that the batch equilibrium method was employed for the metal up take investigation by the resin.

4. Acknowledgment

The authors thank to the Department of Zoology, Madurai for providing support of the work described in this paper.

Reference

- [1] Mathur, P.N., S.Loonker., A.Sharma and N.Rehdu. 2008. Aluminium extraction by means of dihydroximate of iminodiacetic acid derivative of chitosan. *Nature environment and pollution technology*. 7:2. 197-201.
- [2] APHA, AWWA, WEF. 1992. Survey of inorganic contaminants in water supplies. *J.AWWA*. 77:67-72.
- [3] Packham. R.F. 1988. Chemical aspect of water quality and health. *J.Inst. Water. Environ. Health*. (1):11.
- [4] Marani, D., Macci, G., Pagano, M. 1995. Lead Precipitation in The Presence of Sulphate and Carbonate Testing of Thermodynamic Predictions, *Water Res.* 29(4), 1085-1092.
- [5] Petrus, R., Warchol, J., 2003. Ion exchange equilibria between clinoptilolite and aqueous solutions of $\text{Na}^+/\text{Cu}^{2+}$, $\text{Na}^+/\text{Cd}^{2+}$ and $\text{Na}^+/\text{Pb}^{2+}$, *Microporous and Mesoporous Materials*, 61, 137-146.
- [6] Patterson, J.W. 1985. *Industrial Wastewater Treatment Technology*. Butterworths. Boston.
- [7] Patterson, J.W. 1977. *Wastewater Treatment*, Science Publishen Inc. New York, USA.
- [8] Chen, G (2004) Electrochemical technologies in wastewater treatment *Separation and Purification Technology*, 38, 11-41.
- [9] Abad M., P. Noguera, R. Puchades, A. Maquieira, and V. Noguera, 2002. Physico chemical and chemical properties of some coconut coir dusts for use as peat substitute for containerized ornamental plants. *Bioresources Technology*, Vol.82, pp. 241-245.
- [10] Ajmal, M., Rao, R.A.K., Anwar, S., Ahmad, J., and Ahmad, R., 2003. Adsorption Studies on Rice Husk: Removal and Recovery of Cd (II) from Wastewater. *Bioresource Tech.*, 86, pp 147-149.
- [11] Amarasinghe BMWPK and Williams AR. 2007. Tea waste as a low cost adsorbent for the removal of Cu and Pb from waste water. *Chem. Eng. J.*; 132, pp 299-309.
- [12] Jalali R., Ghafourian H., Asef Y., S.J. Davarpanah, S. Sepehr, 2002. Removal and recovery of lead using nonliving biomass of marine algae, *J. Hazard. Mater. B* 92, pp 253-262.
- [13] K. Periasamy, C. Namasivayam, 1993 Bicarbonate treated peanut hull carbon for Hg (II) removal from aqueous solution. *Water Res.* 27, pp 1663-1668.
- [14] Mishra G.K. Meena A. K., Rai, P.K, Chitra R.G, Nagar, P.N. 2005. Removal of heavy metal ions from aqueous solutions using carbon aerogel as an adsorbent. Elsevier B.V. All rights reserved. doi:10.1016/j.jhazmat. 03.02
- [15] Wahi R., Kanakaraju D. and Noor A Yusuf, 2010 Preliminary Study on Zinc Removal from Aqueous Solution by Sago Wastes. *Global Journal of Environmental Research* 4 (2) pp 127-134,
- [16] Wasewar KL, Mohammad A, Prasad B and Mishra IM. 2009. Batch adsorption of Zn using tea factory waste as an adsorbent. *Desalination*; 244 pp 66-71.
- [17] Mahavi AH, Naghipour D, Vaezi F and Nazmara S. 2005. Teawaste as an adsorbent for heavy metal removal from industrial wastewaters. *American J. App. Sci.*; 2(1) pp 372-375.
- [18] Malkoc E and Nuhoglu Y. 2007. Potential of tea factory waste for chromium (VI) removal from aqueous solutions: thermodynamic and kinetic studies. *Sep. Purif. Technol.*; 54, pp 291-298.
- [19] Raut N., Charif G, Amal Al-Saadi., Shinoona Al-Aisri, Abrar Al-Ajmi, 2012. A Critical Review of Removal of Zinc from Wastewater, *Proceedings of the World Congress on Engineering Vol I WCE 2012*, July 4 - 6, 2012, London, U.K.