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Removal of Hexavalent Chromium from Wastewater by Adsorption: A Review

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Abstract

Amount of waste water containing heavy metals is increasing in the environment due to industrialization. Heavy metals treatment of waste water should be done due to increase in pollution and scarcity of water. Hexavalent Chromium is one of the heavy metal emitted from textile dye, tannery, nuclear power plants, and battery making steel and electroplating industries which cause chronic disorders in human. It is one of the most common metal present in the effluents. So it is necessary to remove heavy metals from waste water as it is very toxic. The study was carried out to increase the percentage removal of hexavalent chromium, characteristics, efficiency and economy of waste water by low cost adsorbent.
Keyword- Adsorption, Efficiency, Hexavalent chromium, Isotherms, Kinetics

I. INTRODUCTION

As human demands are increasing, industries are growing rapidly, the problem of polluted waste water discharge increases as a result we have to decrease the water pollution by low cost effective method. Industrial pollution continues to be a potential threat affecting the water. The discharge of non-biodegradable heavy metals like copper, zinc, nickel, lead, cadmium and chromium into water stream is hazardous because the consumption of polluted water causes various health problems. Chromium also exist usually in both trivalent and hexavalent form, but the latter form is of particular concern due to its greater toxicity. The increase in concentration levels of heavy metals in the environment particularly in water is a cause for concern. More than 1,70,000 metric tons of chromium waste are discharged annually in environment as a result of industrial and manufacturing activities.

According to the Indian standards the permissible limit for chromium(VI) for potable drinking water is 0.05mg/l, for industrial effluent discharge into inland surface water is 0.10 mg/l and for public sewage is 2.00 mg/l[2].But the industrial effluent contain much higher concentrations compared to the permissible limit. Hexavalent chromium is a major pollutant released during several industrial operations. It is also reported as one of the metals known to be carcinogenic and has an adverse potential to modify the DNA transcription process [1].

II. METHODS FOR HEXAVALENT CHROMIUM REMOVAL

Generally, Cr^{+6} is removed from wastewater by various methods such as chemical precipitation, electrochemical reduction, sulphide precipitation, ion-exchange, reverse osmosis, electro dialysis, solvent extraction, evaporation, etc. These methods are very costly and are not affordable for large scale treatment of wastewater that is rich in hexavalent chromium.

Arris.S, Bencheikh Lehocine M et.al has aimed at exploring carbon which was prepared by calcination of Cereal By-Product (CBP) and has used as adsorbent for the removal of Chromium (VI) from a surface treating industry. In this the removal effectiveness reached nearly 90.37% when using optimal conditions. The effect of various parameters such as adsorbent dosage, particle size, pH, contact time and stirring speed was studied. Maximum removal efficiency of Cr(VI) in the pH range of 6–8 for an initial chromium concentration of 132 mg/L [1].

M. Venkateswara Rao et.al has investigated, that Azadirachta indica (neem) leaf powder was used as an adsorbent for the removal of chromium from aqueous solutions. The experiments were carried out in a batch process. The adsorbent showed 90 percentage removal. Adsorption behaviour is found to follow Freundlich and Langmuir isotherms. In this study the adsorption mechanism was described by a pseudo second order kinetics [2]. Srivastava S. K. et.al has used mangifera indica bark for chromium (VI) removal, by using adsorbent, which was prepared from Mangifera indica bark. The parameters studied were contact time, adsorbent dosage, temperature, variable initial chromium (VI) concentration and pH. The adsorption processes of chromium (VI) are tested with Linear, Langmuir and Freundlich isotherm models. The adsorption of chromium (VI) was found to be maximum up to 80.2% at low values of pH 2 having Cr (VI) concentration of 50 mg/L and adsorbent dose of 1g/L[3]. Shadreck Mandina, Fidelis Chigondo et.al has studied the adsorption capacity of the orange peel chemically modified with sodium hydroxide. The adsorbent was characterized by FTIR spectroscopy and BET. The biosorption efficiency of the orange peel was dependent on the pH of the Cr (VI) solution, with pH 2 being optimal. The removal rate of Cr (VI) ions increased with increase in contact time and remained constant after an equilibrium time of 180 min. The removal of Cr (VI) ions increased with increase in biosorbent concentration with the optimal adsorbent dosage at 4.0 mg/L. The adsorption data fitted well with the Freundlich isotherm model with R2 = 0.987 for the raw orange peel and R2 = 0.995 for the modified orange peel [4].

Smita M. Honnannavar, Hampannavar U. S. et.al. has aimed to evaluate the potential of utilizing activated sugarcane bagasse, to remove Cr (VI) from aqueous solutions through adsorption process. The extent of adsorption was studied as a function of pH, agitation time, adsorbent dosage, and initial metal ion concentration. The adsorption of hexavalent chromium was found to be 96.1% [5]. S. Dhanakumar, G. Solaraj et.al has aimed to remove chromium (VI) from aqueous solution using decolorized Cooked Tea Dust (CTD) by adsorption technique. Batch mode adsorptive removal was carried out at varying pH (2 - 11), agitation time (5 – 60 min), particle size (125 – 750 μm) and adsorbent dosage (50 – 500 mg/50ml). The optimum pH for Cr (VI) adsorption on CTD was found to be 2.0. Adsorption equilibrium was obtained in 45, 50, 40, 45 and 45 min for the initial Cr (VI) concentrations of 25, 50, 75, 100 and 125 mg/l respectively. 90 % removal of chromium was obtaioned by this adsorbent[6]. Anand S A, Nagarajappa et.al had used Rice husk ash as an adsorbent for removal of chromium, preparation of synthetic Cr(VI) Solutions like 10 mg/L, 20 mg/L,30 mg/L, 40mg/L and 50 mg/L and its adsorption. Different dosages of rice husk ash from 1 mg/L to 10 mg/L were used by varying the pH 2, pH4, pH6, pH8, pH10 for all concentrations of Chromium solutions. Adsorption isotherms were analyzed to know the better performance of the Rice husk ash. 90 % Percentage removal of hexavalent chromium was obtained [7].

S.H. Hasan, K.K. Singh, O. Prakash, M. Talat et.al has studied the removal of Cr(VI) from aqueous solutions using agricultural waste 'maize bran' and the sorption of Cr(VI) was found to be effective in the lower pH range and at higher temperature. Effect of pH showed that maize bran was not only removing Cr(VI) from aqueous solution but also reducing toxic Cr(VI) into less toxic Cr(III). The fitness of the sorption data into Langmuir isotherm confirmed the monolayer adsorption [8]. Tasrina R. Choudhury, M. N. Amin et al. has aimed for the removal of hexavalent chromium from aqueous solution using nutshell, best suited for the treatment of real tannery effluents since Cr salt is used for tanning. Batch adsorption studies were carried out under varying experimental conditions of contact time, pH, adsorbent dose, initial chromium concentration and particle size. The adsorption followed first order rate kinetics expression. The equilibrium data fit well into Langmuir and Freundlich isotherms. Adsorption was maximum at an initial pH of 2.0. Good percentage removal of chromium was obtained [9].

N. Ahalya et.al has aimed to remove chromium (VI) from aqueous solutions through biosorption using coffee husk. The effects of pH, contact time, initial concentration and adsorbent dosage on the adsorption of Cr(VI) were studied. The data obeyed Langmuir and Freundlich adsorption isotherms. The Langmuir adsorption capacity was found to be 44.95 mg/l. The Freundlich constants Kf and n were 1.027 [mg/l (l/mg)l] and 1.493, respectively. [10]. Zainul Akmar Zakaria, Marlini Suratman et.al has studied the ability of untreated local rubber wood sawdust (RWS) to remove Cr(VI) was carried out under a bench-scale shaking condition by varying parameters such as initial Cr(VI) concentrations, adsorbent dosage, pH, temperature and eluting agent. Complete Cr(VI) removal was achieved at pH less than 2, initial Cr(VI) of 100 mg/L and RWS dosage of greater than 1.5 %. FTIR analysis suggests the importance of functional groups such as amino, hydroxyl and carboxyl during Cr(VI) removal. 100% removal of chromium was obtained[11].

R. Gayathri et.al has aimed at Cr(VI) removal capacity from aqueous solution using tamarind seeds which is a low cost adsorbent. The maximum adsorption of Cr(VI) on tamarind seeds is obtained at pH 2. The equilibrium time obtained is 240 min for Cr(VI) adsorption on tamarind seeds. The experimental equilibrium adsorption data are tested for the Langmuir, Freundlich and Temkin equations. The Langmuir isotherm model is found to be most suitable for the Cr(VI) adsorption using tamarind seeds and also confirms the monolayer adsorption of Cr(VI) onto the adsorbent surface. The maximum adsorption capacity obtained using the Langmuir isotherm model is 29.41 mg/g at pH 2. 80% removal of hexavalent chromium was obtained by this adsorbent[12].

D. Krishna and R. Padma Sree has studied about the removal of hexavalent chromium by adsorption on the Custard apple peel powder as adsorbent has been investigated in the batch experiments. The Freundlich model for Cr (VI) adsorption onto Custard apple peel powder has proved to be the best fit followed by Langmuir model and Tempkin model based on high regression coefficient R^2 value. The adsorption behavior is described by a pseudo second order kinetics. The maximum metal uptake is found to be 7.874 mg/l [13]. V.H. Waghmare and U.E. Chaudhari have studied adsorption of Chromium (VI) onto Commiphora Myrrha Bark. The effect of various parameters influencing the Cr (VI) adsorptions such as effect of pH, Contact time. The data obtained from the batch processes have used to fit in Freundlich and Langmuir isotherm equations. The optimum contact time found is equal 360 min. The optimum dosage is equal to 0.5 mgs. The percentage removal is ranging between 75% - 80% [14].

Vikrant Sarin, K.K. Pant et al has used baggase, charred rice husk, activated charcoal and eucalyptus bark (EB) for removal of chromium. All the experiments were carried out in batch process with laboratory prepared samples and wastewater obtained from metal finishing section of auto ancillary unit. The adsorbent, which had highest chromium (VI) removal was EB. Influences of chromium concentration, pH, contact time on removal of chromium from effluent. The adsorption data were fitted well by Freundlich isotherm. The maximum removal of Cr(VI) was observed at pH 2. Adsorption capacity was found to be 45 mg/g of adsorbent, at Cr (VI) concentration in the effluent being 250 mg/l [15]. Jitender Pal, Mandeep Kaur has studied the efficiency of activated saw dust by varying various parameters such as pH, contact time, adsorbent dose and initial metal ion concentration. Two ASD adsorbents of sieve size 0.3mm and 1.0mm were prepared for batch mode experiments. The results revealed that the hexavalent chromium is considerably adsorbed on saw dust and it could be an economically viable method for the removal of Cr (VI) ions from textile industry effluent [16].

Hema Krishna R, A.V.V.S Swamy has used powder of Papaya Seeds (PPS) as an adsorbent for heavy metal like Cr (VI) from aqueous solutions was studied using batch tests. The influence of physico-chemical key parameters such as the initial metal ion concentration, pH, agitation time, adsorbent dosage, and the particle size of adsorbent has been considered in batch tests. The equilibrium data obtained were tested using Langmuir, Freundlich adsorption isotherm models and the kinetic data obtained were fitted to pseudo first order model [17]. Ramakrishna Naidu Gurijala et.al has done research on Datura inoxia, a medicinal plant leaves which was used as adsorbent to remove, chromium (VI) from aqueous solutions. Freundlich isotherm model provided a better fit with the experimental data than Langmuir model by high correlation coefficients R^2, 0.996 for, chromium (VI) at pH 5.5. This adsorption process involves ionexchange and surface complaxation was found to be the main mechanisms. The developed adsorbent found to be more efficient in removal of chromium (VI)[18].

D. Sarala Thambhavani, B. Kavithahas studied the effect of various experimental parameters such as initial concentration of Cr (VI) ions, adsorbent dosage, contact time, pH of solution and agitation speed were studied. The kinetics of chromium (VI) ions was studied which showed that the adsorption followed pseudo second order reaction. Studies revealed that intra- particle diffusion played important role in the mechanism of Cr (VI) adsorption. [19]. S. L. Pandharipande, Rohit P. Kalnake et al.has aimed for the removal of Cr (VI) & Ni (II) ions by the adsorbent synthesized from the Tamarind fruit shell. The synthesis of adsorbent is carried out using thermal method. The specific surface area of the adsorbent is estimated to be 2.1274+ 0.0246 m/g as in BET method[20].

III. CONCLUSION

The review of research work done for removal of hexavalent chromium is presented here. Many methods such as chemical, physical and biological have been tried by different researchers for hexavalent chromium removal from waste water. Adsorption method found to be the best method for removal of hexavalent chromium by low cost adsorbent.The percentage removal upto 92-95 was obtained. There is still scope for research in order to reduce heavy metals economically by using low cost adsorbent. The adsorption technique is also a very effective method in removal of hexavalent chromium from waste water.

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