Solute Uptake, Kinetic and Isotherm Studies for Copper Removal: A Review

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Abstract:

Treatment of industrial effluent by using efficient and economical method is the need of the modern industrialization. Heavy metals are present in industrial effluent of many major industries. Heavy metals affect the human being and other flora and fauna in various ways. They can cause both short term and long term diseases. Copper is one such metal present in the effluent of industrial waste. The copper removal from wastewater can be achieved by methods such as precipitation, coagulation, floatation, ion exchange, adsorption, biosorption etc. The aim of the present review is to summarize the research and studies carried out to study the copper removal by various methods.

Keywords:

Removal; batch; adsorbent; concentration; contact time

Introduction

Industrial wastewater contains various pollutants like organic matter, biological matter and various heavy metals such as chromium, iron, cadmium, zinc, copper etc. Organic matter is one of the major pollutants in the wastewater. Various physical, chemical and biological methods can be used for its removal[1,2,3]. Removal of organic matter has been carried out by membrane separation techniques, biological methods and adsorption [4,5,6,7]. Also removal of organic matter from domestic and industrial waste by biological treatments like trickling filters and activated sludge process is widely studied[8,9,]. Adsorptive removal of heavy metals has shown very good results in terms of removal efficiency and economy[10,11,12]. The removal of heavy metals in batch studies and fixed beds was efficient and economical[13,14,15]. Heavy metals can cause severe damage to man and environment[16,17]. The sources of copper in the effluent are industries such as copper polishing, circuit board manufacturing, paint manufacturing, electronics plating, plating, wire drawing etc. High copper contain in water can cause diarrhea, abdominal cramps and nausea. Removal of copper from the industrial waste has been carried out by various investigators by various physical, biological and chemical methods. The present review summarizes research and studies carried out for copper removal with respect to affecting parameters, removal efficiency, isotherm and kinetic studies.

Research on Solute Uptake, Isotherm and Kinetics of Copper Removal from Wastewater

Kumar and Acharya used rice husk in fixed bed for adsorption of copper [18].They used atomic absorption spectroscopy for the analysis. They obtained the breakthrough time and exhaustion time to be 3.583 and 10.500 h respectively for 10 ml/min flow rate and 10 cm deep column. Also they observed the rate at which the adsorption zone was moving through the bed. It was

1.48 cm/h. Waste tire rubber ash was used for the copper removal by Mousavi et.al. [19]. They studied the influence of pH, adsorbent dose, initial Cu(II) concentration and contact time on the removal of Cu(II) from aqueous solution. They carried out the experiments batch mode. For studying the effect of adsorbent dose , they conducted experiments at a constant initial Cu(II) concentration (100 mg/L), contact time (2 h), temperature (25±1°C), and stirring speed (150 rpm) with varying adsorbent doses (0.1–2.5 g/l). The optimum adsorbent dose was 1.5 g/l. The adsorption followed first order kinetics. Salmani et.al investigated the removal of copper by using activated carbon[20].They obtained the copper removal of 99.7 percent after 127 minutes. The data obtained obeyed, both Langmuir and Freundlich isotherms. Dermentzis et.al used electro coagulation method for copper removal from industrial wastewater [21]. They investigated the parameters like initial pH, current density, initial metal ion concentration, COD and contact time. They observed the best pH range was 4-8 in order to get maximum removal. Almost 100 percent copper removal was obtained in 40 minutes for 250ml sample. Shridhar et.al. carried out copper removal from automotive industry effluent[22]. They used banana pills as adsorbent. They observed the copper removal of 93 percent during their investigation. Activated Acanthaceae was used for copper removal from wastewater by Hussain et.al.[23]. According their investigation, intraparticle diffusion played very important role in the process. They obtained maximum removal for copper in the pH range of 3-6.7. The optimum adsorbent dose was 25 mg/50 ml of effluent and the equilibrium was established in 60 minutes for all concentrations during their investigations. The adsorption process followed Langmuir isotherm. Rao et.al. investigated copper removal by activated carbon derived from ceiba pentandra hulls[24]. They observed that The binding of metal ions by surface functional groups was strongly pH dependent. According to them, below pH value of 5.7, the surface was positively charged. For copper removal from 50ml (80mg/l) of solution , the adsorbent dose required was 0.5g. The equilibrium time was 40 minutes. Johnson et.al carried out investigation by using primary treatment with coagulation-floatation techniques[25]. They observed 200 percent rise in the removal efficiency by using 40 mg/L ferric chloride and 0.5 mg/L polymer enhanced heavy metals. According to them, pH and temperature had no significant influence on metals speciation. Kaminari et.al. carried out investigation on mass transfer correlation for the removal of copper ions from wastewater[26]. They used a fluidized bed electrochemical electrolytic reactor. They observed that the zero order reaction system was controlled by the current and the first-order reaction system was controlled by mass transport. Onundi et.al. used palm shell activated carbon for copper removal from synthetic semiconductor industrial wastewater by adsorption[27]. During their investigation it was observed that the removal capacity was maximum at the pH value of 5 and optimum adsorbent dose was 1 g/l. Copper removal of 97 percent was obtained during the experiment. Langmuir isotherm fitted the batch data. Kutty et.al. studied the feasibility of using groundwater treatment plant sludge (GWTPS) as an adsorbent in removing copper in organic laden wastewater using a continuous flow activated sludge system[28]. The copper removal obtained was above 90 percent during the experiments. Khue et.al. coupled three processes namely electro coagulation, fluidized bed and micro-electrolysis for copper end fluoride removal[29].They obtained the optimum conditions for the

combined process. These were, four aluminum electrodes, an initial pH of 5.0,a hydraulic retention time of 30 minutes, a mass of Fe/C of 45g, an applied voltage of 5V and the particle diameter of Fe/C of 20-27mesh. Negrea et.al. studied copper removal from wastewater by precipitation[30]. They studied several aspects of precipitation such as the dependence of the pH of the reaction mass on the volume of precipitation agent, the evolution of the volume of suspensions in time and the dependence on the pH of the residual concentration of copper ions. They observed that the pH of the reaction mass was dependent on the volume of precipitation agent. Chigondo et.al. carried out investigation on copper removal by baobab (Adononsia digitata) fruit shells biomass[31]. They observed maximum copper removal at pH 6 using adsorbent dosage of 0.9 g. Also Temkin isotherm showed the best fitting model for the process. Dutta and Basu used microwave assisted activated carbon for removal of copper from electrochemical waste[32]. The optimum parameters were an initial concentration of 100 mg/L, adsorbent concentration of 1 g/L, pH of 6, temperature of 30 °C, particle size of 105 µm and agitation speed of 200 rpm. At these conditions, about 99.9 percent copper removal was obtained by the investigators. The kinetics of copper removal was pseudo second order. Prosopis juliflora leaf powder was used for copper removal by adsorption by Halnor et.al.[33]. They studied the effect of temperature, pH, contact time, adsorbent dose and initial concentration of adsorbate. The adsorption increased with pH and initial concentration. Muzenda used ion exchange process for removal of copper from the effluent[34].The objective of their investigation was to investigate the potential of acid activated South Africa clinoptilolite as an adsorbent in the ion-exchange process. For the copper removal, the optimum pH was 6. In batch experiments, the saturation was attained in about 60-70 min. Langmuir isotherm described the adsorption process . Goswami et.al. investigated copper removal by using flyash and teak leaves adsorbent[35,36].For flyash, optimum adsorption time was 40-60 minutes and adsorbent dose was 2 g/l. In case of teak leaves the contact time was 60 minutes and 2 g/l adsorbent dose. The percentage removal obtained was 75 to 85 percent.

Conclusion

Various physical, biological and chemical methods have been studied for copper removal. Application of coagulation-flocculation coupled with physical treatment was very effective. Precipitation is also good method for copper removal. Biological methods such as activated sludge and trickling filters can be investigated. Removal of copper by using various low cost adsorbents is most widely studied method. Low cost, high removal percentage and simplicity are few advantages of this method. It can be concluded that, proper choice of the treatment method depends on available resources, concentration of effluent, end use or disposal facilities for final treated effluent, sludge disposal methods and facilities adopted.

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