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Wastewater Treatment for Lead Removal: A Review

Sunil Jayant Kulkarni*[1]
*[1]Chemical Engineering Department, Datta Meghe College of Engineering, Airoli, Navi Mumbai, Maharashtra, India

ABSTRACT

Lead is a major cause of environmental concern for the industries like paint, pesticides, battery, mine, smelting etc. Lead can cause diseases related to kidney, liver, brain and nervous system. Various methods used for lead removal include electro-coagulation, ion exchange, membrane separation and suspended and attached growth biological techniques. In case of electro-coagulation, factors like current density, pH, initial concentration affect the lead removal. Adsorption is one of the important methods for lead removal. Parameters like pH, initial concentration, adsorbent dose and particle size affect the adsorption process. Various low cost and waste materials can be used to prepare adsorbents. The research on adsorption includes the studies on removal efficiencies, isotherms, kinetics and modelling for the batch and packed bed data. The studies and research carried out for lead removal has been summarized in the current review paper with respect to effect of various parameters, removal efficiencies, kinetics of the solute uptake, modelling approach and isotherm studies.

Keywords: Effluent, concentration, removal efficiency, cost.

I. INTRODUCTION

Wastewater treatment is conventionally carried out in three stages, namely primary secondary and tertiary. Primary treatment includes physical separation by screens, secondary treatments are biological treatments. The tertiary treatments mainly include chemical and advanced treatment techniques. Heavy metal pollution is major concern in the industries like fertilizer, pesticides, paint, pigment, catalyst, mining, electroplating and many other industries. Heavy metals can cause both long term and short term diseases [1,2,3]. The removal of heavy metals from the effluent is widely studied treatment problem in environmental engineering. Many biological and non biological methods have been studies by various investigators for heavy metal removal [4,5,6,7,8]. Adsorption is one of the important methods for removal of heavy metals from the wastewater. Removal of various metal ions like copper, chromium, cadmium, zinc, mercury, arsenic can be carried out by using low cost adsorbents[9,10,11]. One such heavy metal is lead. Lead is present in the effluent from the industries like paint, pesticides, battery, mine, smelting etc. Lead can cause many health problems related to kidney, liver, brain and nervous system. Various methods for lead removal include precipitation, ion exchange, membrane separation, electrochemical treatment and adsorption. The current review summarizes the research on various treatment methods for lead removal from wastewater.

II. RESEARCH ON LEAD REMOVAL FROM EFFLUENT

Rice husk was used for lead removal by Kumar and Acharya[12]. They performed batch experiments to study the effects of pH, initial concentration and contact time on the adsorption of lead. They carried out experiments with synthetic effluent. Thermal and chemical activation methods were used for activation. Analysis was carried out by using atomic absorption spectrophotometer. They observed that the initial rapid solute uptake for 5 minutes was followed by slow uptake. According to them film diffusion was predominant in the solute uptake phenomenon. Pseudo first order model fitted the experimental data. Also the adsorption followed both, Freundlich and Lagmuir isotherms. Nwabanne and Igbokwe used oil Palm Fiber for removal of lead in packed column[13].They studied adsorption performance and effect of the parameters like inlet ion concentration, flow rate and bed height on the breakthrough curves. They observed that the removal efficiency increased with increase in the initial concentration and bed height. It decreased with flow rate. They used Thomas and Yoon and Nelson kinetic models for analyzing kinetic data. Both the models were satisfactory for describing the data. They also observed that the time required for 50 percent saturation decreased with flow rate, bed height and initial ion concentration. Arunlertaree et.al. used egg shells for removal of lead from battery industry wastewater[14]. They studied the effect of parameters like initial pH, contact time, types of egg shell and egg shell dose. They observed that the pH value of 6 was optimum for lead removal. 1.0 g/100 ml was optimum egg shell dose. Contact time required was 90 minutes. Freundlich isotherm was followed by the process. Shakir and Husein used electro-coagulation process for lead removal[15].They used Aluminum electrode as anode and stainless steel electrode as cathode in a glass tank. They used synthetic lead effluent for the experimentation. At constant current density, the removal increased with pH. With time and current density also, the removal increased. They obtained complete removal of lead in 120 minutes for initial concentrations 30, 70 and 120 mg/l. Kinetics, Equilibrium and Thermodynamic studies were carried out by Surchi for lead removal using agricultural waste[16]. He used five low cost adsorbents namely chalf, rice husk, sesame, sun flower and tea waste. It was observed that pseudo-first order model explained the experimental data. The efficiencies for these four adsorbents were 85%, 90%, 100%, 86%, 98% respectively. According to these studies, both chemisorption and physisorption mechanisms were present in the solute uptake process. Danish et.al. carried out investigation on removal of lead by using low cost adsorbents by Chitosan obtained from India sea foods[17]. They carried out batch experiments by using 25 ml of effluent. For this batch size, the equilibrium time was 140 minutes. The sorption process followed first order kinetics. Adsorption increased by almost 20 percent by increasing the pH from 2 to 6.5. Natural Clinoptilolite was used for lead removal by Buasri et.al.[18]. They were able to remove 95 percent lead from the water with initial concentration of 800 ppm. Optimum pH value obtained was 7. Also they observed that the adsorption followed Langmuir and Freundlich isotherm. Sharain-Liew et.al carried out biosorption kinetic studies for lead removal[19]. They used dried leaves of Typha angustifolia (TA), also known as the common cattail. The optimum adsorbent dose was found to be 0.6 grams for 100 ml of effluent. The percentage removal was 86 percent. The solute uptake followed the pseudo-second order model most closely. Oil refining-contaminated wastewater was treated for lead and hydrocarbon oil removal by Bestawy et.al.[20].For lead removal they used three bacterial species namely Pseudomonas florescence (PF), Pseudomonas paucimobilis (PP) and Pseudomonas sp.(PQ).They obtained the removal efficiency of 90.97 percent. A novel biomaterial, Tridax procumbens (Asteraceae) a medicinal plant, was used for the removal of lead ions from synthetic wastewater by Singanan et.al.[21]. They used the adsorbent prepared as homogeneous powder of the biomaterial for the biosorption of lead. They used 100 ml of effluent sample for batch experiments. 3.5 gram of adsorbent was required for 100 ml of effluent. 98 percent removal was obtained at the optimum pH value of 4.5. The contact time required was 160 minutes. The removal efficiency of raw biosorbent was 65 percent. Saponified Melon Peel Gel was used as an adsorbent for lead removal by Chaudhari and Ijaz [22].They carried out saponification of melon peel with calcium hydroxide $Ca(OH)_2$ to obtain the biosorbent. In 10 minutes they were able to remove 80 percent lead from the water at pH of 4. According to them pectic acid was main component in the process. They also observed that calcium hydroxide also played important role in the process. It acted as phase out compound for removal of chlorophyll pigment and other lower weight molecular components that are useless in the biosorbent preparation. Yavuz et.al. investigated the removal of lead by using calcite[23].They carried out experiments with 10 ml of effluent and 0.1 gram of adsorbent for 10 µg/l concentration. For these batch experiments 10 minutes of contact time was sufficient. They also varied initial concentration from 150 to 2500 µg/l. The adsorption of lead remains constant up to 500 µg/ml. With further increase in initial concentration, the adsorption decreased. Calotropis Procera roots were used for lead removal by Ramalingam et.al.[24]. They observed that the adsorption was drastically depended on the parameters like initial metal ion concentration, adsorption dosage, contact time and agitation speed. The solute intake followed both, Langmuir and Freundlich isotherm. Ruangsomboon et.al. investigated lead removal from wastewater by the Cyanobacterium Calothrix marchica[25]. About 42 percent lead removal took place in only 10 minutes. Equilibrium time obtained was 60 minutes and corresponding removal was 61 percent. The Cyanobacterium Calothrix marchica showed no difference in removal efficiency for age change from 4 to 10 days. A 14 day age material showed high removal efficiency. At lower biomass concentration, higher removal efficiency was observed. A mixture of activated charcoal and peanut shell was used for lead removal by Tahiruddin and Rahman[26].They observed better removal efficiency in first 30 minutes. pH value of 4 was optimum and about 99 percent lead removal was obtained. A research was carried out on removal of lead from wastewater by using green algae Cladophora fascicularis by Deng et.al.[27].They observed that the biosorption followed first order kinetics. Also it followed both Langmuir and Freundlich isotherms and was endothermic. pH value of 5 was optimum for lead removal. Ion exchange resin Amberlite and natural zeolites were used for lead removal by Tabatabaei et.al.[28].They carried out treatment with three sizes of zeolites with different concentrations of lead. 59.97 mg of lead was removed per gram of zeolite. In case of Amberlite, removal was 62.35 grams per gram. With Amberlite, maximum removal efficiency of 99 percent was obtained. Carica papaya leaf powder was used as an adsorbent for lead removal by Raju et.al.[29]. They carried out batch experiments for studying the parameters affecting the adsorption process. The data obtained fitted Freundlich adsorption isotherm. The effective pH for lead removal was found to be 4. The kinetics of lead adsorption, according to this research was second order. For 50 ml of 100 mg/l effluent, 1.5 gram of 52 μm size adsorbent was required.. Narwade et.al. used nanoceramics for lead removal from the effluent[30]. In their investigation they used Hydroxyapatite (HAp) $[Ca_{10}(PO_4)_6(OH)_2]$ nano-ceramic material for lead removal. They observed that Calcium Hydroxyapatite was effective for removal of lead from wastewater. Z. Sarkar and F. Sarkar carried out investigation on superparamagnetic monodispersed iron oxide (fe_3o_4)nanoparticles for lead removal[31]. The nanoparticles were coated by polyethylene glycol (PEG-4000).They observed that the optimum pH and contact time were 6 and 10 minutes respectively. Okoye et.al. carried out adsorption modeling and kinetics of lead removal by fluted pumpkin seed shell activated carbon[32]. They observed that with initial concentration, equilibrium adsorption capacity increased. Also film diffusion was a controlling factor in the process. For the data obtained, Langmuir model fitted better than Freundlich model.

III. CONCLUSION

Various methods used for lead removal by researchers includes biosorption, ion exchange, electro-coagulation, adsorption by commercial and low cost adsorbents. The studies on adsorption by using low cost adsorbent is most widely investigated research area. Various low cost adsorbents derived from agricultural waste have been used successfully. The electro-coagulation was also an effective treatment method with 100 percent removal of lead. The electricity cost is limiting factor for this methods. The methods like membrane separation and ion exchange can be used for lead removal. Cost is limiting factor for both these methods. Adsorption is most efficient and cost effective method for lead removal. Effective regeneration of adsorbent and proper disposal of used adsorbent are two important aspects of adsorption techniques which needs to be studied to make this option more effective.

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