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LEAD REMOVAL FROM INDUSTRIAL WASTWATER: A REVIEW OF REMOVAL MTHODS.

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ABSTRACT

Aims: The removing of toxic heavy metal ions from industrial wastewater has been widely studied in recent years. The aim of present study was to investigate the various methods of lead removal from industrial wastewater, evaluate their advantages and drawbacks in applications.

Methods: This study was a review research. The data were collected through different databases in multifarious articles. The various methods and techniques for Lead removal from industrial wastewater were compared to each other, according to their efficiency, economic, and eco-friendly.

Results: the current study showed the various techniques for lead removal from industrial wastewater including chemical precipitation, ion exchange, membrane filtration, reverse osmosis, coagulation and flocculation, electrochemical operations, and adsorption. The key factors that play major roles in the selection of most suitable treatment technique for industrial effluents are technical applicability, plant simplicity, and cost-effectiveness.

Conclusion: Adsorption has been investigated praiseworthy over other methods and is more suitable for removal of moderate to low concentrations of lead and other heavy metals because it is simple, effective and economic.

Keywords: Industrial wastewater, Lead, Heavy Metals, Removal techniques, Adsorption.

Introduction:

The removing of toxic heavy metal ions from industrial wastewater has been widely studied in recent years. Heavy metal contamination could exist in effluent of many industries, such as metal plating, mining operations, chloralkali, radiator manufacturing, tanneries, smelting and alloy industries, wood processing industries, printed circuit board (PCB) manufacturer, petroleum refining industries, storage battery industries. Heavy metals such as chromium (Cr), iron (Fe), copper (Cu), cobalt (Co), nickel (Ni), cadmium (Cd), mercury (Hg), arsenic (As), lead (Pb), and zinc (Zn) represent the major toxic hazardous materials to humans and others living organism. The solubility of heavy metals in aquatic environment are very high and can be absorbed by aquatic plants and animals. If they enter the food chain, large concentrations of heavy metals may accumulate in the human body. If the heavy metals are ingested beyond the permitted concentration, they can cause serious health disorders. Hence, it is essential to treat metal contaminated wastewater before discharging in to the environment.

Lead is a heavy metal toxic for human body. It is among the major pollutants accountable for soil, water, and atmospheric pollution. Lead is of special interest, because of its toxicity and its widespread presence in the environment. Release of lead in environment can be a man-made activity such as mining, sewage discharge, automobile emission, combustion of fossil fuel, discharge of industrial effluent or can result from natural activity such as volcanic eruption, forest fires, urban and agricultural runoff etc. Lead is non-biodegradable and is harmful to both human and other living organisms. It has capability to enter the food chain. Large concentration of Lead may accumulate in the human body, if enter the food chain. Lead more than 0.5 – 0.8 mg/L in the blood cause serious health disorder such as nervous system, reproductive system, anaemia, damage to kidney, liver and brain. It intervenes with body metabolism, causes low I. Q. levels in children and has been classified by the IARC as 2B carcinogen. According to the World Health Organization (WHO), maximum permissible

limit of lead in drinking water is 0.05 mg/L and for surface water is 0.1 mg/L. Lead ions concentration in industrial wastewater approach 200 – 500 mg/L, this is very high related to water quality standards, and must be reduced to level of 0.05 – 0.10 mg/L before discharging into the water body or land surface. Hence, proper treatment of lead contaminated wastewater is necessary before releasing into the environment. Removal of lead from industrial wastewater can be accomplished through various physical and chemical treatment options, including such as chemical precipitation, coagulation and flocculation, ion exchange, membrane filtration, electrochemical process, reverse osmosis, and adsorption. This paper describes these various treatment techniques and methodologies employed for lead removal.

Chemical precipitation: Chemical precipitation is one of the most widely used method for lead removal from industrial effluent due to its simple operation. This method removed lead from industrial wastewater up to ppm level. Lead ions are insoluble in water and precipitate by reacting dissolved metals in the solution. Chemical precipitation process produces insoluble precipitates such as hydroxide, sulphide, carbonate, and phosphate. The commonly used precipitation method is hydroxide treatment. This process is simple, cost effective and easy to pH control. The precipitation process takes place with the addition of a caustic chemical, such as hydroxide to the effluent in order to increase pH to a point that the lead precipitates in the solution, as solid metal hydroxide particles. Precipitated lead particles can be removed from the liquid by using a physical separations process, such as sedimentation or filtration. This technique is cost effective but its efficiency is reduced at low pH and presence of another salt ions. This technique requires addition of others chemicals causes high water contain sludge, which is a cost intensive for its disposal.

Ion exchange: This method is expensive compared to other methods but efficiency is high as ppm level. In this process ion exchanger is used to remove lead ions from industrial wastewater. Ion exchangers are natural materials such as, certain clay, gel polymer, zeolite, montmorillonite, and soil humus or some synthetic organic resins. Ion exchange methods have been widely used for removal heavy metals from industrial wastewater due to their many advantages, such as high treatment capacity, fast and high removal efficiency. The synthetic resins are widely used in ion exchange process as they effectively remove the heavy metals from wastewater. The uptake of metal ions by ion exchange resin is quite affected by certain variables such as pH, initial metal ion concentration, temperature, and contact time. Natural zeolites have been widely used for removing of lead ions from industrial wastewater due to its low cost. It can be used only low concentrated lead ions solution and this method is highly sensitive with the pH of the solution.

Membrane Filtration: Membrane filtration technique used for removing of heavy metals are easy in operation, high efficiency, and space-saving, but high cost, complex operation, and membrane pollution. In this process effluent are passing through a porous membrane, usually applying pressure to the effluent stream. The special sized pores in membrane are allowed certain particle to pass through, while retain others. The membrane filtration techniques include Ultrafiltration (UF), Nanofiltration (NF), Reverse Osmosis (RO) and Electrodialysis (ED). These types of membranes have pores size small enough to remove lead from wastewater. The rate of lead removal is very high and reliable for reuse of treated wastewater. This technique is very costly due to cleaning maintenance, replacement of membrane, and energy required for flow control. The reject stream contains high concentration of lead that will need to be further treated.

Reverse Osmosis (RO): In Reverse Osmosis process the water or wastewater is allowed to pass through the semi-permeable membrane, and at the same time rejecting the contaminants. Reverse Osmosis mere is not applicable for complete recovery and reuse of wastewater. Pre-treatment methods such as media filtration, pH adjustment, and anti-precipitants are required prior to apply the reverse osmosis processes. The main disadvantages of reverse osmosis are high power utilization for pumping pressure and reinstallation of the semi-permeable membranes.

Coagulation and Flocculation: Coagulation followed by sedimentation and filtration is one of the most effective methods for the treatment of industrial wastewater, but this method is restricted only to the hydrophobic colloids and suspended particles. Many coagulants such as aluminium, ferrous sulphate, and ferric chloride are mostly used for effective removal of heavy metals from industrial wastewater. In flocculation process, fine particulates are agglomerate together into flocs. Polyaluminum chloride, polyferric sulphate and polyacrylamide are mostly used flocculants for the treatment of wastewater, but practically, they are ineffective to remove heavy metals. Generally, coagulation and flocculation cannot treat the industrial wastewater completely. Hence, it must be combined with other treatment methods. Coagulation and Flocculation process involves more chemical utilization and sludge formation result secondary pollution.

Electrochemical operations: Electrolytic techniques are effective and widely used for removing of heavy metals from industrial wastewater. This method has been widely used in the mining industry for electrowinning and electrorefining of ores. In this process a direct current is passed through effluent containing metal ions between cathode and insoluble anodes. The positive charged metal ions abide to the negative charged cathodes, leaving a metal deposit that can be stripped off and recovered. The electrochemical operations are electrocoagulation, electro floatation, and electrodeposition. Electro floatation technique is potentially more effective for separation of heavy metal ions such as nickel, copper, iron, lead, zinc, and cadmium. The electrochemical processes are fast, well controlled, required few chemicals, producing less sludge and better metal removal efficiency. The high initial capital cost and requirement of expensive electricity supply restricts wide use of this technique in the treatment of industrial wastewater.

Adsorption: Adsorption is a potentially most effective method, used for lead removal from industrial wastewater. This method is very cost effective using natural materials as adsorbents in natural or some modified forms. It can be removed lead from industrial wastewater up to 95 % by using suitable adsorbents. Adsorption is a surface phenomenon, in which molecules of metal ions (adsorbate) are attracted and deposited on the surface of an adsorbent, until a saturation condition is attained. Adsorption method is a most effective, eco-friendly, and cost-effective process for the treatment of industrial effluent. Activated carbon is widely used adsorbent for removal of heavy metals from industrial wastewater due to its easy operating requirements. Activated carbon is a costly adsorbent, so other low-cost natural adsorbents are the best alternative for treatment of industrial effluents. The agricultural waste materials have shown potential removing efficiency for lead and other heavy metals from industrial wastewater in their natural form, or after some physical or chemical modifications. Agricultural materials, especially cellulosic materials, show a large potential biosorption ability due to their structure that include hemicellulose, lignin, extractives, proteins, lipids, simple sugar, starch, and water hydrocarbons. The agricultural waste materials such as rice husk, black gram and wheat brans and husks, peels of lime, orange, apple, and banana, groundnut, coconut and walnut shells, hazelnut shells, cotton seed hulls, tea waste, maize corn cob, sugarcane bagasse, soyabean hulls, cotton stalks, sunflower stalks, coffee beans, and arjun nuts. These agricultural waste materials have shown effective removal efficiency for heavy metals from wastewater either in their natural form or after some physical or chemical modifications. Adsorption is a cost-effective treatment method with moderate concentrations of lead (usually between 1 ppb and 100 ppm). While adsorption offers relatively low costs of operation, materials, and waste discharge, it has certain drawbacks that stem from limited adsorption capacity of most adsorbent materials. As a result, adsorption by agricultural waste is best used for wastewater treatment with moderate to low concentrations of lead and other heavy metals.

Conclusion

This review study shows various methods for lead removal from industrial wastewater including chemical precipitation, ion exchange, membrane filtration, reverse osmosis, coagulation and flocculation, electrochemical operations, and adsorption. Recently various research work has been done for developing more effective, economical, and eco-friendly technologies for both to improve quality of treated effluent and to reduce the amount of produced sludge. Adsorption has been investigated praiseworthy over other methods and is more suitable for removal of lead and other heavy metals. Natural adsorbents show good result in moderate to low concentrated effluent of heavy metal ions. Natural adsorbents are easily available, abundant in nature; require little processing, and low-cost. In various available techniques for treatment of heavy metals contaminated wastewater, the selection of most suitable treatment method depends on some basic parameters such as pH, initial concentration of metal ions, temperature, BOD, and flow rate. The overall performance compared to other methods, economic feasibility of the process and environmental impact. Finally, technical applicability, process simplicity, legislation set by the government agency, and cost-effectiveness are the impotent factors that play major role in the selection of most suitable treatment method. All the factors mentioned in the conclusion should be taken into consideration in selection of most effective and economical treatment method to protect the environment.

Conflict of interest

The authors declare that they have no conflict of interests.

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