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Ion Exchangers as an Emerging Technique for Removal of Toxic Heavy Metals in Wastewater: A Review

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Abstract: *Ion exchange technique has become one of the most conventional used methods for removal of toxic metals in wastewater. However, the primary application is in water purification due to its simplicity, selectivity, and efficiency. This paper reviews ion exchanger as an emerging technique in the removal of toxic heavy metals from the aquatic environment. The review includes definition, mechanism, and types of an ion exchanger. The objective of this study was to provide important information for researchers. It has been revealed from the literature that natural composites of ion exchangers stand out as the emerging material for the treatment of toxic heavy metals in wastewater. This opinion is due to the fact that ion exchangers are environmentally friendly, available, and cheap.*

Keywords: *Ion exchangers, emerging technique; toxic heavy elements; wastewater*

1. INTRODUCTION

Large quantities of hazardous metals released into the natural environment have caused a number of environmental problems and a significant danger to human health because can accumulate in the environmental elements such as food chain due to their non-biodegradability and persistence in the environment [1]. Toxic heavy metals include byproduct of various industries such as lead, cadmium, and radionuclides from nuclear facilities such as cesium and cobalt [2].

These heavy metals are toxic to humans and the environment [3]. For example, cobalt is carcinogenic and Lead can damage the central nervous system, kidney, liver, and reproductive system, basic cellular processes and brain functions [4].

Therefore, effective treatment and purification of groundwater and surface water are required to bring about potable water. The presence of contaminants such as calcium, magnesium, iron, and manganese ions in industrial water can lead to hard water. These contaminants react with soap anions, thus decreasing the cleaning efficiency [5]. Therefore, this review is aimed at providing information on ion exchangers as an emerging technique for the removal of toxic heavy metals in wastewater.

2. TECHNIQUES USED FOR THE MANAGEMENT OF WASTEWATER

The removal of these metals from industrial wastewaters has recently become one of the most important processes because of which its importance is becoming more profound with increasing industrial activities [6]. There are conventional techniques used in the removal of toxic heavy metal ions from wastewater. These include chemical precipitation, evaporation, and solvent extraction. Conventional techniques such as reverse osmosis, ultra-filtration, micro-filtration process, and electrochemical are less frequently used techniques [7]. However, ion exchanger is an emerging technique used in the treatment of aqueous systems due to its simplicity, selectivity, efficiency, and ability to regenerated by acids. In addition, it is environmentally friendly, available, and cheap [8]. Several types of research on the use of ion exchangers (ion exchange media) for the removal of toxic heavy metals from wastewater exist.

3. APPLICATIONS OF ION EXCHANGERS

The primary application of ion exchangers is in water purification. However, this technique is being used in analytical chemistry. Here, this method is used for the separation and quarantine of elements [9]. In addition, this technique is used in hydrometallurgy, inorganic chemistry, biochemistry, food technology, and atomic energy [10]. Other applications of ion exchangers

include isotope separation [11], removal of specific constituents ([12], purification of cane, corn, and beet sugars [13], detoxification of by-products transferred for bio-cultivation [14], Cd^{2+} removal from drinking water [15], and nitrate removal [16].

4. MECHANISM OF ION EXCHANGE

Ion-exchange is a process in which reversible stoichiometric interchange of ions of the same sign take place between an electrolyte or molten salt and a solid phase [17]. Ion exchangers are called cation exchangers if the negatively charged functional groups are involved. They are called anion exchangers if the positively charged groups are involved. Therefore, ion exchange is associated with adsorption. In both cases, a solid accepts a soluble species. The difference between these processes is in the stoichiometric nature of the exchangeable ions [18].

5. CLASSIFICATION OF ION EXCHANGER

Some ion exchangers are naturally occurring. These natural exchangers include clays and zeolites. Natural exchanges are in common use due to cost effectiveness and their suitability for column operation. In addition, they are useful as backfill materials for radioactive waste disposal sites [19]. Natural organic ion exchangers include a large number of organic materials such as polysaccharides, proteins, and carbonaceous materials. Some charcoal can be doped with chemicals to improve their capacity or selectivity and they are used commercially because they are widely available at a very low cost [20].

Synthetic organic ion exchangers are produced by the synthesis of organic compounds from a solvent or solution. The swelling characteristic of these exchangers is a function of the solution-solvent ratio and the organic compound derivative. Therefore, the polarity of the solvent and the degree of cross-linking are essential elements for a potential ion exchanger [21].

6. CONCLUSIONS

Ion exchange is an emerging technique for clean-up operations in the nuclear industry. Ion exchange revisit is an emerging technology that is efficient in the treatment of low and intermediate level liquid waste. The development of new ion exchangers is narrowing the gap in the search for decontaminants in many industries.

Ion exchange material can be regenerated to and can be reused. Therefore, there is need to research on the various aspects and components of ion exchange technologies to improve the efficiency and economy of their application in liquid waste management.

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