

REMOVE HEAVY METALS FROM WASTEWATER BY ABSORPTION

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Introduction

Effluents from various processing industries and other utilities such as electroplating industries, medical care centers and hospitals is reported to contain high amounts of heavy metal ions, such as nickel, iron, lead, zinc, chromium, cadmium and copper. Heavy metals are naturally occurring elements and the multiple industrial, domestic, agricultural, medical and technological applications have led to their wide distribution in the environment; raising concerns over their potential effects on human health and the environment. Their toxicity depends on several factors including the dose, route of exposure and chemical species, as well as the age, gender, genetics, and nutritional status of exposed individuals. For this reason, heavy metals and their toxicity to environment is being the subject for many studies. Due to mutagenic and carcinogenic properties of heavy metals, much attention has been paid for occurrence, concentrations, movement, fate and the anticipated health and environmental risks that may arise from these heavy metals since they have direct exposure to humans and other organisms. The demand for pharmaceuticals has resulted in a consequent increase in pharmaceutical manufacturing companies in the world and hence increased pharmaceutical waste which most times contain substantial amount of heavy metals. Pharmaceutical residues in the environment, and their potential toxic effects, have been recognized as one of the emerging research area in the environmental chemistry. Pharmaceutical effluents are usually discharged into the environment and when improperly handled and disposed, they affect both human health and the environment.

The presence of pharmaceutical compounds in waters comes from two different sources: production processes of the pharmaceutical industry and common use of pharmaceutical compounds resulting in their presence in urban wastewaters. The pharmaceutical wastewaters generated in different processes in the manufacture of pharmaceuticals and drugs contain a wide variety of dangerous compounds including heavy metals. Further, reuse of water after removal of contaminants, whether pharmaceuticals or otherwise, is required by industry and agriculture. In view of the scarcity of water resources, it is necessary to understand and develop methodologies for treatment of pharmaceutical wastewater as part of water management.

In order to remove toxic heavy metals from water systems, conventional methods have been used such as chemical precipitation, coagulation, ion exchange, solvent extraction and filtration, evaporation and membrane methods. These conventional treatment technologies for the removal of these toxic heavy metals are not efficient and generate huge quantity of toxic sludge. Adsorption of heavy metals on conventional adsorbents such as activated carbon have been used widely in many applications as an effective adsorbent and the activated carbon produced by carbonizing organic materials is the most widely used adsorbent. However, the high cost of the activation process limits its use in wastewater treatment applications.

Bio-sorption using natural materials locally available in certain regions is emerging as a potential alternative to the existing conventional technologies for the removal and/or recovery of metal ions from aqueous solutions. Low cost and availability, high metal binding capacity, minimum production of chemical or biological sludge, possible regeneration of bio-sorbents count for the major advantages of using bio-sorption methodology over conventional treatment methods.

Absorbent

Natural occurring and untreated volcanic tuff rich in zeolite is used as absorbent. The conventional mineral processing techniques of tuff are starting with crushing the materials followed by autogenously tumbling mill and then low intensity magnetic and gravity separation. The crushed original tuff was ground and passed through 4-0.5 mm sieves and was dried in an oven at 104.5°C for 24 h.

The absorbent grains undergo a chemical treatment to eliminate any biological and oxidizable contents, batches of 50 g of reagents were boiled separately with 50 mL of HCl acid or H₂SO₄ acid with concentration of 0.1 M or 1.0 M for 30 min to destroy organic matter, then filtered under vacuum and washed thoroughly with distilled water until a pH of 7 is maintained. The acidified reagents were dried overnight at 80°C. Volcanic tuff was grounded and then passed through 4-0.5 mm sieves and dried in an oven at 104.5°C for 24 h. The tuff was not exposed to any pre-treatment or modification. Samples were just washed and dried at 103.5°C and kept in desiccators for 24 h to ensure complete drying out. Heavy metal concentrations were by spectrophotometer. All the chemicals used were of analytical determined grade reagent and all experiments were carried out in 500 ml glass bottles at the laboratory ambient temperature of $25 \pm 2°C$. Atomic structure to be identified uniquely from each other. Identification of the principal elements; C, O, Fe, Na, Mg, Al, Si, Ca, P, K, Ti. The presence of these elements give the tuff the property of being an excellent ion exchanger.

The structures of volcanic tuff consist of three-dimensional frameworks of Si O_4 ⁺ and AlO₄⁺ tetrahedral. They were characterized by X-ray diffraction (XRD) and chemical analysis Al₂O₃, Fe₂O₃, CaO, and MgO were analyzed using titrimetric methods and SiO2 was analyzed with a gravimetric method. Na₂O and K₂O were found by flame photometry.

Conclusion

On controlling and optimizing all the conditions studied in this work, it was confirmed that untreated natural volcanic tuff is an effective and inexpensive absorbent for the removal of Cr^{+6} , Fe^{+2} , Cu^{+2} , Zn^{+2} and Pb^{+2} from contaminated pharmaceutical wastewater and although unknown, it can compete well with commercial adsorbents such as treated zeolite and activated carbon.

The column experiments provide useful information about the 2 12 transport behavior of the heavy metal contaminants and the relevant parameters for effective removal are contact time, ambient pH, initial concentration and temperature. The sorption behavior of the used samples towards Cr⁺⁶, Fe⁺², Cu⁺², Zn⁺² and Pb⁺² indicated high initial rate of metal ions uptake. The percentage removal of ions found to be between 10-99% influenced mainly by ambient pH. Most probably, acidic metal solutions reduce the performance of natural volcanic tuff in retarding the movement of heavy metals and affect the mineralogical composition of the materials.

The natural volcanic tuff possess good retention capacity for cationic metals showing metal uptake affinity For instance, when a solution containing two different metals is flowing through a fixed bed, the tuff material usually favors one ion over another. It showed that the selectivity sequence of metal ions by the adsorbents was dependent on the system employed, and was mainly influenced by the initial concentrations of the metal ions, but controlled also by the initial pH of the solution.

Breakthrough curves for iron and copper shows that the uptake capacity of iron per gram of tuff material equals 0.217 mg Fe⁺²/g tuff, while the uptake capacity for copper equals 0.1 mg Cu⁺²/g tuff, suggesting the high ability of tuff material to eliminate iron rather than copper from aqueous solutions.

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