Efficiency of removal of cadmium from aqueous solutions by plant leaves and the effects of interaction of combinations of leaves on their removal efficiency

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Abstract

Removal of cadmium from aqueous solutions using 20 species of plant leaves and combinations of these leaves have been studied. Several factors affecting the removal efficiency have been studied. The most efficient types of plant leaves for the removal of cadmium are those of styrax, plum, pomegranate and walnut. The interaction effect of the combined leaf samples on the efficiency of removal of cadmium has been found to be additive in combinations involving styrax plant leaves but seems to be antagonistic in all other combinations. The optimum experimental conditions for removal of cadmium have been found to be at pH 4.1, using high concentrations of naturally dried plant leaves, using ground leaves and to remove cadmium from agitated aqueous solutions. The percentage of metal removed at an initial cadmium concentration of 10 mg/l by the most efficient types of leaves have been found to be 85% for styrax leaves, 85% for plum leaves, 80% for pomegranate leaves, 78% for walnut leaves and 77% for meddler leaves. The presence of foreign ions or complexing agents has been found to reduce the efficiency of removal of cadmium by plant leaves. About 80–85% of the cadmium in charged plant leaves has been released under the influence of changing the pH of the solution, addition of competing ions and the addition of EDTA. The results of removal of cadmium by plant leaves have been found to follow the Freundlich adsorption isotherm, first-order reaction with respect to cadmium and to have intra-pore diffusion as the rate-limiting step.
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1. Introduction

Cadmium is one of the most toxic metals affecting man, animals and plants (Friberg et al., 1974; Brooks, 1978; Ormrod, 1984). It was considered one of the "priority pollutants" by the EEC countries (Barbur, 1983). Its excretion from the body is very low (Friberg et al., 1974) and it has synergistic toxicity with other metals, for example, with zinc (Cheremisinoff and Habib, 1972). Thus the removal of cadmium from polluted water is of great importance. Only very few studies have been done on the level of cadmium in the environment of the West Bank, Palestine. One of these studies showed the concentration of cadmium in soil of the highway between Ramallah and Nablus in the West Bank to be 0.45 μg/g (Swaileh et al., 2001a). The concentration of cadmium in the leaves of six common types of roadside plants around the highway of Nablus–Ramallah was reported in the range of 0.3–0.86 μg/g (Swaileh et al., 2001 b). Land snails were reported to magnify cadmium concentration to an average of 19.4 μg/g total dry weight of land snail *Levantina hierosylima* taken from four locations in the West Bank, Palestine (Swaileh et al., 2001b).

Several sorbents have been suggested in the literature for the removal of toxic metals (including cadmium) from water. These include activated carbon (Ferro-Garcia et al., 1988), fly-ash (Yadava et al., 1987), zeolite (Kesraouiouki et al., 1994), ferrites (Navratil, 1994) and limestone (Chen et al., 1999). The most commonly used sorbent is activated

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