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Removal of Zinc and Cadmium by Activated Carbon Adsorption

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The possibilities of removal of zinc and cadmium have been investigated using activated carbon. The experiments were conducted with soil solutions containing zinc and cadmum. Considerable amounts of zinc and cadmium are removed by powdered activated carbon from soil solutions. The amount of these metals removed strongly depends upon the pH of the solution.

Key Words: Zinc, Cadmium, Removal, Carbon adsorption.

INTRODUCTION

Treatment processes studied in the laboratory are iron coagulation, aluminium coagulation, lime softening, excess lime softening and activated carbon adsorption. Results of the research for the removal of inorganic contaminants have been summarized bv Logsdon[1]. The merits of activated carbon for removal of organic compounds from water have been well documented in the literature, but the potential for adsorption of inorganic compounds has received little or no publicity in the water-field literature. Studies in the field of metallurgy have indicated reasonably good adsorption of many metallic compounds.

Lindstedt and O'Connor[2] have found, however, for several metal ions, that activated carbon treatment results in a surprising reduction. An article, "Study Finds Millions in U.S. Drink Water with Potentially Hazardous Contaminants", appeared in the Aug. 18, 1970 issue of the *Wall Street Journal*. It covered a release by the Department of Health, Education and Welfare on a 1969 survey of 969 water-supply systems, which reportedly found "arsenic, barium, cadmium, chromium, fluoride and selenium in hazardous amounts in some tap water samples"[3]. Many of the above substances have been adsorbed by activated carbon in one form or another, thus suggesting investigation of their removal from water supplies.

Taylor[4] reports cadmium to have a high toxic potential and cites severe cases of food poisoning. American Water Works Association's goal has been set at 0.01 ppm. Studies on a cadmium chloride solution at a pH of 5.2 showed some degree of adsorption, so some slight potential shows exist for activated carbon. Sax[5] indicates that continued administration of small doses of zinc salts to human beings not only affected digestion but also led to constipation. The proposed American Water Works Association goal of 1.0 ppm has apparently been set for aesthetic reasons, chiefly taste. Laboratory tests on a zinc chloride solution at very low concentrations showed poor adsorption at pH 3.7 and no adsorption at pH 2.0. Somewhat better adsorption might be expected at higher pH values. Potential in water treatment would be rated as slight.

The possibilities of removal of zinc and cadmium have been investigated using activated carbon. Keeping in view the low cost investment, easiness in operation, physico-chemical treatment, an adsorption process by activated carbon has been selected. Activated carbon being insoluble, no harm can result from an overdose and zinc and cadmium are removed.

EXPERIMENTAL

The experiment was conducted with soil solutions. Standard procedure was adopted for preparation of soil solutions[6] and determination of concentration of zinc and cadmium in soil solutions using Pye-Unicam SP-9 series atomic absorption spectrophotometer.

The solutions were strongly acidic and required adjustment with sodium hydroxide for studying the effect of pH. For pH adjustment, 0.5 N NaOH was used. For removal of zinc and cadmium 50 cm. long and 1.0 cm diameter glass columns were used and each column had 20 g activated carbon. A 30 mL soil solution was allowed to percolate through columns of activated carbon. Concentrations of zinc and cadmium in filtrate (treated solution) were determined using an atomic absorption spectrophotometer.

RESULTS AND DISCUSSION

Results of percentage of zinc and cadmium removed by activated carbon are given in Table-1. Effects of pH on adsorption are shown in Fig.-1.

TABLE-1
PERCENTAGE REMOVAL OF Cd AND Zn BY CARBON ADSORPTION

S.No.	pH of the solution	% of Cd removal	pH of the solution	% of Zn removal
1.	5.2	33.34	6.2	50.00
2.	5.2	35.00	6.5	55.18
3.	5.4	38.47	7.5	67.40
4.	5.5	45.84	8.6	70.00
5.	6.0	56.67	8.6	70.46
6.	6.0	60.00	8.6	70.59
7.	6.0	60.00	8.6	71.74
8.	6.2	66.67	8.6	71.80
9.	7.4	73.34	8.6	71.84
10.	7.4	76.93	8.6	72.23

It will be seen from Table-1 that considerable amount of zinc and cadmium are removed by powdered activated carbon from soil solutions. The amount of these metals removed strongly depends upon the pH of the solution. The maximum removal of cadmium is in near neutral solutions where up to 76.93% of the metal can be adsorbed on the activated carbon. The percentage of cadmium removal acquires a limiting value at this pH, *i.e.*, 7.4. Likewise, the maximum removal of zinc is about 72% and these values are in the slightly alkaline solutions. At still higher pH, the amount of zinc removed remains same; limiting value is reached as evident from Fig. 1.

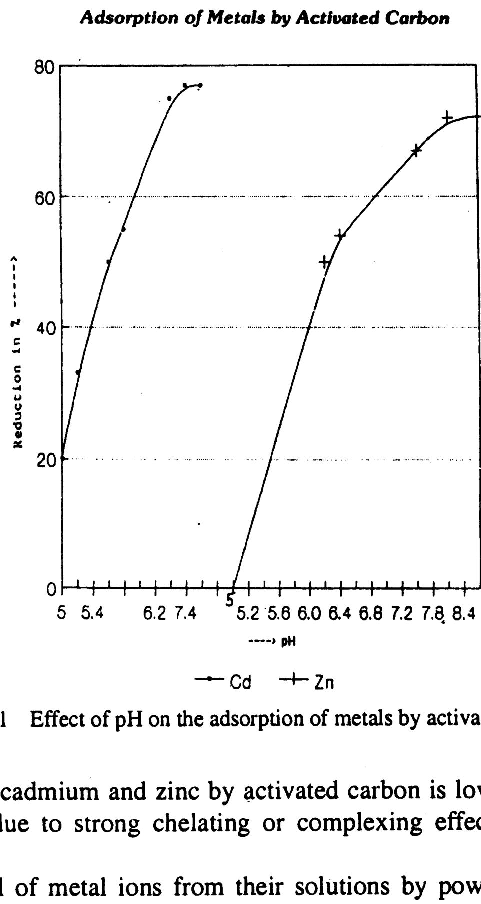

Fig. 1 Effect of pH on the adsorption of metals by activated carbon

Removal of cadmium and zinc by activated carbon is low in acidic medium. It is possible due to strong chelating or complexing effect of Cl^- present in solution.[7]

The removal of metal ions from their solutions by powdered or granulated activated carbon could be due to one or several mechanisms.[3]

First, it should be remembered that carbons will physically adsorb on their tremendous internal surfaces molecular compounds such as acids, complex ions, high molecular weight polymers or other nonpolar species.

Second, by virtue of a relatively small number of oxygen complexes and other functional groups fixed in the carbon surfaces, a limited ion exchange action can take place. Thus, the heavier and higher valance ion can displace H^+, Na^+, Ca^{2+} and other such ions to fix certain metals.

Third, carbon can induce precipitation of a supersaturated solution by nucleation and can reduce the solubility of a metallic salt. Colloidal suspension also can be broken by upsetting the surface structure protecting the colloidal particles. A layer of powdered or granular carbon also will exert an excellent filtering action under proper conditions. Last, commercial activated carbon contains traces of reduced form of iron and other metals which can enter into metathetical reactions with metallic ions lower in the electromotive series causing the heavy metal to be deposited on the surface. Thus, one sees that it is very difficult in a given instance to predict what will happen or to be sure as to what mechanism is responsible for metal removal. It is, however, clear that maximum removal takes place at some hydroxyl ion concentration and in all probability the mechanism described for retention of hydroxide of the metal by reducing the solubility of the metals by inducing the precipitation of supersaturated solutions by nucleation is responsible for metal removal.

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