

Effect of coagulant treatment on the metal composition of raw water

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Abstract

This study reports the results of an investigation on the use of two coagulants, namely $\text{Al}_2(\text{SO}_4)_3$ and $\text{Fe}_2(\text{SO}_4)_3$ which were investigated for their capabilities to reduce the metal levels of raw river water samples when treated. Generally, the percentage removal of the metals from raw water samples increased with mg/l dosage of either coagulant used. Although both coagulants were efficient in removing Cr and Ni, generally $\text{Fe}_2(\text{SO}_4)_3$ was proved to be the more efficient coagulant for the removal of all the metals studied. $\text{Fe}_2(\text{SO}_4)_3$ was 89.58% efficient in removing Cr and 99.73% efficient in removing Ni. It was 68.42% efficient in removing Zn, 40.14% efficient in removing Mn and 35.29% efficient in removing Cd (all at 13 mg/l dosage of coagulant). Judging from these results and taking into consideration the potential health threat to man from the possible Al contamination of treated water from the use of aluminium-based coagulants, the use of $\text{Fe}_2(\text{SO}_4)_3$ as coagulant in water treatment for the removal of suspended matter was preferred and would be highly recommended.

Introduction

Heavy metal removal is an important step in water-treatment processes. The aim of water treatment is to achieve the required standard of final water quality regardless of the quality of the source water. However, the extent of water treatment for domestic use will depend on the freshwater source quality. Some sources, such as rivers, require more extensive treatment than others, such as deep borehole water (Rossi and Ward, 1993). Many coagulants are widely used in conventional water-treatment processes for potable water production. Coagulants can be classified into inorganic coagulants, synthetic organic polymer and naturally occurring coagulants. They are used for various purposes depending on their chemical characteristics. An inorganic polymer 'PAC' (polyaluminium chloride) is the most widely used coagulant in water treatment (Van Benchosten and Edzwald, 1990; Boisvert et al., 1997; Najm et al., 1998; Okuda, et al., 1999, 2001).

Though aluminium-based coagulants are frequently used in water treatment there are fears that aluminium (the major component of PAC and alum) may induce Alzheimer's disease (Crapper et al., 1973; Miller et al., 1984; Martyn, et al., 1989) and that they exhibit strong carcinogenic properties (Dearfield et al., 1964; McCollister et al., 1964; Mallevalle et al., 1984). Some domestic tap waters may contain aluminium in relatively high concentrations because aluminium has been added as a flocculant during the purification process (DWAf, 1996). The implication of this may be serious since aluminium ions have been demonstrated to be toxic especially in individuals with impaired renal function (Savory and Wills, 1991).

Coagulation or chemical precipitation has been known since the previous century when it became widely used in England where lime was used as coagulant alone or with calcium chloride or magnesium (Genovese and Gonzale, 1998). Removal of turbidity by coagulants however, depends on the type of colloids in suspension,

pH, chemical composition of the water, the type of coagulant and coagulant aid, and the degree and time of mixing provided for chemical dispersion and floc formation (Rossi and Ward, 1993). Furthermore, Cheng et al. (1995) studied the coagulation mechanism by using $\text{Al}_2(\text{SO}_4)_3$, a cationic polymer and FeCl_3 . They found two main mechanisms of coagulation: At a relatively high coagulant dosage and higher pH, the adsorption of particles onto a floc of aluminium hydroxide or ferric hydroxide predominates, while the formation of insoluble complexes in a way that is analogous to that of charge neutralisation predominates at low coagulation dosage and lower pH values.

Findings on various coagulation processes have been reported in literature. These include addition of fish scales to enhance the solids removal by dissolved air flotation (Genovese and Gonzalez, 1998); coagulation of liquid effluent from fish-meal processing by heat and pH changes (Civit et al., 1982); effect of dosage and mixing conditions on the flocculation of concentrated suspensions using polymeric coagulants (Gregory and Guibai 1991); phosphate adsorption in flocculation processes of $\text{Al}_2(\text{SO}_4)_3$ and polyaluminium-silicate sulphate (Boisvert et al., 1997), to mention but a few.

In this study, two coagulants, namely $\text{Al}_2(\text{SO}_4)_3$ and $\text{Fe}_2(\text{SO}_4)_3$ were investigated with the aim of determining their capabilities to reduce metal levels (Cd, As, Cr, Ni, Mn, Cu and Zn) of raw river water samples. The interest in coagulation processes and hence the removal of the metals lies in the fact that these metals may constitute a threat to human health particularly when they occur in levels above the minimum allowable threshold in water intended for human consumption (Cd, 5 µg/l, Cr (VI), 0.05 mg/l, As, 10 µg/l, Zn, 3.0 mg/l, Cu, 1.0 mg/l and Mn, 0.05 mg/l) (DWAf, 1996).

Materials and methods

Method

Raw water from Tyume River in Alice was filtered through an acid-washed glass-wool plug to remove large particulates. A 250 ml sample of filtered water was placed in a 500 ml beaker and stirred

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