Characterisation and concentration profile of aluminium during drinking-water treatment

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Abstract

An aluminium(Al) characterisation study was conducted at a surface water treatment plant (Buffalo Pound Water Treatment Plant (BPWTP) in Moose Jaw, Saskatchewan, Canada) to understand better the effect of alum coagulant on various Al fractions. The raw water source for BPWTP is Buffalo Pound Lake water. The Al sources at BPWTP are:

- present naturally Al in the raw water and
- Al derived due to use of alum as a coagulant.

Seasonal evaluations of Al at BPWTP showed that raw lake water total concentrations were highly variable. Suspended (filterable) Al was the predominant species of raw water total Al. Organic-bound or organo-Al complex Al appeared to be the predominant species of dissolved Al in both raw and treated water during the September to November 1997 Al characterisation study. However, during October to December 1998, inorganic Al dominated dissolved Al content. Characterisation of Al at BPWTP showed that the use of (liquid) Al sulphate (alum) did not increase the concentration of total Al levels.

This was because:

- alum coagulation was practised at pH 7, at which the Al is least soluble
- clarifier and filtration units effectively removed particulate Al and
- granular activated carbon (GAC) was capable of removing part of the organic dissolved Al.

The study showed that BPWTP would be able to comply with the requirement of Health Canada Guideline value (for conventional treatment plants) for Al of less than 100 μg/ℓ as total Al. Turbidity and dissolved organic carbon of the raw water influenced the applied alum dose at BPWTP.

Introduction

The presence of Al in treated water for distribution has been a subject of concern for many years. Links have been established between Al in drinking water and human neurological disorders such as dialysis encephalopathy (Parkinson et al., 1979). A recent study by Berend and Trouwborst (1999) showed that excess Al in dialysate fluid was harmful to dialysis patients. Additionally, links in the case of Alzheimer's disease have been proposed (McLachlan et al., 1991). Although much more work is needed before the full implication of the toxic effects of Al is known, it is generally agreed that the knowledge of the form or type of Al species in the water system is of importance since both bio-availability and toxicity are critically dependent on the chemical form of the individual species of a metal. Speciation or characterisation may be defined as the determination of the individual concentrations of the various chemical forms of an element which together make up the total concentration of that element in a sample. The words "characterisation" and "speciation" are used interchangeably in this paper.

Aluminium which is present in alum and naturally present Al in raw water are transformed into various forms during water treatment. The literature indicates that the use of a coagulant containing Al may either increase or decrease Al concentration in the finished water, depending on its speciation in the source water as well as species (change or distribution) of Al during water treatment and conditions of water treatment. It is reported that when alum (i.e $Al_2(SO_4)_3.14\ H_2O$) is used as a coagulant for water treatment there is a 50% chance that it can lead to increased concentrations of Al in the treated water compared to the raw water itself (Miller et al., 1984; Driscoll and Letterman, 1987; Driscoll and Letterman, 1988; Driscoll and Letterman, 1995). A high concentration of Al (3.6 to 6 mg/ℓ) in the treated water contributes to turbidity, reduced disinfection efficiency, and precipitation of Al hydroxide within the distribution system. Most water treatment plants measure effluent levels of total or dissolved Al. However, profiles of various forms of Al levels through a water treatment plant are rarely performed. Added to this, few countries set standards (based on aesthetic considerations only) for Al. In addition, Al is not a routine monitoring parameter in finished water in many water treatment plants. Furthermore, relatively little attention has been paid to the speciation of Al in raw, treated and distributed waters (AWWA Committee Report, 1993). It is generally accepted that free (hydrated) metal ion is the form which is most toxic to aquatic life. Strongly complexed metal or metal associated with colloidal particles is much less toxic (Florence and Batley, 1980). Hence, determination of the total concentration of a metal in a water sample provides very little information about the toxicity of that water.

Aluminium characterisation was conducted at the Buffalo Pound Water Treatment Plant (BPWTP) which is located approximately 85 km west of Regina. The plant supplies drinking water to the cities of Regina and Moose Jaw. The raw water source is Buffalo Pound Lake (29 km long, and 1 km wide, with an average depth of 3 m), a shallow reservoir in the Qu' Appelle Valley. Raw water from Buffalo Pound Lake passes through a series of unit operations including prechlorination, cascade degassification, coagulation and flocculation, clarification, filtration, and carbon adsorption (during summer months). The plant uses liquid Al

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