

**SELECTIVE FLUORIDE REMOVAL BY ALUMINUM PRECIPITATION  
AND MEMBRANE MICROFILTRATION**

Emily Kowalchuk\*, Bruce Thomson, Kerry Howe

**ABSTRACT:** Fluoride (F) is a naturally occurring anionic constituent of most surface and ground waters. It is one of the most familiar drinking water constituents that are beneficial to human health at moderate concentrations but hazardous at high concentrations. At low concentrations it has the beneficial effect of strengthening teeth and reducing dental caries, but at high concentrations it is related to a host of skeletal and other problems. It has been estimated that more than 700 water systems in the United States have water supplies with fluoride concentrations of 2.4 mg/L or higher. Most are small systems which rely upon ground water as their source of supply, and thus do not have the economic base nor technical expertise to support water treatment. Fluoride treatment options are limited because it participates in few aqueous reactions and its chemistry is very similar to that of chloride (Cl) which is almost always present at much higher concentrations. For most communities the only treatment technology for fluoride removal is reverse osmosis which is expensive, wastes 25 to 50% of the feed water, and produces a concentrate stream that is difficult to manage. This paper describes a new process that achieves selective fluoride removal by co-precipitation onto aluminum hydroxide floc ( $\text{Al}(\text{OH})_3$ ) which is subsequently removed by membrane microfiltration. This process is referred to as Al-CMF. Laboratory studies have found: Fluoride removal by  $\text{Al}(\text{OH})_3$  co-precipitation is independent of pH over the range of  $5 < \text{pH} < 9$ . The fluoride co-precipitation reaction is very rapid, occurs in less than 10 sec, and that fluoride removal is enhanced by extremely high mixing energies. Little fluoride removal occurs through adsorption onto pre-formed  $\text{Al}(\text{OH})_3$  floc. The ratio of Al dose to F removed is 7.0 moles Al/1.0 mole F or 10 mg Al/1 mg F. A 1 gal/min pilot Al-CMF plant was constructed and operated to demonstrate the feasibility. An economic analysis shows substantial cost savings over RO treatment.