Dynamic Adsorbents

A Re-Examination of the Role of Fluoride in Municipal Water Supplies

by Gary Witman, MD

Fluoride compounds contained in municipal water systems begin as salts forming when the element fluoride combines with minerals in soil or rocks. Some fluoride compounds such as sodium fluoride and fluorosilicates dissolve easily into ground water as it moves through gaps and pore spaces between rocks. This is a significant problem in some regions of the United States, including New Mexico, West Texas, Colorado, Indiana and Illinois. Fluorides are also a waste product found in industrial waste waters from coal, minerals and clays heated to high temperatures and then released during glass manufacturing, electroplating, and the production of steel and aluminum, pesticides, fertilizer and semiconductor manufacturing. High levels of fluoride are generally reduced by the precipitation of calcium fluoride with lime. However the solubility of calcium fluoride is such that 8 ppm fluoride remains in distilled water, and in industrial water residual fluoride levels may be even higher.

Orally ingested fluoride is readily adsorbed from the GI tract. Nearly all of the fluoride in the body is found in calcified tissues and elimination is through glomerular filtration in the kidneys. Excessive fluoride intake can lead to fluorosis of both teeth and bones. Children between the ages of 2-3 are at most risk of suffering from cosmetic fluorosis. Tooth discoloration and/or pitting may be caused by excess fluoride exposure during the formative period prior to tooth eruption. Additionally in many urban communities up to 10% of children manifest enamel fluorosis in primary teeth as the result of ingesting formula as infants which is reconstituted with fluoridated municipal water.

Fluoride as a strong oxidant had historically over the past 50 years been added in concentrations of 1 ppm to many drinking waters in order to prevent dental caries. However, fluoridation of water is not regulated nationwide. Additionally, the addition of fluoride to the water supply is now banned by virtually every European nation because of the potential and real long term complications of fluorosis. Fluoride is believed to be a carcinogen with high affinity for bone and is linked to hip fractures and brittling of bones. The International Agency for Research on Cancer (IARC) has determined that the carcinogenicity of fluoride to humans is not classifiable.

Skeletal fluorosis results from ingesting excessive levels of fluoride for prolonged periods of time. The first obvious symptoms include pain and stiffness in joints and osteosclerosis and this may then become crippling due to calcification of ligaments, osteoporosis of long bones and neurological defects due to hypercalcification.

All salts of fluoride are toxic. The adequate adult intake (AI) for fluoride is 0.05 ug/kg/day while the tolerable upper intake level is 0.1 ug/kg/day. Although water ingestion is the primary source of fluoride in the diet other sources such as formula may contribute to intake in children. Any food that absorbs water while cooking such as rice, paste and vegetables may be affected by the fluoride content of water. Additionally, significant amounts of fluoride are ingested by swallowing toothpaste, fluoride rinses and mouthwash products. The maximum

contaminant level for fluoride established by the Environmental Protection Agency is currently established at 4 mg per liter (mg/L) or 4 parts per million. The EPA has set a secondary standard for fluoride at 2 mg/L. EPA recommends secondary standards to water systems but does not require systems to comply. However, individual states may choose to adopt them as enforceable standards.

Removal of fluoride from industrial waste water may be obtained using precipitation, as well as membrane and adsorption processes. The membrane processes include reverse osmosis, nanofiltration, electrodialysis and donnan dialysis. The best way, bar none, to reduce the concentration of fluoride to 1 ppm or below is through adsorption onto specially designed wide pore size activated alumina.

DAI Dyna-Aqua™ Fluoride

DAI provides pretreated activated alumina designed to address commercial and industrial needs reducing the concentration of fluoride in wastewater effluent and municipal water systems to less than 1 ppm. This specially designed wide pore activated alumina is cost competitive with any other form of purification and provides simplicity of design and ease of utility. This novel product is an exciting addition to the expanding line of custom designed activated alumina compounds offered to purify municipal and industrial wastewaters.

A key advantage in using activated alumina for fluoride removal is that fluoride extraction is in part dependent upon the pH of waste water contents. Because of its unique amphoteric properties activated alumina works optimally in a pH range of 5.5 to 8.5. If the effluent stream is extremely alkylotic the source waste water may need to be pretreated in order to reach a pH range of 5.5 to 6.5 to achieve peak fluoride removal efficiency. Furthermore there is no simpler means to remove fluoride than through the use of a column of adsorbent material containing specialized activated alumina. Flow rate efficiency is affected by particle size. The smaller the particle size, the higher the flow rate that can be used. This must be balanced against the higher pressure drop which results from smaller size material. Competitive adsorption may occur in the setting of high concentrations of bicarbonate ions. For this reason Dyna-Aqua™ Fluoride is of such high efficiency that even with competitive binding with bicarbonate ions the total effluent concentration of fluoride will remain less than 1%.

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