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Subject: Technical Letter 21
Removal of Water Supply Contaminants -- Barium

April 1977

This is the seventh in a series of Technical Letters dealing with methods for removal of contaminants from water supplies so that the supply will be in compliance with state and federal drinking water standards.

Contaminant

This Technical Letter is concerned with barium (Ba) as a contaminant of drinking water. In 1976 there were approximately 28 supplies in Illinois having barium levels above 1 milligram per liter (mg/l). Most of the supplies are in the northern part of the state, with a few scattered sites in other parts of the state. The levels vary from 10 mg/l to just slightly over 1 mg/l. Many of these wells are deep sandstone wells.

Prevalence and Uses

Barium is found scattered in nature in relatively low levels with some high barium minerals. Small amounts of barium are found associated with calcium and magnesium deposits.

Barium is found in groundwater primarily because of leaching of geological deposits containing barium. Limited contamination from industrial uses of barium would be expected.

Barium has limited usage. It is used as a stabilizer in some plastics, as an additive in some lubricants, and as a component of fireworks and some explosives. Insoluble barium sulfate is used in medicine to obtain contrast in X-ray and fluoroscopic views of a patient's alimentary tract and as the white pigment in high reflectance paints. Barium salts are used in oil drilling processes. Barium carbonate has been used as a rodenticide.

Health Effects

Although the effects of long-term chronic exposure to barium are not known, primary concern about barium is based on its suspected effect on the cardiovascular

system. Chronic exposure to low levels of barium can result in the accumulation of barium in the muscles of the cardiovascular system by replacement of calcium. Barium exerts a digitalis-like effect on the heart, with palpitations and increased blood pressure. The greatest danger is to those persons already suffering from heart trouble.

Maximum Levels

The maximum level of barium in drinking water is 1 mg/l.

Removal

Barium is very similar to calcium in its chemical behavior. Therefore, processes which are effective in removing calcium should effectively reduce the barium level in water.

A. Ion Exchange

Ion exchange softening will effectively remove barium from water. The barium, along with calcium and magnesium, will exchange with the sodium ions of the resin. The barium is removed from the resin during the regeneration of the resin by washing with a brine wash. Regeneration is required when the resin becomes saturated with the elements being removed. For effective barium removal, the resin must be regenerated as soon as calcium breakthrough begins to occur.

Since ion exchange softening removes all the hardness, it is necessary to blend the finished water or to add hardness to the finished water to prevent corrosion of the distribution system. Blending of finished water with raw water will result in decreased cost of treatment by reducing the volume of water treated, which results in less frequent exchanger regeneration and therefore a savings in chemical and brine disposal costs. The ratio of raw to finished water which can be used will depend on the level of barium in the raw water. The level of barium in the blended water must not exceed 1 mg/l.

B. Lime Softening

Lime softening will effectively remove barium from water. The barium is precipitated and carried down with the calcium during softening. Since complete softening of the water does not occur, no addition of hardness to protect the distribution system is necessary. However, depending on the level of barium in the raw water, blending may be used to reduce the amount of water which needs to be treated. Reducing the amount of water treated will realize a savings in chemical costs and sludge disposal costs. Blending can only be done if the distributed water has a barium level not exceeding 1 mg/l.

C. *Reverse Osmosis*

Reverse osmosis involves the removal of soluble minerals by passage of water through a semipermeable membrane. To get water to pass through the membrane it is necessary to apply pressure to the water containing the minerals to overcome the natural direction of flow which would be for pure water to diffuse into the mineral-containing water. The amount of pressure necessary depends on the mineral content of the raw water.

Although reverse osmosis can be used to reduce the barium level, its application is impractical and costly unless it is already in use for the treatment of brackish water. The most significant cost is plant construction. For a 1000 m³/day plant (183 gpm), construction costs are about \$250,000 based on 1976 costs. This cost does not include costs for any interest during construction, site and site improvement, discharge facilities, storage and delivery facilities, or special treatment. Operating costs are about \$18,000 for a plant of that capacity.

D. *Electrodialysis*

Electrodialysis involves the removal of salts by means of ion selective membranes and a d.c. current to assist transport of the ions across the membrane. There is depletion of ions on one side of the membrane if current is passed for any length of time, while there is concentration on the other side of the membrane. Any level of desalting can be achieved by increasing the residence time or increasing the current density.

For efficient operation good water pretreatment is required. This should include coagulation of colloidal particles, oxidation of iron and soluble organics, carbon filtration, and finally acidification.

Although this process can be used for the reduction of barium levels, its application is impractical and costly even if other contaminants are to be removed unless the equipment is already in use or planned for use to reduce brackish water to an acceptable salt level. The cost for electrodialysis depends on the level of contaminant to be reduced. In general it will be more costly than reverse osmosis. The pH of the effluent may require adjustment to protect the distribution system.

E. *Distillation*

Distillation involves the volatilization of water to separate it from all dissolved or suspended materials which are not volatilized. Normally the water is heated under pressure to improve the thermal efficiency of the method by recovering some of the heat. This process produces water of very low dissolved solids. Since the water is corrosive to the distribution system, it is necessary to increase the hardness. This can normally be accomplished by appropriate blending of the finished water and the raw water.

Some pretreatment of the feedwater may be necessary to remove suspended solids and calcium and magnesium to prevent scaling.

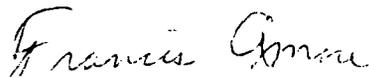
Distillation is a relatively expensive and impractical solution for the removal of specific contaminants from water. The process involves the removal of a large volume of water from a small amount of dissolved material. This results in an unfavorable energy requirement since it is essentially independent of the contaminant level and only dependent on the amount of water to be treated. The major cost is plant construction which will be about \$1.2 million for a 1000 m³/day plant (183 gpm). The operating costs for energy are also high, since there is only partial heat recovery in this process.

General Comments

All of the removal techniques discussed above require pilot-scale testing for a specific application to determine their efficiency. Pilot-scale studies are also needed to determine what, if any, pretreatment is necessary to insure good operating efficiency. All of the processes which effectively demineralize the water require some adjustment of pH and/or hardness and alkalinity to prevent corrosion of the distribution system.

Technical Letters are issued as part of the Water Survey's continuing service to citizens of Illinois. Should you need further clarification, please let us know.

Very truly yours,

A handwritten signature in cursive script that reads "Francis Amore".

Dr. Francis Amore
Associate Professional Scientist