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Subject: Technical Letter 22
Removal of Water Supply Contaminants -- Copper and Zinc

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

Contaminant

This Technical Letter is concerned with copper (Cu) and Zinc (Zn) as contaminants of drinking water. In 1976 there were five supplies in Illinois that exceeded the copper standard of 1 milligram per liter (mg/l) and two supplies that exceeded the zinc standard of 5 mg/l. These two elements are covered in a single letter because of certain similarities in their chemistry, toxicity, and methods of removal.

Prevalence and Uses

Both copper and zinc are necessary trace elements for good health, being involved in a number of essential bodily functions. Both copper and zinc are found widely dispersed in nature with some large localized deposits. Copper and zinc are found in groundwater primarily from leaching of geological deposits containing the metals or from contamination due to industrial usage. Copper may be high in water coming from a tap due to corrosion of the copper tubing, particularly with soft water. Zinc may also be high if brass fittings are used in the system. Copper and zinc will be high in systems where galvanized pipe is connected to copper tubing, because of galvanostatic corrosion.

Both copper and zinc are of great industrial importance, and have been extensively mined and redistributed in the environment through man's activity.

Copper was probably one of the first metals worked by ancient man some 7000 to 8000 years ago. After around 4000 B.C., melting and casting of copper was common practice in the Near East. About 500 years later came the start of the bronze age which had a great impact on the course of civilization. At present copper is used extensively for electrical transmissions because of its high electrical conductivity. It has been used in cooking vessels, in heat exchangers, and in cooling systems because of its high thermal conductivity. It has been used in plates for roofs, and is used in combination with other

metals to form alloys such as brass, bronze, Monel Metal, German silver, etc. Copper salts are used as pigments in paints and dyes, in the manufacture of textiles, in tanning, as a catalyst, as a pesticide, as a wood preservative, as a fixer, desensitizer, and intensifier in photography, in batteries, as a stabilizer of various organic chemicals, etc.

Zinc is a component of many alloys including bronze, brass, babbitt metal, German silver, and others. It is used as the protective coating on galvanized steel and on other metals to prevent corrosion. Its salts are used in wood preservatives, as pesticides, as antibiotics, in the manufacture of glazes and glasses, in various cements and glues, as a mordant in dyeing, as a pigment in paints and inks, as a plastic mold releasing agent, as a waterproofing agent for concrete, rock, wool, paper and textiles, and in the manufacture of rubber in the vulcanizing, compounding, and curing processes, etc.

Health Effects

Both copper and zinc are necessary trace metals with deficiencies being a far greater health problem than excesses. Both are relatively nontoxic to man except at extremely high levels or in some salts in which the other components are the main toxic agents. There are no known health effects from exposure to slight excesses of either copper or zinc. The body appears to be able to maintain the necessary balance for these metals despite wide variations in intake, except in certain diseases such as Wilson's disease in which excessive levels of copper accumulate. Inclusion of drinking water standards for these elements is based on esthetic considerations rather than health considerations. High levels of these metals in water will impart an objectionable metallic taste to the water.

Maximum Levels

The maximum level in drinking water is 1 mg/l for copper and 5 mg/l for zinc.

Removal

A. Ion Exchange

Copper and zinc can be removed from drinking water by ion exchange softening, according to the USEPA data. Removal efficiency is reported to be 95 percent for copper up to levels of 20 mg/l and for zinc up to levels of 100 mg/l. The copper and zinc are removed by ion exchange softeners, along with the calcium and magnesium hardness. In the ion exchange process the elements removed are replaced by sodium from the resin. The ions which are removed are washed from the resin with a brine solution. Regeneration of the resin with brine is required when the resin becomes saturated with the elements being removed and thus no longer effective. For effective removal of copper and zinc, 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 with untreated water or to treat the finished water to prevent corrosion of the distribution system. Blending of finished water with raw water will result in decreased treatment costs. The ratio of treated to untreated water which can be used depends on the level of copper and zinc in the raw water. The final blended water should not exceed 1 mg/l of copper or 5 mg/l of zinc.

B. Lime Soda Softening

Lime soda softening may be effective for removal of copper by precipitation of copper hydroxide, which will be carried down with the calcium carbonate and magnesium hydroxide precipitates. Since zinc is amphoteric, it forms a soluble species in basic media; however, insoluble zinc carbonate or zinc hydroxycarbonate may form and be carried down in the process. The efficiency of this process for removal of copper and zinc will have to be evaluated.

C. Adsorption Processes

Recent work has reported on the use of activated carbon for removal of metals from water. The adsorption process involves removal of metals by adsorption at active sites on a solid material which the water contacts. Only limited work has been carried out in this area. Early studies indicate that removal efficiency for copper and zinc are low under normal water conditions; however, pretreatment of the water may improve the removal efficiency.

D. 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 copper and zinc levels, 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 will be 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.

E. Electro dialysis

Electrodialysis involves the removal of salts by means of ion selective membranes and a d.c. current to assist transport of the ion 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 copper and zinc 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.

F. 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.

G. *Miscellaneous Processes*

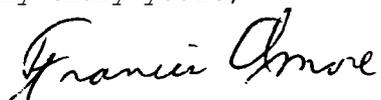
Recently a number of new processes have been applied to the removal of these metals from waste waters, particularly in the metal plating industry. Some of these processes involve use of starch polymers as precipitants of the metals, and modified cellulosic material and humic type compounds as absorbents for the metals. These processes may be applicable to treating drinking water, but their applicability for this purpose has not been evaluated at this time. Future work may determine whether they might be practical processes for water treatment.

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

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