Illinois State Water Survey

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Subject: Technical Letter
Removal of Water Supply Contaminants -- Organochlorine Pesticides

This is the eleventh in a series of Technical Letters dealing with state of the art 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 organochlorine pesticides as contaminants of drinking water supplies. The primary drinking water regulations list limits for endrin, lindane, methoxychlor, and toxaphene. In 1976 there were no water supplies in Illinois known to exceed the allowable limits for these compounds.

Prevalence and Uses

All of these compounds are man-made and do not exist in the environment naturally. They can occur in water supplies as a result of runoff from or percolation through agricultural land, industrial discharges during manufacture or formulation, improper disposal of pesticide containers, and drift from aerial spraying. All of these compounds have very low solubility in water. Levels of these compounds can apparently exceed the solubility because of their adsorption onto suspended solids in the water.

All of these compounds have been used as economic poisons to control insect damage to agricultural crops and diseases spread by insect vectors. These compounds have been incorporated into soil for control of soil insects and sprayed on crops for control of leaf or foliage insects.

Both endrin (structurally similar to dieldrin) and methoxychlor (structurally similar to DDT) breakdown rather rapidly relative to most organochlorine pesticides (including dieldrin and DDT). Lindane (yBHC) and toxaphene are more resistive to breakdown and can remain in the environment for relatively long periods of time.

Health Effects

Concern about these compounds is based on their long-term cumulative effects rather than acute toxicities. The limited solubility in water prevents buildup of levels which might result in acute toxicity. All of these compounds when ingested in sufficient amounts can affect the central nervous system and cause dizziness, headache, nausea, tremors, weakness, convulsions, cyanosis, and circulatory collapse. Chronic exposure may cause kidney or liver damage and some nerve degeneration.

Since both methoxychlor and endrin are metabolized and excreted fairly rapidly, there is little accumulation of these compounds from chronic exposure and only limited serious health problems. Lindane and toxaphene are not rapidly metabolized and eliminated from the body and tend to accumulate in the fat tissue with chronic exposure. It is unknown whether accumulation of these compounds causes any serious health problem. There is some concern about the potential carcinogenicity of these compounds.

Maximum Levels

The maximum levels in drinking water for the organochlorine pesticides specified are: endrin, 0.0002 mg/1; lindane, 0.004 mg/1; methoxychlor, 0.1 mg/1; and toxaphene, 0.005 mg/1.

Removal

The low water solubility makes removal of relatively large amounts of. these compounds easy. However, their removal becomes increasingly difficult as the concentrations decrease below 0.1 mg/1. It may be very difficult and costly to achieve reductions to the maximum levels in certain waters. Cost will be high for removal because there are no specific methods for the removal of organochlorine pesticides.

A. *Activated Carbon Adsorption*

Activated carbon adsorption has been effective in removing organochlorine pesticides from water. The process involves contact of the water and activated carbon to achieve removal by means of adsorption of the material onto active sites on the carbon. Both granular carbon in a column and powder carbon added directly to the water have been used. The granular activated carbon is somewhat more expensive at this time but it can be regenerated by thermal methods. Continuous countercurrent systems have been used which provide for maximum removal efficiency without the need for shutdown to regenerate the carbon. This continuous system also greatly reduces the need for close monitoring of the effluent for the materials being removed.

Powdered activated carbon is mixed directly with the water and is removed by filtration. Under normal operation the carbon is used on a once-through basis as a disposable item, which provides for easier operation than with the granular carbon beds. Also, the required dosage is somewhat lower than for granular carbon because of more efficient contact and mixing.

Systems for using powdered carbon with regeneration are under development. At the present time losses during regeneration affect any cost savings between granular and powdered carbon. Because the costs of both powdered and granular carbon are continually fluctuating, the price advantage of one over the other is uncertain.

Granular carbon can also be used in a conventional filter bed. Eighteen to twenty-four inches of sand can be replaced by carbon. Simple backwashing does not regenerate the carbon relative to pesticide removal so it must be replaced periodically or regenerated by thermal methods. If the carbon is not replaced or regenerated, it serves only as a filtering media in removing suspended material rather than as adsorption media removing the pesticides in solution. Some means of monitoring would be required to determine when the carbon needed to be changed. This makes the system somewhat impractical for routine use. The lifetime of activated carbon for removal of single contaminants is on the order of several months compared with several years for taste and odor removal. This requires careful monitoring of the treated water in a fixed bed system.

B. Porous Resin Adsorption

Several years ago ion exchange resins with well-characterized pore structures were prepared. Unlike previous gel-type resins the new materials have a definite pore structure and porosity similar to the classical adsorbents such as aluminas, silicas, and carbons. These porous structured resins were found to be effective in removing organics from water without the problem of clogging as observed with the gel-type resins. In addition, regeneration was possible with sodium hydroxide. Although weakly basic anion exchange resins were found to be the most effective for removing organics, the removal is not an ion exchange process but an adsorption process. The resins have been used for treatment of boiler feed waters for removing organics and other water treatment processes, for concentrating pesticides from water prior to analysis, and for removing pesticides from waste streams in the manufacture of pesticides. These resins should be effective in treating drinking water.

For water with high organic content and high suspended solids it may be necessary to treat the water before it passes through the resin. Coagulation and sedimentation can be used to reduce the amount of material to be removed by the resins. This will increase the run time of the resin between regenerations. Monitoring of effluent is essential to determine when regeneration is necessary.

C. Coagulation, Sedimentation, and Filtration

Coagulation is the removal of material from solution by precipitation. Either iron or aluminum salts are added to the water and the pH raised by the addition of lime. The iron or aluminum added precipitate as the insoluble hydrated oxides. The precipitate carries down suspended matter and some soluble material as it settles. The compound removed may be occluded in the precipitate or adsorbed onto the surface. The process has been effective in the removal of organics from water when the organics were present as suspended solids or adsorbed onto suspended solids. Since organochlorine pesticides are adsorbed onto suspended solids, this process should be effective in reducing the level of pesticides. However, it is unlikely that this process alone will be able to reduce the pesticides to the level required. Improved removal efficiencies have been obtained by the addition of powdered activated carbon. Whether this process will be sufficient to achieve reductions to the maximum allowed levels will have to be evaluated on a given water by pilot studies.

D. Polyurethane Foam Plug Adsorption

Plugs of polyurethane foam have been used for collecting various organochlorine pesticides from water for the purpose of analysis. It is possible that a somewhat similar system might be useful for treatment of contaminated waters. The removal process is based on the adsorption of the pesticides onto the surface of the polyurethane. Some limited studies have been carried out with polyurethane foam for removal of organics from water. Very little information is available on their practicality and utility.

Since removal of adsorbed material from the polyurethane requires rinsing with alcohol or another organic solvent, it is unlikely that a convenient regeneration scheme can be developed. The plugs would have to be used on a throwaway basis. Polyurethane plugs may be of use for fine polishing of water, after other treatment methods have reduced the levels of pesticides to near the allowable level. In waters with high suspended solids, pretreatment would be necessary to prevent clogging of the plugs and excessive replacement of the adsorption media. Monitoring of the effluent would determine when replacement is necessary.

E. Reverse Osmosis

Reverse osmosis involves the removal of soluble materials 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 dissolved materials to overcome the natural direction of flow which would be for the pure water to diffuse into the water containing dissolved material. The amount of pressure necessary depends on the mineral content of the raw water. For waters with high suspended solids, pretreatment is necessary to prevent clogging of the membrane.

Although reverse osmosis can be used to reduce the organochlorine pesticide level, its application is impractical and costly unless it is already in use for the treatment of brackish water. It is reported by the Federal Environmental Protection Agency that 99 percent or better removal efficiencies can be obtained for the pesticides for which limits are established. The most significant cost is plant construction. For a 1000 m^3/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 any special treatment. Operating costs are about $18,000 for a plant of that capacity.

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.

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,

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