INVESTIGATION OF PLASTIC PIPE PERMEATION BY ORGANIC CHEMICALS

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AWWA Section Meeting
Lexington, Kentucky

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In the past several years there has been an increasing awareness of the potential for plastic pipe to be permeated by organic chemicals. Numerous incidents have been reported in the literature and at industry meetings. This awareness has no doubt resulted from improved analytical capability and availability. Several years ago the response to taste and odor complaints may have been limited to more traditional tests for bacteria and inorganic chemicals. Today, a complaint which might suggest the presence of an organic chemical will probably be tested for volatile organic chemicals or other more sophisticated analysis.

CASE HISTORIES

The East Bay Municipal Utilities District in Oakland, California reported in 1979 that at least four instances of apparent petroleum distillate penetration of PB water service lines had been encountered by their field personnel (1). Later laboratory testing confirmed this supposition to their satisfaction. A case in Maryland was reported in which concentrations up to 5,500 ug/L of toluene were found in a water sample collected from service line consisting of both PE and PB (2). The soil surrounding the service line was contaminated with gasoline as a result of a leaking underground storage tank that had been abandoned.

Similar incidents were reported by the Alabama Department of Environmental Management (3). One incident, typical of most reported cases, started with a complaint of an unusual odor which resulted in the collection of a sample for organics analysis. The

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Similar incidents were reported by the Alabama Department of Environmental Management (3). One incident, typical of most reported cases, started with a complaint of an unusual odor which resulted in the collection of a sample for organics analysis. The

organics detected could not be traced to the water source, so service pipe permeation was suspected. During replacement of the PB service pipe the soil excavation released a strong fuel odor. Further investigation revealed that this site was the fuel storage yard during construction of the subdivision and the soil was still saturated with diesel fuel. A second incident reported in Alabama occurred as a gasoline truck accident spilled fuel which then saturated the soil and permeated PB service pipe. In this instance the spilled gasoline travelled under the road bed to permeate another service line 60 feet away.

In the past several years there have been occasions within the American System where permeation of potable water system service line materials by petroleum products has occurred. Both occasions were similar in that the water company became alerted by a customer complaint of odor in the drinking water. One instance occurred at a private residence in Chattanooga, Tennessee where the customer service line was 3/4 inch PE. The investigation was initially confounded because the problem was temporarily corrected by flushing the customer's plumbing. The customer's service line was replaced with copper after it became known that gasoline had leaked from the customer's car in the vicinity of the line. The presence of gasoline could be observed in the ditch during the line replacement. A section of the PE line was taken to the water company laboratory where it was filled with plant tap water and sealed. After two weeks exposure, the water was found to contain toluene (3100 ug/L), benzene (520 ug/L) and ethylbenzene (440

ug/L), all of which were absent in the plant tap water, but are constituents of gasoline.

A similar instance occurred in Darien, Connecticut where a customer complaint of gasoline odor resulted in sample analysis which showed benzene (>100 ug/L) and toluene (>50 ug/L) in the tap water. As in the other case, the odors were absent after flushing and when the homeowners' plumbing was in daily use. Samples collected after the system had not been in use for 2 days contained approximately 16 ug/L benzene and a gasoline odor. The customers' 1 1/4 inch PE service line was replaced with copper after it was determined that an abandoned underground gasoline storage tank on the customers' property had developed a leak and saturated the ground surrounding the line.

The introduction of organic contamination through pipeline permeation may not only cause complaints, but can render the water unfit for consumption (4). Seven employees of a Columbus, Ohio business reported symptoms of light headedness, weakness, abdominal cramps, and diarrhea. The suspected cause was gasoline permeation through a 1 1/2" PE water service line. A gasoline station had occupied the site prior to the present business.

PROJECT DESCRIPTION

The American Water Works System is made up of over 100 separate water supply systems serving approximately 5 million consumers in 20 states. Individual systems range in size from fewer than 1000 to more than 125,000 customers. With this diversity in size of operations and geographical locations, there

are a variety of pipe and service line materials in use. Plastic pipe, predominately polyethylene (PE) and polybutylene (PB), is used for service lines in many locations. Additionally, PVC pipe is used in many locations for distribution mains. Because of concerns over the permeation of service line by organic chemicals, we decided to conduct our own research investigation.

The objective of the study was to determine the extent and nature of permeation of several different organic compounds through the types of service line material in use in the American System. Service lines were examined, rather than mains, because the greater surface area to water content ratio in the smaller diameter service line will make the impact of any permeation more severe. Perhaps more significant, the daily static water conditions experienced in residential service line would magnify the impact of any permeation. Additionally, plastic pipe materials are more widely used for service lines than for distribution mains.

The conditions of exposure were designed to simulate worst case field conditions. Because of concerns over the effects of industrial environments on plumbing materials two exposure tanks were used. One involved exposure of the five different pipe materials to a vapor environment. The second was performed separately but concurrently with exposure of the five different pipe sections to a moist soil environment to which sufficient contaminant was added so the pipe was above the satu-

rated soil, yet still within the moist capillary zone. Three organic compounds (gasoline, trichloroethylene and chlordane) were investigated separately in each study. The contaminated environment (and the pipes) was contained in enclosed glass tanks, with the pipes extending through the end walls of the tanks (see Figure

Each phase of the project (gasoline, chlordane and trichloroethylene) lasted for a minimum 10 week exposure with water samples analyzed at 4 intervals during the exposure period. The pipe systems were all unjointed 3/4 inch lines filled with tap water. After each exposure interval the pipe contents were removed for analyses, and fresh tap water was again placed in each pipe for the next exposure interval. Plastic pipe materials were also used for controls by placing PB, PE and CPVC pipe sections outside the contaminated environment. These were sampled in an identical manner to the exposed pipes.

RESULTS

The results, summarized in Table I were as follows:

1. Iron and copper pipes were not permeated by any of the organic contaminants (TCE, chlordane, and gasoline) in either the soil or the vapor environments.

2. PE pipe was permeated by TCE within 1 week in both the soil and vapor exposures. Gasoline permeation occurred within 1 day in the vapor and 3 weeks in the soil exposure. The chlordane did not permeate the PE pipe.

3. PB pipe was permeated by TCE and gasoline within 1 day and not by chlordane within 10 weeks. Results were the same in both the soil and vapor environments.

4. CPVC pipe was permeated by TCE within 1 day in the soil environment and not until 14 weeks in the vapor environment. Gasoline permeation occurred within 6 weeks in the soil environment and not at all in the 14 week vapor exposure. The chlordane did not permeate the CPVC pipe.

5. In both the TCE and gasoline exposures, the CPVC was softened by the chemical exposure. After removal from that environment, the pipe returned to its original stiffness.

CONCLUSIONS

As a result of this study, we have confirmed that plastic pipe is susceptible to permeation from certain organic chemicals, particularly solvents. Permeation of service line material, because of the small surface area to water volume ratio when compared to larger distribution piping, is most likely to create a problem. This is aggravated by the fact that water in the service lines will remain static for longer periods of time, thus allowing concentrations to rise.

AWWSC has developed guidelines concerning the use of plastic materials for service line applications within the System. Some

limitations are desirable in areas where the potential for soil contamination is high, e.g. a gasoline storage area. However, since water company responsibility for customer service lines is limited, further restrictions concerning the use of plastic pipe may require some broader regulatory or plumbing code controls to be effective.

TABLE I

SERVICE LINE PERMEATION RESULTS

TIME TO PERMEATE (1)

PIPE		TRICHLOROETHYLENE		CHLORDANE		GASOLINE (2)	
MATERIAL	CONTROLS	SOIL	VAPOR	SOIL	VAPOR	SOIL	VAPOR
Copper	---	dnp (3)	dnp	dnp	dnp	dnp	dnp
Iron	---	dnp	dnp	dnp	dnp	dnp	dnp
PB	dnp	1 day	1 day	dnp	dnp	1 day	1 day
PE	dnp	1 week	1 week	dnp	dnp	3 weeks	1 day
CPVC	dnp	1 day	14 weeks	dnp	dnp	6 weeks	dnp

(1) Sampling interval during which organic contaminant was present at a concentration of 1 mg/l or higher.

(2) Permeation defined as 1 mg/l benzene, toluene, xylene or ethylbenzene.

(3) dnp: did not penetrate during exposure period; trichloroethylene - 14 weeks, chlordane - 10 weeks, gasoline - 14 weeks.

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