Item SWM-29-83

The Proctor & Redfern Group

Proctor & Redfern Limited
Consulting Engineers and Planners
20 Hughson Street South
Hamilton, Ontario L8N 2A1
Telephone (416) 529-7128

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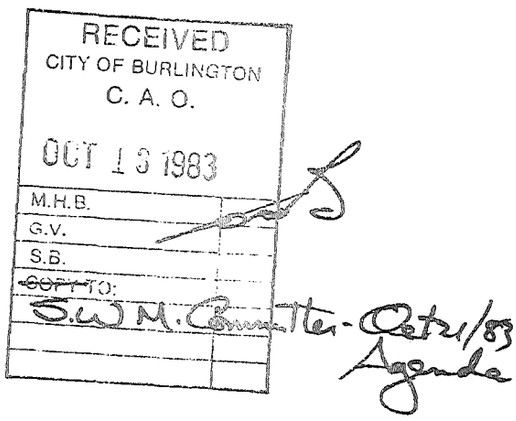


Michael H. Boggs
Chief Administrative Officer
City of Burlington
426 Brant Street
Burlington, Ontario
L7R 2G2

Dear Sir

National Sewer Pipe Limited

As promised at the Solid Waste Management Committee Meeting held on 83 09 22, we enclose herewith a copy of the paper, "Uptake and Release of Lead, Chromium and Trace Level Volatile Organics Exposed to Synthetic Well Casings".

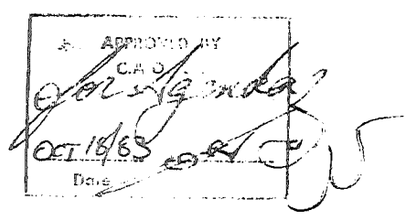
Yours very truly

The Proctor & Redfern Group

R. Tait, P. Eng.
Branch Manager

RT:at
Encl.

c.c. Mr. R. Christensen



Proceedings of the Second National Symposium on Aquifer Restoration and Ground Water Monitoring, Columbus, OH May 26-28, 1982; National Water Well Association
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Uptake and Release of Lead, Chromium and Trace Level Volatile Organics Exposed to Synthetic Well Casings

by G.D. Miller, National Center for Ground Water Research

The pollution of ground water by organic and inorganic chemicals is being given increased attention by researchers, environmental regulators and the general public. Highly sensitive research tools are being applied to the detection and identification of trace levels of these chemicals. Detection of organic chemicals and metal pollutants at concentrations in the low parts per billion (ppb) and less range is now possible. However, at these very low detection limits, sampling and measurement inaccuracies may result from the adsorption (or uptake) of some chemicals and the leaching (or release) of others from monitoring well-casing materials, sampling apparatus and analytical equipment.

Relatively small amounts of adsorption or leaching can greatly affect sensitive analytical results when measuring trace levels in the low parts per billion range. The amount of adsorption and leaching that occurs in ground-water quality monitoring wells has not been determined under controlled conditions for the metals and toxic organic chemicals for which the U.S. EPA has established or proposed test procedures. Other investigators have studied the sorption and leaching characteristics of many metals and some organics with laboratory plastic and glass containers. This laboratory study examines sorption and leaching interferences associated with three types of synthetic well-casing materials and selected metal and volatile organic pollutants under static conditions. The objectives of this study are to identify chemicals that may leach from well-casing material when exposed to selected pollutants, to quantify adsorption of selected pollutants on various well-casing materials and to guide materials selection and data interpretation during ground-water monitoring.

Background

Studies have been conducted on the adsorption of metals in various types of containers during storage or preservation of water samples. Robertson (1968a, 1968b) investigated the adsorption of trace amounts of 11 elements from sea water on various containers. He indicated that certain trace elements (especially iron, indium, scandium and silver) are significantly adsorbed on container surfaces when stored in glass and polyethylene. This adsorption can be prevented by adjusting the pH to 1.5 with hydrochloric acid. Smith's (1973) results were in agreement that a pH of 1.5 is necessary to ensure that metals remain in solution. Shendrikar, et al. (1976) studied the adsorption characteristics of barium, beryllium, cadmium, manganese, lead and zinc on Pyrex, flint glass and polyethylene. Eichnolz, Nagel and Hughes (1965) found borosilicate glassware is preferable over polypropylene for the storage of most metals. Robertson (1968a) noted that significant amounts of zinc, iron, antimony and copper may be contained in polyvinyl chloride (PVC) well-casing and that polyethylene contains antimony. These metals potentially may leach from these materials and pollute contacting water.

Factors commonly associated with the adsorption of metals at low concentrations on container walls include 1) concentration, 2) pH, 3) contact time, 4) container composition, 5) composition of dissolved salts and 6) complexing agents (Massee, Maessen and DeGoeij, 1980). Dissolved organic carbon may also increase the adsorption of metals on container walls.

The adsorption and leaching of organic pollutants with various container and potential well-casing materials has been studied to a much lesser extent than have metals. One study of the interaction of m-cresol with two types of plastic tubing has been reported (U.S. EPA, 1980). Industrial grade PVC tubing and bev-a-line VHT

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tubing were exposed to the m-cresol solution for varying lengths of time up to two hours. The m-cresol was progressively lost to the PVC tubing in amounts proportional to the increasing contact time, while no measurable loss of m-cresol to the VHT tubing occurred.

Junk, et al. (1974) determined that organic contamination ranging from 1 ppb to 5,000 ppb by weight was detected in "organic free" water which had flowed through tubes of polyethylene, polypropylene, black latex, six formulations of PVC and a plastic garden hose. Among the contaminants found from PVC were o-cresol, napthalene, butyloctylfumarate and butylchloroacetate. The amount of plasticizers in PVC tubing is approximately 40 percent by weight and represents an essentially inexhaustible supply of contamination. Should this supply of plasticizers eventually be depleted the contamination will decrease but the tubing will have lost its flexibility and will therefore need to be replaced. However, in the case of relatively rigid polyethylene and polypropylene tubes, Junk, et al. (1974) found that they may eventually become noncontaminanting.

Curran and Tomson of Rice University (1982) passed "organic free" water through five types of plastic tubing. These included polypropylene, polyethylene, Teflon, Tygon, PVC (with glue) and PVC (nonglued). Their results indicate low levels of leachates from all the tubing tested except no leachates were found with Teflon. Between one and five contaminants were found leached into the water from nonglued PVC, polyethylene and polypropylene at less than 0.5 ppb. Numerous contaminants were found leached from glued PVC and Tygon. Two organic chemical spikes, naphthalene and para-dichlorobenzene, were not retained (sorbed) significantly by any of the tubing except Tygon.

Leaching of organic and organotin compounds from PVC and chlorinated PVC (CPVC) pipe has been studied by Boettner, et al. (1981) at the University of Michigan. They found that alkyltin species and organic pipe cement solvent components can leach into potable water (pH 5 at 37°C). For example, they found from 10 ppm to 10 ppb of methylethylketone (MEK), tetahydrofuran (THF), and cyclohexanone from the solvent leached into the water in a miniature pipe loop exposed for 14 days. From the PVC pipe dimethyltin (as dichloride) was found to be leached at a concentration of 45 ppb after one day of exposure at 37°C. During 21 additional days of exposure the concentration of dimethyltin decreased, in a diphasic manner, from 3.0 to 0.25 ppb per day. Lesser levels of dibutyltin were leached from CPVC.

A recent field and laboratory study by Sosebee, et al. (1982) included assessment of the potential for contamination of ground-water samples by six PVC primers and one PVC adhesive. THF, MEK, methylisobutylketone (MIBK), and cyclohexanone were found to be leached into the water surrounding bonded joints. Even though a well was developed after installation and bailed prior to sampling, they found detectable levels of these compounds in well water several months after installation. After immersion of freshly cemented PVC pipe for five days up to 110 mg/l of MEK was found. After five washings and a 24-hour equilibrium the concentration of MEK was reduced to about 0.54 mg/l. Similar trends were noted for the other three pollutants studied although the presence of each constituent and their relative concentrations varied significantly between solvent brands and manufacturers. All four compounds could be introduced into monitoring wells by one or more of the brands of adhesive. Concentrations of contaminants declined significantly with successive washes with deionized water, from a mean total concentration of 77,800 μg/l after five days of soaking to a mean total of 591 μg/l after being washed four more times with deionized water and soaked for an additional 24 hours.

Field sampling with a PVC bailer constructed several weeks before resulted in samples with low levels of THF and MEK. With a PVC bailer constructed 30 minutes prior to sampling Sosebee, et al. found 16,000 ppb cyclohexanone, 3,800 ppb MEK and 1,400 ppb THF in a ground-water sample. Contaminants in PVC solvents can mask the presence of other volatile priority pollutants that elute from the chromatograph at similar retention times. For example, MEK and 1,2-dichloroethane, cyclohexanone and bromoform, and THF and 1,1-dichloroethane all coelute with the EPA analytical protocol. All these problems can most simply be circumvented by using well-casings and bailers constructed with threaded PVC or with other materials (Sosebee, et al. 1982).

While PVC is the most common type of synthetic well casing material in use, other materials have been used or could be used including, for example, acrylonitrile butadiene styrene (ABS), styrene-rubber (SR), polyethylene, polypropylene, Teflon and Kynar. Pettyjohn, et al. (1981) indicated in a recent article that, when sampling for organic contaminants, the preferred order of choice of well-casing and sampling materials includes glass, Teflon, stainless steel, polypropylene, polyethylene, other plastics and metals and rubber. But they indicated detailed experimental data on materials selection are simply not available.

Experimental Methods

Three types of well-casing materials were selected for testing including schedule 40 PVC 1120, low density polyethylene and polypropylene. All materials were purchased from Almac Plastics of Illinois Inc. Polyethylene and polypropylene were selected because of their potential usage and relatively low cost (compared to Teflon and stainless steel).

Three general experiments were conducted with the well-casing materials and selected metal and volatile organic pollutants. These are listed along with the concentrations used in Table 1. Each of the six organic

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chemicals used is an EPA listed priority pollutant and a purgeable aliphatic halocarbon. Drinking water standards have been established for the two metals studied.

Water free of interferences, "organic free," was prepared with a Barnstead Nanopure unit followed by an Organicpure unit. It was also necessary to briefly boil the water to remove all purgeables. The pH of the water was about 7.2. All experiments were conducted at about 23°C and in the dark.

Table 1
Metal and Organic Pollutants Studied and Concentrations Used

	Initial Concentration
Metals	
Chromium (VI)	0.5 ppm
Lead	0.5 ppm
Organics	
Bromoform	4 ppb
Tetrachloroethylene	2 ppb
Trichloroethylene	3 ppb
Trichlorofluoromethane	2 ppb
1,1,1-Trichloroethane	2 ppb
1,1,2-Trichloroethane	14 ppb

In the first experiment the adsorption (uptake) of these pollutants was measured weekly for six weeks versus controls for each of the casing materials. Borosilicate glass exposure chambers with 40 milliliter capacity and Teflon lined caps were used for this experiment. The experimental setup is shown in Table 2. The same setup was used in the second experiment. This second experiment included an initial four-week exposure of the pollutants to each of the well-casings followed by replacement with "organic free" water. The release or leaching of adsorbed pollutants was then measured weekly for four weeks. Duplicate exposure chambers were used to measure variability and the chambers were sacrificed since no head space could be allowed. Each of the well-casing materials used for these two experiments was cut to a 3-inch length. The surface areas exposed were 60.09 square centimeters for PVC, 57.17 square centimeters for polyethylene and 57.73 square centimeters for polypropylene.

The objective of the third experiment was to determine the leaching of solvent extractable leachates such as plasticizers or other additives from each of the well-casing materials after exposure to the metal and organic pollutants. The well-casing material was cut into 6-inch lengths and exposed in 1 liter borosilicate glass chambers for three and six week periods. The setup for this experiment is shown in Table 3.

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Table 2
Setup for Adsorption and Adsorption/Leaching Experiments

	Numbers of Chambers in Treatment			
Well-Casing Material	Blank	Metals	Organics	Metals and Organics
None	2	1	1	1
PVC	2	2	2	2
Polyethylene	2	2	2	2
Polypropylene	2	2	2	2

Table 3
Setup for Leaching of Extractables Experiment

	Numbers of Chambers in Treatment			
Well-Casing Material	Blank	Metals	Organics	Metals and Organics
None	1	1	1	1
PVC	1	1	1	1
Polyethylene	1	1	1	1
Polypropylene	1	1	1	1

Table 4
Precision and Accuracy of Analytical Method

Parameter	Mean percent recovery	Standard deviation of the mean percent recovery
Trichlorofluoromethane	98.64	1.123
1,1,1-Trichloroethane	105.37	1.323
Trichloroethylene	92.18	0.906
1,1,2-Trichloroethane	100.12	0.750
Bromoform	104.68	1.148
Tetrachloroethylene	96.59	0.922

The well-casing material was cut on a table saw and rinsed in "organic free" water to remove fines prior to placement in the exposure chambers. Glassware was cleaned by rinsing with 1:1 nitric acid, "organic free" water, 1:1 hydrochloric acid, "organic free" water,

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Table 5
Trends of Organic Pollutants Exposed to PVC Well Casing (Compared to Controls)

	Adsorption		Adsorption/Leaching	
Pollutant	**Organics only**	**Organics & metals**	**Organics only**	**Organics & metals**
Trichlorofluoromethane	No adsorption	No adsorption	No leaching	No leaching
1,1,1-Trichloroethane	No adsorption	No adsorption	No leaching	No leaching
Trichloroethylene	No adsorption	Slight (25%) adsorption	No leaching	No leaching
1,1,2-Trichloroethane	No adsorption	No adsorption	No leaching	No leaching
Bromoform	No adsorption	No adsorption	No leaching	No leaching
Tetrachloroethylene	Moderate (50%) adsorption	Slight (25%) adsorption	Slight (25%) leaching - readsorption?	Slight (25%) leaching - readsorption?

methylene chloride and "organic free" water. All chemicals used were reagent grade or better.

The sample analyses for lead and chromium were completed with an Instrumentation Laboratory Inc. 551 Atomic Absorption/Emission Spectrophotometer. Samples were preserved after organics analysis and removal of the well-casing material by the addition of four to five drops of nitric acid. Output was the mean of 30 one-second readings.

For purgeable organics analysis was performed with Hewlett-Packard 5750 gas chromatograph and a nickel-63 electron capture detector (ECD). Results were recorded with a Hewlett-Packard 3380A integrator and samples were concentrated with a Hewlett-Packard model 7675A purge and trap unit. The column packing used was 1 percent (w/w) SP-1000 on 60/80 mesh Carbopack B (Supelco, 1-1815). The 10 milliliter samples were purged with 40 milliliters per minute helium carrier gas for 10 minutes and desorbed at 250° C. Auxiliary gas was 5 percent methane in argon at 110 milliliters per minute. The ECD temperature was 320° C. The temperature program was 45° C for three minutes and increasing at 8° C per minute to a final temperature of 195° C for eight minutes. An internal standard, 1-chloro-2-bromopropane, was used for calibration and interpretation of results.

For the analysis of extractables in the third experiment a Hewlett-Packard 5880A gas chromatograph with a flame ionization detector (FID) was used. Results were recorded with a Hewlett-Packard 3388A reporting/integrator. Sample preparation included extraction of 1 liter with methylene chloride using separatory funnel techniques. The extract was then dried and concentrated in a Kuderna-Danish flask to 1 milliliter. An injection (splitless) of about 1 microliter was then made of this concentrated sample onto a 15 meter J&W DB-5 (Durabond) fused silica capillary column and detected by flame ionization (FID). The temperature program was initially 40° C, increasing at 8° C per minute to a final temperature of 250° C. Nitrogen was the carrier gas. Mass spectroscopy was performed on selected samples with a Finnigan 3200 GC-MS system and 6100 Interaction data system.

Quality assurance requirements followed those generally given by EPA for metals (U.S. EPA, 1979b) and those given for organics analysis (U.S. EPA, 1979a). For metals analysis calibration, standards were prepared and the sensitivity limit, linear range and analytical precision for each metal was determined. The analytical technique was demonstrated to be interference free and calibration standards were analyzed daily. For the analysis of volatile organics the sensitivity limit and linear range of the purge and trap—gas chromatography system were first determined for each compound. The entire system was demonstrated to be interference free on a daily basis by the analysis of an "organic free" water blank. The system was also calibrated daily with a midrange concentration level of the internal standard. The accuracy and precision of the analytical system was determined by the analysis of replicate and fortified samples (U.S. EPA, 1979a). Results of this analysis are shown in Table 4. The mean percent recoveries and the associated standard deviations are within acceptable limits.

Results and Discussion

The results of the adsorption experiment and the adsorption/leaching experiment are summarized for organics in Tables 5 through 7. Tables 8 and 9 summarize the results for the chromium (VI) and lead adsorption and leaching experiments. The terms slight, moderate and mostly in these tables are used in the following way. Slight adsorption means that about 25 percent of the chemical is adsorbed compared to the controls. Slight leaching means about 25 percent of that chemical leached compared to the amount adsorbed. Moderate adsorption is defined as about 50 percent adsorption versus the controls. About 50 percent leaching com-

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Table 6

Trends of Organic Pollutants Exposed to Polyethylene Well Casing (Compared to Controls)

	Adsorption		Adsorption/Leaching	
Pollutant	**Organics only**	**Organics & metals**	**Organics only**	**Organics & metals**
Trichlorofluoromethane	Mostly (75%) adsorbed	Mostly (75%) adsorbed	Slight (25%) leaching	No leaching
1,1,1-Trichloroethane	Mostly (75%) adsorbed	Mostly (75%) adsorbed	Slight (25%) leaching	Slight (25%) leaching
Trichloroethylene	Mostly (75%) adsorbed	Mostly (75%) adsorbed	No leaching	Slight (25%) leaching
1,1,2-Trichloroethane	Moderate (50%) adsorption	Moderate (50%) adsorption	Slight (25%) leaching	Slight (25%) leaching
Bromoform	Moderate (50%) adsorption	Mostly (75%) adsorbed	Moderate (50%) leaching (delayed)	Moderate (50%) leaching
Tetrachloroethylene	Adsorbed (100%)	Adsorbed (100%)	No leaching	No leaching

Table 7

Trends of Organic Pollutants Exposed to Polypropylene Well Casing (Compared to Controls)

	Adsorption		Adsorption/Leaching	
Pollutant	**Organics only**	**Organics & metals**	**Organics only**	**Organics & metals**
Trichlorofluoromethane	Moderate (50%) adsorption	Mostly (75%) adsorbed	Slight (25%) leaching	No leaching
1,1,1-Trichloroethane	Moderate (50%) adsorption	Moderate (50%) adsorption	Slight (25%) leaching	Slight (25%) leaching
Trichloroethylene	Mostly (75%) adsorbed	Mostly (75%) adsorbed	Slight (25%) leaching	Slight (25%) leaching
1,1,2-Trichloroethane	Slight (25%) adsorption	Slight (25%) adsorption	Slight (25%) leaching (delayed)	No leaching
Bromoform	Slight (25%) adsorption	Slight (25%) adsorption	All (100%) leached (delayed)	All (100%) leached (delayed)
Tetrachloroethylene	Adsorbed (100%)	Adsorbed (100%)	No leaching	No leaching

Table 8

Trends of Chromium (VI) Exposed to Synthetic Well Casing (Compared to Controls)

	Adsorption		Adsorption/Leaching	
Casing material	**Metals only**	**Metals & organics**	**Metals only**	**Metals & organics**
PVC	No adsorption	Slight (25%) adsorption	No leaching	No leaching
Polyethylene	No adsorption	Slight (25%) adsorption	No leaching	No leaching
Polypropylene	No adsorption	Slight (25%) adsorption	No leaching	No leaching

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Table 9
Trends of Lead Exposed to Synthetic Well Casing (Compared to Controls)

Casing material	Adsorption		Adsorption/Leaching	
	Metals only	Metals & organics	Metals only	Metals & organics
PVC	Mostly (75%) adsorbed	Mostly (75%) adsorbed	No leaching	Mostly (75%) leached
Polyethylene	Moderate (50%) adsorption (delayed)	Moderate (50%) adsorption	No leaching	Mostly (75%) leached
Polypropylene	Moderate (50%) adsorption (delayed)	Moderate (50%) adsorption	No leaching	Mostly (75%) leached

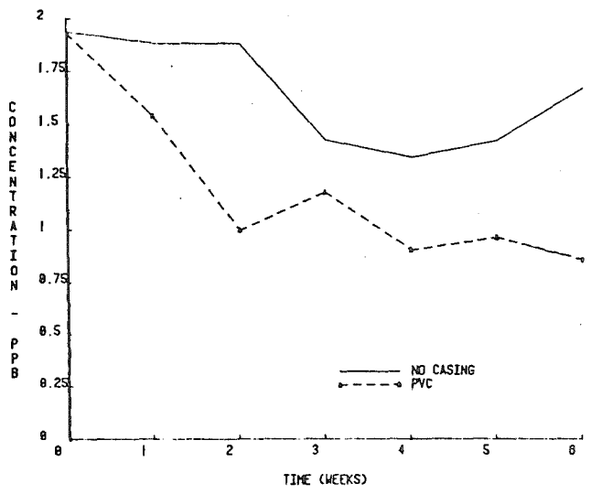

Figure 1. Tetrachloroethylene adsorption exposed to organics (average)

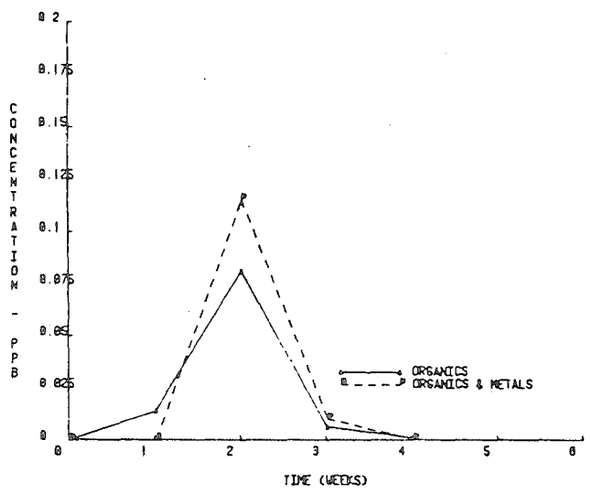

Figure 2. Leaching of tetrachloroethylene from PVC (organic and metals)

pared to the amount adsorbed is defined as moderate leaching. A chemical is described as mostly adsorbed when 75 percent or more is adsorbed on the well-casing compared to controls and moderate leaching means at least 75 percent is leached compared to the amount adsorbed.

During the first (adsorption) and second (adsorption/leaching) experiments it was found that the PVC well-casing material did not adsorb or leach (release) five of the six organics tested. Only tetrachloroethylene was adsorbed to a slight to moderate extent (25 to 50 percent retained on the well-casing versus controls). This is shown in Figure 1. The maximum adsorption of tetrachloroethylene found was about 0.6 nanograms per square centimeter of well-casing material. Slight leaching of tetrachloroethylene (less than 0.08 nanograms per square centimeter) was observed in the second experiment as shown in Figure 2.

All six of the organic chemicals tested adsorbed to a moderate or greater extent to polyethylene. Tetrachloroethylene was completely adsorbed while half or more of each of the other five chemicals was adsorbed onto the well-casing. For example, the adsorption of trichloroethylene to each of the well-casing materials tested is shown in Figure 3. About 1.05 nanograms per square centimeter was adsorbed to the polyethylene after seven days of exposure. While trichlorothylene did not leach or was not released to a great extent from any of the well-casing materials about 1.7 nanograms per square centimeter of bromoform was adsorbed to polyethylene and about 1.2 nanograms per square centimeter leached or was released. This was about the same whether exposed only to the six organics or when exposed to the solution containing the six organics and the two metals. A similar adsorption pattern was found for 1,1,2-Trichloroethane on polyethylene as shown in

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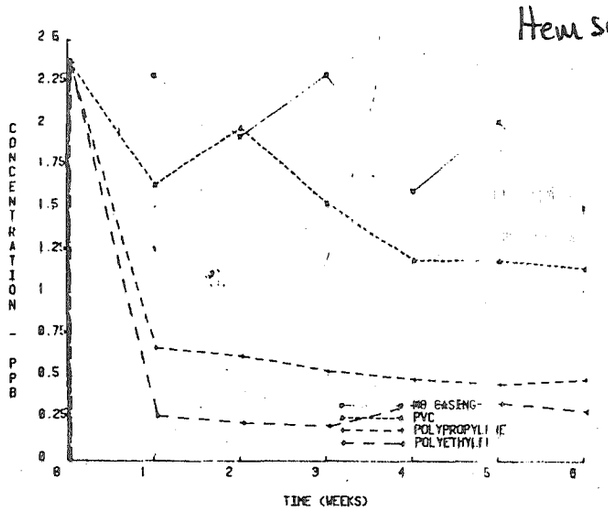

Figure 3. Trichloroethylene adsorption exposed to organics and metals (average)

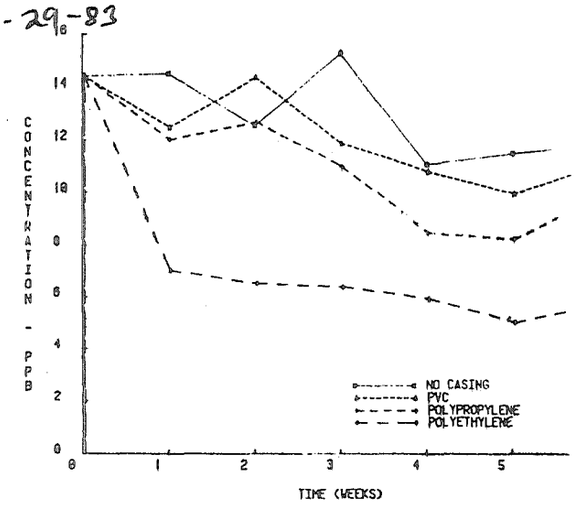

Figure 4. 1,1,2-trichloroethane adsorption exposed to organics and metals

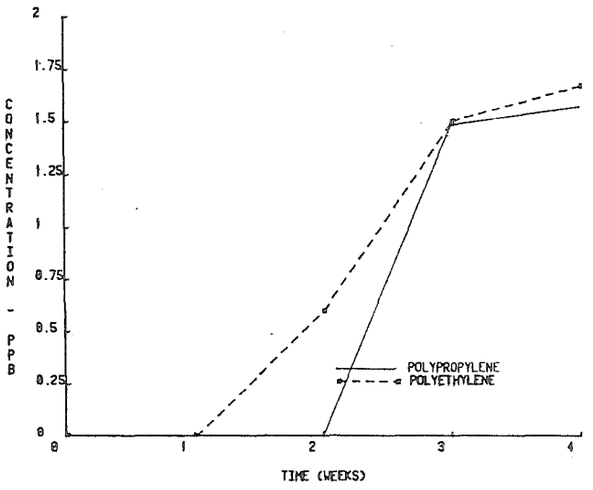

Figure 5. Bromoform adsorption/leaching exposed to organics (average)

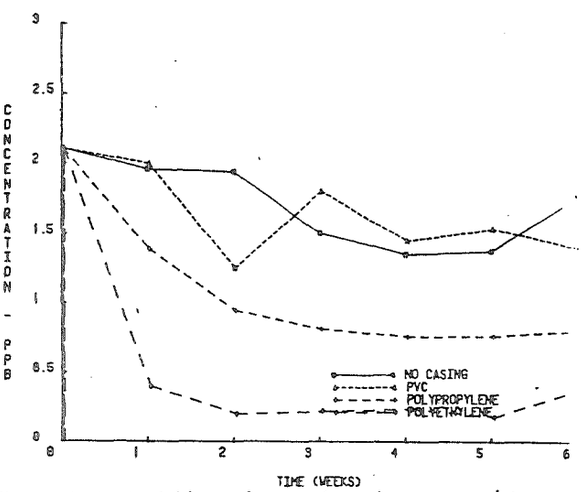

Figure 6. 1,1,1-trichloroethane adsorption exposed to organics (average)

Figure 4. About 4.8 nanograms per square centimeter were adsorbed and about 1.3 nanograms per square centimeter leached.

As noted in Table 6 and shown in Figure 5 the release of bromoform was delayed. The experiment was not designed to determine the release mechanism but one possibility that has been suggested is that some microbiological activity may be the predominant influence. Tetrachloroethylene was completely adsorbed by the first week on polyethylene and did not leach. Two of the other chemicals, 1,1,2-Trichloroethane and 1,1,1-Trichloroethane, were released to a slight extent (about a quarter of the amount adsorbed was released). Lesser leaching was found with the other two pollutants. All six organic pollutants tested adsorbed to polyethylene to an equal or greater extent than to either PVC or polypropylene.

Four of the organics tested adsorbed to a moderate extent (50 percent) or greater to polypropylene well-

casing. The adsorption of trichloroethylene to pol propylene is shown in Figure 3. The adsorption of 1,1, Trichlrorethane is shown in Figure 6. As can be se adsorption to polypropylene was intermediate in exte between PVC and polyethylene and the rate of adsor tion was delayed compared to polyethylene. No add tional leaching was found after about three weeks exposure. This was generally the trend for all of th organic pollutants except tetrachloroethylene whi was completely adsorbed by the first week. About 0 nanograms per square centimeter of 1,1,1-Trichlor ethane were adsorbed and about 0.14 nanograms p square centimeter were released or leached with pol propylene. Bromoform leached or was released, shown in Figure 5, from polypropylene. About nanogram per square centimeter of bromoform a sorped on polypropylene and all of that was release although delayed by about three weeks. For two oth pollutants, 1,1,1-trichloroethane and trichloroethylen

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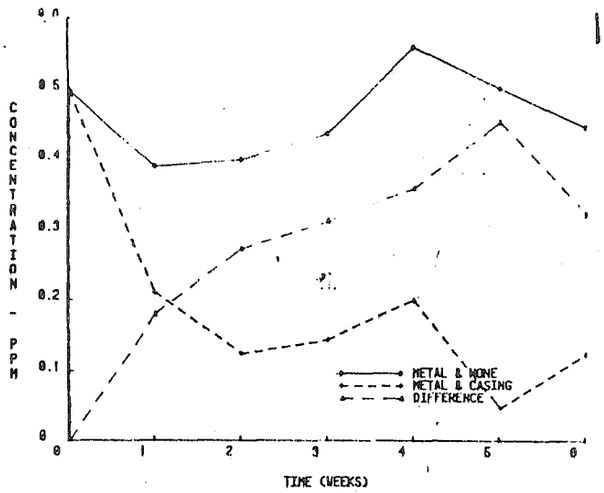

Figure 7. Lead adsorption to PVC exposed to metals (average)

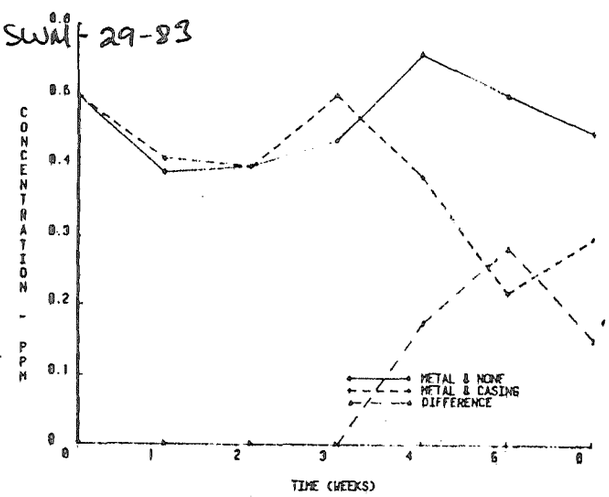

Figure 8. Lead adsorption to polyethylene exposed to metals (average)

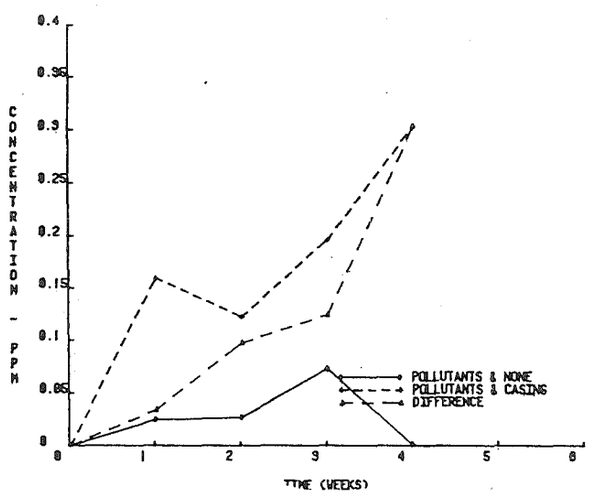

Figure 9. Lead released from PVC exposed to metals and organics (average)

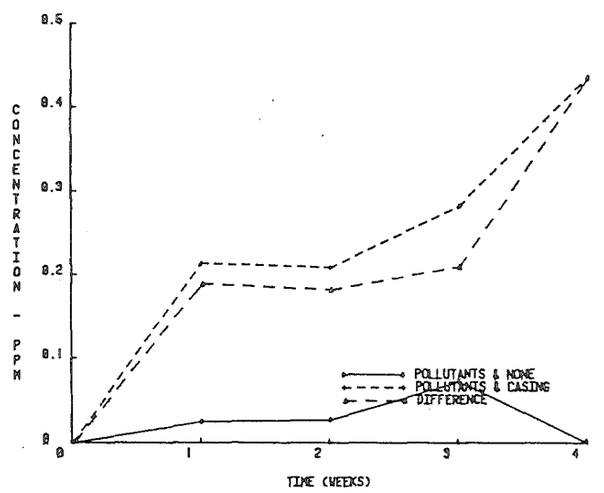

Figure 10. Lead released from polyethylene exposed to organics and metals (average)

about 25 percent of the amount adsorbed was released. As with polyethylene, all of the tetrachloroethylene was adsorbed and none of it was released from the polypropylene well-casing material.

As shown in Table 8 chromium (VI) did not adsorb to any of the well-casing materials to any significant extent when in the solution with lead. When in solution with lead and the six other organics slight (25 percent) adsorption (about 125 nanograms per square centimeter) of chromium was observed. No significant leaching of chromium was found from any of the well-casing materials with any of the treatments.

Lead was found to adsorb to the greatest extent (about 75 percent) to PVC and about 50 percent to polyethylene and polypropylene. An example of the adsorption of lead to PVC is shown in Figure 7. In this experiment about 400 nanograms of lead were adsorbed. An example of the delayed adsorption of lead to polyethylene is shown in Figure 8. About 170 nanograms per square centimeter were adsorbed.

No significant leaching or release of lead from any of the well-casing materials was observed when in solution with chromium only. When the metals and organics were exposed to the well-casing material about half of the lead adsorbed was released. A slow and nearly constant rate of release of lead was observed from PVC and polyethylene during the four week experiment as shown in Figures 9 and 10. Lead was more rapidly released from polypropylene as shown in Figure 11.

No identifiable leachates were found in the third experiment from any of the well-casing materials examined. There were no differences between exposure of the well-casing materials to only the two metals, only the six organics or to a solution containing the metals and organics. Some leachates may have been present which were below the detection limit of the analytical technique used. No interference with flame ionization detection was found after liquid/liquid extraction and

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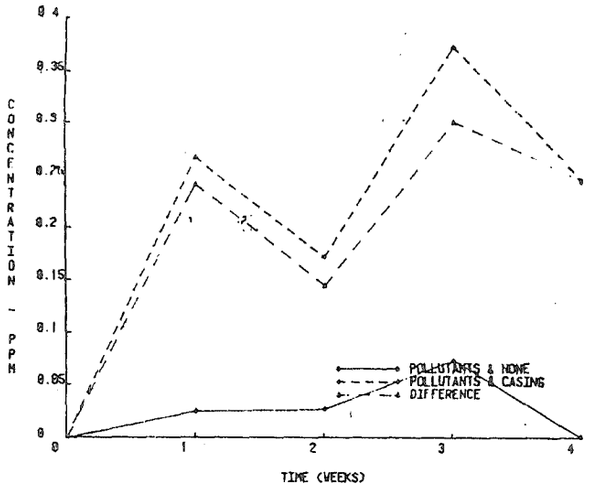

Figure 11. Lead released from polypropylene exposed to metals and organics

approximately a thousandfold concentration. Leaching of plasticizers or other additives might be greater when exposed to other pollutants and under flowing water conditions.

Conclusions and Future Directions

This research examined three types of well-casing materials exposed under static (batch) conditions to two metal pollutants and six volatile organic pollutants. It was generally found that schedule 40 PVC causes fewer monitoring interferences with volatile organics than polyethylene or polypropylene under the conditions of this experiment. However, some variation by chemical was found and tetrachloroethylene was adsorbed by each well-casing material with little or no subsequent release observed. Adsorption and leaching (release) of the organic pollutants examined were more rapid with polyethylene than polypropylene and were slowest with PVC well-casing.

Lead reached a maximum level of adsorption in about two weeks with PVC, from two to five weeks with polyethylene, and in one to four weeks with polypropylene depending on the treatment. The release of lead after an exposure period also varied by treatment ranging from one to six weeks with polyethylene and polypropylene, and four to six weeks with PVC. The adsorption and release of lead was more rapid when in a solution with chromium and the six other volatile organics examined than when in a solution with only chromium. Chromium (VI) did not adsorb or leach with any of the well-casing materials examined. Also, no extractable pollutants were leached from the well-casing materials under any treatment and the conditions of this study.

Organic pollutants were adsorbed and released at a relatively slow rate with PVC well-casing. The most rapid adsorption occurred with polyethylene where no additional adsorption was observed after one week. The release rates of these adsorbed organics from polyethylene varied greatly. For example, no additional release of trichlorofluoromethane, 1,1,1-Trichloroethane, and 1,1,2-Trichloroethane was observed after one week. Increasing amounts of Tetrachloroethylene were found to be released throughout the four weeks of the observations.

The results of the experiments to date suggest several interesting questions for future research. During the next year additional sources of PVC well-casing and other well-casing materials including ABS will be examined. Similar experiments to those reported here will be conducted on those materials with higher concentrations of additional pollutants such as selected phenols, phthalates and polynuclear aromatic hydrocarbons. Emphasis will be on pollutants likely to be found in ground water, less volatile and more polar than those examined to date. It is thought that more hydrophilic pollutants may be more readily adsorbed.

Experimental conditions similar to those encountered in the field will be used. This includes the examination of a range of pH conditions, exposure at a lower temperature, and the addition of pollutants to an organic-interference-free ground water. The well-casing material will be exposed to the pollutants for longer periods of time (about six months) followed by an examination of how rapidly and at what concentration levels the pollutants are released. This should provide a better indication of the potential for the well-casing to interfere with ground-water monitoring efforts. The well-casing will also be examined microbiologically to determine if microorganisms are influencing the uptake and release of any of the pollutants.

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Fig. 19

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Biography of Presenting Author

Gary D. Miller received his B.S. in biology from Oral Roberts University in 1972, his M.S. in environmental science from the University of Oklahoma in 1974 and his Ph.D. in engineering from the University of Oklahoma in 1980. Since 1980, he has worked as assistant co-director of the National Center for Ground Water Research at the University of Oklahoma on several research projects and is assistant professor of civil engineering and environmental science. Dr. Miller's research experience includes field and laboratory investigations of both ground-water and surface-water pollution, a variety of environmental impact assessments and environmental policy-related analyses. He is currently involved in several research projects including further investigations into pollutant/well casing chemistry and laboratory models of pollutant transport and transformation in the subsurface environment.

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