

# Comparison of low flow pumping and bailing for VOC groundwater sampling at landfills. [DNR-114] 1997?

Svavarsson, Gunnar; Connelly, Jack; Kuehling, Hank Madison, Wisconsin: Wisconsin Department of Natural Resources, 1997?

https://digital.library.wisc.edu/1711.dl/ZCXCCORA7YHC48I

http://rightsstatements.org/vocab/InC/1.0/

For information on re-use see: http://digital.library.wisc.edu/1711.dl/Copyright

The libraries provide public access to a wide range of material, including online exhibits, digitized collections, archival finding aids, our catalog, online articles, and a growing range of materials in many media.

When possible, we provide rights information in catalog records, finding aids, and other metadata that accompanies collections or items. However, it is always the user's obligation to evaluate copyright and rights issues in light of their own use.

232192 Comparison of Low Flow Pumping and Bailing for VOC Groundwater Sampling at Landfills



RECEIVED - UNK

## SEP 4 1997

BUREAU OF DRINKING WATER & GROUNDWATER

#### A COMPARISON OF LOW FLOW PUMPING AND BAILING FOR VOC GROUNDWATER SAMPLING AT LANDFILLS<sup>1</sup>

Gunnar Svavarsson, Jack Connelly, and Hank Kuehling

Wisconsin Department of Natural Resources Bureau of Solid and Hazardous Waste Management

#### Abstract

The state of Wisconsin has more than 10,000 groundwater monitoring wells that will continue to be sampled into the future. Most samplers in this state use a bailer to purge and sample these wells. The EPA has questioned the use of a bailer for volatile organic compound (VOC) sampling because of the potential to increase sample aeration and cause significantly more turbidity than using a low flow pumping method.

A total of nine monitoring wells that had a history of VOC contamination were sampled at three landfills. The wells were sampled using both a low flow pump and bailer in the summer of 1994 and again in the following winter.

Generally, only small differences were found between the VOC results collected using the low flow pumping and the bailing techniques. In addition, the method resulting in higher recovery of organic compounds differed, depending on the particular well, season, and compound.

#### Introduction

The purpose of a groundwater monitoring program is to obtain reliable and representative water quality information and to detect and assess levels of groundwater contamination. The two different devices available for collecting groundwater samples are grab samplers and pumps. In addition to the sample collection method used, sample quality and representativeness is a function of: experience of the technician, volatilization and degassing from the sample, type and concentration of colloidal particles in the well water, adsorption to and leaching from sampling equipment, dilution of a representative sample with stagnant water in the monitoring well, chemical changes when sampling and storing, and handling and analytical work at the laboratory. Many researchers have investigated one or more of these factors, which has lead to innovations and

<sup>&</sup>lt;sup>1</sup> Presented at the Eighteenth International Madison Waste Conference, September 20-21, 1995, Department of Engineering Professional Development, University of Wisconsin-Madison.

improvement in sampling practices. Study results have shown, for example, that some devices, such as suction and gas-lift pumps, are not suitable for VOC sampling. Barcelona, et al. (1985) studied effects of different tubing materials on samples and concluded that Teflon® had the least sorption and leaching problems. Teflon® or stainless steel bailers are considered to be better for VOC sampling than PVC bailers. Gibs, et al. (1994) determined that pouring sample water out of the top of a bailer produced 8% lower results than when a bottom-emptying device was used.

2

Wisconsin has about 100 active landfills and over 450 closed landfills with over 10,000 monitoring wells that will be sampled far into the future. Connelly (1994) surveyed those sampling Wisconsin landfill monitoring wells and received 305 responses (71% response rate). Eighty percent of the respondents used a bailer to purge their wells and 89% used a bailer to collect samples. The other respondents used various types of pumps.

This study compares the use of a bailer and a submersible pump for well purging and VOC sample collection. Three monitoring wells with a history of VOC detects were sampled, at each of three landfills, once in summer and again in mid-winter. The sampled wells had different design configurations and were screened in different geological environments, as described later.

#### Method

#### Study Sites and Wells

:::F#

Three landfills sites, which will be called Site A, B, and C, in south-central Wisconsin were selected for the study. Each of these sites has from 15 to 40 monitoring wells and the three wells selected at each site are installed in different soils and screened in different geologic units (see Figure 5, Appendix). VOCs had been detected consistently in these wells, ranging from low to high concentrations.

All the wells were constructed in accordance with NR 141, Wisconsin Administrative Code, "Groundwater Monitoring Well Requirements", and consist of 2" PVC pipe with flush-threaded joints. Four of the wells are screened at the water table and five are screened below the water table. Screen length varied from 5' to 10' and the depth to the water table varied from about 10' to 100'. Most wells were accessible by car. For those that were not, all sampling equipment had to be carried by sampling staff.

#### Equipment

A Teflon<sup>®</sup> bailer with a one-way ball valve in the bottom was used. The sample was transferred to a sample vial through a bottom-emptying device

installed in the bottom of the bailer. The bailer used was 48" long with a 1.5" ID, and a 1.6" OD. A thin Nylon line was used for lowering the bailer in and lifting it out of the well and was discarded after sampling at each well was completed.

The pump used was a submersible KECK SP-81. The pump consists of a stainless steel body and a helical rotor, and semiflexible Viton (fluorocarbon elastomers) stator which creates the progressing cavity which lifts the water to the surface. The pump rate can be controlled between 100 to 2500 mL/min. The pump tubing to the surface has an inner Teflon<sup>®</sup> lining. A 125' power cable sheathed in polyethylene supplies the pump motor with 12 volts from a battery. A clamp is placed on the power cable at the well head to fix the location of the pump in the well. The pump tubing connects to a multiprobe monitoring chamber (flow-through cell).

#### Sampling Procedure

Each well was first sampled using the low flow pump and immediately thereafter using the bailer. The following sampling procedure was used, in the order given, for all sampling events of the study:

1. Measure the water level in the well.

2. Slowly lower the pump into the well to the center of the screened interval.

**3.** Lock the cable clamp.

4. Connect the pump tubing to the flow-through cell and the power to the pump controller.

**5.** Calibrate conductivity, dissolved oxygen (DO), and pH/temperature meters and install their probes in the chamber ports.

6. Calibrate the turbidity meter.

7. Start the pump and adjust the flow rate to as close to 200 mL/min. as possible.

**8.** Record measurements of the 5 field parameters at 5 minute intervals until all measured parameters stabilize.

**9.** Disconnect the pump tubing from the chamber to minimize interferences and fill four 40 mL glass sample vials prepared with a hydrochloric acid sample preservative.

**10.** Place the sample vials in a container with ice for transport to the laboratory.

**11.** Remove the pump from the well and purge with the bailer.

**12.** Remove four well casing volumes of groundwater as the Wisconsin Department of Natural Resources (WDNR) sampling guidelines recommend.

**13.** Fill the flow-through cell to measure field parameters.

**14.** Use the bottom-emptying device on the bailer to fill four 40 mL glass sample vials prepared with a hydrochloric acid sample preservative.

**15.** Place the sample vials in a container with ice for transport to the laboratory.

#### **Decontamination of Equipment**

Cleaning was done following the sampling at each well. The pump and tubing were cleaned by mixing one spoon of Red Devil TSP/90<sup>®</sup> (phosphate free) powder detergent to 3 gallons of deionized water. The pump was placed in a PVC stand pipe and the soap solution was constantly poured into the stand pipe and pumped through the pump tubing. Three gallons of deionized water (the equivalent of 3 tubing volumes) were then pumped through the tubing.

The bailer, bottom-emptying device and monitoring chamber were cleaned by rinsing three times with deionized water. To confirm that the cleaning method was adequate, rinse blank samples were taken six times during the project and analyzed for VOC compounds. No VOCs were detected.

#### Analytical Procedure

Samples were analyzed for 49 VOCs at the Wisconsin State Laboratory of Hygiene, using EPA method 8260 (purge and trap). Six samples were taken in duplicate, three with the bailer and three with the pump, to confirm the precision of the laboratory methods used (see Table 2, Appendix). Duplicate sampling was done by filling 8 glass vials instead of the 4 discussed above.

#### **Results and Discussion**

#### Well Purging

Each well was purged until each of the field parameters stabilized. Samples were then assumed to be representative of the aquifer water. Of the 5 parameters measured, turbidity and conductivity were the most reliable indicators of stabilization since the trends for them generally stabilized without significant fluctuation. (See Figure 1, Appendix.) Turbidity was frequently the last parameter to stabilize and was used to determine when to collect a sample. Temperature, pH, and DO were least useful for this purpose, since these parameters often fluctuated to a greater extent, even when other parameters had stabilized.

Initial turbidity values were quite different in the wells, ranging from 2 nephelometric turbidity units (NTU) to over 200 NTU, but then decreased to stable values ranging from less than 1 NTU to 23 NTU. (See Table 1, Appendix.) A reason for the elevated turbidity at the beginning of purging may be that maximum power must be used to start the pump spinning, resulting in greater turbulence at a flow rate of about 2 L/min. It is not

believed that installing the pump caused significant turbidity since the pump was lowered very slowly to its destination in the well. Purging time was generally longer for wells with higher initial turbidity. The bailer, however, despite being lowered into the well at a slow rate frequently caused much higher turbidity results than the pump and in a few cases exceeded the scale of the turbidity meter. The purging time was on average 65 minutes for the pump and 25 minutes for the bailer. However, purging volume for the pump was on average only half of the 4 well volumes for the bailer.

#### **Analytical Results**

Tables 2A, 2B, and 2C, Appendix, contain analytical results from the sampling. Twenty-one different VOCs were detected overall. Cis-1,2-dichloroethylene and 1,1-dichloroethane were detected most often. One of the wells that had a history of very low detects had no detects during this study.

The absolute concentrations difference within a pump and bailer sampling pair (for each compound) was generally small, but in some cases quite large. From the total of 98 sampling pairs 7 had no difference between the two methods. The pump results were higher for 50 pairs and the bailer results were higher for 41 pairs. The absolute difference between the sampling pairs was less than 1 microgram-per-liter ( $\mu$ g/L) for 74 pairs. Of the 24 pairs where the difference was greater than 1  $\mu$ g/L the pump results were higher 11 times and the bailer 13 times.

Some of the concentration differences between the two methods may be attributed to factors such as laboratory analytical precision. Variability of lab method analytical precision can cause up to a 10% or greater difference when analyzing duplicates. The percentage difference for duplicate samples in the study was 17% on average. Other factors can also affect results from a pair of samples such as: homogeneity of the water quality in the bailer, spatial variation of the water quality pumped from the aquifer, aeration of the samples, transport of the samples, and handling in the laboratory.

The percent difference was calculated for all sampling pairs by taking the absolute difference of concentrations between the two methods and dividing by the average of the two results, then multiplying the ratio by 100. The results are presented with bar graphs in Figure 2, Appendix. It should be noted that for the same absolute difference the percent difference becomes higher for lower concentrations. The results from P-18S at Site A indicate that the pump results are higher during winter sampling, while the bailer results are higher during summer sampling. The opposite pattern is found in well P-21D at the same site. Such an obvious pattern is not repeated in other wells. However, the pump results are 10% higher overall in the

summer, while the bailer results are 3% higher in the winter.

Another factor of concern was whether compounds with a higher tendency to adsorb to a solid surface might cause a difference in compound recovery rates for the two sampling methods. The pump tubing had up to 7 times more surface area than the bailer. In general, solubility of VOCs is related to the tendency to adsorb to a solid surface in that the lower the solubility the higher the tendency to adsorb. On the graphs of Figures 2A, 2B, and 2C, the compounds have been ranked in order of increasing solubility along the x-axis. Therefore, if adsorption was affecting the results in this study, a greater percent difference would be expected for the compounds with low solubility. However, this tendency is not exhibited in the graphs.

To examine whether a compound's tendency to evaporate affects the difference in sampling results the compounds were graphed according to their Henry's constant. Analytical results for compounds with high Henry's constants, such as vinyl chloride, trichloroethylene, and tetrachloroethylene, do not exhibit a difference in recovery between the two methods. Figure 3, Appendix, shows the total amount of each VOC for each sampling technique from all wells sampled. It can be seen in Figure 3 that the VOCs having the greatest difference between the total compound concentration for each method were not the compounds having highest Henry's constant. This graph also shows that the difference between the methods cannot be explained by the level of solubility or adsorption tendency. To further test if volatility or adsorption affects analysis results, a regression test was done that did not show any correlation between percent difference and a compound's characteristics (r=0.15 for solubility and r=0.24 for Henry's constant).

To see if a specific well or a site affected the difference between results for the two sampling techniques, recovery of all VOCs detected for both sampling events was added up for each well. Adding up the analytical results for each well decreases some of the uncertainty imposed by limited analytical precision. However, some VOCs were detected more frequently than others and therefore the aggregate data is skewed toward those compounds. Figure 4, Appendix, illustrates that the pump gives slightly higher recovery in all wells at Site A. At Site B the pump has significantly higher recovery in two wells, but the bailer has higher recovery in one well. Site C had both the most contaminated well in the study and two of the least contaminated wells. Well MW-7 which had total VOC concentrations up to 165  $\mu$ g/L did not show a difference between the two sampling techniques, while MW-6 had insufficient results.

Figure 5, Appendix shows the well configuration did not affect the results. Total recovery concentration values for each sampling technique can be seen underneath each well in the table along with the percentage difference that ranges from 0 to 37%. Total VOCs recovery from all sampling in the study is 4.3% higher for the pump than for the bailer.

#### Timing of Sampling Process

It took an average of 61 minutes to set up the equipment for the low flow pump, while it took only 7 minutes for the bailer. Purging and sampling took an average of 65 minutes for the pump, and 25 minutes for the bailer. Decontamination took on average 18 minutes for the pump compared with 5 minutes for the bailer. Total sampling time for the pump was an average of 144 minutes and was an average of 36 minutes for the bailer. Sampling time for the pump was therefore four times longer than for the bailer. However, if a dedicated pump system was used for each well, the set up time would decrease significantly and could be reduced further if the pump could be started at a very low flow rate to avoid disturbance of settled particles in a well.

#### **Difficulties Encountered With Sampling**

Several disadvantages were apparent when operating the pump. The pump needs to be started at the maximum pumping rate to establish sufficient spinning momentum for the metal rotor inside it. This creates initial turbidity which takes time to purge after the flow rate has been decreased. When sampling was performed at less than 20 °F ambient temperature, water had a tendency to freeze in the tubing, especially after removing the tubing from the well for decontamination. The intended flow rate of 200 mL/min. while purging was difficult to consistently achieve because the pump had a tendency to shut off at this low flow rate. Consequently the overall mean flow rate was 345 mL/min. It is quite difficult to carry all the equipment needed for the pump to a location that cannot be reached by car or truck. For example, it took 130 minutes to carry all the equipment and set it up at a well located about 300 yards downhill from the car, while it took 42 minutes at another well located by a road.

The bailer also had several disadvantages. The ball valve had a tendency to freeze to the bailer on the coldest days, but this was easier to thaw than the pump tubing. When the bottom emptying device is installed into the bailer, a large air bubble works its way up through the bailer sample. This produces a potential for evaporation loss of VOCs. Another disadvantage of the bailer is that it disturbs sediments at the bottom of a well as it is lowered into the well and pulled out. This in turn causes increased turbidity. Higher turbidity necessitates filtering for metal samples.

#### Conclusion

The sampling technique resulting in the higher recovery differed, depending

on well, season, and compound, but there was no consistent pattern. Although when all the results were added together the low flow pump had 4% higher recovery than the bailer, when sample pairs were compared neither the low flow pump nor the bailer produced consistently higher VOC results. The individual characteristics of the VOCs or ambient temperature did not affect the results in any consistent way. Difference was noticed between wells, but it could not be related to the well configuration, the geology around the well screen, or depth to groundwater. Turbidity was generally the last field parameter to stabilize in the pump purging process, and seemed to be a good indicator for collecting a representative aquifer sample.

On average, it took four times as long to set up, purge and sample a well with the pump than it did using the bailer. The purging volume removed with the pump was half that removed using the bailer. More freezing problems were encountered with the pump than the bailer on cold December and January sampling events. Both of the sampling methods studied are viable and effective for VOC sampling when used in conformance with accepted field practices.

#### Recommendations

- Allow the use of a bailer or a low flow pump for collection of VOC samples from monitoring wells.
- Use a bailer at sites where wells are not easily accessed.
- Use a bailer for sampling on days with temperature below 20 °F.
- Save time when using a low flow pump by using a pump which:
  - a) begins at a low flow rate and
  - b) is dedicated to the well.

#### References

- Barcelona, M.J., J.A. Helfrich, and E.E. Garske. 1985. <u>Sampling Tubing</u> <u>Effects on Groundwater Samples.</u> Analytical Chemistry. 57:460-464.
- Connelly, J. 1994. <u>Monitoring Well Sampling You Can't Always Get What</u> <u>You Want But Can You Get What You Need?</u> EPA/600/R-94/205, 43-53.
- Gibs, J., T.E. Imbrigiotta, J.H. Ficken, J.F. Pankow, and M.E. Rosen. 1994. <u>Effects of Sample Isolation Handling on the Recovery of Purgeable</u> <u>Organic Compounds</u>. Ground Water Monitoring Review 14(2),142-152.

### Disclaimer

The use of brand and trade names is for identification purposes only and does not constitute endorsement by the WDNR.

## APPENDIX

Tables and Figures on next 9 pages

Well	Low Flow	Deiler					
(two rounds for each well)	First Reading	Last Reading	after purging				
P-18	18.7	0.8	3.8				
P-18	46.4	1.6					
P-21D	12.8	. 2.6	14.4				
P-21D	30.1	3.2	14.5				
P-21S	6.4	0.7	14.5				
P-21S	9.3	1.6	1.9				
MW12PR	1.5	1.3	152.0				
MW12PR	3.4	0.7	39.1				
MW12R	200.0	7.8	200.0				
MW12R	170.1	13.9	200.0				
MW14	10.8	1.2	25.0				
MW14	41.1	6.3	36.5				
MW-9	21.7	3.0	59.0				
MW-9	195:0	3.1	10.9				
MW-7	29.3	23.0	112.4				
MW-7	41.3	14.3	200.0				
MW-6	4.6	2.9	12.1				
MW-6	6.9	5.2	41.2				

Table 1 Turbidity (NTU)

## Table 2, A, B, and C Data Summary

SITE A															
	monitoring well->				P-21	5		P-21S							
	date->	Aug	.'94	Dec.'94		Aug.'94		Dec.'94		Aug.'94			De	c.'94	
Substance	method->	LFP	B	LFP	в	LFP	в	LFP	в	B d*.	LFP	LFP d	B	LFP	B
CIS-1,2-DICH	ILOROETHYLEN	0.88	1.4	1.5	1.3	8	7.1	9.1	9.5	. 11	25	25	24	20	21
TETRACHLC	ROETHYLENE	16	16	15	14								1.3		
TRICHLORO	ETHYLENE	2.2	2.5	2.3	1.8						5.3	6.5	6.2	4.6	5
TRICHLORO	FLUOROMETHA	0.7	0.9												
1,1-DICHLOF	ROETHANE			0.78	0.67	6	5.5	5.1	5	5.3	8.6	8.8	8.2	7.5	6.7
TRANS-1,2-D	DICHLOROETHYL					1.8	1.4	0.98	1.1	1.1	4	3.7	3.7	4.1	3.4
VINYL CHLO	RIDE					7.4	6.2	10	10	10	8	6	6.2	6.7	6.8
BENZENE											3.5	3.4	3.5	3	3
	Total VOCs->	19.8	20.8	19.6	17.8	23.2	20.2	25.2	25.6	27.4	54.4	53.4	53.1	45.9	45.9

		_
<b>C</b> 1	-	_
		_

• .

	monitoring well->		MW	12PR		MW12R					MW14					
	date->	Aug	.'94	Dec	:'94	A	ug.'94		Dec	.'94	Aug	1.'94	D	ec.'94		
Substance	method->	LFP	B	LFP	B	LFP	LFP d	В	LFP	в	LFP	в	LFP	В	B d*.	
CIS-1,2-DIC	HLOROETHYLEN	6.4	2.7	4.6	3.8	8.2	9.5	5	6.8	6.4	1.1	1.2	1.6	1.6	1.7	
TETRACHLO	DROETHYLENE	1.5	1.4	3	2.6	11	13	9.4	10	10	15	18	13	13	- 14	
TRICHLORC	DETHYLENE	4.4	3.6	3	2.6	7.6	8.6	3.9	5.2	4.7	3	4	3.4	3.3	3.6	
TRICHLORC	<b>OFLUOROMETHA</b>										2.4	3.3				
1,1-DICHLO	ROETHANE	5.2	1.1	2.9	2.3	8.9	9.9	5.5	5.8	5.3	3	3.7	2.8	2.8	2.8	
VINYL CHLC	DRIDE	1.1	0.8	1.1	1.2	1.2	2.5	2.5	2.2	1.8						
BENZENE						0.66	0.7	0.74	0.94	0.81						
1,2-DICHLO	ROPROPANE			1.1	0.9	1.2	1.1	1.3	1.6	1.4						
METHYLEN	E CHLORIDE										1.4	1.7	2	1.9		
1,1,1-TRICH	LOROETHANE										1.8	1.8	1.8	1.7	2	
CHLOROET	HANE			2.5	2.3				6.4	6.2			14	13	14	
	Total VOCs->	18.6	9.6	18.2	15.7	38.8	45.3	28.3	38.9	36.6	27.7	33.7	38.6	37.3	38.1	

-	_	-	-
<b>C</b> 1	T		-
-		_	ι.
~		_	_

SITE C															
monite	oring well->		MW	/-9				MV	V-7		MW-6				
	date->	Aug	1.'94	Jan	.'95		Aug.'9	4	Ja	an.'95		Aug.'94		Jan	.'95
Substance	method->	LFP	в	LFP	в	LFP	LFP d	В	LFP	В	B d⁴.	LFP	в	LFP	В
CIS-1,2-DICHLORC	ETHYLEN					1.3	1.3	0.95	1.1	0.77	0.73	1	1		
1,1-DICHLOROETH	IANE				1	2.6	2.9	2.3	2.5	2.2	2				
BENZENE						7.8	7.8	7.5	4.5	5.3	4.8	0.58	0.77		
1,2-DICHLOROPRO	DPANE					1.3	1	0.95	1	0.85	0.86				
1,4-DICHLOROBEN	IZENE				1	3.2	2.5	3.5	2.6	3	2.9	(	1.2		
ETHYLBENZENE						12	9.3	9.8	11	16	13	1			
P-ISOPROPYLTOL	UENE					43	31	41	13	17	11				
NAPHTALENE						10	9.4	10	17	21	16				
TOLUENE						52	43	28	2.4	18	16				
1.2.4-TRIMETHYLB	ENZENE		1		1	1			5.2	5.2	7.9				
1.3.5-TRIMETHYLB	ENZENE					15	22	22	22	12	4.8				
M/P-XYLENE				1		11	9	9.2	9.2	16	14				
O-XYLENE						5.6	5.1	5.1	5.1	5.4	5.4				
To	tal VOCs->					165	144	140	96.6	123	99.4	1.58	2.97		

Total VOCs->

Units for concentrations are ug/L

\* d=duplicate sample LFP=Low Flow Pump, B=Bailer Empty cell=not detected

Figure 1 Purging With Pump (MW14,August):Field Measurements



## Figure 2A

Percent Difference Between Low Flow Pump (LFP) and Bailer (B) for Wells at Site A



Figure 2B

Percent Difference Between Low Flow Pump (LFP) and Bailer (B) for Wells at Site B



Above 0 on Y-axis indicates that the LFP results are higher than B results; negative Y-axis indicates that B is higher. ND=not detected

Compounds on X-axis (numb.) 1 TETRACHLOROETHYLENE 2 TRICHLOROETHYLENE 3 TRICHLOROFLUOROMETHANE 4 BENZENE 5 VINYL CHLORIDE 6 1,2-DICHLOROPROPANE 7 CIS-1,2-DICHLOROETHYLENE 8 1,1,1-TRICHLORETHANE 9 1,1-DICHLOROETHANE 10 CHLOROETHANE 11 METHYLENE CHLORIDE

🖾 Aug.'94	
Dec.'94	

## Figure 2C

Percent Difference Between Low Flow Pump (LFP) and Bailer (B) for Wells at Site C



Well MW-7



## Figure 3 Total Recovery of VOCs from 9 Wells

Increasing Adsorbency



Figure 4 Accumulated Recovery of VOCs



Figure 5 Well Configuration and Recovery Comparison

## 232192 Comparison of Low Flow Pumping and Bailing for VOC Groundwater Sampling at Landfills

Water Resources Center University of Wisconsin - MSN 1975 Willow Drive Madison, WI 53706

DEMCO

