

Groundwater quality impacts from the storage of sludge and septage. [DNR-085] 1995

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Title Groundwater Quality Impacts from the Storage of Sludge and Septage

Abstract

This study was undertaken to assess the possible migration of substances from a wastewater sludge storage lagoon to groundwater. Research indicates that volatile organic compounds (VOCs) may be present in domestic wastewater sludge and may migrate to groundwater. This study was conducted around the sludge storage lagoon owned and operated by Pat's Sanitary Service, a septage/sludge hauling business located in southeastern Wisconsin. Pat's collects septage from area septic systems and sludge generated at municipal wastewater treatment facilities. This material is stored in a clay lined lagoon until it can be spread on agricultural land. Based on the results of ongoing groundwater monitoring for inorganic substances at the site, Pat's storage lagoon is considered to be leaking and impacting groundwater. For this study, samples were collected of the sludge material being stored in Pat's lagoon and from site groundwater monitoring wells. These samples were analyzed for NPDES Priority Pollutants and three organic compounds were detected at the site. 2-Methylphenol and phenol were detected in the stored sludge material but not in groundwater below the site. Chlorobenzene was detected in one of the three facility monitoring wells sampled but was not detected in the stored sludge material. The levels of chlorobenzene detected in groundwater at the site were considerably lower than the Safe Drinking Water Act maximum contaminant level (MCL) of 100 UG/L. There is currently no Wisconsin state NR 140 Groundwater Quality Standard for chlorobenzene. Because only a limited number of samples were collected for this study it is difficult to draw definite conclusions, however, the sample results obtained do seem to indirectly support the concern that organic compounds can be present in stored sludge and septage material and that, if mobile, these substances may migrate to groundwater.

Acknowledgements

Investigators: Tom Portle, Wastewater Soils Specialist Wisconsin Department of Natural Resources

> Jamie Dunn, Hydrogeologist Wisconsin Department of Natural Resources

Funding: The Wisconsin Department of Natural Resources provided funding of this project through the Groundwater Management Monitoring Program.

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Introduction

Pat's Sanitary Service operates a sludge and septage hauling business in southeastern Wisconsin. The business collects sludge from municipal wastewater treatment plants and septage from individual septic systems. This collected material is held in a lined storage lagoon until it is land applied on DNR approved fields surrounding the lagoon site.

Pat's operates under a Wisconsin Pollutant Discharge Elimination System (WPDES) permit issued January 31, 1990. One of the requirements of this permit is that the groundwater around the sludge/septage storage lagoon be monitored. There are currently seven groundwater monitoring wells in place around the storage lagoon and Pat's permit requires that groundwater samples be collected from these wells four times per year. These samples are analyzed for inorganic parameters, as specified in the permit, and the results are reported to the DNR.

Results show that significantly elevated levels of chlorides, total dissolved solids and nitrogen have been detected in groundwater samples from some of the monitoring wells surrounding the lagoon. Based on the results of this ongoing site monitoring, Pat's storage lagoon appears to be leaking and impacting groundwater at the site.

A 1988 study (Hunger) suggests that VOCs may be present in wastewater sludge and may migrate from unlined sludge storage lagoons to groundwater. Because there appears to be evidence that leakage from Pat's sludge storage lagoon is impacting groundwater there is a concern that if VOCs are present in the stored sludge material, these compounds may migrate to groundwater below the site.

Study Objective

The objective of this study was to assess the concentrations of NPDES Priority Pollutants present in stored sludge/septage material and to evaluate the possibility of these compounds migrating to groundwater.

Facility Description

Pat's Sanitary Service sludge/septage storage lagoon is located in the SE 1/4 of the NW 1/4 of Section 36, Township 2N, Range 18E, in the Town of Lyons, Walworth County, Wisconsin (see Figs. 1 & 2). The lagoon covers approximately two acres (190 feet by 500 feet) and is approximately nine feet deep. It was constructed in 1982 and was reported to be lined with 2 feet of compacted clay. This clay was obtained from a "borrow area" located at the facility, southeast of the lagoon. Samples taken of this clay were reported to have a permeability of less than $2x10^9$ cm/s.

The groundwater monitoring system in place around Pat's storage lagoon consists of 7 groundwater monitoring wells, designated: MW-1/201, MW-2/202, MW-3/203, MW-4/204, MW-1A/205, MW-5/206 and MW-6/207. These wells have been installed surrounding the lagoon and all of them, except MW-4, are located within 100 feet of the lagoon edge (see Fig. 3 for well locations). All site wells have been constructed of 2 inch PVC well casing to depths of between 50 and 70 feet.

Geology/Hydrogeology

The lagoon site is underlain with an estimated 150 feet (Borman 1976) of pleistocene glacial material consisting of unconsolidated pitted outwash soils. Bedrock below this material is Silurian Dolomite. 1989 soil borings completed at the site to 55 + feet (see Appendix A), indicate that the glacial soil material is primarily a medium sand, with some gravel, silt and clay reported present. The borings show sand and gravelly sand to about 30 feet. This is underlain with tighter, silty, clayey sands to approximately 55 feet.

Groundwater is encountered below the site at a depth of approximately 40 to 50 feet (about elevation 850'- 854' MSL). Local groundwater flow, based on groundwater elevations measured in site monitoring wells, appears to be to the northwest, towards a wetland area approximately one half mile from the storage lagoon site. The U.S. Geological Survey Hydrologic Atlas (HA-360) for the area indicates that regional groundwater flow is to the east, toward the Fox River.

Study Procedures/Methods

The field investigation at this site consisted of collecting samples of the sludge/septage material being stored in Pat's lagoon and of groundwater from some of the monitoring wells located around the lagoon. These samples were analyzed for the National Pollutant Discharge Elimination System (NPDES) Priority Pollutants.

Groundwater samples were collected from 3 facility monitoring wells: MW-1, MW-3 and MW-4. Permit sampling indicates that wells MW-3 and MW-1 are being impacted by leakage from the storage lagoon, while well MW-4 appears to be unimpacted. Local groundwater flow is assumed to be toward the northwest and well MW-4, located approximately 200 feet directly east of the lagoon, yields samples considered to be representative of unimpacted background quality.

Samples from well MW-1, located approximately 100 feet southeast of the lagoon, and MW-3, located approximately 50 feet northeast of the lagoon, show levels of chlorides, total dissolved solids and nitrogen considerably higher than the levels measured in MW-4 (see Table 1). Although wells MW-1 and MW-3 appear to be located upgradient and side gradient of the storage lagoon the apparent impacts to groundwater at the well locations are likely due to their close proximity to leaking areas of the lagoon.

Two rounds of samples were collected from the three facility wells, on February 20, 1991 and on May 1, 1991. A sample of the sludge material in the lagoon was also collected for analysis on May 1, 1991. The collected sludge and groundwater samples were sent to the State Lab of Hygiene and were analyzed for NPDES Priority Pollutants.

Results of sample analysis for NPDES Priority Pollutants (see Table 2)

Sludge/Septage

A sample of the sludge/septage material in the storage lagoon was collected on 2/20/91. Analysis of this sample for NPDES Priority Pollutants resulted in the detection of two organic compounds: phenol and 2-methylphenol.

Organic Compounds Detected	ed Measured Level
2-Methylphenol	210 UG/L
Phenol	630 UG/L

Analysis of the collected sludge material for NPDES metals was done and various heavy metals were detected in the sample (see Table 2). These metals are commonly present in domestic wastewater sludge and the levels detected in the sludge/septage material in Pat's storage lagoon are generally well below the mean levels listed in the National Sewage Sludge Survey, a nationwide survey of domestic wastewater sludge quality.

Groundwater

Analysis of the two rounds of groundwater samples collected resulted in detection of one organic compound in one monitoring well. Chlorobenzene was detected in monitoring well MW-1 on both sampling occasions.

Sample Date	Well Number	Compound Detected	Measured Level
2/20/91	MW-1/201	Chlorobenzene	18 UG/L
2/20/91	MW-3/203	ND	-
2/20/91	MW-4/204	ND	
5/1/91	MW-1/201	Chlorobenzene	15 UG/L
5/1/91	MW-3/203	ND	-
5/1/91	MW-4/204	ND	-

The groundwater samples collected on 5/1/91 were also analyzed for metals and some were detected. For the most part the measured metals concentrations were very low (Table 2). However, in the sample from well MW-3, lead was detected at a level above the NR 140 Preventive Action Limit (PAL) and in well MW-4 cadmium and chromium were found at levels above the NR 140 PAL and lead was detected above the NR 140 Enforcement Standard (ES).

Discussion/Conclusions

It appears that contaminants from the leaking storage lagoon are infiltrating through the unsaturated zone sands and gravels below the study site to groundwater. Relatively high levels of dissolved chlorides and nitrogen are detected in monitoring wells at the site. These substances are found in domestic wastewater, sludge and septage and are highly mobile in groundwater.

The two organic compounds, phenol and 2-methylphenol, detected in the sample of material from Pat's storage lagoon have been associated with septage in other studies (Greer 1987). As these two compounds were not detected in groundwater beneath the site, it appears that they may be adsorbed to the sludge/septage solids and are not migrating to groundwater. The one volatile organic compound, chlorobenzene, found in the samples from well MW-1 at the study site has been reported in wastewater sludge (Hunger 1988) and has been detected in groundwater at a septage disposal site (Greer 1987). Chlorobenzenes are considered to be mobile in groundwater and studies have shown them to be transported with little retardation (Barber 1988). Based on detection of this substance in an impacted site well and the absence of any other probable source in the area it seems reasonable to assume that the chlorobenzene levels detected in well MW-1 at Pat's were found to be low, 15 and 18 micrograms/liter, well below the federal drinking water maximum contaminant level (MCL) of 100 micrograms/liter.

A variety of metals were detected in the material stored in Pat's lagoon and in the groundwater samples from the three facility wells monitored. Heavy metals are commonly present in domestic wastewater sludge and the levels detected in the stored

sludge/septage at Pat's are below those reported in the National Sewage Sludge Survey and well below the most stringent federal standards (40 CFR Part 503 Pollutant Concentrations) established for land spreading this material.

The detection of elevated levels of some heavy metals in study site well MW-4 raises a number of questions. The concentrations of these substances present in the source material, the stored sludge/septage, is reported to be very low. Under normal circumstances any heavy metals present in sludge would not be expected to migrate to groundwater but would instead be retained by adsorption to the sludge material or to soil fines present in the unsaturated zone above the water table. Well MW-4 appears to be hydraulically upgradient of the storage lagoon and samples collected from it and analyzed for chlorides, total dissolved solids and nitrogen do not indicate that it is being impacted by lagoon leakage. For these reasons: relatively low levels in source material, low mobility of substances and no evidence of other groundwater impacts from the lagoon, it seems reasonable to assume that Pat's sludge storage facility is not the source of the reported metals in groundwater collected from well MW-4.

Because only a limited number of samples were collected for this project it is difficult to draw definite conclusions. This study, however, does seem to provide additional evidence to support the claim that organic compounds can be present in domestic wastewater sludge and septage. It also seems to show that the more mobile organic substances, if present, may infiltrate through the unsaturated zone and impact groundwater. The levels of organic substances detected in groundwater at this site were quite low and there does not seem to be any indication of possible public health or welfare concerns.

Priority pollutant substances exist in a variety of household and consumer products and their presence in domestic wastewater sludge and septage is not uncommon. The specific substances and levels vary considerably making it difficult to establish general guidance for dealing with them at sludge/septage storage sites. "Conventional" pollutants such as nitrogen and chlorides are very much of concern at these sites and current Departmental policy requires that all new sludge and septage storage facilities meet specific minimum design requirements and that storage lagoons be constructed with approved liners. Existing storage facilities are evaluated and, if excessive leakage is confirmed, repair or relining is required. The WPDES permit issued to Pat's Sanitary Service requires that the facility be upgraded to address leakage from the storage lagoon.

Appendices

Appendix A - Soil Boring Logs

References

Barber, Larry B., Thurman, E. Michael & Schroeder, Michael, P. 1988. Long-Term Fate of Organic Micropollutants in Sewage-Contaminated Groundwater. Environ. Sci. Technol. Vol. 22, No. 2, p. 205-211

Borman, R. G. 1976. Ground-Water Resources and Geology of Walworth County, Wisconsin. University of Wisconsin-Extension Geological and Natural History Survey. Madison, WI

Greer, Bruce A. 1987. Volatile Organic Compounds in Small Community Wastewater Disposal Systems Using Soil Absorption. Independent Study Report. University of Wisconsin. Madison, WI

Hunger, Carolyn 1988. The Occurrence of Volatile Compounds in Wastewater, Sludges and Groundwater at Selected Wastewater Treatment Plants. Wisconsin Department of Natural Resources Study. Madison, WI

TABLE 1 - Permit Sampling Results

Listed concentrations are averages of sample analysis through 3/12/91.

	MW-1/201	MW-2/202	MW-3/203	MW-4/204
Substance	<u>(in MG/L)</u>	<u>(In MG/L)</u>	<u>(11 MG/L)</u>	<u>(1n MG/L)</u>
Chloride	548	4.4	257	2.8
TDS	1,864	264	1,057	338
Nitrate +				
Nitrite-N	23.4	0.3	1.3	0.4
Ammonia-N	47.0	0.5	7.3	0.4
Organic-N	30.2	0.4	0.6	0.3
Sulfate	46.2	5.3	55.0	18.4
pH (field)	7.4	7.8	7.5	7.8
pH (lab)	7.1	7.8	7.2	7.8
	MW-1A/205	MW-5/206	MW-6/207	
Substance	<u>(in MG/L)</u>	<u>(in MG/L)</u>	<u>(in MG/L)</u>	
Chloride	12.2	10.8	152	• • • • • • • • • • • • • • • • • • •
TDS	558	528	890	
Nitrate +				
Nitrite-N	2.7	3.8	37.1	
Ammonia-N	0.2	0.2	0.6	
Organic-N	0.6	0.3	0.3	
Sulfate	91.0	61.0	39.4	
pH (field)	7.5	7.4	7.3	
pH (lab)	7.3	7.5	7.4	

TABLE 2 - Study Sampling Results - NPDES Priority Pollutants

1) Organic Compounds Detected - 2/20/91 & 5/1/91 Sample Dates

2/20/91 Sample D	ate			
	Sludge	MW-1/201	MW-3/203	MW-4/204
Substance	(in UG/L)	<u>(in UG/L)</u>	<u>(in UG/L)</u>	<u>(in UG/L)</u>
2-Methylphenol	*	ND	ND	ND
Phenol	*	ND	ND	ND
Chlorobenzene	*	18	ND	ND

* No sludge sample collected on this date

5/1/91 Sample Date

	Sludge	MW-1/201	MW-3/203	MW-4/204
Substance	<u>(in UG/L)</u>	<u>(in UG/L)</u>	<u>(in UG/L)</u>	<u>(in UG/L)</u>
2-Methylphenol	210	ND	ND	ND
Phenol	630	ND	ND	ND
Chlorobenzene	ND	15	ND	ND

2) Metals - 5/1/91 Sample Date

	Pat's Sludge/Septage	National Sewage Sludge Survey - National Mean	40 CFR 503 Land Spreading Standards
Substance	(in MG/KG)	(in MG/KG)	(in MG/KG)
Antimony	**	-	-
Arsenic	1.67	9.93	41
Beryllium	< 0.3	-	-
Boron	110	· -	
Cadmium	6	6.94	38
Chromium	37	118.57	1200
Copper	380	742.20	1500
Lead	120	134.37	300
Mercury	0.69	5.22	17
Molybdenum	13	-	-
Nickel	23	42.66	420
Selenium	< 2	5.16	36
Silver	**	-	-
Thallium	< 25	_	-
Zinc	760	1,201.88	2800

** Lab reported analysis rejected as Q.C. limits were exceeded

2) Metals - 5/1/91 Sample Date (con.)

				NR 140				
	MW-1 /201	MW-3 /203	MW-4 /204	PAL	ES			
Substance	<u>(in UG/L)</u>							
Antimony	< 5	< 5	< 5	-	-			
Arsenic	< 10	< 10	<10	5	50			
Beryllium	ND	ND	ND	-	-			
Boron	740	180	73	-	-			
Cadmium	< 0.2	0.2	3.3	0.5	5			
Chromium	< 3	4	22	10	100			
Copper	22	6	33	130	1300			
Lead	< 3	3	44	1.5	15			
Mercury	0.05	ND	0.03	0.2	2			
Molybdenum	ND	ND	ND	. –	-			
Nickel	45	ND	ND	-	-			
Selenium	< 5	< 5	< 5	10	50			
Silver	< 0.5	< 0.5	< 0.5	10	50			
Thallium	< 3	< 3	< 3	· _	-			
Zinc	ND	ND	92	2500	5000			







APPENDIX A - SOIL BORING LOGS

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Boring No .MW-1A Surface Elevation 89.9.5' Job No .1020 Sheet ...1. .of ...2

\square		SAM	PLE				S	DIL P	ROPI	ERTIE	ES
F	Recov	very	Mo	istur	9	VISUAL CLASSIFICATION					
No.	Туре			N	Depth		Qu	W	ш	PL	D
1	SS	15	11	23		SAND(SP)-medium dense, light brown, moist, little gravel,-trace silt, medium to fine grained				-	
2	SS	16	17	28		10'					
3	ss	12	19	72		GRAVELLY SAND(SW)-dense to very dense, light brown, moist, coarse to fine grained sand					
4	SS	13	17	41							
5	55	1 4	11	51		Less gravel noted between 25 to 30' depth					
6	ss	19	11	37							
7	SS	14"		36		SILTY SAND(SM)-medium dense to very dense, light brown, moist, medium to fine grained sand.(cap graded)					
8	SS	16'		70		-		GRA	IN S	IZE	
					WAT	ER LEVEL OBSERVATIONS	G	ENE	RAL	NOT	ES
W	/hile ()epth	Drillin to Wa	g ater SI	Start. 6:1989 Complete. 6-22-89 KD CME Crew Chief Rig Drilling Method . HSA ASTM D1452 & D1586							

Boring No ...MW-1A Surface Elevation . 8.99.50 Job No 1.020 Sheet 2....of 2.

\square		SAM	PLI	E			SC	DIL P	ROP	ERTIE	<u>:s</u>			
F	Recov	very	Mc	oistu	re	VISUAL CLASSIFICATION								
No.	Туре		\downarrow	N	Depth		Qu	W	ц	PL.	D			
9	SS	16"		17	بالالالا	SILTY SAND(SM)-medium dense to dense brown,moist, medium to fine grained sand.	e							
	6.6	1 -7 11		47		48' CLAYEY SAND(SC)-medium dense,grey								
	55	17		<u>++</u> /	50	saturated, little gravel and trace silt.	{ 	-						
11	SS	13"		18	55		-	11.	2 GI	AIN	SIZ			
						END OF BORING@ 56.5'								
					ւեր									
-					երերե	•								
	L	<u>I</u>			WA	TER LEVEL OBSERVATIONS	(GENE	ERAL	NOT	ES			
N C	WATER LEVEL OBSERVATIONS While Drilling								Start.6-19-89 Complete					

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	IPLE			SC		TOPE	HIE	<u>:5</u>		
Recovery	Mo	istur	•	VISUAL CLASSIFICATION						
No. Type	J	N	Depth	and Hemarks	Qu	w	ш	PL.	D	
1 55 8"		26		SAND(SP)-medium to very dense, brown, moist, little gravel, medium to fine grained.						
2 55 16"		37	511111	•						
3 SS 13"		52	ביוויויוים							
4 SS 16"		55		20' SAND(SW)-dense to very dense,brown						
5 ss 12"		66	111112	moist, some coarse to fine gravel, coarse to fine grained, trace silt noted@ 25' depth.						
6 SS 14'	•	50		30'					 	
7 SS 17'	1	37		moist, medium to fine grained, sat- urated @ 44'.		19.	2			
8 SS 18		21		-						
	WATER LEVEL OBSERVATIONS								TES	
While Drilli Depth to V	While Drilling 44' Start.6-23-89 Depth to Water 44' Complete STNGH & ASSOCIATES, INC. Drilling Method									

Project .. Hydrogeologic Investigation Location. Town of Lyons, WI Soil Testing Firm .. Wisconsin Testing Laboratories, WI

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Boring No MW-5..... Surface Elevation 9.7.7. Job No ... 1.0.20...... Sheet ... 2.....of .2....

	\$	SAM	PL	E			S	DIL P	ROPI	ERTIE	s
F	Recon	/егу	Mc	oistu		VISUAL CLASSIFICATION					
No.	Туре	\downarrow	\downarrow	N	Depth		Qa	W	ц	PL.	D
		•		Τ	E	SILTY SAND(SM)-medium dense, brown,					
					E	Saturated, medium to rine grained					
9	SS.	8"		21	45	Sandy clay seam noted @ 43.5'		ļ	Grai	n si	.ze
					E	48.5	•				
10	ss	13		70	50	CLAYEY SAND (SC)-very dense, grey,		9.3			
		·				morse, filtere site and graver					
					55	55'					
						End of Boring @ 55'					
					E						
					F -						
					E						
					F						
					E						
					E						
					F						
					E						
					E						
					E						
					E	•					
					F						
					WA	TER LEVEL OBSERVATIONS		GENE	RAL	NOT	ES
							Sta	art	· · · · ·		 D
W	Vhile I	Drillin	g		14 f	eet	Co	mplet			7 7mf
	epth	to W	ater		14 f	eet		ew Ch	leiri é ;	v.₩41g \ ⊨uc»	ىلىد ى پ
			CT		דדי	& ASSOCIATES INC	AS	TM I)1452	2 &	•••
			31	TAC	π	& ASSULIAILS, INC.	DI	586	••••	· · · · ·	/

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Boring No .MW-6 Surface Elevation 88.9 . 6.' Job No 1020 Sheet . 1 of . 2

\bigcap	SAMPLE						SC	SOIL PROPERTIES					
F	Recov	ery	Mc	oistur	•	VISUAL CLASSIFICATION and Remarks				~	·		
No,	Туре	\downarrow		N	Depth		Qu	W	ш.	۳.	<u> </u>		
-	55	13	11	21	11111	CLAYEY SILT (CL-ML)- very stiff, brown, moist, little gravel, and some sand4'							
2	SS	16		51		SAND (SW)- dense, brown, moist, little gravel, coarse to fine grained	1						
3	ss	14		52		15'							
4	ss	14		51		GRAVELLY SAND (SW)- medium dense to							
5	SS	12	41	32		very dense, brown, moist, coarse to fine grained 25'							
6	SS	14	11	33		SAND (SP-SM)- medium dense, light brown, moist, trace of gravel.							
7	ss	13	17	_		medium to fine grained			 				
Q	c	1.7	11	27	วิโปปปน	Boring continued on next page Clay seams noted at 40 feet							
	~~~33				WA.	TER LEVEL OBSERVATIONS		GENI	ERAL		res		
	While Drilling 40 feet Depth to Water 40 feet SINGH & ASSOCIATES, INC.						Start 6-19-89 6-22-89 Complete						

 Boring No . MW-6 Surface Elevation 889.6' Job No .1020 Sheet ... 2....of .2....

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Rei No. Ty	cov	0.74													
No. Ty		Recovery			0	VISUAL CLASSIFICATION and Remarks									
	ype	\downarrow	\downarrow	N	Depth		Qu	W	Щ	PL	D				
			4												
9 5	55	18"		33		SAND (SP-SM)- medium dense, brown, saturated, some gravel, coarse to fine grained									
						- 50'									
10 5	ss	18	1	47	50			GRA	INS	SIZE					
					E	End of Boring @ 50 feet depth									
			· .		Ę.										
					E										
					E										
					E										
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					F				<u> </u>	<u> </u>	<u> </u>				
					E	•									
WATER LEVEL OBSERVATIONS							GENERAL NOTES								
							Start6-19-89								
While Drilling						40 feet	Crew Chief KD . Rig CME				CME				
								Drilling Method HSA							
SINGH & ASSOCIATES, INC.								D1586							