

Liver Dysfunction in Residents Exposed to Leachate from a Toxic Waste Dump

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It has been estimated that there are some 30,000 chemical waste dumps in the United States. Many of these landfill operations were undertaken in the early 1950s and 1960s, when knowledge regarding the safe and prolonged containment of the waste buried was nonexistent or minimal at best. As a result, many of these dump sites were located in areas that were geologically unsuitable for toxic chemical wastes. The Love Canal area in Niagara Falls, NY, is probably the best known of these dump sites.

While a few of these sites have attracted wide media coverage, the availability of objective scientific information regarding the health effects of such sites has been deficient. The present study of a large toxic waste dump located in Hardeman County, TN, its contamination of surface and underground aquifers and the health effects on the area residents exposed via ingestion of contaminated water, offers the first objective evidence of organ dysfunction in such a human population. During this study comprehensive evaluation of that population revealed multiple symptoms, evidence of hepatomegaly and elevated liver function tests apparently caused by ingestion of water contaminated by numerous organic chemicals, many of which are known to be hepatotoxins.

The presence of a toxic waste dump in Hardeman County, TN, 60 miles north of Memphis, first came to the attention of researchers from the Department of Environmental Health, University of Cincinnati, during the performance of a seroepidemiologic study of wastewater treatment plant workers in Memphis.

Workers at the treatment plant complained of eye irritation and respiratory distress, especially in the aeration and open basin areas of the plant. Chemical odors were very intense during this study, and analysis of wastewater and air revealed the presence of hexachlorocyclopentadiene and hexachlorobicycloheptadiene. A screen of urine from the workers in the plant in May and June of 1978 revealed the presence of the two compounds mentioned. A local pesticide manufacturer whose effluent fed into the wastewater treatment plant was implicated.

About the time the wastewater treatment plant study was being performed, residents of Hardeman County began to complain of foul odors and bad

taste in their well water and asked for an investigation. This led to the discovery of a chemical land dump on a 200 acre site in the area from which the complaints of bad water had arisen. The land dump was operated from 1964 to 1972 by the chemical company implicated in the wastewater treatment plant study. It was estimated that 300,000 to 500,000 55-gallon barrels of liquid and solid waste were buried in shallow trenches dug into the ridges of the approximately 200-acre site. Poor records were kept and the dump was subcontracted so the total amount and the variety of chemicals buried there were unknown.

The dump was closed in 1972 because contaminated water was detected in test wells close to the burial areas. Tests at that time showed no contamination in the private wells closest to the dump site. Estimates are that between 16×10^6 and 25×10^6 gallons of solid and liquid waste were buried at this dump site.

Hardeman County Study

As the investigation of Hardeman County began, it appeared as though the complaints of bad odor and foul taste in the water seemed to begin in mid

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Table 1. Contaminants detected in private wells serving exposed groups: participants in Toone-Teague area of Hardeman County, TN.

Compound	NP/NT ^a	Contaminant level, $\mu\text{g/L}$	
		Range	Median
Benzene	7/7	5-15	15
Carbon tetrachloride (CCl_4)	15/15	61-18,700	1500
Chlordene	5/24	Trace-0.81	Trace
Chlorobenzene	23/25	Trace-41	5.0
Chloroform (CHCl_3)	14/15	2.1-1890	140
Hexachlorobutadiene	22/28	Trace-2.53	0.15
Hexachloroethane	19/31	Trace-4.6	0.26
Hexachlorobicycloheptadiene (HEX-BCH)	24/31	Trace-2.2	0.05
Methylene chloride	11/11	1.5-160	45
Naphthalene	13/31	Trace-6.7	ND
Tetrachloroethylene	27/28	Trace-2405	3.5
Toluene	14/24	0.1-2	0.6
Xylenes	2/3	0.07-1.6	0.07

^aNumber of samples with contaminant present/total number of samples taken.

to late 1977. Following this there were reports of skin and eye irritation, muscle weakness, shortness of breath, nausea, vomiting, diarrhea and abdominal pain. In 1978, investigation of the U.S. Geologic Survey confirmed the contamination of wells. In November 1978, the EPA advised all water consumption be stopped although many residents had discontinued use of the contaminated water weeks or months earlier. EPA studies showed that more than one dozen chlorinated organic compounds were contained in these wells (Table 1, Figs. 1 and 2).

In November, the Department of Environmental Health at the University of Cincinnati Medical Center decided that if the families using contaminated water were to be studied, it had to be done quickly, since many families had ceased water consumption and the rest would soon be stopping

and essentially end any further dosing of the population that was taking place. A team of environmental specialists, including public health nurs-

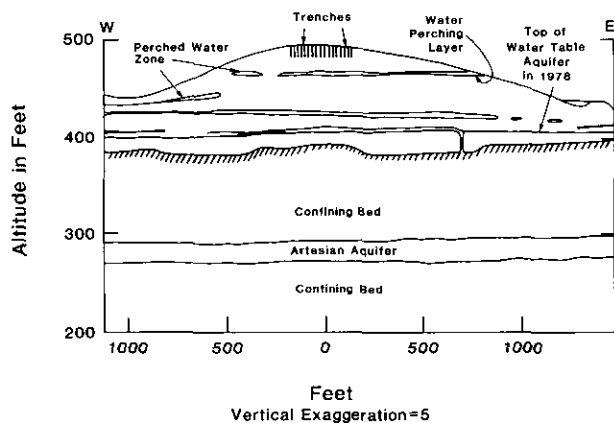


FIGURE 1. Conceptual diagram of contaminant percolation below the disposal trenches.

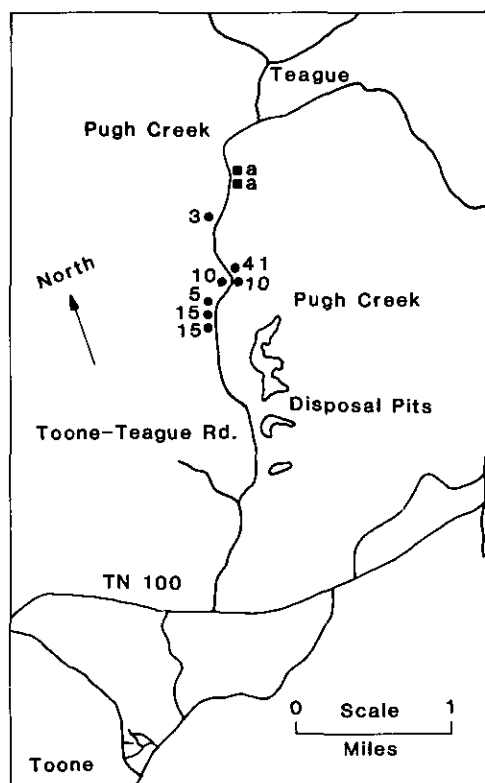


FIGURE 2. Location of contaminated private wells near Hardeman County toxic waste dump (●) and percentage of exposed group using each well. Wells designated by letter "a" were contaminated to a lesser degree and were used by two intermediate-exposed households.

es, went on-site in November 1978. The study included exposed people only and consisted of: (1) an analysis of organics in air and water from residences known to be contaminated, (2) a medical questionnaire with information on alcohol and drug consumption, history of hepatitis or other liver problems as well as an in-depth medical history, (3) blood collected for a liver profile and bile acid survey, and (4) urine collected for organic chemical analysis (Table 2). The specimens were analyzed at the Cincinnati General Hospital for GGTP, SGOT, SGPT, alkaline phosphatase and total bilirubin, and

controls were used from nonexposed wastewater treatment plant workers done at the same time in Memphis, TN. Statistical analysis was performed using age and sex as variables. Analysis of variance was performed on all of the data.

A larger study with local controls was planned immediately and performed in January 1979. Histories and physical examinations were performed with collection of information similar to that on the screening histories performed in November; biologic specimens were collected for liver profile, renal profile, hepatitis serology and bile acids, both fasting and postprandial (Table 3). Statistical analysis included the testing of dependent variables for normality and making transformations when necessary. Analysis of covariance was used to assess effects of age, sex, alcohol consumption and their interactions on the dependent variables of the controls. Analysis of variance was used to test for any differences between the exposed, intermediate and control groups, those people who were actively consuming water being the exposed group, those who had visited in the contaminated area and who were on the perimeter of the contamination being the intermediate group and the control population being those from the area whose water supply was tested and found not to be contaminated. Significant level was set at $p = 0.02$.

Table 2. Study elements.

	November 1978	January 1979
Air and water monitoring	X	X
Chemical analysis of urine	X	X
Hepatitis serology		X
Biochemical screening	X	X
Health questionnaire	X	X
Physical examination		X

Table 3. Biochemical screening.

	November 1978	January 1979
Liver function profile ^a	X	X
Renal function profile ^b		X
Fasting serum bile acids ^c		X
Nonfasting serum bile acids	X	X
Fasting urine bile acids		X
Nonfasting urine bile acids		X

^aGamma glutamyl transpeptidase (GGTP), serum glutamic oxaloacetic transaminase (SGOT), serum glutamic pyruvic transaminase (SGPT), alkaline phosphatase and total bilirubin.

^bSodium (Na), potassium (K), chlorides (Cl), total carbon dioxide (Total CO₂), glucose, blood urea nitrogen (BUN) and creatinine.

^cSulfated conjugates of lithocholate (SLCC) and cholyglycine (CG).

Results

There were 36 individuals in the exposed group tested in November 1978, and this group was expanded to 49 persons in January 1979 with 31 individuals participating in both the November and January testing. There were 33 individuals classified in the intermediate group and 57 individuals in the control population (Table 4).

The November testing results showed that those individuals exposed to the contaminated water had

Table 4. Age and sex profile of exposed, intermediate-exposed and control groups in Hardeman County study.

Age	Exposed ^a		Intermediate-exposed		Control	
	Male	Female	Male	Female	Male	Female
0-14	6 (5)	13 (9)	3	12	4	7
15-24	2 (2)	3 (2)	0	2	1	4
25-34	5 (4)	8 (8)	5	7	7	10
35-44	3 (0)	1 (1)	0	0	3	4
45-54	0 (0)	1 (2)	0	0	2	2
55-64	3 (3)	1 (0)	1	1	1	7
≥ 65	1 (0)	2 (0)	1	1	1	3
Total	20 (14)	29 (22)	10	23	19	38 ^b

^aAge and sex profile of population seen in November 1978 shown in parentheses.

^bOne missing age.

an increased elevation of their alkaline phosphatase and SGOT liver enzymes when compared with the control population at levels of 0.016 and 0.010, respectively. In addition, the exposed individuals had albumin and total bilirubin levels that were significantly lower than the control population $p = 0.0001$ and $p = 0.0001$, respectively.

The larger, more comprehensive study performed in January 1979 showed no differences between the control, intermediate and exposed groups in the January study. All groups were found to be similar regarding their hepatitis serology, renal profiles,

alcohol and drug intake.

Of the 31 people who participated in both the November 1978 and January 1979 studies, there was a significant decrease from November to January in all liver enzyme values including alkaline phosphatase, GGTP, SGPT and SGOT. Albumin and total bilirubin increased significantly (Tables 5 and 6). In the bile acid study, only the sulfated conjugates of lithocholate (SLCC) showed any significant differences from control to exposed group. The SLCC values were significantly lower in the exposed than in the control population.

Table 5. Hepatic profile comparison of Hardeman County: exposed group (November 1978) and control group.

Parameter ^a		Results		Significance of difference (<i>t</i> test)
		November 1978 Exposed group	Control group	
Alkaline phosphatase (32-72 mU/mL age 21, 25-150 mU/mL age 21)	Mean ^b	88.1	61.5	0.016
	Range	34-360	31-220	
	No. above normal/total tested	17/36	8/56	
Serum gamma glutamic transaminase (SGGT) (5-29 mU/mL)	Mean ^b	9.47	11.56	0.430
	Range	2-54	4-56	
	No. above normal/total tested	3/36	3/56	
Albumin (3.5-5.0 g/dL)	Mean ^b	4.35	4.93	0.0001
	Range	3.9-4.8	4.2-6.2	
	No. above normal/total tested	0/36	0/57	
Total bilirubin (0.1-1.1 mg/dL)	Mean ^b	0.240	0.51	0.0001
	Range	0.1-0.8	0.2-1.7	
	No. above normal/total tested	0/31	4/52	
Serum glutamic pyruvic transaminase (SGPT) (5-25 mU/mL)	Mean ^b	15.9	14.25	0.324
	Range	9-50	6-70	
	No. above normal/total tested	5/36	4/56	
Serum glutamic oxaloacetic transaminase (SGOT) (8-22 mU/mL)	Mean ^b	19.5	16.08	0.001
	Range	12-36	9-140	
	No. above normal/total tested	11/36	7/56	

^aNormal range indicated in parentheses.

^bGeometric mean.

Table 6. Comparison of hepatic profile test results for exposed participants tested in both November 1978 and January 1979 studies.

	<i>N</i>	Mean difference ^a	Standard error	<i>t</i>	Degrees of freedom	<i>p</i>
Alkaline phosphatase	31	13.3	6.3	2.125	30	< 0.0409
SGGT [log (5-SGGT)]	31	-2.6	1.1	2.302	30	< 0.0284
Albumin	31	-0.5	0.13	3.922	30	< 0.0004
Total bilirubin	26	-0.2	0.03	6.405	25	< 0.0001
SGPT	31	3.6	1.2	3.044	30	< 0.0048
SGOT	31	4.4	1.0	3.989	30	< 0.0003

^aNovember results minus January results.

Conclusion

This series of studies, while far from being epidemiologically perfect, shows strong indications and is certainly indicative of a subclinical transitory liver insult that appeared to be associated with consumption of water from wells contaminated by leachate from the chemical waste dump located in that area. The symptoms and abnormal liver function tests in all but one case returned to normal during the period of November 1978 through March 1979. Had the study of the wastewater treatment plant workers not been in the process of being

performed, the November 1978 Hardeman County study would have never been done. Had some method of funding not been available (EPA grant), the January 1979 study probably would not have been performed. In the future, it seems unwise to wait until an episode such as that in Hardeman County occurs to start the laborious process of assembling a team, procuring a funding source and getting the team into the field to do the work. This would better be done in anticipation. One of the major objectives of this conference should be to consider carefully the creation of a rapid deployment environmental health team as a possible solution to this and to similar future problems.