Occupational Exposure to Hexachlorocyclopentadiene

How Safe Is Sewage?

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• **In March 1977, a large volume of the industrial chemical hexachlorocyclopentadiene (HCCPD) was dumped into a municipal sewage system in Kentucky. We evaluated the health effects of exposure to HCCPD in 145 sewage treatment plant workers. We found that 85 (59%) had noted eye irritation, 65 (45%) had headaches, and 39 (27%) had throat irritation. Symptoms occurred throughout the plant; however, highest attack rates occurred in primary sewage treatment areas. Medical examination of 41 employees three days after the plant was closed showed proteinuria and elevation of serum lactic dehydrogenase levels; these findings were not present three weeks later. This episode demonstrates the toxicity of HCCPD and emphasizes the vulnerability of sewage workers to chemical toxins in wastewater systems.**

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SEWAGE TREATMENT plants in the United States process billions of tons of wastewater every year. The greatest source of wastewater is domestic, but approximately 19% of sewage volume is of industrial origin.[1] It has been recognized since the 18th century that workers in sewage treatment plants are at increased risk of exposure to leptospires, parasites, enteroviruses, and enterotoxins.[2-6] Until recently, however, there have been few reports of exposure of sewage workers to toxic chemicals.

Sewage workers experienced an episode of acute exposure to the industrial chemical hexachlorocyclopentadiene (HCCPD). Hexachlorocyclopentadiene is an intermediate compound in the manufacture of pesticides, including aldrin, dieldrin, and kepone. It can be decomposed by heat to produce phosgene, chlorine, and hydrogen chloride.[7] Hexachlorocyclopentadiene is volatile and can cause extreme, short-term toxic effects by dermal, oral, and inhalation routes of exposure.[8] In animals, prolonged intermittent exposure to HCCPD vapor in concentrations of as low as 0.15 ppm has led to slight liver and kidney damage and in higher concentrations has caused diffuse degenerative changes of brain, heart, adrenal glands, liver, and kidneys, with pulmonary hyperemia and edema.[9]

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BACKGROUND

On March 26, 1977, an odoriferous, highly viscous, sticky substance entered a sewage treatment plant in Kentucky and coated the bar screens and grit collectors in the primary treatment area. A number of workers immediately experienced tracheobronchial irritation and required medical attention. On March 29, the plant was closed when chemical analysis showed wastewater at the plant to be contaminated with large amounts of HCCPD, smaller amounts of octachlorocyclopentene, and traces of other chlorinated cyclohydrocarbons. Airborne concentrations of HCCPD at the time of exposure were unknown, but four days later air concentrations in the primary treatment areas (screen and grit chambers) ranged from 270 to 970 parts per billion (ppb).[10] By comparison, the American Conference of Governmental Industrial Hygienists recommended in 1977 that eight-hour, time-weighted, average occupational exposure to HCCPD not exceed 10 ppb.[11] The source of the HCCPD in this episode was traced to the unauthorized discharge of the compound into a municipal sewer line.

METHODS

We recognized 193 employees who had worked at the sewage plant for two or more days from March 14 to 29. We sent each a questionnaire that sought information on demographic background, work history, personal habits, symptoms, and

extraoccupational sources of exposure to chemicals. We conducted physical examinations of workers with complaints of skin or mucous membrane irritation, and we obtained from them samples of venous blood and urine for clinical screening. We also reviewed the medical records of all workers who had received medical care after the chemical exposure.

RESULTS

We obtained questionnaire data on 145 (75%) of the 193 employees; questionnaire response rates varied by work area from 50% to 89% (Table). We evaluated and collected specimens from 41 workers, including 24 (83%) of the 29 who had originally sought medical care, as well as from a 10% random sample of the remaining workers.

Demographic data showed that most plant employees were men (85%). They were generally healthy and had an average age of 35.1 years.

Seventy-five percent of employees had detected an unusual odor at the plant during March. This odor was noted as early as March 1, grew stronger by March 14, and increased further until the plant was closed on March 29 (Figure).

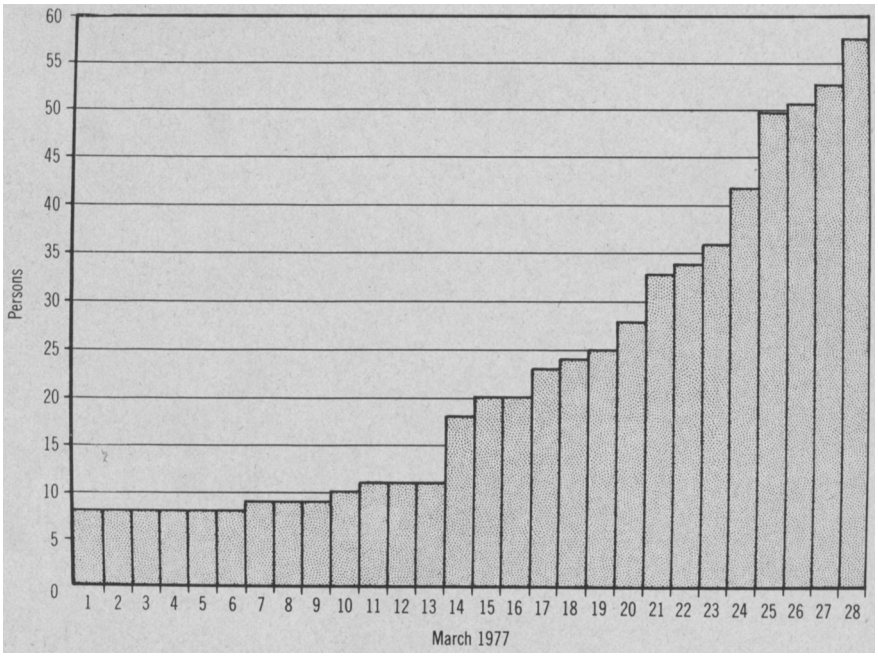
Eye irritation (59%), headaches (45%), and throat irritation (27%) were the symptoms reported most frequently by employees. Other symptoms included skin irritation, cough, nausea, and abdominal cramps. In 94% of workers, odor detection preceded onset of symptoms. Detailed information on duration of symptoms was not available, as many persons were still symptomatic at the time of our survey. However, even six weeks after the episode, a follow-up questionnaire of 177 plant employees showed residual symptoms—fatigue in 15%, respiratory tract irritation in 9%, headache in 18%, and eye irritation in 9%.

Five employees had physical signs of eye irritation (tearing or redness); five had signs of skin irritation. Laboratory results showed elevations of lactic dehydrogenase (LDH) in 11 (27%) of 41 workers and proteinuria in six (15%) but no other notable abnormalities. There were no LDH or urinalysis abnormalities found on repeated tests run in a different laboratory three weeks later, nor were LDH elevations or proteinuria noted in persons screened initially at the hospital or by the plant physician.

Attack Rates for Employees by Work Area in Kentucky, March 1977

Main Work Area	No. of Employees	Respondents	
		No. (%)	Attack Rate, %*
Primary treatment	19	17 (89)	59
Throughout plant	71	54 (76)	48
Vacuum filtration	19	15 (79)	47
Secondary aeration chamber	14	12 (86)	42
Administration and laboratory	30	22 (73)	41
Final effluent pump station	10	5 (50)	40
Low-pressure oxidation	13	10 (77)	30
Incineration	17	10 (59)	20
Total	**193**	**145 (75)**	**44**

*For the purpose of determining attack rates, affected workers were defined as those who experienced either two major symptoms (eye irritation and headache) or one major symptom and two minor symptoms (sore throat, cough, chest pain, difficult breathing, and skin irritation).



Employees who noticed unusual odor at plant in Kentucky. Plant closed March 29, 1977.

A review of medical records for 51 employees seen at the emergency room or by the plant physician from March 26 to April 1 showed symptoms similar to those noted on the questionnaire.

In our epidemiologic analysis, we found no notable differences in demographic characteristics, in medical histories, or in laboratory results between workers who experienced symptoms and those who did not. Symptoms occurred throughout the plant in all work areas and in all job categories. Detailed work histories obtained on 124 employees for the period of most intense odor (March 25 to 28) showed, however, that attack rates were significantly higher for persons who had been exposed to the screen and grit chambers area (χ^2=16.2, $P<10^{-4}$) and to the primary settling-tank area (χ^2=5.25, $P<.02$) than for workers not exposed to these areas (Table).

COMMENT

Sewage is a mixture of liquids and solids of domestic and industrial origin which varies in composition from sewer to sewer and from hour to hour. Most of us think of sewage as being composed of kitchen water, bath water and human excreta, but to the sewerman working in industrial towns trade wastes are the important constituents.[6]

In this study wastewater treatment plant workers experienced headache and mucous membrane, skin, and respiratory tract irritation after they were exposed to vapors from sewage

contaminated with industrial chemical wastes. Their symptoms were consistent with the known toxic properties of HCCPD, and the distribution of symptoms coincided in time and place with the distribution of HCCPD, the compound later found to have been present in highest concentration. Thus, the episode demonstrates the potential of HCCPD for causing human illness. Octachlorocyclopentene, a related compound with relatively unknown toxicity, was also present and may have contributed to symptom production. Concentrations of HCCPD in air at the time of exposure are not known but were probably many times the recommended threshold-limit value. Although the exact date of HCCPD dumping is not known, the epidemiologic evidence (Figure) suggests that it may have occurred as early as March 14 when there were concurrent increases in odor detection and symptom incidence.

This episode supports the notion, espoused by Hunter,[6] that sewage workers, who are known already to be at increased risk of exposure to infectious agents, must be considered also at risk of exposure to toxic chemicals. As increasing volumes of industrial effluents are channeled each year through municipal wastewater treatment plants, there will be an increasing potential for both short-[12] and long-term[13] exposure of sewer workers to such toxins. This source of occupational disease deserves continuing evaluation.

This episode underscores the potential hazards inherent in a recent policy decision by the US Environmental Protection Agency to encourage widespread application of partially treated municipal wastes on agricultural soils in the United States.[14] This policy decision appears not to recognize that a wide variety of industrial toxins, including persistent pesticides, organic compounds, and heavy metals, are present in municipal waste[15] and that with repeated application these materials may accumulate in soils[15,16] and have the potential to be absorbed by plants, eventually to reach human foodstuffs.[17] We urge that before a policy of extensive on-land application of municipal waste is implemented, a full evaluation of the potential impact of this decision on public health be undertaken.

Truman W. DeMunbrun, MD, Louisville, Ky, provided clinical data on acute findings in many affected workers.

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