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To: HSE Technical Committees

VISTA

December 8, 1987

Roy T. Gottesman
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355 Lexington Avenue
New York, NY 10017

SUBJECT: PAPER ON VCM CONTAMINATION

Dear Mr. Gottesman

I met Dr. Kathleen Wolf at a recent conference on waste minimization. Subsequently, she sent me the attached reprint of her paper on VCM contamination. I thought you may be interested.

Sincerely,

Joseph C. Ledvina

Joseph C. Ledvina
Director, Environmental Activities

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Attachment

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VINYL CHLORIDE CONTAMINATION: THE HIDDEN THREAT*

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Summary

Vinyl chloride – an established human carcinogen – has been found in groundwater and in gases emitted from sanitary landfills. In many cases, the chemical itself was not placed in those locations and its origin is unknown. This paper presents and analyses a number of possible origins. The two most likely include biotransformation and chemical reaction. Biotransformation leading to a vinyl chloride end product has been observed in the laboratory. The analysis shows chemical reaction resulting in the formation of vinyl chloride might be favored in certain instances. The results suggest that further research, particularly focusing on these two routes, could shed light on the processes of vinyl chloride formation in the environment.

1. Introduction

In the last several years, vinyl chloride (VC) has been detected in the air, water, and soil in locations where the substance was not disposed of or stored. This raises questions about the origin of the VC, an established human carcinogen, about how widespread it is in the environment, and about its ultimate fate. Indeed, if the VC is being created through an environmental process, then concentrations may increase over time and human health may eventually be adversely affected.

In this paper, we explore the possible origin of the vinyl chloride. Our results suggest that there may be more than one source or mechanism of formation in land disposal sites and groundwater aquifers. The existing data are insufficient for a more rigorous analysis at the present time, and our conclusions are speculative and designed primarily to focus more attention on the question.

In what follows in Section II, we describe several locations where vinyl chloride has been found. In section III, we present production and use data that suggest the chemical was probably not used or disposed of near these sites. Its presence, however, is of concern because of potential human health effects

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which we also describe. In Section IV, we analyze six possible explanations of vinyl chloride's presence. These include formation through reduction by microorganisms, formation through chemical reaction, and migration of VC from various sources. In Section V, we summarize our results and make some concluding remarks.

II. Sources of vinyl chloride

VC has been found in trace amounts in the Santa Clara Valley. It was detected in the range of 50 to 500 parts per billion in the groundwater in the vicinity of three separate plants manufacturing electronics equipment [1]. Such plants use significant amounts of chlorinated solvents each year, most of which is stored in underground tanks. This so-called clean industry received a great deal of publicity in recent years when it was found that a number of the storage tanks were leaking. Because it is unlikely that these plants ever purchased VC for any purpose, its detection in the soil and groundwater in the area is curious. Another source also reports the presence of VC and groundwater in the same general area [2,3]. VC has, in fact, been found in groundwater in trace concentrations throughout the U.S. [4,5].

The chemical has also been detected in the gas collection systems and the ambient air surrounding hazardous waste disposal sites. At one such site – BKK landfill in West Covina, California – VC was detected in spite of the fact that the firm had not accepted the chemical for disposal for some time [6]. Two separate industry sources indicate that VC has also been detected at the perimeter of sanitary landfills where only municipal trash was buried and where disposal of VC was never permitted.

III. Background data on vinyl chloride

Production and use

In 1984, production of VC – called VC monomer – amounted to somewhat more than 6 billion pounds or about 2.7 million metric tons. VC is produced by eight manufacturers in eleven domestic plants. Virtually all of the VC produced today is used as an intermediate in the manufacture of polyvinyl chloride (PVC) or other copolymers [7]. PVC is today used in a variety of products throughout the economy including piping, tubing, flooring, textiles, coating, wire, cable, film, photograph records, and bottles [8].

Prior to 1974, VC was used as an aerosol propellant in a variety of products such as pesticides, drugs, and cosmetics. Although manufacturers may have actually stopped using VC for this purpose for financial reasons, in 1974 three government agencies – the Food and Drug Administration (FDA), the Environmental Protection Agency (EPA), and the Consumer Product Safety Com-

mission (CPSC) – banned VC's use in self-pressurized aerosols for household use [9,10].

Health effects

The ban on use of VC in aerosol applications in 1974 was prompted by indisputable evidence that VC was a human carcinogen. At that time, Goodrich, a VC and PVC producer, announced that four of its workers had died of angiosarcoma, a rare liver cancer. By the spring of 1968, 68 cases of the disease had been reported [10]. The highest incidence appeared in workers who cleaned the polymerization reactor where concentrations of VC averaged between 250 and 300 parts per million (ppm) and peak concentrations were as high as several parts per thousands.

The results of animal studies confirm the unequivocal carcinogenicity of VC. In 1974, an Italian group reported that rats had developed angiosarcoma in inhalation studies with VC concentrations at 250 ppm [11]. Another experiment conducted in 1975 reported angiosarcoma at 50 ppm [12]. Since then, other studies have verified that VC is a carcinogen through inhalation and ingestion [13].

There is today a consensus that VC is carcinogenic. The National Toxicology Program lists it as one of the few dozen chemicals that are established human carcinogens [14]. Its identification in groundwater and at the perimeters land disposal sites therefore is cause for concern.

IV. Vinyl chloride origins

In what follows, we discuss several possible processes that could result in VC's presence in inexplicable locations. These include anaerobic microbial transformation, chemical transformation, PVC outgassing, PVC depolymerization, emission from aerosol cans, and solvent contamination. We examine the first two – biotransformation and chemical transformation – in some detail and only briefly discuss the other processes.

By way of introduction, we first describe several chemicals that are widely used, disposed of in hazardous waste landfills, and stored in underground storage tanks. Such chemicals include the industrial solvents 1,1,1-trichloroethane (TCA), trichloroethylene (TCE), and perchloroethylene (PERC). Annual historical production of these chemicals is presented by Wolf and Chesnutt [15] and reproduced here in Table 1 for 1984.

The values of Table 1 show that the combined annual production of the three industrial solvents is huge – 760 thousand metric tons. They are used in a variety of applications including the dry cleaning and metal cleaning industries. They are stored in underground tanks near businesses across the U.S. and are present in hazardous waste land disposal sites all over the nation. In

TABLE 1

Production of chlorinated solvents - 1984

Solvent	Production (thousand metric tons)
TCA	306
TCE	200
PERC	260

Source: U.S. ITC [16]; CMR [17].

the discussion of VC origins that follows, we will refer to these chemicals frequently.

Biotransformation

Three investigators have presented evidence that under the anaerobic condition that exists in groundwater, certain chlorinated hydrocarbons are biodegraded. For reference, we show the degradation sequence in Fig. 1.

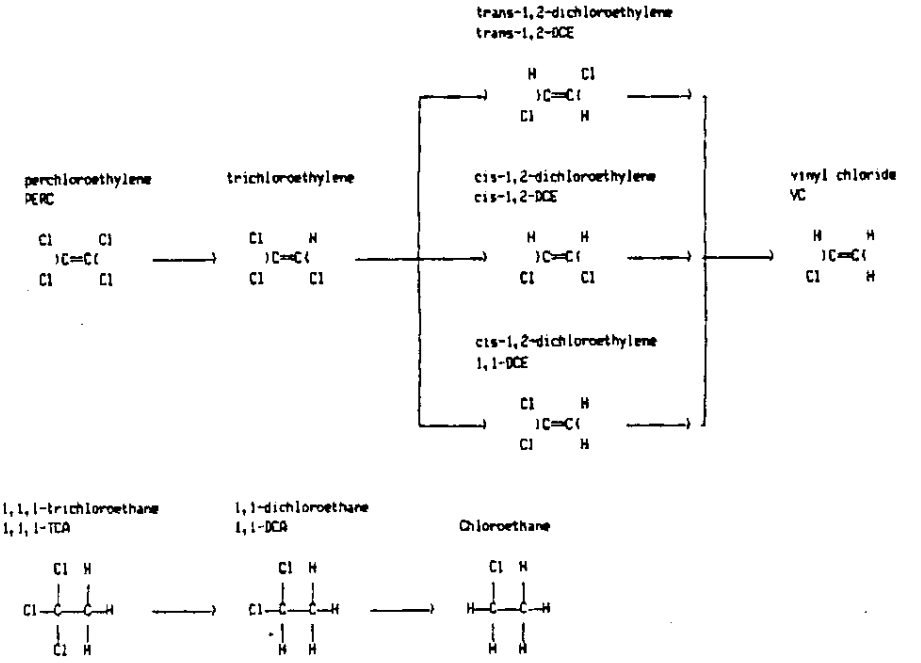

Fig. 1. Possible biodegradation sequence.