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**Environmental Monitoring Series**

**AMBIENT AIR MEASUREMENTS  
OF VINYL CHLORIDE  
IN THE NIAGARA FALLS AREA**



U.S. Environmental Protection Agency  
Office of Research and Development  
National Environmental Research Center  
Research Triangle Park, N. C. 27711



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OF VINYL CHLORIDE  
IN THE NIAGARA FALLS AREA**

by

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# AMBIENT AIR MEASUREMENTS OF VINYL CHLORIDE IN THE NIAGARA FALLS AREA

## INTRODUCTION

Vinyl chloride is a synthetically produced colorless gas that is polymerized to polyvinyl chloride and made into a variety of plastic products. Health studies of employees at vinyl chloride and polyvinyl chloride plants have shown that exposure to vinyl chloride can cause rare angiosarcoma of the liver, cancers in other tissues, and other damage to both the liver and spleen.<sup>1-4</sup> Occupational instances of liver angiosarcoma have occurred primarily among workers exposed to extremely high levels of vinyl chloride. Ambient air concentrations of vinyl chloride are, of course, much lower than those found in industrial atmospheres; however, it is not known if there is a concentration limit below which no adverse health effects occur even when people are exposed for long periods of time.

At the Niagara Falls Goodyear Tire and Chemical Plant, three cases of angiosarcoma of the liver have been reported among workers.<sup>5</sup> The plant produces vinyl chloride resins by emulsion and suspension

polymerization processes. The emulsion process was used first and began operation in 1946.<sup>6</sup> The plant is located on the eastern edge of an industrial chemical complex. Hooker Chemical and other chemical companies in the complex also produce various halogenated organic compounds, chlorine, and polymers. Residential areas are located to the northeast, north, and east-south east of the chemical complex in Niagara Falls.

Angiosarcoma of the liver had been tentatively diagnosed in a resident of the area adjacent to the chemical plants, prompting the present survey. The resident lived on 57th street, two streets to the southeast of the Good-year Chemical Plant. There was no known occupational exposure to vinyl chloride, but the person lived at this address for some 50 or more years.

Ambient air samples were taken in the residential areas near the chemical plants, in areas around the chemical complex, and in the areas of downtown Niagara Falls to determine the concentration of vinyl chloride in the atmosphere. Figure 1 shows all of the sites in Niagara Falls from which ambient air samples were taken.

Three suspected cases of angiosarcoma of the liver were also reported in the Buffalo area.<sup>7</sup> Spot samples of ambient air in the residential neighborhoods of each of these patients were taken for vinyl chloride analysis.

CITY OF NIAGARA FALLS

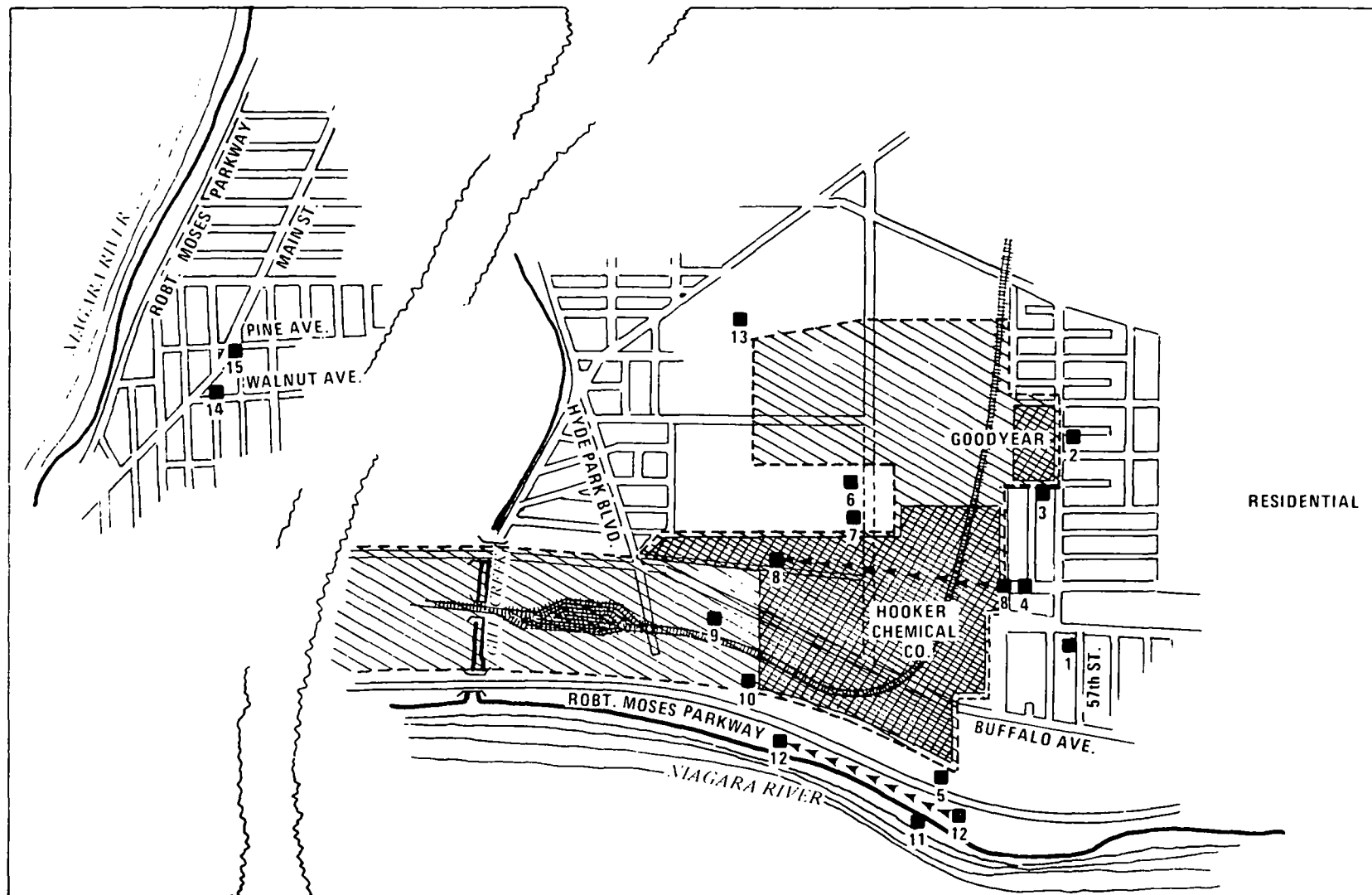


Figure 1. Locations of sampling sites for vinyl chloride measurements in Niagara Falls.



## EXPERIMENTAL

Time-integrated ambient air samples at the 57th Street residence (Sampling Site No. 1) were collected in 300-liter Tedlar bags using a stainless steel diaphragm pump over a period of 4 to 12 hours. From the 300-liter bags containing the collected time-integrated samples, 20 to 25 liters of the sample were transferred into smaller Tedlar bags. Ambient air grab samples of 20 to 30 liters were collected over 10- to 30-minute periods in small Tedlar bags using a 1-liter syringe as a hand-operated pump. Care was taken not to unduly expose the bags to sunlight after collection of the samples. Previous laboratory experiments have shown Tedlar bags to be good sample containers for vinyl chloride air samples.<sup>8</sup>

The collected air samples were flown to Houston, Texas, for analysis of vinyl chloride by equipment being used there in an ambient air study. Analysis of vinyl chloride was by gas chromatography with flame ionization detection. One hundred milliliters of the air sample were trapped in a 12-inch by 1/8-inch stainless steel column packed with 60/80 mesh glass beads at liquid nitrogen temperature.<sup>9</sup> The liquid nitrogen was removed and the trapped components were flushed into the separating column consisting of a 12-foot by 1/8-inch stainless steel column packed with 0.4 percent Carbowax 1500 on Carbopack A. The helium carrier gas flow rate was 33 cm<sup>3</sup>/minute. The column was maintained at 20°C during analysis. Conditioning of the column for 1 hour at 200°C was carried out before use in an effort to increase the

separation of vinyl chloride from Freon-12. A calibration or response factor for vinyl chloride was obtained by chromatographing known concentrations that were made up volumetrically and by plotting measured peak area response from the chromatogrammed sample versus the concentration of vinyl chloride. Vinyl chloride concentrations in the samples were calculated from measured response peak area multiplied by the experimentally obtained response factor.

## RESULTS

The analytical results shown in Table 1 are of air samples collected at Sampling Site No. 1, the 57th Street residence of the non-occupational case of angiosarcoma of the liver. The highest concentration of vinyl chloride was 40 parts per billion (ppb) measured from an air sample taken over a 5-hour integrated period. During the early morning hours, the concentrations of vinyl chloride were usually higher by a factor of two or more. With wind direction from the north or north-northwest, there was greater probability of observing vinyl chloride in the residential area. In samples taken when the wind direction was from the north or northwest, vinyl chloride levels were below the detection limits of approximately 1.0 ppb. Also, the highs of 40 ppb and 9 ppb were observed when the wind direction was north-northeast. It is not unreasonable that the wind was at times from the northwest or other directions since only generalized wind directions were obtained.

The data in Table 2 are for samples collected in the vicinity of Goodyear Chemical (Sampling Sites 2 through 7). The samples from Sites 2 and 6, obtained downwind of the plant, showed 3 ppb and 12.7 vinyl chloride, respectively. The sample from Site 7, collected at the west side of the plant when the wind was from the north, contained no vinyl chloride. This was to be expected since the air parcel sampled had not come over the plant. Samples from Sites 3 through 5 were taken to show the dispersion and dilution effects of vinyl chloride emissions downwind of a source. However, no vinyl chloride was observed in any of the three samples. This

Table 1. AMBIENT AIR SAMPLES FROM 57th STREET, NIAGARA FALLS  
(Sampling Site No. 1)

Samples from sampling site no. 1	Remarks	Vinyl chloride concentration, ppb
1	8:00 p.m. to 8:00 a.m., 6/22, wind north-northwest 10-17 mph.	0 <sup>a</sup>
2	8:00 p.m. to 8:00 a.m., 6/22, wind north-northwest 10-17 mph (sample taken indoors in the upstairs hallway).	0
3	12:00 midnight to 5:00 a.m., 6/24, wind north-northeast 5/10 mph.	40
4	5:00 a.m. to 10:00 a.m., 6/24, wind north-northeast 7-12 mph.	9
5	12:00 noon to 4:00 p.m., 6/24, wind north-northeast 7-12 mph.	0
6	4:00 p.m. to 8:00 p.m., 6/24, wind north-northeast 7-12 mph.	9
7	8:00 p.m. to 8:00 a.m., 6/24 - 6/25, wind north 5-10 mph.	6.1
8	9:00 a.m. to 1:00 p.m., 6/25, wind north 5-10 mph.	0
9	1:00 p.m. to 6:00 p.m., 6/25, wind north-northeast 5-12 mph.	0
10	7:00 p.m. to 1:00 a.m., 6/25 - 6/26, wind north - northwest 5-10 mph.	6.6
11	1:00 a.m. to 9:00 a.m., 6/26, wind north-northwest 5-10 mph.	27.5
12	10:00 a.m. to 2:00 p.m., 6/26, wind northwest 5-10 mph.	5.5
13	2:00 p.m. to 6:00 p.m., 6/26, wind north-northwest 5-10 mph.	6.6

<sup>a</sup>Below the detection limit of ~ 1.0 ppb.

Table 2. AMBIENT AIR SAMPLES FROM VICINITY OF GOODYEAR CHEMICAL  
(Sampling Sites No. 2 through 7)

Sampling site no.	Remarks	Vinyl chloride concentration, ppb
2	4:00 p.m. to 4:15 p.m., 6/21, wind north-northwest 5-12 mph.	3
3	11:00 a.m. to 11:10 a.m., 6/24, wind north-northeast 7-12 mph.	0
4	11:15 a.m. to 11:25 a.m., 6/24, wind north-northeast 7-12 mph.	0
5	12:00 a.m. to 12:30 p.m., 6/24, wind north-northeast 7-12 mph.	0
6	3:05 p.m. to 3:35 p.m., 6/25, wind north-northeast 5-10 mph.	12.7
7	10:00 a.m. to 11:00 a.m., 6/26, wind north 5-10 mph.	0

indicates either that emissions were low at the time or considerably below the limit of detection.

Samples taken in or around the chemical complex contained vinyl chloride in two of the five samples. The sample from Site No. 11 (Table 3), collected over 35 minutes downwind of the Goodyear Chemical and Hooker Chemical plants, contained 28.6 ppb vinyl chloride. The sample site was about 0.5 mile from Hooker Chemical and 1 mile from Goodyear Chemical. The sample from Site No. 6 (Table 2), collected 1 hour earlier at a location 1 mile downwind of Goodyear Chemical, contained only 12.7 ppb vinyl chloride. It is difficult to determine from these limited data if the higher value obtained downwind of both plants was caused by emissions from both Good-

Table 3. AMBIENT AIR SAMPLES FROM VICINITY OF CHEMICAL  
 CHEMICAL COMPLEX LOCATED ON BUFFALO ROAD  
 (Sampling Sites No. 8 through 12)

Sampling site no.	Remarks	Vinyl chloride concentration, ppb
8	11:25 a.m. to 11:55 a.m., 6/24, wind north-northeast 7-12 mph; sample taken while walking 3/4 mile distance on Buffalo Road.	0
9	11:15 p.m. to 1:30 p.m., 6/25, wind north-northeast 5-10 mph	0
10	2:15 p.m. to 2:30 p.m., 6/25, wind north-northeast 5-10 mph;	0
11	4:00 p.m. to 4:35 p.m., 6/25, wind north-northeast 5-10 mph.	28.6
12	3:00 p.m. to 4:00 p.m., 6/25, wind northeast 5-10 mph; sample collected over 1.2-mile distance along River Road.	2.5

year Chemical and Hooker Chemical or by an increase in emissions from Goodyear Chemical. Hooker Chemical does produce halogenated organics; vinyl chloride may or may not be one of them. However, no vinyl chloride was detected in samples taken in close proximity of the Hooker Chemical Plant (Sites 8, 9, and 10; Table 3).

Samples taken upwind of the chemical complex and in downtown Niagara Falls (Table 4) showed no detectable vinyl chloride. An indoor air sample taken in a downtown beauty shop (Site No. 15) frequented by the 57th Street angiosarcoma case contained 3 ppm Freon-12. At a concentration of 3 ppm Freon-12, 5 ppb of vinyl chloride could have gone undetected, since chromatographic elution times of Freon-12 and vinyl chloride do not differ greatly. However, if vinyl chloride

Table 4. AMBIENT AIR SAMPLES OUTSIDE NIAGARA FALLS INDUSTRIAL AREA  
(Sampling Sites No. 13 through 15)

Sampling site no.	Remarks	Vinyl chloride concentration, ppb
13	10:40 a.m. to 11:00 a.m., 6/25, wind north-northeast 5-12 mph.	0
14	11:50 a.m. to 12:10 p.m., 6/25, wind north-northeast 5-12 mph; sample taken over three block area of Main Street downtown Niagara Falls area.	0
15	3:00 p.m. to 3:15 p.m., 6/21, beauty shop, large room 30 ft by 30 ft well-ventilated. Sample included a one-second burst of aerosol hair spray into the room. (Three ppm Freon-12 was observed in sample.)	0

was present in the beauty shop sample, its concentration was probably much less than 1 ppm. Freons-11 and -12 are commonly used as propellants in aerosol spray cans; vinyl chloride has also been used as a propellant.

No measurable amounts of vinyl chloride were found in the three Buffalo air samples (Table 5) collected near the homes of the other reported angiosarcoma cases. These samples were all collected on one day within a 4-hour period. The three locations were in the northwest and north-central section of Buffalo; no large chemical plants were observed in the vicinity of these areas. The probability of observing vinyl chloride from just three samples all taken within 4 hours is small. More samples, particularly 12- or 24-hour time-integrated samples, would be necessary to determine conclusively if there are any vinyl chloride emissions in the area.

Table 5. AMBIENT AIR SAMPLES FROM BUFFALO AREA

Sample no.	Remarks	Vinyl chloride concentration, ppb
1	12:45 p.m. to 1:00 p.m., 6/25, wind north-northeast 7-12 mph, in area of Dearborn Street.	0
2	1:10 p.m. to 1:30 p.m., 6/25, wind north-northeast 7-12 mph, in area of Fargo Street.	0
3	3:30 p.m. to 4:00 p.m., 6/25, wind north-northeast 7-12 mph, in area of Elmer Street.	0



## DISCUSSION AND CONCLUSIONS

Emissions of vinyl chloride to the ambient atmosphere at vinyl chloride plants usually occur as leaks from valves, flanges, seals, and pumps. Other losses occur in venting processes and in the opening and purging of equipment in cleanup operations. Accidental release of gas as a result of operator error or equipment failure occurs at times. Vinyl chloride emissions can also result from unreacted vinyl chloride gas that is given off from polyvinyl chloride resins. At fabricating plants the release of vinyl chloride may be facilitated by heating and forming operations.

Vinyl chloride released either continuously or at intervals in the above-mentioned ways is dispersed and diluted by air movements. Amounts of vinyl chloride emitted and climatic conditions at the time of emissions will dictate not only the concentrations to be found in the ambient atmosphere, but also the areas in which highest concentrations will occur.

Many chemical plants in the area were producing or using chemicals such as chlorine, halogenated organics, and inorganics that are emitted into the atmosphere. Although analyses were not conducted to determine concentrations of these various compounds, when samples were taken downwind or between the chemical plants, one's eyes, nose, and throat were irritated by the chlorine or by other compounds present.

People in the residential area near the chemical plants complain of damage done to aluminum exposed to the atmosphere. Aluminum windows and doors are pitted, and aluminum screens are not very durable; most people have replaced the eroded screens with fiberglass or plastic screens. Paints on homes are somewhat affected;

in one instance, a house painted green had slowly turned blue in color. Iron guard rails along the road and telephone pole guide wires near the chemical complex are badly corroded. Aluminum alloy lamp poles on River Drive south of the chemical complex have corrosion on the side facing the chemical plants.

Although the concentrations of vinyl chloride found were not in the parts-per-million range, it is not known what past emissions may have been, or if samples collected were all on days of low emissions or atmospheric conditions favoring dispersal. It has been estimated that up to 4 tons of vinyl chloride per year might be emitted from the Goodyear Chemical Plant through various mentioned losses. These data were obtained by EPA, Emission Standards and Engineering Division, National Environmental Research Center, Research Triangle Park, from a report submitted by the Goodyear Chemical Company.<sup>6</sup>

This survey indicates that residential areas adjacent to the chemical complex in Niagara Falls are exposed to at least low levels of vinyl chloride resulting from emissions by the chemical plants. The residential areas to the east-southeast and west of the Goodyear Chemical Plant are more susceptible to emissions from the plants because of the close proximity of each and the frequency of wind direction from chemical plants to residential areas.

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16. ABSTRACT  A 6-day survey was conducted in the Niagara Falls area to determine the concentration of vinyl chloride in the atmosphere. Samples were obtained in a residential area adjacent to the chemical plants where vinyl chloride emissions were suspected, in areas around the plants, and in other areas of Niagara Falls. The highest concentration of vinyl chloride measured was 40 ppb for a 5-hour integrated sample observed at a residential area two blocks east of a vinyl chloride polymerization plant. Grab samples taken downwind of chemical plants exhibited a high of 28 ppb. Samples taken from downtown Niagara Falls and upwind north of the chemical plants contained no detectable vinyl chloride. The areas surrounding the chemical plants, including the adjacent residential areas, are also affected by emissions into the atmosphere of chlorine and other halogenated compounds as exhibited by the deterioration of metal surfaces, particularly aluminum windows and doors.				
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