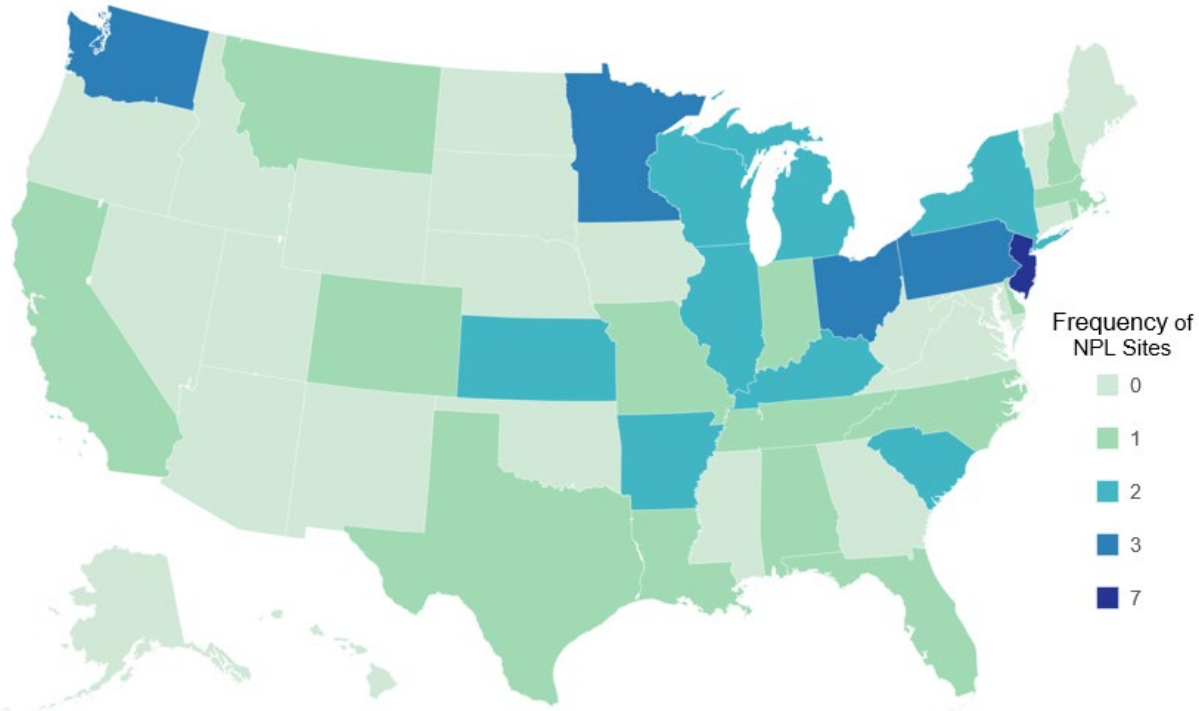


## CHAPTER 5. POTENTIAL FOR HUMAN EXPOSURE

### 5.1 OVERVIEW

Vinyl acetate has been identified in at least 51 of the 1,868 hazardous waste sites that have been proposed for inclusion on the EPA National Priorities List (NPL) (ATSDR 2022a). However, the number of sites in which vinyl acetate has been evaluated is not known. The number of sites in each state is shown in Figure 5-1. Of these sites, 50 are located within the United States, 1 is located in Puerto Rico (not shown).

**Figure 5-1. Number of NPL Sites with Vinyl Acetate Contamination**



Source: ATSDR 2022a

- Workplace exposure via inhalation or dermal contact appears to be the most important source of human exposure to vinyl acetate.
- The general population is most likely exposed to low levels of vinyl acetate through inhalation of contaminated ambient air and cigarette smoke, inhalation of contaminated indoor air from vapor intrusion or vaporization from water (during domestic water use activities) or products containing the compound (e.g., glues and paints), dermal contact with products containing the compound (e.g., glues and paints), and ingestion of low levels of residual vinyl acetate monomers in food

## 5. POTENTIAL FOR HUMAN EXPOSURE

(that may have migrated from plastic food wraps) or food items containing the compound as a starch modifier.

- Low levels of vinyl acetate have been detected in outdoor air, surface water, groundwater, soil, and sediment. Vinyl acetate was detected infrequently and at low levels in the air of residence and office buildings. No biomonitoring data for levels in food or drinking water were located.
- Vinyl acetate is highly water soluble and volatile. It is principally released to the atmosphere as a result of emissions from manufacturing, processing, and storage facilities. Vinyl acetate partitions to the atmosphere, surface water, and groundwater.
- Vinyl acetate undergoes indirect photolysis with an atmospheric lifetime of up to 6 days and undergoes hydrolysis with a half-life of around 7 days. Limited available evidence supports the potential for biodegradation.

## 5.2 PRODUCTION, IMPORT/EXPORT, USE, AND DISPOSAL

### 5.2.1 Production

The manufacturing process most widely used to produce vinyl acetate is the vapor phase process, an oxidative reaction in which ethylene is bubbled through acetic acid at 120°C in the presence of palladium chloride catalyst (Daniels 1983; IARC 1995). Impurities found in the reaction have been reported at <1% (for one manufacturer) and have included acetaldehyde, ethyl acetate, and methyl acetate. Alternative catalysts include salts of rhodium, gold, platinum, ruthenium, vanadium, and iridium (Daniels 1983; Leonard 1970; Llewellyn and Williams 1972). A liquid-phase process can also be used to produce vinyl acetate by bubbling acetylene through a mixture of mercurous sulfate and anhydrous acetic acid (IARC 1995; Leonard 1970). A less important commercial manufacturing process for vinyl acetate involves the reaction between acetaldehyde and acetic anhydride. The intermediate species, ethylidene diacetate, undergoes pyrolytic cleavage to vinyl acetate and acetic acid (Daniels 1983; Leonard 1970). Vinyl acetate can also be synthesized in high yields by reacting vinyl chloride with sodium acetate in solution at 50–75°C, using palladium chloride as a catalyst (Daniels 1983).

Vinyl acetate is normally produced in three grades that differ only in their content of inhibitor, which is added to prevent spontaneous polymerization (Daniels 1983). To obtain these grades, either 3–7, 12–17, or 200–300 ppm p-hydroquinone is added to freshly produced vinyl acetate, depending upon how long the product is to be stored prior to use. Longer storage times require higher concentrations of inhibitor (Daniels 1983). Vinyl acetate is often stored and/or shipped with a variety of other inhibitors including benzoquinones, nitrobenzenes, diphenyls, toluenes, anthracene, phenanthrene, naphthalene, and others (U.S. Coast Guard 1974).

## 5. POTENTIAL FOR HUMAN EXPOSURE

Table 5-1 summarizes information on U.S. companies that manufactured or used vinyl acetate in 2021 (TRI21 2022). In 2019, the following chemical companies manufactured vinyl acetate in the United States: H.B. Fuller Company at their facilities in Morris, Illinois; Celanese at their facilities in Bay City and Pasadena, Texas; Lyondell Chemical Company at their facilities in La Porte, Texas; Kuraray America, Inc. at their facilities in La Porte, Texas; Troy Corporation at their facilities in Phoenix, Arizona; and The Dow Chemical Company at their facilities in Texas City, Texas (EPA 2022). Domestic production of vinyl acetate from 2012 to 2019 was between 1,000,000,000 and < 5,000,000,000 pounds, annually (EPA 2022).

**Table 5-1. Facilities that Produce, Process, or Use Vinyl Acetate**

State <sup>a</sup>	Number of facilities	Minimum amount on site in pounds <sup>b</sup>	Maximum amount on site in pounds <sup>b</sup>	Activities and uses <sup>c</sup>
AL	3	10,000	9,999,999	6
AR	2	10,000	99,999	6, 9, 12
CA	4	100	9,999,999	6, 7, 8, 11
CT	1	100,000	999,999	6
GA	5	1,000	9,999,999	6, 14
IA	1	100,000	999,999	1, 6, 13
IL	9	100	9,999,999	6, 7, 10, 11
IN	3	100	9,999	9, 11, 12, 14
KY	5	1,000	49,999,999	6, 10, 12
LA	4	100,000	9,999,999	6, 12, 14
MA	4	1,000	9,999,999	6, 7, 10, 12
MD	2	0	99	14
MI	2	1,000,000	9,999,999	6
MN	1	10,000	99,999	6, 12, 14
MO	2	1,000	999,999	6, 7
NC	7	1,000	999,999	6, 7, 14
NE	2	10,000	99,999	9, 10, 12
NJ	2	10,000	99,999	6
NY	1	100,000	999,999	6
OH	13	100	9,999,999	6, 7, 10, 12
OR	1	1,000,000	9,999,999	6
PA	2	100,000	999,999	6
SC	11	1,000	49,999,999	6, 7, 9, 12
TN	4	100	9,999	6, 14
TX	39	0	49,999,999	1, 2, 3, 4, 5, 6, 7, 9, 10, 12, 13, 14

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**Table 5-1. Facilities that Produce, Process, or Use Vinyl Acetate**

State <sup>a</sup>	Number of facilities	Minimum amount on site in pounds <sup>b</sup>	Maximum amount on site in pounds <sup>b</sup>	Activities and uses <sup>c</sup>
UT	1	1,000	9,999	9, 12
WI	1	1,000	9,999	7, 8

<sup>a</sup>Post office state abbreviations used.

<sup>b</sup>Amounts on site reported by facilities in each state.

<sup>c</sup>Activities/Uses:

- |                      |                             |                          |
|----------------------|-----------------------------|--------------------------|
| 1. Produce           | 6. Reactant                 | 11. Manufacture Aid      |
| 2. Import            | 7. Formulation Component    | 12. Ancillary            |
| 3. Used Processing   | 8. Article Component        | 13. Manufacture Impurity |
| 4. Sale/Distribution | 9. Repackaging              | 14. Process Impurity     |
| 5. Byproduct         | 10. Chemical Processing Aid |                          |

Source: TRI21 2022 (Data are from 2021)

### 5.2.2 Import/Export

Only a small fraction of the vinyl acetate consumed in the United States is imported. Approximately 1,050,000 pounds of vinyl acetate were imported in 2011, 7,607,00 pounds were reported as imported between 2012 and 2015, and around 13,500,000 pounds of vinyl acetate were reportedly imported between 2016 and 2019 (EPA 2022). These values may be lower than the actual total amount imported; companies must meet a volume threshold to trigger reporting to the EPA Chemical Data Reporting (CDR), and some quantities were not available in the public dataset.

Reported export quantities of vinyl acetate were 209,960,000 pounds between 2012 and 2015 and 366,080,000 pounds between 2016 and 2019 (EPA 2022). These export quantities are representative and may be lower than actual total export quantities due to threshold reporting requirements and publicly withheld data.

### 5.2.3 Use

The primary use for vinyl acetate is as a monomer in the production of polyvinyl acetate, polyvinyl alcohol, and polyvinyl acetals (IARC 1995). Vinyl acetate is also polymerized with vinyl chloride to produce ethylene-vinyl acetate and polyvinyl chloride-acetate copolymers. Industrial uses for vinyl acetate reported in the 2020 CDR included use as an adhesion/cohesion promotor in adhesive manufacturing; a monomer in petrochemical manufacturing, paint and coating manufacturing, plastics and resin manufacturing, and adhesive manufacturing; and an intermediate in plastics and resin

## 5. POTENTIAL FOR HUMAN EXPOSURE

manufacturing. Consumer and commercial uses included use as an adhesive, intermediate, or monomer for packaging; an adhesive or intermediate in single- and two-component glues and adhesives; an intermediate in powder coatings, water-based paints, rubber foam, sporting equipment (e.g., ski boots, bicycle seats), and auto-related films; and an intermediate in construction and building materials (EPA 2022). Vinyl acetate also has a few approved uses as a food additive (masticatory substance, solvent/vehicle) and polymerized vinyl acetate (e.g., ethylene-vinyl acetate copolymers) are approved for use in food packaging (FDA 2022a, 2022b).

### 5.2.4 Disposal

Limited information on preferred disposal methods of vinyl acetate wastes in the United States is available.

Incineration is an accepted disposal method in the United States, but specific methods and conditions were not reported (EPA 1981). The incineration method used in Japan, as reported in 1982 by the International Technical Information Institute, was to incinerate the compound by mixing it with a more flammable solvent and spraying it into a furnace (ITII 1982).

Landfill disposal may also be a common practice as criteria for vinyl acetate monitoring are included for municipal solid waste landfills under the Resource Conservation and Recovery Act (RCRA) (EPA 1991).

## 5.3 RELEASES TO THE ENVIRONMENT

The Toxics Release Inventory (TRI) data should be used with caution because only certain types of facilities are required to report (EPA 2005). This is not an exhaustive list. Manufacturing and processing facilities are required to report information to the TRI only if they employ  $\geq 10$  full-time employees; if their facility is included in Standard Industrial Classification (SIC) Codes 10 (except 1011, 1081, and 1094), 12 (except 1241), 20–39, 4911 (limited to facilities that combust coal and/or oil for the purpose of generating electricity for distribution in commerce), 4931 (limited to facilities that combust coal and/or oil for the purpose of generating electricity for distribution in commerce), 4939 (limited to facilities that combust coal and/or oil for the purpose of generating electricity for distribution in commerce), 4953 (limited to facilities regulated under RCRA Subtitle C, 42 U.S.C. section 6921 et seq.), 5169, 5171, and 7389 (limited S.C. section 6921 et seq.), 5169, 5171, and 7389 (limited to facilities primarily engaged in solvents recovery services on a contract or fee basis); and if their facility produces, imports, or processes

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≥25,000 pounds of any TRI chemical or otherwise uses >10,000 pounds of a TRI chemical in a calendar year (EPA 2005).

### 5.3.1 Air

Estimated releases of 916,449 pounds (~416 metric tons) of vinyl acetate to the atmosphere from 136 domestic manufacturing and processing facilities in 2021, accounted for about 76.5% of the estimated total environmental releases from facilities required to report to the TRI (TRI21 2022). These releases are summarized in Table 5-2.

**Table 5-2. Releases to the Environment from Facilities that Produce, Process, or Use Vinyl Acetate<sup>a</sup>**

State <sup>c</sup>	RF <sup>d</sup>	Reported amounts released in pounds per year <sup>b</sup>							
		Air <sup>e</sup>	Water <sup>f</sup>	UI <sup>g</sup>	Land <sup>h</sup>	Other <sup>i</sup>	Total release		On- and off-site
							On-site <sup>j</sup>	Off-site <sup>k</sup>	
AL	3	2,754	0	0	0	0	2,754	0	2,754
AR	2	1	0	0	2	0	1	2	3
CA	4	5,742	644	0	2,895	0	5,742	3,539	9,281
CT	1	375	0	0	0	0	375	0	375
FL	1	0	0	0	0	0	0	0	0
GA	5	2,151	18	0	90	0	2,151	108	2,259
IL	9	21,361	846	0	1,753	745	21,361	3,344	24,705
IN	3	15,375	0	0	11,558	0	15,375	11,558	26,933
IA	1	15,453	0	0	0	0	15,453	0	15,453
KS	1	0	0	0	0	0	0	0	0
KY	5	48,493	7,077	0	0	0	55,570	0	55,570
LA	4	108,372	0	0	0	0	108,372	0	108,372
MD	2	30	0	0	0	0	30	0	30
MA	4	11,956	5,316	0	0	0	11,956	5,316	17,272
MI	2	4,030	1	0	0	0	4,030	1	4,030
MN	1	3,134	0	0	0	0	3,134	0	3,134
MO	2	626	12	0	0	0	626	12	638
NE	2	1,983	0	0	84	0	1,983	84	2,067
NV	1	0	0	0	0	0	0	0	0
NJ	2	698	0	0	0	0	698	0	698
NY	1	10,425	0	0	0	0	10,425	0	10,425
NC	7	14,185	0	0	0	8,732	14,185	8,732	22,917
OH	13	49,740	5	0	30	3,799	49,740	3,834	53,574

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**Table 5-2. Releases to the Environment from Facilities that Produce, Process, or Use Vinyl Acetate<sup>a</sup>**

State <sup>c</sup>	RF <sup>d</sup>	Reported amounts released in pounds per year <sup>b</sup>							
		Air <sup>e</sup>	Water <sup>f</sup>	UI <sup>g</sup>	Land <sup>h</sup>	Other <sup>i</sup>	Total release		On- and off-site
							On-site <sup>j</sup>	Off-site <sup>k</sup>	
OR	1	11,837	0	0	0	0	11,837	0	11,837
PA	2	4,070	14	0	0	0	4,075	9	4,083
SC	11	133,931	1	0	1,531	0	133,931	1,532	135,462
TN	4	91	0	0	0	0	91	0	91
TX	39	413,163	68,557	146,856	20,360	1,139	561,039	89,036	650,074
UT	1	0	0	0	0	43	0	43	43
WV	1	0	0	0	0	0	0	0	0
WI	1	36,474	0	0	0	0	36,474	0	36,474
<b>Total</b>	<b>136</b>	<b>916,449</b>	<b>82,491</b>	<b>146,856</b>	<b>38,303</b>	<b>14,458</b>	<b>1,071,407</b>	<b>127,149</b>	<b>1,198,556</b>

<sup>a</sup>The TRI data should be used with caution since only certain types of facilities are required to report. This is not an exhaustive list. Data are rounded to nearest whole number.

<sup>b</sup>Data in TRI are maximum amounts released by each facility.

<sup>c</sup>Post office state abbreviations are used.

<sup>d</sup>Number of reporting facilities.

<sup>e</sup>The sum of fugitive and point source releases are included in releases to air by a given facility.

<sup>f</sup>Surface water discharges, wastewater treatment (metals only), and publicly owned treatment works (POTWs) (metal and metal compounds).

<sup>g</sup>Class I wells, Class II0V wells, and underground injection.

<sup>h</sup>Resource Conservation and Recovery Act (RCRA) subtitle C landfills; other onsite landfills, land treatment, surface impoundments, other land disposal, other landfills.

<sup>i</sup>Storage only, solidification/stabilization (metals only), other offsite management, transfers to waste broker for disposal, unknown.

<sup>j</sup>The sum of all releases of the chemical to air, land, water, and underground injection wells.

<sup>k</sup>Total amount of chemical transferred offsite, including to POTWs.

RF = reporting facilities; UI = underground injection

Source: TRI21 2022 (Data are from 2021)

EPA's National Emission Inventory (NEI) database contains information regarding sources that emit criteria air pollutants (CAPs) and their precursors, and hazardous air pollutants (HAPs) for the 50 United States, Washington DC, Puerto Rico, and the U.S. Virgin Islands. Emissions are estimated from multiple sources, including state and local environmental agencies; the TRI database; computer models for on- and off-road emissions; and databases related to EPA's Maximum Achievable Control Technology (MACT) programs to reduce emissions of HAPs. Vinyl acetate emissions estimated from the 2017 inventory are summarized in Table 5-3.

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**Table 5-3. Vinyl Acetate Emissions Estimations from the 2017 National Emissions Inventory**

Emission sector	Pounds of vinyl acetate emitted
Industrial processes; chemical manufacturing	600,056.62
Industrial processes; storage and transfer	190,544.94
Solvent; industrial surface coating and solvent use	150,085.02
Industrial processes; NEC	147,313.63
Industrial processes; pulp and paper	92,017.70
Solvent; non-industrial surface coating	80,314.56
Solvent; graphic arts	18,134.59
Solvent; degreasing	12,069.52
Bulk gasoline terminals	11,296.60
Waste disposal	5,925.43
Fuel combustion; electric generation, coal	1,841.64
Fuel combustion; industrial boilers, ICEs, coal	1,478.61
Gas stations	367.00
Industrial processes; cement manufacturing	340.24
Industrial processes; petroleum refineries	302.93
Fuel combustion; industrial boilers, ICEs, other	209.72
Fuel combustion; electric generation, natural gas	139.31
Fuel combustion; industrial boilers, ICEs, natural gas	47.78
Fuel combustion; electric generation, biomass	34.86
Industrial processes; ferrous metals	13.47
Fuel combustion; commercial/institutional, coal	10.36
Industrial processes; non-ferrous metals	6.16
Fuel combustion; commercial/institutional, natural gas	5.46
Fuel combustion; commercial/institutional, biomass	2.20
Fuel combustion; commercial/institutional, oil	0.37
Fuel combustion; industrial boilers, ICEs, biomass	0.23
Fuel combustion; industrial boilers, ICEs, oil	0.16
Solvent; consumer and commercial solvent use	0.09
Industrial processes; mining	0.05
Fuel combustion; electric generation, other	0.03
Fuel combustion; residential, other	0.01
Fuel combustion; electric generation, oil	0.00

ICE = internal combustion engine; NEC = not elsewhere classified

Source: EPA 2017



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**5.3.2 Water**

Estimated releases of 82,491 pounds (~37.4 metric tons) of vinyl acetate to surface water from 136 domestic manufacturing and processing facilities in 2021, accounted for about 6.9% of the estimated total environmental releases from facilities required to report to the TRI (TRI21 2022). These releases are summarized in Table 5-2.

Recent data on wastewater detections were not located.

**5.3.3 Soil**

Estimated releases of 38,303 pounds (~17.4 metric tons) of vinyl acetate to soil from 136 domestic manufacturing and processing facilities in 2020, accounted for about 3.2% of the estimated total environmental releases from facilities required to report to the TRI (TRI21 2022). Estimated releases of 146,856 pounds (~66.6 metric tons) of vinyl acetate via underground injection from 136 domestic manufacturing and processing facilities in 2020, accounted for about 12% of the estimated total environmental releases from facilities required to report to the TRI (TRI21 2022). These releases are summarized in Table 5-2.

**5.4 ENVIRONMENTAL FATE****5.4.1 Transport and Partitioning**

No information was found in the available literature regarding the transport and partitioning of vinyl acetate in environmental media. Based on its physical/chemical properties, vinyl acetate is expected to partition to the atmosphere and surface water and groundwater (Fujisawa and Masuhara 1981; Hansch and Leo 1979).

Vinyl acetate is a volatile compound that is released mainly to the atmosphere. Vinyl acetate is also highly soluble in water. Therefore, dissolution of vinyl acetate released to the atmosphere in rainwater and transport of the compound back to surface waters and soils in wet deposition can be expected.

**Air.** The reported vapor pressure for vinyl acetate is 83 mm Hg at 20°C, indicating that it will exist primarily in the vapor phase when released to the ambient atmosphere (Verschuere 1983). Removal of

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the compound from the atmosphere may occur during precipitation events, based on reported water solubilities of 1 g/100 mL and  $2 \times 10^4$  mg/L (EPA 2012; Windholz 1983).

**Water.** Using the vapor pressure and water solubility data presented in Table 4-2, a Henry's law constant value of  $5.11 \times 10^{-4}$  atm·m<sup>3</sup> mol<sup>-1</sup> can be calculated. The magnitude of this value indicates that volatilization to the atmosphere will be an important transport process for vinyl acetate released to surface waters. Using this value and the methods reviewed by Thomas (1990), a volatilization half-life of about 4 hours at 20°C can be estimated for a river 1 meter deep flowing at a current of 1 m/second, with a wind velocity of 3 m/second.

**Sediment and Soil.** Based on the calculated Henry's law constant, vinyl acetate released to moist surface soils is also expected to volatilize to the atmosphere, but this may be limited by its high water solubility. Releases of vinyl acetate to subsurface soils may leach to and be transported in groundwater, depending upon site-specific hydrogeological conditions, if the compound is not transformed or degraded. Experimental partition coefficients ( $K_d$ ) or n-octanol/water partition coefficient normalized to organic carbon ( $K_{oc}$ ) were not available; however, estimated log  $K_{oc}$  values were 0.75 and 1.3 (Table 4-2), suggesting negligible sorption to soils and sediments. Negligible sorption of vinyl acetate is further supported by the high measured water solubility and low logarithm of the n-octanol/water partition coefficient (log  $K_{ow}$ ).

**Other Media.** Experimental data for bioaccumulation of vinyl acetate were not located. The log  $K_{ow}$  can be used to estimate the potential for bioaccumulation. Log  $K_{ow}$  values for vinyl acetate have been reported to be 0.21 (Fujisawa and Masuhara 1981) and 0.73 (Howard 1989). The magnitude of these values indicates that bioconcentration and food chain biomagnification are not expected to be important processes for vinyl acetate.

#### 5.4.2 Transformation and Degradation

**Air.** Vinyl acetate does not absorb ultraviolet light at wavelengths >250 nm (Daniels 1983); therefore, direct photolytic degradation of the compound in the troposphere is not expected to occur. However, vinyl acetate has been found to undergo rapid photochemical oxidation and polymerization in laboratory studies in the absence of inhibitor (NLM 2022). The average second-order rate constant for reaction with singlet molecular oxygen has been reported to be 0.82 L mole<sup>-1</sup> second<sup>-1</sup> (Datta and Rao 1979). In smog chamber studies with NO<sub>x</sub> concentrations representative of rural and urban atmospheres, the

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photooxidation half-life of vinyl acetate was determined to be 4.1–6.5 hours (Joshi et al. 1982). In a laboratory at room temperature, tropospheric lifetimes of vinyl acetate based on reactions with OH, NO<sub>3</sub>, and O<sub>3</sub> were estimated per reactant to be 6 hours, 6 days, and 5 days, respectively (Picquet-Varrault et al. 2010).

**Water.** Vinyl acetate undergoes hydrolysis in surface water and groundwater. The hydrolytic half-life of the compound at 25°C and pH 7.0 has been estimated to be 7.3 days (Mabey and Mill 1978). Decreasing pH decreases the hydrolysis rate; for example, the rate is minimal at pH 4.4 (Daniels 1983). Acetic acid and acetaldehyde are the main products of vinyl acetate hydrolysis (Daniels 1983; Stuckey et al. 1980).

Vinyl acetate also undergoes biologically-mediated transformation. The results of several older laboratory studies with aqueous solutions of the compound suggest the occurrence of biodegradation by domestic sewage effluent microorganisms both under aerobic (Pahren and Bloodgood 1961; Price et al. 1974) and anaerobic (Chou et al. 1979; Stuckey et al. 1980) conditions. Nieder et al. (1990) studied 17 isolates of bacteria and yeasts capable of utilizing vinyl acetate as a sole carbon source under aerobic conditions from samples of domestic sewage and loamy soil. Microorganisms contained in a sludge inoculum were also found to be capable of biotransforming vinyl acetate under anaerobic conditions. Under both aerobic and anaerobic conditions, enzymatic hydrolysis of vinyl acetate yielded acetaldehyde as a metabolic intermediate and acetate as an end product, although the reaction was more rapid under aerobic conditions. A half-life of 12 hours was obtained for the enzymatic hydrolysis utilizing one of the bacterial isolates under aerobic conditions, whereas the half-life for the nonenzymatic hydrolysis of the compound in a sterile medium was found to be 60 hours (Nieder et al. 1990).

Vinyl acetate is readily biodegradable, suggesting that it will not be persistent in the environment under aerobic conditions. In an Organisation for Economic Cooperation and Development (OECD) 301C test guideline study of ready biodegradability, vinyl acetate achieved 90% degradation based on biological oxygen demand and 98% degradation based on total organic carbon after 28 days (NITE 2010). One hundred percent test substance loss was also observed, due in part to hydrolysis to acetic acid and acetaldehyde.

**Sediment and Soil.** In soils, vinyl acetate is also expected to be transformed by hydrolysis and biotransformation. The rate of hydrolysis should increase as soil moisture content and pH increase. Microbial isolates obtained from a loamy soil were found to be capable of utilizing vinyl acetate as a sole carbon source under aerobic conditions (Nieder et al. 1990). Metabolism studies utilizing one of the

## 5. POTENTIAL FOR HUMAN EXPOSURE

bacterial isolates indicated that vinyl acetate was transformed via enzymatic hydrolysis to acetaldehyde and acetate. The half-life for this biologically mediated hydrolysis was found to be about one-fifth that of the nonenzymatic hydrolysis of the compound (12 versus 60 hours). Three bacteria strains isolated from soil were able to completely degrade vinyl acetate at concentrations of 47 and 124 g/m<sup>3</sup> after 5–12 hours under aerobic conditions (Greń et al. 2011). Buildup of acetaldehyde as an intermediate degradation product inhibited microbial growth at concentrations >10 g/m<sup>3</sup>.

Aqueous solutions containing 4.5 g/L of polyvinyl acetate have been reported to undergo biotransformation by the soil fungi *Aspergillus niger* and *Penicillium* following incubation for 15 days at 22–25°C (Garcia 1988). Polyvinyl acetate was the sole carbon source in the test media. Evidence of biotransformation included increased biomass of the fungi and increased esterase levels in the media.

**Other Media.** No studies were located regarding the degradation or transformation of vinyl acetate in other media.

## 5.5 LEVELS IN THE ENVIRONMENT

Reliable evaluation of the potential for human exposure to vinyl acetate depends, in part, on the reliability of supporting analytical data from environmental samples and biological specimens. Concentrations of vinyl acetate in unpolluted atmospheres and in pristine surface waters are often so low as to be near the limits of current analytical methods. In reviewing data on vinyl acetate levels monitored or estimated in the environment, it should also be noted that the amount of chemical identified analytically is not necessarily equivalent to the amount that is bioavailable.

Table 5-4 shows the lowest limit of detections that are achieved by analytical analysis in environmental media. An overview summary of the range of concentrations detected in environmental media is presented in Table 5-5.

**Table 5-4. Lowest Limit of Detection Based on Standards<sup>a</sup>**

Media	Detection limit	Reference
Air	3.0–290 ppbv 1.0–19 µg/m <sup>3</sup> (0.28–5.4 ppbv; indoor)	WQP 2022 Montana DEQ 2012
Drinking water	0.031 ppb 11.8–23.0 ppb	Munch and Eichelberger 1992 EPA 1996

## 5. POTENTIAL FOR HUMAN EXPOSURE

**Table 5-4. Lowest Limit of Detection Based on Standards<sup>a</sup>**

Media	Detection limit	Reference
Surface water and groundwater	0.031 ppb 11.8–23.0 ppb	Munch and Eichelberger 1992 EPA 1996
Soil	2–15 ppb	WQP 2022
Sediment	9.00–29.0 ppb	WQP 2022
Whole blood <sup>b</sup>	–	–

<sup>a</sup>Detection limits based on using appropriate preparation and analytics. These limits may not be possible in all situations.

<sup>b</sup>No analytical methods for detection of vinyl acetate in whole blood were located.

**Table 5-5. Summary of Environmental Levels of Vinyl Acetate<sup>a</sup>**

Media	Low	High	For more information
Outdoor air (ppbv)	0.333	10.6	Section 5.5.1
Indoor air (ppbv)	1.9	9.1	Section 5.5.1
Surface water (ppb)	0.5	200	Section 5.5.2
Ground water (ppb)	0.5	200	Section 5.5.2
Drinking water <sup>b</sup>	–	–	
Food <sup>b</sup>	–	–	
Soil (ppb)	2.6	500	Section 5.5.3
Sediment (ppb)	16	36	Section 5.5.3

<sup>a</sup>Unit conversion: ppb = µg/L (aqueous); = µg/kg (sediment and soil); ppbv = 24.45 concentration µg/m<sup>3</sup>/86.09 g/mol (air). Summary values represent most recent ambient data available. Ranges do not reflect values below the limit of detection.

<sup>b</sup>No data were located.

Detections of vinyl acetate in air, water, and soil at NPL sites are summarized in Table 5-6.

**Table 5-6. Vinyl Acetate Levels in Water, Soil, and Air of National Priorities List (NPL) Sites**

Medium	Median <sup>a</sup>	Geometric mean <sup>a</sup>	Geometric standard deviation <sup>a</sup>	Number of quantitative measurements	NPL sites
Water (ppb)	No data	No data	No data	No data	No data
Soil (ppb)	580	321	30.7	8	6
Air (ppbv)	45.4	444	51.8	3	3

<sup>a</sup>Concentrations found in ATSDR site documents from 1981 to 2022 for 1,868 NPL sites (ATSDR 2022a). Maximum concentrations were abstracted for types of environmental media for which exposure is likely. Pathways do not necessarily involve exposure or levels of concern.

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**5.5.1 Air**

The EPA maintains data collected from outdoor air monitoring sites across the country, which report annual averages of HAPs detected at these monitoring sites. The earliest available data from this source are from 1998, where annual averages per monitor ranged from 0.53 to 1.33 ppbv vinyl acetate (EPA 2021). Annual averages per monitor ranged from 0 (not detected) to 14.8 ppbv between 2000 and 2009 (year range average: 0.730 ppbv) and from 0 to 4.90 ppbv between 2010 and 2019 (year range average: 0.333 ppbv). The most recent data available report averages of vinyl acetate by monitors in 2020 of 0–10.6 and 0–7.85 ppbv in 2021.

The EPA maintains a Water Quality Portal database which aggregates air monitoring data from the National Water Information System (NWIS) and STORage and RETrieval (STORET) system. Air samples data were limited to those collected between May and June 2004, from the Superfund Intermountain Waste Oil Refinery site in Bountiful, Utah; vinyl acetate was not detected (WQP 2022).

Indoor air samples were collected by the Montana Department of Environmental Quality in March 2012, from 50 nonsmoking residential buildings in urban and rural areas (Montana DEQ 2012). Vinyl acetate was detected in 2% of samples analyzed; an average of  $9.3 \pm 3.89 \mu\text{g}/\text{m}^3$  (ranging from 6.7 to  $32 \mu\text{g}/\text{m}^3$ ; equivalent to  $2.6 \pm 1.10$  and 1.9–9.1 ppbv) was reported. In another study, indoor air samples were collected between 2013 and 2015 in school and office buildings in 18 states (Rago et al. 2021). Vinyl acetate was detected in 6% of samples ( $n=14,668$ ) at concentrations ranging from 1.3 to  $1.83 \mu\text{g}/\text{m}^3$  (0.37–0.520 ppbv); vinyl acetate was detected in office air samples only.

**5.5.2 Water**

Surface and ground water monitoring data was available from EPA's NWIS, STORET, and STEWARDS systems. No drinking water monitoring data were located for vinyl acetate. Vinyl acetate is not a contaminant that has been monitored for during the first five rounds of the Unregulated Contaminant Monitoring Rule (UCMR), which monitors occurrence data for contaminants in public water systems (PWSs) around the United States that may be present but are not currently subject to EPA drinking water regulations.

Levels detected in ambient surface water samples show a trend of increasing in the 1990s and early 2000s, followed by a decrease in the 2010s. Between 1988 and 1999, vinyl acetate was detected in 3.1%

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of samples, with an average concentration of 7.69 µg/L (range 1.00–250.0 µg/L; n=2,494) (WQP 2022). During the next decade, this increased to a 59% detection rate in water samples collected between 2000 and 2009, with an average concentration of 22.18 µg/L (range 0.005–5,000.00 µg/L; n=11,068). However, between 2010 and 2019, vinyl acetate was only detected in 13% of samples, with an average of 9.39 µg/L (range 0.5–200.00 µg/L; n=6,457). Vinyl acetate was not detected in surface water samples (n=7) collected by the New Mexico Environmental Department in 2020 (WQP 2022).

A similar trend was observed for ambient ground water samples. Between 1988 and 1999, vinyl acetate was detected in 3.5% of ambient ground water samples at an average concentration of 12 µg/L (range 1–250 µg/L; n=1,295). Between 2000 and 2009, vinyl acetate was detected in 60% of ambient groundwater samples at an average concentration of 21 µg/L (range 1–5,000 µg/L; n=9,267). Vinyl acetate was detected at an average of 9.0 µg/L (range 0.5–200 µg/L; n=6,008) in 13% of samples from 2010 to 2018. Vinyl acetate was not detected in ground water samples collected in 2019 (n=126) or between 2020 and March 2022 (n=36) by the Arizona Department of Environmental Quality (WQP 2022).

Groundwater monitoring data for Superfund sites is also available; these values may be higher than typical ambient concentrations due to the sites superfund status and should not be used for general population exposure. EPA Region 10 historical superfund groundwater data for an unspecified site collected between 1987 and 1989 had an average vinyl acetate concentration of 34 µg/L (range 10–1,000 µg/L). Groundwater samples collected from the Boomsnub Superfund site in Vancouver, Washington, from 1995 to 2001 had an average of 6.2 µg/L detected (range 0.80–200.00 µg/L). Vinyl acetate was not detected in groundwater samples collected from the Intermountain Waste Oil Refinery Superfund site in 2004. Groundwater samples collected between 2002 and 2007 from the Portland Harbor Superfund site in Oregon had an average of 4.9 µg/L vinyl acetate detected (range 0.67–91 µg/L). Groundwater samples from the Palermo Wellfield superfund site in Tumwater, Washington, collected between 2013 and 2020 had an average vinyl acetate concentration of 1.30 µg/L (WQP 2022).

### 5.5.3 Sediment and Soil

Sediment monitoring data is available through the EPA's NWIS and STORET systems. Between 1989 and 1998, vinyl acetate was detected in 6.1% of sediment samples at an average of 36,000 µg/kg (range 5.5–350,000 µg/kg; n=377). The most recent sediment samples were collected in 2000; vinyl acetate was detected in 11% of samples at an average of 25 µg/kg (range 16–36 µg/kg; n=85) (WQP 2022).

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Sediment samples collected in July of 2003 and February of 2006 at the Lower Duwamish Waterway superfund site in Seattle, Washington, had an average concentration of 7.0 µg/kg (range 4.6–9.9 µg/kg) (WQP 2022). Sediment samples collected between 2002 and 2007 from the Portland Harbor Superfund site in Oregon had vinyl acetate detected at an average of 314 µg/kg (range 0.41–23,000 µg/kg). Samples collected in May of 2021 at the Palermo Wellfield Superfund site in Tumwater, Washington, had an average of 11 µg/kg vinyl acetate detected (range 4.8–24 µg/kg) (WQP 2022). These values may be elevated in comparison to ambient data and should not be considered reflective of general population exposure.

From ambient monitoring of soil between 1997 and 2009, vinyl acetate was detected at an average of 64 µg/kg (range 2.6–500 µg/kg; n=748) in 1.7% of samples (WQP 2022). Vinyl acetate was not detected in soil samples collected in 2004 from the Intermountain Waste Oil Refinery superfund site in Bountiful, Utah (WQP 2022). More recent soil monitoring data are not available.

#### 5.5.4 Other Media

Vinyl acetate was not detected in 251 fish tissue samples collected between 1984 to 1992 in Indiana (WQP 2022). The top species represented included *Cyprinus carpio*, *Ictalurus punctatus*, *Ictiobus cyprinellus*, and *Micropterus salmoides*. More recent fish biomonitoring data are not available.

Vinyl acetate was detected in the volatile organic carbon (VOC) emissions of one carpet type representative of those used in residence, school, and office buildings. The measured emission rates were 853±41.5 µg/m<sup>2</sup>/hour over 24 hours and 103±20.2 µg/m<sup>2</sup>/hour over 168 hours (1 week) (Hodgson et al. 1993).

Available monitoring data for other media are limited to reports of vinyl acetate as a constituent of the vapor phase of cigarette smoke at concentrations of 0.4 µg/cigarette (Guerin 1980) and 0.5 µg/puff (Battista 1976). A more recent analysis of reference and commercial Chinese cigarettes reported 0.096–1.014 µg/vinyl acetate per cigarette (Xu et al. 2017).

Since vinyl acetate has a few approved uses as a food additive, it may be present in certain foods. However, no food biomonitoring data are available.



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**5.6 GENERAL POPULATION EXPOSURE**

Quantitative exposure estimates for the general population are not available; however, vinyl acetate has been detected in outdoor air, surface water, groundwater, and soil. Concentrations have typically been low, and vinyl acetate has been infrequently detected in soil and water. The ambient environment may not be a significant exposure route due to the relatively short residence times of vinyl acetate. Therefore, exposure to the general population is expected to be low. The most likely sources of general population exposure to very small amounts of vinyl acetate include: (1) inhalation of contaminated ambient air and cigarette smoke; (2) inhalation, dermal contact, or ingestion of residual monomers in consumer products containing the compound (e.g., paints, adhesives); (3) ingestion of food items containing vinyl acetate; and (4) dermal and inhalation exposure during domestic water use activities (e.g., showering) if water contains vinyl acetate. Vapor intrusion of vinyl acetate into buildings and residences from contaminated groundwater may result in indoor air inhalation exposure. Since vinyl acetate has been detected at NPL sites (see Section 5.1), populations living near hazardous waste sites may be exposed.

Vapor intrusion may be a potential source of vinyl acetate exposure, though indoor and ambient sources may also contribute to indoor air levels. The EPA (2016) includes vinyl acetate in its Vapor Intrusion Screening Levels (VISL) Calculator, indicating that it is sufficiently volatile and sufficiently toxic to be considered a concern for vapor intrusion from soil and ground water. A review of vapor intrusion data from ATSDR public health assessments identified five sites with vinyl acetate in soil or outdoor air; vinyl acetate was detected in indoor air at three of the sites ranging from 0.21  $\mu\text{g}/\text{m}^3$  (0.06 ppb) to 17.6  $\mu\text{g}/\text{m}^3$  (5 ppb) (ATSDR 2005a, 2005b, 2005c, 2007, 2009). Accordingly, ATSDR (2016) recommends that health assessors should evaluate potential health implications of vapor intrusion for vinyl acetate during site risk assessments.

Vinyl acetate in water is expected to rapidly volatilize; thus, there is potential for inhalation exposure during domestic water use activities, primarily showering and bathing. ATSDR's three-compartment Shower and Household-Use Exposure (SHOWER) model predicts air concentrations in the shower stall, bathroom, and main house throughout the day by estimating the contribution from showering or bathing and the contribution from other water sources in the house, such as the dishwasher, clothes washer, and faucets (ATSDR 2022b). This information, along with human activity patterns, is used to calculate a daily time-weighted average (TWA) exposure concentration via inhalation exposure and from dermal uptake from skin contact. ATSDR's SHOWER model is available by sending a request to [showermodel@cdc.gov](mailto:showermodel@cdc.gov). Reasonable Maximum Exposure (RME) levels for vinyl acetate were calculated

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based on concentrations in water and outdoor air; RME levels for different exposure groups are presented in Table 5-7. Since treated water levels were not available, the average of the most recent detections in groundwater and surface water were used as a surrogate value (discussed in Section 5.5.2), and representative outdoor air levels reported by EPA's HAP monitoring sites (discussed in Section 5.5.1) were used.

**Table 5-7. RME Daily Inhalation Dose in  $\mu\text{g}/\text{kg}/\text{day}$  and Administered Dermal Dose of Vinyl Acetate for the Target Person**

Exposure group	Inhalation	Dermal
Birth-<1 year	4.2	0.0073
1-<2 years	4.5	0.0068
2-<6 years	2.9	0.0058
6-<11 years	1.6	0.0047
11-<16 years	1.1	0.0039
16-<21 years	0.81	0.0036
Adult	0.73	0.0035
Pregnant and breastfeeding women	1.0	0.0035

Source: ATSDR 2022b

## 5.7 POPULATIONS WITH POTENTIALLY HIGH EXPOSURES

Workers involved in the production, processing, storage, transport, or use of vinyl acetate are potentially exposed to high concentrations of the compound (IARC 1995; NIOSH 1978, 1983, 1990). Workplace air concentration levels reviewed by NIOSH (1978, 1983) were generally within the recommended 15-minute ceiling limit of 4 ppm. In a corn starch processing plant, where vinyl acetate was one of the chemicals used to modify starch, air levels ranged from 0.94 ppmv on a tank to 20 ppmv on a starch drying press (NIOSH 1990). Personal air samples ranged measured for a period of 165 minutes ranged from below detectable to 5.7 ppmv (NIOSH 1990). In another survey of vinyl acetate production facilities in Texas, the following workplace airborne concentrations were reported: average time-weighted average concentrations of 5.2–8.2 ppmv; average breathing zone concentrations of 8.6 ppmv; intermittent exposure concentrations of about 50 ppmv; and potential short-term exposures of up to 300 ppmv (Deese and Joyner 1969). More recent occupational exposure data are not available.

Members of the general population living in the vicinity of industrial point emission sources, and individuals living near waste sites that are contaminated with vinyl acetate may also be exposed to

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potentially high concentrations of the compound. The sizes of these populations and the concentrations of vinyl acetate in the contaminated media to which these people may be exposed have not been adequately characterized.

Based on measured vapor concentrations from cigarettes, smokers have potentially increased exposure to vinyl acetate. In comparison, second-hand smoke exposure may not be as high; in an exposure chamber study of room air levels after 4-hour use of cartridge- or tank-based e-vapor products and cigarettes, vinyl acetate was not detected in the air (limit of detection of  $6.11 \mu\text{g}/\text{m}^3$ , or 1.74 ppbv) after pre-specified (80 puffs per volunteer) or *ad libitum* use (Liu et al. 2017).