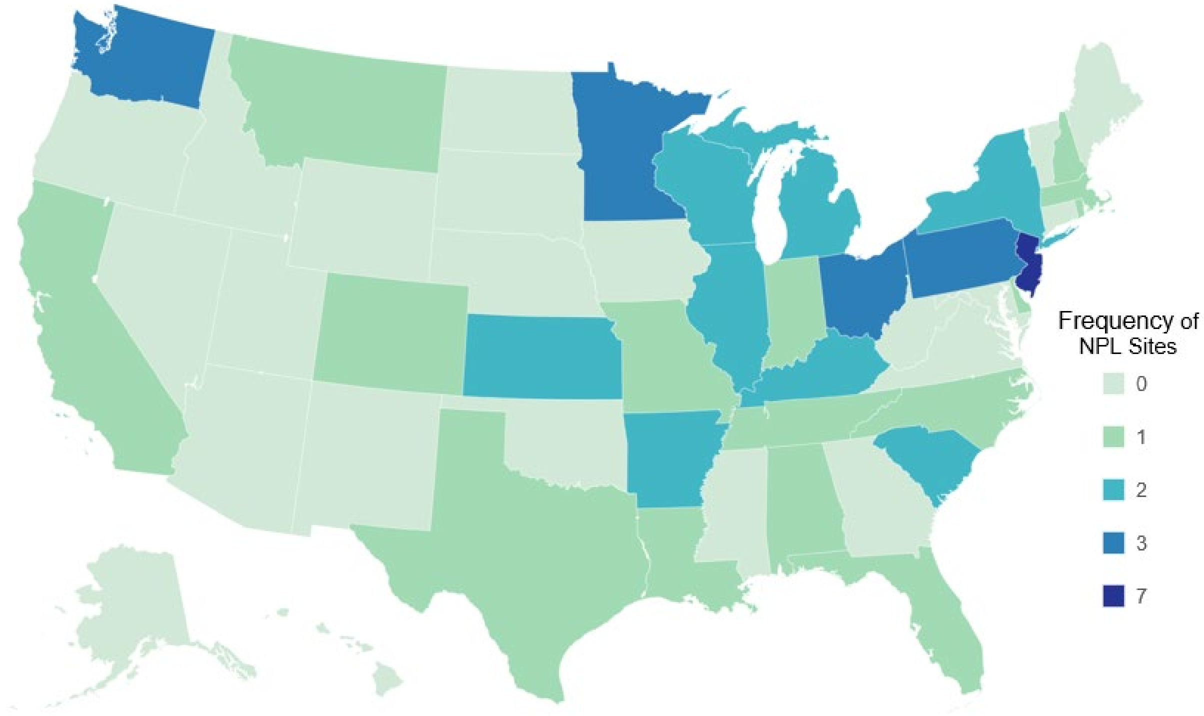
CHAPTER 5. POTENTIAL FOR HUMAN EXPOSURE

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 (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. Vinyl acetate has been infrequently detected in surface water and groundwater. 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).

Table 5-1 summarizes information on companies that reported the production, import, or use of vinyl acetate for the Toxics Release Inventory (TRI) in 2023 (TRI23 2024). TRI data should be used with caution since only certain types of industrial facilities are required to report. This is not an exhaustive list. 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 2022a). Domestic production of vinyl acetate from 2016 to 2019 was between 1,000,000,000 and <5,000,000,000 pounds, annually (EPA 2022a).

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

State[a]	Number of facilities	Minimum amount on site in pounds[b]	Maximum amount on site in pounds[b]	Activities and uses[c]
AL	3	100,000 (or N/A)	9,999,999 (or N/A)	6
AR	1	10,000	99,999	2, 3, 9, 12
CA	4	100 (or N/A)	9,999,999 (or N/A)	6, 7
CT	1	100,000	999,999	6
FL	1	1,000	9,999	7
GA	3	1,000,000 (or N/A)	9,999,999 (or N/A)	6
IA	1	100,000	999,999	1, 6, 13
IL	9	0 (or N/A)	9,999,999 (or N/A)	6, 10, 11
IN	1	1,000	9,999	14
KS	1	N/A	N/A	
KY	5	1,000 (or N/A)	49,999,999 (or N/A)	6, 10, 12
LA	5	10,000	9,999,999	6, 12, 14
MA	4	1,000	9,999,999	6, 7, 10, 12
MD	2	0 (or N/A)	99 (or N/A)	14
MI	1	100,000	999,999	6
MO	2	1,000	99,999	6, 7, 9
NC	6	10,000	999,999	6, 7
NE	2	1,000	99,999	9, 10, 12
NJ	4	10,000 (or N/A)	999,999 (or N/A)	6, 7
NV	1	N/A	N/A	
NY	1	10,000,000	49,999,999	6
OH	11	100 (or N/A)	9,999,999 (or N/A)	6, 7, 12
OR	1	1,000,000	9,999,999	6

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

State[a]	Number of facilities	Minimum amount on site in pounds[b]	Maximum amount on site in pounds[b]	Activities and uses[c]
PA	2	100,000	999,999	6
SC	10	10,000	49,999,999	6, 12
TN	4	100 (or N/A)	99,999 (or N/A)	6, 9, 12, 14
TX	36	0 (or N/A)	49,999,999 (or N/A)	1, 2, 3, 4, 5, 6, 7, 9, 10, 12, 13, 14
UT	1	1,000	9,999	9, 12
WI	1	1,000	9,999	7, 8
WV	1	N/A	N/A	

[a] Post office state abbreviations used.

[b] Amounts on site reported by facilities in each state. Facilities may report N/A (not applicable) instead of a numeric value “if the waste stream that contains or contained the EPCRA Section 313 chemical is not directed to the relevant environmental medium, or if leaks, spills, and fugitive emissions cannot occur” (EPA 2022b).

[c] Activities/uses:

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

EPCRA = Emergency Planning and Community Right-to-Know Act

Source: TRI23 2024 (Data are from 2023)

5.2.2 Import/Export

Only a small fraction of the vinyl acetate consumed in the United States is imported. Approximately 14,074,000 pounds of vinyl acetate were imported in 2023, 28,788,000 pounds were imported in 2022, and around 69,202,000 pounds of vinyl acetate were imported in 2021 (USITC 2024). In 2023, the United States imported vinyl acetate primarily from Singapore, Saudia Arabia, South Korea, and China.

Exports of vinyl acetate greatly exceed imports. The United States exported approximately 1,137,000,000 pounds in 2023; 1,093,000,000 pounds in 2022; and 1,172,000,000 pounds of vinyl acetate in 2021 (USITC 2024). Some of the top importers of American vinyl acetate were Belgium, Mexico, Canada, and Brazil.

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 (EVA) 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 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 2022a). Vinyl acetate also has a few approved uses as a food additive (masticatory substance, solvent/vehicle) and polymerized vinyl acetate (e.g., EVA copolymers) are approved for use in food packaging (FDA 2022a, 2022b). EVA copolymers are also used in solar photovoltaic cells (Lee et al. 2008). Due to low toxicity and biocompatibility, EVA copolymers are also used to make medical devices, drug delivery systems, and implants; advances in 3D-printing technologies continue to expand these applications (Brandl et al. 2024; Moroni et al. 2023).

5.2.4 Disposal

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

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 of the polymerized solid 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 2022b). This is not an exhaustive list. Manufacturing and processing facilities are required to report information to the TRI only if they employ ≥10 full-time employees; if their facility's North American Industry Classification System (NAICS) codes is covered under EPCRA Section 313 or is a federal facility; and if their facility manufactures (defined to include importing) or processes any TRI chemical in excess of 25,000 pounds, or otherwise uses any TRI chemical in excess of 10,000 pounds, in a calendar year (EPA 2022b).

5.3.1 Air

Estimated releases of 858,455 pounds (~389 metric tons) of vinyl acetate to the atmosphere from 125 domestic manufacturing and processing facilities in 2023, accounted for about 72% of the estimated total environmental releases from facilities required to report to the TRI (TRI23 2024). These releases are summarized in Table 5-2.

Table 5-2. Releases to the Environment from Facilities that Produce, Process, or Use Vinyl Acetate[a]

		Reported amounts released in pounds per year[b]							
							Total release		
State[c]	RF[d]	Air[e]	Water[f]	UI[g]	Land[h]	Other[i]	On-site[j]	Off-site[k]	On- and off-site
AL	3	2,420	0[l]	0	0	0	2,420	0	2,420
AR	1	1	0	0	0	0	1	0	1
CA	4	4,565	580	0	1,937	0	4,574	2,509	7,082
CT	1	496	0	0	0	0	496	0	496
FL	1	423	0	0	43	0	423	43	466
GA	3	966	14	0	351	0	966	365	1,331
IL	9	17,503	512	0	500	100	17,503	1,112	18,615
IN	1	40	0	0	406	0	40	406	446
IA	1	7,622	0	0	0	0	7,622	0	7,622
KS	1	<RQ	<RQ	<RQ	<RQ	<RQ	<RQ	<RQ	<RQ
KY	5	53,722	0	0	0	0	61,022	0	61,022
LA	5	112,395	0	0	48,023	9	160,395	32	160,427
MD	2	38	0	0	125	0	38	125	163
MA	4	8,838	3,852	0	0	0	8,838	3,852	12,690
MI	1	196	0	0	0	0	196	0	196
MO	2	597	1	0	0	0	597	1	598
NE	2	1,517	0	0	9	0	1,517	9	1,526
NV	1	<RQ	<RQ	<RQ	<RQ	<RQ	<RQ	<RQ	<RQ
NJ	4	1,758	8	0	0	2,132	1,758	2,140	3,898
NY	1	9,554	0	0	0	0	9,554	0	9,554
NC	6	9,065	0	0	0	2,742	9,065	2,742	11,807
OH	11	55,895	1	0	12	2,121	55,895	2,134	58,028
OR	1	11,555	0	0	0	0	11,555	0	11,555

Table 5-2. Releases to the Environment from Facilities that Produce, Process, or Use Vinyl Acetate[a]

		Reported amounts released in pounds per year[b]							
							Total release		
State[c]	RF[d]	Air[e]	Water[f]	UI[g]	Land[h]	Other[i]	On-site[j]	Off-site[k]	On- and off-site
PA	2	3,875	16	0	0	0	3,880	16	3,896
SC	10	135,854	1	0	3	26	135,854	30	135,884
TN	4	120	0	0	3,417	4	120	3,421	3,541
TX	36	394,250	129,123	115,377	11,845	1,062	513,220	139,350	652,569
UT	1	0	0	0	1	0	0	1	1
WV	1	<RQ	<RQ	<RQ	<RQ	<RQ	<RQ	<RQ	<RQ
WI	1	25,191	0	0	0	0	25,191	0	25,191
Total	125	858,455	134,107	115,377	66,672	8,196	1,032,739	158,286	1,191,025

[a] 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.
[b] Data in TRI are maximum amounts released by each facility.
[c] Post office state abbreviations are used.
[d] Number of reporting facilities.
[e] The sum of fugitive and point source releases are included in releases to air by a given facility.
[f] Surface water discharges, wastewater treatment (metals only), and publicly owned treatment works (POTWs) (metal and metal compounds).
[g] Class I wells, Class II-V wells, and underground injection.
[h] Resource Conservation and Recovery Act (RCRA) subtitle C landfills; other onsite landfills, land treatment, surface impoundments, other land disposal, other landfills.
[i] Storage only, solidification/stabilization (metals only), other off-site management, transfers to waste broker for disposal, unknown.
[j] The sum of all releases of the chemical to air, land, water, and underground injection wells.
[k] Total amount of chemical transferred off-site, including to POTWs.
[l] Due to reporting guidelines, a zero may represent that the facility or facilities in each state's row reported "0," and "NA," or left the cell blank in their Form R submission.

NA = not applicable; RF = reporting facilities; RQ = reportable quantity; UI = underground injection

Source: TRI23 2024 (Data are from 2023)

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 2020 inventory are summarized in Table 5-3.

Table 5-3. Vinyl Acetate Emissions Estimations from the 2020 National Emissions Inventory

Emission sector	Pounds of vinyl acetate emitted
Fires, prescribed fires	1,197,648
Industrial processes, chemical manufacturing	715,417
Solvent, industrial surface coating and solvent use	528,141
Solvent, consumer and commercial solvent use	343,560
Industrial processes, storage and transfer	160,023
Industrial processes, NEC	72,944
Industrial processes, pulp and paper	63,133
Industrial processes, cement manufacturing	27,015
Solvent, graphic arts	19,233
Waste disposal	17,187
Bulk gasoline terminals	10,777
Solvent, degreasing	9,460
Gas stations	1,379
Fuel combustion, industrial boilers, ICEs, coal	1,193
Fuel combustion, electric generation, coal	722
Industrial processes, petroleum refineries	307
Fuel combustion, electric generation, natural gas	211
Fuel combustion, industrial boilers, ICEs, oil	163
Fuel combustion, industrial boilers, ICEs, other	148
Fuel combustion, industrial boilers, ICEs, natural gas	122
Dust, construction dust	50
Solvent, non-industrial surface coating	39
Fuel combustion, commercial/institutional, natural gas	27
Fuel combustion, electric generation, biomass	10
Industrial processes, non-ferrous metals	5
Fuel combustion, commercial/institutional, biomass	2
Industrial processes, ferrous metals	2
Industrial processes, mining	0
Fuel combustion, industrial boilers, ICEs, biomass	0
Fuel combustion, residential, other	0
Fuel combustion, electric generation, oil	0
Fuel combustion, electric generation, other	0
Fuel combustion, commercial/institutional, other	0
Fuel combustion, commercial/institutional, coal	0

ICE = internal combustion engine; NEC = not elsewhere classified

Source: EPA 2020

5.3.2 Water

Estimated releases of 134,107 pounds (~60.8 metric tons) of vinyl acetate to surface water from 125 domestic manufacturing and processing facilities in 2023, accounted for about 11% of the estimated total environmental releases from facilities required to report to the TRI (TRI23 2024). These releases are summarized in Table 5-2.

Recent data on wastewater detections were not located.

5.3.3 Soil

Estimated releases of 66,672 pounds (~30.2 metric tons) of vinyl acetate to soil from 125 domestic manufacturing and processing facilities in 2023, accounted for about 5.5% of the estimated total environmental releases from facilities required to report to the TRI (TRI23 2024). Estimated releases of 115,377 pounds (~52.3 metric tons) of vinyl acetate via underground injection from 125 domestic manufacturing and processing facilities in 2023, constituting about 9.7% of the estimated total environmental releases from facilities required to report to the TRI (TRI23 2024). These releases are summarized in Table 5-2.

5.4 ENVIRONMENTAL FATE

5.4.1 Transport and Partitioning

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 or snow 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 (Verschueren 1983), indicating that it will exist primarily in the vapor phase when released to the ambient atmosphere. Removal of the compound from the atmosphere may occur during precipitation events, based on reported water solubilities of 1 g/50 mL and 2×10^4 mg/L (EPA 2012; Windholz 1983). Its relatively short atmospheric half-life indicates that it will not undergo long-range transport.

Water. Using the vapor pressure and water solubility data presented in Table 4-2, a Henry's law constant value of $5.11x10^{-4}$ atm-m^3 mol^{-1} 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 $mole^{-1}$ $second^{-1}$ (Datta and Rao 1979). In smog chamber studies with NOx concentrations representative of rural and urban atmospheres, the 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_3, and O_3 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 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^3 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^3.

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[a]

Media	Detection limit	Reference
Air	0.01–0.125 ppbv 1.0–19 μg/m^3 (0.28–5.4 ppbv; indoor)	EPA 2023a Montana DEQ 2012
Drinking water	0.031 ppb 11.8–23.0 ppb	Munch and Eichelberger 1992 EPA 1996
Surface water and groundwater	0.031 ppb 11.8–23.0 ppb	Munch and Eichelberger 1992 EPA 1996
Soil	4.8–24 ppb	WQP 2024

Table 5-4. Lowest Limit of Detection Based on Standards[a]

Media	Detection limit	Reference
Sediment	4.8–24 ppb	WQP 2024
Whole blood[b]	–	–

[a]Detection limits based on using appropriate preparation and analytics. These limits may not be possible in all situations.
[b]No analytical methods for detection of vinyl acetate in whole blood were located.

Table 5-5. Summary of Environmental Levels of Vinyl Acetate[a]

Media	Low	High	For more information
Outdoor air (ppbv)	0.010	4444	Section 5.5.1
Indoor air (ppbv)	1.9	9.1	Section 5.5.1
Surface water (ppb)	0.5	2	Section 5.5.2
Ground water (ppb)	0.5	100	Section 5.5.2
Drinking water[b]	–	–	
Food[b]	–	–	
Soil (ppb)	<LOD	580	Section 5.5.3
Sediment (ppb)	<LOD	<LOD	Section 5.5.3

[a]Unit conversion: ppb = μg/L (aqueous); = μg/kg (sediment and soil); ppbv = 24.45 concentration μg/m^3/86.09 g/mol (air). Summary values represent most recent ambient data available. Ranges do not reflect values below the limit of detection.
[b]No recent data were located.

LOD = level of detection

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[a]	Geometric mean[a]	Geometric standard deviation[a]	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

[a]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.

5.5.1 Air

The national Air Quality System (AQS) database contains ambient air monitoring data for criteria gases, particulates, other toxics, and meteorological parameters collected by EPA, state, local, and tribal air pollution control agencies from monitors throughout the country. Table 5-7 shows the yearly mean 24-hour percentile distributions of vinyl acetate at monitoring stations across the United States. The minimum mean site-specific values reported were below the level of detection for all years.

Table 5-7. Percentile Distribution of Annual Mean Vinyl Acetate Concentrations (ppbv) Measured in Ambient Air at Locations Across the United States[a,b]

Year	Number of U.S. locations	10th	50th	75th	95th	Maximum
2019	33	0.037	0.176	0.269	0.554	7.7
2020	32	0.059	0.205	0.361	2.50	114
2021	33	0.026	0.393	0.741	1.71	29.4
2022	31	0.023	0.173	0.306	0.750	5.38
2023[c]	17	0.010	0.125	0.223	0.480	1.78

[a] Values were originally reported in parts per billion carbon (ppbC) and converted to ppbv.
[b] 24-hour sampling period.
[c] As of October 26, 2023.

Source: EPA Air Quality System (AQS) annual summaries (EPA 2023a)

Vinyl acetate has been detected in the air at NPL sites between 1981 and 2002, with a median value of 45.5 ppbv (ATSDR 2022a). A summary of this data is provided in Table 5-6.

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±3.89 μg/m^3 (ranging from 6.7 to 32 μg/m^3; equivalent to 2.6±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 μg/m^3 (0.37–0.520 ppbv); vinyl acetate was detected in office air samples only.

5.5.2 Water

Surface water and groundwater monitoring data are 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.

Vinyl acetate is not a common contaminant of surface water. Between 2010 and 2019, vinyl acetate was only detected in 3% of samples, at an average of 1.2 µg/L (range 0.5–2 µg/L; n=594) (WQP 2024). Vinyl acetate was not detected in more recent surface water samples, collected between 2020 to early March 2024 (n=197).

Vinyl acetate has been more frequently detected in groundwater: between 2010 and 2019, vinyl acetate was detected in 11% of ambient groundwater samples at an average concentration of 7.6 µg/L (range 0.15–100 µg/L; n=6,410) (WQP 2024). More recently, however, vinyl acetate was not detected in samples collected between 2020 and early March 2024 (n=1,886).

Recent monitoring data for groundwater from Superfund sites are limited. Vinyl acetate was not detected in samples from the Palermo Wellfield superfund site in Tumwater, Washington, collected between 2013 and 2020 (WQP 2024).

5.5.3 Sediment and Soil

Limited recent ambient soil and sediment monitoring data are available. Vinyl acetate was present at levels below the quantification limit in six sediment samples collected from Indiana in 2000 or in two sediment samples collected as part of the EPA Great Lakes National Program in 2007 (WQP 2024). Reported quantitation limits ranged from 14 to 82 µg/kg in Indiana and from 3,900 to 5,300 µg/kg in the Great Lakes Program. In soil, vinyl acetate was not detected in 11 samples collected from Washington state in 2004 or in 273 samples collected from New Mexico in 2009 (WQP 2024).

Vinyl acetate has typically not been detected in soil or sediment samples collected from several Superfund sites since 2000 (WQP 2024). The single exception is 10 µg/kg vinyl acetate reported in one soil sample from the Ogden Railyard site in Ogden, Utah collected in 2000; vinyl acetate was not detected in any other soil or sediment samples from the Ogden Railyard site between 2000 and 2001. Similarly, vinyl acetate was not detected in sediment samples from the Portland Harbor site in Portland, Oregon from 2002, 2004, 2006, and 2007; sediment samples from the Lower Duwamish Waterway site in Seattle, Washington from 2003 and 2006; soil samples from the Intermountain Waste Oil Refinery site in Bountiful, Utah from 2004; or sediment samples from the Palermo Wellfield site in Tumwater, Washington from 2021 (WQP 2024).

Vinyl acetate has been detected in the soil at NPL sites between 1981 and 2002, with a median value of 580 µg/kg (ATSDR 2022a). A summary of NPL data is provided in Table 5-6.

5.5.4 Other Media

Vinyl acetate was present, but below the quantification limits, in 160 biota samples collected between 1984 to 1992 in Indiana (WQP 2024). Reported limits of detection ranged from 10 to 25 µg/kg. The most frequent sampling occurred in three species of fish (*Cyprinous carpio*, *Ictalurus punctatus*, and *Micropterus salmoides*). More recent fish biomonitoring data are not available (WQP 2024).

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^2/hour over 24 hours and 103±20.2 µg/m^2/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 monitoring data are available.

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 $\mu g/m^3$ (0.06 ppb) to 17.6 $\mu g/m^3$ (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. Reasonable Maximum Exposure (RME) levels for vinyl acetate were calculated based on concentrations in water and outdoor air; RME levels for different exposure groups are presented in Table 5-8. Since treated water levels were not available, the average value of detections in groundwater and surface water (discussed in Section 5.5.2) was used as a surrogate value, in addition to a representative outdoor air level reported by EPA's HAP monitoring sites (discussed in Section 5.5.1).

Table 5-8. RME Daily Inhalation Dose and Administered Dermal Dose of Vinyl Acetate for the Target Person[a]

Exposure group	Inhalation (μg/m^3)	Dermal (μg/kg/day)
Birth–<1 year	1.1	0.0017
1–<2 years	1.1	0.0015
2–<6 years	1.1	0.0013
6–<11 years	1.1	0.0011
11–<16 years	1.1	0.00089
16–<21 years	1.1	0.00081
Adult	1.1	0.00079
Pregnant and breastfeeding women	1.1	0.00080

[a]Based on 2.1 μg/L in water and 0.125 ppb in air.

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 (European Chemicals Bureau 2008; 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 ppmv. 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 detectible 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.

Occupational exposures for European Union workers were estimated for three scenarios: production of vinyl acetate and polymerization in the chemical industry; manufacturing of formulations and products;

and use of formulations and products containing residual vinyl acetate monomer (European Chemicals Bureau 2008). The results suggested that handling the monomer substance in the areas of production and polymerization, the formulation of adhesives, as well as the use of formulations, especially of adhesives, are the main sources for occupational exposure.

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 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 $\mu g/m^3$, or 1.74 ppbv) after pre-specified (80 puffs per volunteer) or *ad libitum* use (Liu et al. 2017).