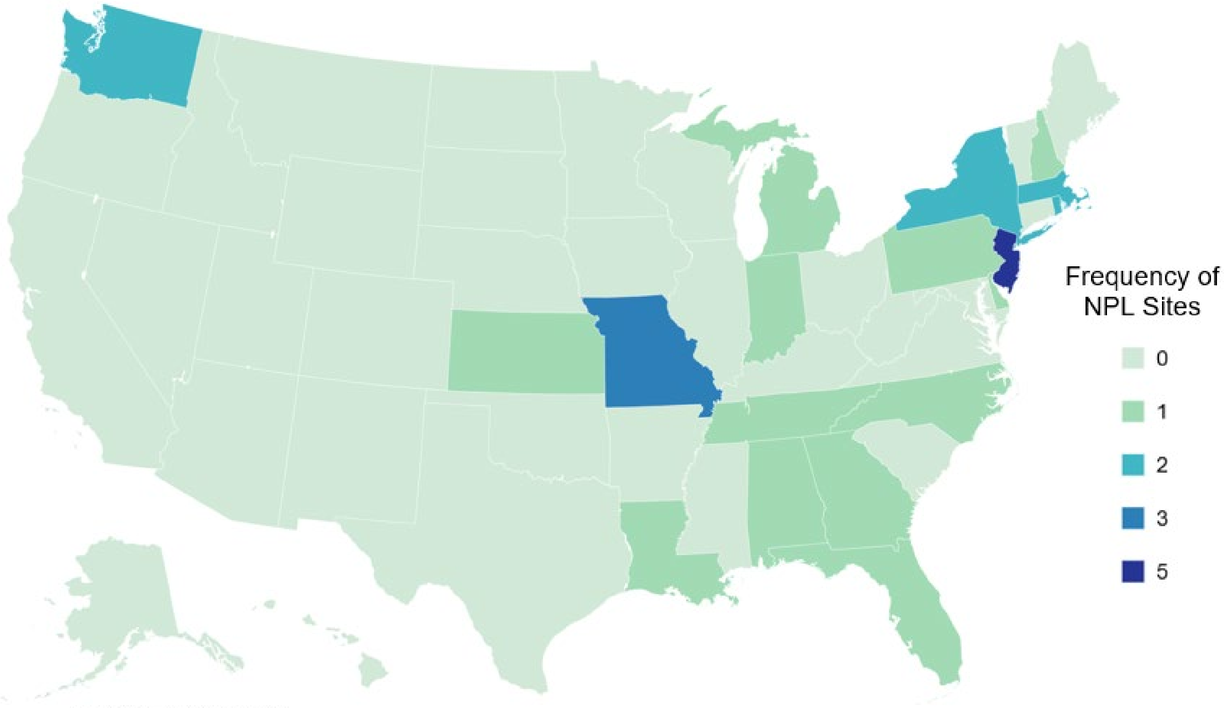
CHAPTER 5. POTENTIAL FOR HUMAN EXPOSURE

5.1 OVERVIEW

Acrylonitrile has been identified in at least 28 of the 1,868 hazardous waste sites that have been proposed for inclusion on the EPA National Priorities List (NPL) (ATSDR 2022). However, the number of sites in which acrylonitrile has been evaluated is not known. The number of sites in each state is shown in Figure 5-1.

Figure 5-1. Number of NPL Sites with Acrylonitrile Contamination



Source: ATSDR 2022

- The primary routes of exposure for the general population are the oral and inhalation routes. Members of the general public are most likely exposed to acrylonitrile through the use of products that contain acrylonitrile, such as acrylic fiber clothing or carpeting, and acrylonitrile-based plastics. Environmental exposures through air and water, especially for people near industrial or chemical waste sites, are also possible.

- Acrylonitrile may enter human food materials by leaching from plastic food containers. Data regarding acrylonitrile in food or drinking water were not available.

- Acrylonitrile is primarily released via underground injection and to the air. It has been detected at low levels in ambient air and groundwater, and in sediment, surface water, and groundwater at Superfund sites.
- Based on its volatility and water solubility, acrylonitrile will preferentially volatilize to air or remain dissolved in water. It has high mobility in soils and may migrate to groundwater. It is not expected to be persistent in air or water; however, biodegradation may be inhibited in water at high concentrations.

Acrylonitrile is primarily used to make acrylic fibers and plastics (Brazdil 2012). Previously, acrylonitrile, in combination with carbon tetrachloride, was used as a fumigant for flour milling, bakery food processing equipment, and stored tobacco; these fumigants were voluntarily withdrawn in the late 1970s (IARC 1979). Cigarette smoke is expected to still be a source of exposure for smokers based on presumed formation of acrylonitrile during combustion (Chen et al. 2019; Moldoveanu 2010).

Acrylonitrile is readily volatile (EPA 1982a), and significant quantities may escape into air during manufacture and use. Volatilization may also occur from chemical waste sites. In air, acrylonitrile is degraded primarily by reaction with hydroxyl radicals, with an estimated half-life of 1.2–12 hours (EPA 1980a; Harris et al. 1981; Teruel et al. 2007). Historically, acrylonitrile has been detected in air in the vicinity of various industrial sources at concentrations up to 150 ppbv (EPA 1980a), and recently in ambient air at up to 0.446 ppbv (EPA 2022a).

Acrylonitrile is readily soluble in water, and current total discharges to water via industrial effluents are likely low (TRI23 2024). Water contamination may occur following a spill or near a chemical site. In water, acrylonitrile has little tendency to adsorb to sediment, but is subject to biodegradation by microorganisms. The rate and extent of degradation depend upon conditions and upon the time for microbial acclimation. Degradation may approach 100% under favorable circumstances but may be inhibited by high concentrations of acrylonitrile. Acrylonitrile has not been detected in ambient surface water but was detected in surface water and groundwater at Superfund sites (WQP 2022). The vast majority of releases to the environment are via underground injection (TRI23 2024); acrylonitrile has been detected in ambient groundwater at concentrations up to 1.82 ppb (WQP 2022).

Acrylonitrile is expected to be highly mobile in soils (EPA 1992) and showed reduced biodegradation at high concentrations (Donberg et al. 1992). Acrylonitrile was not detected in ambient soil or sediment; at Superfund sites, it was detected at a maximum of 89,000 ppb in sediment (WQP 2022).

The highest exposures are expected for people working in facilities that manufacture or use acrylonitrile, and, to a lesser degree, people who smoke (Moldoveanu 2010; Stewart et al. 1998). For members of the general public who do not live near an industrial source or a chemical waste site, exposure to very low levels of acrylonitrile may occur through leaching/volatilization from consumer products, such as acrylic carpeting, or by ingestion of food stored in acrylic plastic containers (EPA 1978; IARC 1979; Lickly et al. 1991). Contact with consumer products is expected to be a primary exposure pathway, although no data quantifying this route were available. No drinking water monitoring data were available. Low environmental exposures may occur through ambient air (EPA 2022a). For people who do live near industrial or hazardous waste sites, inhalation of acrylonitrile in air is likely to be the main route of exposure (EPA 1980a), although intake through water could also be of concern.

5.2 PRODUCTION, IMPORT/EXPORT, USE, AND DISPOSAL

5.2.1 Production

Acrylonitrile is produced commercially by the process of propylene ammoxidation, in which propylene, ammonia, and air are reacted in a fluidized bed in the presence of a catalyst (EPA 1984, 1985). The propylene ammoxidation process was first patented in 1949 but became the primary process after the development of a bismuth molybdate catalyst in 1959 (Brazdil 2012). The majority of the world’s production of acrylonitrile has shifted to the Asia Pacific, accounting for an estimated 58.1% of the production capacity, in comparison to 22.8% production capacity in North America (Brazdil 2012). The nationally aggregated production of acrylonitrile has held steady between 1,000,000,000 and <5,000,000,000 pounds between 2016 and 2019 (EPA 2020a).

Acrylonitrile manufacturing was reported to the Chemical Data Reporting (CDR) Rule in 2019 by three companies: Ascend Performance Materials Holdings Inc. in Harris Texas; INEOS Nitriles USA LLC, at two plants in Aurora, Illinois; and CSTN Holdings Inc. in Waggaman, Louisiana (EPA 2020a). This is not an exhaustive list; companies must meet a threshold to trigger reporting to the CDR, and other manufacturers may therefore be unreported. Table 5-1 summarizes information on companies that reported the production, import, or use of acrylonitrile 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.

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

State[a]	Number of facilities	Minimum amount on site in pounds[b]	Maximum amount on site in pounds[b]	Activities and uses[c]
AL	5	10,000	49,999,999	6, 7, 12, 14
AR	1	10,000	99,999	9, 12
CA	1	100,000	999,999	6
CT	2	100,000	999,999	6
GA	1	1,000,000	9,999,999	6
IL	3	10,000	9,999,999	6
IN	3	1,000	99,999	6, 9, 12
KS	1	100,000	999,999	6
KY	4	10,000	9,999,999	6, 7
LA	8	100	49,999,999	1, 4, 5, 6, 10, 12
MA	1	10,000	99,999	6
MI	3	1,000,000 (or N/A)	9,999,999 (or N/A)	6
MO	2	100	999,999	6, 12
MS	2	100,000	9,999,999	6, 7
NC	3	1,000	99,999	6
NJ	2	10,000	999,999	6
NY	2	1,000	99,999	1, 5, 6
OH	10	1,000	9,999,999	1, 4, 6, 8, 12, 14
PA	2	100,000	9,999,999	6
SC	6	1,000 (or N/A)	9,999,999 (or N/A)	6, 12
TN	3	100 (or N/A)	99,999 (or N/A)	1, 5, 6
TX	15	1,000 (or N/A)	99,999,999 (or N/A)	1, 4, 5, 6, 7, 8, 9, 10, 11, 12
VA	2	1,000	999,999	1, 3, 4, 6
WA	1	N/A	N/A	
WI	2	1,000 (or N/A)	999,999 (or N/A)	6, 8
WV	3	0	9,999,999	6, 10, 14

[a] Post office state abbreviations used.

[b] Amounts on site reported by facilities in each state. Facilities may report N/A 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 2022d).

[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

Note: Facilities that report N/A for amounts on site do not report activities/uses.

EPCRA = Emergency Planning and Community Right-to-Know Act; N/A = not applicable

Source: TRI23 2024 (Data are from 2023)

5.2.2 Import/Export

Imports of acrylonitrile have been relatively small. In 2019, about 1,840,000 pounds of acrylonitrile were reported as imported to the CDR (EPA 2020a). Values reported by the CDR may be lower than actual import or export quantities; companies must meet a threshold to trigger reporting, and some information may not be available in the public dataset.

A substantial fraction of the acrylonitrile produced in the United States is exported. In 2019, about 528,000,000 pounds of acrylonitrile were reported as exported to the CDR (41% of reported U.S. production) (EPA 2020a).

5.2.3 Use

The primary use of acrylonitrile is as the raw material for the manufacture of acrylic and modacrylic fibers. Other major uses include the production of plastics (acrylonitrile-butadiene-styrene [ABS] and styrene-acrylonitrile [SAN]), nitrile rubbers, nitrile barrier resins, adiponitrile, and acrylamide (EPA 1984). ABS plastics may be used for food packaging, but the residual acrylonitrile content must be <11 ppm (FDA 2022).

Acrylonitrile has been used, in a mixture with carbon tetrachloride, as a fumigant for flour milling and bakery food processing equipment and for stored tobacco. However, pesticide products containing acrylonitrile were voluntarily withdrawn by the manufacturers (IARC 1979). Registration of pesticide products in the United States containing acrylonitrile was cancelled in the late 1980s (EPA 2022b).

U.S. commercial use of acrylonitrile is 42% for acrylic fibers, 34% for ABS resins, 8% for adiponitrile, 7% for acrylamide, 3% for nitrile rubber, and 2% for carbon fiber or other uses (Brazdil 2012). Industrial uses for acrylonitrile as reported to the 2020 CDR are reproduced in Table 5-2; six companies reported consumer and commercial use of acrylonitrile, as part of chemical manufacturing (EPA 2020a).

Table 5-2. Industrial Uses of Acrylonitrile Reported Under the Chemical Data Reporting (CDR)

Industrial function category	Sector
Catalyst	Synthetic rubber manufacturing
Other; bulk liquid storage terminal	Wholesale and retail trade
Monomers	All other basic organic chemical manufacturing
	All other chemical product and preparation manufacturing
	Organic fiber manufacturing
	Paint and coating manufacturing
	Plastics material and resin manufacturing
	Synthetic rubber manufacturing
Intermediates	All other basic organic chemical manufacturing
	All other chemical product and preparation manufacturing
	Paint and coating manufacturing
	Petrochemical manufacturing
	Plastics material and resin manufacturing
	Synthetic rubber manufacturing

Source: EPA 2020a (data are from 2016–2019)

5.2.4 Disposal

Acrylonitrile is listed as a hazardous substance under the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA), as amended by the Superfund Amendments and Reauthorization Act (SARA), and wastes containing acrylonitrile are considered hazardous wastes under Resource Conservation and Recovery Act (RCRA) (EPA 2022c). Because acrylonitrile is listed as a hazardous substance, disposal of waste acrylonitrile is controlled by a number of federal regulations (see Chapter 7). Rotary kiln, fluidized bed, and liquid injection incineration are acceptable methods of acrylonitrile disposal (EPA 1981). Biological treatment of hazardous leachate containing acrylonitrile is very effective; activated carbon treatment was also investigated but was not as effective (EPA 1982b). Underground injection is another commonly implemented disposal method (TRI23 2024).

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 2022d). 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 2022d).

5.3.1 Air

Estimated releases of 293,212 pounds (~133 metric tons) of acrylonitrile to the atmosphere from 88 domestic manufacturing and processing facilities in 2023, accounted for about 3.7% of the estimated total environmental releases from facilities required to report to the TRI (TRI23 2024). These releases are summarized in Table 5-3.

Table 5-3. Releases to the Environment from Facilities that Produce, Process, or Use Acrylonitrile[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	5	120,279	62	0[l]	12,002	0	132,301	42	132,343
AR	1	1	0	0	0	0	1	0	1
CA	1	324	0	0	2	0	324	2	326
CT	2	140	0	0	0	0	140	0	140
GA	1	2,533	0	0	0	0	2,533	0	2,533
IL	3	13,645	4	0	60	372	13,649	432	14,081
IN	3	949	0	0	0	0	949	0	949
KS	1	1,130	0	0	0	0	1,130	0	1,130
KY	4	3,200	7	0	2,218	0	3,207	2,218	5,425
LA	8	19,767	53	73,569	9	0	93,389	9	93,398
MA	1	5	0	0	0	0	5	0	5
MI	3	3,346	5	0	5	0	3,356	0	3,356
MS	2	3,656	0	0	0	0	3,656	0	3,656
MO	2	32	0	0	0	0	32	0	32
NJ	2	39	0	0	0	0	39	0	39
NY	2	323	0	0	5	0	323	5	328
NC	3	792	0	0	0	0	792	0	793
OH	10	23,133	2,312	1,076,683	250	422	1,099,827	2,973	1,102,801
PA	2	408	3	0	0	0	411	0	411
SC	6	36,690	0	0	13	0	36,690	13	36,703
TN	3	1,093	123	0	0	0	1,093	123	1,216
TX	15	58,598	16	6,300,202	8	0	6,358,808	16	6,358,825
VA	2	1,669	0	0	0	0	1,669	0	1,669

Table 5-3. Releases to the Environment from Facilities that Produce, Process, or Use Acrylonitrile[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
WA	1	<RQ	<RQ	<RQ	<RQ	<RQ	<RQ	<RQ	<RQ
WV	3	1,200	179	0	0	0	1,202	177	1,379
WI	2	261	2	0	0	0	261	2	262
Total	88	293,212	2,768	7,450,454	14,572	794	7,755,787	6,014	7,761,801

[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.

RF = reporting facilities; RQ = reportable quantity; UI = underground injection

Source: TRI23 2024 (Data are from 2023)

Because acrylonitrile is readily volatile, significant releases to air may occur during acrylonitrile production and use. 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 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. Acrylonitrile emissions estimated from the 2017 inventory are summarized in Table 5-4.

Table 5-4. Acrylonitrile Emissions Estimated by Sector

Sector	Emissions (pounds)
Industrial processes, chemical manufacturing	291,274.66
Waste disposal	229,796.53
Industrial processes, not elsewhere classified	23,342.01
Industrial processes, storage and transfer	20,135.49
Fuel combustion, electric generation, coal	7,908.17
Solvent, industrial surface coating and solvent use	3,044.18
Fuel combustion, industrial boilers, internal combustion engines, coal	2,539.87
Fuel combustion, electric generation, other	2,168.22
Industrial processes, petroleum refineries	1,734.29
Industrial processes, pulp and paper	378.38
Bulk gasoline terminals	318.74
Solvent, degreasing	264.32
Fuel combustion, commercial/institutional, other	149.05
Fuel combustion, industrial boilers, internal combustion engines, natural gas	113.22
Fuel combustion, commercial/institutional, natural gas	87.44
Industrial processes, cement manufacturing	47.58
Fuel combustion, electric generation, biomass	34.86
Fuel combustion, industrial boilers, internal combustion engines, other	32.95
Industrial processes, non-ferrous metals	19.61
Fuel combustion, commercial/institutional, biomass	10.20
Industrial processes, ferrous metals	9.42
Fuel combustion, commercial/institutional, oil	5.83
Fuel combustion, electric generation, natural gas	0

Source: EPA 2017

5.3.2 Water

Estimated releases of 2,768 pounds (~1.26 metric tons) of acrylonitrile to surface water from 88 domestic manufacturing and processing facilities in 2022, accounted for about <1% of the estimated total environmental releases from facilities required to report to the TRI (TRI23 2024).

Acrylonitrile may be released to water during production and use. No data were located on acrylonitrile releases to water from other sources, but because acrylonitrile is readily soluble and is not strongly adsorbed to soil or sediment, large accidental spills or leaks from chemical waste sites could lead to significant water contamination. Several examples of groundwater contamination following spills have been reported (EPA 1978). Acrylonitrile may also be released to water by leaks or emissions from hazardous waste sites.

5.3.3 Soil

Estimated releases of 14,572 pounds (~6.61 metric tons) of acrylonitrile to soil from 88 domestic manufacturing and processing facilities in 2023 accounted for about <1% of the estimated total environmental releases from facilities required to report to the TRI (TRI23 2024). Estimated releases of 7,450,454 pounds (~3,379 metric tons) of acrylonitrile via underground injection from 88 domestic manufacturing and processing facilities in 2023 accounted for about 95.99% of the estimated total environmental releases from facilities required to report to the TRI (TRI23 2024). These releases are summarized in Table 5-3.

Direct release of acrylonitrile to soil during acrylonitrile production and use is believed to be minimal (<1 metric ton/year) (EPA 1982c).

5.4 ENVIRONMENTAL FATE

5.4.1 Transport and Partitioning

Air. No data regarding the transportation and partitioning of acrylonitrile in the environment were located. However, physical-chemical properties can be used to estimate environmental behavior. Acrylonitrile is both readily volatile to air from dry surfaces (0.13 atm at 23°C) (EPA 1982a) and highly soluble in water (6,803–79,000 mg/L) (Klein et al. 1957; Yalkowsky et al. 2010). These characteristics dominate the behavior of acrylonitrile in the environment. Based on these properties, acrylonitrile will be primarily in the vapor phase in the atmosphere and may be removed through precipitation. EPA (1980c) estimated the half-time of acrylonitrile clearance from air in wet precipitation to be >10 months. While present in air, acrylonitrile has little tendency to adsorb to particulate matter (EPA 1980c), so air transport of volatilized material is determined mainly by wind speed and direction.

Water. Based on the measured Henry's law constant of 1.18×10^{-5} atm-m^3/mol (Sander 2015), acrylonitrile is moderately volatile from surface water. Further, based on its relatively high water solubility and relatively low log K_{ow} (0.25) (EPA 1982a), acrylonitrile dissolved in water has a low tendency to adsorb to suspended soils or sediments (Roy and Griffin 1985). Surface transport is determined by water flow parameters. In addition, acrylonitrile may penetrate into groundwater from surface spills or from contaminated surface water.

Sediment and Soil. In two low-organic carbon soils, log K_{oc} values for acrylonitrile were determined to be 1.10 in silt loam (1.49% organic carbon) and 1.00 in sandy loam (0.66% organic carbon) (EPA 1992). Based on these relatively low log K_{oc} values, supported by its relatively high water solubility, acrylonitrile is expected to be highly mobile in moist soils. The high vapor pressure indicates that evaporation from dry soil is expected to occur rapidly, and the Henry's law constant indicates that it will be moderately volatile from moist soils.

Other Media. Based on the relatively low log K_{ow} value, it would not be expected that acrylonitrile would bioaccumulate greatly in the tissues of aquatic organisms (Kenaga 1980; Neely et al. 1974). Data in aquatic organisms exposed to water containing acrylonitrile support some accumulation. Barrows et al. (1978) measured a steady-state bioconcentration factor (BCF) of 48 in bluegill sunfish. Based on the relative proportion of fat in sunfish and other aquatic organisms, EPA (1980b) estimated an average BCF of about 30 for the edible portions of freshwater and marine species.

5.4.2 Transformation and Degradation

Air. The principal pathway leading to degradation of acrylonitrile in air is believed to be photooxidation, mainly by reaction with hydroxyl radicals (OH). The rate constant for acrylonitrile reaction with OH has been measured as 4.1×10^{-12} and 1.11×10^{-11} cm^3/molecule/second (Harris et al. 1981; Teruel et al. 2007). This would correspond to an atmospheric half-life of about 1.2–3.1 hours based on a 12-hour daylight OH concentration of 1.50×10^{6} molecules/cm^3. This is similar to the half-life of 9–10 hours measured in a smog chamber (EPA 1980a).

The photooxidation of acrylonitrile by hydroxyl radicals in the presence of nitric oxide has been observed to yield formaldehyde (HCHO) and formyl cyanide (HCOCN) (Hashimoto et al. 1984). From these results, the following reaction was proposed:

$$OH + CH_2CHCN + 2NO + 2O_2 \rightarrow HCHO + HCOCN + 2NO_2 + OH$$

Data given by Hashimoto et al. (1984) suggest that the half-life of acrylonitrile in the atmosphere may be on the order of 12 hours.

Acrylonitrile may also be oxidized by other atmospheric components such as ozone and oxygen, but the rates of these reactions are much lower than for OH; the experimentally determined tropospheric lifetime based on ozone oxidation is 84 days (Munshi et al. 1989). This is not considered to be an important degradative pathway.

Water. Very little is known about nonbiologically mediated transformations of acrylonitrile in water. It is not expected to hydrolyze under ambient conditions (EPA 1979). While it is known that acrylonitrile photooxidizes in air, no reliable information was found on photochemical reactions in water. There were also no data on the oxidation of acrylonitrile in water. Acrylonitrile is susceptible to oxidation by strong oxidants such as chlorine used to disinfect drinking water.

Acrylonitrile is readily degraded by aerobic microorganisms in water, especially if there is time for acclimation (Cherry et al. 1956; Mills and Stack 1954, 1955; Stover and Kincannon 1983). After 27 days of acclimation, about 70% of the acrylonitrile initially present in river water was degraded under laboratory conditions, yielding acrylic acid and ammonia. Complete degradation occurred under ideal conditions where nutrients were added to promote microbial growth (Cherry et al. 1956).

A bacterium classified as *Nocardia rhodochrous* LL 100-2 has been reported to be able to degrade acrylonitrile (DiGeronimo and Antoine 1976). An aerobic bacterium classified as Arthrobacter in an acclimated sludge completely degraded acrylonitrile after 48 hours yielding acrylic acid (Yamada et al. 1979). It was proposed that acrylonitrile was biodegraded by the following reaction:

$$CH_2CHCN + H_2O \rightarrow CH_2CHCONH_2 + H_2O \rightarrow CH_2CHCOOH + NH_3$$

It has been shown that low concentrations of acrylonitrile in solution (≤10 mg/L) can be completely degraded in a laboratory, static-culture batch experiment where domestic sewage water was the source of the microbial inoculum (Tabak et al. 1981). A solution of acrylonitrile (152 mg/L) was degraded to <0.05 mg/L in a continuous flow activated sludge system under laboratory conditions (Kincannon et al. 1983). Under simulated aerobic wastewater treatment conditions, acrylonitrile was degraded by 61–100% after 2 weeks (NITE 2022).

Studies performed using sewage sludge indicate that acrylonitrile may also be degraded by methanogenic bacteria under anaerobic conditions, although concentrations of 50–1,000 mg/L led to moderate inhibition of bacterial fermentation (EPA 1978). This suggests that microbial degradation of acrylonitrile in anaerobic groundwater may not proceed efficiently if acrylonitrile levels were high, as might occur after a spill.

Sediment and Soil. One study regarding biodegradation of acrylonitrile in soil was located. In a study with sandy (0.53% organic carbon), sandy loam (2.6% organic carbon), and loamy clay (4.0% organic carbon) soil, mineralization half-lives were 11–19 days in the sandy soil, 0.5–1 day in the sandy loam, and 0.5 days in the loamy clay soil (Donberg et al. 1992). Decreased biodegradation was observed with increased concentrations; in the sandy soil, degradation was observed at acrylonitrile concentrations between 10 and 50 ppm, but negligible degradation was observed at 100 ppm after 78 days. In the sandy loam soil, rapid degradation occurred between 10 and 100 ppm, with decreased >50 and 80% acrylonitrile remaining after 21 days at 500 and 1,000 ppm. Data regarding transformation in sediment were not located, but similar behavior as seen in soil would be expected.

5.5 LEVELS IN THE ENVIRONMENT

Reliable evaluation of the potential for human exposure to acrylonitrile depends, in part, on the reliability of supporting analytical data from environmental samples and biological specimens. Concentrations of acrylonitrile 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 acrylonitrile 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 5-5 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 5-6.

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

Media	Detection limit	Reference
Air	0.003–0.14 ppb 0.012 ppmv	EPA 2022a OSHA 2001
Drinking water	0.02–20 ppb	EPA 1994b, 1994c
Surface water and groundwater	0.02–20 ppb	EPA 1994b, 1994c, 1995
Soil	9–360 ppb	EPA 1990

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

Media	Detection limit	Reference
Sediment	30–900 ppb	EPA 2018d
Whole blood	–	–[b]

[a]Detection limits based on using appropriate preparation and analytics. These limits may not be possible in all situations.
[b]No method located.

Table 5-6. Summary of Environmental Levels of Acrylonitrile[a]

Media	Low	High	For more information
Outdoor air (ppbv)	0.446	1.1	Section 5.5.1
Indoor air (ppbv)[b]	1.2	2.2	Section 5.5.1
Surface water (ppb)	Not detected	Not detected	Section 5.5.2
Groundwater (ppb)	1.82	13.0	Section 5.5.2
Drinking water (ppb)[b]	–	–	
Food (ppb)[b]	–	–	
Soil	Not detected	Not detected	Section 5.5.3

[a]Unit conversion: ppb = μg/L (aqueous); = μg/kg (sediment and soil); = [concentration ppbc] / 4 carbons
ppbv = 24.45 * [concentration μg/m^3] / 53.06 g/mol. Summary values represent most recent (2015–2022) ambient data available.
[b]No data located.

Detections of acrylonitrile in air at NPL sites are summarized in Table 5-7. No data are available on levels of acrylonitrile in water or soil at NPL sites (ATSDR 2022).

Table 5-7. Acrylonitrile 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		
Soil (ppb)			No data		
Air (ppbv)	2.2	2.5	10.5	5	3

[a]Concentrations found in ATSDR site documents from 1981 to 2022 for 1,868 NPL sites (ATSDR 2022). 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

Acrylonitrile is a pollutant included in the national Air Quality System (AQS) database, which contains ambient air pollution data collected by EPA, state, local, and tribal air pollution control agencies from monitors throughout the country. Table 5-8 shows the yearly mean 24-hour percentile distributions of acrylonitrile at monitoring stations across the United States. Average concentrations have been decreasing over the 5-year intervals. No air monitoring data was available in the Water Quality Portal (WQP 2022).

Table 5-8. Summary of Annual Concentration of Acrylonitrile (ppbv) Measured in Ambient Air at Locations Across the United States[a,b]

Year	Number of monitoring locations	Number of samples	Average of the arithmetic mean at all locations	Maximum concentration
2020–2022[c]	63	18,277	0.0101	0.446
2015–2019	86	22,094	0.0198	0.985
2010–2014	86	25,806	0.0485	1.42
2005–2009	110	23,925	0.0617	2.14
2000–2004	103	17,773	0.110	5.98

[a] Values were originally reported in parts per billion carbon (ppbC) and converted to ppbv.
[b] 24-hour sampling period.
[c] As of July 28, 2022.

Source: EPA 2022a

Measurable levels of atmospheric acrylonitrile are typically associated with industrial sources; however, no recent monitoring data around industrial sites were available. Air samples collected in one acrylonitrile-fiber plant ranged from 1.4 to 9.2 ppmv (3–20 mg/m^3) (EPA 1980b). Mean 24-hour acrylonitrile concentrations in atmospheric samples collected within 5 km of 11 factories producing or using acrylonitrile ranged from <0.05 to 150 ppbv (<0.1–325 μg/m^3) (EPA 1980a). The occurrence of acrylonitrile was correlated to wind patterns; the highest concentrations were downwind of, and in close proximity to, the plant. The median concentration of acrylonitrile for 43 measurements in "source-dominated areas" (i.e., near chemical plants) was 0.97 ppbv (2.1 μg/m^3) (EPA 1983b). From Table 5-7, acrylonitrile was detected at 1.04±4.47 ppbv in air at NPL sites; there were no other data available on the concentration of acrylonitrile in air near chemical waste sites. However, air is an exposure pathway of concern due to the volatility of acrylonitrile.

A review of 148 vapor intrusion public health assessments and health consultations by ATSDR found three sites with air concentrations of acrylonitrile above 0.9 ppb (2.0 μg/m^3) (ATSDR 2005, 2007, 2008; Burk and Zarus 2013). Indoor air concentrations in three residential buildings ranged from 1.2 ppb (2.7 μg/m^3) to 2.2 ppb (4.8 μg/m^3) (ATSDR 2005, 2008). Outdoor air was detected in a play yard at 1.1 ppb (2.4 μg/m^3) (ATSDR 2007).

5.5.2 Water

Acrylonitrile is not a common contaminant of typical surface water or groundwater. The most likely source of acrylonitrile in water is industrial discharges. Recent water monitoring data around industrial sites, including NPLs, was not available, and water releases of acrylonitrile accounts for a low percentage of total reported releases (Table 5-3). Acrylonitrile was not detected in 19 wastewater samples collected between 2003 and 2009 (WQP 2022).

The Water Quality Portal (WQP) is an aggregated database of environmental monitoring data collected by EPA, U.S. Department of Agriculture (USDA), the National Water Quality Monitoring Council, state, local, and tribal water pollution control agencies, and other volunteer groups. Table 5-9 reports the concentrations of acrylonitrile detected in surface water and groundwater. Acrylonitrile was not detected in ambient surface water and was detected in low amounts in groundwater. Concentrations and detection frequency in groundwater have generally continued to decrease across the 5-year time intervals.

Table 5-9. Summary of Concentrations of Acrylonitrile (ppb) Measured in Surface Water and Groundwater Across the United States

Year range	Average	Maximum concentration	Number of samples	Percent detected
Surface water				
2020–2022[a]	–	–	87	0%
2015–2019	–	–	381	0%
2010–2014	–	–	717	0%
2005–2009	–	–	980	0%
2000–2004	–	–	1,107	0%
Groundwater				
2020–2022[a]	1.82	1.82	1,121	0.089%
2015–2019	5.89	13.0	1,337	0.67%
2010–2014	16.6	1,000	3,651	8.93%

Table 5-9. Summary of Concentrations of Acrylonitrile (ppb) Measured in Surface Water and Groundwater Across the United States

Year range	Average	Maximum concentration	Number of samples	Percent detected
2005–2009	25.5	2,500	6,969	27.4%
2000–2004	–	–	4,448	0%

[a]As of July 28, 2022.

Source: WQP 2022

Limited sampling campaigns of Superfund sites are reported in Table 5-10. More recent data were not available. No general conclusions can be determined without more data, but the detections of acrylonitrile support the possibility of increased exposure at polluted sites.

Table 5-10. Summary of Concentrations of Acrylonitrile (ppb) Measured in Surface and Groundwater at Superfund Sites

Year rage	Average	Maximum concentration	Number of samples	Percent detected
Palermo Wellfield Superfund Site				
Surface water				
2010–2014	10.0	10.0	8	100%
Groundwater				
2010–2014	10.0	10.0	53	100%
EPA Region 10 Boomsnub Superfund Site				
Groundwater				
2010–2014	0.786	1.0	42	100%
2000– 2004	10.1	100	71	100%
EPA Region 10 Superfund Portland Harbor Site				
Surface water				
2005–2009	1.0	1.0	23	100%
Groundwater				
2005–2009	6.51	250	382	100%
2000–2004	1.88	5.0	31	100%

Source: WQP 2022

Acrylonitrile is not regulated under the Safe Drinking Water Act (SDWA) and is not monitored under the Unregulated Contaminant Monitoring Rule. No data regarding acrylonitrile concentrations in drinking water were located.

5.5.3 Sediment and Soil

Limited monitoring data of acrylonitrile in soil and sediment were available. Historical data did not detect acrylonitrile in 351 sediment samples collected from lake and river bottoms across the United States (Staples et al. 1985). From sampling campaigns across the country, acrylonitrile was not detected in 87 sediment samples collected between 2010 and 2019, or in 97 samples collected between 2000 and 2009 (WQP 2022).

In 2004, acrylonitrile was detected at a maximum of 210.0 ppb (average of 47.5 ppb, n=11) in soil samples collected from Bainbridge Island, Seattle, Washington (WQP 2022). It is unclear if these are ambient samples, or if they are impacted by the Wyckoff Eagle Harbor Superfund Site on Bainbridge Island. Acrylonitrile was not detected in 274 soil samples collected between 2005 to 2009, or in 144 samples collected between 2000 to 2004 (WQP 2022). No recent data were available.

Limited sampling campaigns of Superfund sites are reported in Table 5-11. The presence of acrylonitrile at these sites supports the possibility of increased exposure at hazardous waste and other impacted sites.

Table 5-11. Summary of Concentrations of Acrylonitrile (ppb) Measured in Sediment at Superfund Sites

Year range	Average	Maximum concentration	Number of samples	Percent detected
EPA Region 10 Superfund Portland Harbor Site				
2005–2009	427	89,000	450	100%
2000–2004	85.9	12,000	406	100%
EPA Region 10 Superfund Lower Duwamish Waterway Site				
2005–2009	8.57	9.9	12	100%
2000–2004	5.34	6.9	11	100%

Source: WQP 2022

5.5.4 Other Media

As part of a biomonitoring campaign in Honolulu, Hawaii, acrylonitrile was not detected in *Lutjanus kasmira* (n=22), *Myripristis berndti* (n=22), or *Selar crumenophthalmus* (n=22) collected between 2004 and 2014 (WQP 2022). No other biomonitoring data were located.

Foods may become contaminated with acrylonitrile as a result of the migration of the monomer from chemical containers made of acrylonitrile polymers. Acrylonitrile has been found to desorb from polyacrylonitrile resins and partition into cooking oil (Gilbert et al. 1980). Other foods that may be contaminated by acrylonitrile from their containers include luncheon meat, peanut butter, margarine, fruit juice, and vegetable oil (EPA 1980b, 1983a; FDA 2022). There are few data on the extent of food-related acrylonitrile exposure. The FDA reported typical acrylonitrile concentrations in margarine of 25 μg/kg (FDA 2022), and the Commission of European Communities (CEC 1983) reported that the levels of acrylonitrile in contaminated foods are generally about 1 μg/kg. While past data suggested potential exposure, somewhat more recent data showed that there was little migration of the monomer from packaging materials because food was packaged in vastly different resins that have been drastically improved (AN Group 1990). Migration increased under simulated conditions when heated to ≥120°F, especially when heated for increasing durations of time (Lickly et al. 1991). A linear relationship between the residual acrylonitrile in the polymer and the amount that migrated was observed.

Acrylonitrile was detected in the smoke of cigarettes made in the United States in the 1960s and 1970s, usually at levels of 1–2 mg per cigarette (IARC 1979). At that time, acrylonitrile was used as a fumigant for stored tobacco. Most pesticide registrations for acrylonitrile were cancelled in 1978, and the use of acrylonitrile as a fumigant has been discontinued. This was previously believed to be the only source of acrylonitrile in cigarettes; however, the formation of acrylonitrile from nitrate and nitrite during cigarette burning has been proposed (Chen et al. 2019). This is supported by more recent detections of acrylonitrile in smoking products, at 5.10–11.59 μg/cigarette in tobacco cigarettes, and even 6.63 and 15.82 μg/cigarette in herbal cigarettes, long after the ending of usage of acrylonitrile as a fumigant (Moldoveanu 2010).

Residual acrylonitrile monomer may also occur in commercially made polymeric materials used in rugs and other products. Estimated levels include acrylic and modacrylic fibers (<1 mg acrylonitrile/kg polymeric material), acrylonitrile-based resins (15–50 mg/kg), and nitrile rubber and latex (0–750 mg/kg) (EPA 1978; IARC 1979). It is possible that acrylonitrile may evaporate into air or leach into water from these products, but no data on this topic were located.

5.6 GENERAL POPULATION EXPOSURE

Recent general population exposure estimates, based on environmental exposure measures of acrylonitrile in air and water, were not located. Based on a study published in 1979, as shown in Table 5-12, only people living near chemical factories or work sites are likely to be exposed to measurable amounts of acrylonitrile in air and water (EPA 1980a). Because acrylonitrile has been detected recently at low levels in ambient air, some environmental exposure may occur. Members of the general population may also be potentially exposed to acrylonitrile through the consumption of acrylonitrile-contaminated food. However, it should be recalled that only foods in direct contact with acrylonitrile-based plastics are subject to contamination, and then only at very low levels. The acrylonitrile metabolite, 2CyEMA, has been used as a biomarker of exposure and was measured in urine using National Health and Nutrition Examination Survey (NHANES) 2005–2006, 2011–2012, and 2013–2014, 2015–2016, and 2017–2018 data. These monitoring data are presented in Table 5-13.

Table 5-12. Estimated Levels of Human Exposure to Acrylonitrile for Nonoccupational and Occupational Exposure

Population type	Medium	Typical concentration in medium	Assumed rate of intake of medium	Assumed absorption fraction	Estimated dose (μg/kg/day)
General[a] (70-kg adult)	Air	0.0 μg/m^3	20 m^3/day	0.9	0
	Water	0.0 μg/L	20 L/day	0.9	0
	Food	1 μg/kg	2 kg/day	0.5	0.01
Population living within 5 km of a chemical factory or waste site	Air	2–12 μg/m^3	20 m^3/day	0.9	0.5–3.0
	Water[b]	0.1 μg/L	20 L/day	0.9	0.003
Workers in an acrylonitrile factory	Air	0.1–4 mg/m^3	10 m^3/day	0.9	12.9–514

[a] Potential exposures from chemical spills and acrylic clothing were not considered.

[b] Untreated well water assuming waste effluent or leachate initially containing 10 μg/L is reduced by a factor or 100 by groundwater dilution and biodegradation before it reaches the well.

Source: EPA 1980a

Table 5-13. Urinary N-Acetyl-S-(2-Cyanoethyl)-L-Cysteine (2CyEMA) Levels (Creatinine Adjusted) (µg/g Creatinine) in the U.S. General Population

	Geometric mean	50th Percentile	75th Percentile	90th Percentile	95th Percentile	Sample size
Survey year 2005—2006						
Total population	4.04 (3.38–4.84)	1.61 (1.46–1.82)	10.2 (4.55–34.4)	159 (124–192)	271 (234–290)	3,334
Age 12–19 years	2.24 (1.89–2.66)	1.33 (1.22–1.42)	3.24 (2.29–4.51)	37.4 (13.4–57.2)	86.9 (57.2–119)	1,029
Age 20+ years	4.44 (3.64–5.41)	1.67 (1.50–1.88)	21.2 (5.38–52.1)	182 (147–206)	281 (250–306)	2,305
Males	4.53 (3.61–5.70)	1.59 (1.41–1.84)	35.4 (8.66–63.0)	165 (124–196)	235 (206–281)	1,583
Females	3.62 (3.02–4.34)	1.63 (1.43–1.89)	4.41 (3.26–8.17)	147 (115–188)	284 (242–316)	1,751
Mexican Americans	2.34 (1.96–2.79)	1.42 (1.32–1.49)	3.03 (2.64–3.96)	31.7 (11.7–73.5)	91.0 (44.2–126)	817
Non-Hispanic Blacks	4.79 (3.95–5.81)	1.83 (1.51–2.46)	35.3 (10.2–63.3)	147 (109–183)	217 (183–259)	897
Non-Hispanic Whites	4.36 (3.41–5.56)	1.61 (1.43–1.94)	19.1 (4.11–57.2)	184 (138–225)	287 (259–315)	1,365
Survey years 2011–2012						
Total population	3.89 (3.44–4.40)	1.83 (1.73–1.93)	5.28 (4.08–7.59)	157 (119–194)	256 (224–300)	2,464
Age 6–11 years	2.11 (1.91–2.33)	2.00 (1.81–2.22)	2.95 (2.53–3.59)	5.00 (3.92–5.78)	6.31 (5.74–7.95)	393
Age 12–19 years	2.58 (2.10–3.18)	1.73 (1.51–1.88)	3.28 (2.35–5.84)	19.3 (7.61–58.9)	157 (17.6–228)	384
Age 20+ years	4.43 (3.85–5.09)	1.82 (1.66–2.00)	8.86 (5.46–20.6)	188 (151–224)	292 (238–339)	1,687
Males	4.02 (3.34–4.83)	1.76 (1.61–1.93)	7.71 (4.18–20.2)	153 (116–220)	238 (220–278)	1,250
Females	3.77 (3.01–4.73)	1.87 (1.71–2.09)	4.37 (3.22–6.59)	158 (86.4–228)	292 (229–315)	1,214
Mexican Americans	2.84 (2.20–3.66)	1.65 (1.49–1.86)	3.52 (2.40–7.27)	41.8 (20.0–93.2)	128 (39.4–345)	313
Non-Hispanic Blacks	3.91 (3.18–4.81)	1.92 (1.74–2.10)	7.14 (3.58–33.5)	120 (92.2–139)	199 (145–241)	662
Non-Hispanic Whites	4.25 (3.67–4.92)	1.85 (1.74–1.97)	6.40 (4.02–13.7)	200 (157–230)	292 (238–342)	808
All Hispanics	2.88 (2.37–3.49)	1.62 (1.53–1.78)	3.38 (2.65–4.56)	54.1 (31.6–91.7)	146 (67.8–230)	566
Asians	2.55 (2.26–2.87)	1.76 (1.61–2.15)	3.50 (2.89–4.18)	13.0 (5.64–37.8)	68.0 (26.8–98.5)	341
Survey years 2013–2014						
Total population	3.72 (3.29–4.20)	1.87 (1.71–2.02)	5.83 (4.37–8.61)	121 (97.0–144)	227 (180–286)	2,575
Age 6–11 years	2.04 (1.80–2.31)	1.87 (1.62–2.29)	3.18 (2.77–3.97)	5.74 (4.30–7.22)	7.27 (5.91–9.83)	387
Age 12–19 years	2.21 (1.77–2.75)	1.46 (1.29–1.78)	3.47 (2.35–4.83)	14.1 (5.53–84.7)	89.7 (15.1–152)	438
Age 20+ years	4.27 (3.74–4.87)	1.95 (1.76–2.08)	9.07 (6.10–17.0)	144 (122–176)	272 (215–332)	1,750
Males	3.56 (3.05–4.15)	1.73 (1.56–1.97)	6.39 (4.64–8.89)	110 (67.2–146)	228 (168–281)	1,275

Table 5-13. Urinary N-Acetyl-S-(2-Cyanoethyl)-L-Cysteine (2CyEMA) Levels (Creatinine Adjusted) (µg/g Creatinine) in the U.S. General Population

	Geometric mean	50th Percentile	75th Percentile	90th Percentile	95th Percentile	Sample size
Females	3.88 (3.21–4.68)	1.95 (1.72–2.21)	5.43 (3.91–9.19)	135 (91.6–172)	223 (176–353)	1,300
Mexican Americans	2.24 (1.85–2.71)	1.44 (1.33–1.53)	2.72 (2.07–3.68)	26.4 (6.62–57.4)	71.0 (36.3–184)	447
Non-Hispanic Blacks	5.26 (4.35–6.34)	2.28 (2.00–2.79)	31.0 (13.5–60.5)	177 (121–226)	280 (206–387)	558
Non-Hispanic Whites	3.98 (3.35–4.72)	1.95 (1.74–2.18)	7.21 (4.45–12.0)	126 (99.3–172)	260 (179–332)	934
All Hispanics	2.51 (1.96–3.23)	1.49 (1.40–1.69)	2.97 (2.28–4.51)	43.2 (8.51–89.7)	146 (51.3–235)	693
Asians	2.46 (1.94–3.12)	1.97 (1.61–2.31)	3.22 (2.72–4.12)	9.28 (4.23–82.3)	82.3 (8.63–144)	286
Survey years 2015–2016						
Total population	2.82 (2.33–3.40)	1.37 (1.26–1.48)	3.57 (2.61–6.83)	105 (65.5–143)	190 (153–225)	3,012
Age 3–5 years	2.27 (2.11–2.44)	2.13 (1.89–2.31)	3.34 (3.06–3.58)	5.06 (4.19–6.20)	7.39 (6.12–9.35)	458
Age 6–11 years	1.54 (1.35–1.75)	1.42 (1.26–1.61)	2.07 (1.74–2.51)	3.37 (2.51–4.55)	5.37 (3.28–8.85)	373
Age 12–19 years	1.39 (1.10–1.76)	.991 (.887–1.11)	1.76 (1.39–2.43)	6.40 (2.72–25.4)	35.7 (5.79–85.0)	395
Age 20+ years	3.34 (2.70–4.13)	1.41 (1.30–1.51)	6.83 (3.25–27.7)	135 (94.8–171)	216 (173–255)	1,786
Males	3.08 (2.47–3.83)	1.34 (1.23–1.47)	6.14 (2.90–19.9)	114 (70.2–161)	188 (149–222)	1,499
Females	2.59 (2.08–3.22)	1.41 (1.22–1.54)	3.03 (2.36–4.32)	85.0 (57.6–129)	196 (140–240)	1,513
Mexican Americans	1.88 (1.69–2.08)	1.20 (1.11–1.30)	2.22 (1.89–2.75)	21.5 (10.0–33.7)	81.4 (31.0–142)	577
Non-Hispanic Blacks	4.57 (3.38–6.19)	1.78 (1.48–2.49)	32.2 (7.79–66.8)	134 (106–163)	205 (163–252)	654
Non-Hispanic Whites	2.95 (2.30–3.78)	1.38 (1.23–1.49)	3.73 (2.36–12.9)	117 (61.2–184)	206 (159–251)	912
All Hispanics	2 (1.78–2.24)	1.24 (1.14–1.34)	2.40 (2.00–2.75)	30.2 (15.2–51.8)	96.4 (61.7–145)	969
Asians	1.77 (1.51–2.09)	1.34 (1.18–1.46)	2.10 (1.82–2.45)	6.93 (3.80–21.6)	38.2 (6.93–110)	329
Survey years 2017–2018						
Total population	2.77 (2.48–3.10)	1.38 (1.24–1.54)	3.44 (2.63–4.32)	106 (74.7–134)	186 (155–240)	2,653
Age 3–5 years	2.21 (1.94–2.53)	2.08 (1.79–2.36)	3.22 (2.73–3.37)	5.00 (3.76–9.31)	9.31 (4.69–14.8)	334
Age 6–11 years	1.77 (1.58–1.98)	1.63 (1.40–1.86)	2.45 (2.08–3.07)	4.23 (3.10–5.14)	5.50 (4.50–7.57)	314
Age 12–19 years	1.39 (1.12–1.73)	1.01 (0.901–1.12)	1.75 (1.46–2.42)	4.84 (2.88–33.3)	33.3 (3.41–68.5)	351
Age 20+ years	3.22 (2.78–3.73)	1.40 (1.22–1.58)	4.88 (3.41–14.2)	134 (102–162)	225 (170–278)	654
Males	3.00 (2.46–3.67)	1.35 (1.18–1.55)	4.31 (3.03–11.4)	115 (83.9–158)	212 (144–274)	1,310
Females	2.56 (2.25–2.92)	1.42 (1.24–1.61)	2.72 (2.21–3.93)	74.0 (45.2–116)	179 (127–250)	1,343

Table 5-13. Urinary N-Acetyl-S-(2-Cyanoethyl)-L-Cysteine (2CyEMA) Levels (Creatinine Adjusted) (µg/g Creatinine) in the U.S. General Population

	Geometric mean	50th Percentile	75th Percentile	90th Percentile	95th Percentile	Sample size
Mexican Americans	1.49 (1.23–1.79)	1.05 (0.957–1.25)	1.67 (1.54–2.14)	9.53 (2.63–23.5)	58.7 (16.4–86.7)	412
Non-Hispanic Blacks	4.52 (3.55–5.76)	1.67 (1.38–2.14)	36.5 (14.8–63.4)	160 (119–209)	253 (208–303)	601
Non-Hispanic Whites	2.77 (2.33–3.31)	1.36 (1.21–1.56)	3.41 (2.36–4.43)	107 (72.3–144)	179 (134–286)	861
All Hispanics	1.54 (1.34–1.78)	1.08 (0.994–1.25)	1.79 (1.64–2.07)	6.32 (3.15–20.2)	62.7 (18.2–90.3)	639
Asians	1.79 (1.51–2.12)	1.53 (1.28–1.69)	2.36 (2.03–2.85)	3.93 (3.23–5.78)	25.6 (4.40–111)	354

Source: CDC 2022

Acrylonitrile in water is expected to rapidly volatilize; thus, there is potential for inhalation exposure during 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. The SHOWER model also estimates dermal uptake from showering, bathing, and handwashing. This information, along with human activity patterns, is used to calculate a daily TWA exposure concentration via inhalation exposure and from dermal uptake from skin contact. ATSDR's SHOWER model is a stand-alone application and is available by sending a request to showermodel@cdc.gov.

5.7 POPULATIONS WITH POTENTIALLY HIGH EXPOSURES

Occupational exposures via inhalation of acrylonitrile vapor at the workplace are likely to be considerably greater than exposures outside the workplace (see Tables 5-12 and 5-14). Exposure levels may be highest for workers in plants where the chemical is used as a feedstock (EPA 1984).

Table 5-14. Estimated Levels of Worker Exposure to Acrylonitrile (ppm) at Plants Across Three Decades

		Estimated exposure per decade[a]			
Job title	Plant type	1952–1959	1960–1969	1970–1979	1980–1983
Assistant reactor operator	Fiber	6.89	6.89	4.36	1.85
Monomer operator	Monomer	0.71–1.91	0.63–16.82	0.49–6.18	0.31–1.26
Wet tow operator	Fiber	20.82	15.38	9.13	0.80
Polymer operator and helper	Fiber	18.78	18.05	3.73	1.24
Production laborer	Resin	–	7.50	3.04	0.68
Maintenance mechanic	Fiber	2.05–7.72	2.05–6.44	1.50–2.70	0.36–0.67
	Monomer	0.02–1.52	0.03–8.17	0.04–2.07	0.01–0.58
	Resin	0.36	1.57	0.09	0.05
Quality control technician[b]	Fiber	0.23–2.24	0.25–2.03	0.24–1.58	0.20–0.93
	Monomer	0.05–0.06	0.07–3.57	0.08–2.07	0.07–0.81
	Resin	0.17	0.16	0.13	0.10

[a] Expressed as 8-hour time-weighted averages.
[b] This job was performed in a laboratory in a building separate from production and was not directly related to production.

Source: Stewart et al. 1998

Occupational exposures to acrylonitrile include plastic and polymer manufacturers, polymer molders, polymer combustion workers, furniture makers, and manufacturers of fibers and synthetic rubber (EPA 1980b). Other populations that could have elevated exposure to acrylonitrile include residents in the vicinity of industrial sources or chemical waste sites.

In a cohort study of workers in facilities which manufacture acrylonitrile monomer (n=4), acrylic fiber (n=3), and acrylic resins (n=1) in Virginia, Ohio, Texas, Louisiana, Florida, and Alabama, exposure to acrylonitrile was estimated based on short-term area samples collected prior to 1977 or personal air samples collected after 1977 (Stewart et al. 1998). Exposure estimates are reported in Table 5-14. The decreasing estimated exposure reflects plant operation and engineering changes, including exhaust ventilation, process and work practice changes, and equipment. Of these changes, 47% were implemented after 1977. While occupational exposures are likely to be the highest exposure setting for acrylonitrile, steps can be taken to limit this exposure.

Case studies of acrylonitrile poisoning in humans following fumigation of living quarters in post-World War II Germany suggest that children are more susceptible to acrylonitrile than adults (Grunske 1949). Children died after sleeping in rooms recently fumigated with acrylonitrile for lice and bed bugs, while adults sharing the same quarters reported few, if any, effects (skin or eye irritation).