

***HYDROGEN CYANIDE
ECOLOGICAL FATE AND EFFECTS PROFILE***

CAS No. 74 - 90 - 8

Prepared for

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Chemical Name: Hydrogen Cyanide

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1.0 SUMMARY

Hydrogen cyanide (HCN) is produced during the combustion of some plastics and it is believed to be one of the toxic compounds responsible for immobilization of fire victims. Hydrogen cyanide may be produced naturally by microorganisms as well as from the cyanogenic degradation of glycosides. Many plants may synthesize cyanoglucosides, which upon decomposition may lead to the formation of free cyanide.

The major sources of cyanide releases to water are discharges from metal finishing industries, iron and steel mills and organic chemical industries. Effluents from the cyanidation process used in precious metal extraction contain high amounts of cyanide. The major source of the cyanide released to air is vehicle exhaust and the major sources of cyanide releases to soil appear to be disposal of cyanide wastes in landfills and the use of cyanide-containing road salts. Cyanide released to air is expected to exist almost entirely as hydrogen cyanide gas. This compound has the potential to be transported over long distances before reacting with photochemically generated hydroxyl radicals. The residence time of HCN in the troposphere has been estimated to be 1.4 to 4.3 years. Neither photolysis nor deposition by rainwater is expected to be an important removal mechanism. In water, cyanide is expected to be removed primarily by volatilization.

At low concentrations, some hydrogen cyanide may also be removed by aerobic or anaerobic biodegradation. At soil surfaces with pH <9.2, volatilization of hydrogen cyanide is expected to be an important loss mechanism for cyanides. In subsurface soil, cyanide present at low concentrations would probably biodegrade. In cases where levels of cyanide are toxic to microorganisms (i.e., landfills, spills), hydrogen cyanide may leach into groundwater.

Cyanide is moderately toxic to invertebrates but is highly toxic to freshwater fish regardless the growth stage. Hydrogen cyanide is not expected to bioaccumulate in living organisms.

2.0 Environmental Fate

2.1 Environmental Fate Data

TYPE OF FATE	DATA	REFERENCE
Hydrolysis	N.A. ¹	
Water Solubility	Miscible with water	Merck, 1989
Photolysis - soil	N.A.	
Photolysis - water	N.A.	
Photolysis - air	Half-life = 334 days	ATSDR, 1995
Sorption/desorption (K_d)	not strongly partitioned into the sediments or suspended adsorbents.	ATSDR, 1995
Organic Carbon/Water Partition Coefficient (K_{OC})	N.A.	
Octanol/water partition Coefficient (K_{OW})	Log K_{OW} = 1.07	Verschueren, 1996
Bioconcentration - Bluegill Sunfish	not accumulated in any mammalian species	USEPA, 1980
	Log BCF = -0.42	Lyman <i>et al.</i> , 1982
Henry's Law Constant	N.A.	
Vapor Pressure	630 mm Hg at 20°C	White-Stevens, 1971

¹ N.A. = not available

2.2 Summary of Environmental Fate of Hydrogen Cyanide

2.2.1 Environmental Degradation/Bioconcentration: Hydrogen cyanide is resistant to direct photolysis; thus it is expected to be persistent in the environment. Hydrogen cyanide has the potential to be transported over long distances before being removed by physical or chemical processes due to its relatively slow rate of degradation. HCN is not expected to accumulate in either aquatic organisms or any mammalian species.

2.2.2. Aquatic Fate: Hydrogen cyanide can be formed from soluble alkali metal cyanides in aqueous media, and hydrogen cyanide is not expected to be formed from insoluble metal cyanides in water. Volatilization is expected to be an important fate process for hydrogen cyanide. At pH <9.2, most of the free cyanide should exist as hydrogen cyanide. Hydrogen cyanide is not expected to undergo direct photolysis to sediments or to bioaccumulate significantly in aquatic organisms (Callahan *et al.*, 1979)

Cyanide occurs most commonly in the form of hydrogen cyanide in water, although it can also occur as the cyanide ion, alkali metal cyanides (i.e., KCN, NaCN), relatively stable metalocyanide complexes (i.e., $[\text{Fe}(\text{CN})_6]^{-3}$), moderately stable metalocyanide complexes (i.e., copper cyanide), or easily decomposable metalocyanide complexes [i.e., $\text{Zn}(\text{CN})_2$]. The environmental fate of these cyanide compounds can vary widely (Callahan *et al.*, 1979).

2.2.3 Atmospheric Fate: Most cyanide in the atmosphere is expected to exist almost entirely as hydrogen cyanide gas, although small amounts of metal cyanides may be present as particulate matter in air. The reaction of hydrogen cyanide with photochemically generated hydroxyl radicals proceeds fairly slowly. Based on a reaction rate constant of $3 \times 10^{-14} \text{ m}^3/\text{molecules}\cdot\text{sec}$ at 25°C and assuming an ambient hydroxyl radical concentration of $8 \times 10^5 \text{ molecules}/\text{m}^3$, the half-life for the reaction of hydrogen cyanide vapor with hydroxyl radicals in the atmosphere has been approximately 334 days (ATSDR, 1995). Hydrogen cyanide is expected to be resistant to direct photolysis. The relatively slow rate of degradation of hydrogen cyanide suggests that this compound has the potential to be transported over long distances before being removed by physical or chemical processes. Since hydrogen cyanide is miscible in water, it appears that wet deposition may be an important fate process. Metal cyanide particles are expected to be removed from air by both wet and dry deposition (ATSDR, 1995).

2.2.4 Terrestrial Fate: The fate of cyanide in soil is pH dependent. Cyanide may occur in the form of hydrogen cyanide, alkali metal salts or immobile metalocyanide complexes. In acidic soils, the loss of hydrogen cyanide through volatilization may be the predominant mechanism of loss from soil surfaces. In subsurface soil, cyanides that are present in small concentrations may undergo some microbial degradation (Callahan *et al.*, 1979); in addition, considering cyanide's low soil sorption characteristics and high water solubility some may leach through the soil. In basic soils the mobility of cyanides in soil is expected to be greatly restricted. At soil surfaces with pH less than 9.2, it is expected that volatilization of hydrogen cyanide would be an important loss mechanism for cyanides. In subsurface soil, cyanide present at low concentrations would probably biodegrade. In soil with pH less than 9.2, hydrogen cyanide is expected to be highly mobile, and in cases where cyanide levels are toxic to microorganisms (i.e., landfills, spills), HCN may leach into groundwater (ATSDR, 1995).

2.2.5 Soil Adsorption and Soil Mobility: Hydrogen cyanide is not strongly partitioned into the sediments or suspended adsorbents, primarily due to its high solubility in water (Callahan *et al.*, 1979). In soil with pH less than 9.2, hydrogen cyanide is expected to be highly mobile (ATSDR, 1995). Cyanide mobility is least where soils exhibit low pH, high concentration of free iron oxides and positively charged particles (e.g., kaolin, chlorite, gibbsite). Mobility is greatest at high pH, high concentration of free calcium carbonate (high negative charge) and low clay content (Callahan *et al.*, 1979). Adsorption of hydrogen cyanide by montmorillonitic clays is fairly weak and is decreased by the presence of water (Callahan *et al.*, 1979).

2.2.6 Volatilization from Water and Soil: Volatilization is expected to be an important (if not dominant) fate process for hydrogen cyanide. At pH less than 9.2, most of the free cyanide

should exist as hydrogen cyanide, a volatile form of cyanide. Wide variations in the rate of volatilization are expected since this process is affected by a number of parameters including temperature, pH, wind speed and cyanide concentration (ATSDR, 1995).

3.0 ENVIRONMENTAL EFFECTS

3.1 Environmental Effects Data

TYPE OF EFFECTS	DATA	REFERENCE
Acute Toxicity - Fathead Minnow (<i>Pimephales promelas</i>)	LC ₅₀ = 124 - 152 Φg/L, 96-hour	Broderius <i>et al.</i> , 1977
Acute Toxicity - Fathead Minnow juvenile (<i>Pimephales promelas</i>)	LC ₅₀ = 82 - 137 Φg/L, 96-hour	McKee and Wolf, 1963
	LC ₅₀ = 123 Φg/L, 96-hour	USEPA, 1980
	LC ₅₀ = 117-157 Φg/L, 96-hour	Broderius <i>et al.</i> , 1977
Acute Toxicity - Bluegill juvenile (<i>Lepomis macrochirus</i>)	LC ₅₀ = 75-125 Φg/L, 96-hour	McKee and Wolf, 1963
Acute LC ₅₀ Rainbow Trout (<i>Salmo gairdnerii</i>)	LC ₅₀ = 57 Φg/L, 96-hour	McKee and Wolf, 1963
	LC ₅₀ = 28 - 68 mg/L, 96-hour	Kovacs and Leduc, 1982
Acute LC ₅₀ <i>Daphnia</i>	EC ₅₀ = 1.8 mg/L, 48-hour	Eckenfelder, 1966
	LC ₅₀ = 3.4 mg/L, 48-hour	Cole, 1941
Acute Toxicity - marine organisms - Shrimp (<i>Crangon crangon</i>)	N.A.	
Early Life Stage - Bluegill Sunfish (<i>Lepomis macrochirus</i>)	Mortality at 80 Φg/L, 1 st and 2 nd year spawners after 289 days	Kimball <i>et al.</i> , 1978
Chronic Life Cycle - <i>Daphnia</i>	N.A.	
Avian/Terrestrial wildlife oral LD ₅₀ Toxicity	N.A.	
Avian/Terrestrial Wildlife Dietary LC ₅₀ Toxicity	N.A.	
Chronic Avian/Terrestrial Wildlife Toxicity	N.A.	
Bacteria - Toxicity Test	N.A.	
Acute Toxicity to Benthic organisms	N.A.	

3.2 Summary of Environmental Effects of Hydrogen Cyanide

3.2.1 Acute Toxicity to Aquatic Organisms: Hydrogen cyanide is moderately toxic to invertebrates (>1 mg/L and <100 mg/L); but it is highly toxic (<1,000 μ g/L) to freshwater organism regardless the growth stages (i.e., eggs, swim up fry, juvenile, adults) of these fish.

3.2.2 Acute Toxicity to Benthic Organisms or Animals Exposed to Contaminated Sediments: No data available.

3.2.3 Acute Toxicity to Terrestrial Wildlife via Oral Dose: No data available.

3.2.4 Acute Toxicity to Terrestrial Wildlife via Diet or Food: No data available.

3.2.5 Acute Toxicity to Plants or Soil Organisms Exposed through Soil Concentrations: No data available.

3.2.6 Chronic Toxicity to Aquatic Organisms: No data available.

3.2.7 Chronic Toxicity to Terrestrial Wildlife via Diet or Food: No data available.

3.2.8 Toxicity to Bacteria or Algae: No data available

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5.0 SOURCE

Computer data base: August 1998
HSDB (Hazardous Substances Data Bank)
BIODEG
CHEMFATE
DATALOG
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