ENVIRONMENTAL CONTAMINANTS ENCYCLOPEDIA

ACENAPHTHENE ENTRY

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Like a library or most large databases (such as EPA's national STORET water quality database), this document contains information of variable quality from very diverse sources. In compiling this document, mistakes were found in peer reviewed journal articles, as well as in databases with relatively elaborate quality control mechanisms [366,649,940]. A few of these were caught and marked with a "[sic]" notation, but undoubtedly others slipped through. The [sic] notation was inserted by the editors to indicate information or spelling that seemed wrong or misleading, but which was nevertheless cited verbatim rather than arbitrarily changing what the author said.

Most likely additional transcription errors and typos have been added in some of our efforts. Furthermore, with such complex subject matter, it is not always easy to determine what is correct and what is incorrect, especially with the "experts" often disagreeing. It is not uncommon in scientific research for two different researchers to come up with different results which lead them to different conclusions. In compiling the Encyclopedia, the editors did not try to resolve such conflicts, but rather simply reported it all.

It should be kept in mind that data comparability is a major problem in environmental toxicology since laboratory and field methods are constantly changing and since there are so many different "standard methods" published by EPA, other federal agencies, state agencies, and various private groups. What some laboratory and field investigators actually do for standard operating practice is often a unique combination of various standard protocols and impromptu "improvements." In fact, the interagency task force on water methods concluded that [1014]:

> It is the exception rather than the rule that water-quality monitoring data from different programs or time periods can be compared on a scientifically sound basis, and that...
>
> No nationally accepted standard definitions exist for water quality parameters. The different organizations may collect data using identical or standard methods, but identify them by different names, or use the same names for data collected by different methods [1014].

Differences in field and laboratory methods are also major issues related to (the lack of) data comparability from media other than water: soil, sediments, tissues, and air.

In spite of numerous problems and complexities, knowledge is often power in decisions related to chemical contamination. It is therefore often helpful to be aware of a broad universe of conflicting results or conflicting expert opinions rather than having a portion of this information arbitrarily censored by someone else. Frequently one wants to know of the existence of information, even if one later decides not to use it for a particular application. Many would like to see a high percentage of the information available and decide for themselves what to throw out, partly because they don't want to seem uniformed or be caught by surprise by potentially important information. They are in a better position if they can say: "I knew about that data, assessed it based on the following quality assurance criteria, and decided not to use it for this application." This is especially true for users near the end of long decision processes, such as hazardous site cleanups, lengthy ecological risk assessments, or complex natural resource damage assessments.

For some categories, the editors found no information and inserted the phrase "no information found." This does not necessarily mean that no information exists; it

simply means that during our efforts, the editors found none. For many topics, there is probably information "out there" that is not in the Encyclopedia. The more time that passes without encyclopedia updates (none are planned at the moment), the more true this statement will become. Still, the Encyclopedia is unique in that it contains broad ecotoxicology information from more sources than many other reference documents. No updates of this document are currently planned. However, it is hoped that most of the information in the encyclopedia will be useful for some time to come even with out updates, just as one can still find information in the 1972 EPA Blue Book [12] that does not seem well summarized anywhere else.

Although the editors of this document have done their best in the limited time available to insure accuracy of quotes as being "what the original author said," the proposed interagency funding of a bigger project with more elaborate peer review and quality control steps never materialized.

The bottom line: The editors hope users find this document useful, but don't expect or depend on perfection herein. Neither the U.S. Government nor the National Park Service make any claims that this document is free of mistakes.

The following is one topic entry (one file among 118). See the file entitled RERENCE for the indentity of numbered references in brackets. See the README file for an introduction, an explanation of how to search and otherwise use this document, the oganization of each entry, information quality, copyright issues, and other entries (other topics) covered.

HOW TO CITE THIS DOCUMENT: As mentioned above, for critical applications it is better to obtain and cite the original publication after first verifying various data quality assurance concerns. For more routine applications, this document may be cited as:

> **Irwin, R.J., M. VanMouwerik, L. Stevens, M.D. Seese**, and **W. Basham.** 1997. Environmental Contaminants Encyclopedia. National Park Service, Water Resources Division, Fort Collins, Colorado. Distributed within the Federal Government as an Electronic Document (Projected public availability on the internet or NTIS: 1998).

Acenaphthene (CAS number 83-32-9)

Brief Introduction:

Br.Class: General Introduction and Classification Information:

Acenaphthene is a low molecular weight, 2-ring polyaromatic hydrocarbon (PAH), and is classified as a non-carcinogenic EPA priority pollutant [446,634,680,848]. Acenaphthene has a two-ring bridged structure [863].

Acenaphthene is included on the expanded scan list used by the Geochemical and Environmental Research Group (GERG) Laboratory at Texas A&M [828]. This list includes most of the PAHs recommended by the NOAA's National Status and Trends program [680].

Acenaphthene is a toxic pollutant designated pursuant to section 307(a)(1) of the Clean Water Act and is subject to effluent limitations. /Polynuclear aromatic hydrocarbons [366, 40 CFR 401.15 (7/1/87)].

Br.Haz: General Hazard/Toxicity Summary:

Studies conclude that the toxicity of an oil appears to be a function of its di-aromatic and tri-aromatic hydrocarbons (which includes two-ring hydrocarbons such as acenaphthene) [770].

The heavier (4-, 5-, and 6-ring) PAHs are more persistent than the lighter (2- and 3-ring) PAHs such as this one and tend to have greater carcinogenic and other chronic impact potential [796].

Acute toxicity is rarely reported in humans, fish, or wildlife, as a result of exposure to low levels of a single PAH compound such as this one. PAHs in general are more frequently associated with chronic risks. These risks include cancer and often are the result of exposures to complex mixtures of chronic-risk aromatics (such as PAHs, alkyl PAHs, benzenes, and alkyl benzenes), rather than exposures to low levels of a single compound (Roy Irwin, National Park Service, Personal Communication, 1996, based on an overview of literature on hand). See also "PAHs as a group" entry.

The Human Health (E-06 Risk Level for Carcinogens) Published Criteria for Water and Fish is 20 ug/liter (see W.Human section below) indicating strong concern for human health (see W.Human section below). The sediment

Effects Range Low (ERL), relating to estuarine ecological health, is 16 ppb, indicating strong potential for biological effects (see Sed.General section below).

The solubility of this compound is greater than for some heavier PAHs, increasing potential mobility and risk in certain habitats.

May cause acute vomiting if swallowed in large quantities. [366, Sax, N.I. Dangerous Properties of Industrial Materials. 5th ed. New York: Van Nostrand Rheinhold, 1979. 331].

Points of attack include the liver, kidneys, and skin. [366, Sittig, M. Handbook of Toxic And Hazardous Chemicals. Park Ridge, NJ: Noyes Data Corporation, 1981. 18].

See also: PAHs (as a group) entry.

Br.Carc: Brief Summary of Carcinogenicity/Cancer Information:

Acenaphthene has not been classified for carcinogenic effects by DHHS, IARC, or EPA [788].

IRIS EPA Carcinogenicity Assessment: Under Review as of 1996 [893].

This compound has not been treated as a carcinogen for calculation purposes in some EPA risk-based (RBC and PRG) models [868,903], but this tentative distinction was made for the purpose of choosing a modeling scenario based on current (often inadequate) knowledge rather than for the purpose of strongly stating that this compound is definitely not a carcinogen; the non-carcinogenic benchmarks are sometimes nearly as low as the carcinogenic benchmarks (Stan Smucker, personal communication, EPA, 1996).

Br.Dev: Brief Summary of Developmental, Reproductive, Endocrine, and Genotoxicity Information:

Acenaphthene was found to be both mutagenic and non-mutagenic in experiments with bacteria [366]. Produces nuclear and cytological changes in microbial and plant species. Most of these changes, such as an increase in cell size and DNA content are associated with disruption of the spindle mechanism during mitosis and the resulting induction of polyploidy.

Often found in the company of other PAHs. See also: PAHs (as a group) entry.

Br.Fate: Brief Summary of Key Bioconcentration, Fate, Transport, Persistence, Pathway, and Chemical/Physical Information:

Acenaphthene is widely distributed in the environment and is transported as absorbed matter on particulates suspended in air or water [366].

Polycyclic aromatic hydrocarbons with 4 or less aromatic rings (such as acenaphthene) are degraded by microbes and are readily metabolized by multicellular organisms; biodegradation may be the ultimate fate process [366].

The heavier (4-, 5-, and 6-ring) PAHs are more persistent than the lighter (2- and 3-ring) PAHs [796].

Biodegradation is probably slower in the aquatic system than in the soil, and biodegradation may be much more important in those aquatic systems which are chronically affected by contamination [366].

Two significant processes which can influence the fate of acenaphthene in the sediment are sorption and biodegradation [863]. Sorption of acenaphthene onto solids in the water column and subsequent settling, as well as partitioning onto organics in the sediment, can significantly affect acenaphthene transport. Oxidation, hydrolysis and volatilization processes were found to have no effect on the fate of acenaphthene in sediment [863].

Acenaphthene was found in groundwater at a coal and oil gasification plant some 30 years after the plant shut down [788].

Volatilization of acenaphthene (a low molecular weight PAH) from soil may be substantial [788].

Synonyms/Substance Identification:

1,8-hydroacenaphthylene [848]
ethylenaphthalene [848]
periethylenaphthalene [848]

Molecular Formula [366]:
C12-H10

Associated Chemicals or Topics (Includes Transformation Products):

See also individual entry:

PAHs as a group

Metabolism/Metabolites [366]:

Metabolized to naphthalene-1,8-dicarboxylic acid in rats. LH Chang & L Young, J Biol Chem 151, 87 (1943). /from table/ [Goodwin, B.L. Handbook of Intermediary Metabolism of Aromatic Compounds. New York: Wiley, 1976.,p. A-1].

Possibility of limited metabolism of acenaphthene to naphthalic acid & naphthalic anhydride. [Acenaphthene; PP 46-7 in Priority toxic pollutants; Sittig M, ED (1980)].

A Beijerinckia species and a mutant strain, Beijerinckia species strain B8/36, were shown to cooxidize the polycyclic aromatic hydrocarbons acenaphthene and acenaphthylene. Both organisms oxidized acenaphthene to the same spectrum of metabolites, which included 1-acenaphthenol, 1-acenaphtheneone, 1,2-acenaphthenediol, acenaphthenequinone, and a compound that was tentatively identified as 1,2-dihydroxyacenaphthylene. In contrast, acenaphthylene was oxidized to acenaphthenequinone and the compound tentatively identified as 1,2-dihydroxyacenaphthylene was also formed when the organism was incubated with synthetic cis-1,2-acenaphthenediol. A metabolite identified as cis-1,2-acenaphthenediol was formed from acenaphthylene by the mutant Beijerinckia species strain B8/36. Cell extracts prepared from the wild-type Beijerinckia strain contain a constitutive pyridine nucleotide-dependent dehydrogenase which can oxidize 1-acenaphthenol and 9-fluorenol. The results indicate that although acenaphthene and acenaphthylene are both oxidized to acenaphthenequinone, the pathways leading to the formation of this end product are different. [Schocken MJ, Gibson DT; Appl Environ Microbiol 48 (1): 10-16 (1984)].

Water Data Interpretation, Concentrations and Toxicity (All Water Data Subsections Start with "W."):

W.Low (Water Concentrations Considered Low):

No information found.

W.High (Water Concentrations Considered High):

In water extracted by macroreticular resins from a contaminated well in Ames, Iowa, investigators isolated acenaphthene at a level of 1.7 ppm. ... The contamination is believed to be the result of residue from a coal gas plant which may have leached into the aquifer after the plant closed in 1930. [Burnham AK et al; Anal Chem 44: 139 (1972) as cited in USEPA; Ambient Water Quality Criteria Doc: Acenaphthene (Draft) p.C-1 (1980)] [366].

Groundwater samples from the site of a Seattle coal and oil gasification plant which ceased operation in 1956

were found to contain acenaphthylene, acenaphthene, fluorene, phenanthrene, fluoranthene, pyrene, and chrysene at concentrations ranging from not detected (detection limit 0.005 mg/L) to 0.25, 0.18, 0.14, 0.13, 0.05, 0.08, and 0.01 mg/L, respectively [881].

W.Typical (Water Concentrations Considered Typical):

An analysis of the settling pond water from a wood preserving plant showed acenaphthene present at a level of 0.2 mg/l. [USEPA; Frequency of Organic Compounds Identified in Water EPA 600/4-76-062 (1976) as cited in USEPA; Ambient Water Quality Criteria Doc: Acenaphthene (Draft) p.C-1 (1980)] [366].

W.Concern Levels, Water Quality Criteria, LC50 Values, Water Quality Standards, Screening Levels, Dose/Response Data, and Other Water Benchmarks:

W.General (General Water Quality Standards, Criteria, and Benchmarks Related to Protection of Aquatic Biota in General; Includes Water Concentrations Versus Mixed or General Aquatic Biota):

National Water Quality Criteria in ug/L:

Freshwater Acute Criteria: Insufficient data to develop criteria. Lowest Observed Effect Level: 1,700 [446,689].

Freshwater Chronic Criteria: Insufficient data to develop criteria. Lowest Observed Effect Level: 520 [689].

Marine Acute Criteria: Marine Acute Criteria: Insufficient data to develop criteria. Lowest Observed Effect Level: 970 [446].

Marine Chronic Criteria: Insufficient data to develop criteria. Lowest Observed Effect Level: 710 [446].

Criteria Federal Register Notice Number: 45 FR 79324 [446,689].

NOTE: EPA had a "Gold Book" listing for this compound in 1986 [302,689]. EPA revises their water quality criteria periodically, so before citing a concentration as EPA's water quality criteria, it is prudent to make sure you have the latest one.

Oak Ridge National Lab, 1994: Ecological Risk

Assessment Freshwater Screening Benchmarks for concentrations of contaminants in water [649]. To be considered unlikely to represent an ecological risk, field concentrations should be below all of the following benchmarks [649]:

> NOTE: Although most of the lab tests done to develop water quality criteria and other benchmarks were originally based on "total" values rather than "dissolved" values, the lab settings were typically fairly clean and the numbers generated by the lab tests are therefore often even more comparable to field "dissolved" values than to field "total" values (Glen Suter, Oak Ridge National Lab, Personal Communication, 1995).

Acenaphthene (ug/L, ppb) Freshwater Benchmarks:

80 = National Ambient Water Quality (NAWC) Final Acute Value
23 = National Ambient Water Quality Final Chronic Value
74 = Lowest Chronic Value - Fish
6646 = Estimated Lowest Chronic Value - Daphnids
227= Lowest Chronic Value - Non-Daphnid Invertebrates
520 = Lowest Chronic Value - Aquatic plants
<197 = Lowest test EC20 - Fish

Numeric standards for acenaphthene in Hawaii [881]:

Applied to all waters: 570 ug/L
Freshwater (acute): 320 ug/L

The Final Acute Value (FAV) for freshwater organisms, derived from twelve standard acute toxicity tests on ten freshwater genera, was determined to be 80.01 ug/L. The FAV for saltwater organisms, derived from ten standard acute tests on ten saltwater genera, was 140.8 ug/L [863]. See the W.Invertebrate and W.Fish sections below for more acute toxicity data.

Chronic toxicity test were conducted with acenaphthene using a freshwater invertebrate, freshwater fish, and saltwater invertebrate. The Final Chronic Value (FCV) for freshwater organisms was determined to be 22.96 ug/L. The FCV for saltwater organisms was 40.41 ug/L. The invertebrate mean Acute-Chronic Ratio (ACR) was 3.484 for both freshwater and saltwater organisms [863].

The acute toxicity of acenaphthene from individual toxicity tests ranges from 120.0 to 2,045 ug/L for freshwater and 160 to 16,440 ug/L for saltwater organism [863].

Historical General Water Standards [366]:

Permissible concn in water: To protect freshwater aquatic life - 1700 ug/l. To protect salt-water aquatic life on an acute basis 970 ug/l and on a chronic basis 520 ug/l. [Sittig, M. Handbook of Toxic And Hazardous Chemicals. Park Ridge, NJ: Noyes Data Corporation, 1981. 17] [366].

W.Plants (Water Concentrations vs. Plants):

No information found.

W.Invertebrates (Water Concentrations vs. Invertebrates):

LC50 Snail adult > 2040 ug/l/96 hr at 22.9 deg C flow-through test [Holcombe GW et al; Ecotoxicol Environ Saf 7 (4): 400-9 (1983)] [366].

LC50 Mysidopsis bahia (mysid shrimp) 970 ug/l/96 hr in a static bioassay [USEPA; Ambient Water Quality Criteria Doc: Acenaphthene (Draft) p.B-4 (1980)] [366].

LC50/ EC50 96-hour acute values, ug/L (ppb) [863]:

Freshwater invertebrates [863]:
Snail (Aplexa hypnorum) >2,040 ppb, FT
Cladoceran (Daphnia magma) - 320 ppb, S
Cladoceran (Daphnia magma) - 1,300 ppb, FT
Amphipod (Gammarus minus) - 460 ppb, S
Stonefly (Peltoperla maria) - 240 ppb, S
Midge (Paratanytarsus sp.) - 2,000 ppb, S

Saltwater invertebrates [863]:
Annelid worm (Neanthes arenaceodentata) - 3,600 ppb, S
Mysid (Mysidopsis bahia) - 460 ppb, FT
Amphipod (Leptocheirus plumulosus) - 589.4 ppb, FT
Grass shrimp (Palaemonetes pugio) - 676.8 ppb, S
Sand shrimp (Crangon septemspinosus) - 245 ppb, S
Sea urchin (Arbacia punctalata) - 8,163 ppb, S

NOTES: Test conditions: FT = flow-through, R = renewal, S = static

W.Fish (Water Concentrations vs. Fish):

Chronic Criteria for aquatic and wildlife uses in Arizona is 550 ug/L [881].

Chronic Criteria for Cold-Water Fisheries in Arizona is 5500 ug/L [881].

LC50/ EC50 96-hour acute values, ug/L (ppb) [863]:

Freshwater fish [863]:

Rainbow trout (Oncorhynchus mykiss) - 670 ppb, FT
Brown trout (Salmo trutta) - 580 ppb, FT

Fathead minnow (Pimephales promelas)- >1140 ppb, FT

Channel catfish (Ictalurus punctatus)- 1720 ppb, FT

Bluegill (Lepomis macrochirus) - 1700 ppb, S

Saltwater fish [863]:

Sheepshead minnow (Cyprinodon variegatus) - 3100 ppb, FT

Inland silverside (Menidia beryllina)- 2300 ppb, S

NOTES: Test methods: FT = flow-through, R = renewal, S = static

Ecotoxicity Values [366]:

LC50 Lepomis macrochirus (bluegill) 1,700 ug/l/96 hr in a static bioassay [USEPA; Ambient Water Quality Criteria Doc: Acenaphthene (Draft) p.B-4 (1980)].

LC50 Cyprinodon variegatus (sheepshead minnow) 2,230 ug/l/96 hr in a static bioassay [USEPA; Ambient Water Quality Criteria Doc: Acenaphthene (Draft) p.B-1 (1980)].

LC50 Fathead minnow 1700 ug/l/72 hr at 22.9 deg C wt 0.16 g flow-through test (95% confidence limits 1610-1780 ug/l) [Holcombe GW et al; Ecotoxicol Environ Saf 7 (4): 400-9 (1983)].

LC50 Fathead minnow 1600 ug/l/96 hr at 22.9 deg C wt 0.16 g flow-through test (95% confidence limits 1560-1630 ug/l) [Holcombe GW et al; Ecotoxicol Environ Saf 7 (4): 400-9 (1983)].

LC50 Channel catfish 1720 ug/l/96 hr at 22.9 deg C wt 5.0 g flow-through test (95% confidence limits 1570-1880 ug/l) [Holcombe GW et al; Ecotoxicol Environ Saf 7 (4): 400-9 (1983)].

LC50 Rainbow trout 1570 ug/l/24 hr at 12.0 deg C wt 1.3 g flow-through test (95% confidence limits 1330-1850 ug/l) [Holcombe GW et al; Ecotoxicol Environ Saf 7 (4): 400-9 (1983)].

LC50 Rainbow trout 1130 ug/l/48 hr at 12.0 deg C wt 1.3 g flow-through test (95% confidence limits 1010-1270 ug/l) [Holcombe GW et al; Ecotoxicol Environ Saf 7 (4): 400-9 (1983)].

LC50 Rainbow trout 800 ug/l/72 hr at 12.0 deg C wt 1.3 g flow-through test (95% confidence limits 710-900 ug/l) [Holcombe GW et al; Ecotoxicol Environ Saf 7 (4): 400-9 (1983)].

LC50 Rainbow trout 670 ug/l/96 hr at 12.0 deg C wt 1.3 g flow-through test (95% confidence limits 600-750 ug/l) [Holcombe GW et al; Ecotoxicol Environ Saf 7 (4): 400-9 (1983)].

LC50 Brown trout 840 ug/1/24 hr at 12.0 deg C wt 0.16 g flow-through test (95% confidence limits 750-950 ug/l) [Holcombe GW et al; Ecotoxicol Environ Saf 7 (4): 400-9 (1983)].

LC50 Brown trout 650 ug/l/48 hr at 12.0 deg C wt 0.16 g flow-through test (95% confidence limits 590-720 ug/l) [Holcombe GW et al; Ecotoxicol Environ Saf 7 (4): 400-9 (1983)].

LC50 Brown trout 600 ug/l/72 hr at 12.0 deg C wt 0.16 g flow-through test (95% confidence limits 530-670 ug/l) [Holcombe GW et al; Ecotoxicol Environ Saf 7 (4): 400-9 (1983)].

LC50 Brown trout 580 ug/l/96 hr at 12.0 deg C wt 0.16 g flow-through test (95% confidence limits 510-660 ug/l) [Holcombe GW et al; Ecotoxicol Environ Saf 7 (4): 400-9 (1983)].

Flow-through, acute (96 hr) and early life stage (28 days after hatch) toxicity tests were performed with 8 chemicals on sheepshead minnows. Max acceptable toxicant concn were greater than 0.52 and less than 0.97 mg/l for acenaphthene. [Ward GS et al; J Toxicol Environ Health 8 (1-2): 225-40 (1981)].

A set of 4 embryo-larval bioassays, 2 each with

isophorone and acenaphthene, respectively, were conducted with the fathead minnow. The no effect levels when compared to the controls were 0.208 and 0.226 mg/l acenaphthene. [Lemke AE et al; Govt Reports Announcements & Index (24): 30 (1983)].

Flow-through 96 hr and early-life-stage toxicity tests were conducted with acenaphthene and isophorone using fathead minnows (Pimephales promelas) as test animals. The 96 hr median lethal concentrations were 608 ug/l for acenaphthene and 145 mg/l and 255 mg/l for isophorone, depending on fish age. No-effect concentrations from early-life-stage exposures were 413 ug acenaphthene and 14 mg isophorone/l. [Cairns MA, Nebeker AV; Arch Environ Contam Toxicol 11 (6): 703-7 (1982)].

Six laboratories conducted toxicity experiments according to a supplied protocol using acenaphthene and isophorone. Test organisms were fathead minnow (Pimephales promelas) embryos which were raised until 28 days post hatch. All fish were weighed and compared with the controls. Results ranged between 0.049 mg/l and 0.42 mg/l for the low solubility acenaphthene and between 1.35 mg/l and 45.4 mg/l for a more soluble isophorone. [Lemke AE; Gov't Reports Announcements & Index Issue 05 (1984)].

W.Wildlife (Water Concentrations vs. Wildlife or Domestic Animals):

Chronic Criteria for aquatic and wildlife uses in Arizona is 550 ug/L [881].

W.Human (Drinking Water and Other Human Concern Levels):

Published Criteria for Water for Humans Exposed to Water and Organisms: 20 ug/L [689].

Drinking Water MCL: None Published [446,893].

IRIS Drinking Water Health Advisories: empty [893].

EPA Preliminary remediation goals (PRGs) for tap water [868]: 3.7E+02 ug/L

EPA 1996 Water Health Based Limits: 2 mg/L [952].

The State of New York ambient water quality standard (AWQS) aesthetic limit (that is, whose presence in excess of the limit does not present a risk to human health, but may render the water unpalatable or otherwise unacceptable to the

consumer) is set at 20 ug/L (ppb) [859].

The threshold concentration for causing taste and odor in water (not toxic to humans) for acenaphthene in Wisconsin is 20 ug/L [881].

Numeric Water Quality Criteria in Arizona [881]:

Domestic water supply: 420 ug/L
Fish consumption: 2600 ug/L
Full body contact: 8400 ug/L
Partial body contact: 8400 ug/L

Concern levels for acenaphthene in Alabama [881]:

Consumption of water and fish: 20 ug/L
Fish consumption only: 20 ug/L

Criteria for various classes of human health protection in Missouri [881]:

Fish consumption (class II): 2700 ug/L
Drinking water supply (class III): 20 ug/L
Groundwater (class VII): 20 ug/L

Information from HSDB [366]:

The lowest human responses were reported at 0.022-0.22 ppm, & thus 20 ug/l is the recommended ambient water criterion. Until more toxicological data are generated, an interim criterion based upon organoleptic data is proposed. It must be emphasized, however, that this value is not related to health effects and that the significance of odor thresholds is unknown. This value will need to be reviewed when more toxicological data are available. [Acenaphthene; pp 46-7 in Priority Toxic Pollutants; Sittig M, ED (1980)].

W.Misc. (Other Non-concentration Water Information):

Differences between concentrations of acenaphthene causing acute lethality and chronic toxicity are small; acute-chronic ratios range from 1.5 to 6.7 [863]. Although acenaphthene bioaccumulates in aquatic biota, the associated health or ecological risks are unknown [863].

Sediment Data Interpretation, Concentrations and Toxicity (All Sediment Data Subsections Start with "Sed."):

Sed.Low (Sediment Concentrations Considered Low):

No information found.

Sed.High (Sediment Concentrations Considered High):

No information found.

Sed.Typical (Sediment Concentrations Considered Typical):

Acenaphthene was detected in 61.2 percent of urban-bay samples from the Puget Sound area. The mean concentration was 1172.1 ug/kg dry weight (ppb), while the median concentration was 71 ug/kg (ppb) [852].

Acenaphthene was detected in 35.6 percent of non-urban-bay samples from the Puget Sound area. The mean concentration was 1131.13 ug/kg dry weight (ppb), while the median concentration was 45 ug/kg (ppb) [852].

NOTE: The above values are not normalized for total organic carbon (TOC) content. Urban bay concentrations may be lower than or near non-urban bay concentrations due to more frequent dredging practices in urban bays, and also to the fact that most of the urban bays are at the mouths of rivers which are continually depositing "clean" sediment into these bays.

In an assessment of STORET data covering the period 1980-1982, Staples et al. (1985) reported median concentrations in sediment of less than or equal to 500 ug/kg dry weight for 15 PAHs (acenaphthene, acenaphthylene, anthracene, benz[a]anthracene, benzo[b]fluoranthene, benzo[k]fluoranthene, benzo[g,h,i]perylene, benzo[a]pyrene, chrysene, fluoranthene, fluorene, indenopyrene, naphthalene, phenanthrene, and pyrene). The number of sample ranged from 236 (anthracene) to 360 (benzo[a]pyrene, fluoranthene); the percentage of samples in which these PAHs were detected ranged from 6.0 (acenaphthene, benzo[b]fluoranthene, benzo[k]fluoranthene, indeno[1,2,3-c,d]pyrene) to 22.0 (fluoranthene, pyrene) [881].

Sed.Concern Levels, Sediment Quality Criteria, LC50 Values, Sediment Quality Standards, Screening Levels, Dose/Response Data, and Other Sediment Benchmarks:

Sed.General (General Sediment Quality Standards, Criteria, and Benchmarks Related to Protection of Aquatic Biota in General; Includes Sediment Concentrations Versus Mixed or General Aquatic Biota)

Oak Ridge National Lab, 1994: Risk Assessment Screening Benchmarks for Sediment Concentrations.

To be considered unlikely to represent an ecological risk, field concentrations should be below the following benchmark in mg/kg (ppm) dry weight [652]:

> 1.3 is the sediment quality criterion at 1% Organic Carbon (EPA)

Various Sediment Concern Levels (organic carbon basis): The Sediment Quality Criteria on a sediment organic carbon basis (SQC oc) was determined to be 130 ug/g oc in freshwater, and 230 ug/g oc in saltwater [863]. Additional detail from EPA [863]:

> The procedures described in the "Technical Basis for Deriving Sediment Quality Criteria for Nonionic Organic Contaminants by Using Equilibrium Partitioning" indicate that benthic organisms should be acceptably protected in freshwater sediments containing less than or equal to 130 ug acenaphthene/g organic carbon and saltwater sediments containing less than or equal to 230 ug acenaphthene/g organic carbon, except possibly where a locally important species is very sensitive or sediment organic carbon is < 0.2% [863].
>
> These values were derived from acenaphthene Final Chronic Values (FCV) of 23.0 ug/L for freshwater and 40.4 ug/L for saltwater, and an organic carbon partition coefficient (Log 10 K oc) of 3.76 [863]. Dry weight concentrations can be converted to organic carbon normalized concentrations with the following formula [863]:
>
> ug/g oc = ug/g dry weight x 100 / % TOC
>
> NOTES: TOC = total organic carbon content. The use of the FCV (that is, the chronic effects-based water quality criteria) as the effects concentration for calculation of the equilibrium partition (EqP)-based SQC assumes that benthic species as a group have sensitivities similar to the benthic and water column species tested to derive the FCV concentrations (see reference [863] values in the above W.General, W.Invertebrates, and W.Fish sections). This method also assumes that the partitioning of the chemical between sediment organic carbon and interstitial water is at equilibrium. Therefore, SQC values may also need to be adjusted because of site

specific considerations. In spill situations, where chemical equilibrium between water and sediments has not yet been reached, sediment chemical concentrations less than the SQC may pose risks to benthic organisms because disequilibrium concentrations in interstitial and overlying water may be proportionally higher relative to sediment concentrations [863].

Confidence limits of 62 to 280 ug/g(oc) for freshwater sediments and 110 to 500 ug/g(oc) for saltwater sediments are provided as an estimate of the uncertainty associated with the degree to which the observed concentration in sediment [ug/g(oc)], which may be toxic, can be predicted [863]. This can be done by using the organic carbon partition coefficient, K(oc), and the water-only effects concentration [863]. Confidence limits do not incorporate uncertainty associated with water quality criteria [863]. Sound judgements involve understanding the theoretical basis of the equilibrium partitioning methodology, uncertainty, the partitioning and toxicity of acenaphthene, and are required in the regulatory use of SQC and their confidence limits [863].

These concentrations represent the U.S. EPA's current best judgement at this time of the levels of acenaphthene in sediments that would be protective of benthic species [863]. It is the philosophy of the Agency and the EPA Science Advisory Board that the use of sediment quality criteria (SQCs) as stand-alone, pass-fail criteria is not recommended for all applications and should frequently trigger additional studies at sites under investigation [863]. The upper confidence limit should be interpreted as a concentration above which impacts on benthic species should be expected [863]. Conversely, the lower confidence limit should be interpreted at a concentration below which impacts on benthic species should be unlikely [863].

AET, EPA 1988: The Apparent Effects Threshold concentrations for acenaphthene in sediments proposed for Puget Sound ranged from .50 mg/kg dry weight (microtox) to 2.0 mg/kg dry weight (amphipod) [416]. Although the authors of the Puget Sound AETs have cautioned that Puget Sound AETs may not be appropriate for comparison with

data from other geographic areas, so few concern levels for this chemical have been published that the proposed Puget Sound concern level is included in this text as a reference item.

The Canadian AET concentration, adapted from NOAA (1990), for acenaphthene sorbed to marine sediments is 0.150 mg/kg dry weight [864]. An AET is defined as the lowest concentration of a compound in sediment at which biological effects (usually changes in composition of benthic invertebrate communities) are observed to occur [864].

> NOTE: Even lower concentrations of this PAH may be of concern related to its contribution to "total PAH" sums (see the "PAHs as a group" entry).

NOAA 1995 Concern Levels for Coastal and Estuarine Environments: After studying its own data from the National Status and Trends Program as well as many literature references concerning different approaches to determining sediment criteria, NOAA suggested that the potential for biological effects of this contaminant sorbed to sediments was highest in sediments where its concentration exceeded the 500 ppb dry weight Effects Range-Median (ERM) concentration and was lowest in sediments where its concentration was less than the 16 ppb dry weight Effects Range-Low (ERL) concentration [664]. To improve the original 1990 guidelines [233], the 1995 report included percent (ratios) incidence of effects for ranges below, above, and between the ERL and ERM values. These numbers represent the number of data entries within each concentration range in which biological effects were observed divided by the total number of entries within each range [664]:

<ERL	20.0
ERL-ERM	32.4
>ERM	84.2

The 1995 study also compared these derived ERM values to criteria developed with other methods. For example, the national sediment quality criteria proposed by the US EPA (1993) for acenaphthene is 240 ug/gram organic carbon (goc), with 95% confidence limits of 110 and 500 ug/goc [664]. Assuming a total organic carbon (TOC) concentration of 1%, this is equivalent to 2400 (1100 - 5000) ppb dry weight. This exceeds the ERM value of 500 ppb by a factor of 4.8. Note that increasing the percent TOC would increase the EPA criteria value

[664].

St. Lawrence River Interim Freshwater Sediment Criteria, 1992. No effect level: 10 ug/kg dry weight [761].

Sed.Plants (Sediment Concentrations vs. Plants):

No information found.

Sed.Invertebrates (Sediment Concentrations vs. Invertebrates):

The acute toxicity of acenapthene spiked into sediments was tested with two saltwater amphipod species. Test results follow and include both pore water toxicities and organic carbon conditions of the tests [863]:

LC50s [863]:

Amphipod (Eohaustorius estuarius) -
sediment toxicity = 44.4 ug/g dry weight
pore water toxicity = 800 ug/L
Organic carbon conditions: 1.23% TOC

Amphipod (Eohaustorius estuarius) -
sediment toxicity = 47.8 ug/g dry weight
pore water toxicity = 609 ug/L
Organic carbon conditions: 2.49% TOC

Amphipod (Eohaustorius estuarius) -
sediment toxicity = 68.4 ug/g dry weight
pore water toxicity = 542 ug/L
Organic carbon conditions: 4.21% TOC

Amphipod (Leptocheirus plumulosus) -
sediment toxicity = >193 ug/g dry weight
pore water toxicity = >1720 ug/L
Organic carbon conditions: 1.62% TOC

Amphipod (Leptocheirus plumulosus) -
sediment toxicity = 193 ug/g dry weight
pore water toxicity = 1410 ug/L
Organic carbon conditions: 2.52% TOC

Amphipod (Leptocheirus plumulosus) -
sediment toxicity = 382 ug/g dry weight
pore water toxicity = 1490 ug/L
Organic carbon conditions: 3.66% TOC

NOTE: TOC = total organic carbon content; All tests were static, 10-day tests.

Sed.Fish (Sediment Concentrations vs. Fish):

No information found.

Sed.Wildlife (Sediment Concentrations vs. Wildlife or Domestic Animals):

No information found.

Sed.Human (Sediment Concentrations vs. Human):

No information found.

Sed.Misc. (Other Non-concentration Sediment Information):

Description of the equilibrium partitioning methodology related to this compound [863]:

Sediment quality criteria (SQC) are the numerical concentrations of individual chemicals which are intended to be predictive of biological effects, protective of the presence of benthic organisms and applicable to the range of natural sediments from lakes, streams, estuaries, and near coastal marine waters [863]. As a consequence, they can be used in much the same way as water quality criteria (WQC); i.e., the concentration of a chemical which is protective of the intended use(e.g. aquatic life protection). For non-ionic organic chemicals, SQC are expressed as ug chemical/g organic carbon and apply to sediments having greater than or equal to 0.2% organic carbon by dry weight [863].

A brief overview of the concepts which underlie the equilibrium partitioning methodology for deriving SQC follows [863]. The methodology is discussed in detail in the "Technical Basis for Deriving Numerical National Sediment Quality Criteria for Nonionic Organic Contaminants by Using Equilibrium Partitioning for the Protection of Benthic Organisms," hereafter referred to as the SQC Technical Basis Document [863].

Soil Data Interpretation, Concentrations and Toxicity (All Soil Data Subsections Start with "Soil."):

Soil.Low (Soil Concentrations Considered Low):

No information found.

Soil.High (Soil Concentrations Considered High):

Soil Concentrations (mg/kg dry weight) Polycyclic

Aromatic Hydrocarbons (PAHs) at Contaminated Sites. Highest values found at wood preserving, gas works, and coking site plants (mg/kg dry weight) [881]:

Acenaphthene	1,368

Soil.Typical (Soil Concentrations Considered Typical):

Background Soil Concentrations of Acenaphthene (PAH concentration in ug/kg) [881]:

Rural soil	1.7
Agricultural Soil	6

Soil.Concern Levels, Soil Quality Criteria, LC50 Values, Soil Quality Standards, Screening Levels, Dose/Response Data and Other Soil Benchmarks:

Soil.General (General Soil Quality Standards, Criteria, and Benchmarks Related to Protection of Soil-dwelling Biota in General; Includes Soil Concentrations Versus Mixed or General Soil-dwelling Biota):

No information found.

Soil.Plants (Soil Concentrations vs. Plants):

No information found.

Soil.Invertebrates (Soil Concentrations vs. Invertebrates):

No information found.

Soil.Wildlife (Soil Concentrations vs. Wildlife or Domestic Animals):

No information found.

Soil.Human (Soil Concentrations vs. Human):

EPA 1996 National Generic Soil Screening Level (SSL) designed to be conservative and protective at the majority of sites in the U.S. but not necessarily protective of all known human exposure pathways, land uses, or ecological threats [952]:

SSL = 4700 mg/kg for ingestion pathway [952].

SSL = 29 to 570 mg/kg for protection from migration to groundwater at 1 to 20 Dilution-Attenuation Factor (DAF) [952].

EPA Region 9 Preliminary remediation goals (PRGs) [868]:

Residential Soil: 3.6E+02 mg/kg wet wt.

Industrial Soil: 3.6E+02 mg/kg wet wt.

NOTE:

1) PRGs focus on the human exposure pathways of ingestion, inhalation of particulates and volatiles, and dermal absorption. Values do not consider impact to groundwater or ecological receptors.

2) PRGs for residential and industrial landuses are slightly lower concentrations than EPA Region III RBCs, which consider fewer aspects (more limited to soil ingestion) [903].

EPA Region III Risk Based Concentration (RBC) to protect from transfers to groundwater:

200 mg/Kg dry weight [903].

Soil.Misc. (Other Non-concentration Soil Information):

No information found.

Tissue and Food Concentrations (All Tissue Data Interpretation Subsections Start with "Tis."):

Tis.Plants:

A) As Food: Concentrations or Doses of Concern to Living Things Which Eat Plants:

No information found.

B) Body Burden Residues in Plants: Typical, Elevated, or of Concern Related to the Well-being of the Organism Itself:

Treatment of cherry-mazzard hybrid seeds with acenaphthene powder for 10 hr inhibited the seed germination & seedling growth. [Zhukov OS; Tr Tsent Genet Lab, Vses Akad Selskokhoz Nauk 12: 179-82 (1971)] [366].

Tis.Invertebrates:

A) As Food: Concentrations or Doses of Concern to Living Things Which Eat Invertebrates:

No information found.

B) Concentrations or Doses of Concern in Food Items Eaten by Invertebrates:

No information found.

C) Body Burden Residues in Invertebrates: Typical, Elevated, or of Concern Related to the Well-being of the Organism Itself:

No detections of this compound were made in certain samples of Exxon Valdez fish or mussels [971].

Levels of > or = 3.2 ug acenaphthene/kg (the detection limit) were reportedly identified in the tissues of shellfish of an unspecified species and location. [Onuska FI et al; Anal Lett 9: 451 (1976) as cited in USEPA; Ambient Water Quality Criteria Doc: Acenaphthene (Draft) p.C-2 (1980), 366].

Tis.Fish:

A) As Food: Concentrations or Doses of Concern to Living Things Which Eat Fish (Includes FDA Action Levels for Fish and Similar Benchmark Levels From Other Countries):

No information found.

B) Concentrations or Doses of Concern in Food Items Eaten by Fish:

No information found.

C) Body Burden Residues in Fish: Typical, Elevated or of Concern Related to the Well-being of the Organism Itself:

No detections of this compound were made in certain samples of Exxon Valdez fish or mussels [971].

Tis.Wildlife: Terrestrial and Aquatic Wildlife, Domestic Animals and all Birds Whether Aquatic or not:

A) As Food: Concentrations or Doses of Concern to Living Things Which Eat Wildlife, Domestic Animals, or Birds:

No information found.

B) Concentrations or Doses of Concern in Food Items

Eaten by Wildlife, Birds or Domestic Animals (Includes LD50 Values Which do not Fit Well into Other Categories, Includes Oral Doses Administered in Laboratory Experiments):

Acenaphthene at 2 g/kg body weight administered orally in olive oil to seven young rats (sex not specified) daily for 32 days caused loss of body weight and changes in peripheral blood, increased aminotransferase levels in blood serum, and produced mild morphological damage to both the liver and kidney. ... The morphological damage to the kidney and the liver was greater when acenaphthene was administered in a subacute manner than when an acute dose was given. After 32 days of treatment the animals showed mild bronchitis and localized inflammation of the peribronchial tissue. [Knobloch K et al; Med Pracy 20: 210 (1969) as cited in USEPA; Ambient Water Quality Criteria Doc: Acenaphthene (Draft) p.C-5 (1980)] [366].

Pretreatment of rats with 20 mg/kg ip dose of acenaphthene prolonged by up to 50% the duration of paralysis induced with 90 mg/kg zoxazolamine 24 hr later. [Buu-hoi NP, Hien-do-phouc; CR Hebd Seances Acad Sci, Ser D 268 (2): 423-6 (1969)] [366].

C) Body Burden Residues in Wildlife, Birds or Domestic Animals: Typical, Elevated, or of Concern Related to the Well-being of the Organism Itself:

No information found.

Tis.Human:

A) Typical Concentrations in Human Food Survey Items:

No information found.

B) Concentrations or Doses of Concern in Food Items Eaten by Humans (Includes Allowable Tolerances in Human Food, FDA, State and Standards of Other Countries):

For risk to human adults eating fish, separate carcinogenic and non-carcinogenic risk-based fish tissue concentrations were calculated [903]. The following EPA Region III fish tissue risk-based concentration (RBC) benchmark utilizes the lower of the two (carcinogenic vs. non-carcinogenic) concentrations, rounded to two significant figures [903]: 81 mg/Kg wet weight. The reader should keep in mind that fish metabolize PAHs and therefore the concentrations would seldom if ever be this high.

A greater risk to humans may be from invertebrates, PAH metabolites, or routes of exposure other than fish. However, concentrations of individual PAHs often occur in the presence of complex mixtures of PAHs, and that complex mixtures of PAHs often display carcinogenic and phototoxic properties (see "PAHs as a group" entry).

EPA IRIS Information [893]:

Crit. Dose: 175 mg/kg-day [Study 1 NOAEL]
UF: 3000

RfD: 6E-2 mg/kg-day Confidence: Low

C) Body Burden Residues in Humans: Typical, Elevated, or of Concern Related to the Well-being of Humans:

EPA has suggested that taking into your body each day the following amounts of acenaphthene is not likely to cause any significant (noncancer) harmful health effects: 0.06 mg acenaphthene per kg body weight [788].

Tis.Misc. (Other Tissue Information):

No information found.

Bio.Detail: Detailed Information on Bioconcentration, Biomagnification, or Bioavailability:

Bioaccumulation is not considered a significant fate process for acenaphthene [863].

Although acenaphthene bioaccumulates in aquatic biota, the associated health or ecological risks are unknown [863].

During the Exxon Valdez spill, bioconcentration explained the buildup of PAHs in tissues better than biomagnification; most accumulation was of an equilibrium partitioning nature across the gills rather than from the food chain [971]. Immature fish seem have higher bioconcentration of PAHs than adults, perhaps because their PAH breakdown systems are not fully developed and at times perhaps because of a higher percentage of lipid tissues (yolk tissues, etc) [971] (confirmed by Jerry Neff, Battelle Ocean Sciences, Duxbury, MA, personal communication 1996).

Bioconcentration information [366]:

The bluegill accumulated acenaphthene during a 28-day exposure and the bioconcentration factor was 387 using (14)C-acenaphthene and thin-layer chromatography for verification. [USEPA; Ambient Water Quality Criteria Doc: Acenaphthene (Draft) p.B-2 (1980)].

Bioaccumulation, especially in vertebrate organisms, is considered to be short-term, and is not considered an important fate process. /Polycyclic aromatic hydrocarbons/ [Callahan, M.A., M.W. Slimak, N.W. Gabel, et al. Water-Related Environmental Fate of 129 Priority Pollutants. Volume I. EPA-440/4 79-029a. Washington, DC: U.S. Environmental Protection Agency, December 1979.,p. 95-9].

Freshwater acute value for bluegill was 1,700 ug/l, & bioconcentration factor was 397. Saltwater toxicity to sheepshead minnow was 2,230 ug/l, & no bioconcentration data were available. [Acenaphthene; PP 46-7 in Priority Toxic Pollutants; Sittig M, ED (1980)].

Some marine organisms have no detectable aryl hydrocarbons hydroxylase enzyme systems, namely: phytoplankton, certain zooplankton, mussels (Mytilus edulis), scallops (Placopecten sp), and snails (Litternia littorea). ... Those organisms which lack a metabolic detoxification enzyme system, tend to accumulate polycyclic aromatic hydrocarbons. /Polycyclic aromatic hydrocarbons/ [Malins DC; Ann NY Acad Sci 298: 482-496 (1977) as cited in: Health and Welfare Canada; Polycyclic Aromatic Hydrocarbons p.37 (1979) Report No. 80-EHD-50].

Polycyclic aromatic hydrocarbons (PAH) were analyzed in surfical sediments & benthic organisms in southeastern lake erie, near a large coal-fired power plant. Sediment concn (530-770 ppb PAH) were relatively homogenous throughout most of the 150 square km area, although river & nearshore concentrations reached 4 ppm. Oligochaete worms did not bioconcentrate (on wet wt basis) any of the PAH. Chironomide midges collected 1 km offshore exhibited bioconcentration of 5 PAH one of which was pyrene. Further offshore, these apparent bioconcentrations disappeared, with midges at near equilibrium with sediments. [Eadie BJ et al; Chemosphere 11 (2): 185-92 (1982)].

Biological Half-Life [366]:

The half-life of acenaphthene in /the bluegill fish/ is less than 1 day. [USEPA; Ambient Water Quality Criteria Doc: Acenaphthene (Draft) p.B-2 (1980)].

Interactions:

No information found.

Uses/Sources:

See Chem.Detail section below for acenaphthene concentrations in various petroleum products.

Acenaphthene occurs both naturally in coal tar, and as a by-

product of manufacturing processes such as petroleum refining, shale oil processing and coal tar distilling [863]. Acenaphthene was found in groundwater at a coal and oil gasification plant some 30 years after the plant shut down [788]. Other man-made sources of acenaphthene include its generation as a by-product of the combustion of tobacco, and its presence in asphalt and in soots generated by the combustion of aromatic fuels amended with pyridine [863].

Acenaphthene is used in manufacturing processes to produce dyes, plastics, insecticides and fungicides [863]. It is one of the components of Panasol AN-2 solvent which is used in pesticides [186].

The potential impact of motorboat activity on the Occoquan (drinking-water) reservoir east of Washington, D.C. was evaluated at both marina and nonmarina sites. The presence of PAHs (especially the lower molecular weight compounds like acenaphthene and naphthalene) in June during peak boating activity, and the absence of PAHs in October, a period of low boating activity, indicated boating to be a source of PAH to the water [653].

Major Uses [366]:

Dye intermediate; mfr plastics; insecticide; fungicide [The Merck Index. 10th ed. Rahway, New Jersey: Merck Co., Inc., 1983. 5].

Mfr pharmaceuticals [Hawley, G.G. The Condensed Chemical Dictionary. 10th ed. New York: Van Nostrand Reinhold Co., 1981. 4].

Admin of (0.10%) Acenaphthene as a dietary supplement for 10 days accelerated liver regeneration in partially hepatectomized male rats. [Gershbein ll; res commun chem pathol pharmacol 11 (3): 445-66 (1975)].

Artificial Sources [366]:

Acenaphthene has been detected in cigarette smoke, automobile exhaust, in urban air, & is present in coal tar & several fossil fuel oils. Also reported in wastewater from petrochemical, pesticide, & wood preservative industries. [Priority Toxic Pollutants: Health Impacts and Allowable Limits; Sittig M, ED, 46-7 (1980)].

Combustion of tobacco; constituent in asphalt; in soots generated by the combustion of aromatic fuels doped with pyridine. [Verschueren, K. Handbook of Environmental Data of Organic Chemicals. 2nd ed. New York, NY: Van Nostrand Reinhold Co., 1983. 138].

Occurs in petroleum bottoms [Patty. Indus Hyg & Tox 3rd ed VoL2A, 2B, 2C 1981-1982 p.3353].

Mfr source: shale oil processing, coal tar distilling;

constituent in asphalt, /found/ in soots generated by combustion of aromatic fuels doped with pyridine [Verschueren. Hdbk Environ Data Org Chem 1983 p.138].

Occurs in high temperature coal tar [Kirk-othmer Encyc Chem Tech 3rd ed 1978-present V15 p.717].

Is found in 0.42-1.28 wt% of dry tar, in coke oven-tars; 0.50-0.80 wt% of dry tar, in cvr tars, uk; 0.19 wt% of dry tar in low temp tars uk average; and 0.57 wt% of dry tar, in lurgi tars uk average [Kirk-othmer Encyc Chem Tech 3RD ED 1978-present V22 p.572].

Forms/Preparations/Formulations:

No information found.

Chem.Detail: Detailed Information on Chemical/Physical Properties:

Petroleum-derived PAH assemblages contain higher amounts of the smaller molecular wight PAHs such as naphthalene, acenaphthene, and fluorene, and also alkylated PAHs such as methylnaphthalenes. A higher ratio of three to four ring PAHs and a higher ratio of three to five ring PAHs exists in petroleum and petroleum-polluted sediments compared to recently formed or uncontaminated sediments [653].

Solubility:

It has a solubility in water at 25 degrees C of 3.94 mg/l, and is a solid at room temperature (melting point of 116 degrees C) [863].

3.47 - 4.47 mg/L at 25 degrees C [848].

Density [848]: 1.042 - 1.069 g/cm3 at 95 degrees C.

Melting point:

93.0 - 96.2 degrees C [848].
90 - 95 degress C [863].

Boiling point [848]: 278 degrees C.

Vapor pressure [848]: 0.287 - 0.378 Pa at 25 degrees C.

Octanol/Water partition coefficient (low Kow) [848]: 3.92 - 4.45

Log Kow [971]: 3.92

Sorption partition coefficient (low Koc) [848]: 3.59 - 3.79

PAH concentrations (ug/g oil sampled) were determined for

three different crude oil sample types (weathered and unweathered oil) taken from the Exxon Valdez oil spill. Acenaphthene was not detected in any of them [790; Reprinted with permission from Environmental Toxicology and Chemistry, Vol.14(11), W.A. Stubblefield, G.A. Hancock, W.H. Ford, and R.K. Ringer, "Acute and Subchronic Toxicity of Naturally Weathered Exxon Valdez Crude Oil in Mallards and Ferrets." Copyright 1995 SETAC].

Details of acenaphthene content (mg/kg or ppm) in one fresh sample of Exxon Valdez Crude Oil [971]: 2 mg/kg = ppm

Acenaphthene content in one fresh sample of NSFO (Fuel Oil 5, Chuck Rafkind, National Park Service, Personal Communication, 1996): 111.2 ng/mg or ppm.

Acenaphthene content in one sample of groundwater subjected to long-term contamination of NSFO (Fuel Oil 5), possibly mixed with some JP-4, motorgas, and JP-8, Colonial National Historical Park Groundwater Site MW-10 (Chuck Rafkind, National Park Service, Personal Communication, 1996): 1517.6 ng/L (or ppt)

> NOTE: The above two PAH concentrations were analyzed by a GC/MS/SIM NOAA protocol [828] modified with methylene chloride extraction for use with water samples (Guy Denoux, Geochemical and Environmental Research Group, Texas A&M University, personal communication 1996).

Acenaphthene concentration in Used Engine Oil: 3.7 ppm [519; Reprinted with permission from Environmental Toxicology and Chemistry, Volume 12, Upshall, C., J.F. Payne and J. Hellou. Induction of MFO enzymes and production of bile metabolites in rainbow trout (Oncorhynchus mykiss) exposed to waste crankcase oil. Copyright 1992 SETAC].

Fate.Detail: Detailed Information on Fate, Transport, Persistence, and/or Pathways:

The lower molecular weight PAHs (acenaphthene, naphthalene, fluorene) may be rapidly lost from the water column due to volatilization and microbial degradation, while the large molecular weight PAHs [B(a)A, B(a)P] are more susceptible to losses due to photo-oxidation and may be removed as a result of sedimentation. Thus PAHs have a short residence time in aqueous solution and, when present in the water column, they are usually a result of recent or chronic pollution [653].

Volatilization of acenaphthene, anthracene, fluorene, and phenanthrene (low molecular weight PAHs) from soil may be substantial. Of 14 PAHs studied in two soils, volatilization was found to account for about 20% of the loss of 1-methylnaphthalene and 30% of the loss of naphthalene; volatilization was not an important loss mechanism for the other compounds. Lower molecular weight compounds may also volatilize from sediments; this process is not significant for the higher molecular weight compounds [788].

Environmental Fate [366]:

Terrestrial Fate: The transport and effects of (14)C-labeled wood preservatives (creosote with labeled phenanthrene or acenaphthene, pentachlorophenol, and bis(tri-n-butyltin) oxide) impregnated in wood posts were examined in a terrestrial microcosm chamber (TMC-II) in comparison to a reference compound, the insecticide dieldrin. The TMC-II contained a Willamette Valley topsoil, ryegrass, invertebrates, and a gravid gray-tailed vole (Microtus conicaudus). Approximately 2.5 months after introduction of the posts, 95% of the chemicals remained in the posts. Of the material released into the ecosystem, most remained in the upper soil layer immediately surrounding the posts. ... Residue accumulation by the invertebrates was highly variable. Of the chemicals tested, creosote accumulated in the vole to the greatest extent (eg, whole body concn of 7.2 and 37.0 ppm for phenanthrene and acenaphthene, respectively. [Gile J D et al; J of Agricultural and Food Chemistry 30 (2): 295-310 (1981)].

Absorption, Distribution and Excretion [366]:

Polynuclear aromatic hydrocarbons (PAH), some of which are potent carcinogens, are common environmental pollutants. The transport processes for these hydrophobic compounds into cells and between intracellular membranes are diverse and are not well understood. A common mechanism of transport is by spontaneous desorption and transfer through the aqueous phase. From the partitioning parameters, we have inferred that the rate limiting step involves solvation of the transfer species in the interfacial water at the phospholipid surface. Transfer of 10 PAH ... out of phosphatidylcholine vesicles has been examined. Our results show that the molecular volume of the PAH is a rate-determining factor. Moreover, high performance liquid chromatography (HPLC) data confirms the hypothesis that the rate of transfer is correlated with the size of the molecule and with the partitioning of the molecule between a polar and hydrocarbon phase. The kinetics and characteristics of the spontaneous transfer of carcinogens are likely to have a major impact on the competitive processes of PAH metabolism within cells. /Polynuclear aromatic hydrocarbons/ [Plant AL et al; Chem-biol Interact 44 (3): 237-46 (1983)].

Laboratory and/or Field Analyses:

Recommended detection limits:

Most of the PAH methods which have been commonly used historically for routine monitoring, including PAH parent compound standard methods:

EPA 8270 (8270 includes several PAH parent compounds along with a long list of other organics)

for solid waste/RCRA applications [1013], and

EPA NPDES method 610 as specified in 40 CFR Part 136 (method 610 includes 16 PAH parent compounds) [1010],

EPA method 625 for Base/Neutral Extractables (method 625 includes several PAH parent compounds along with a long list of other organics) as specified in 40 CFR Part 136 [1010],

are all inadequate for generating scientifically defensible information for Natural Resource Damage Assessments [468]. These standard EPA scans do not cover important alkyl PAHs and do not utilize low-enough detection limits. When biological effects, ecological risk assessment, damage assessment, or bio-remediation are being considered, detection limit should be no higher than 1-10 ng/L (ppt) for water and 1 ug/kg (ppb) dry weight for solids such as tissues, sediments, and soil.

Note: Utilizing up to date techniques, many of the better labs can use detection limits of 0.3 to 1 ppb for tissues, sediments, and soils. When no biological resources are at risk, detection limits for solids should nevertheless generally not be above 10 ppb. One reason that low detection limits are needed for PAHs is that so many of the criteria, standards, and screening benchmarks are in the lower ppb range (see various entries on individual PAHs).

In the past, many methods have been used to analyze for PAHs [861,1010,1013]. However, recent (1991) studies have indicated that EPA approved methods used for oil spill assessments (including total petroleum hydrocarbons method 418.1, semivolatile priority pollutant organics methods 625 and 8270, and volatile organic priority pollutant methods 602, 1624, and 8240) are all inadequate for generating scientifically defensible information for Natural Resource Damage Assessments [468]. These general organic chemical methods are deficient in chemical selectivity (types of constituents analyzed) and sensitivity (detection limits); the deficiencies in these two areas lead to an inability to interpret the environmental significance of the data in a scientifically defensible manner [468].

For risk, damage assessment, drinking water, or to determine if biodegradation has occurred, the NOAA expanded scan for PAHs and alkyl PAHs [828], or equivalent rigorous and comprehensive scans. (such as SW-846 method 8270 modified for Selective Ion Mode detection limits and an equivalent list of parent compound and alkyl PAH analytes), are recommended.

If a Park Service groundwater investigation at Colonial National Historical Park performed in response to contamination by Fuel Oil 5 had utilized EPA semi-volatile scan 8270 or any of the

other typical EPA scans (625, etc.) all of which only include parent compounds and typically utilize detection limits in the 170-600 ppb range, the false conclusion reached would have been that no PAHs were present in significant (detection limit) amounts. This false negative conclusion would have been made because the parent compound PAHs present constituted only 7.6% of the PAHs detected in groundwater by the expanded scan [828], and the highest concentration found for any parent compound was 8.4 ppb, far below the detection limits used on the older standard EPA scans. Utilizing the NOAA protocol expanded scan [828], it was determined that 92.4% of the total concentration values of the PAHs detected in groundwater were alkyl PAHs, and that all 39 PAHs and alkyl PAHs were present. Of course, all 39 PAHs were also present in the fresh product, in much higher concentrations, and also having alkyl compounds with the highest percentage of higher values compared to parent compounds.

In a similar vein, if the Park Service sediment investigation at Petersburg National Historical Battlefield (this study was performed in response to contamination by Diesel) had utilized EPA semi-volatile scan 8270 or any of the other typical EPA scans (625, etc.), all of which only include parent compounds and often utilize detection limits no lower than the 170-600 ppb range, the false conclusion reached would have been that only one PAH was present in significant (detection limit) amounts. This false negative conclusion would have been made because the parent compound PAHs present constituted only 2.4% of the PAHs detected in sediments, and the highest concentration found for any parent compound except pyrene was 85.5 ppb, far below the detection limits used on the older standard EPA scans. Pyrene was 185 ppb, which would have been non-detected on many of the EPA scans, but not all. However, utilizing the NOAA protocol expanded scan [828], it was determined that 97.6% of total quantity of PAHs detected in sediments were alkyl PAHs, and that all 39 PAHs and alkyl PAHs were present in these sediments.

When taking sediment samples for toxic organics such as PCBs, PAHs, and organochlorines, one should also routinely ask for total organic carbon analyses so that sediment values may be normalized for carbon. This will allow comparison with the newer EPA interim criteria [86,127]. TOC in sediments influences the dose at which many compounds are toxic (Dr. Denny Buckler, FWS Columbia, personal communication).

In some cases (where the expanded scans are too expensive) an alternative recommendation is that one screen sediments with a size-exclusion high-performance liquid chromatography (HPLC)/fluorescence method. The utility and practicality of the HPLC bile and sediment screening analyses were demonstrated on board the NOAA R/V Mt. Mitchell during the Arabian Gulf Project. Estimates of petroleum contamination in sediment and fish were available rapidly, allowing modification of the sampling strategy based on these results [522].

Variation in concentrations of organic contaminants may sometimes be due to the typically great differences in how individual investigators treat samples in the field and in the lab rather than true differences in environmental concentrations. This

is particularly true for volatiles and for the relatively lighter semi-volatiles such as the naphthalene PAHs, which are so easily lost at various steps along the way. Contaminants data from different labs, different states, and different agencies, collected by different people, are often not very comparable. For additional discussion of important data comparability issues, see the disclaimer at the beginning of this entry.

As of 1997, the problem of lack of data comparability (not only for water methods but also for soil, sediment, and tissue methods) between different "standard methods" recommended by different agencies seemed to be getting worse, if anything, rather than better. The trend in quality assurance seemed to be for various agencies, including the EPA and others, to insist on quality assurance plans for each project. In addition to quality control steps (blanks, duplicates, spikes, etc.), these quality assurance plans call for a step of insuring data comparability [1015,1017]. However, the data comparability step is often not given sufficient consideration. The tendency of agency guidance (such as EPA SW-846 methods and some other new EPA methods for bio-concentratable substances) to allow more and more flexibility to select options at various points along the way, makes it harder in insure data comparability or method validity. Even volunteer monitoring programs are now strongly encouraged to develop and use quality assurance project plans [1015,1017].

At minimum, before using contaminants data from diverse sources, one should determine that field collection methods, detection limits, and lab quality control techniques were acceptable and comparable. The goal is that the analysis in the concentration range of the comparison benchmark concentration should be very precise and accurate.

It should be kept in mind that quality control field and lab blanks and duplicates will not help in the data quality assurance goal as well as intended if one is using a method prone to false negatives. Methods may be prone to false negatives due to the use of detection limits that are too high, the loss of contaminants through inappropriate handling, or the use of an inappropriate methods such as many of the EPA standard scans. This is one reason for using the NOAA expanded scan for PAHs [828]; or method 8270 [1013] modified for Selective Ion Mode (SIM) detection limits (10 ppt for water, 0.3 to 1 ppb for solids) and additional alkyl PAH analytes; or alternative rigorous scans. These types of rigorous scans are less prone to false negatives than many of the standard EPA scans for PAH parent compounds (Roy Irwin, National Park Service, Personal Communication, 1997).

For a much more detailed discussion of the great many different lab and field methods for PAHs in general, see the entry entitled PAHs as a group (file name starting with letter string: PAHS). There the reader will find much more detailed discussions of lab methods, holding times, containers, comparability of data from different methods, field sampling methods, quality assurance procedures, the relationship of various methods to each other, the various EPA standard methods for various EPA programs, the pros and cons of various methods, and additional documentation concerning why many standard EPA methods are inadequate for certain

applications. A decision tree key for selecting the most appropriate methods for oil or oil products spills is also provided in the lab section of the PAHs entry. Due to the length of these discussions, they are not repeated here (see PAHs entry).