ENVIRONMENTAL CONTAMINANTS ENCYCLOPEDIA

DIBENZ(A,H)ANTHRACENE [DIBENZO(A,H)ANTHRACENE] 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 or summaries 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 chemical topic entry (one file among 118). Before utilizing this entry, the reader is strongly encouraged to read the README file (in this subdirectory) for an introduction, an explanation of how to use this document in general, an explanation of how to search for power key section headings, an explanation of the organization of each entry, an information quality discussion, a discussion of copyright issues, and a listing of other entries (other topics) covered.

See the separate file entitled REFERENC for the identity of numbered references in brackets.

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).

Dibenz(a,h)anthracene [Dibenzo(a,h)anthracene, CAS number 53-70-3]

Brief Introduction:

Br.Class: General Introduction and Classification Information:

Dibenz(a,h)anthracene is a high molecular weight, 5-ring polycyclic aromatic hydrocarbon (PAH) and an EPA Priority Pollutant [697,634]. It is a toxic pollutant designated pursuant to section 307(a)(1) of the Clean Water Act and is subject to effluent limitations [366, 40 CFR 401.15 (7/1/87)].

Dibenz(a,h)anthracene is included on the expanded scan of PAHs and alkyl PAHs recommended by NOAA [828]; this list includes the PAHs recommended by the NOAA's National Status and Trends program [680].

On many hazardous substances lists. If only one pound of dibenz[a,h]anthracene is released to the environment within a 24-hour period, EPA must be notified [881]. The only other PAHs having this stingent requirement are benzo[b]fluoranthene and benzo[a]pyrene [881].

Br.Haz: General Hazard/Toxicity Summary:

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

Humoral immunity was monitored in male iron foundry workers in Poland [881]. Coke oven workers (199) were compared to cold-rolling mill workers (76) [881]. The groups were similar with respect to age, length of employment, and smoking habits [881]. The results showed that coke oven workers, exposed to high concentrations of atmospheric PAHs, including fluoranthene, perylene, pyrene, benzo[a]pyrene, chrysene, benz[a]anthracene, dibenz[a,h]anthracene, and benzo[g,h,i]perylene, had reduced levels of serum immunoglobins [881]. The workers most exposed to PAHs worked at the topside area of the coke ovens [881]. Benzo[a]pyrene exposure was used as a reference point [881]. Coke oven workers, exposed to 0.0002-0.50 mg/m3 benzo[a]pyrene, were compared to cold-rolling mill workers, whose exposure to benzo[a]pyrene was 3-5 orders of magnitude less [881]. Average length of employment was 15 years [881]. IgG, IgA, IgM, and IgE concentrations were measured [881]. Coke oven workers exhibited a marked depression of mean serum IgG and IgA, compared to mill workers [881]. IgM tended to decrease, whereas IgE tended to increase in the coke oven workers [881]. The biological significance of this finding is unclear and is not addressed by the authors [881].

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

EPA 1996 IRIS database information [893]:

Human carcinogenicity weight-of-evidence classification:

Classification: B2; probable human carcinogen
BASIS: Based on no human data and sufficient data from animal bioassays. Dibenz(a,h)anthracene produced carcinomas in mice following oral or dermal exposure and injection site tumors in several species following subcutaneous or intramuscular administration. Dibenz(a,h)anthracene has induced DNA damage and gene mutations in bacteria as well as gene mutations and transformation in several types of mammalian cell cultures.

Animal carcinogenicity data

Sufficient. Dibenz(a,h)anthracene has been shown to be carcinogenic when administered to mice by the oral route (Snell and Stewart, 1962, 1963).

The Department of Health and Human Services (DHHS) has determined that dibenz(a,h)anthracene may reasonably be anticipated to be a carcinogen [788]. EPA also has determined that dibenz(a,h)anthracene is a probable human carcinogen [788].

IARC Summary and Evaluation [366]: No data are available in humans. Sufficient evidence of carcinogenicity in animals. OVERALL EVALUATION: Group 2A: The agent is probably carcinogenic to humans. [IARC. Monographs on the Evaluation of the Carcinogenic Risk of Chemicals to Man. Geneva: World Health Organization, International Agency for Research on Cancer, 1972-1985. (Multivolume work).,p. S7 61 (1987)].

For dibenz(a,h)anthracene there is experimental evidence of mammary carcinogenesis [571].

Studies have established that L-region methyl derivatives of dibenz(a,h)anthracene (DBA) were more carcinogenic than the parent hydrocarbon [366].

This compound has been treated as a carcinogen for model calculation purposes in some EPA risk-based (RBC and PRG) models [868,903].

Relative (equivalency factor) oral carcinogenic potency value compared to benzo(a)pyrene (BAP, which is ranked 1.0): 1.0; the only other PAH ranked 1.0 is BAP [EPA, 1993, Provisional Guidance for Quantitative Risk Assessment of Polycyclic Aromatic Hydrocarbons]. Although the information is based on mouse skin painting studies, until better guidance is available, the relative oral carcinogenic potency value may be used in superfund site human risk assessments in conjunction with the oral carcinogenic slope factor for benzo(a)pyrene found in EPA's IRIS database [893] (Stan Smucker, EPA Region 9, personal communication, 1996).

EPA Historical (modeling purposes only) Classification: Carcinogen [302,446].

This is a very phototoxic PAH [887,891]. Although not definitive, as discussed above, phototoxicity represents one clue suggesting possible carcinogenicity.

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

One study suggested that dibenz(a,h)anthracene or its metabolites cross the placenta [847].

Dibenz(a,h)anthracene is embryotoxic to rats when given at high doses. The available data on teratogenicity were inadequate for evaluation [847].

Dibenz(a,h)anthracene may be a xenoestrogen since there is experimental evidence of its association with mammary carcinogenesis (and breast cancer risk factors can be linked to total lifetime exposure to bioavailable estrogens) [571].

Mutagenic data are reported. (Sax, N.I. Dangerous Properties of Industrial Materials. 6th ed. New York, NY: Van Nostrand Reinhold, 1984. 901) [366].

The mutagenic activity of dibenz[a,h]anthracene [DB(a,h)A] increased progressively with the substitution of a methyl group at one or both non-benzo bay-region sites. (Diamond L et al; Mutat Res 136 Iss 1: 65-72 (1984) [366].

Significant enhancement of mutagenicity occurs with dibenz(a,h)anthracene when 3-methylcholanthrene-induced guinea pig liver S9 is substituted for arochlor-induced rat liver S9 in ames test with salmonella typhimurium. (Baker R SU et al; mutat res 71, 1: 43-52, 1980) [366].

It is known that the metabolism of alternant PAHs (such as benzo[a]pyrene, benz[a]anthracene, chrysene, and dibenz[a,h]anthracene) differs from nonalternant PAHs (such as benzo[b]fluoranthene, benzo[k]fluoranthene, benzo[j]fluoranthene, and indeno[1,2,3-c,d]pyrene) [881]. Alternant PAHs, in contrast to several nonalternant PAHs, appear to exert their genotoxic effect primarily through the metabolic formation of simple dihydrodiol epoxides [881]. See PAHs entry.

Dibenz[a,h]anthracene tested positive for reverse mutation in Salmonella typhimurium strains TA100 and TA98 (3-5 ug/plate) and positive for forward mutation in strain TM677 (21 ug/mL) [893].

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

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

Based on an estimated bioconcentration factor (BCF) of 51,000, dibenz(a,h)anthracene will be expected to bioconcentrate in aquatic organisms. However, it may not bioconcentrate in aquatic organisms which contain microsomal oxidase, such as fish, as this enzyme enables the rapid metabolism of certain polycyclic aromatic hydrocarbons [366].

Environmental Fate/Exposure Summary [366]:

Dibenz(a,h)anthracene's (DBahA) release to the environment is quite general since it is a ubiquitous product of incomplete combustion. It is largely associated with particulate matter, soils, and sediments. Its presence in places distant from primary sources indicates that it is reasonably stable in the atmosphere and capable of long distance transport. If it is released to soils it will be expected to adsorb very strongly to the soils and will not be expected to leach to the groundwater, hydrolyze or evaporate from soils or surfaces. It will be subject to biodegradation in soils with reported half-lives of 18 and 21 days. If DBahA is released to water it will be expected to adsorb very strongly to sediments and particulate matter and to bioconcentrate in aquatic organisms which lack microsomal oxidase (this enzyme enables the rapid metabolism of certain polycyclic aromatic hydrocarbons). Based on limited data from laboratory screening tests using settled domestic wastewater and activated sludge, DBahA may be subject to biodegradation in natural waters. Since DBahA absorbs solar radiation strongly, it may be subject to direct photolysis in natural waters. However, adsorption may significantly retard photolysis as the photosensitivity of polyaromatic hydrocarbons is strongly dependent upon the nature of the surface upon which the compound is adsorbed. It will not hydrolyze and should not evaporate from water. If released to the atmosphere it will likely be associated with particulate matter and may be subject to moderately long range transport, depending mainly on the particle size distribution and climatic conditions which will determine the rates of wet and dry deposition. Its presence in areas remote from primary sources demonstrates the potential for this long range transport as well as DBahA's considerable stability in the air. It may be subject to direct photolysis in the atmosphere; however, adsorption may significantly retard photolysis as the photosensitivity of polyaromatic hydrocarbons is strongly dependent upon the nature of the surface upon which the compound is adsorbed. The estimated vapor phase half-life in the atmosphere is 1.00 day as a result of reaction with photochemically produced hydroxyl radicals. Human exposure will be from inhalation of contaminated air and consumption of contaminated food and water. (SRC).

Synonyms/Substance Identification:

1,2,5,6-Dibenzanthracene [366]
1,2:5,6-Benzanthracene [366]
1,2:5,6-Dibenz(a)anthracene [366]
1,2:5,6-Dibenzanthracene [366]
1,2:5,6-Dibenzoanthracene [366]
1,2,7,8-dibenzanthracene [847]
DB(a,h)A [366]
DBA [366]
Dibenzo(a,h)anthracene [366,617]
RCRA Waste Number UO63 [870]

Molecular Formula:
C22-H14 [366]

Associated Chemicals or Topics (Includes Transformation Products):

See also individual entry:

PAHs as a group

Metabolism/Metabolites [366]:

Yields 2-phenylphenanthrene-2',3-dicarboxylic acid in rats: Van Duuren BL; acta unio intern contra concrum 19: 524 (1963). /From table/ [Goodwin, B.L. Handbook of Intermediary Metabolism of Aromatic Compounds. New York: Wiley, 1976.,p. D-11].

Yields 1,2-dihydro-1,2-dihydroxydibenzanthracene, 3,4-dihydro-3,4-dihydroxydibenzanthracene, 5,6-dihydro-5,6-dihydroxydibenzanthracene, & s-(5,6-dihydro-6-hydroxydibenzanthr-5-yl)glutathione in rats: Boyland E, Sims P; Biochem J 97: 7 (1965). /From table/ [Goodwin, B.L. Handbook of Intermediary Metabolism of Aromatic Compounds. New York: Wiley, 1976.,p. D-11].

Yields dibenzanthracene-7,14-quinone in mice: Heidelberger C et al; J Am Chem Soc 75: 1303 (1953) & in rats: Van Duuren BL; acta unio intern contra concrum 19: 524 (1963). /From table/ [Goodwin, B.L. Handbook of Intermediary Metabolism of Aromatic Compounds. New York: Wiley, 1976.,p. D-11].

Yields dibenzanthracene-5,6-oxide in rats: Sims P et al; Biochem J 125: 28p (1971); yields dibenzanthracene-5,6-quinone in mice: Heidelberger C et al; J Am Chem Soc 75: 1303 (1953), & in rats: Van Duuren BL; acta unio intern contra concrum 19: 524 (1963). /From table/ [Goodwin, B.L. Handbook of Intermediary Metabolism of Aromatic Compounds. New York: Wiley, 1976.,p. D-11].

Dibenz(a,h)anthracene subjected to chemical oxidation in an ascorbic acid-ferrous sulfate-edta system or by rat-liver microsomal fractions yielded th 1,2-, 3,4-, & 5,6-dihydrodiols. [Macnicoll AD et al; chem-biol interact 27 (2-3): 365-80 (1979)].

Pretreatment of rats with 3-methylcholanthrene or aroclor-1254 caused a 2- of 3-fold enhancement in the rate of metabolism of (14)c-labeled dibenzo(a,h)anthracene by liver microsomes & altered the relative amt of some of the metabolites formed compared to metabolism by microsomes from untreated rats. Pretreatment of rats with phenobarbital caused less changes in profile of metabolites formed, & the rate of metabolism of db(a,h)a was reduced per mole of cytochrome p450 compared to microsomes from untreated rats. Under all incubation conditions, dibenzo(a,h)anthracene-3,4-dihydrodiol was major dihydrodiol metabolite (24-28% of the total metabolites) under all incubation conditions in rat liver microsomes. Less than half this amt of the 1,2-dihydrodiol was formed, as were trace amt of the k-region 5,6-dihydrodiol. The predominance of dibenzo(a,h)anthracene-3,4-dihydrodiol as a metabolite is of importance: this is the most carcinogenic metabolite known. Bay region diol epoxides are possibly formed from racemic 3,4-dihydrodiol. [Nordqvist M et al; Mol Pharmacol 16 (2): 643-55 (1979)].

Previous studies by other investigators have established that L-region methyl derivatives of dibenz(a,h)anthracene (DBA) were more carcinogenic than the parent hydrocarbon. ... [Flesher JW et al; Chem Biol Interact 57 Iss 2: 223-33 (1989)].

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):

No information found.

W.Typical (Water Concentrations Considered Typical):

DRINKING WATER: Identified, not quantified, in finished drinking water(1). [(1) Callahan MA et al; Water-Related Environ Fate of 129 Priority Pollut Vol 2 p 98-8 USEPA-440/4-79-029b (1979)] [366].

Effluent Concentrations [366]:

USA Nationwide Urban Runoff Program, not detected in 86 samples from 15 cities(1). Coal coking wastewaters, plant A (plant B) final effluent from biological oxidation process discharged to river, 0.062-0.23 ppb (0.017- 0.08 ppb), suspended solid, 2.0-2.9 ppb (0.06-0.5 ppb)(2). Gasoline engine exhaust, 96 ug/g, coke oven, 84-124 ug/g sample(3). Combined o-Phenylene pyrene and dibenz(a,c and/or a,h)anthracene: effluent channel from a coking plant, water, 0.95 ppb, sediment, 8.6 ppm dry wt(4). [(1) Cole RH et al; J Water Pollut Control Fed 56: 898-908 (1984) (2) Walters RW, Luthy RG; Water Res 18: 795-809 (1984) (3) Verschueren K; Handbook of Environ Data on Org Chemicals 2nd ed Von Nostrand Reinhold NY pp 460-1 (1983) (4) Griest WH; pp 173-83 in Hydrocarbon Halo Hydrocarbon Aquatic Environ Afghan BK, Mackay D eds NY Plenum Press (1980)].

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):

Cautionary note: This is a phototoxic compound (see more detailed discussion in the "PAHs as a group" entry). Therefore, any of the water criteria which have been developed for it using bioassays performed in the absence of UV light may be under-protective. Phototoxicity of certain PAHs was discovered when organisms which had survived lab exposures to PAHs died quickly after being moved into sunlight. An increase in toxicity due to photo-induced changes is called phototoxicity. For certain PAHs, tests performed in the presence of UV or other solar radiation show greatly increased toxicity to those same organisms at PAH concentrations below maximum solubility [887,888,889,911]. The reader should be aware that the authors of this document have not yet been able to determine which of the following criteria and benchmarks were developed in the presence or absence of UV light:

Canada's Interim Assessment Criterion for dibenz(a,h)anthracene is 0.01 ug/L [656].

NOTE: a) For most of the organic chemical parameters in [656], criteria are based on analytical detection limits; b) criterion is considered "Interim" since complete supporting rationale do not exist.

Water Quality Criteria in ug/L :

Freshwater Acute Criteria: None Published [446,689,928].

Freshwater Chronic Criteria: None Published [446,689,928].

Marine Acute Criteria: None Published [446,928].

Marine Chronic Criteria: None Published [446,928].

W.Plants (Water Concentrations vs. Plants):

No information found.

W.Invertebrates (Water Concentrations vs. Invertebrates):

TLm Neanthes arenaceodentata > 1 ppm/96 hr at 22 deg C in a static bioassay. [Verschueren, K. Handbook of Environmental Data of Organic Chemicals. 2nd ed. New York, NY: Van Nostrand Reinhold Co., 1983. 461 [366].

W.Fish (Water Concentrations vs. Fish):

No information found.

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

No information found.

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

EPA 1996 IRIS database criteria, benchmarks, and recommendations [893]:

EPA 1996 IRIS Drinking Water MCL [893]: Maximum Contaminant Level (MCL) Value: 0.0002 mg/L Status/Year: Proposed 1990.

Maximum Contaminant Level Goal: Value: 0 mg/L Status/Year: Proposed 1990 Reference: 55 FR 30370 (07/25/90).

Contact: Health and Ecological Criteria Division / (202)260-7571 Safe Drinking Water Hotline / (800)426-4791, Discussion: The proposed MCLG is zero.

This value is based on carcinogenic PAH's as a class. For the maximum protection from the potential carcinogenic properties of this chemical, the ambient water concentration should be zero. However, zero may not be obtainable at this time, so the recommended criteria represents a E-6 estimated incremental increase of cancer over a lifetime. The values given represent polynuclear aromatic hydrocarbons as a class.

National 1996 (IRIS) EPA Water Quality Criteria: Human Health (10-6 = E-06) Risk Level for Carcinogens:

For Water & Fish Routes of exposure: 2.8E-3 ug/liter [893]. Same concentration previously published as Criteria for Water and Organisms: 0.0028 ug/L [689].

For Fish Only Route of exposure: 3.11E-2 ug/liter [893]. Same concentration previousl published as Criteria for Organisms Only: 0.0311 ug/L [689].

Note: For critical applications, before citing a concentration as EPA's water quality criteria, it is prudent to make sure you have the latest one. Work on the replacement for the Gold Book [302] was underway in March of 1996, and IRIS is updated monthly [893].

EPA Region IX Preliminary Remediation Goal (PRG) for tap water 9.2E-03 ug/L [868].

The warm water- and cold water sport fish community human cancer criteria for DB(a,h)A in Wisconsin public water supplies are each 0.023 mg/L [881].

The warm water- and cold water sport fish community human cancer criteria for DB(a,h)A in Wisconsin non-public water supplies are each 0.1 mg/L [881].

Numeric Water Quality Criteria in Arizona [881]:

Domestic water supply: 0.003 ug/L
Fish consumption: 0.00003 ug/L

Full body contact: 0.12 ug/L

Criteria for human health protection in Missouri [881]:

Fish consumption: 0.03 ug/L
Drinking water supply: 0.003 ug/L
Groundwater: 0.003 ug/L

For the maximum protection of human health from the potential carcinogenic effects due to exposure of polynuclear aromatic hydrocarbons through ingestion of contaminated water and contaminated aquatic organisms, ... therefore, the levels which may result in incremental increase of cancer risk over the lifetime are estimated at 1x10-5, 1x10-6, and 1x10-7. The corresponding ambient water criteria are 28.0 ng/l, 2.8 ng/l, and 0.28 ng/l, respectively. If the above estimates are made for consumption of aquatic organisms only, excluding consumption of water, the levels are 311.0 ng/l, 31.1 ng/l, and 3.11 ng/l respectively. /Polynuclear aromatic hydrocarbons based on benzo(a)pyrene as the model PAH/ [USEPA; Ambient Water Quality Criteria Doc: Polynuclear Aromatic Hydrocarbons (Draft) p.C-121 (1980)].

> NOTE: The attempt to develop a drinking water criterion for polynuclear aromatic hydrocarbons (PAH) as a class is hindered by several gaps in the scientific data base: (1) The PAH class is composed of numerous compounds having diverse biological effects and varying carcinogenic potential. A "representative" PAH mixture, has not been defined. (2) The common practice of using data derived from studies with benzo(a)pyrene to make generalizations concerning the effects of environmental PAH may not be scientifically sound. (3) No chronic animal toxicity studies involving oral exposure to PAH mixtures exist. (4) No direct human data concerning the effects of exposure to defined PAH mixtures exist. /Polynuclear aromatic hydrocarbons/ [USEPA; Ambient Water Quality Criteria Doc: Polynuclear Aromatic Hydrocarbons] [366].

Based on limited data ... utilizing a probablistic model /which/ defines the acceptable risk as 1x10+9, the resultant ambient water quality criterion is /calculated/ at 13.3 ng/l. [USEPA; Ambient Water Quality Criteria Doc: Polynuclear Aromatic Hydrocarbons (Draft) p.C-119 (1980)].

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

This is a very phototoxic PAH [887,891].

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):

Dibenz(a,h)anthracene was detected in 45.2 % of urban-bay samples from the Puget Sound area. The mean concentration was 338 ug/kg dry weight (ppb), while the median concentration was 58.5 ug/kg (ppb) [852].

Dibenz(a,h)anthracene was detected in 32.7 % of non-urban-bay samples from the Puget Sound area. The mean concentration was 988 ug/kg dry weight (ppb), while the median concentration was 80 ug/kg (ppb) [852].

> NOTE: The above values are not normalized for total organic carbon (TOC) content. Urban bay concentrations may be lower than 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.

Information from HSDB [366]:

> SEDIMENTS: Cayuga Lake, NY, Sept 1978, 16 km north to 8 km south of coal-fired power plant, < 15-< 67 ng/g deepwater(1). Duwamish River, WA 230 ppb (wet wt)(2). Dibenz(a,h)anthracene and dibenz(a,c)anthracene, concn, ppb (dry wt, depth, cm): Remote Adirondack Lakes, NY, Sagamore Lake, 30(0-4), 25(4-8), 4(8-12), 2(12-85); Woods Lake, 92(0-4), 17(4-8), <2(8-11), 3(12-17), <2(24-84)(3). Saudafjord, Norway, Oct 1976, 6 sites, 83% pos, 0-2 cm depth, 2.2-1969.6 ppb (dry wt), 5.3-1589.5 ppb, 11.9-1204.5 ppb, 2.6-633.8 ppb(4). Puget Sound, WA, 1979-82, identified, not quantified(6). Eagle Harbor, Puget Sound, WA, 3 sites, 15 samples, 22-230 ppb (dry wt), avg 274 ppb(7). Penobscot Bay, ME, 1982, 55 stations, 2-

120 ppb (dry wt)(8). [(1) Heit M; Water Air Soil Pollut 24: 41-61 (1985) (2) Varanasi U et al; Environ Sci Techol 19: 836 (1985) (3) Tan YL, Heit M; Geochim Cosmochim Acta 45: 2267-79 (1981) (4) Bjorseth A et al; Sci Total Environ 13: 71-86 (1979) (6) Malins LDC et al; Environ Sci Technol 18: 705-13 (1984) (7) Malins DC et al; Carcinogenesis 6: 1463-9 (1985) (8) Johnson AC et al; Marine Environ Res 15: 1-16 (1985)].

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):

AET, EPA, 1988: The apparent effects threshold (AET) concentrations for Dibenzo(a,h)anthracene in sediments proposed for Puget Sound ranged from 0.23 mg/kg dry weight (microtox) to 0.97 mg/kg dry weight (benthic) [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.

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

NOAA 1995: 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 260 ppb dry weight Effects Range-Median (ERM) concentration and was lowest in sediments where its concentration was less than the 63.4 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	11.5
ERL-ERM	54.5
>ERM	66.7

Ontario Ministry of the Environment Freshwater Sediment Guidelines, 1993 [761]. Lowest effect level: 60 ug/kg dry weight. Severe effect level: 130 mg/kg organic carbon.

St. Lawrence River Interim Freshwater Sediment Criteria, 1992 [761]. No effect level: 5 ug/kg dry weight.

Sed.Plants (Sediment Concentrations vs. Plants):

No information found.

Sed.Invertebrates (Sediment Concentrations vs. Invertebrates):

No information found.

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):

No information found.

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):

No information found.

Soil.Typical (Soil Concentrations Considered Typical):

SOILS: Iceland, lava and humus, 0-2.3 ppb, airfield sample, 351 ppb(5). (5) IARC; Polynuclear Aromatic Hydrocarbons Part I Chem and Environ Data 32: 299-300 (1983) [366].

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):

Canada's Interim Assessment Criterion for dibenz(a,h)anthracene in soil is 0.1 ug/g dry weight [656].

NOTE: a) "Interim" means complete supporting rationale do not exist; b) for most of the organic parameters in [656], criteria are based on analytical detection limits and are intended to provide general guidance only for the protection of both human and environmental health [656].

Canada's Interim Remediation Criteria for dibenz(a,h)anthracene in soil for three different land-uses (ug/g dry weight) [656]:

Agricultural = 0.1
Residential/Parkland = 1
Commercial/Industrial = 10

NOTE: a) "Interim" means complete supporting rationale do not exist; b) if contaminant concentrations exceed the criterion for a current or anticipated land use at a site, then the need for further investigation and/or remediation exists; c) criteria are relevant to protection of both human and environmental health [656].

The Canadian AET concentration (adapted from NOAA 1990) for DB(a,h)A sorbed to marine sediments is 0.100 mg/kg dry weight [864]. An AET (apparent effects threshold) 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].

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):

Soil.Human (Soil Concentrations vs. Humans):

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 = 0.09 mg/kg for ingestion pathway [952].

SSL = 0.08 to 2 mg/kg for protection from migration to groundwater at 1 to 20 Dilution-Attenuation Factor (DAF) [952].

EPA 1995 Region 9 Preliminary remediation goals (PRGs) [868]:

Residential Soil: 0.061 mg/kg wet weight
Industrial Soil: 0.26 mg/kg wet weight

NOTE:

1) Values are based on a one-in-one million cancer risk.
2) 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.
3) PRGs for residential and Industrial are slightly lower concentrations than EPA Region III RBCs, which consider fewer aspects [903].

EPA 1995 Region III Risk Based Concentration (RBC) for protection from transfers to groundwater: 11 mg/kg [903].

See also Canada's Interim Criteria [656] in Soil.General section above.

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:

No information found.

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:

Details of dibenz(a,h)anthracene content (ug/kg or ppb) in whole body samples of mussels) from Snug Harbor, Alaska, an area heavily oiled by the Exxon Valdez Crude Oil, 4/15/89 [971]:

Note: Concurrent measurements of water quality, as well as equilibrium partitioning estimates of water quality based on concentrations in fish and mussels, both confirm that PAH concentrations did not exceed water quality criteria at the time these concentrations were measured in mussel tissues [971]. These values are wet weight (Jerry Neff, Battelle Ocean Sciences, Duxbury, MA, personal communication 1996):

Dibenz(a,h)anthracene: 2.63 ug/kg = ppb

Seafood Concentrations [366]:

Coos Bay, OR, 1978-79, softshell clams (Mya arenaria), 2 sites, 6 sampling days, 100% pos, ranges, 1.5-6.7 ppb, avgs 4.7 and 6.9 ppb(1). Yaquina Bay, OR, 1979-80, mussels (Mytilus edulis), 2 sites, 16 and 12 sampling days, respectively, 100% pos, ranges, 0.5-3.6 ppb and 4.9-12.6 ppb, avgs, 2.1 and 9.6 ppb(2). [(1) Mix MC, Schaffer RL; Marine Pollut Bull 14: 94-7 (1983) (2) Mix MC, Schaffer RL; Marine Environ Res 9: 193-209 (1983)].

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 [971].

Fish Concentrations [366]:

Eagle Harbor, Puget Sound, WA, English sole, stomachs, 11 stomachs in 2 composite samples, 300 and 370 ppb(3). [(3) Malins DC et al; Carcinogenesis 6: 1463-9 (1985)].

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):

Information from HSDB [366]:

Acute ip admin of 3 to 90 mg/kg body wt DB(a,h)A in sesame oil produced reduction in growth rate of young rats that persisted for at least 15 weeks. [IARC. Monographs on the Evaluation of the Carcinogenic Risk of Chemicals to Man. Geneva: World Health Organization, International Agency for Research on Cancer, 1972-1985. (Multivolume work).,p. V32 301 (1983).

DB(a,h)A at dose of 5 mg/rat given SC daily from 1st day of pregnancy resulted in fetal death & resorption & may also have affected subsequent fertility of dams (Wolfe & Bryan, 1939). (The working group noted the small number of animals used.) ... /DB(a,h)A/ can also induce benzo(a)pyrene hydroxylase activity in rat placenta. [IARC. Monographs on the Evaluation of the Carcinogenic Risk of Chemicals to Man. Geneva: World Health Organization, International Agency for Research on Cancer, 1972-1985. (Multivolume work).,p. V32 301 (1983).

Addition of db(a,h)a to food for total dose of 9-19 mg over a period of 5-7 months /in mice/ led to appearance of tumors of forestomach in 7/22 survivors after 1 year; 1 of these tumors was a carcinoma (Larionow & Soboleva, 1938). In later expt, 20 a back-cross mice receiving 0.4 Mg db(a,h)a per day /orally/ in mineral oil emulsion which replaced drinking-water developed 2 squamous cell carcinomas & 11 papillomas of forestomach for 406 days (Lorenz & Stewart, 1948). In similar expt in which sodium hydroxide was used as emulsifying agent, tumors were produced in lung, heart & intestine. Squamous carcinomas of forestomach were induced if emulsion was stabilized against breaking effect of gastric juices (Lorenz & Stewart, 1947; Snell & Stewart, 1962). [IARC. Monographs on the Evaluation of the Carcinogenic Risk of Chemicals to Man. Geneva: World Health Organization, International Agency for Research on Cancer, 1972-1985. (Multivolume work).,p. V3 182 (1973).

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:

See also Tis.Invertebrates, C) and Tis.Fish, C) sections above.

Food Survey Results [366]:

UK, total diets, 1979, range (avg) ppb: cereals, 0.04-0.14(0.06), meat, not detected (nd)-0.03(0.01), oils and fats, nd-0.23(0.06), fruit and sugar, nd-0.03(0.01), vegetables, nd-0.03(0.01)(5). Spinach, 0.3 ppb, tomatoes, 0.04 ppb, cereals, 0.1-0.6 ppb, charcoal-broiled steaks, 0.2 ppb(1). Identified, not quantified in fats and oils(2). Canada: breakfast cereals, puffed wheat, 3.0 ppb, wheat bran, 3.6 ppb; barley malt, 1.2 ppb; cooking oil, soya, 0.7 ppb, corn, 1.1 ppb(3). Spinach, 0.3 ppb, salad, 0.6-1.0 ppb, kale, 0.1-2.6 ppb, tomatoes, 0.04 ppb, cereals, 0.1-0.6 ppb (4). Yeast, 9 samples, 11% pos, 0.9 ppb, refined vegetable oil, 0-3 ppb, crude vegetable oil 0-19 ppb (max, coconut oil)(6). Edible oils, 0-1.9 ppb, vegetables, 0.5 - 2.6 ppb(7). [(1) National Research Council; pp 6-36 to 58 in Polycyclic Aromatic Hydrocarbons Eval of Sources and Effects, National Acad Press Washington, DC (1983) (2) Fazio T, Howard JW; pp 461-506 in Handbook of Polycyclic Aromatic Hydrocarbons Bjorseth LA ed (1983) (3) Lawrence JF, Weber DF; J Agric Food Chem 32: 794-7 (1984) (4) Vaessen HAMG et al; Toxicol Environ Chem 7: 297-324 (1984) (5) Dennis MJ et al; Food Chem Toxicol 21: 569-74 (1983) (6) IARC; Certain Polynuclear Aromatic

Hydrocarbons and Heterocyclic Compounds 3: 178-81 (1973) (7) IARC; Polynuclear Aromatic Hydrocarbons Part I Chem and Environ Data 32: 299-300 (1983)].

Average Daily Intake [366]:

Typical FOOD INTAKE: 0.00043 ug/kg body wt/day, UK, 1979(1). [(1) Dennis MJ et al; Food Chem Toxicol 21: 569-74 (1983)].

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]:

RBC Benchmark = 0.00043 mg/Kg wet weight.

RfD: none given [893].

Oral Slope Factor: 7.3 mg/kg/day [868].

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

Human liver, not detected in 3 males and 3 females(1). Human fat, not detected in 6 males and 4 females(1). [(1) National Research Concil; pp 6-36 to 58 in Polycyclic Aromatic Hydrocarbons Evaluation of Sources and Effects, National Acad Press Washington, DC (1983)] [366].

Tis.Misc. (Other Tissue Information):

This is a very phototoxic PAH [887,891].

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

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 to 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 Factors (log BCF) are [848]: 5.84 for microorganisms in water, 3.38 for algae, 1.0 for fish, and 4.00 for Daphnia magna.

Information from HSDB [366]:

> Daphnia magna, BCF (concn Aldrich humic acids added), 652 (0.2 ppm), 773(2.0)(1). Using a reported log octanol/water partition coefficient of 6.50(2), an estimated BCF of 51,000 was calculated (3,SRC). Based on this estimated BCF, dibenz(A,H)anthracene will be expected to bioconcentrate in aquatic organisms. However, it may not bioconcentrate in aquatic organisms which contain microsomal oxidase, such as fish, as this enzyme enables the rapid metabolism of certain polycyclic aromatic hydrocarbons(4). [(1) Leversee GJ et al; Can J Fish Aquatic Sci 40: 63-9 (1983) (2) Karickhoff SW; Chemosphere 10: 833-46 (1981) (3) Lyman WJ et al; Handbook of Chem Property Estimation Methods Environ Behavior of Org Compounds McGraw- Hill NY p 5-5 (1982) (4) Santodonato J et al; Health and Ecological Assessment of Polynuclear Aromatic Hydrocarbons; Lee SD, Grant L eds; Pathotox Publ Park Forest South IL (1981)].
>
> ... 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 surfacial 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)].

Interactions:

Carcinogenicity of hydrocarbon mixture predominantly found in automobile exhaust gas condensate was attributed to the syncarcinogenic action of benzo(a)pyrene, dibenz(a,h)anthracene, benz(a)anthracene, & benzo(b)fluoranthene. The 4 carcinogenic hydrocarbons were tested in mice with single dosage levels of 4-12 mug. [Schmaehl D et al; Iarc Sci Publ 16 (air pollut cancer man, proc hanover int carcinog meet, 2nd): 53-9 (1977) [366].

Uses/Sources:

See also Chem.detail section below for dibenz(a,h)anthracene concentrations in various petroleum products.

Major Uses [366]:

Research chemical [SRI].

No known use of this compound [IARC. Monographs on the Evaluation of the Carcinogenic Risk of Chemicals to Man. Geneva: World Health Organization, International Agency for Research on Cancer, 1972-1985. (Multivolume work).,p. V32 300 (1972)].

Natural Sources [366]:

Since dibenz(a,h)anthracene is a product of incomplete combustion, there will be natural sources arising from forest fires, etc. (SRC).

Occurs in fossil fuels [SRI].

In peat deposit areas ... dibenzanthracene ... /has/ been observed. [Clayton, G. D. and F. E. Clayton (eds.). Patty's Industrial Hygiene and Toxicology: Volume 2A, 2B, 2C: Toxicology. 3rd ed. New York: John Wiley Sons, 1981-1982. 3345].

Artificial Sources [366]:

2.5 mg/kg of exhaust tar were isolated from first run gasoline engine exhaust, & 0.16 From automobile exhaust gas after 1-min run. ... In smoke condensate of 100 cigarettes 0.05-0.4 Ug were found, & 0.1-0.15 mg/kg were detected in cigarette smoke condensate. Db(a,h)a is formed on pyrolysis of tobacco constituent stigmasterol (400 mg/kg) at 700 deg c. In soot, concn ranging from 64-705 mg/1000 cu m have been detected, & coal-tar contained between 230-300 mg/kg. [IARC. Monographs on the Evaluation of the Carcinogenic Risk of Chemicals to Man. Geneva: World Health Organization, International Agency for Research on Cancer, 1972-1985.

(Multivolume work).,p. V3 180 (1973)].

... Dibenzanthracene ... has been identified in the exhaust gases of diesel engines. In peat deposit areas ... dibenzanthracene ... /has/ been observed. [Clayton, G. D. and F. E. Clayton (eds.). Patty's Industrial Hygiene and Toxicology: Volume 2A, 2B, 2C: Toxicology. 3rd ed. New York: John Wiley Sons, 1981-1982. 3345].

Ubiquitous product of incomplete combustion, occurring, for example, in exhaust from motor vehicles, in fossil fuels, and cigarette smoke(1,2). [(1) IARC; Certain Polynuclear Aromatic Hydrocarbons and Heterocyclic Compounds 3: 178-81 (1973) (2) IARC; Polynuclear Aromatic Hydrocarbons Part I Chem and Environ Data 32: 299-300 (1983)].

It has been identified in ... coal-heating exhaust ... used engine oil ... & wastewater. [IARC. Monographs on the Evaluation of the Carcinogenic Risk of Chemicals to Man. Geneva: World Health Organization, International Agency for Research on Cancer, 1972-1985. (Multivolume work).,p. V32 300 (1983)].

Mainstream cigarette smoke, 0.1-0.15 ppm(1). Cigarette smoke condensate, 0.05-0.4 ug/100 cigarettes, 0.1-0.15 ppm(2,3). Used engine oil, 14.32 ppm(3). [(1) IARC; Polynuclear Aromatic Hydrocarbons Part I Chem and Environ Data 32: 299-300 (1983) (2) IARC; Certain Polynuclear Aromatic Hydrocarbons and Heterocyclic Compounds 3: 178-81 (1973) (3) Verschueren K; Handbook of Environ Data on Org Chem 2nd ed Von Nostrand Reinhold NY pp 460-1 (1983)].

Forms/Preparations/Formulations:

No information found.

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

Water Solubilities:

Virtually insoluble in water [847].

0.00029 to 0.146 mg/L at 25 degrees C (most values near 0.0005 mg/L at 25 degrees C) [848].

Other Solubilities [366]:

Sol in most organic solvents & oils; slightly sol in alcohol & ether [IARC. Monographs on the Evaluation of the

Carcinogenic Risk of Chemicals to Man. Geneva: World Health Organization, International Agency for Research on Cancer, 1972-1985. (Multivolume work).,p. V3 179 (1973)].

Sol in petroleum ether, benzene, toluene, xylene [The Merck Index. 10th ed. Rahway, New Jersey: Merck Co., Inc., 1983. 436].

Soluble in acetone, or absolute alcohol [Weast, R.C. (ed.) Handbook of Chemistry and Physics. 67th ed. Boca Raton, FL: CRC Press, Inc., 1986-87.,p. C-241].

Vapor Pressure [848]:

3.70x10(-10), and 1.3x10(-8) Pa at 25 degrees C.

Henry's Law Constant [848]:

0.0074, and 0.0076 Pa m(3)/mol.

Molecular Weight [366]:

278.33 [The Merck Index. 10th ed. Rahway, New Jersey: Merck Co., Inc., 1983. 436].

Density/Specific Gravity [366]:

1.282 [IARC. Monographs on the Evaluation of the Carcinogenic Risk of Chemicals to Man. Geneva: World Health Organization, International Agency for Research on Cancer, 1972-1985. (Multivolume work).,p. V3 178 (1973)].

Octanol/Water Partition Coefficient, log Kow [848]:

5.80 to 7.19 (most values near 6.50).

Sorption Partition Coefficient, log Koc [848]:

5.20 to 6.52 (most values near 6.22).

Melting Point [848]:

266 to 270 degrees C.

Boiling Point [848]:

524 degrees C

Color/Form [366]:

Colorless plates or leaflets /recrystallized/ from acetic acid; soln in concentrated sulfuric acid is red [IARC. Monographs on the Evaluation of the Carcinogenic Risk of Chemicals to Man. Geneva: World Health Organization, International Agency for Research on Cancer, 1972-1985. (Multivolume work).,p. V3 178 (1973)].

Crystals may be monoclinic or orthorhombic [The Merck Index. 10th ed. Rahway, New Jersey: Merck Co., Inc., 1983. 436].

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. Dibenz(a,h)anthracene 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].

Dibenz(a,h)anthracene content (mg/kg or ppm) in one fresh sample of Exxon Valdez Crude Oil [971]: 1 mg/kg = ppm

Dibenz(a,h)anthracene content in one fresh sample of NSFO (Fuel Oil 5, Chuck Rafkind, National Park Service, Personal Communication, 1996): 4.0 ng/mg (ppm).

Dibenz(a,h)anthracene 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): 117.1 ng/L (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).

Dibenz(a,h)anthracene concentration in Used Engine Oil: 1.5 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]; 14.32 mg/kg [847].

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

Half-lives in surface water range from 6 to 782 hours (based on sunlight photolysis half-life in water) [848].

Half-lives in groundwater range from 17,328 to 45,120 hours (based on estimated unacclimated aqueous aerobic biodegradation half-life) [848].

Half-lives in soil are [848]: 361 days for Kidman sandy loam soil, and 420 days for McLaurin sandy loam soil; 8,664 to 22,560 hours (based on aerobic soil dieaway test data); and 20.6 weeks.

Information from HSDB [366]:

TERRESTRIAL FATE: If dibenz(a,h)anthracene is released to the soil, it will adsorb very strongly to the soil and will not be expected to leach to the groundwater. It will not hydrolyze or evaporate from soils or surfaces. It will be subject to biodegradation in soil systems with reported half-lives of 18 and 21 days(1). [(1) Sims RC, Overcash MR; Res Rev 88: 1-68 (1983)].

AQUATIC FATE: If dibenz(A,H)anthracene (DBahA) is released to water, it will be expected to adsorb very strongly to sediments and particulate matter. It will not hydrolyze and volatilization will not be an important process. It will be expected to bioconcentrate in aquatic organisms which lack microsomal oxidase (this enzyme enables the rapid metabolism of certain polycyclic aromatic hydrocarbons). No information was found on the biodegradation of DBahA in natural waters; however, based on limited data from laboratory screening tests using settled domestic wastewater and activated sludge, it may be subject to biodegradation in natural waters. Since DBahA's absorbs solar radiation strongly, it may be subject to direct photolysis in natural waters; however, the photosensitivity of polyaromatic hydrocarbons is strongly dependent upon the nature of the surface upon which the compound is adsorbed. (SRC).

ATMOSPHERIC FATE: Dibenz(a,h)anthracene (DBahA) released to the atmosphere will likely be associated with particulate matter and may be subject to moderately long range transport, depending mainly on the particle size distribution and climactic conditions which will determine the rates of wet and dry deposition. Its presence in areas remote from primary sources demonstrates the potential for this long range transport as well as DBahA's considerable stability in the air. The estimated vapor phase half-life in the atmosphere is 1.00 day as a result of reaction with photochemically produced hydroxyl radicals. (SRC).

Biodegredation [366]:

Half-lives of 18 and 21 days were reported for biodegradation of dibenz(a,h)anthracene (DBahA) in soil systems(4). Percent biodegradation of DBahA by microbes in settled domestic wastewater in original culture, 1st, 2nd, 3rd subculture, respectively (7 days between each measurement and subculture), concn doped (percent degradation): 1.10 ppm(82%), 1.18 ppm (82%), 1.14 ppm(82%), 1.22 ppm(75%)(1). Degradation of DBahA using activated sludges from municipal wastewater plant in Warburg tests resulted in approx 96% theoretical BOD in

144 hr(2). Percent microbial mineralization by 6 fresh (6 ripe) composted municipal waste in 10 weeks as measured by (14)CO2 formation: 0.1-1.4% (0.8-20.8%), avg 0.4% (12.6%)(3). [(1) Tabak HH et al; pp 267-328 in Test Protocols for Environ Fate and Movement of Toxicants Proc Symp AOAC 94th Ann Mtg Washington, DC (1981) (2) Lutin PA et al; Purdue U Eng Bull, Wastewater Conf Ext Ser No.118: 131-45 (1965) (3) Martens R; Chemosphere 11: 761-70 (1982) (4) Sims RC, Overcash MR; Res Rev 88: 1-68 (1983)].

Abiotic Degredation [366]:

Polyaromatic hydrocarbons do not contain hydrolyzable groups and would therefore not be expected to hydrolyze(1). Since dibenz(a,h)anthracene (DBahA) absorbs solar radiation strongly, it may be subject to direct photolysis in the environment(1). One month (Nov) of sunlight exposure in heptane solution in an Erlenmeyer flask led to the recovery of 54% of the original amount of DBahA(2). Half-lives reported for DBahA coated on TLC plates upon various exposures: simulated sunlight, 9.60 hr, simulated sunlight and 0.2 ppm ozone, 4.80 hr, dark reaction with 0.2 ppm ozone, 2.71 hr(3). Pronounced photodegradation reported for DBahA adsorbed on silica and alumina with less pronounced changes for DBahA adsorbed on cellulose and acetylated cellulose; experiments show that the photosensitivity of polyaromatic hydrocarbons is strongly dependent upon the nature of the surface upon which the compound is adsorbed(4). The estimated vapor phase half-life in the atmosphere is 1.00 day as a result of reaction with photochemically produced hydroxyl radicals(5). [(1) Callahan MA et al; Water-Related Environ Fate of 129 Priority Pollut Vol 2 pp 98-8 USEPA-440/4-79-029b (1979) (2) Muel B, Saguem S; Intern J Environ Anal Chem 19: 111-31 (1985) (3) Bjorseth A, Olufsen BS; pp 507-24 in Handbook of Polycyclic Aromatic Hydrocarbons; Bjorseth A ed (1983) (4) National Res Council; pp 6-36 to 58 in Polycyclic Aromatic Hydrocarbons Evaluation of Sources and Effects, National Acad Press Washington, DC (1983) (5) Santodonato J et al; Hazard Profiles on PAH Syracuse Res Corp, Syr, NY p 77 TR 81-633 (1981)].

Soil Adsorption/Mobility [366]:

Koc: sediments, range of 11 values, 805,292 to 3,059,425, soils, range of 3 values, 565,014 to 3,020,262, avg sediments and soils, 2,029,000(1). [(1) Sims RC, Overcash MR; Res Rev 88: 1-68 (1983)].

Volatilization from Water/Soil [366]:

Using a reported water solubility of 0.0005 ppm(1) and an estimated vapor pressure of 1X10-10(1), an estimated Henry's Law constant of 7X10-8 atm-cu m/mol was calculated(2,SRC). Since the estimated Henry constant is < 3X10-7 atm-cu m/mol, volatilization should not be an important process(2). [(1) Sims RC, Overcash MR; Res Rev 88: 1-68 (1983) (2) Lyman WJ et al; Handbook of Chem Property Estimation Methods. McGraw-Hill NY pp.15-1 to 34 (1982)].

Absorption, Distribution and Excretion [366]:

Upon topical application /1 umole/mouse/ to mouse skin, dibenz(a,h)anthracene became bound to DNA in skin at treated area to the extent of 15 pmol/mg DNA. This cmpd showed a max level of binding 72 hr after treatment, compared with 19-24 hr for other polycyclic hydrocarbons similarly tested. [Phillips DH et al; Int J Cancer 23 (2): 201-8 (1979).

In study reported as abstract, it was suggested that DB(a,h)A or its metabolites cross the placenta. [IARC. Monographs on the Evaluation of the Carcinogenic Risk of Chemicals to Man. Geneva: World Health Organization, International Agency for Research on Cancer, 1972-1985. (Multivolume work).,p. V32 301 (1983).

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. [Plant AL et al; Chem-biol Interact 44 (3): 237-46 (1983).

Polynuclear aromatic hydrocarbons are highly soluble in adipose tissue and lipids. /Polynuclear aromatic hydrocarbons/ [Sittig, M. Handbook of Toxic And

Hazardous Chemicals. Park Ridge, NJ: Noyes Data Corporation, 1981. 564.

Polycyclic aromatic hydrocarbons (PAHs) differing in mol size and structure were added to aseptic seedlings and cell suspension cultures of wheat, sugar beets, and Atriplex hortensis to study the metabolic fate of these compds. The uptake depended on the size of the particular molecule. Uptake and translocation ... dibenz[a,h]anthracene was very low. ... [Harms H; Landbauforsh Voelkenrode 31 (1): 1-6 (1981).

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 (see Chem.Detail section in separate "PAHs as a group" entry for more details).

In a similar vein, if the Park Service sediment investigation at Petersburg National Historical Battlefield (see Chem.Detail section in separate "PAHs as a group" entry; 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. In fact, as mentioned in the disclaimer section at the top of this entry, 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].

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).