ENVIRONMENTAL CONTAMINANTS ENCYCLOPEDIA

BIPHENYL 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 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).

Biphenyl (Diphenyl; Phenylbenzene; 1,1-Biphenyl; CAS number 92-52-4)

Brief Introduction:

Br.Class: General Introduction and Classification Information:

Biphenyl is a low molecular weight, 2-ring polyaromatic hydrocarbon (PAH) [697].

NOTE: Biphenyl belongs to a class of hydrocarbons referred to a polynuclear aromatic hydrocarbons (PNA) [495]. Some would consider it a PNA but not a PAH since it does not have "two or more benzene rings FUSED together," but there is a lack on consistency on this issue in various references.

For example, biphenyl is included in some standard laboratory scans for polycyclic aromatic hydrocarbons (PAHs), including the Texas A. and M. "expanded scan" for PAHs and alkylated homologues [828]. (This expanded scan includes most of the PAHs recommended by the NOAA's National Status and Trends program [680].) Although biphenyl's two benzene rings are not "fused," biphenyl does meet the most crucial part of the PAH definition by having "two or more aromatic rings" [177]. Therefore, most people would classify biphenyl as a PAH, and most would say that the terms PNA and PAH are synonyms (Charlie Henry, Louisiana State University, personal communication, 1994).

The biphenyl group is also a common component or base structure for PCBs and various other toxic organic compounds [366].

Br.Haz: General Hazard/Toxicity Summary:

Toxic Hazard Rating = "moderately toxic" [366].

Exposure to biphenyl has resulted in CNS depression, paralysis, convulsions in experimental animals [366].

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.

Two-ring PAHs tend to account for a large percentage of the acute aquatic risk from PAHs (see "PAHs as a group" and "Naphthalene" entries).

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

EPA 1996 IRIS Database [893]:

Classification as to human carcinogenicity: weight-of-evidence classification:

Classification: D; not classifiable as to human carcinogenicity

BASIS: No human data and inadequate studies in mice and rats. Results of genotoxicity tests are generally negative.

HUMAN CARCINOGENICITY DATA: None.

ANIMAL CARCINOGENICITY DATA

Inadequate. The animal carcinogenicity data was found to be inadequate because the studies were designed to study the toxicology rather than oncology of 1,1-biphenyl and small group sizes were used.

Phototoxicity: No information found. Possible reference of interest: Hirayama, T., M. Nohara, H. Shindo and S. Fukui. 1981. Mutagenicity assays of photochemical reaction products of biphenyl (BP) and o-phenylphenol (OPP) with NOx. Chemosphere. 10(2): 223-228 [893].

Not treated as a carcinogen for certain EPA modeling purposes [903].

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

Biphenyl is a central nervous system toxicant in experimental animals. Biphenyl is genotoxic in yeast and sea urchin embryos but not in bacteria [606].

DNA damage and mutations occurred in mouse lymphocyte cells at doses of 50 umol/L and 296 umol/L, respectively [365].

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

Biphenyl was considered by EPA to be likely to accumulate in fish tissues (in areas where it is present) to be included among the chemicals analyzed in EPA's National Bioaccumulation Study [507].

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

Synonyms/Substance Identification:

1,1'-Biphenyl [366,607]
1,1'-Diphenyl [366]
Bibenzene [366,607]
Biphenyl [366,607]
Lemonene [366,607]
Phenador-X [366,607]
Phenylbenzene [366,607]
PHPH [366,607]
Xenene [366,607]
Carolid AL [607]
Diphenyl [607]
Tetrosin LY [607]

Molecular Formula [366]:
C_{12}-H_{10}

Associated Chemicals or Topics (Includes Transformation Products):

See also individual entry in this volume:

PAHs as a group

The biphenyl group is also a common component or base structure for PCBs and various other toxic organic compounds [366]. Unusually high concentrations of biphenyl in an environmental sample may therefore be one potential clue that various PCBs may also be present [619].

Metabolism/Metabolites [366]:

After rabbits ingested biphenyl...64%...was accounted for in the urine primarily as the corresponding glucosiduronic acid and smaller amt of phenols and ether sulfates. From the urine, 4-hydroxybiphenyl, and 4-biphenyl glucosiduronic acid were isolated... [Menzie, C.M. Metabolism of Pesticides. U.S. Department of the Interior, Bureau of Sport Fisheries and Wildlife, Publication 127. Washington, DC: U.S. Government Printing Office, 1969. 63].

Liver microsomal preparations from New Zealand white rabbits converted biphenyl into 2- and 4-hydroxybiphenyl... other studies.../noted/ that the 4-isomer and practically no 2-isomer were found... The extent of 4-hydroxylation varies with species being poor in cat and trout high in mouse and coypu. [Menzie, C.M. Metabolism of Pesticides. U.S. Department of the Interior, Bureau of Sport Fisheries and Wildlife, Publication 127. Washington, DC: U.S. Government Printing Office, 1969. 63].

After feeding of biphenyl to rabbits, 2-hydroxy-, 4-hydroxy-, 3,4-dihydroxy-, & 4,4'-dihydroxy-biphenyl were demonstrated. Three other phenolic metabolites were present but not identified... [Menzie, C. M. Metabolism of Pesticides, An Update. U.S. Department of the Interior, Fish, Wild-life Service, Special Scientific Report - Wildlife No. 184, Washington, DC: U.S. Government Printing Office, l974. 58].

Gram-negative bacteria...from soils...utilizing biphenyl as...carbon source. 2,3-Dihydroxybiphenyl was isolated... A...fraction from biphenyl-grown cells cleaved.../this product/ to give alpha-hydroxy-beta-phenylmuconic semialdehyde. ...Converted to phenylpyruvate...by sol cell free extract... [Menzie, C. M. Metabolism of Pesticides, An Update. U.S. Department of the Interior, Fish, Wild-life Service, Special Scientific Report - Wildlife No. 184, Washington, DC: U.S. Government Printing Office, l974. 58].

It is metabolized in rat to 4-hydroxybiphenyl (30% of dose) & its glucuronide (20%), 4,4'- & 3,4-dihydroxybiphenyls (5% & 3% respectively) & 4-phenylphenylmercapturic acid (1.3%). Principal metabolite in rabbit, dog & mouse is also 4-hydroxybiphenyl, but mouse also excretes 2-hydroxybiphenyl in urine. [Parke, D. V. The Biochemistry of Foreign Compounds. Oxford: Pergamon Press, 1968. 169].

Yields n-acetyl-s-biphenyl-4yl-l-cysteine in rat: West et al, archs biochem biophys, 60, 14 (1956): benzoic acid & cis-2,3-dihydro-2,3-dihydroxybiphenyl in pseudomonas: catelani et al, experientia, 27, 1173 (1971). /From table/ [Goodwin, B.L. Handbook of Intermediary Metabolism of Aromatic Compounds. New York: Wiley, 1976.,p. B-16].

3-Hydroxybiphenyl, 2-hydroxybiphenyl, & 4-hydroxybiphenyl were identified as metabolites of biphenyl incubated with liver microsomes from hamster, mouse & rabbit. Ratio of 2-oh biphenyl to 3-oh biphenyl is about 2:1 with hamster & rabbit microsomes & 1:1 with mouse. [Billings & McMahon; mol pharmacol 14(1) 145 (1978)].

Ability to form 2-hydroxybiphenyl is almost absent in livers of adult rabbits and rats, guinea pigs, hens, trout and fox. Livers of mice, hamsters, cats, coypus, frogs, and young rabbits and rats form measurable amt of the 2-isomer... [Menzie, C.M. Metabolism of Pesticides. U.S. Department of the Interior, Bureau of Sport Fisheries and Wildlife, Publication 127. Washington, DC: U.S. Government Printing Office, 1969. 63].

Biphenyl...was monohydroxylated by hamster-liver microsomes @ positions 2 (minor) & 4; small quantities of 2,2'- & 4,4'-dihydroxybiphenyl were also tentatively identified. [The Chemical Society. Foreign Compound Metabolism in Mammals. Volume 4: A Review of the Literature Published during 1974 and 1975. London: The Chemical Society, 1977. 226].

Phenobarbital type inducers incr 4-oh biphenyl formation & 3-methylcholanthrene type inducers incr 2-oh biphenyl formation. [Snyder R, Remmer H; classes of hepatic microsomal mixed function oxidase inducers; pharmac ther 7 203 (1979)].

Hepatic microsomal hydroxylation rates for biphenyl & its deriv were determined in phenobarbitone & 3-methylcholanthrene-induced rats. [Bridges et al; microsomal biphenyl hydroxylation: the effect of selective deuterium substitution on the rate of formation of the monohydroxybiphenyls; biochem soc trans 7(5) 1073 (1979)].

10-4 Molar betamethasone enhanced 2-hydroxylation of biphenyl in liver microsomes approx 100%. [Benford DJ, Bridges JW; biochem soc trans 7(5) 1107 (1979)].

Effect of various metabolic inhibitors on biphenyl metabolism in isolated rat hepatocytes was studied. Compounds studied were menadione, rotenone & 2,4-dinitrophenol. [wiebkin et al; effect of various metabolic inhibitors on biphenyl metabolism in isolated rat hepatocytes; biochem pharmacol 28(22) 3315 (1979)].

Comparative effects of biphenyl & deriv on hepatic drug metabolizing enzymes in rat. 2-Hydroxybiphenyl had greater inducing effect on activity of aniline hydroxylase & aminopyrine n-demethylase than did 4-hydroxybiphenyl. [Miller & Bajaj; ircs med sci: libr compend 7(10) 521 (1972)]].

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):

No information found.

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):

No information found.

W.Plants (Water Concentrations vs. Plants):

No information found.

W.Invertebrates (Water Concentrations vs. Invertebrates):

LC50s for Daphnia magna (water flea) were 1.3 and 27 mg/L (ppm) for 24-hr exposures, and 0.36, 2.1 and 4.7 mg/L for 48-hr exposures [998].

W.Fish (Water Concentrations vs. Fish):

LC50 for Cyprinodon variegatus (sheepshead minnow) was 4.6 mg/L (ppm) for a 96-hr exposure [998].

LC50 for Lepomis macrochirus (bluegill) was 4.7 mg/L for a 96-hr exposure [998].

LC50 for Oncorhynchus mykiss (rainbow trout, donaldson trout) was 1.5 mg/L for a 96-hr exposure [998].

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

No information found.

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

EPA 1996: No MCL or Drinking Water Health Advisories available in IRIS [893].

EPA Region IX tap water preliminary remediation goal (PRG) and Region 3 RBC benchmark: 1.8E+03 ug/L [868,903].

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

No information found.

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):

Biphenyl was detected in 89.2 % of urban-bay samples from the Puget Sound area. The mean concentration was 83 ug/kg dry weight (ppb), while the median concentration was 30 ug/kg (ppb) [852].

NOTE: The above values are not normalized for total organic carbon (TOC) content.

Sed.Typical (Sediment Concentrations Considered Typical):

Biphenyl was detected in 43% of non-urban-bay samples from the Puget Sound area. The mean concentration was 4 ug/kg dry weight (ppb), while the median concentration was 4 ug/kg (ppb) [852]. NOTE: these values based on only three samples where biphenyl was detected.

NOTE: The above values are not normalized for total organic carbon (TOC) content.

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):

NOAA 1990: 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 there was too little data available to ascertain firm concern levels, but that effects in the two marine studies which were available were associated with the range of 6.6 mg/kg dry weight to 443 mg/kg dry weight [233]. See entry entitled ERL.

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):

No information found.

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 Region IX residential soil preliminary remediation goal (PRG): 3.3E+03 mg/Kg [868].

EPA Region IX industrial soil preliminary remediation goal (PRG): 3.4E+04 mg/Kg [868].

EPA Region 3 RBC benchmark to protect groundwater from contamination: 110 mg/kg [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:

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:

No information found.

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):

EPA Region 3 risk based concentration (RBC) for fish tissues: 68 mg/kg [903]. Note: this concentration is unlikely to occur since fish break down PAHs; the real risk is from mixtures of PAHs including more harmful and carcinogenic PAHs, and PAHs tend to occur in mixtures (Roy Irwin, National Park Service, personal communication, 1996).

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 information found.

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):

The acute oral LD50 for rats is 75-105 mg/kg [154,619].

LD50 rat; ROUTE: Oral; DOSE: 2400 mg/kg; REFERENCE: Monsanto Co. Toxicity Information. [365].

LD50 mouse; ROUTE: Oral; DOSE: 1900 mg/kg; TOXIC EFFECTS: BEHAVIORAL - Somnolence (general depressed activity); GASTROINTESTINAL - Hypermotility, diarrhea; REFERENCE: Shokuhin Eiseigaku Zasshi. Food Hygiene Journal 24:268, 1983. [365].

LD50 rabbit; ROUTE: Oral; DOSE: 2400 mg/kg; REFERENCE: Nagoya Shiritsu Daigaku Igakkai Zasshi. Journal of the Nagoya City University Medical Association 28:983, 1977. [365].

DOSAGES OF 2.5-64 MG/KG/day orally were not tumorigenic in mice. /FROM TABLE/ [Hayes, W. J., Jr. Toxicology of Pesticides Baltimore: Williams & Wilkins, 1975. 193] [366].

Dietary levels of 0.5% fed to rats for 60 days produced polyuria & reversible kidney lesions (focal tubular dilation). [Gosselin, R.E., H.C. Hodge, R.P. Smith, and M.N. Gleason. Clinical Toxicology of Commercial Products. 4th ed. Baltimore: Williams and Wilkins, 1976.,p. II-104] [366].

Acute oral LD50's in rats 3.28 g/kg... after single doses animals showed incr rate of resp, lacrimation, anorexia & wt loss, muscular weakness, ataxia with death in coma occurring in from 2 hr to 18 days. ... pathological findings incl...Visceral congestion, myocarditis, hepatitis, nephritis...pneumonia. [Gosselin, R.E., H.C. Hodge, R.P. Smith, and M.N. Gleason. Clinical Toxicology of Commercial Products. 4th ed. Baltimore: Williams and Wilkins, 1976.,p. II-104] [366].

Assessment of teratogenic potential of biphenyl. Admin of 125-500 mg/kg by esophageal intubation to rats days 6-15 of gestation was not teratogenic & caused no maternal effects. At 1000 mg/kg, it produced fetal & maternal toxicity. [Khera et al; Toxicol appl pharmacol 47(2) 353 (1979)] [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):

EPA 1996 IRIS Database [893]:

Crit. Dose: 50 mg/kg-day [893].

RfD is 5E-2 mg/kg-day Confidence: Medium [868,893].

Probable oral lethal dose (human) 0.5-5 g/kg, between 1 oz & 1 pint (or 1 lb) for 70 kg person (150 lb). [Gosselin, R.E., H.C. Hodge, R.P. Smith, and M.N. Gleason. Clinical Toxicology of Commercial Products. 4th ed. Baltimore: Williams and Wilkins, 1976. p.II-104] [366].

EPA Region 3 risk based concentration for fish tissues: 68 mg/kg [903]. Note: this concentration is unlikely to occur since fish break down PAHs; the real risk is from mixtures of PAHs including more harmful and carcinogenic PAHs, and PAHs tend to occur in mixtures (Roy Irwin, National Park Service, personal communication, 1996).

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

No information found.

Tis.Misc. (Other Tissue Information):

No information found.

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

Half-life in fish (estimated from a simulated ecosystem) is 29 hours [848].

Bioconcentration Factor, log BCF [848]:

2.73 in algae,
2.64 in trout,
3.12 in rainbow trout,
2.45, 2.53, and 3.0 in fish.

Interactions:

The biphenyl group is also a common component or base structure for PCBs and various other toxic organic compounds. Major components of Aroclor 1221 include biphenyl, 12.7% [366]. The aqueous chlorination of biphenyl at 40 degrees centigrade over a pH range of 6.2 to 9.0 yielded o-chlorobiphenyl and m-chlorobiphenyl [619]. Aroclors such as 1221 1254, and 1260, are mixtures of different congeners of chlorobiphenyl and the relative importance of the environmental fate mechanisms generally depends on the degree of chlorination [366]. Sodium hypochlorite as a chlorinating agent in acidic (ph 4.5) solution containing bromide ions yielded 4-bromodiphenyl from biphenyl [619].

Uses/Sources:

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

Used for: organic synthesis; heat transfer agent; fungistat in packaging of citrus fruit; plant disease control; mfr of benzidine; dyeing assistant for polyesters, intermediate for polychlorinated biphenyls [366].

Forms/Preparations/Formulations:

No information found.

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

Water Solubilities:

1.90 to 23.6 mg/L at 25 degrees C (most values near 7.1 mg/L; most values determined as "subcooled liquid" were near 20.3 mg/L at 25 degrees C) [848].

Insoluble (sic, they really mean relatively insoluble) in water [366].

Other Solubilities [366]:

Sol in alc, ether; [The Merck Index. 9th ed. Rahway, New Jersey: Merck & Co., Inc., 1976. 443].

Soluble in most organic solvents [Martin, H. and C.R. Worthing (eds.). Pesticide Manual. 4th ed. Worcestershire, England: British Crop Protection Council, 1974. 219].

Very sol in benzene & methanol; sol in carbon tetrachloride & carbon disulfide [Weast, R.C. (ed.). Handbook of Chemistry and Physics. 60th ed. Boca Raton, Florida: CRC Press Inc., 1979.,p. C-209].

Vapor Pressure:

0.031 to 7.7 Pa at 25 degrees C (most values near 1.3 Pa at 25 degrees C; most values determined as "subcooled liquid" were near 6.0 Pa at 25 degrees C) [848].

1 MM HG @ 71 DEG C [International Labour Office. Encyclopedia of Occupational Health and Safety. Volumes I and II. New York: McGraw-Hill Book Co., 1971. 391] [366].

Henry's Law Constant [848]:

13.7 to 157 Pa m(3)/mol (most between 30 and 70 Pa m(3)/mol.

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

3.09 to 4.52 (most values near 4.0).

Sorption Partition Coefficient, log Koc [848]:

3.15 to 5.58 (most values < 4.0).

Molecular Weight [366]:

154.20 [The Merck Index. 9th ed. Rahway, New Jersey: Merck & Co., Inc., 1976. 443].

Density/Specific Gravity [366]:

1.041 [The Merck Index. 9th ed. Rahway, New Jersey: Merck & Co., Inc., 1976. 443.

Boiling Point:

254-255 DEG C [The Merck Index. 9th ed. Rahway, New Jersey: Merck & Co., Inc., 1976. 443] [366].

246 degrees C [848].

Melting Point:

69-71 DEG C [The Merck Index. 10th ed. Rahway, New Jersey: Merck Co., Inc., 1983. 485] [366].

87 degrees C [848].

Odor [366]:

Pleasant, peculiar odor [The Merck Index. 9th ed. Rahway, New Jersey: Merck & Co., Inc., 1976. 443].

Color/Form [366]:

White scales [Sax, N.I. Dangerous Properties of Industrial Materials. 5th ed. New York: Van Nostrand Rheinhold, 1979. 622].

Leaflets from dil alcohol [Weast, R.C. (ed.). Handbook of Chemistry and Physics. 60th ed. Boca Raton, Florida: CRC Press Inc., 1979.,p. C-209].

Colorless leaflets [The Merck Index. 9th ed. Rahway, New Jersey: Merck & Co., Inc., 1976. 443].

One of the most thermally stable of all organic compounds [Patty, F. (ed.). Industrial Hygiene and Toxicology: Volume II: Toxicology. 2nd ed. New York: Interscience Publishers, 1963. 1220.

Max absorption (alcohol): 247 NM (LOG E= 4.24); SADTLER REF NUMBER: 783 (IR, PRISM); 163 (IR, GRATING); 255 (UV); V289 (NMR) [Weast, R.C. (ed.). Handbook of Chemistry and Physics. 60th ed. Boca Raton, Florida: CRC Press Inc., 1979.,p. C-209.

Vapor Density [366]:

5.31 (AIR= 1) [Sax, N.I. Dangerous Properties of Industrial Materials. 5th ed. New York: Van Nostrand Rheinhold, 1979. 622.

Biphenyl content in one fresh sample of NSFO (Fuel Oil 5, Chuck Rafkind, National Park Service, Personal Communication, 1996): 3.5 ng/mg (ppm)
Biphenyl 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): 129.7 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).

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

Half-life in river water estimated to be 1.5 days [848].

Absorption, Distribution and Excretion [366]:

The biliary excretion of metabolites of biphenyl...was shown...to be increased by pre-treatment with hepatic-microsomal-enzyme inducers & to be decreased by enzyme inhibitors after dosing with parent compounds, but no effect was observed after dosing with metabolites. [The Chemical Society. Foreign Compound Metabolism in Mammals. Volume 2: A Review of the Literature Published Between 1970 and 1971. London: The Chemical Society, 1972. 436].

Not local irritant but absorbed through intact skin. [Gosselin, R.E., H.C. Hodge, R.P. Smith, and M.N. Gleason. Clinical Toxicology of Commercial Products. 4th ed. Baltimore: Williams and Wilkins, 1976.,p. II-104].

Studies with rabbits fed biphenyl, showed that 3-hydroxybiphenyl & mixt of monomethylated analogs of 3,4-dihydroxybiphenyl...Were present in urine. [Menzie, C.M. Metabolism of Pesticides, Update II. U.S. Department of the Interior, Fish Wildlife Service, Special Scientific Report - Wildlife No. 2l2. Washington, DC: U.S. Government Printing Office, 1978. 45].

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 disclaimers 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).