ENVIRONMENTAL CONTAMINANTS ENCYCLOPEDIA

BENZO(G,H,I)PERYLENE 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).

Benzo(g,h,i)perylene (CAS number 191-24-2)

Brief Introduction:

Br.Class: General Introduction and Classification Information:

Benzo(g,h,i)perylene is a six-ring, high molecular weight polycyclic aromatic hydrocarbon (PAH), and an EPA priority pollutant [847,928]. Various sources have determined that it is not classifiable as to its carcinogenicity to humans [788,881,893].

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

Clean Water Act Requirements: This is a toxic pollutant designated pursuant to section 307(a)(1) of the Clean Water Act and is subject to effluent limitations. /Polynuclear aromatic hydrocarbons/ [609] (40 CFR 401.15 7/1/88).

This is a CERCLA hazardous substance. Reportable Quantities: Persons in charge of vessels or facilities are required to notify the National Response Center (NRC) immediately, when there is a release of this designated hazardous substance, in an amount equal to or greater than its reportable quantity of 5000 lb or 2270 kg., (54 FR 33419 8/14/89) [609].

Br.Haz: General Hazard/Toxicity Summary:

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].

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.

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

EPA 1996 IRIS Database [893]:

> Evidence for classification as to human carcinogenicity; weight-of-evidence classification:
>
> > Classification: D; not classifiable as to human carcinogenicity
> >
> > BASIS: Based on no human data and inadequate animal data from lung implant, skin-painting and subcutaneous injection bioassays.
> >
> > HUMAN CARCINOGENICITY DATA: None.
>
> ANIMAL CARCINOGENICITY DATA: Inadequate. Benzo(g,h,i)perylene appeared to increase lung epidermoid tumors when administered with trioctanonin in a lung implant study [893].

The debates on exactly how to perform both ecological and human risk assessments on the complex mixtures of PAHs typically found at contaminated sites, are likely to continue. There are some clearly wrong ways to go about it, but defining clearly right ways is more difficult. PAHs such as this one usually occur in complex mixtures rather than alone. Perhaps the most unambiguous thing that can be said about complex PAH mixtures is that such mixtures are often hazardous in many ways, including carcinogenicity and phototoxicity. (James Huckins, National Biological Service, and Roy Irwin, National Park Service, personal communication, 1996).

The International Agency for Research on Cancer (IARC) and EPA have determined that benzo(g,h,i)perylene is not classifiable as to its carcinogenicity to humans [788].

No data are available in humans. Inadequate evidence of carcinogenicity in animals. OVERALL EVALUATION: Group 3: The agent is not classifiable as to its carcinogenicity 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-PRESENT. (Multivolume work).,p. S7 58 (1987) [609].

The 4- to 7-ring PAHs have been especially implicated in the carcinogenic effect of used oil [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].

This is a phototoxic PAH [891,887; Reprinted with permission from Environmental Toxicology and Chemistry, Volume 6, Newstead, J.L. and J.P. Geisy. Predictive models for photoinduced acute toxicity of polycyclic aromatic hydrocarbons to Daphnia magna. Copyright 1987 SETAC]. Although not definitive, as discussed above, phototoxicity represents one clue suggesting possible carcinogenicity.

Found to be one of the three principal mutagenic compounds in a coal-tar-contaminated sediment [816]. The other two [benzo(a)pyrene and indeno(1,2,3-cd)pyrene] are known to be carcinogenic [881]. Mutagenicity represents one clue suggesting possible carcinogenicity.

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

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

The higher molecular weight PAHs benzo(a)pyrene, benzo(g,h,i)perylene, indeno(1,2,3-cd)pyrene, and compounds of molecular weight 302 amu were found to be mutagenic to the bacteria Salmonella typhimurium [816; Reprinted with permission from Environmental Toxicology and Chemistry, Volume 14, Marvin, C.H., J.A. Lundrigan, B.E. McCarry and D.W. Bryant. Determination and genotoxicity of high molecular mass polycyclic aromatic hydrocarbons isolated from coal-tar-contaminated sediment. Copyright 1995 SETAC].

The mutagenicity of 6 polycyclic aromatic hydrocarbons found in african smoked fish was tested using several salmonella typhimurium strains. In the presence of fortified rat liver postmitochondrial fractions, mutagenic activity was observed with benzo(g,h,i)perylene in the plate incorporation method. [609, Mossanda k et al; food cosmet toxicol 17 (2): 141-4 (1979)].

Benzo(g,h,i)perylene has growth-promoting effects on some higher plants as well as on planktonic algae [366].

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].

HSDB Information [609]:

Benzo(g,h,i)perylene is absorbed readily from the gastrointestinal tract and lung. In general, polycyclic aromatic hydrocarbons are highly lipid soluble and can pass across epithelial membranes. [USEPA; Health and Environmental Effects Profile for Benzo(g,h,i)perylene p.18 (1987) EPA/600/x-87/395.

Benzo(g,h,i)perylene is a component of crude oil and a product of combustion which may be produced and released to the environment during natural fires. Emissions from petroleum refining, coal tar distillation, and the combustion of wood, coal, oil, propane, gasoline and diesel fuels are major contributors of benzo(g,h,i)perylene to the environment. Benzo(g,h,i)perylene is not commercially produced in the USA; however, benzo(g,h,i)perylene may be released to the environment through industrial effluents, municipal waste water treatment facilities and waste incinerators. Benzo(g,h,i)perylene biodegrades slowly in the environment. The reported biodegradation half-lives for benzo(g,h,i)perylene in aerobic soil range from 600 to 650 days. Benzo(g,h,i)perylene is not expected to hydrolyze in the environment. A calculated Koc range of 9X10+4 to 4X10+5 indicates benzo(g,h,i)perylene will be highly immobile in soil. In aquatic systems, benzo(g,h,i)perylene partitions from the water column to organic matter contained in sediments and suspended solids. Benzo(g,h,i)perylene also has the potential to bioconcentrate in aquatic systems. A Henry's Law constant of 1.6X10-6 atm-cu m/mole at 25 deg C suggests volatilization of benzo(g,h,i)perylene from shallow, fast moving environmental waters may be important. The volatilization half-lives from a model river and a model pond, the latter considers the effect of adsorption, have been estimated to be 38 days and over 1500 years, respectively. In the atmosphere, the vapor phase reaction with photochemically produced hydroxyl radicals (half-life of 2 hr) may be an important fate process. However, benzo(g,h,i)perylene is expected to exist almost entirely in the particulate phase in ambient air. Nevertheless, benzo(g,h,i)perylene may undergo direct photolysis in the atmosphere. Photolytic half-lives of benzo(g,h,i)perylene adsorbed onto silica gel, alumina, fly ash and carbon black were 7, 22, 29 and greater than 1000 hours, respectively. The most probable human exposure would be occupational exposure, which may occur through dermal contact or inhalation at places where benzo(g,h,i)perylene is produced as a waste by-product. Atmospheric workplace exposures have been documented. Non-occupational exposures would most likely occur via urban atmospheres, smoked and barbecued foods, contaminated drinking water supplies and recreational activities at contaminated waterways. (SRC)

Synonyms/Substance Identification:

1,12-Benzoperylene [609]
1,12-Benzperylene [609]

Molecular Formula [609]:
C22-H12

Associated Chemicals or Topics (Includes Transformation Products):

See also individual entry:

PAHs as a group
Petroleum, General

Metabolism/Metabolites [609]:

After incubation with liver microsomes from nonpretreated rats, no metabolites were found from benzo(g,h,i)perylene. [Jacob J et al; polynucl aromat hydrocarbons: chem biol eff int symp 4th: 807-17 (1980)].

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):

The benzo(g,h,i)perylene concentration in surface waters of the Atlantic region of Canada is <0.006 ug/L (based on 61 samples taken 1980-81) [754].

Water Concentrations [609]:

It has been identified in ... surface water (0.3-28.5 ng/l); tap water (0.8-7.1 ng/l); rain water (2.3-10.8 ng/l); subterranean water (0.7-6.4 ng/l); /&/ waste water (0.4-2.8 ug/l). [IARC. Monographs on the Evaluation of the Carcinogenic Risk of Chemicals to Man. Geneva: World Health

Organization, International Agency for Research on Cancer,1972-PRESENT. (Multivolume work).,p. V32 196 (1983)].

In an analysis of the USEPA STORET database, benzo(g,h,i)perylene was positively detected in 1.0% of 914 surface water observation stations and 1.5% of 1211 effluent reporting stations. Benzo(g,h,i)perylene /was detected/ at concn of 7.3 ug/g (dry sediment) in the sediment and 2.0 ug/l in the water in an effluent wastewater channel from a coking plant. Levels <90 ug/l in wastewaters from two coal coking plants. /were detected/[USEPA; Health and Environmental Effects Profile for Benzo(g,h,i)perylene p.10 (1987) EPA/600/x-87/395].

DRINKING WATER: Benzo(g,h,i)perylene was listed as a contaminant found in drinking water(1). [(1) Kool HJ et al; Crit Rev Env Control 12: 307-57 (1982)].

SURFACE WATER: Benzo(g,h,i)perylene is listed as a contaminant of Great Lakes Ontario, Erie, Michigan and Superior including Lake St Clair(1). Benzo(g,h,i)perylene had a median concn less than 10 ug/L and tested positive in 1.0% of 914 ambient waters in surface waters from EPA's STORET database(2). Benzo(g,h,i)perylene was detected at 2 of 4 sampling stations along the Mississippi River at an average concn of 7 ng/L(3). [(1) Great Lakes Water Quality Board; Report on Great Lakes Water Quality p 195 (1983) (2) Staples CA et al; Environ Toxicol Chem 4: 131-42 (1985) (3) DeLeon IR et al; Chemosphere 15: 795-805 (1986].

GROUNDWATER: Benzo(g,h,i)perylene was detected in a coal tar contaminated aquifer in St Louis Park, MN(1). Benzo(g,h,i)perylene was listed as a ground water contaminant in the Netherlands(2). [(1) Rostad CE et al; Chemosphere 14: 1023-36 (1985) (2) Zoeteman BCJ et al; Sci Total Environ 21: 187-202 (1981].

RAIN/SNOW: Rain water in Witteveen, de Bilt, Vlissingen and Biest-houtakker, Netherlands contained benzo(g,h,i)perylene at concn up to from 125, 145, 142 and 241 ng/L with average concn of 39, 68, 61 and 55 ng/L, respectively(1). [(1) Den Hollander H et al; Sci Total Environ 52: 211-9 (1986].

Effluents Concentrations [609]:

It has been identified in ... sludge (200-1220 ug/kg) and freeze-dried sewage sludge samples (400-8700 ug/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-PRESENT. (Multivolume work).,p. V32 196 (1983].

Benzo(g,h,i)perylene was detected in 1.5% of 1211 effluent reporting stations. Also levels of <90 ug/l in wastewater and 2.0 ug/l in the water in an effluent wastewater channel from a coking plant /were detected/.[USEPA; Health and Environmental Effects Profile for Benzo(g,h,i)perylene p.10 (1987) EPA/600/x-87/395].

Benzo(g,h,i)perylene was identified as a stack emission and a component of fly and grate ash from municipal waste incinerators(1). A sewage sludge incinerator emitted benzo(g,h,i)perylene to the air at concn ranging from 0.2 to 5.0 ug/cu m(2). Effluent from the Bekkelaget sewage treatment plant benzo(g,h,i)perylene at concn less than 21 and 16 ng/L after dry and rainy days in Nov 1979(3). Benzo(g,h,i)perylene was identified as a component of sewage sludge(8). Benzo(g,h,i)perylene comprised between 9 and 15% of the PAH in municipal sewage sludge(6). Municipal refuse and compost from municipal refuse also contained benzo(g,h,i)perylene(6). The combustion of a diesel fuel containing benzo(g,h,i)perylene at a concn of 26.3 ng/mL emitted benzo(g,h,i)perylene at rates of less than 2.0, 35, 12, 8.3, 20 and 1636 ug/hr(4). Exhaust gas of a light oil and n-decane diesel fuels contained benzo(g,h,i)perylene at concn of 5.6 and 14.9 ug/cu m(5). Gasoline fueled vehicles also emit benzo(g,h,i)perylene(9). Benzo(g,h,i)perylene comprised 0.015% of the particulate matter emitted from traffic in the Caldecott Tunnel east of Berkeley, CA(10). Benzo(g,h,i)perylene was emitted from the combustion of propane(7).[(1) Junk GA, Ford CS; Chemosphere 9: 187-230 (1980) (2) Lao RC et al; pp 813-27 in PAHs Cooke M, Dennis AJ (ed) Battelle Press (1985) (3) Kveseth K et al; Chemosphere 11: 623-639 (1982) (4) Hoekman SK, Ingham MC; Measurement of PAH and Nitro-PAH from a Heavy-duty Diesel Engine, Proc-APCA Annu Meet 1: 1-22 (1987) (5) Hayano S et al: Atmos Environ 19: 1009-15 (1985) (6) Hagenmaier H et al; Int J Environ Anal Chem 23: 331-45 (1986) (7) Eklund G et al; Chemosphere 16: 161-6 (1987) (8) Diercxsens P, Tarradellas J; Intern J Environ Anal Chem 28: 143-59 (1987) (9) Daisey JM et al; J Air Pollut Control

Assoc 36: 17-33 (1986) (10) Hering SV et al; Sci Total Environ 36: 39-45 (1984)].

Both the biotreatment and final effluents of a Class B and E oil refinery contained benzo(g,h,i)perylene at concn of less than 0.2, and less than 1 ug/L, respectively(1). Benzo(g,h,i)perylene was identified as a product of coal combustion(2). The combustion of coal liquids with 3% oxygen emitted benzo(g,h,i)perylene at concn ranging from 6.6 to 46.9 ug/cu m with an average of 23.0 ug/cu m for 20 samples(3). The carbon black combustion product of coal tar contained benzo(g,h,i)perylene at a concn of 7.0 mg/g(4). Coal combustion leaked benzo(g,h,i)perylene to indoor air at a concn of 7.1 ug/cu m(5). The effluent channel form a coking plant contained benzo(g,h,i)perylene in the water and sediments at concn of 2.0 ug/L and 7.3 ug/g, respectively(6). Residential coal and oil burning emit benzo(g,h,i)perylene(7). Coal dust containing benzo(g,h,i)perylene at 3,641 ng/g leached from piles of coal in VA(8). [(1) Snider EH, Manning FS; Environ Int 7: 237-58 (1982) (2) Junk GA et al; ACS Symp Ser 319 (Fossil Fuels Util): 109-23 (1986) (3) Schirmer RM et al; pp 1173-97 in PAHs Cooke M, Dennis AJ (ed) Battelle Press (1985) (4) Nishioka, M et al; Environ Sci Technol 20: 1023-7 (1986) (5) Mumford JL et al; Environ Sci Technol 21: 308-11 (1987) (6) Griest WH; pp 183-83 in Hydrocarbon Halo Hydrocarbon Aquatic Environ Afghan BK, Mackay D (ed) NY NY Pleenum Press p 173-83 (1980) (7) Daisey JM et al; J Air Pollut Control Assoc 36: 17-33 (1986) (8) Bender ME et al; Environ Pollut 44: 243-60 (1987)].

Wastewater from the gaseous diffusion plant operated by Union Carbide at Oak Ridge, TN contained benzo(g,h,i)perylene(1). Emissions from the pouring, cooling and shakeout of aluminum castings contained benzo(g,h,i)perylene at an average concn of 31 ug/kg(2). Benzo(g,h,i)perylene had a median concn less than 10 ug/L and tested positive in 1.5% of 1,211 industrial discharges in waste waters from EPA's STORET database(3). Non-air tight and air tight wood burning stoves emitted benzo(g,h,i)perylene to indoor air at average concn of 105 and 1.5 ng/cu m for 11 and 7 samples, respectively(4). Non-air tight and air tight wood burning stoves emitted benzo(g,h,i)perylene to outdoor air at average concn of 1.73 and 1.11 ng/cu m for 4 and 7 samples, respectively(4). The 1978 Amoco Cadiz oil spill emitted benzo(g,h,i)perylene to the waters and coastal environment of northern France(5). A power plant in Boston, MA emitted benzo(g,h,i)perylene to the ambient air at an estimated concn of 5.2X10-7 ug/cu m(6). Effluents from refineries, petrochemical industry, metallurgic industry and municipal wastewater treatment plants in Norway contained benzo(g,h,i)perylene with a 68% frequency of appearance(7). Domestic fire soot contained benzo(g,h,i)perylene at concn ranging from 1 to 29 ug/cu m with an average of 11 ng/cu m for 12 samples collected at Christchurch, New Zealand(8). [(1) McMahon LW; Organic Priority Pollutants in Wastewater. NTIS DE83010817 Gatinburg, TN p 220-49 (1983) (2) Gressel MG et al; Appl Ind Hyg 3: 11-17 (1988) (3) Staples CA et al; Environ Toxicol Chem 4: 131-42 (1985) (4) Traynor GW et al; Environ Sci Technol 21:691-7 (1987) (5) Berthou F et al; Marine Environ Res 23: 103-33 (1987) (6) Brown HS; JAPCA 38: 15-21 (1988) (7) Sporstoel S et al; Intern J Environ Anal Chem 21: 129-38 (1985) (8) Cretney JR et al; Environ Sci Technol 19: 397-404 (1985).

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 [888,889,911,887; Reprinted with permission from Environmental Toxicology and Chemistry, Volume 6, Newstead, J.L. and J.P. Geisy. Predictive models for photoinduced acute toxicity of polycyclic aromatic hydrocarbons to Daphnia magna. Copyright 1987 SETAC]. 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:

EPA 1996 National Ambient Water Quality Criteria for Aquatic Organisims [893]:

Freshwater Acute Criteria: None Published

Freshwater Chronic Criteria: None Published

Marine Acute Criteria: Marine: 3.0E+2 ug/L LEC.

Marine Chronic Criteria: None Published

Reference: 45 FR 79318 (11/28/80)

Contact: Criteria and Standards Division / OWRS / (202)260-1315

Discussion: The values that are indicated as "LEC" are not criteria, but are the lowest effect levels found in the literature. LEC's are given when the minimum data required to derive water quality criteria are not available. The values given represent polynuclear aromatic hydrocarbons as a class.

W.Plants (Water Concentrations vs. Plants):

No information found.

W.Invertebrates (Water Concentrations vs. Invertebrates):

No information found.

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 National Water Quality Criteria [893]:

Human Health 10-6 (1E-06) Risk Level for Carcinogens), Ambient Water Quality Criteria for Human Health:

Water & Fish: 2.8E-3 ug/liter. The 1996 criteria for Water & Fish routes of exposure: 2.8E-3 ug/liter [893].

Previous criteria for Water and Organisms was the same: 0.0028 ug/L [446,689,928].

The 1996 criteria for fish consumption route of exposure only: 3.11E-2 ug/liter [893].

Previous IRIS Recalculated (9/90) Criteria for Organisms Only: 0.0311 ug/L [446,689,928].

Drinking Water MCL:

None Published, however, 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 [893].

Reference: 45 FR 79318 (11/28/80)

Contact: Criteria and Standards Division / OWRS / (202)260-1315

NOTE: 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].

The warm water- and cold water sport fish community human cancer criteria for benzo(g,h,i)perylene 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 benzo(g,h,i)perylene 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: 0.0001 ug/L

Full body contact: 0.12 ug/L

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

This is a phototoxic PAH [891, 887; Reprinted with permission from Environmental Toxicology and Chemistry, Volume 6, Newstead, J.L. and J.P. Geisy. Predictive models for photoinduced acute toxicity of polycyclic aromatic hydrocarbons to Daphnia magna. Copyright 1987 SETAC].

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):

Benzo(g,h,i)perylene was detected in 75.3 % of urban-bay samples from the Puget Sound area. The mean concentration was 792 ug/kg dry weight (ppb), while the median concentration was 160 ug/kg (ppb) [852].

Benzo(g,h,i)perylene was detected in 43.7 % of non-urban-bay samples from the Puget Sound area. The mean concentration was 1913 ug/kg dry weight (ppb), while the median concentration was 114 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.

Sediment Concentrations [609]:

Polynuclear aromatic hydrocarbons (PAH) including benzo(g,h,i)perylene were identified and determined in sediments from Tokyo bay. Their concentrations were in a range from several tens to several hundred u/kg of dry samples. This seems to suggest that the smaller the average particle sizes of sediments, the higher the total amounts of pah concentrations. Statistically significant positive correlations were observed between the following pairs: total amount of pah versus clay content; total amount of pah versus the sum of (clay + silt) contents; total amount of pah versus ignition loss. [Matsushima H; Agric biol chem 46 (6): 1489-94 (1982)].

It has been identified in ... dried sediments from lakes (1-1930 ug/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-PRESENT. (Multivolume work).,p. V32 196 (1983].

Sediment from the Duwamish River delta, WA contained benzo(g,h,i)perylene at an average concn of 620 ng/g(1). Sediments from three sites in Eagle Harbor and one at President Point, WA contained benzo(g,h,i)perylene at an average concn of 580, 740, 170 and less than 23 ng/g for 4, 9, 2 and 1 sample(s) respectively(2). Benzo(g,h,i)perylene was also detected in sediments from the Elizabeth River, VA(3,4) and the Black River, OH(5). Four of 5 sediment samples from along the "Golfe de Gascogne", France contained benzo(g,h,i)perylene at concn of 1, 72, 400 and 1969 ng/g(6). Benzo(g,h,i)perylene had a median concn less than 500.0 ug/kg and tested positive in 8.0% of 343 sediments in ambient waters from EPA's STORET database(7). [(1) Varanasi U et al; Environ Sci Technol 4: 721-6 (1985) (2) Malins DC et al; Carcinogenesis 6: 1463-9 (1985) (3) Merrill EG, Wade TL; Eviron Sci Technol 19: 597-603 (1985) (4) Bieri R et al; Intern J Environ Anal Chem 26: 97-113 (1986) (5) West WR et al; Environ Sci Technol 22: 224-8 (1988) (6) Garrigues P et al; Intern J Environ Anal Chem 28: 121-131 (1987) (7) Staples CA et al; Environ Toxicol Chem 4: 131-42 (1985)].

Sediments off the coast of northern France contained benzo(g,h,i)perylene 7 years after the Amoco Cadiz oil spill of 1978(1). Benzo(g,h,i)perylene was detected in the sediments of 5 small lakes in Southern Finland(2). Litter under a coniferous forest in Stenungsund, Sweden contained benzo(g,h,i)perylene at concn ranging from 41 to 43 ng/g with an average concn of 42 ng/g(3). Sediments form Lake Ontario's Hamilton Harbor at Toronto, Canada contained benzo(g,h,i)perylene at concn ranging from 1.6 to 8.6 ug/g(4). Sediments from Saguenay Fjord, Canada also contained benzo(g,h,i)perylene(5). Sediments from the Black and Cuyahoga Rivers, OH, and Menominee River, WI contained benzo(g,h,i)perylene at average concn of 5.40, 1.10 and 0.20 ug/g, respectively(6). Benzo(g,h,i)perylene was detected in Black and Buffalo River sediments at average concn of 3448 and 1155 ng/g, respectively(7). Benzo(g,h,i)perylene was contained to sediments off the Great Barrier Reef, Australia at concn up to 2.6 ug/kg(8). [(1) Berthou F et al; Marine Environ Res 23: 103-33 (1987) (2) Wickstrom K, Tolonen K; Water Air Soil Pollut 32: 155-75 (1987) (3) Thomas W et al; Environ Pollut 36: 295-310 (1984) (4) Poulton DJ; J Great Lakes Res 13: 193-202 (1987) (5) Martel L: Bull Environ Contam Toxicol 37: 133-40 (1986) (6) Fabacher DL et al; Environ Toxicol Chem 7: 529-43 (1988) (7) Black J et al; Chap 33 in Chem Environ Impact Health Eff Proc Conf 5: 415-27 (1985) (8) Baag J, Smith JD; Preprint in: ACS Natl Meet 28: 328-30 (1988)].

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: The apparent effects threshold concentrations for benzo(g,h,i)perylene in sediments proposed for Puget Sound ranged from 0.67 mg/kg dry weight (microtox) to 2.6 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).

Ontario Ministry of the Environment Freshwater Sediment Guidelines, 1993 [761]. Lowest effect level: 170 ug/kg dry weight. Severe effect level: 320 mg/kg organic carbon.

St. Lawrence River Interim Freshwater Sediment Criteria, 1992 [761]. No effect level: 100 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):

PAHs are ubiquitous in soil and are distributed globally. One study found benzo(g,h,i)perylene and fluoranthene at concentrations above 150 ug/kg in arctic soils [788].

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):

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:

See also Tis.Fish, C), below.

Details of benzo(g,h,i)perylene 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):

benzo(g,h,i)perylene: 7.41 ug/kg = ppb

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].

The benzo(g,h,i)perylene concentration in mosquitofish with extremely elevated total PAH concentrations (60.79 mg/kg) was 8.1 mg/kg [201].

Fish/Seafood Concentrations [609]:

Two year old brown bullhead from the Black River in Ohio had a liver tumor rate of 1.2% Whereas those 3 years or older had a 33% rate. None of the brown bullhead from buckeye lake in ohio had visually observable hepatomas. A wide range of polycyclic aromatic hydrocarbons (pah) including benzo(g,h,i)perylene and other organics were present in black river bullheads, whereas those from buckeye lake had a much lower contaminant burden. Amounts of individual compounds were generally higher in black river fish. Black river coke plant sediment had concentrations of pah, based on dry weight, ranging from 4800 ppb coronene to 390,000 ppb phenanthrene. [Baumann PC et al; polynucl aromat hydrocarbons: phys biol chem, int symp 6th: 93-102 (1982].

The level of benzo(g,h,i)perylene in the same digestive gland oil of lobsters was 227.8 and 382.0 ng/g according to 2 different laboratories(1). Bullhead, catfish from the Black River, OH and striped bass from the Potomac River, MD contained benzo(g,h,i)perylene(2). Coral rock oysters (Saccostrea cucculata) collected in Sept 1982 from six locations at Mermaid Sound in NW Australia contained benzo(g,h,i)perylene at concn ranging from less than 0.1 to 5 ppb with a 60% frequency of occurrence(3). Fish samples from the Great Lakes harbors and tributary mouths contained benzo(g,h,i)perylene(4). Benzo(g,h,i)perylene was detected in mussels (Mytilus galloprovincialis) from the Thermaikos Gulf, Greece(5) and the Finnish Archipelago Sea(6). Benzo(g,h,i)perylene had a median concn less than 2.5 mg/kg and tested positive in 0.8% of 123 biota of ambient waters form EPA's STORET Database(7). [(1) Uthe JF, Musial CJ; J Assoc Off Anal Chem 71: 363-8 (1988) (2) Vassilaros, DL et al; Anal Chem 54: 106-12 (1982) (3) Kagi R et al; Intern J Environ Anal Chem 22: 135-53 (1985) (4) Camanzo J et al; J Great Lakes Res 13(3): 296-309 (1987) (5) Iosifidou HG et al; Bull Environ Contam Toxicol 28: 535-41 (1982) (6) Rainio K et al; Bull Environ Contam Toxicol 37: 337-43 (1986) (7) Staples CA et al; Environ Toxicol Chem 4: 131-42 (1985].

Oysters off the coast of northern France contained benzo(g,h,i)perylene 7 years after the Amoco Cadiz oil spill of 1978(1). Oysters off the coast of VA contained benzo(g,h,i)perylene from coal dust(2). Three samples of mussel, 1 sample of oyster, 1 corb shell and 3 samples of shortnecked clam from Prefecture, Japan contained benzo(g,h,i)perylene at concn of 0.83, 2.28, 1.44, 0.87, 0.95, 0.53, 1.13 and 1.89 ppb(3). Oysters from 3 marinas on the South Carolina coast also contained benzo(g,h,i)perylene(4). The stomach contents of 11, 6 and 5 white sucker fish from Smokes Creek, Eighteen Mile

Creek and Cresent Beach, Lake Erie contained benzo(g,h,i)perylene at average concn of 14.07, 2.04 and 2.68 ng/g(5). [(1) Berthou F et al; Marine Environ Res 23: 103-33 (1987) (2) Bender ME et al; Environ Pollut 44: 243-60 (1987) (3) Takatsuki K et al; J Assoc Off Anal Chem 68: 945-9 (1985) (4) Marcus JM, Stokes; Bull Environ Contam Toxicol 35: 835-44 (1985) (5) Maccubbin AE et al; Bull Environ Contam Toxicol 34: 876-82 (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):

No information found.

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.Fish, C), above.

Food Survey Results [609]:

The quantity of polycyclic aromatic hydrocarbons in hungarian foods and other consumables were measured in more than 300 samples. In more than 60% of the samples, pah compounds including benzo(g,h,i)perylene were detectable. [SO:OS K; Arch Toxicol (suppl) 4: 446-8 (1980].

... Total-diet samples of food groups in England /were examined/ and found the following mean benzo(g,h,i)perylene concentrations /were found/ (in ug/kg) in the various food groups: cereal (0.28), meat (0.06), vegetables (0.06-0.08), beverages (0.01) and milk (0.01). Total benzo(g,h,i)perylene dietary load in England /was estimated/ to be 0.21 ug/person/day. Based on monitoring of total diet samples collected in the Netherlands, ... estimated the maximum food intake to be 0.9 ug/person/day. [Dennis MJ et al; Food Chem Toxicol 21: 569-74 (1983) as cited in USEPA; Health and Environmental Effects Profile for Benzo(g,h,i)perylene p.14 (1987) EPA/600/x-87/395].

The following benzo(g,h,i)perylene concentrations (in ppb) have been reported for various foods: corn oil (0.6), sunflower oil (4.0), soybean oil (1.0), olive oil(0.9), peanut oil (0.9), smoked herring (2.4), smoked cod (2.2), smoked mackerel (0.2-0.3), charcoal broiled steaks (6.7), barbecued ribs (4.7), smoked ham (1.4), barbecued beef (4.3), smoked bologna (0.04-0.20), smoked mortadella (0.4), heavily smoked bacon (3.0), charcoal-broiled hamburger (trace-14.9), broiled T-bone steak (6.2-12.4) and heavily smoked ham (2.5-25.0). [Santodonato JP et al; Pathotox Publishers Inc, Park Forest South, IL (1981) as cited in USEPA; Health and Environmental Effects Profile for Benzo(g,h,i)perylene p.14 (1987) EPA/600/x-87/395].

Nineteen of 23 samples of margarines, butter and vegetable oils contained benzo(g,h,i)perylene at concn ranging from 0.02 to 2.4 ug/kg with an average of 0.59 ug/kg(1). Composite fish samples from the Great Lakes harbors and tributary mouths contained benzo(g,h,i)perylene(2). Smoked fish including dried herring, whitefish and Kippered cod showed benzo(g,h,i)perylene at concn of 1.0, 2.4 and 2.2 ppb, respectively(3). Japanese horse mackerel contained benzo(g,h,i)perylene for 3 different methods of preparation at concn of 2-10, 2 and 1 ppb(3). Broiled steaks, smoked ham and barbecued ribs and beef contained benzo(g,h,i)perylene at concn of 6.7, 1.2, 4.7 and 4.3 ppb, respectively(3). Smoked sausage and cooked bologna contained benzo(g,h,i)perylene at concn raging from 0.25 to 0.50 and 0.04 to 0.20 ppb, respectively(3). Coffee soots contained benzo(g,h,i)perylene at concn ranging from 100 to 140 ppb(3). Smoked cod liver oil, halibut liver oil and coconut oil each contained benzo(g,h,i)perylene at a concn of 20 ppb(3). The minimum and maximum benzo(g,h,i)perylene concn in lettuce grown 8, 15, 25, 35, 45 and 65 m from a major highway were 1.7, 2.7; 1.1, 1.6; 0.9, 1.3; 0.9, 1.3; 0.8, 1.3; and 0.7, 1.0; ug/kg, respectively(4). [(1) Hopia A et al; JAOCS 63: 889-93 (1986) (2) DeVault DS; Arch Environ Contam Toxicol 14: 587-94 (1985) (3) Lo M, Sandi E; Res Rev 69: 35-86 (1978) (4) Larsson BK; J Sci Food Agric 36: 463-70 (1985].

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):

No information found. IRIS 1996 contains no RfD or slope factor information [893].

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

Polycyclic aromatic hydrocarbons were detected in human fat and liver and their average concentrations were 1100 and 380 ppt (undefined), respectively. Benzo(g,h,i)perylene levels in liver were lower than those in fats. [Obana H et al; Bull environ contam toxicol 27 (1): 23-7 (1981) [609].

An analytical procedure is described which includes extraction of polycyclic aromatic hydrocarbons (pah), including benzo(g,h,i)perylene, and polycyclic aromatic hydrocarbons metabolites from urine, reduction of metabolites to the original polycyclic aromatic hydrocarbons and subsequent analysis by HPLC. The mean value of the sum of the 11 polycyclic aromatic hydrocarbons in non smoker's urine was 1.1 ug/mmol creatinine. The sum of polycyclic aromatic hdrocarbons in smoker's urine was significantly higher. Increased levels of pah were found in the urine of aluminum reduction workers. (Becher G, Bjorseth A; Cancer Lett 17 (3): 301-11 (1983) [609].

Tis.Misc. (Other Tissue Information):

This is a phototoxic PAH [891,887; Reprinted with permission from Environmental Toxicology and Chemistry, Volume 6, Newstead, J.L. and J.P. Geisy. Predictive models for photoinduced acute toxicity of polycyclic aromatic hydrocarbons to Daphnia magna. Copyright 1987 SETAC].

From HSDB [609]:

> Benzo(g,h,i)perylene was found in blood serum and skin oil collected from roofing workers. [Wolff MS et al; chemosphere 11 (6): 595-600 1982). Workers are exposed to polynuclear aromatic hydrocarbons (incl benzo(g,h,i)perylene) during roofing and paving operations. [Malaiyandi M et al; polynucl aromat hydrocarbons: Phys Biol Chem, int symp 6th: 471-89 (1982].

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) were 5.54 for microorganisms in water, and 4.45 for Daphnia magna [848]:

Bioconcentration [609]:

> Based on a water solubility of 2.6X10-4 mg/L at 25 deg C(1) and an estimated log Kow of 6.58(2), the log BCF of benzo(g,h,i)perylene has been calculated to range from 4.44 to 4.77 from various regression-derived equations(3,SRC). These log BCF values suggest benzo(g,h,i)perylene has the potential to bioconcentrate in aquatic systems(SRC). [(1) Mackay D, Shiu WY; J Chem Eng Data 22: 399-402 (1977) (2) CLOGP; PCGEMS Graphical Exposure Modeling System USEPA (1986) (3) Lyman WJ et al; Handbook of Chemical Property Estimation Methods NY:McGraw-Hill p. 5-4, 5-10 (1982)].

Interactions:

Information from HSDB [609]:

> In tests for cocarcinogenic activity, benzo(a)pyrene was tested as the carcinogen at 5 ug applied simultaneously in the same solution with the cocarcinogen benzo(g,h,i)perylene (0.007 or 0.021 mg/dose) 3 times weekly in 0.1 mL acetone to groups of 50 female ICR/HU mice. Lower dose group had first papilloma in 238 days,

with papillomas in 19 mice and squamous carcinomas in 10 mice; the higher dose group had first papilloma in 222 days, with papillomas in 20 mice and squamous carcinomas in 18 mice. No effects were observed in benzo(g,h,i)perylene admin at 0.021 mg/dose without benzo(a)perylene. /From table/ [Searle, C. E. (ed.). Chemical Carcinogens. ACS Monograph 173. Washington, DC: American Chemical Society, 1976. 35].

12-O-Tetradecanoylphorbol 13-Acetate (TPA), a known tumor promoter, enhances the morphologic transformation of syrian hamster embryo cells induced by low transforming concentrations of benzo(g,h,i)perylene. [Popescu NC et al; Proc natl acad sci usa 77 (12): 7282-6 (1980)].

Uses/Sources:

See also Chem.detail section below for benzo(g,h,i)perylene concentrations in various petroleum products.

Major Uses [609]:

Small amounts are used for scientific research. [USEPA; Health and Environmental Effects Profile for Benzo(g,h,i)perylene; p.2 (1987) EPA/600/x-87/395.

U.S. Production [609]:

There is no commercial production or known use of this cmpd. [IARC. Monographs on the Evaluation of the Carcinogenic Risk of Chemicals to Man. Geneva: World Health Organization, International Agency for Research on Cancer,1972-PRESENT. (Multivolume work).,p. V32 196 (1983].

Natural Sources [609]:

Benzo(g,h,i)perylene is a natural component of crude oil(1) and coal tar(2). Benzo(g,h,i)perylene is also a product of combustion and can be released to the environment via natural fires associated with lightening, volcanic activity, and spontaneous combustion(SRC). [(1) Elliott JJ, Melchior MT; Kirk-Othmer Encycl Chem Tech 3rd NY,NY: Wiley 17: 119-31 (1982) (2) Gaydos RM; Kirk-Othmer Chem Tech 3rd NY,NY: Wiley 15: 698-719 (1981].

Artificial Sources [609]:

Benzo(g,h,i)perylene is a constituent of crude petroleum, motor and machine oils, marine sediments, typewriter ribbons, asphalt fumes.

Emission of polycyclic aromatic hydrocarbons from residential wood-fired stoves and fireplaces. [Peters JA et al; Chem anal and biol fate: polynucl aromat hydrocarbons int symp, 5TH: 571-81 (1981)].

Benzo(g,h,i)perylene occurs ubiquitously in products of incomplete combustion; it also occurs in considerable amounts in coal-tar and is an important component of gasoline engine exhaust. ... It has been identified in ... exhaust emissions from gasoline engines (115-333 ug/l fuel); /& in/ emissions from the burning of various types of coal ... [IARC. Monographs on the Evaluation of the Carcinogenic Risk of Chemicals to Man. Geneva: World Health Organization, International Agency for Research on Cancer,1972-PRESENT. (Multivolume work).,p. V32 196 (1983)].

Benzo(g,h,i)perylene may be emitted to the environment by effluents from petroleum refining and coal tar distillation(1-2). The combustion of wood(11) coal(3), oil(4), propane(5), gasoline(6,7) and diesel fuels(7,8) can release benzo(g,h,i)perylene to the atmosphere. Benzo(g,h,i)perylene is not commercially produced in the US(9); however, benzo(g,h,i)perylene may be released to the environment through industrial effluents(10), municipal waste water treatment facilities(12-15) and waste incinerators(16). [(1) Gaydos RM; Kirk-Othmer Encycl Chem Tech 3rd NY,NY: Wiley 15: 698-719 (1981) (2) Snider EH, Manning FS; Environ Int 7: 237-58 (1982) (3) Junk GA et al; ACS Symp Ser 319 (Fossil Fuels Util): 109-23 (1986) (4) Hayano S et al: Atmos Environ 19: 1009-15 (1985) (5) Eklund G et al; Chemosphere 16: 161-6 (1987) (6) Daisey JM et al; J Air Pollut Control Assoc 36: 17-33 (1986) (7) Hering SV et al; Sci Totol Environ 36: 39-45 (1984) (8) Hoekman SK, Ingham MC; Measurement of PAH and Nitro-PAH from a Heavy-duty Diesel Engine, Proc-APCA Annu Meet 1: 1-22 (1987) (9) IARC; Some Polyaromatic Compounds Part I 32: 196-204 (1972) (10) Staples CA et al; Environ Toxicol Chem 4: 131-42 (1985) (11) Traynor GW et al; Environ Sci Technol 21:691-7 (1987) (12) Lao RC et al; pp 813-27 in PAHs Cooke M, Dennis AJ (ed) Battelle Press (1985) (13) Kveseth K et al; Chemosphere 11: 623-639 (1982) (14) Hagenmaier, H et al; Int J Environ Anal Chem 23: 331-45 (1986) (15) Diercxsens P, Tarradellas J; Intern J Environ Anal Chem 28: 143-59 (1987) (16) Junk GA, Ford CS; Chemosphere 9: 187-230 (1980)].

Benzo(g,h,i)perylene in fresh motor-oil, 0.12 mg/kg; in used motor oil after 5000 km, 108.8-207.6 mg/kg; in used motor oil after 1000 km, 153.0-289.4 mg/kg; in Kuwait crude oil, less than 1 ppm; in South Louisiana crude oil, less than 1.6 ppm; in bitumen, 1.37-5.50 ppm; in low octane number gasoline, 0.32-1.24 mg/kg (N= 13); in high octane number gasoline, 0.42-9 mg/kg (n= 15); emission from space heating installation, 0.3-4.5 mg per million

Btu input (Verschueren, K. Handbook of Environmental Data of Organic Chemicals. 2nd ed. New York, NY: Van Nostrand Reinhold Co., 1983. 260) [609].

Grimmer et al. reported concentrations of dibenz(a,c)-anthracene, 4-methylpyrene, fluoranthene, benz(a)anthracene, benzo(e)pyrene, benzo(g,h,i)perylene, and benzo(a)pyrene, respectively, 36, 49, 253, 720, 1,112, 4,770, and 7,226 times higher in "used" compared to "fresh" oil [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].

Forms/Preparations/Formulations:

No information found.

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

Solubilities:

0.00022 to 0.00083 mg/L at 25 degrees C (most values near 0.00026 mg/L) [848].

0.00026 + or - 0.00001 MG/L AT 25 DEG C IN WATER [MACKAY D, SHIN WY; J CHEM ENG DATA 22: 399 (1977)] [609].

Insoluble (sic, actually they mean "relatively insoluble) in water. [Pearlman RS et al; J Phys Chem Ref Data 13: 555-562 (1984) as cited in USEPA; Health and Environmental Effects Profile for Benzo(g,h,i)perylene; p.1 (1987) EPA/600/x-87/395] [609].

Sol in 1,4-dioxane, dichloromethane, benzene, & acetone [IARC. Monographs on the Evaluation of the Carcinogenic Risk of Chemicals to Man. Geneva: World Health Organization, International Agency for Research on Cancer,1972-PRESENT. (Multivolume work).,p. V32 196 (1983)] [609].

Vapor Pressure:

1.38x10(-8) Pa at 25 degrees C [848].

1.0x10(-10) mm Hg at 25 deg C [(2) Murray JJ et al; Can J Chem 52: 557-63 (1974)] [609].

Henry's Law Constant [848]:

0.001 to 0.709 Pa m(3)/mol (most values near 0.015 Pa m(3)/mol).

Molecular Weight [609]:

276.34 [IARC. Monographs on the Evaluation of the Carcinogenic Risk of Chemicals to Man. Geneva: World Health Organization, International Agency for Research on Cancer,1972-PRESENT. (Multivolume work).,p. V32 195 (1983)].

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

6.25 to 7.60 (most values near 7.10).

Sorption Partition Coefficient, log Koc [848]:

6.20, 6.26

Boiling Point [609]:

550 DEG C AT 760 MM HG [MACKAY D, SHIN WY; J CHEM ENG DATA 22: 399 (1977)].

Melting Point [609]:

277 DEG C [YALKOWSKY SH, VALVANI SC; J CHEM ENG DATA 24: 127 (1979)].

Color/Form [609]:

Large, pale yellow-green plates (recrystallized from xylene) [IARC. Monographs on the Evaluation of the Carcinogenic Risk of Chemicals to Man. Geneva: World Health Organization, International Agency for Research on Cancer,1972-PRESENT. (Multivolume work).,p. V32 195 (1983)].

Benzo(g,h,i)perylene concentrations were determined for three different crude oil sample types taken from the Exxon Valdez oil spill. Concentrations in 1) unweathered oil from the tanker itself (March 1989), 2) oil skimmed from the water immediately after the spill and held in the skimmer barge for about 90 days (July 1989), and 3) weathered oil from Prince William Sound shorelines (May 1989) were: ND (not detected), ND, and 1 ug/g oil sampled, respectively [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].

Benzo(g,h,i)perylene content (mg/kg or ppm) in one fresh sample of Exxon Valdez Crude Oil [971]: 2 mg/kg = ppm

Benzo(g,h,i)perylene content in one fresh sample of NSFO (Fuel Oil 5, Chuck Rafkind, National Park Service, Personal Communication, 1996): 11.4 ng/mg (ppm).

Benzo(g,h,i)perylene 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): 421.4 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).

Benzo(g,h,i)perylene concentration in Used Engine Oil: 72.0 ppm [519; Reprinted with permission from Envionmental 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]; and 334 mg/kg [847].

Benzo(g,h,i)perylene concentrations in gasolines have been found to range from 0.32 to 2.66 mg/kg [847].

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

Half-lives in surface water ranged from 14,160 to 15,600 hours (based on aerobic soil dieaway test data at 10-30 degrees C) [848].

Half-lives in groundwater ranged from 28,320 to 31,200 hours (based on aerobic soil dieaway test data at 10-30 degrees C) [848].

Half-lives in soil [848]: range from 14,160 to 15,600 hours (based on aerobic soil dieaway test data); >50 days; and a mean of 9.1 years for Luddington soil.

Anaerobic biodegradation half-lives ranged from 56,640 to 62,400 hours (based on aerobic soil dieaway test data at 10-30 degrees C) [848].

Environmental Fate [609]:

> Occurrence and potential uptake of polynuclear aromatics (including benzo(g,h,i)perylene) of highway traffic origin by proximally grown food crops are discussed. [Wang DT, Meresz O; polynucl aromat hydrocarbons: phys biol chem int symp 6th: 885-96 (1982).
>
> TERRESTRIAL FATE: In the atmosphere, adsorption to stabilizing substrates will allow benzo(g,h,i)perylene to be transported over long distances in the atmospheric aerosol. Its detection in the remote rural air of South Carolina and in sediments from remote lakes in the Adirondack Forest, NY may indicate that long-range transport occurs. Removal of adsorbed benzo(g,h,i)perylene from the atmosphere may occur by wet and dry deposition. Its presence in lake sediments in the Adirondack Forest, NY, has been attributed to physical deposition. [USEPA; Health and Environmental Effects Profile for Benzo(g,h,i)perylene p.7 (1987) EPA/600/x-87/395].

ATMOSPHERIC FATE: If released to the atmosphere, benzo(g,h,i)perylene will exist almost entirely in the particulate (adsorbed) phase. The rate of photolysis has been found to vary with the adsorbing substrate; photolysis of benzo(g,h,i)perylene adsorbed to fly ash may have some importance, but adsorption to carbon black stabilizes the compound toward potential phototransformation. [Beymer TD, RA Hites; Environ Sci Technol 19: 1004-6 (1985) as cited in USEPA; Health and Environmental Effects Profile for Benzo(g,h,i)perylene p.VI (1987) EPA/600/x-87/395].

TERRESTRIAL FATE: The reported biodegradation half-lives for benzo(g,h,i)perylene in aerobic soil range from 600 to 650 days(1). Benzo(g,h,i)perylene is not expected to undergo hydrolysis in soils; yet, should undergo direct photolysis on sunlit surface soils. Photolytic half-lives of benzo(g,h,i)perylene adsorbed onto silica gel, alumina, fly ash and carbon black were 7, 22, 29 and greater than 1000 hours, respectively(2). A calculated Koc range of 9X10+4 to 4X10+5(3), indicates benzo(g,h,i)perylene will be highly immobile in soil(4). [(1) Coover MP, Sims RC; Haz Waste Haz Mat 4: 69-82 (1987) (2) Behymer TD, Hites RA; Environ Sci Technol 19: 1004-6 (1985) (3) Lyman WJ et al; Handbook of Chemical Property Estimation Methods NY:McGraw-Hill p. 4-9 (1982) (4) Swann RL et al; Res Rev 85: 16-28 (1983).

AQUATIC FATE: Aerobic aqueous screening test data and soil grab sample data suggest the biodegradation of benzo(g,h,i)perylene in aquatic systems will be slow. Benzo(g,h,i)perylene is not expected to undergo hydrolysis in environmental waters. However, benzo(g,h,i)perylene may undergo direct photolysis in sunlit waters(1). Monitoring data and an estimated Koc ranging in the highly immobile class for soil(2), suggests benzo(g,h,i)perylene will partition from the water column to organic matter contained in sediments and suspended solids. Benzo(g,h,i)perylene also has the potential to bioconcentrate in aquatic systems. A Henry's Law constant of 1.6X10-6 atm-cu m/mole at 25 deg C(SRC) suggests volatilization of benzo(g,h,i)perylene from shallow, fast moving environmental waters may be important(3). Based on this Henry's Law constant, the volatilization half-life from a model river has been estimated to be 38 days(3,SRC). The volatilization half-life from a model pond, which considers the effect of adsorption, has been estimated to be over 1500 years(4,SRC). [(1) Behymer TD, Hites RA; Environ Sci Technol 19: 1004-6 (1985) (2) Swann RL et al; Res Rev 85: 16-28 (1983) (3) Lyman WJ et al; Handbook of Chemical Property Estimation Methods NY:McGraw-Hill p. 15-15 to 15-29 (1982) (4) USEPA; EXAMS II Computer Simulation (1987].

ATMOSPHERIC FATE: If released to the atmosphere as a gas, the vapor phase reaction of benzo(g,h,i)perylene with photochemically produced hydroxyl radicals is likely to be an important fate process. The rate constant for the vapor-phase reaction of benzo(g,h,i)perylene with photochemically produced hydroxyl radicals has been estimated to be 2.0X10-10 cu cm/molecule-sec at 25 deg C; which corresponds to an atmospheric half-life of about 2 hours at an atmospheric concn of 5X10+5 hydroxyl radicals per cu cm(1). However, based upon a vapor pressure of 1.0X10-10 mm Hg at 25 deg C(2), benzo(g,h,i)perylene is expected to exist almost entirely in the particulate phase in ambient air(3). Nevertheless, benzo(g,h,i)perylene may undergo direct photolysis in the atmosphere. Photolytic half-lives of benzo(g,h,i)perylene adsorbed onto silica gel, alumina, fly ash and carbon black were 7, 22, 29 and greater than 1000 hours, respectively(4). [(1) Atkinson R; Intern J Chem Kin 19: 799-828 (1987) (2) Murray JJ et al; Can J Chem 52: 557-63 (1974) (3) Eisenreich SJ et al; Environ Sci Technol 15: 30-8 (1981) (4) Behymer TD, Hites RA; Environ Sci Technol 19: 1004-6 (1985)].

Biodegradation [609]:

The soil bacterium Bacillus megaterium has been found to metabolize benzo(g,h,i)perylene and other PAH, however, sufficient data are not available to predict the significance of the soil biodegradation for benzo(g,h,i)perylene. ... Benzo(g,h,i)perylene may be slowly biodegraded in soil under aerobic conditions. [USEPA; Health and Environmental Effects Profile for Benzo(g,h,i)perylene p.7 (1987) EPA/600/x-87/395].

If released to the atmosphere, benzo(g,h,i)perylene may be susceptible to slow biodegradation under aerobic conditions. Under most conditions, it is not expected to leach or volatilize from soils. [USEPA; Health and Environmental Effects Profile for Benzo(g,h,i)perylene p.VI (1987) EPA/600/x-87/395].

Within 7 days, an aerobic aqueous screening test inoculated with sewage showed a 60% loss of 1 ppm benzo(g,h,i)perylene; after 3 successive incubation periods where suspensions were prepared using seed from the previous week(1). Eighty-one and 76% of an initial concn of 9.96 ug/g benzo(g,h,i)perylene remained after 240 days in an unacclimated agricultural sandy loam soil incubated at 10 and 20 deg C, respectively(2). Corresponding half-lives were estimated to be about 650 and 600 days(2). After 1,280 days, 78.3% of an initial concn of benzo(g,h,i)perylene at 3.1 ug/g remained in a soil treated with oil sludge at a concn of 17.0 ug/g(3). [(1) Fochtman EG; Biodegradation and Carbon Adsorption of

Carcinogenic and Hazardous Organic Compounds USEPA-600/S2-81-032 Cincinn OH p 38 (1981) (2) Coover MP, Sims RC; Haz Waste Haz Mat 4: 69-82 (1987) (3) Bossert ID et al; Applied Environ Microbial 47: 763-7 (1984)].

Abiotic Degradation [609]:

Polycyclic aromatic hydrocarbons are generally resistant to hydrolysis(1). Therefore, benzo(g,h,i)perylene probably will not undergo hydrolysis in the environment. Photolytic half-lives of benzo(g,h,i)perylene adsorbed onto silica gel, alumina, fly ash and carbon black were 7, 22, 29 and greater than 1000 hours, respectively; when placed in a pyrex photoreactor and exposed to a 450 W medium pressure mercury lamp, which had an irradiance of 17.6 +/- 1.4 W/sq m between the spectral region of 300 to 410 nm(2). The rate constant for the vapor-phase reaction of benzo(g,h,i)perylene with photochemically produced hydroxyl radicals has been estimated to be 2.0X10-10 cu cm/molecule-sec at 25 deg C; which corresponds to an atmospheric half-life of about 2 hours at an atmospheric concn of 5X10+5 hydroxyl radicals per cu cm(3). [(1) Lyman WJ et al; Handbook of Chemical Property Estimation Methods NY: McGraw-Hill p. 7-4 (1982) (2) Behymer TD, Hites RA; Environ Sci Technol 19: 1004-6 (1985) (3) Atkinson R; Intern J Chem Kin 19: 799-828 (1987)].

Soil Adsorption/Mobility [609]:

The estimated Koc values, which are >1 million, and the widespread detection of benzo(g,h,i)perylene in various USA sediments indicate that adsorption to suspended particulate matter and sediments is an important environmental process. Movement by sediment sorbed benzo(g,h,i)perylene is probably an important transport process for this compound. [USEPA; Health and Environmental Effects Profile for Benzo(g,h,i)perylene p.5 (1987) EPA/600/x-87/395].

Based on a water solubility of 2.6x10(-4) mg/L at 25 deg C(1) and an estimated log Kow of 6.58(2), the Koc of benzo(g,h,i)perylene has been calculated to range from 9x10(+4) to 4x10(+5) from various regression-derived equations(4,SRC). These Koc values indicate benzo(g,h,i)perylene will be highly immobile in soil(4). [(1) Mackay D, Shiu WY; J Chem Eng Data 22: 399-402 (1977) (2) CLOGP; PCGEMS Graphical Exposure Modeling System USEPA (1986) (3) Lyman WJ et al; Handbook of Chemical Property Estimation Methods NY:McGraw-Hill p. 4-9 (1982) (4) Swann RL et al; Res Rev 85: 16-28 (1983).

Volatilization from Water/Soil [609]:

Based upon a water solubility of 2.6X10-4 mg/L at 25 deg C(1) and a vapor pressure of 1.0X10-10 mm Hg at 25 deg C(2), a Henry's Law constant of 1.6X10-6 atm-cu m/mole has been calculated(SRC). This value indicates volatilization of benzo(g,h,i)perylene from shallow, fast moving environmental waters may be important(3). The volatilization half-life from a model river (1 meter deep flowing 1 m/sec with a wind speed of 3 m/sec) has been estimated to be 38 days(3,SRC). The volatilization half-life from a model pond, which considers the effect of adsorption, has been estimated to be over 1500 years(4,SRC). [(1) Mackay D, Shiu WY; J Chem Eng Data 22: 399-402 (1977) (2) Murray JJ et al; Can J Chem 52: 557-63 (1974) (3) Lyman WJ et al; Handbook of Chemical Property Estimation Methods NY: McGraw-Hill p. 15-15 to 15-29 (1982) (4) USEPA; EXAMS II Computer Simulation (1987)].

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).