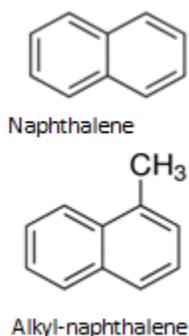


Pollution Tracker Fact Sheet

Polycyclic aromatic hydrocarbons (PAHs)

What are they?

Polycyclic aromatic hydrocarbons (PAHs) are ubiquitous in the environment, occurring both naturally and as a result of human activities. They contain several carbon and hydrogen rings (benzene rings) that are linked together.



There are two major types of PAHs:

1. *Pyrogenic PAHs* are formed as a result of the incomplete combustion of organic matter (e.g., forest fires, agricultural burning, and vehicular and industrial emissions). Combustion results primarily in the formation of parent (non-alkylated) PAHs;
2. *Petrogenic PAHs* are found in fossil fuels (e.g., oil, gasoline) and include a wide range of alkylated compounds (PAHs with an additional carbon-containing group or groups attached) that are more persistent than their parent.

Some PAHs are also used to make dyes, plastics, and pesticides.

PAH 'fingerprinting' can be used to distinguish different sources of PAHs by comparing the PAH composition of environmental samples to the profiles of known source mixtures.

How do they get into the ocean?

Both natural and anthropogenic sources contribute to the thousands of different PAH compounds found in the environment. In the marine environment, natural PAH sources include crude oil seeps and coal and shale deposits, while

anthropogenic sources include oil spills and chronic oil discharges from vessels. Terrestrial sources, including forest fires and agricultural burning, industrial activities, and vehicle use, can also introduce PAHs to the marine environment via atmospheric circulation, urban run-off, and discharge from wastewater treatment facilities.¹

On a global scale, major contributors to environmental PAH levels include the burning of biofuels (including coal), biomass burning (agricultural waste, deforestation, and wildfires), and vehicle emissions.^{2,3}

Are they a problem?

PAHs derived from human activities are considered persistent organic pollutants (POPs)⁴ and can accumulate in food webs. Depending on their size, individual PAHs vary significantly in toxicity and the way they behave in the environment.

The smallest PAH compounds (less than three benzene rings) can break down quickly in the environment via volatilization, dissolution, and microbial degradation. However, their relatively small size also makes them more soluble in water, where they can reach concentrations that make them acutely toxic to fish and other aquatic organisms.⁵

Mid-sized PAHs (with three to five benzene rings) are less water soluble and can stick to solid particles and accumulate in the tissues of aquatic organisms. In fish, these compounds can cause cardiac dysfunction, deformities, reduced growth, and increased mortality⁶. They can also affect the reproductive⁷ and immune systems^{8,9}, and some are known to cause cancer¹⁰. Larger PAHs (five or more benzene rings) do not break down quickly and are most commonly found in sediment, where they can persist for years. Some large PAHs are known to cause cancer and affect DNA.¹¹

FACT: In the hours and days following an oil spill, smaller, lighter PAHs are lost to evaporation and dissolution, while larger, heavier PAHs can sink and remain in the environment for months to years.

While many organisms can break down parent PAHs, alkylated PAHs may be more difficult to break down and therefore may accumulate in food webs.¹² In many cases, alkylated PAHs have also been shown to be more toxic than parent (non-alkylated) PAHs.^{10,13,14}

The United States Environmental Protection Agency has identified 16 priority parent PAHs that are thought to cause cancer as well as effects on the immune,

reproductive, nervous and endocrine systems. The most toxic parent PAH is benzo(a)pyrene (five benzene rings).

What is being done?

Federal and provincial sediment quality guidelines protective of marine aquatic life are available for several PAHs, including benzo(a)pyrene (Table 1).^{15,16} However, these guidelines are not protective of marine organisms higher in the food chain (e.g., marine mammals, birds).

Table 1. Federal and Provincial Sediment Quality Guidelines for Benzo(a)pyrene^{15,16}

Parameter	Sediment (mg/kg dry weight)
Benzo(a)pyrene	0.088* / 0.763**

Notes: * CCME Interim Sediment Quality Guideline (ISQG); ** CCME Probable Effects Level (PEL)

Tsleil-Waututh Nation and the British Columbia Ministry of Environment and Climate Change Strategy are collaboratively updating water quality objectives for Burrard Inlet in the Metro Vancouver area. As part of this process, tissue screening values for fish and shellfish protective of human health have been developed for several contaminants of concern, including certain PAH compounds. These screening values represent a suggested safe level of contaminants in fish tissue. Exceedance of screening levels may indicate that further investigation to assess human health risk is warranted but does not imply risk to human health.¹⁷

What can we do?

As individual and organizations we can:

- Learn more about PAHs using the resource links below
- Recycle and dispose of waste according to local regulations

More information?

¹ Latimer, JS, Zheng, J. 2003. The sources, transport, and fate of PAHs in the marine environment. In Douben, PET, ed., *PAHs: An Ecotoxicological Perspective*, John Wiley & Sons, p. 9-34.

² Shen G, Chen Y, Liu J. 2013. Global atmospheric emissions of polycyclic aromatic hydrocarbons from 1960 to 2008 and future predictions. *Environmental Science and Technology* 47: 6415-6424.

- ³ Ramesh A, Archibong AE, Hood DB, Guo Z, Loganathan BG. 2011. Global environmental distribution and human health effects of polycyclic aromatic hydrocarbons. In: Lam, PKS, ed., *Global Contamination Trends of Persistent Organic Chemicals*, CRC Press, p. 97-126.
- ⁴ Burgess, RM, Ahrens MJ, Hickey CW. 2003. Geochemistry of PAHs in aquatic environments: source, persistence, and distribution. In Douben, PET, ed., *PAHs: An Ecotoxicological Perspective*, John Wiley & Sons, p. 35-45.
- ⁵ Greer CD, Hodson PV, Li Z, King T, Lee K. 2012. Toxicity of crude oil chemically dispersed in a wave tank to embryos of Atlantic herring (*Clupea harengus*). *Environmental Toxicology and Chemistry* 31(6): 1324-1333.
- ⁶ Heintz RA, Rice SD, Wertheimer AC, Bradshaw RF, Thrower FP, Joyce JE, Short JW. 2000. Delayed effects on growth and marine survival of pink salmon *Oncorhynchus gorbusha* after exposure to crude oil during embryonic development. *Marine Ecology Progress Series* 208:205-216.
- ⁷ Hall AT, Oris JT. 1991. Anthracene reduces reproductive potential and is maternally transferred during long-term exposure in fathead minnows. *Aquatic Toxicology* 19:249–264.
- ⁸ Reynaud S, Deschaux P. 2006. The effects of polycyclic aromatic hydrocarbons on the immune system of fish: A review. *Aquatic Toxicology* 77: 229-238.
- ⁹ Kennedy CJ, Farrell AP. 2008. Immunological alternations in juvenile Pacific herring, *Clupea pallasii*, exposed to aqueous hydrocarbons derived from crude oil. *Environmental Pollution* 153:638-648.
- ¹⁰ Canadian Council of Ministers of the Environment (CCME), 2008. Canadian Soil Quality Guidelines for Carcinogenic and Other Polycyclic Aromatic Hydrocarbons (Environmental and Human Health Effects). Scientific Supporting Document. 218 pp.
- ¹¹ Tuvikene A. 1995. Responses of fish to polycyclic aromatic hydrocarbons (PAHs). *Annales Zoologici Fennici* 32:295-309.
- ¹² Harris KA, Nichol LM, Ross PS. 2011. Hydrocarbon concentrations and patterns in free-ranging sea otters (*Enhydra lutris*) from British Columbia, Canada. *Environmental Toxicology and Chemistry* 30: 2184-2193.
- ¹³ Hodson PV, Khan CW, Saravanabhavan G, Clarke LMJ, Brown RS, Hollebone B, Wang Z, Short J, Lee K, King T. 2007. Alkyl PAH in crude oil cause chronic toxicity to early life stages of fish. In *Proceedings of the 30th Arctic and Marine Oil Spill Program (AMOP) Technical Seminar*. 939 pp. Edmonton, Alberta: Emergencies Science and Technology Division, Environment Canada.
- ¹⁴ Le Bihanic F, Morin B, Cousin X, Le Menach K, Budzinski H, Cachot J. 2014. Developmental toxicity of PAH mixtures in fish early life stages. Part I: adverse effects in rainbow trout. *Environmental Science and Pollution Research* 21: 13720-13731.
- ¹⁵ Canadian Council of Ministers of the Environment (CCME). 1998. Canadian sediment quality guidelines. Canadian Council of Ministers of the Environment, Winnipeg. Available at: <http://ceqg-rcqe.ccme.ca/en/index.html#void>

¹⁶ British Columbia Ministry of Environment and Climate Change Strategy. 2021. Working Water Quality Guidelines: Aquatic Life, Wildlife & Agriculture. Water Quality Guideline Series, WQG-08. Prov. B.C., Victoria B.C. Available at: [bc_env_working_water_quality_guidelines.pdf \(gov.bc.ca\)](https://www2.gov.bc.ca/assets/gov/environment/air-land-water/water/waterquality/water-quality-objectives/burrard_inlet_water_quality_objectives_methods_tissue_rec_june_3-2021.pdf)

¹⁷ Thompson HC, and Stein D. 2021. Tissue Quality Objectives Recommendations for Burrard Inlet. Prepared for Tsleil-Waututh Nation and the Province of B.C. Available at: https://www2.gov.bc.ca/assets/gov/environment/air-land-water/water/waterquality/water-quality-objectives/burrard_inlet_water_quality_objectives_methods_tissue_rec_june_3-2021.pdf