Pentachlorophenol (PCP)

Pentachlorophenol (PCP) is a synthetic chlorinated aromatic compound that was widely used for decades as a heavy-duty wood preservative because of its effectiveness against fungi, insects, termites, and wood-boring organisms. Beginning in the 1930s, pentachlorophenol became one of the most common preservatives used to treat utility poles, crossarms, bridge timbers, fence posts, and other industrial wood products requiring long-term protection from biological degradation. Commercial pentachlorophenol formulations are typically dissolved in petroleum-based carrier oils that facilitate penetration into wood during pressure treatment. Technical-grade pentachlorophenol has historically contained impurities, including polychlorinated dibenzo-*p*-dioxins (PCDDs), polychlorinated dibenzofurans (PCDFs), and other chlorinated phenols, which have contributed significantly to environmental and human health concerns associated with its use.

Scientific concern regarding pentachlorophenol increased during the latter half of the twentieth century as occupational studies and environmental investigations identified contamination surrounding wood-treatment facilities and adverse health effects among exposed workers. Researchers determined that many toxicological effects associated with technical-grade pentachlorophenol resulted not only from PCP itself but also from the highly toxic dioxin and furan impurities generated during manufacturing. As a result, extensive toxicological, epidemiological, and environmental research led to increasingly restrictive regulations on pentachlorophenol production, use, and disposal throughout much of the world. In 2021, the Stockholm Convention on Persistent Organic Pollutants added pentachlorophenol and its salts and esters to the list of chemicals targeted for global elimination, with limited exemptions for specific industrial uses.

Pentachlorophenol is regulated under numerous federal environmental programs because of its toxicity, persistence, and widespread historical use. The U.S. Environmental Protection Agency (EPA) regulates pentachlorophenol as a Restricted Use Pesticide under the Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA), restricting its application to certified applicators. PCP is also regulated under CERCLA, RCRA, TSCA, and the Clean Water Act because of its potential to contaminate soil, groundwater, sediment, surface water, and air. Occupational exposure is regulated by the Occupational Safety and Health Administration (OSHA), which has established a permissible exposure limit (PEL) of 0.5 mg/m^3 as an 8-hour time-weighted average with a skin notation, recognizing that significant absorption may occur through dermal contact. Numerous former wood-treatment facilities utilizing pentachlorophenol have been designated as Superfund sites because of persistent environmental contamination.

Pentachlorophenol has been extensively evaluated by regulatory and public health agencies because of its carcinogenicity and systemic toxicity. The International Agency for Research on Cancer (IARC) classifies pentachlorophenol as Group 1 (carcinogenic to humans) based on sufficient evidence that occupational exposure causes cancer. The U.S. Environmental Protection Agency (EPA) classifies pentachlorophenol as a probable human carcinogen and has established cancer slope factors and reference values for

environmental risk assessment. The National Toxicology Program (NTP) lists pentachlorophenol as reasonably anticipated to be a human carcinogen, and California has listed pentachlorophenol under Proposition 65 as a chemical known to cause cancer. Although impurities such as dioxins and furans contribute to the toxicity of technical-grade formulations, laboratory studies have demonstrated that pentachlorophenol itself also possesses carcinogenic and systemic toxic properties.

Scientific understanding of pentachlorophenol toxicity has expanded substantially through occupational, toxicological, and epidemiological research. Pentachlorophenol readily enters the body through inhalation, ingestion, and dermal absorption and acts primarily by disrupting oxidative phosphorylation, impairing normal cellular energy production. Acute exposure may cause skin and eye irritation, excessive sweating, fever, headache, dizziness, nausea, rapid breathing, and elevated body temperature, while severe poisoning can result in hyperthermia, cardiovascular collapse, and death. Chronic exposure has been associated with liver toxicity, kidney damage, immune system effects, endocrine disruption, reproductive toxicity, neurological effects, and increased risks of non-Hodgkin lymphoma and other cancers. Because pentachlorophenol is semi-volatile and strongly adsorbs to soils and organic matter, environmental contamination may persist for decades, particularly at historical wood-treatment facilities.

Pentachlorophenol remains one of the most significant contaminants evaluated in environmental forensic investigations because of its historical use at wood-treatment facilities, utility pole treatment plants, railroad tie operations, and industrial storage yards. Environmental investigations commonly evaluate pentachlorophenol in soil, groundwater, sediment, surface water, ambient air, soil gas, and treated wood products while considering historical treatment operations, preservative formulations, petroleum carrier oils, groundwater migration, weathering processes, and historical site activities. Because technical-grade pentachlorophenol frequently contains characteristic dioxin, furan, and chlorophenol impurities, forensic investigations often evaluate complete chemical fingerprints to distinguish pentachlorophenol releases from creosote, chlorinated solvent contamination, and other historical wood preservation practices. These source-specific chemical profiles are valuable for reconstructing historical operations, identifying contaminant sources, evaluating environmental fate and transport, and assessing long-term human and ecological exposures.

References

Agency for Toxic Substances and Disease Registry. (2021). *Toxicological profile for pentachlorophenol*. U.S. Department of Health and Human Services. https://www.atsdr.cdc.gov/toxprofiles/tp51.pdf

California Office of Environmental Health Hazard Assessment. (2025). *Proposition 65 chemicals list*. https://oehha.ca.gov/proposition-65/proposition-65-list

International Agency for Research on Cancer. (2019). *Some chemicals that cause tumours of the kidney or urinary bladder in rodents and some other substances* (IARC Monographs on the Evaluation of Carcinogenic Risks to Humans, Vol. 117). World Health Organization. https://monographs.iarc.who.int/

National Toxicology Program. (2021). *Report on carcinogens* (15th ed.). U.S. Department of Health and Human Services. https://ntp.niehs.nih.gov/whatwestudy/assessments/cancer/roc

Occupational Safety and Health Administration. (n.d.). *Pentachlorophenol*. https://www.osha.gov/chemicaldata/583

Stockholm Convention on Persistent Organic Pollutants. (2021). *Pentachlorophenol and its salts and esters.*https://chm.pops.int

U.S. Environmental Protection Agency. (2024). *Pentachlorophenol (PCP).* https://www.epa.gov/ingredients-used-pesticide-products/pentachlorophenol

U.S. Environmental Protection Agency. (2024). *Integrated Risk Information System (IRIS): Pentachlorophenol.*https://iris.epa.gov