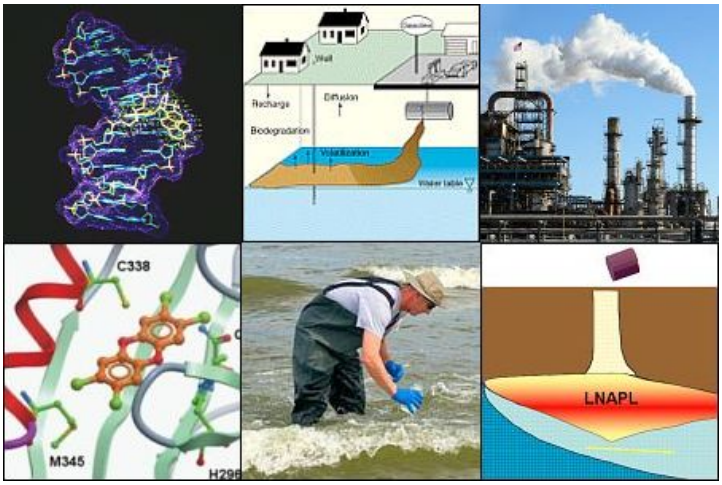
Toxicology of Hydrocarbons

Overview

Hydrocarbons are a class of organic chemical compounds containing only hydrogen and carbon. Although hydrocarbons all possess structural similarities, there is a vast spectrum of compounds and each has different physical, chemical and reactive properties. Similarly, each type of hydrocarbon can affect human health in different ways. Hydrocarbons include a wide range of toxic compounds, some of which can cause cancer, respiratory problems, nervous system damage and a variety of adverse health effects.

It is not possible to provide a comprehensive overview of hydrocarbon toxicology in this brief section; however, the following hydrocarbons represent compounds with which *TCAS* has acquired extensive experience over a period of more than 28 years and which have repeatedly appeared on our radar as recurring toxic and/or causative agents. These include benzene, benzo[a]pyrene, BTEX, dioxins and PCBs, LNAPL, PAHs, and petroleum products.



TCAS has broad experience assessing the health effects of hydrocarbons[a]

Click on any substance to view the corresponding entry.

Benzene | Benzo[a]pyrene | BTEX | Dioxins and PCBs | LNAPL | PAHs | Petroleum

Click to view other types of hazardous substances.

Environmental Hazards | Industrial Chemicals | Compounds & Metals | Pesticides | Dioxins | Hazardous Substances Index

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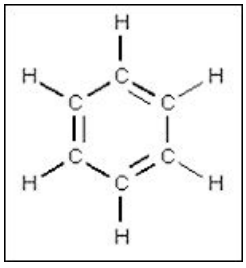
Benzene

Show all results for "Benzene"


Chemical structure of benzene[b]

Benzene is a solvent used extensively as a gasoline additive and in a variety of manufacturing processes for drugs, chemicals, plastics, rubber, elastomers, phenol and acetone. A colorless, highly flammable, volatile organic chemical, benzene is primarily introduced to the environment through industrial processes, air emissions from burning coal and oil, vehicle exhaust, industrial discharge, spills, gasoline leaks and improper disposal. Benzene is moderately soluble in water, highly mobile in soil and readily leaches into groundwater.[1] Acute effects of low-level benzene exposure (700–3,000 ppm) include drowsiness, dizziness, rapid heart rate, headaches, tremors, confusion, and unconsciousness. Ingestion of benzene in foods or liquids can cause vomiting, irritation of the stomach, dizziness and sleepiness. Benzene also causes dermal irritation effects including redness and sores, as well as damage to the cornea if introduced in the eyes. Brief exposure (5–10 minutes) to high levels in air (10,000–20,000 ppm) can be fatal. Chronic effects of benzene exposure include rapid heart rate convulsions, disruption of blood production, anemia and damage to bone marrow . Long-term exposure can result in acute myeloid leukemia (AML) and damage to the immune system.[2]

Both the U.S. EPA and the International Agency for Cancer Research (IARC) have determined that benzene is carcinogenic to humans. *TCAS* has extensive experience in toxicologically assessing benzene exposures and remediation issues in residential, environmental and industrial cases in both causative and risk assessment scenarios. Please contact our office for additional information.

Benzo[a]pyrene

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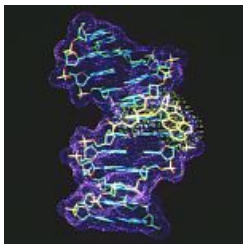

Benzo[a]pyrene[c]

Benzo[a]pyrene is a specific type of PAH (polycyclic aromatic hydrocarbon) which is listed as a hazardous substance under CERCLA (the Comprehensive Environmental Response, Compensation and Liability Act). It has been identified at 524 hazardous waste sites on the National Priorities List (NPL) and is ranked number 8 out of 275 chemicals on U.S. EPA's Priority List of Hazardous Substances. Benzo[a]pyrene is also listed as a drinking water contaminant and is one of the 20 chemicals included in U.S. EPA's "Persistent Bioaccumulative and Toxic Chemical Program."[3] The most common routes of exposure are oral (through contaminated drinking water) or the consumption of certain food products (such as charred meats) or by eating foods grown in contaminated areas (air and/or soil). Aside from natural releases to the environment (such as forest fires), benzo[a]pyrene is released via anthropogenic sources including stoves/furnaces burning fossil fuels (especially wood and coal), motor vehicle exhaust, cigarettes, and various industrial combustion processes. Dermal exposure may occur from contact with soils or materials containing soot, tar or crude petroleum products.[4]

Although human epidemiological studies are inconclusive, a vast number of animal studies have demonstrated strong associations between benzo[a]pyrene and cancers. The most recent U.S. EPA toxicological review (in draft form as of this writing) notes multiple indications that benzo[a]pyrene targets the protective p53 gene, which is a transcription factor that functions as a tumor suppressor. Studies in multiple animal species demonstrate that benzo[a]pyrene is carcinogenic at multiple tumor sites (alimentary tract, liver, kidney, respiratory tract, pharynx, and skin) by all routes of exposure. Consequently, U.S. EPA presently classifies benzo[a]pyrene as a "Probable Human Carcinogen" based on sufficient evidence of carcinogenicity in animals, whereas IARC (the International Agency for Research on Cancer) presently classifies benzo[a]pyrene as a "Group 1 Known Human Carcinogen."[5]

TCAS has regularly produced toxicological assessments involving benzo[a]pyrene contamination in residential areas, as well as individual exposures involving both B[a]P and other polycyclic aromatic hydrocarbons (see below). We have regularly provided expert opinions and testimony over a period of more than 28 years on behalf of both plaintiffs and defendants. Please contact our office for additional information.

BTEX

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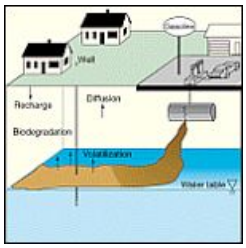

BTEX fate & transport[d]

BTEX refers to a compound consisting of benzene, toluene, ethylbenzene and xylene. These volatile aromatic compounds are most frequently found in combination in gasoline and diesel fuel. Historically, BTEX contamination of groundwater and soil occurs most frequently near petroleum refineries, natural gas production facilities, petrol loading stations and sites with above- or below-ground storage tanks containing gasoline or petroleum products.

BTEX represents a light aromatic fraction of a broader value called Total Petroleum Hydrocarbons (TPH), which describes a broad family of hundreds of different chemical compounds originating from crude oil. EPA provides guidelines for calculating BTEX in which the concentrations of benzene, toluene, ethylbenzene and total xylene are added together to obtain a value for "Total BTEX" (xylene is treated as a separate calculation as three isomers are added together to obtain total xylene).[6]

BTEX is important from a toxicological perspective because the health effects of the most typical constituent chemicals (benzene, toluene, ethylbenzene and xylene) have been more extensively studied than most of the heavier petroleum components present in TPH. A number of detailed toxicological profiles have been developed by ATSDR on individual TPH constituents. These and other studies have documented many of the generally-recognized health effects in humans. Benzene (a recognized carcinogen) can cause vomiting, irritation of the stomach, dizziness, sleepiness, convulsions, rapid heart rate, coma and death. The main effect of toluene is on the brain and nervous system. Ethylbenzene has been shown to cause damage to the inner ear and hearing of animals. High concentrations of xylene affects the nervous system, causing headaches, lack of muscle coordination, dizziness, confusion and irritation of the eyes and respiratory tract.[7]

A scientifically credible toxicological health risk assessment involving BTEX requires measurement and laboratory analyses of the individual hydrocarbons present in the contaminated media. However, other constituent chemicals (such as naphthalene and styrene) may also be present in such analyses and must be accounted for. *TCAS* has extensive experience with BTEX exposures and remediation issues in residential, environmental and industrial cases and has produced objective toxicological assessments on behalf of both plaintiffs and defendants. Please contact our office for additional information.

Dioxins and PCBs

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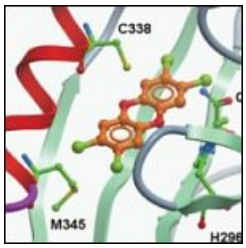
- **NOTE:** This website contains a comprehensive review of TCDD and TCDF toxicology, as well as an index of human dioxin exposure studies organized by various adverse health impacts and diseases.



Dioxin bonding to AhR (Aryl Hydrocarbon Receptors)[e]

Of the many toxic substances confronting the expert toxicologist, dioxins are among the most challenging. The dioxin family of compounds is vast and complex. There are three basic sets of chlorinated compounds with intrinsically similar chemical structures: (a) 75 polychlorinated dibenzo-p-dioxins (PCDDs), (b) 135 polychlorinated dibenzofurans (PCDFs) and (c) 209 polychlorinated biphenyls (PCBs). Dioxins can be produced from incomplete combustion and a variety of other sources. Although PCBs are no longer manufactured in the United States, they were used in electrical transformers and other commercial products and can still be found in the environment.

Although some dioxins and PCBs are relatively harmless, others can induce a wide range of adverse health effects when only very tiny amounts are present in the blood. TCDD [2,3,7,8-tetrachlorodibenzo-p-dioxin] is generally regarded as the most toxic. TCDD is classified as a "Group 1 Known Human Carcinogen" by the World Health Organization (WHO) and by the U.S. EPA.[8] WHO created a set of standardized *Toxic Equivalency Factors (TEFs)* which allow the toxicologist to perform dose calculations and objectively assess risk by expressing dose in terms of TCDD potency (TCDD has a TEF of 1.0, the highest toxicity).

It is generally believed that dioxin causes genetic damage by activating specific gene subgroups through an AhR (Aryl Hydrocarbon Receptor). This ultimately produces cancer through a process called "tumor promotion" in which the descendents of a single initiated (carcinogenic) cell survive and expand in number. A multi-site carcinogen, dioxins can induce multiple types of cancer in different locations in the human body. This phenomenon has been repeatedly observed in both human and animal studies.[9]

A scientifically credible toxicological assessment of a dioxin exposure must meet many requirements. The body of ongoing research is vast and there are a great many human epidemiological studies covering a wide range of potentially adverse health effects. Additionally, there are numerous remedial and regulatory guidelines which set precise limits for dioxins and dioxin-like compounds, some of which vary widely by state and locale. Thus, there are many complex issues the expert toxicologist must consider when conducting a formal dioxin exposure and corresponding risk assessment, particularly in cases involving whole communities.

TCAS has extensive experience in toxicologically assessing dioxin exposures, contamination and remediation issues in residential, environmental and industrial cases in both causative and risk assessment scenarios. Our work in this field has been voluminous and we are regularly consulted by clients seeking toxicological opinions and assessments. Please contact our office for additional information.

LNAPL

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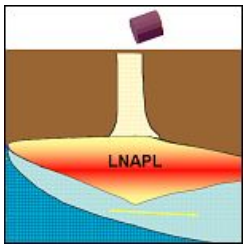

LNAPL[f]

LNAPL (Light Non-Aqueous Phase Liquid) refers to a group of organic chemical substances (often petroleum) which are relatively insoluble and less dense than water. These characteristics cause them to form a layer at or near the surface of a water table. LNAPL can pose significant environmental and toxicological issues with respect to both short- and long-term exposures. LNAPL analyses can involve aspects of analytical and reconstructive chemistry as well as modeling of liquid behavior, migration and fate. U.S. EPA provides general guidance[10,11] with respect to LNAPL analyses, health impacts and remediation of contamination.

A comprehensive toxicological risk assessment will typically include objective analyses and determination of total petroleum hydrocarbons (TPH). Health effects from TPH exposures depend on many factors and the compounds in different TPH fractions impact the body in different ways. Toxicological variables include (but are not limited to) the types of chemical compounds present in contamination, exposure dose, duration and pathways. Some TPH compounds, particularly the smaller compounds such as benzene, toluene, and xylene (which are present in gasoline) impact the human central nervous system. However, human studies are lacking for the majority of TPHs and the documented toxicity and effects of some TPH compounds are presently based largely on animal studies. Thus, in human health risk assessments, the expert toxicologist must rely upon animal and human epidemiological studies of TPH mixtures with respect to identifying specific potential adverse health effects.[12]

Scientifically credible LNAPL analyses frequently require the combined efforts of a qualified hydrogeologist working in concert with an analytical toxicologist. An objective LNAPL toxicological assessment involves compositional chemistry analyses designed to assess source and age, followed by a comprehensive health risk assessment based on a quantitative evaluation of water ingestion, vapor intrusion and other factors. It is highly recommended that in view of the scope of potential liabilities associated with LNAPL, any individual, company or government agency engaged in LNAPL litigation matters always retain an experienced expert toxicologist and hydrologist. *TCAS* has performed numerous LNAPL assessments and provided objective reports as well as expert opinions and expert witness consults for many types of LNAPL and DNAPL contamination. This website contains a comprehensive review of LNAPL toxicology. Please contact our office for additional information.

PAHs

Show all results for "PAHs"

Gulf oil clean-up worker[g]

PAHs (polycyclic aromatic hydrocarbons) have been found in at least 600 of the sites on the U.S. EPA's National Priorities List. Found in crude oil, coal, coal tar pitch, creosote, roofing tar and many other substances, PAHs can be found throughout the environment in the air, water, and soil. PAHs generally occur as complex mixtures or as part of combustion products (such as soot). Some PAHs occur naturally whereas others are manufactured as individual compounds. As pure chemicals, PAHs generally exist as colorless, white, or pale yellow-green solids. A few PAHs are used in medicines and to make dyes, plastics, and pesticides.[13]

Although most PAHs are only slightly mutagenic, their metabolites or derivatives can be potent mutagens. The most significant toxicological endpoint of PAH toxicity is cancer. However, some studies have shown non-carcinogenic effects based on exposure dose [Gupta et al. 1991]. Non-carcinogenic effects involve the pulmonary, gastrointestinal, renal, dermatologic and respiratory systems. Increased incidences of lung, skin, and bladder cancers are also associated with occupational exposure to PAHs.[14]

The most recent large-scale release of PAHs occurred in the 2010 "Deepwater Horizon" oil release. Vast quantities of "dispersant" were applied to floating crude oil causing PAHs in the oil to be liberated. The release of these chemicals into the water had pronounced adverse health effects on aquatic life in the Gulf region as well as clean-up workers, local residents and others. Dr. Sawyer was directly involved in sampling and assessing the toxicological impacts of these PAH releases (litigation continues to the present time). *TCAS* has extensive experience in toxicologically assessing PAH exposures and remediation issues in both causative and risk assessment scenarios. Please contact our office for additional information.

Petroleum Products

Show all results for "Petroleum"

Petroleum[h]

Human health hazards with respect to petroleum products are a significant problem for both occupationally exposed individuals and among the general population. Petroleum products are widely used as fuels, greases, solvents and intermediates in many branches of industry. Products derived from petroleum constitute a vast and complex universe of substances, some of which are classified as both hazardous and toxic. U.S. EPA maintains a comprehensive *Consolidated List of Chemicals Subject to the Emergency Planning and Community Right-To-Know Act* which lists hazardous substances and toxic chemicals subject to regulation under CERCLA.[15] A long list of petroleum-derived substances appears in ATSDR's *Priority List of Hazardous Substances* including such toxic agents as benzene, polycyclic aromatic hydrocarbons (PAHs), benzo(b)fluoranthene and many others.[16]

Variable composition of individual petroleum products and limited human epidemiological studies for some substances impose challenging complexities when producing a scientifically credible toxicological assessment of human health risks. In some cases, contamination may consist of a historical progression of substances released over a period of decades. In other cases, unintentional releases (such as waste products from refineries) can infiltrate into groundwater and soil and/or release volatile vapors. In residential exposure scenarios, the population may not even be aware of the hazards until adverse health effects begin to appear. In the case of consumer products, cosmetics, cleaning and janitorial chemicals and substances that emit volatile vapors (such as certain plastics) all possess different toxicological characteristics.

The expert toxicologist must account for all of these variables in any objective health risk assessment relating to petroleum products. Exposure assessment involves a process whereby the toxicologist calculates the magnitude, frequency and duration of exposure, compiles sets of information describing exposure concentrations and intake variables, applies the appropriate assessment methodologies and arrives at pathway-specific exposure doses for each substance of concern. Uncertainties must also be taken into account as some exposure events may have occurred in the distant past and may represent a *cumulative exposure dose*.

Thus, petroleum-related assessments frequently fall within the realm of forensic toxicology. *TCAS* has substantial experience in assessing the health hazards associated with petroleum products and has regularly provided written reports and expert testimony on behalf of both plaintiffs and defendants in accordance with federal, state and local regulations. Please contact our office for additional information.

Notes and References

1. U.S. Environmental Protection Agency, "Benzene," Drinking Water Treatability Database, July, 2009.
2. ATSDR, Division of Toxicology and Environmental Medicine, "Toxicological Profile for Benzene," August, 2007.
3. U.S. Environmental Protection Agency, "Toxicological Review of Benzo[a]pyrene," (External Review Draft) September, 2014
4. ATSDR, Division of Toxicology and Environmental Medicine, "Toxicological Profile for Polycyclic Aromatic Hydrocarbons," August, 1995.
5. International Agency for Research on Cancer, "IARC Monographs: Benzo[a]pyrene," July, 2012.
6. U.S. Environmental Protection Agency, "Region VIII Pretreatment Guidance on the Analysis of BTEX," August, 1999.
7. ATSDR, Division of Toxicology and Environmental Medicine, "Toxicological Profile for Total Petroleum Hydrocarbons (TPH)," September, 1999.
8. U.S. Environmental Protection Agency, "Supplemental guidance for assessing cancer susceptibility from early-life exposure to carcinogens," 2005
9. Beischlag et al., "The aryl hydrocarbon receptor complex and the control of gene expression," Critical Reviews in Eukaryotic Gene Expression, 2008;18(3):207-50
10. U.S. Environmental Protection Agency, "Light Non-Aqueous Phase Liquids (LNAPLs),"
11. U.S. Environmental Protection Agency, "A Decision-Making Framework for Cleanup of Sites Impacted With Light Non-Aqueous Phase Liquid (LNAPL)"
12. ATSDR, Centers for Disease Control and Prevention, "Public Health Statement for Total Petroleum Hydrocarbons (TPH)," September, 1999.
13. ATSDR, Division of Toxicology and Environmental Medicine, "Toxicological Profile for Polycyclic Aromatic Hydrocarbons," August, 1995.
14. ATSDR, Division of Toxicology and Environmental Medicine, "Health Effects Associated With PAH Exposure," December, 2013
15. U.S. Environmental Protection Agency, "List of Chemicals Subject to the Emergency Planning and Community Right-To-Know Act," March, 2015.
16. ATSDR, Division of Toxicology and Environmental Medicine, "Priority List of Hazardous Substances," February, 2016.

Images

a. Montage image sources as cited below
b. U.S. Environmental Protection Agency, "Benzene"
c. National Coordination Office for Networking and Information Technology Research and Development, "Benzo[a]pyrene"
d. U.S. Geological Survey, "BTEX," Fact Sheet FS-019-98
e. National Institutes of Health, Department of Health & Human Services, "Molecular Docking of TCDD in Aryl Hydrocarbon Receptors"
f. Adapted from U.S. EPA, "Understanding Light Non-Aqueous Phase Liquid (LNAPL) Behavior in Soil"
g. U.S. Fish and Wildlife Service, "PCB Marking Requirements"
h. U.S. Bureau of Labor Statistics, "Petroleum Manufacturing: Beyond the Numbers"

A Message from Dr. William R. Sawyer
Chief Toxicologist, *TCAS, LLC*

Hydrocarbon exposure assessments must be based on compelling evidence and credible science. Causative conclusions must be supported by peer-reviewed studies and appropriate application of the required investigative methodologies.

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