

## **APPENDIX II: Pollutant Technical Summaries**

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## **Appendix II: Pollutant Technical Summaries**

### **Heavy Metals**

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Asbestos  
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Cyanide  
Dioxins  
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Oil/Petroleum Products  
PAH's (Polycyclic Aromatic Hydrocarbons)  
Pesticides  
PCB's (Polychlorinated biphenyls)  
VOC's (Volatile Organic Compounds)

## Heavy Metals

### Lead, *Pb*

#### Description of Pollutant

Lead is a bluish-gray metal that occurs naturally in the earth's crust. It has been used by humans for hundreds of years to produce pipes, and was widely used as a gasoline additive until the 1980's, when a worldwide movement began to ban its usage in fuel.

#### Sources

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- Mining and smelting operations;
- Fossil fuel combustion from industries and vehicles;
- Industrial sources like battery production and recycling facilities, gun and ammunition factories, metal disposal and recycling facilities and electrical components manufacture;
- Domestic sources like flaking lead-based paint and water supply pipes;
- Naturally present in the environment.

#### Human Exposure Pathways

- Exposure to lead occurs mainly via inhalation of lead dust and particles.
- Lead dust/particles can be deposited in soil and when people come into direct contact, it can be absorbed through the skin.
- Humans can be exposed to lead through drinking water where contamination has occurred by the corrosion of old lead pipes. In rural areas, drinking water sources may be contaminated by industrial discharges containing lead.

#### Human Health Effects

- Exposure to excessive quantities of lead may cause lead encephalopathy, a neurological disorder.
- According to WHO, children with blood lead concentrations of between 12 micrograms per deciliter ( $\mu\text{g}/\text{dl}$ ) and  $120\mu\text{g}/\text{dl}$  can suffer from lower IQ, shorter attention span, reading or learning disabilities, hyperactivity, impaired physical growth, hearing and visual problems or impaired motor skills.
- At blood concentrations above  $70\mu\text{g}/\text{dl}$ , risk of encephalopathy is high and treatment is required.

- Acute symptoms from high levels of exposure include stomachache, irritation of the colon, kidney malfunction, blood anemia and eventually brain damage.
- Unborn children can be exposed to lead through their mothers. Harmful effects include premature births, smaller babies, decreased mental ability in the infant, learning difficulties, and reduced growth in children.
- At blood concentrations of 70µg/dl in adults, symptoms are not readily noticeable; however, changes such as increased fatigue, short term memory loss or lack of coordination may occur. At levels of 150 µg/dl acute poisoning, which can cause adult encephalopathy can occur and can ultimately lead to brain damage.

## Exposure Standards

### USEPA

- The maximum contaminant level for lead in drinking water is 0.015 milligrams per liter (mg/L).
- The US Clean Air Act lists the safe limit for lead in air as 1.5 micrograms per cubic meter (µg/m<sup>3</sup>.)
- The US Resource Recovery and Conservation Act lists the safe level of lead in soil at 5 parts per million (ppm).

### WHO

- The WHO drinking water standard for lead is 0.01 mg/liter

### US Center for Disease Control and Prevention

- It has set a threshold level of 10 µg/dl of lead in the blood of children.

## Remediation Processes

- Soil washing
- Stabilization
- Solidification
- Vitrification
- Capping
- Phytoremediation

## References

Agency for Toxic Substances and Disease Registry (ATSDR). ToxFAQ's-lead.  
<http://www.atsdr.cdc.gov/toxprofiles/tp13.html>

eMedicine. Online Resource Center.

<http://www.emedicine.com/neuro/topic185.htm>

US Environmental Protection Agency. Lead in the Environment -Tutorial.

<http://www.epa.gov/seahome/leadenv/src/title.htm>

World Health Organization. Children's Environmental Health

<http://www.who.int/ceh/publications/leadpoison/en/>

## **Mercury, Hg**

### **Description of Pollutant**

Mercury occurs naturally in the environment and exists in several forms that can be broadly categorized into metallic mercury (elemental mercury), organic (bound with carbon), and inorganic mercury (not bound with carbon). It is a dense, silvery white, shiny metal, which is liquid at room temperature in its elemental form. One organic form of mercury, methyl mercury, is of particular concern as it can accumulate in fish and thus get transferred through the food chain. Mercury is widespread and persistent in the environment.

### **Sources**

- Burning of fossil fuels (particularly coal-fired utilities) is the major source of mercury emissions to the atmosphere.
- Any facility using mercury in its process is a potential source of mercury emission.
- Smelting processes may contribute to a large percentage of mercury releases.
- Some inorganic mercury compounds are used as fungicides.
- It is used in measuring and control equipment (thermometers, medical equipment).
- Also used in copper and silver amalgams in tooth filling materials.
- Mercury-containing products such as batteries and electric lamps contribute to mercury emissions at municipal and hazardous waste dumps, and medical waste incinerators, and may leach out from landfills.
- Chlor-alkali plants, metal processing, and mining of gold and mercury contribute greatly to mercury concentrations in some areas, but atmospheric deposition is the dominant source of mercury over most of the landscape.
- Natural sources of atmospheric mercury include volcanoes, geologic deposits of mercury, and volatilization from the ocean. Some local mineral occurrences and thermal springs naturally high in mercury have also been documented.

### **Human Exposure Pathways**

- The general population is commonly exposed to mercury primarily by consuming mercury-contaminated fish and from the release of elemental mercury from dental amalgams used in fillings.

- Humans can be exposed to metallic mercury vapor in the atmosphere, which can be very dangerous when inhaled.
- Additional exposure may occur occupationally and in heavily polluted areas or in areas where mercury-containing fungicides are used extensively.
- Elemental mercury can also be absorbed through the skin.

## Human Health Effects

In general, mercury affects the immune system, alters genetic and enzyme systems, and damages the nervous system, including coordination and the senses of touch, taste, and sight. But the specific health effects of mercury and its compounds depend on its chemical form owing to differences in toxicokinetics.

### Methyl Mercury

- Exposure to very small amounts of methyl mercury can result in devastating neurological damage or death.
- Can also cause permanent damage to the brain and kidneys.
- Symptoms of acute mercury poisoning include cough, chest tightness, trouble with breathing, and an upset stomach. Pneumonia can develop, which can be fatal.
- Mental retardation, blindness, and cerebral palsy have been observed in children born to women having high levels of methyl mercury exposure. Exposure could have a negative impact on their neurological development resulting in psychological abnormalities like deficits in short-term memory, irritability, and social withdrawal.

### Inorganic Mercury

- Ingestion of inorganic mercury compounds can cause severe renal and gastrointestinal toxicity.
- Swallowing inorganic mercury compounds results in nausea, vomiting, diarrhea, and severe kidney damage.

### Elemental Mercury

- Elemental mercury, the form released from broken thermometers, causes tremors, gingivitis, and excitability when vapors are inhaled over a long period of time.

## Exposure Standards

The likely observed adverse effect level for mercury vapor are around 15-30  $\mu\text{g}/\text{m}^3$ .

### US EPA/FDA

- 2 ppb (parts per billion) inorganic mercury in drinking water.
- The level of inorganic mercury in rivers, lakes and streams should be no more than 144 parts mercury per trillion.
- Maximum permissible level of 1 ppm of methyl mercury in seafood products sold through interstate commerce in the U.S.

### OSHA (Occupational Safety and Health Administration)

- 0.1 milligrams of mercury per cubic meter of air ( $\text{mg}/\text{m}^3$ ) for organic mercury and  $0.05 \text{ mg}/\text{m}^3$  for metallic mercury vapor in workplace air to protect workers during an 8-hour shift and a 40-hour work week.

### **Remediation Processes**

- *In situ* treatment technologies like excavation, low temperature thermal desorption followed by landfill disposal;
- Bacteria which detoxifies mercury compounds;
- Acid leaching or soil leaching;
- Amalgamation;
- Soil Washing;
- Retorting;
- Stabilization.

### **References**

Agency for Toxic Substances and Disease Registry (ATSDR). ToxFAQ's-Mercury.

<http://www.atsdr.cdc.gov/toxprofiles/tp46.html>

The Breast Cancer Fund. Chemical Fact Sheets: Mercury.

<http://www.breastcancerfund.org/site/pp.asp?c=kwKXLdPaE&b=84513>

U.S. Environmental Protection Agency. Mercury.

<http://www.epa.gov/mercury/>

## Chromium, Cr

### Description of Pollutant

Chromium is a steel-gray, naturally occurring element found as ore in natural deposits. It is commonly used in metal alloys like stainless steel, plumbing coatings, magnetic tapes, and pigments for paints, cement, paper, and rubber. It also finds application in wood preservatives. Although it is found widely in plants and soils, it is rare in natural waters. The most hazardous form of chromium is hexavalent chromium (Cr VI).

### Sources

- The chemical manufacturing industry;
- Combustion of natural gas, coal, and oil;
- Metallurgical facilities, electroplating, leather tanning, and dye industries;
- Small amounts of chromium are found in vegetables, grains, and cereals;
- Implants like cobalt-chromium knee and hip arthroplasts;
- Contaminated landfills and cement dust.

### Human Exposure Pathways

- People can be exposed to chromium by eating food, drinking water, or breathing air that is contaminated;
- In air, chromium compounds are present mostly as fine dust particles that eventually settle over land and water;
- Cigarettes contain 0.24 to 14.6 milligrams (mg) chromium per kilogram (kg). Thus cigarette smoking might constitute a significant source of chromium intake;
- Skin contact with chromium-contaminated dust, dirt, and puddles.

### Human Health Effects

- Hexavalent chromium, the most hazardous form, can cause cancer and other health problems at high levels.
- Chromic acid or chromate dusts can cause permanent eye damage.
- Short-term exposure causes skin irritation and ulceration.
- Chronic health effects include damage to liver, kidney, circulatory and nerve tissues, and skin irritation.
- It can cause allergic reactions, such as skin rash. Breathing it can cause nose irritations and nosebleeds.

- Inhalation of hexavalent chromium compounds can result in ulceration, asthmatic bronchitis, and edema.
- Other health effects include upset stomach and ulcers, respiratory problems, weakened immune systems, and alteration of genetic material.

### Exposure Standards

#### EPA

- Maximum contaminant level for chromium in drinking water is 100 µg/L (micrograms per liter).

#### National Academy of Science

- Safe and adequate daily intake for chromium in adults is 50 - 200 micrograms per day (µg/day).

#### OSHA

- Mandates a ceiling concentration of 100 µg CrO<sub>3</sub>/m<sup>3</sup> for chromic acid and chromates. For Cr (II) and Cr (III) salts, the Permissible Exposure Limits (PEL) is an 8-hour time-weighted average (TWA) of 500 µg Cr/m<sup>3</sup>. For chromium metal and for insoluble salts, the TWA is 1,000 µg Cr/m<sup>3</sup>.

### Remediation Processes

- Soil flushing
- Fixation/stabilization
- Reduction

### References

Agency for Toxic Substances and Disease Registry (ATSDR).

ToxFAQ's- Chromium. <http://www.atsdr.cdc.gov/tfacts7.html>

Scorecard. Chemical profile for chromium compounds.

[http://www.scorecard.org/chemical-profiles/summary.tcl?edf\\_substance\\_id=CMJ500](http://www.scorecard.org/chemical-profiles/summary.tcl?edf_substance_id=CMJ500)

US Environmental Protection Agency. Consumer Factsheet on:

Chromium. <http://www.epa.gov/safewater/dwh/c-ioc/chromium.html>

## **Cadmium, Cd**

### **Description of Pollutant**

Cadmium is a soft, bluish-white metal which occurs naturally in the environment. It is usually found as a mineral combined with other elements and is extracted during the production of metals like zinc, lead, and copper. It finds application in the manufacture of batteries, pigments, metal coatings, and plastics as it does not corrode easily.

### **Sources**

- Cadmium compounds are primarily released into the environment by copper, lead, and zinc smelters and municipal incinerators.
- A very large amount of cadmium is released naturally into the environment, about 25,000 tons a year.
- It is also released by the application of phosphate fertilizers or sewage sludge to soils.

### **Human Exposure Pathways**

- Human uptake of cadmium takes place mainly through food. Liver, mushrooms, shellfish, mussels, cocoa powder, dried seaweed, oysters, shrimp, lobster, and fish are potential sources. Cadmium also tends to bioaccumulate in aquatic life.
- Smoking exposes people to significant amounts of cadmium. Tobacco smoke transports cadmium into the lungs.
- People who live near hazardous waste sites or factories that release cadmium into the air and people who work in the metal refinery industry are significantly exposed to cadmium.

### **Human Health Effects**

- Damage to kidneys and lungs;
- Diarrhea, stomach pains and severe vomiting;
- Debilitating effects on bones and the skeletal structure;
- Reproductive failure and possibly even infertility;
- Damage to the central nervous system;
- Damage to the immune system;
- Psychological disorders;
- Possibly DNA damage or cancer development;
- Lung cancer is one potential result of chronic inhalation of fine-particle cadmium compounds, particularly cadmium oxide, which readily dissolves in the body.

## Exposure Standards

### WHO

- The tolerable Tolerable daily cadmium intake established by WHO is 60 and 70 µg/day (micrograms per day), respectively, for adult women and men.

### ATSDR (Agency for Toxic Substances and Disease Registry)

- ATSDR has derived a chronic-duration oral minimal risk level (MRL) of 0.0002 mg/kg/day based on renal effects in humans.

### EPA

- EPA has established a reference dose of  $5 \times 10^{-4}$  mg/kg/day in water and  $1 \times 10^{-3}$  mg/kg/day in food. The maximum contaminant level for cadmium in drinking water is 0.005 mg/L.

### OSHA

OSHA standards require the cadmium permissible exposure limits to be 5 µg/m<sup>3</sup> (micrograms per cubic meter) or lower for 8-hour time weighted average.

- The new Universal Treatment Standards (UTS) criteria reduced the leachable cadmium limit to 0.11 mg/l (from 1.0 mg/l under prior RCRA legislation).

## Remediation Processes

- Soil flushing;
- Phytoextraction;
- Phytostabilization;
- Chemical stabilization;
- Solidification/stabilization;
- Vitrification;
- Electrokinetic remediation.

## References

Agency for Toxic Substances and Disease Registry. ToxFAQ's - Cadmium. <http://www.atsdr.cdc.gov/tfacts5.html>

International Cadmium Association. <http://www.cadmium.org/>

Lenntech Water Purification & Air Purification: Cadmium  
<http://www.lenntech.com/Periodic-chart-elements/Cd-en.htm>

USEPA. Technical Factsheet on Cadmium  
<http://www.epa.gov/OGWDW/dwh/t-ioc/cadmium.html>

## **Arsenic, As**

### **Description of Pollutant**

Arsenic is a naturally-occurring, brittle, steel gray semi-metallic solid. Arsenic and its compounds are highly toxic. It finds application in the manufacture of insecticides, pesticides and various alloys. It is also used for bronzing and as a wood preservative.

### **Sources**

- Human activities like mining, smelting and agricultural applications.
- Arsenic can be released from pesticides and wood preservatives.
- Natural sources include volcanic activity, the erosion of rocks and minerals, and forest fires.

### **Human Exposure Pathways**

- Arsenic exposure occurs by ingestion, inhalation of dust, and, to a much lesser degree, by absorption through the skin.
- Accidental poisoning has been reported to occur from wearing inadequate clothing when applying arsenic-based products.
- Arsenic exposure in the workplace occurs through inhalation, ingestion, or dermal or eye contact.

### **Human Health Effects**

- Arsenic in drinking water causes bladder, lung and skin cancer, and may cause kidney and liver cancer. Studies have also found that arsenic harms the central and peripheral nervous systems, as well as heart and blood vessels, and causes serious skin problems. It also may cause birth defects and reproductive problems.
- Arsenic can be carcinogenic at very low levels and one-tenth of a gram accumulated over a two-month period can be fatal.
- Symptoms of mild poisoning include loss of appetite, nausea, and diarrhea.
- Severe exposure causes cramps, vomiting, neurological effects like restlessness, chronic headache, fainting, dizziness, convulsions or coma.
- Acute exposures can cause lung distress and death.
- Chronic exposure to arsenic can lead to dermatitis, pigmentation of the skin, wart formation, decreased nerve conduction velocity, and lung cancer.

## Exposure Standards

### EPA

- Maximum contaminant level for arsenic in drinking water is 0.010 mg/l.
- EPA has set a limit of 10 ppm (10 mg per kg) of arsenic in soil.

### OSHA

- Has established a maximum permissible exposure limit for workplace airborne inorganic arsenic of 10 micrograms per cubic meter averaged over an eight-hour day.

## Remediation Processes

- Soil solidification/stabilization
- Electro-kinetics
- Groundwater recovery
- Excavation
- Soil flushing

## References

Agency for Toxic Substances and Disease Registry (ATSDR). ToxFAQ's-Arsenic. <http://www.atsdr.cdc.gov/tfacts2.html>

Arsenic and CCA Wood: toxicological effects of arsenic.  
<http://www.origen.net/arsenic.html>

Markey, R.M. Arsenic Remediation.  
<http://www.google.com/search?hl=en&q=arsenic+remediation&spell=1>

NRDC: Arsenic in Drinking Water FAQ.  
<http://www.nrdc.org/water/drinking/qarsenic.asp>

## Radionuclides

### Description of Pollutant

Radionuclides are a group of elements that are present throughout the environment in small concentrations and are radioactive. Over 2,000 radionuclides exist on the earth, most of them naturally occurring (USEPA). They are unstable in the environment and are constantly decaying - a process that causes them to release radiation. The type of radiation that is emitted (alpha, beta or gamma rays) is what determines whether or not the radionuclide poses a risk. Beta and gamma rays can penetrate the body and cause damage to the cells, whereas alpha rays are harmful when released from inside the body after being inhaled or ingested.

### Sources

- Mining of uranium;
- Nuclear power production;
- Nuclear weapons manufacturing and test sites;
- Spent nuclear fuel;
- Erosion of natural deposits of certain minerals that are radioactive;
- Decay of natural and man-made deposits of radioactive minerals.

### Human Exposure Pathways

- Airborne dust can be inhaled.
- Once in soil, it can be absorbed by water used for drinking purposes.
- Walking on contaminated soil directly exposes humans to radiation.
- Medical tests and treatments.
- Another pathway can be through food that has been contaminated with radionuclides like milk (if cow feeds on contaminated vegetation) and fish (found in contaminated waters).

### Human Health Effects

- Cancer is the major effect of concern from the long-term exposure to radionuclides.
- Short term exposure to high levels of radiation can cause acute radiation poisoning, symptoms of which include radiation burns, nausea, fatigue, vomiting and hair loss. Other effects include

diarrhea, hemorrhage, internal bleeding, and death in cases of severe exposure.

- Internal exposure to plutonium may cause damage to the kidneys.
- Chronic (long-term) inhalation exposure to uranium and radon in humans has been linked to respiratory effects, such as chronic lung disease, while radium exposure has resulted in acute leukopenia, anemia, and necrosis of the jaw.
- Radium, via oral exposure, is known to cause bone, head, and nasal passage tumors in humans. Radon, via inhalation exposure, causes lung cancer in humans. Uranium may cause lung cancer and tumors of the lymphatic and hematopoietic tissues. <http://www.epa.gov/ttnatw01/hlthef/radionuc.html>
- Internal exposure to strontium-90 is linked to bone cancer, cancer of the soft tissue near the bone, and leukemia.

## Exposure Standards

### EPA

The maximum contaminant levels in drinking water for Alpha particles is 15 picocuries per Liter (pCi/L), Beta particles and photon emitters 4 millirems per year, Radium 226 and Radium 228 (combined) 5 pCi/L and Uranium 30 micrograms per liter (ug/L).

The EPA has set standards for the maximum amount of radionuclides that nuclear facilities may release to the air. EPA also sets risk-based criteria for the cleanup of soil and groundwater at contaminated sites before they are approved for public use.

For the general population, the USEPA limits human exposure levels to 0.1 millirems (mrem)/year. (ATSDR)

## Remediation Processes

- Permeable reactive barriers
- Water treatment technologies

## References

Agency for Toxic Substances and Disease Registry. ToxFAQs for Ionizing Radiation.

<http://iier1.isciii.es/tfacts149.html>

US Environmental Protection Agency. Radiation Information – Radionuclides

<http://www.epa.gov/radiation/radionuclides/index.html>

US Environmental Protection Agency. Understanding Radiation – Health Effects.

[http://www.epa.gov/radiation/understand/health\\_effects.htm](http://www.epa.gov/radiation/understand/health_effects.htm)

US Nuclear Regulatory Commission. Homepage.

<http://www.nrc.gov/>

## Other Contaminants

### Asbestos

#### Description of Pollutant

Asbestos is a mineral fiber resistant to heat and corrosive chemicals, due to which it was commonly used for insulation and as a fire retardant. It found wide application in the construction industry prior to the 1970s. Typically, asbestos appears as a whitish, fibrous material which may release fibers that can be dangerous if inhaled.

#### Sources

- Indoors, deteriorating, damaged, or disturbed insulation, fireproofing, acoustical materials, and ceiling and floor tiles may be sources of asbestos.
- Asbestos is released into the air from erosion of asbestos-bearing rocks, asbestos-related industries, or from clutches and brakes on vehicles.
- Asbestos may be released to water from the erosion of natural deposits and corrosion from asbestos-cement pipes.

#### Human Exposure Pathways

- We are all exposed to low levels of asbestos in the air we breathe. People working in industries that make or use asbestos products (shipbuilding, mining, milling, and fabricating) are exposed to high levels of asbestos. People living near these industries may also be exposed to high levels of asbestos in air.
- Drinking water may contain asbestos from natural sources or from asbestos-containing cement pipes.

#### Human Health Effects

- Lung cancer;
- Mesothelioma (cancer of chest and abdominal lining);
- Asbestosis (irreversible lung scarring that can be fatal);
- Asbestos exposure via inhalation causes pulmonary hypertension and immunological effects.

#### Exposure Standards

OSHA

The Occupational Safety and Health Administration has set limits of 100,000 fibers with lengths greater than or equal to 5 micrometers per cubic meter of workplace air for 8-hour shifts and 40-hour work weeks.

## EPA

- EPA has proposed a concentration limit of 7 million fibers per liter of drinking water for long fibers (lengths greater than or equal to 5 micrometers).
- EPA has not established a Reference Concentration ([RfC](#)) or a Reference Dose ([RfD](#)) for asbestos.

## **Remediation Processes**

- Asbestos abatement covers the removal, encapsulation and repair of construction materials containing asbestos.
- Typically for commercial office buildings, fireproofing removal, conduit demolition, duct demolition, dry sweeping and wall demolition are done for the removal of asbestos.
- To remove asbestos from carpets, furniture and vehicles, High Efficiency Particulate Air Filter vacuuming can be done.

## **References**

Agency for Toxic Substances and Disease Registry. ToxFAQs for Asbestos.  
<http://www.atsdr.cdc.gov/tfacts61.html>

National Safety Council. Asbestos.  
<http://www.nsc.org/library/facts/asbestos.htm>

USEPA. Asbestos and Vermiculite.  
<http://www.epa.gov/asbestos/>

## Coal/Coke

### Description of Pollutant

Coal is a readily combustible fossil fuel. It is a sedimentary rock that is extracted by mining and is divided into four classes: anthracite, bituminous, sub-bituminous, and lignite. Coal remains an enormously important fuel and is the most common source of electricity world-wide. Coke forms a desirable fuel for stoves and furnaces as the smoke-producing constituents are removed during the coking of the coal.

Coal-fired power plants pollute the environment with some 200,000 pounds of mercury annually. Other atmospheric emissions from burning coal include sulfur dioxide (SO<sub>2</sub>), carbon dioxide (CO<sub>2</sub>), particulate matter, and nitrogen oxides (NO<sub>x</sub>), which in turn form ground-level ozone. SO<sub>2</sub> and NO<sub>x</sub> are the primary causes of acid rain. CO<sub>2</sub> is the dominant gas responsible for the greenhouse effect that is warming the planet.

Solid wastes from coal-fired power plants also contain heavy metals like arsenic, selenium, chromium, and cadmium; carcinogenic organic compounds; and radioactive elements. These toxins can leach into streams and groundwater supplies, compromising people's health.

### Sources

- Coal is mined from reserves under the earth;
- It is a common source of energy for industrial purposes and power plants and may be included in its waste;
- Hazardous waste sites;
- By-products from the combustion of coal/coke are extremely harmful for the environment as well as human health.

### Human Exposure Pathways

- Exposure to coal dust can occur through inhalation, ingestion, and eye contact.
- Inhalation exposure: Exposure to coke oven emissions may occur for workers in the aluminum, steel, graphite, electrical, and construction industries.
- The most common routes of exposure to coal tar creosote are likely to be through the skin, and drinking water contaminated with creosote. Eating soil contaminated with coal-tar creosote can also provide a source of exposure.

### Human Health Effects

- Several well-publicized epidemiology studies conducted over the past 10 years have suggested that sulfate particles were positively correlated with adverse health effects such as respiratory disease, cardiovascular disease, and lung cancer.
- Chronic (long-term) exposure to coke oven emissions in humans results in conjunctivitis, severe dermatitis, and lesions of the respiratory system and digestive system. Cancer is the major concern from exposure to coke oven emissions. Epidemiologic studies of coke oven workers have reported an increase in cancer of the lung, trachea, bronchus, kidney, prostate, and other sites.
- Brief exposures to large amounts of coal-tar creosote can cause harmful effects on the skin, eyes, nervous system, and kidneys and can result in death. Longer-term exposure to lower levels of coal-tar creosote can also result in damage to the skin, such as reddening, blistering or peeling.
- Effects of coal mine dust in coal miners include pneumoconiosis, progressive massive fibrosis, emphysema, chronic bronchitis and accelerated loss of lung function.
- SO<sub>2</sub> and ozone are highly corrosive gases that cause respiratory distress and contribute to low birth weight and increased infant mortality.

## Exposure Standards

### NIOSH

- National Institute of Occupational Safety and Health's recommended exposure limit for an 8- or 10-hour time-weighted-average exposure is 0.5-0.7 milligrams per cubic meter (mg/m<sup>3</sup>) for coke oven emissions and 0.1 mg/m<sup>3</sup> for coal tar pitch volatiles.
- The National Institute for Occupational Safety and Health has not established a recommended exposure limit for coal dust.

### OSHA

- OSHA has set a legally enforceable limit (permissible exposure limit, or PEL) of 0.2 mg/m<sup>3</sup> coal-tar pitch volatiles and 0.15 mg/m<sup>3</sup> coke oven emissions in workroom air to protect workers during an 8-hour shift or a 40-hour.
- The current Occupational Safety and Health Administration (OSHA) permissible exposure limit (PEL) for the respirable fraction of coal dust (greater than or equal to 5 percent silica) is 10 mg/m<sup>3</sup> / % SiO<sub>2</sub> + 2 as an 8-hour time-weighted average (TWA) concentration.

## Remediation Processes

- Solvent extraction for coal tar wastes
- Constructed wetlands for acid mine drainage

## References

Earth Policy Institute. Coal Takes Heavy Human Toll.  
<http://www.earth-policy.org/Updates/Update42.htm>

Eco-usa.net. Creosote.  
<http://www.eco-usa.net/toxics/creosote.shtml#expath>

EPA. Coke Oven Emissions.  
<http://www.epa.gov/ttn/atw/hlthef/cokeoven.html>

EW&R- Air Quality Research. Health Effects of Coal Plant Emissions.  
[http://www.netl.doe.gov/coal/E&WR/air\\_q/health\\_effects.html](http://www.netl.doe.gov/coal/E&WR/air_q/health_effects.html)

OSHA. Occupational Safety and Health Guideline for Coal Dust (Greater than or Equal to 5 % SiO<sub>2</sub>).  
<http://www.osha.gov/SLTC/healthguidelines/coaldust-greater5percentsio2/recognition.html>

# Cyanide

## Description of Pollutant

Cyanide is a carbon-nitrogen chemical unit that is a rapidly-acting, potentially deadly chemical that can exist in various forms. Cyanide is manmade but also occurs naturally in the environment. Very small amounts of cyanide are essential in the human diet in the form of Vitamin B12. The most common cyanide compounds are hydrogen cyanide, sodium cyanide, and potassium cyanide.

## Sources

- Cyanide exposure can occur from smoke inhalation from residential or industrial fires.
- Humans can be exposed to cyanide from environmental, occupational, and consumer product sources.
- The single largest source of cyanide in air is from vehicle exhaust.
- Other sources of release to the air may include emissions from chemical processing industries, metallurgical industries, metal plating and finishing industries, and petroleum refineries.
- Cyanides may also be released from public waste incinerators and during the use of cyanide-containing pesticides.
- When certain types of plastics, silk, wool, and paper are burned, cyanides are released.
- People who smoke tobacco take in larger amounts of cyanide than nonsmokers.
- The major sources of cyanide release to water are discharges from publicly owned wastewater treatment works, iron and steel production plants, and organic chemical industries.
- The largest sources of cyanide releases to soil are probably from the disposal of cyanide wastes in landfills and the use of cyanide-containing road salts.
- Cyanide gas is used to exterminate pests and vermin in ships and buildings.

## Human Exposure Pathways

- Smoking cigarettes is probably one of the major sources of cyanide exposure for people who do not work in cyanide-related industries.
- Cyanides are readily absorbed by the inhalation, oral, and dermal routes of exposure.

## Human Health Effects

- Skin contact with dust from certain cyanide compounds can cause skin irritation and ulcerations.
- Inhalation exposure to cyanide causes rapid effects. Exposure of humans at a level of 110 ppm can cause death within 30 minutes to 1 hour.
- Occupational exposure to lower concentrations causes breathing difficulties, nervousness, vertigo, headache, nausea, vomiting, precordial pain, and electrocardiogram (EKG) abnormalities.
- Exposure to higher concentrations results in convulsions, low blood pressure, slow heart rate, loss of consciousness, lung injury and respiratory failure leading to death.
- Neurotoxicity has been observed following ingestion and inhalation of cyanides.
- Effects on the nervous system believed to be from long-term exposure to cyanide include deafness, vision problems, and loss of muscle coordination. Effects on the thyroid gland can cause cretinism (retarded physical and mental growth in children), or enlargement and overactivity of the gland.
- Survivors of serious cyanide poisoning may develop heart and brain damage.

### Exposure Standards

- The subchronic and chronic oral RfDs are 0.02 mg/kg/day for cyanide; 0.04 mg/kg/day for sodium cyanide, calcium cyanide, and cyanogen; 0.05 mg/kg/day for potassium cyanide, chlorine cyanide, and zinc cyanide; 0.1 mg/kg/day for silver cyanide; and 0.2 mg/kg/day for potassium silver cyanide.
- The Environmental Protection Agency (EPA) allows levels of cyanide in food ranging from 25 ppm in dried beans, peas, and nuts to 250 ppm in spices. The EPA has set a maximum contaminant level of cyanide in drinking water of 0.2 milligrams cyanide per liter of water (0.2 mg/L).
- Cyanide levels in the workplace are regulated by the Occupational Safety and Health Administration (OSHA). OSHA has a legally enforceable exposure limit of 5 milligrams of cyanide per cubic centimeter of air ( $\text{mg}/\text{cm}^3$ ) for cyanide and 11  $\text{mg}/\text{cm}^3$  (or 10 ppm) hydrogen cyanide in air for an 8-hour workday, 40-hour workweek.

### Remediation Processes

- Physical methods of remediation include dilution, membranes, electrowinning, and hydrolysis/distillation.

- Cyanide treatment can also be done with several complexation methods such as acidification/volatilization, metal addition, flotation and solvent extraction.
- Adsorption methods by using minerals, activated carbons and resins to adsorb cyanide from solution.
- Oxidation methods: Bio-oxidation, catalysis, electrolysis, chemical addition and photolysis.

## References

Agency for Toxic Substances and Disease Registry ToxFAQ's- Cyanide.

<http://www.atsdr.cdc.gov/tfacts8.html>

EPA. Consumer Factsheet on Cyanide.

<http://www.epa.gov/safewater/dwh/c-ioc/cyanide.html>

The Risk Assessment Information System: Toxicity summary for cyanide.

[http://risk.lsd.ornl.gov/tox/profiles/cyanide\\_c\\_V1.shtml](http://risk.lsd.ornl.gov/tox/profiles/cyanide_c_V1.shtml)

Young, C. A. and Jordan, T.S. Cyanide Remediation: Current and Past Technologies. <http://www.engg.ksu.edu/HSRC/95Proceed/young.pdf>

# Dioxins

## Description of Pollutant

Dioxins are organic environmental pollutants, sometimes referred to as the most toxic compounds made by mankind. Dioxins accumulate in the fatty, liver, and skin tissue of organisms, and they are very persistent – in other words, dioxins do not dissipate over time. The World Health Organization categorized 2,3,7,8-TCDD as a "known human carcinogen" in February, 1997. Other dioxins are also suspected of being carcinogenic.

## Sources

- Byproducts of incineration and fuel combustion.
- Natural processes such as forest fires and volcanoes.
- Manufacture and use of certain herbicides and chlorine bleaching of pulp and paper.

## Human Exposure Pathways

- Over 95% of the human intake of dioxins is through food, mainly from animal origin.
- People can be accidentally exposed to dioxins from fires in electrical equipment containing PCB's. An explosion at a chemical factory in 1976 in Seveso, Italy and the accidental poisoning of rice oil in Japan and Taiwan are instances where populations were accidentally exposed to high dioxin levels.
- Small amounts of exposure occur from breathing air containing trace amounts of dioxins on particles and in vapor form, from inadvertent ingestion of soil containing dioxins, and from absorption through the skin contacting air, soil, or water containing minute levels.

## Human Health Effects

- Short-term exposure of humans to high levels of dioxins may result in skin lesions, such as chloracne and patchy darkening of the skin, and altered liver function.
- Long-term exposure is linked to impairment of the immune system, the developing nervous system, the endocrine system and reproductive functions.
- Some delay in nervous system development as well as changes of behavior were seen in children of mothers who had been exposed to high levels of dioxins.

- Diabetes, weight loss, liver and heart diseases, conjunctivitis, fatigue, malaise and slowed nervous reactions are some other effects. <http://www.who.int/mediacentre/factsheets/fs225/en/>

## Exposure Standards

### WHO

In 1990, the WHO set a safe daily exposure level of 10 picograms per kilogram of body weight. (A picogram = one millionth of a millionth of a gram.) However, following further studies, this was re-evaluated in 1998 to one to four picograms per day.

### EPA

Maximum contaminant level in drinking water for Dioxin (2,3,7,8-TCDD) is 0.00000003 mg/L.

## Remediation Processes

- Incineration
- SET (non-thermal process equivalent to incineration)
- Subcritical water extraction
- Steam distillation

## References

World Health Organization. Dioxins and their Effect on Human Health. <http://www.who.int/mediacentre/factsheets/fs225/en/>

## Fluorides

### Description of Pollutant

Fluorides are chemical compounds that occur naturally in air, water, soil and most foods.

Fluorides are properly defined as binary compounds, or salts of fluorine and another element. Examples of fluorides include sodium fluoride and calcium fluoride

### Sources

- Coal combustion;
- Waste from steel manufacture, primary aluminum, copper and nickel production, phosphate ore processing, phosphate fertilizer production and use, glass, brick and ceramic manufacturing, and glue and adhesive production;
- Pesticides and controlled fluoridation of drinking-water supplies;
- Phosphate ore production and aluminum manufacture are the major industrial sources of fluoride release into the environment;
- Natural sources include the weathering and dissolution of minerals, volcanic emissions and marine aerosols.

### Human Exposure Pathways

- For adults, the consumption of foodstuffs and drinking water is the principal route for the intake of fluoride.
- In areas of the world in which coal rich in fluoride is used for heating and food preparation, the inhalation of indoor air and consumption of foodstuffs containing increased levels of fluoride also contribute to elevated intakes.
- Infants fed formula receive 50–100 times more fluoride than exclusively breast-fed infants.
- Swallowing toothpaste and other dental products can account for a large percentage of the fluoride to which a small child might be exposed.
- Occupational exposure to fluoride via inhalation or dermal contact likely occurs in individuals involved in the operation of welding equipment or in the processing of aluminum, iron ore or phosphate ore.

### Human Health Effects

- An increased incidence of lung and bladder cancer and increased mortality due to cancer.
- Skeletal fluorosis.

- If you eat large amounts of sodium fluoride at one time, it can cause stomachaches, vomiting, and diarrhea. Extremely large amounts can cause death by affecting your heart.
- Dental fluorosis develops only while the teeth are forming in the jaw and before they erupt into the mouth (age <8 years).
- Several human studies found an increase in birth defects or lower IQ scores in children living in areas with very high levels of fluoride in the drinking water.

## Exposure Standards

### WHO

Drinking water guideline is 1.5 milligrams per liter (mg/L).

<http://www.atsdr.cdc.gov/toxprofiles/tp11-c8.pdf>

### EPA

- EPA determined that the maximum amount of fluoride allowed in drinking water is 4.0 mg/L.
- EPA derived an oral reference dose (RfD) of 0.06 mg/kg/day for fluorine (soluble fluoride).

### OSHA

OSHA has set a legally enforceable limit of 0.2 milligrams per cubic meter (mg/m<sup>3</sup>) for fluorine, 2.0 mg/m<sup>3</sup> for hydrogen fluoride, and 2.5 mg/m<sup>3</sup> for fluoride in workroom air to protect workers during an 8-hour shift over a 40-hour work week.

### National Institute for Occupational Safety and Health

NIOSH recommends air levels of 0.2 mg/m<sup>3</sup> for fluorine, 2.5 mg/m<sup>3</sup> for hydrogen fluoride, and 2.5 mg/m<sup>3</sup> for sodium fluoride in workroom air to protect workers during an 8-hour shift over a 40-hour work week.

### Public Health Service

For the prevention of dental decay, the Public Health Service (PHS) has, since 1962, recommended that public water supplies contain fluoride at concentrations between 0.7 and 1.2 mg/L

## Remediation Processes

- Solidification/stabilization

## References

Agency for Toxic Substances and Disease Registry (ATSDR). Public Health Statement for fluorides, hydrogen fluoride and fluorine.

<http://www.atsdr.cdc.gov/toxprofiles/phs11.html>

Agency for Toxic Substances and Disease Registry (ATSDR). Regulations and advisories

<http://www.atsdr.cdc.gov/toxprofiles/tp11-c8.pdf>

Inchem. Fluorides.

<http://www.inchem.org/documents/ehc/ehc/ehc227.htm>

## **Oil/Petroleum Products**

### **Description of Pollutant**

The word petroleum literally means rock oil or oil from the earth. Petroleum is a fossil fuel and a non-renewable energy source. It is a naturally-occurring liquid that can be distilled or refined to make fuels, lubricating oils, asphalt, and other valuable products. Petroleum products fall into three major categories: fuels such as motor gasoline and distillate fuel oil (diesel fuel); finished non-fuel products such as solvents and lubricating oils; and feedstock, such as naphtha and various refinery gases, for the petrochemical industry. Demand is greatest for products in the fuels category, especially motor gasoline. Transportation is the greatest single use of petroleum, followed by industrial use.

### **Sources**

- Spills during transportation;
- Leaking underground storage tanks;
- Waste oil from industries;
- Occurs naturally.

### **Human Exposure Pathways**

- Air: Inhalation exposure to petroleum vapors.
- Water: Surface and groundwater that are sources of drinking water may be contaminated with oil and petroleum products.
- Soil: Humans may come in contact with soil contaminated with oil through spills or leaks.
- Dermal contact through skin absorption.

### **Human Health Effects**

- Benzene is a naturally occurring hydrocarbon found in crude oil, and in natural gas. High levels of exposure to benzene – often 100 parts per million (ppm) or greater – have been found to be associated with an increased incidence of leukemia among workers in various industries. Benzene is a recognized carcinogen.
- Oil mists contain sulfur and lead, and inhaling them over an extended period of time may cause respiratory illnesses such as larynx cancer, skin or eye diseases.
- Inhalation of high concentrations of oil mist may cause irritation of the lungs.
- Prolonged contact with mineral oil has the associated risk of developing skin conditions such as oil folliculitis, eczematous dermatitis, melanosis of the face and plantar warts.

- A number of studies have linked cancers of the skin and scrotum to mineral oil exposure.
- Other effects include fatigue, breathlessness, cough, headache, diarrhea, weight loss, memory loss, immune suppression and chemical sensitivity.
- Skin exposure to petroleum has been known for many years to cause skin cancer, rashes, eczema, acne, and dermatitis.

## Exposure Standards

### USEPA

The EPA has set the maximum permissible level of benzene in drinking water at 0.005 milligrams per liter (0.005 mg/L).

### OSHA

The Occupational Safety and Health Administration (OSHA) has set a permissible exposure limit of 1 part of benzene per million parts of air (1 ppm) in the workplace during an 8-hour workday, 40-hour work week.

## Remediation Processes

- Bioremediation;
- Thermal resorption;
- Containment and Recovery using booms and skimmers;
- Absorption;
- Dispersants;
- Insitu burning.

## References

Overview of Oil spills

[http://www.temple.edu/environment/review\\_oil\\_spills.htm](http://www.temple.edu/environment/review_oil_spills.htm)

## PAHs (Polycyclic Aromatic Hydrocarbons)

### Description of Pollutant

Polycyclic aromatic hydrocarbons (PAHs) are hydrocarbon compounds with multiple benzene rings. PAHs are typical components of asphalts, fuels, oils, and greases and a few are used in medicines or to make dyes, plastics, and pesticides. They are also called Polynuclear Aromatic Hydrocarbons. Although hundreds of PAHs exist, two of the more common ones are benzo(a)pyrene and naphthalene

### Sources

- PAHs are released during the incomplete burning of coal, oil and gas, and garbage.
- Forest fires and volcanoes can produce PAHs naturally.
- In the home, PAHs are present in tobacco smoke, smoke from wood burning stoves and fireplaces, creosote-treated wood products and some food.
- Barbecuing, smoking or charring food over a fire greatly increases the amount of PAHs in food.
- Roasted coffee, roasted peanuts, refined vegetable oil, grains, vegetables and fruits may contain low levels of PAHs.
- A variety of cosmetics and shampoos are made with coal tar and therefore may contain PAHs.
- The PAH compound naphthalene is present in some mothballs.

### Human Exposure Pathways

- Exposure to polycyclic aromatic hydrocarbons usually occurs by breathing air contaminated by wild fires or coal tar.
- Eating foods that have been grilled.
- PAH can be absorbed through the skin. Exposure can come from handling contaminated soil or bathing in contaminated water. Low levels of these chemicals may be absorbed when a person uses medicated skin cream or shampoo containing PAHs.

### Human Health Effects

- Short term exposure may cause red blood cell damage leading to anemia and consequently a suppressed immune system
- Long term exposure is believed to cause developmental and reproductive effects and cancer.
- Other long-term health effects caused by exposure to PAHs may include cataracts, kidney and liver damage and jaundice.

- Dermal contact can result in skin redness and irritation.

## Exposure Standards

### EPA

Benzo(a)pyrene a common PAH has a maximum contaminant level (MCL) of 0.0002 mg/l (milligrams per liter) in drinking water

### OSHA

Has set a limit of 0.2 milligrams of PAHs per cubic meter of air (0.2 mg/m<sup>3</sup>). The OSHA Permissible Exposure Limit (PEL) for mineral oil mist that contains PAHs is 5 mg/m<sup>3</sup> averaged over an 8-hour exposure period.

## Remediation Processes

- Soil washing
- Insitu bioremediation
- Wet sorting
- Pumping and filtration
- Biodegradation, volatilization, irreversible sorption, and direct plant uptake

## References

ATSDR. Toxfaqs for Polycyclic Aromatic Hydrocarbons (PAHS).  
<http://www.atsdr.cdc.gov/tfacts69.html>

## Pesticides

### Description of Pollutant

Pesticides find wide application in the agricultural industry to protect food from pests, such as insects, rodents, weeds, mold, and bacteria. It constitutes a major portion of the pollutants found in rivers and streams. The application of pesticides may be harmful to the targeted organism but also to useful insects and has the capacity to accumulate in the food chain.

### Sources

- Runoff from heavy rainfall;
- Illegal dumping;
- Agriculture industry;
- Over application in lawns etc.

### Human Exposure Pathways

- People can be exposed to pesticides and insecticides by eating food on which it has been applied or by drinking water from sources contaminated by pesticides. A 1994 study estimated that some 14.1 million Americans drank water contaminated with the pesticides atrazine, cyanazine, simazine, alachlor, and metolachlor. The manufacturers of these agricultural herbicides have shown that these chemicals may cause cancer, birth defects, and genetic mutations.  
<http://www.nrdc.org/health/kids/ocar/chap7.asp>
- Children maybe exposed to pesticide residues from their agriculture-worker parents through dust and soil.

### Human Health Effects

- Children, infants, and fetuses may be especially vulnerable to the health effects of pesticides. Children may be more susceptible to loss of brain function if exposed to neurotoxins, and may be more susceptible to damage to their reproductive systems. Increased odds of childhood leukemia, brain cancer and soft tissue sarcoma have been associated with children living in households where pesticides are used. Other childhood malignancies associated with pesticide exposures include neuroblastoma, Wilms' tumor, Ewing's sarcoma, non-Hodgkin's lymphoma, and cancers of the brain, colorectum, and testes.
- Pesticides are intentionally toxic substances. Some chemicals commonly used on lawns and gardens have been associated

with birth defects, mutations, adverse reproductive effects, and cancer in laboratory animals.

- *Toxicology and Industrial Health* published a study showing that the natural mix of chemical pesticides and fertilizers – in concentrations mirroring levels found in groundwater – can significantly affect immune and endocrine systems as well as neurological health
- The Canadian Institute for Child Health has found that children are increasingly at risk of serious diseases from pesticides. The study said cancer rates in children grew 25 percent since 1975.
- <http://www.ecochem.com/pesticides.html>
- Many herbicides are known, probable, or suspected carcinogens (cancer-causing chemicals).

## Exposure Standards

### EPA

- Maximum Contaminant Level (MCL) of 3.0 parts per billion (ppb) was established in 1991 (Safe Drinking Water Act) for atrazine (herbicide);
- MCL for chlordane is 2ppb;
- MCL for endrin is 2 ppb.

## Remediation Processes

- On site bioremediation;
- Phytoremediation;
- Dehalogenation;
- Chemical extraction;
- High temperature thermal desorption;
- Incineration.

## References

Ecochem. Health Risks associated with pesticides and herbicides.

<http://www.ecochem.com/pesticides.html>

Natural Resources Defense Council. Drinking Water Contamination.

<http://www.nrdc.org/health/kids/ocar/chap7.asp>

## PCB's (Polychlorinated biphenyls)

### Description of Pollutant

PCB's or polychlorinated biphenyls are manmade industrial chemicals that were synthesized and commercialized in North America from 1929. They were used in many different types of products including hydraulic fluid, casting wax, pigments, carbonless copy paper, vacuum pumps, compressors, heat transfer systems, and electrical equipment. Because of their fire resistance and insulating properties they were the fluid of choice for transformers and capacitors. PCB's are resistant to degradation and therefore persist for many years in the environment. Furthermore, they bioaccumulate in the food chain and are stored in the body fat of animals and humans. PCB's were banned from use in the U.S. in the early 70's.

### Sources

- PCB's may be released into the environment during manufacture, use, or by the careless disposal of materials and obsolete equipment.
- Accidental leakage and spills during transport or from fires and leaks in products containing PCBs.
- PCBs may leach out from hazardous waste disposal sites and landfills. Additionally it may be released from illegally dumped industrial wastes.
- PCB's are highly persistent in the environment and bind strongly to soils, organic particles, and bottom sediments. PCB's accumulate in fish and marine mammals and can be magnified several thousand times above background levels.

### Human Exposure Pathways

- A major route of human PCB exposure is through eating PCB-contaminated fish.
- Inhalation is a more direct exposure route to certain sensitive tissues (such as the nasal passages) and the blood stream. Several occupational health studies have detected PCB health effects primarily through inhalation of PCB vapors.
- PCBs can be rapidly absorbed through the skin. Experts with the National Institute of Health speculate that, due to the transport of PCBs on dust particles, the current primary route of exposure of most people (non-fish-eaters) to PCBs is through skin exposure.
- Occupational studies show that skin absorption of PCBs is generally the route of entry into the bodies of exposed workers.
- PCB's are known to be passed from the mother to the fetus through placental blood, and to the baby via breast milk.

## Health Effects

PCB exposure of the smallest amount poses serious health risks. Health effects include:

- Skin ailments called chloracne;
- Reproductive disorders;
- PCB's are a known animal carcinogen. The EPA and the International Agency for Research on Cancer (IARC) have determined that PCBs are probably carcinogenic to humans.
- Health risks include nervous system damage. (Parkinson's, mood disorders, memory problems, etc.).
- Liver damage - jaundice, nausea, weight loss, edema, abdominal pain from internal poisoning.
- Rice Oil Disease in Japan - 2000 ppm caused eye discharge, acne, uterine ulcer, excess pigmentation, miscarriage, stillbirth, abnormal pigmentation on infants.
- Chronic PCB toxicities can result in liver damage in mammals, damaged pericardia, kidneys, spleen and liver and shell thinning in birds.
- Other effects include progressive weight loss, bone marrow depression, abdominal pain, numbness of limbs, swelling of joints, chronic cough, menstrual irregularity, abnormal tooth development, low birth weight, hyperpigmentation, fatigue and headache.
- Elevations in blood pressure, serum triglyceride, and serum cholesterol have also been reported with increasing serum levels of PCBs in humans.

## Exposure Standards

### FDA

- Advises against eating fish with more than 2 parts per million PCB's.
- Infant foods, eggs, milk and other dairy products, fish and shellfish, poultry and red meat should contain no more than 0.2-3 parts of PCBs per million parts (0.2-3 ppm) of food.

### EPA

Established a maximum contaminant level of 0.5 parts per billion of PCB's in drinking water.

### NIOSH (National Institute of Occupational Safety and Health)

The federal occupational health limit for PCBs in the air of workplaces is 1 microgram/m<sup>3</sup>, based on an 8-hour day, 5-days a week.

### Remediation Processes

- Incineration;
- Slurry-phase bioremediation;
- Solvent extraction;
- Thermal desorption;
- Other processes include vitrification, solidification/stabilization and direct chemical oxidation.

### References

Agency for Toxic Substances and Disease Registry (ATSDR). ToxFAQ's- Polychlorinated biphenyls. <http://www.atsdr.cdc.gov/toxprofiles/tp17.html>

Berends, D. Remediation Technologies. <http://www.envirotools.org/factsheets/remeditech.pdf>

Envirotools. Soil, Sediment, Bedrock and Sludge <http://www.envirotools.org>

U.S. Environmental Protection Agency. Polychlorinated biphenyls. <http://www.epa.gov/opptintr/pcb/>

## VOCs (Volatile Organic Compounds)

### Description of Pollutant

VOCs are carbon-based compounds that easily evaporate into the atmosphere. VOCs typically are industrial solvents, such as trichloroethylene; fuel oxygenates, such as Methyl Tertiary Butyl Ether (MTBE); or by-products of chlorination in water treatment, such as chloroform. VOCs are often components of petroleum fuels, hydraulic fluids, paint thinners, and dry cleaning agents and are common ground-water contaminants.

### Sources

- Emission sources include paints, varnishes, moth balls, solvents, gasoline and newspapers.
- They are present in exhaust fumes, cigarette smoke, synthetic materials and household chemicals.
- Point sources of VOCs include chemical plants, cement manufacturers, steel mills, power plants, surface coating operations, and printing operations.
- Construction and industrial machinery, farm equipment, railroads, lawn and garden equipment, boats, and aircrafts are other sources of VOCs.

### Human Exposure Pathways

- Inhalation of VOCs from new carpeting, adhesives, draperies; wood products that use certain glues, finishes, and waxes in the manufacturing process; and vinyl type flooring and wall coverings.
- VOCs may enter the water supply through agricultural or industrial run-off.
- Dermal contact is another exposure pathway.

### Human Health Effects

- Acute health effects are eye, nose and throat irritation, headaches, nausea, vomiting, dizziness and asthma exacerbation;
- Chronic effects are cancer, liver, kidney and central nervous system damage;
- It could be irritating to the skin upon contact.

### Exposure Standards

EPA

There are many different VOCs, with different standards for each. Maximum contaminant levels of VOCs in drinking water can be obtained from the EPA website: <http://www.epa.gov/safewater/mcl.html#mcls>

## ATSDR

Minimal risk levels for hazardous substances can be obtained from the ATSDR website: <http://www.atsdr.cdc.gov/mrls.html>

## **Remediation Processes**

- Air stripping
- Soil vapor extraction
- Groundwater/air sparging
- Biosparging
- Enhanced vapor recovery
- Bioremediation
- Pump and treat systems
- Trench and gate containment

## **References**

USEPA: Sources of Indoor Air Pollution - Organic Gases (Volatile Organic Compounds - VOCs) <http://www.epa.gov/iaq/voc.html>

USGS: Toxic Substances Hydrology Program: VOCs.  
<http://toxics.usgs.gov/definitions/vocs.html>