

**Appendix B
Major Pollutants Chart**

Pollutant	Location	Source(s)	Environmental Impact	Human Health Effects	Prevent/Remediate
Aluminum	Soil; naturally occurring element	Naturally occurring	More soluble if acidic conditions Toxic to fish unless pH > 5.5; High levels of Al toxic to plants; Does not bioaccumulate	Pulmonary problems The FDA has ruled Al in cooking utensils, foil, antacids, and antiperspirants is safe	Prevent—maintain pH in ecosystems by preventing acid deposition Remediate—increase the pH with buffers to decrease solubility
Arsenic	Soil; water; naturally occurring element	Used in wood preservation; chemical processes; petroleum mining, mining and smelting Was formerly used in pesticides, rodenticides, and herbicides Humans usually ingest arsenic in food or drinking water	Plant toxicity—wilt, brown, die Animal toxicity—causes aquatic organisms to have decreased growth; metabolic failure in many species	Acute—anemia; nausea Chronic—carcinogen, teratogen, likely mutagen, induces chronic fatigue, gastrointestinal disease, anemia, death Acceptable levels in U.S. drinking water is 10 ppb	Prevent—remove arsenic from drinking water; government regulatory action; use other wood preservatives Remediate—phytoremediation with brake fern, which readily removes arsenic; some bacteria can oxidize arsenic
Asbestos	Air (indoor); natural mineral fiber	Added to materials for strengthening and for fire resistance in ceiling tiles, floor tiles, roofing, shingles and siding, textured paints and joint compounds, brake pads, and firefighter equipment	Human health effects	Chronic—mesothelioma, lung cancer, asbestosis (scarred lungs from inhaling fibers)	Prevent—banned use in paint/joint compound in 1977; government regulatory action; cover the asbestos with another material; use alternative materials as fire retardants Remediation—removal by qualified professionals
Benzene	Air; water; naturally in petroleum; produced by forest fires and volcanoes	Used as a solvent to make plastics, rubber, and synthetic textiles; gasoline combustion; petroleum refining; ETS	Toxic to aquatic species; Kills plants by damaging roots and leaves Does not bioaccumulate	Acute—anemia, depressed nervous and immune function Chronic—cancer, gene mutation, known human carcinogen	Prevent—avoid spills Remediate—can be broken down by bacteria
Cadmium	Soil; Naturally occurring element	Electroplating; smelting; chemical processes; incineration	Toxic to plants Toxic to wildlife; bioaccumulates in liver and kidney	Acute—affects respiratory system, muscle contractions Chronic—Carcinogen, teratogen, affects growth; reproduction; kidney disease; hypertension	Prevent—Government regulatory action; use an alternative metal in chemical processes Remediate—Phytoremediation with pennycress; bioremediation with bacteria

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CFCs	Air—move from troposphere to stratosphere	Used as solvents; propellants; refrigerants; foam blowing agents Includes methyl chloroform (solvent), halons (fire extinguishers), methyl bromide (crop fumigant), carbon tetrachloride (solvent) and freons (refrigerant)	Chlorine radicals convert ozone to oxygen gas $2O_3 \rightarrow 3O_2$ Increased UV radiation pass through stratosphere Damage to living organisms due to increased UV CFCs are greenhouse gases	Health effects indirect; due to increased ultraviolet radiation Increased skin cancer; cataracts; immunosuppression	Prevent—use other refrigerants and propellants; government regulatory action Difficult to remediate
CO	Air	Incomplete combustion of fossil fuels; gas furnace/space heaters; gas/wood stoves; ETS; car exhaust	Minimal environmental impact except human health; no direct effect on plants	Blood's ability to carry oxygen is impaired Acute—fatigue, impaired vision, headache, dizziness, nausea, confusion High concentrations are fatal	Prevent—maintain wood/gas appliances; catalytic converter in autos; decrease use fossil fuels; government regulatory action Remediate—increase ventilation; improve efficiency
CO ₂	Air	Combustion of biomass, solid waste, or fossil fuels		Very little unless CO ₂ increases dramatically as in a confined space; then causes acidosis Climate change due to CO ₂ will have more human health impacts	Prevent—government regulatory action; use alternative energy resources; maintain forests; improve energy efficiency to decrease fossil fuel consumption; mass transit, carpooling, bicycles to decrease CO ₂ emissions from vehicles Remediate - Plant vegetation; Pump carbon dioxide into underground storage
Copper	Soil; water	CuSO ₄ (copper sulfate)— Algicide	Plant micronutrient Highly toxic to amphibians; bioaccumulates in some species	Acute—nausea, vomiting, cough, headache, difficulty breathing Chronic—liver cirrhosis; low blood pressure; fetal mortality; kidney and brain necrosis	Prevent—use mechanical or biological methods to remove algae Remediate—electric current can remove copper from contaminated soil

Pollutant	Location	Source(s)	Environmental Impact	Human Health Effects	Prevent/Remediate
Cyanide	Soil; water	HCN; CN Gold mining; industrial discharge	Fish very sensitive—does not bioaccumulate; not persistent Sublethal fish effects—decreased reproduction; growth altered	Acute—suppresses aerobic respiration; rapid breathing and tremors Chronic—weight loss, nerve damage	Prevent—avoid release; utilize other chemical processes Remediate - bioremediation; Chemical remediation
Dioxins	Soil; water	Group of similar chemical compounds Not produced intentionally; naturally produced in forest fires; anthropogenic sources include incineration; chlorine bleaching at paper mills; ETS Most toxic is TCDD Human exposure in fish ingested from contaminated waterways; ingestion of animal fat	Bioaccumulates in fat Animal toxicity—Liver toxicity; affects endocrine, immune, nervous and reproductive systems Highly persistent	Acute—chloracne, skin rashes, skin discoloration Bioaccumulates in fat Chronic—liver damage, teratogen, immunotoxic, likely human carcinogen	Prevent—government regulatory action, use chemicals other than chlorine to bleach or sterilize, remove plastics containing chlorine prior to waste incineration, pollution control devices to remove dioxins after incineration Remediate - bioremediation; Chemical remediation; Physical removal of contaminated soil.
Disease agents	Water	Animal and human wastes Indicated by increased levels of fecal coliforms, which may indicate presence of human pathogens	Includes bacteria that cause cholera, typhoid, dysentery, and viruses like hepatitis A May also include <i>Cryptosporidium</i> and <i>Giardia</i> , protozoal parasites that cause gastrointestinal disease	Causes human disease including diarrhea, nausea, and so on.	Prevent—ensure wastes are treated prior to discharge into surface water or groundwater, chlorination, government regulatory action Remediate - treat water to kill organisms
Environmental Tobacco Smoke (ETS)	Air (indoor)	Cigarette smoking	Human health effects	Lung cancer, respiratory disease, heart disease	Prevent—improve ventilation, prevent smoking indoors, government regulatory action Remediate - ventilate; Clean area thoroughly
Formaldehyde	Air (indoor)	Released from building material such as plywood, textiles, furniture stuffing, carpets	Human health effects	Acute/chronic—dizziness, rash, breathing problems, headaches, and nausea	Prevent—use other materials to manufacture materials, use other materials that do not contain formaldehyde Remediate—improve ventilation

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Lead	Air, soil, water	leaded gasoline, leaded paint, leaded solder, lead shot/sinkers, contaminated soil, smelters, incinerators, utilities, automobile batteries	Plants—decreased growth; decreased photosynthesis Animals—CNS damage; sterility; effects similar to human exposures	Acute—abdominal pain, fatigue, sleep disturbance, high blood pressure; death Bioaccumulates in bone Chronic—developmental retardation, impaired IQ, attention deficit, hyperactivity, learning disorders, aggression, carcinogen, damages liver, kidney, thyroid and immune system Adults—high blood pressure, digestive and nerve disorders, memory problems Acceptable levels in U.S. drinking water is 20 ppb	In United States, leaded gasoline, lead shot, leaded solder, and leaded paint banned in United States In older homes—replace copper plumbing that may contain lead solder and remove lead paint (house built before 1978) Remediate—Phytoremediation of soil with sunflowers
Mercury	Air, soil, water	Coal combustion, incineration, smelting Mercury in air settles into water where the inorganic mercury is methylated by bacteria to create the most toxic form methyl mercury Inorganic mercury salts may be in fungicides and disinfectants Human exposure from eating contaminated fish and shellfish—shark, swordfish, kingfish, and tilefish contain high levels of methyl mercury	Highly bioaccumulated and biomagnified Fish of particular concern are shark, swordfish, king mackerel and tilefish Inhibit frog metamorphosis Birds and mammals that eat fish also have high exposures Effects—reduced reproduction, slow growth and development, death	Acute—difficulty walking; loss of coordination; difficulty swallowing; tremors Bioaccumulates in many organs and directly damages cells Chronic—mutagen; teratogen, carcinogen; hallucinations; psychosis; irreversible brain damage Fetal exposure—mental retardation; attention disorders; seizures; blindness	Prevent—reduce release of mercury into atmosphere—EPA issued Clean Air Mercury Rule in 2005 to regulate emissions of mercury by utilities Federal bans on mercury in paint and pesticides Remediate—phytoremediation

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Methane	Air	Naturally produced during decomposition Anthropogenic sources are decomposition in landfills, wastewater treatment, and livestock production Emitted by the production and transport of fossil fuels	Greenhouse gas—20 times greater heat holding capacity than CO ₂	Human health impacts related to global warming	Prevent—government regulatory action; use methane from decomposition as energy source
MTBE	Water	Gasoline additive that promotes complete combustion to reduce CO and O ₃ release	Persistent in the environment, no studies indicate specific damage to wildlife	Not considered a threat to human health at this time; inhalation may be linked to lung cancer	Prevent—prevent leaking from underground storage tanks; use an alternative oxygenate in fuel Remediate—chemical processing of contaminated soil and water
NO _x	Air; water	Fossil fuel combustion—particularly gasoline; burning of solid wastes; industrial processes; Primary air pollutant that leads to photochemical smog N ₂ O from feedlots is a greenhouse gas Water pollutant derived from movement of fertilizers	Forms nitric acid (HNO ₃) in atmosphere—contributes to acid deposition Directly damages cuticles on plants so damages leaves Reduces crop yields Reacts with sunlight to form photochemical smog Eutrophication when in the form of nitrites (NO ₂) or nitrates (NO ₃) Decreases visibility Low pH in aquatic systems may stress sensitive organisms; increases Al solubility and toxicity; decreases biodiversity by reducing food available at lower trophic levels	See impacts of ozone because NO _x forms ozone in photochemical smog Human health impacts from drinking excess nitrates Acute—children can have impaired oxygen transport; death may result Chronic—urinary problems, spleen damage, hypertension	Prevent—increase efficiency; decrease fossil fuel use; use fluidized bed combustion; emissions standards for motor vehicles and power plant government regulatory action Remediate—treat acidified ecosystems with lime

Pollutant	Location	Source(s)	Environmental Impact	Human Health Effects	Prevent/Remediate
Oil (petroleum)	Water	Natural release; leaks from oil rigs, tankers, and pipelines	Directly kills animals; suffocation of filter feeders; damage to habitat	Toxicity related to specific chemicals in petroleum	Prevent—government regulatory action; require double hulls on tankers Remediate—oil degrading microbes
Oxygen demanding wastes	Water	Sewage; wastes from food production; meatpacking plants	Decomposition of the wastes removes DO in water resulting in anoxia	Human health impacts related to pathogens carried in the wastes	Prevent—government regulatory action; increase oxygenation of contaminated water
Ozone	Air	O ₃ : Secondary air pollutant arising from NO _x and VOCs; major component of photochemical smog	Damages plant cells; interferes with food storage in plants; reduces crop yields and increases disease susceptibility Decreases visibility	Usually highest during the summer; respiratory problems; irritate respiratory system resulting in discomfort, coughing, and throat irritation; impairs respiration; exacerbates lung disease	Prevent—government regulatory action; improved fuel efficiency; alternative fuel methods for automobiles; mass transit, carpooling, bicycles
Particulates (PM)	Air	Solid and liquid droplets in air; soot, dust, soil, and smoke from erosion or combustion source	If densely accumulate on plant leaves, can impair photosynthesis If particles are acidic, contributes to acid deposition May increase nutrient levels in surface water Impairs visibility Can damage and stain stone, which decreases the aesthetic value of monuments and statues	Irritate respiratory tract, leading to coughing and difficulty breathing; exacerbates lung disease	Prevent—electrostatic precipitators, bag filter, cyclone collector; wet scrubber; government regulatory action; energy efficiency decreasing fossil fuel use
PCBs	Soil; water	Solids and oily liquids used as lubricants, fire retardants, hydraulic fluids, adhesives, transformer fluids; landfills; incineration	Highly persistent; bioaccumulate Wildlife—deformities; high mortality rates; impairs reproduction	Acute—acnelike skin eruptions; skin pigmentation; vision and hearing impairment; spasms Chronic—mutagen; carcinogen; teratogen; interferes with function of thyroid hormones bioaccumulates in liver, muscle, and fat	Prevent—government regulatory action; use alternative materials Remediation—High temperature incineration; bacterial bioremediation
Pesticides	Soil; water	Agriculture; urban areas; golf courses	DDT—Very persistent Birds—eggshell thinning; infertility Mammals—toxic to embryos and fetuses	Neurotoxin—increases neurotransmitter release increasing excitability of muscles; tremors; convulsions; death	Prevent—government regulatory action; use nonpersistent nonbioaccumulating pesticides; IPM

Pollutant	Location	Source(s)	Environmental Impact	Human Health Effects	Prevent/Remediate
Phosphates	Water	Fertilizer; sewage effluent	Eutrophication	None noted	Prevent—decrease nonpoint runoff from agricultural areas; ban detergents that use phosphates; government regulatory action; aerate contaminated water
Plastics	Water	Boat wastes	Harms wildlife by wrapping around their bodies	Production more dangerous than product	Prevent—government regulatory action; ban ocean dumping from ships
Radioactive isotopes	Air; soil; water	Naturally occurring; used in medicine, nuclear power, nuclear weapons, tracers	Increased genetic damage due to radiation	Acute—radiation sickness; death Chronic—cancers	Prevent—government regulatory action; use alternative materials
Radon	Indoor air; rock Produced by the natural radioactive decay of uranium	Naturally occurring radioactive gas in rock beneath homes; well water More frequent in buildings with foundations, basements and in airtight buildings Action level is 4 picocuries/L	None due to ventilation	Chronic—second leading cause of lung cancer in United States; carcinogen	Remediate—build houses without basements or slabs; improve ventilation; avoid building on hot spots; seal cracks
Sediment	Water	Deforestation leading to erosion Agricultural erosion Natural weathering of rock Mining	Increased water turbidity decreases photosynthesis due to decreased light penetration; sediment may cover benthic organisms; sediment may clog gills of filter feeders; may cover rocks in salmon spawning sites in streams	None—it is a water quality issue	Prevent—government regulatory action; sediment buffers when constructing; erosion control methods used in agriculture and mining

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SO ₂	Air	Coal combustion; industrial processes; smelting; petroleum refineries; natural sources such as volcanoes	<p>Acid deposition when combines with water vapor in the atmosphere to form sulfuric acid (H₂SO₄)</p> <p>Directly damages cuticles on plants so damages leaves; weathers carbonate rocks; acidifies ecosystems; reduces crop yield</p> <p>Low pH in aquatic systems may stress sensitive organisms; increases Al solubility and toxicity; decreases biodiversity by reducing food available at lower trophic levels</p> <p>Damages buildings, statues, and monuments</p> <p>May create sulfur haze which reflects sunlight resulting in global cooling</p> <p>Decreases visibility</p>	Respiratory difficulty; exacerbates lung and heart disease	<p>Prevent—wash coal; use anthracite (less S); increase energy efficiency; decrease fossil fuel use; fluidized bed combustion; coal liquefaction; coal gasification; use natural gas; lime scrubbers; pollution credits and other government regulatory action; decreases fossil fuel use and increase energy efficiency</p> <p>Remediate—treat acidified ecosystems with lime or ammonia</p>

Pollutant	Location	Source(s)	Environmental Impact	Human Health Effects	Prevent/Remediate
Thermal pollution	Water	Power plant and industrial cooling	<p>Temperature sensitive organisms may be killed</p> <p>Hotter temperatures may interfere with reproduction, growth rates, and levels of biodiversity</p> <p>Fish may require more food because they grow all year around in warmer waters</p> <p>Dissolved oxygen levels decrease in warmer water</p>	None	Prevent—use alternative energy resources that do not require cooling; cooling ponds or towers to cool hot water prior to being released into natural systems
VOCs	Air	<p>Indoor—paints, building materials, cleaning supplies, permanent markers, copiers, ETS</p> <p>Outdoor—component of photochemical smog; natural production from plants; vehicles</p>		<p>Acute—headache, nausea, eye, nose and throat irritation; CNS damage; difficulty breathing</p> <p>Chronic—some cause cancer, such as benzene, due to DNA mutation</p>	<p>Prevent—Avoid products that release VOCs; throw away partly used containers; catalytic converter in cars; government regulatory action</p> <p>Remediate—increase ventilation; remove source</p>