PUBH 7120: Environmental Health I

Lecture 07
Metals and Organics

School of Public Health
University of Memphis

Outline

1. Metals
2. Organic chemicals
    1) VOCs
    2) PAHs
    3) PCBs and Dioxins
    4) Pesticides
    5) PBDEs
    6) Plasticizers
    7) PFAS
    8) ECDs
    9) POPs

Learning Objectives

1. Identify metals and organics that pose health hazards to humans.
2. Distinguish between essential and toxic levels of metals.
3. Identify sources and routes of human exposure to organics and metals.
4. Describe and assess the adverse health effects of exposure to organics and metals.

Required Readings

Friis 2018 (3rd Ed.). Chapters 6 and 7.

Section 1
Metals in the Environment

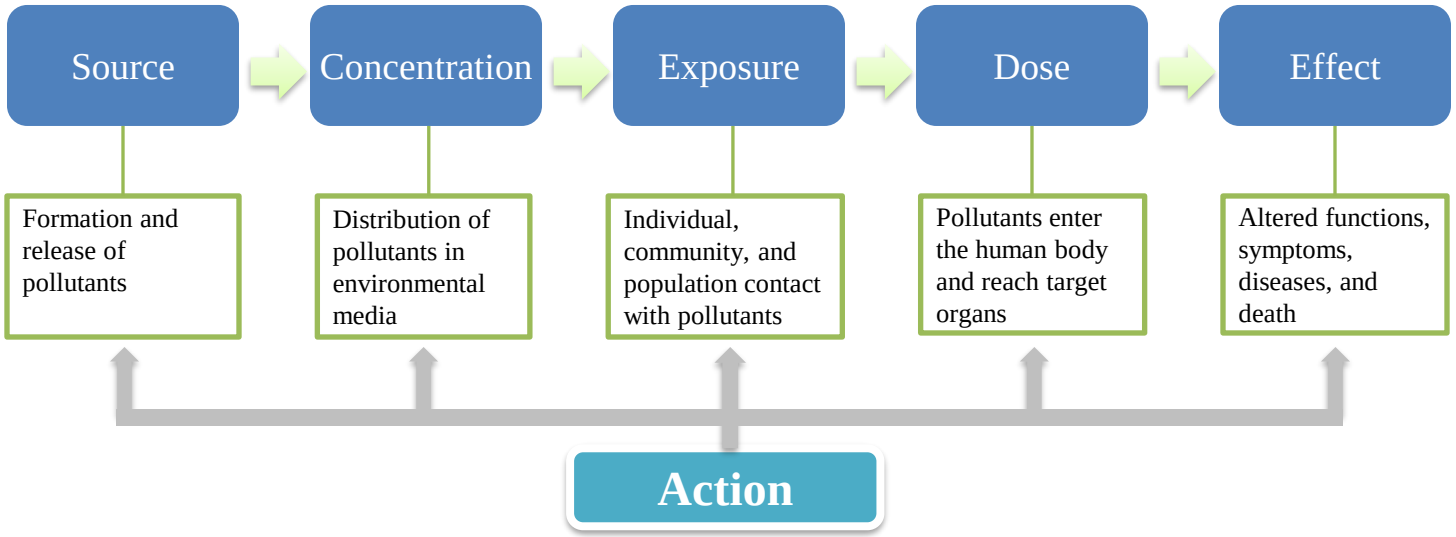
The CERCLA Substance Priority List (SPL)

- The Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA)

2015 RANK	SUBSTANCE NAME	TOTAL POINTS	2013 RANK	CAS RN
1	ARSENIC	1671.6	1	007440-38-2
2	LEAD	1529.4	2	007439-92-1
3	MERCURY	1458.6	3	007439-97-6
4	VINYL CHLORIDE	1358.9	4	000075-01-4
5	POLYCHLORINATED BIPHENYLS	1345.1	5	001336-36-3
6	BENZENE	1327.6	6	000071-43-2
7	CADMIUM	1318.8	7	007440-43-9
8	BENZO(A)PYRENE	1304.4	8	000050-32-8
9	POLYCYCLIC AROMATIC HYDROCARBONS	1279.1	9	130498-29-2
10	BENZO(B)FLUORANTHENE	1249.7	10	000205-99-2
11	CHLOROFORM	1202.4	11	000067-66-3
12	AROCLOR 1260	1190.0	12	011096-82-5
13	DDT, P,P'-	1182.0	13	000050-29-3
14	AROCLOR 1254	1171.3	14	011097-69-1
15	DIBENZO(A,H)ANTHRACENE	1155.6	15	000053-70-3

This priority list is not a list of "most toxic" substances, but rather a prioritization of substances based on a combination of their frequency, toxicity, and potential for human exposure at NPL sites. https://www.atsdr.cdc.gov/spl/

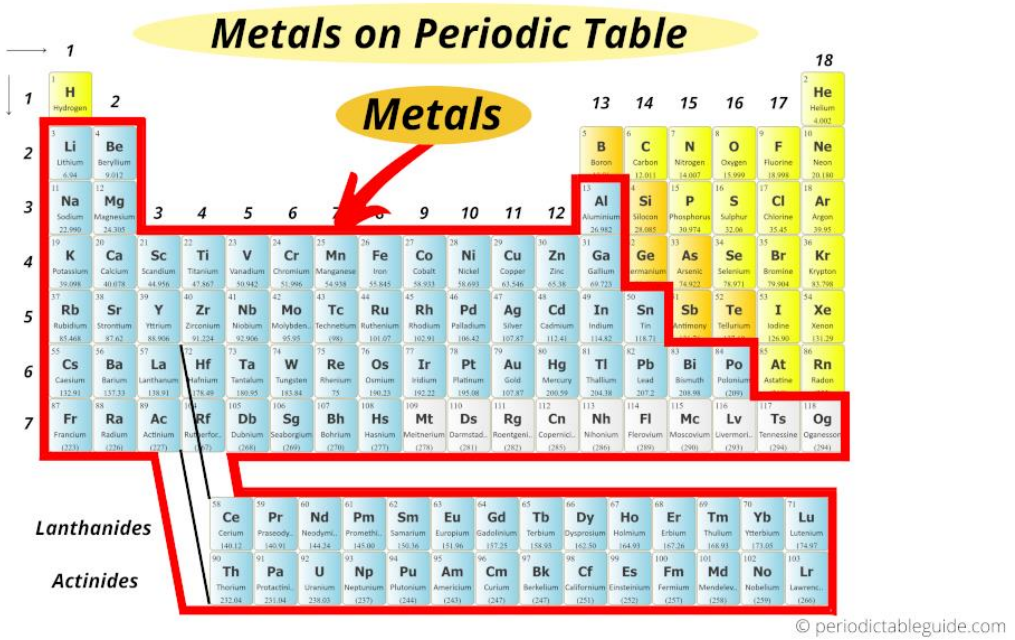
EH framework: the SCEDEA Model



- What is this chemical?
- What are the sources?
- How persistent is it in various environ. media?
- What are the major exposure pathways/routes?
- What are the health effects from exposure?
- What are the regulations and standards?

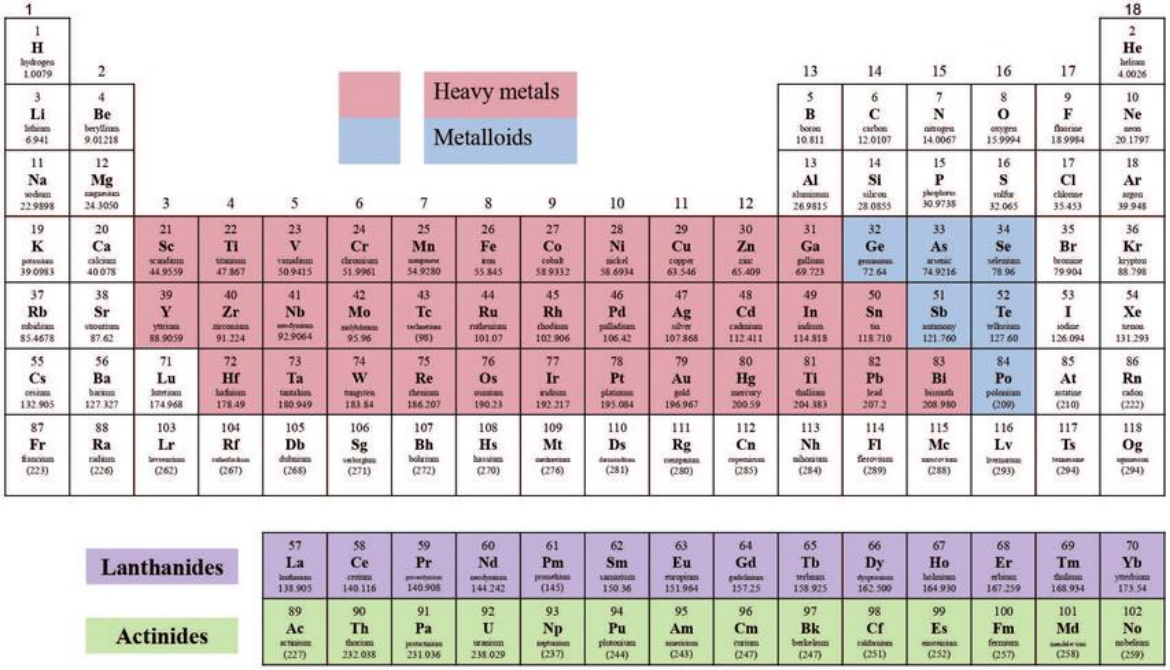
What is a metal?

- high electrical and thermal conductivity
- three-quarters of all known chemical elements are metals
- Earth's crust are aluminum, iron, calcium, sodium, potassium, and magnesium.
- found in ores (mineral-bearing substances)
- a few such as copper, gold, platinum, and silver frequently occur in the free
  - Luster
  - Conductive
  - Crystalline
  - Malleable
  - Solid



What is a heavy metal?

- Atomic density above 5 g cm^{-3}
- Atomic number greater than 20
- Essential and nonessential heavy metals
  - Cu, Fe, Mn, Co, Zn (essential)
    - Can be toxic at high dose
  - Cd, Pb, Hg, Cr, As



Sources

- **Lead** – Gasoline, Paint, Waste Incineration, Coal Combustion, Natural Sources, Lead Shot and Sinkers
- **Arsenic** – Natural Sources, Burning Treated Wood, Metal Smelting, Pesticides
- **Mercury** – Coal Combustion, Medical Waste Incineration, Smelting, Pesticides, Accidents (breaking thermometers)
- **Cadmium** – Fuel Combustion, Cu/Ni Smelting, Cd Refining (from Zn ores), Electroplating, Battery Manufacture, Pigments, Smelting/Refining Metals, Combustion of Fossil Fuels

Classification of the toxic effects of metals

Major Toxic Metals	Essential Metals	Metals Related to Medical Therapy	Minor Toxic Metals
Arsenic (As) Beryllium (Be) Cadmium (Cd) Chromium (Cr) Lead (Pb) Mercury (Hg) Nickel (Ni)	Cobalt (Co) Trivalent chromium, (CIII) Copper (Cu) Iron (Fe) Magnesium (Mg) Manganese (Mn) Molybdenum (Mo) Selenium (Se) Zinc (Zn)	Aluminum (Al) Bismuth (Bi) Gallium (Ga) Gold (Au) Lithium (Li) Platinum (Pt) and related metals	Antimony (Sb) Barium (Ba) Germanium (Ge) Indium (In) Silver (Ag) Tellurium (Te) Thallium (Tl) Tin (Sn) Titanium (Ti) Uranium (U) Vanadium (V)

Heavy metals - high atomic weight with a density that exceeds the density of water by five or more times.

Health effects

- Historically focused on effects of acute exposure to high concentrations
  - Lead – Abdominal colic
  - Mercury – Bloody diarrhea/suppression of urine formation
- Contemporary toxicology focused on chronic exposure to lower concentrations
  - Lead/Mercury – cognitive and developmental effects in children
  - Arsenic – skin cancer

Carcinogenic and non-carcinogenic effects

- Carcinogenic
  - Arsenic
  - Beryllium
  - Cadmium
  - Chromium (hexavalent)
  - Nickel (compounds)

- Non-carcinogenic
  - Neurotoxicity (As, Pb, Hg)
  - Hepatotoxicity (As)
  - Reproductive/Developmental Toxicity (As, Pb, Hg)
  - Skin/Dermatitis (As, Be, Cr, Hg, Ni)
  - Pulmonary Toxicity (Be, Cd, Hg)
  - Cardiovascular Toxicity (Cd, Hg?)
  - Nephrotoxicity (Cd, Cr, Pb, Hg)
  - Skeletal Effects (Cd)

Diseases caused by metals - Mercury

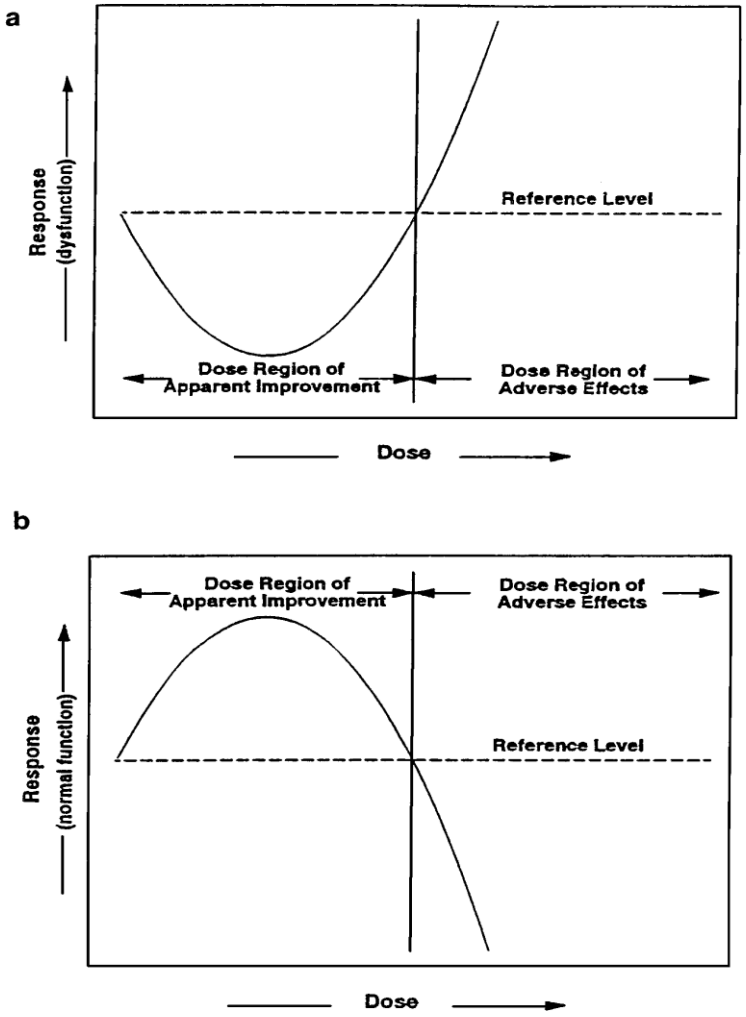
- Minamata Disease
  - Mercury discharged to Minamata Bay, Japan (1950s)
  - Accumulated in fish, consumed by anglers and their families
  - Neurological effects
    - numbness in hands and feet
    - muscle weakness, paralysis
    - impairment of vision, hearing, speech
    - coma
    - death
  - Over 2,000 victims, 1700+ died

Diseases caused by metals - Cadmium

- Itai-Itai (ouch ouch) Disease
  - Cadmium from a mine contaminated rice fields in Japan - early 1900s
  - Contaminated rice consumed by humans caused weak or brittle bones
    - Bone fractures
    - Extreme pain
    - Kidney failure

Essentiality and Hormesis

- Necessary for optimum growth and development - Cobalt, Copper, Iron, Magnesium, Manganese, Molybdenum, Selenium, Zinc
- Toxic at concentrations higher than needed for growth and development.
  - e.g., Cobalt essential as a component of vitamin B12 (production of red blood cells). Toxic effects include Goiter, cardiomyopathy, respiratory irritation.



Flint Water Crisis

- Water crisis in Flint, Michigan
  - April 2014, switch to the Flint River as an interim drinking water source.
  - Complaints of foul look, smell, and taste of water by local residents.
  - The government ignored the public's complaints.
- Water test results after one year:
  - 17% of samples >15 ppb lead (action level)
  - 40% of samples >5 ppb lead (indication of serious problems)
- Causes:
  - Failure to apply corrosion inhibitors
  - Leach of lead from aging pipes to water
- Health impacts:
  - 6,000 – 12,000 children exposed
  - Elevated BLLs from 2.5% in 2013 to 5% in 2015

Lead in Memphis drinking water

- Memphis Light, Gas and Water - Water Quality Report (mlgw.com)

RESULTS OF LEAD AND COPPER SAMPLING AT RESIDENTIAL WATER TAPS

Component	Amount Detected	Maximum Contaminant Level (MCL)	Maximum Contaminant Level Goal (MCLG)	Sites Exceeding Action Level (AL)	Major Sources in Drinking Water
LEAD	6.25 parts per billion (90% of homes tested had lead levels less than 6.25ppb)	Action Level (AL)= 90% of the homes tested must have lead levels less than 15 parts per billion	Zero parts per billion	1 site of 55 exceeded AL	Corrosion of household plumbing systems; erosion of natural deposits
COPPER	0.37 parts per million (90% of homes tested had copper levels less than 0.37ppm)	Action Level (AL)= 90% of the homes tested must have copper levels less than 1.3 parts per million	1.3 parts per million	0 sites of 55 exceeded AL	Corrosion of household plumbing systems; erosion of natural deposits; leaching from wood preservatives

Inequities in heavy metal exposures

- High BLLs in disadvantaged groups
  - The poor
  - African Americans
- Heavy metals in soil – The Urban Backgr

International Journal of *Environmental Research and Public Health*

MDPI

Article

Racial Disparities in the Heavy Metal Contamination of Urban Soil in the Southeastern United States

Daleniece Higgins Jones [1,*], Xinhua Yu [2], Qian Guo [3], Xiaoli Duan [3] and Chunrong Jia [2,*]

Metal	Ranking of Poverty (n = 423)			Ranking of Minority (n = 423)		
	Estimate [1]	%Change [2]	*p*-Value	Estimate [1]	%Change [2]	*p*-Value
Arsenic	1.047	4.7%	0.037	1.134	13.5%	<0.0001 *
Barium	−1.006	−0.6%	0.722	1.036	3.6%	0.048
Cadmium	1.047	4.7%	0.0002 *,[3]	1.055	5.5%	<0.0001 *
Chromium	−1.008	−0.8%	0.516	1.018	1.8%	0.149
Lead	1.054	5.4%	0.011	1.106	10.6%	<0.0001 *
Selenium	1.002	0.2%	0.830	−1.003	−0.3%	0.773
Silver	1.013	1.3%	0.254	1.009	0.9%	0.463

Heavy metals in our daily life

- A toy drive at the University of Memphis collected 72 toys during the 2022 holiday season.
- 10% of toys had Pb or As on their surfaces.
- The toys of major concern were metal, wood, and plastic electronic toys.

SCIBASE Journals
SciBase Epidemiology and Public Health

Screening Toxic Metals in Toys Collected in a Charitable Program

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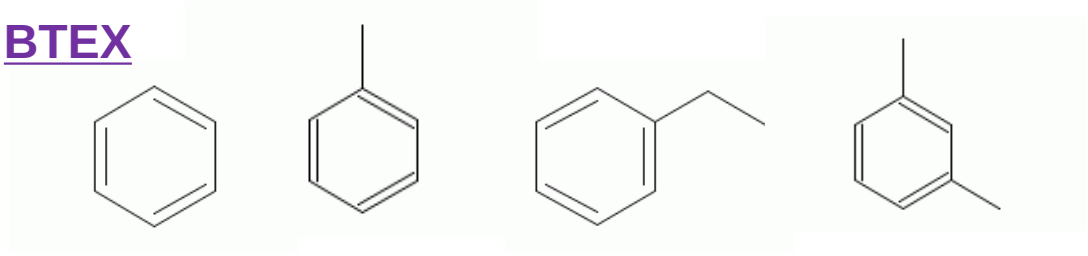
Section 2
Organic Chemicals in the Environment

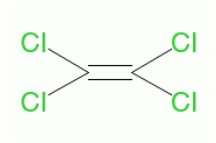
1. Volatile Organic Compounds (VOCs)

- Organic hydrocarbons with vapor pressures >0.1 mm Hg at the room temperature.
- Examples

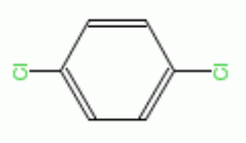
BTEX



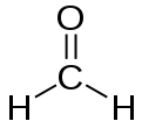
Benzene **Toluene** **Ethyl benzene** **Xylene**



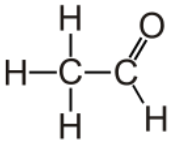
Tetrachloroethylene



p-Dichlorobenzene



Formaldehyde



Acetaldehyde

Sources, concentrations and exposure

- Outdoors
  - Industrial facilities
  - Vehicle exhausts
  - Evaporations of organic solvents

- Indoors

Building Materials	Home and Personal Care Products	Behaviors
• Carpets and adhesives • Composite wood products • Paints • Sealing caulks • Solvents • Upholstery fabrics • Varnishes • Vinyl floors	• Air fresheners • Cleaning and disinfecting chemicals • Cosmetics • Fuel oil, gasoline • Moth balls • Vehicle exhaust in an attached garage	• Cooking • Dry cleaning • Hobbies • Newspapers • Non-electric space heaters • Photocopiers • Smoking • Stored paints and chemicals • Wood burning stoves

Concentrations and exposure

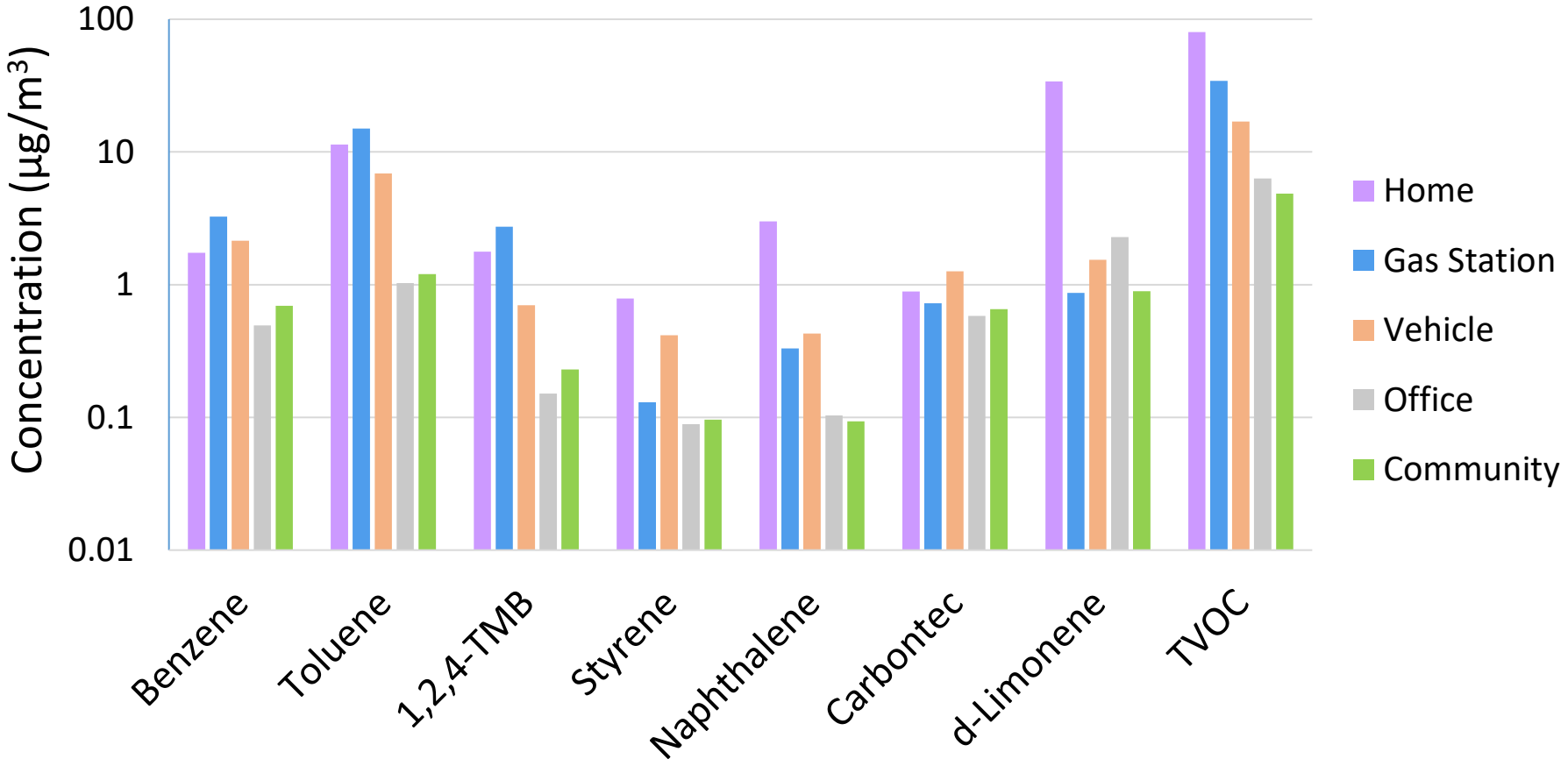
- Concentrations

Medium	Ambient air (µg/m^3)	Indoor air (µg/m^3)	Occupational air (µg/m^3)	Water (µg/L)
Concentration	<10	<10 - 100	> 1000	1-20

- Exposure
  - Mainly from breathing air that contains VOCs
  - Ingestion of contaminated water or food
    - Trihalomethanes (THMs) in tap water
    - By-products of chlorinated disinfectants
  - Skin contact
    - Skin exposure to THMs during shower
    - Occupational exposure to solvents

VOCs in various environments

Home > Gas Station > In-vehicle > Office > Outdoors



Dr. Jia's research on VOCs

Atmospheric Pollution Research 15 (2024) 102236

Contents lists available at ScienceDirect

Atmospheric Pollution Research

journal homepage: www.elsevier.com/locate/apr

Fragrance chemicals in nail salons: Personal inhalation exposures and potential sources

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Air Quality, Atmosphere & Health (2022) 15:465–477
https://doi.org/10.1007/s11869-021-01124-5

Exposure to volatile organic compounds (VOCs) at gas stations: a probabilistic analysis

Chunrong Jia[1] · Xianqiang Fu[1] · Bhavin Chauhan[1] · Zhuqing Xue[1] · Reeva Joyce Kedia[2] · Chaitanya S. Mishra[3]

Received: 23 March 2021 / Accepted: 29 October 2021 / Published online: 10 November 2021

Abstract
Gasoline evaporation and spills may cause high air pollution at gas stations. This study aimed to assess exposure to volatile

International Journal of Environmental Research and Public Health

MDPI

Article

Variability of Total Volatile Organic Compounds (TVOC) in the Indoor Air of Retail Stores

Chunrong Jia [1,*], Kevin Cao [2], Riya Valaulikar [3], Xianqiang Fu [1] and Anna Bess Sorin [3]

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Biomarkers

http://informahealthcare.com/bmk
ISSN: 1354-750X (print), 1366-5804 (electronic)

Biomarkers, 2014; 19(6): 457–462
 DOI: 10.3109/1354750X.2014.935956

informa healthcare

RESEARCH ARTICLE

Blood 2,5-dimethyfuran as a sensitive and specific biomarker for cigarette smoking

Chunrong Jia#, Kenneth D. Ward, Fawaz Mzayek, and George Relyea

School of Public Health, University of Memphis, Memphis, TN, USA

Atmospheric Environment 81 (2013) 112–116

Contents lists available at ScienceDirect

Atmospheric Environment

journal homepage: www.elsevier.com/locate/atmosenv

Short communication

Air toxics concentrations, source identification, and health risks: An air pollution hot spot in southwest Memphis, TN

Chunrong Jia*, Jeffery Foran [1]

School of Public Health, University of Memphis, 337 Robison Hall, Memphis, TN 38152, United States

Environmental Pollution 169 (2012) 152–159

Contents lists available at SciVerse ScienceDirect

Environmental Pollution

journal homepage: www.elsevier.com/locate/envpol

Variability of indoor and outdoor VOC measurements: An analysis using variance components

Chunrong Jia[a,*], Stuart A. Batterman[b], George E. Relyea[a]

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ARTICLE INFO

Article history:

ABSTRACT

This study examines concentrations of volatile organic compounds (VOCs) measured inside and outside

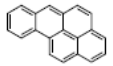
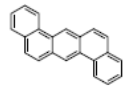
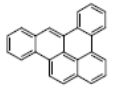
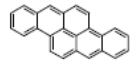
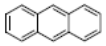
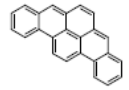
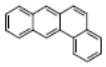
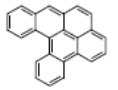
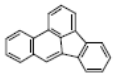
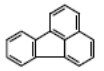
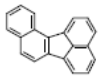
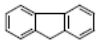
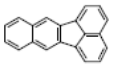
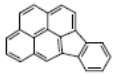
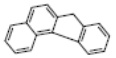
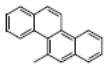
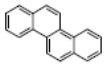
Health effects of VOC exposure

- Short-term (acute) to high levels of VOCs
  - Eye, nose and throat irritation
  - Headaches
  - Nausea / Vomiting
  - Dizziness
  - Worsening of asthma symptoms
- Long-term (chronic) to high levels of VOCs

  Increased risk of:
  - Cancer
  - Liver damage
  - Kidney damage
  - Central nervous system damage

2. Polycyclic Aromatic Hydrocarbons (PAHs)

- PAHs are a class of structurally similar chemical compounds characterized by the presence of fused aromatic rings.
- There are over 100 different PAHs.
- Priority PAHs:
  - US EPA:16 PAHs;
  - EU: 16 PAHs;
  - EU Scientific Committee for Food (SCF): 15 PAHs.

List	Common Name	Structure	List	Common Name	Structure
EPA, SCF, EU	Benzo[*a*] pyrene		EPA, SCF, EU	Dibenzo[*a,h*] anthracene	
EPA	Acenaphthene		EU+SCF	Dibenzo [*a,e*]pyrene	
EPA	Acenaphthylene		EU+SCF	Dibenzo [*a,h*]pyrene	
EPA	Anthracene		EU+SCF	Dibenzo [*a,i*]pyrene	
EPA, SCF, EU	Benzo[*a*] anthracene		EU+SCF	Dibenzo [*a,l*]pyrene	
EPA, SCF, EU	Benzo[*b*] fluoranthene		EPA	Fluoranthene	
SCF, EU	Benzo[*j*] fluoranthene		EPA	Fluorene	
EPA, SCF, EU	Benzo[*k*] fluoranthene		EPA, SCF, EU	Indeno[1,2,3-*cd*]pyrene	
EU	Benzo[*c*]fluorene		EU+SCF	5-Methyl chrysene	
EPA, SCF, EU	Benzo[*ghi*] perylene		EPA	Naphthalene	
EPA, SCF, EU	Chrysene		EPA	Phenanthrene	
SCF, EU	Cyclopenta [*cd*]pyrene		EPA	Pyrene	

Sources and exposures

- PAHs form in incomplete combustion of organic materials.
- Exposure
  - Breathing cigarette smoke, wood smoke, vehicle exhausts, asphalt roads, or agricultural burn smoke
  - Contact with air, water, or soil near hazardous waste sites.
  - Eating grilled or charred meats.

Typical concentrations of PAHs in environment

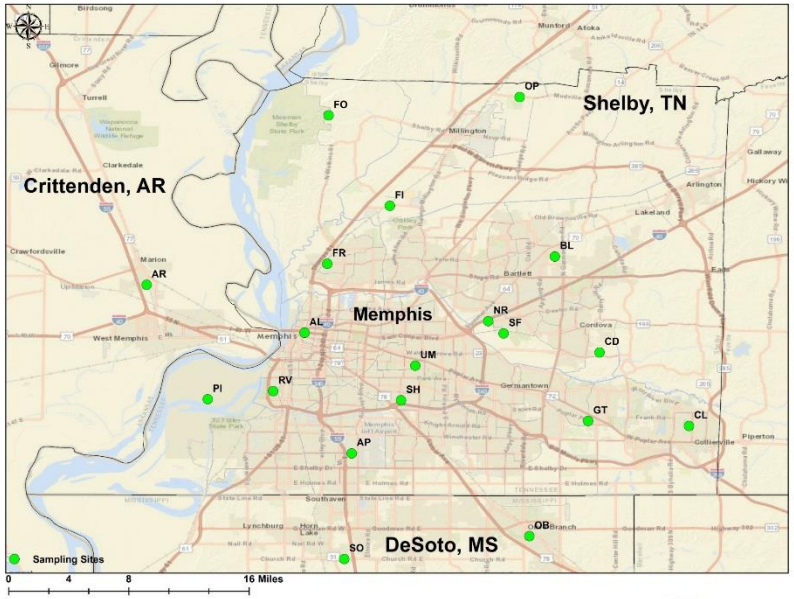
- In air, the average concentration of gas-phase ΣPAHs is ~50 ng/m^3, and that of particulate-phase ΣPAHs is ~2.5 ng/m^3.
- Concentrations of individual PAHs in air:
  - 0.001 ~ 5 ng/m^3 in gas-phase;
  - 0.005 ~ 0.2 ng/m^3 in particulate-phase.
- In drinking water, ΣPAHs concentrations range from 0.1 to 25 ng/L.
- Benzo(a)pyrene in food:
  - cooking oils: 0.5-8 ppb (μg/kg)
  - margarine: 0.2-6.8 ppb
  - smoked fish: trace-6.6 ppb
  - smoked or broiled meats: trace-105 ppb
  - grains and cereals: not detected-60 ppb
  - fruits: not detected-29.7 ppb
  - vegetables: not detected-24.3 ppb

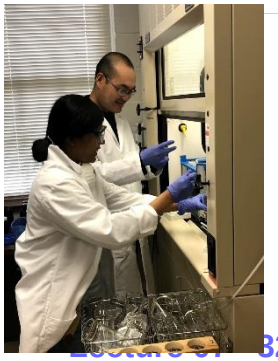
Chronic health effects of PAHs

- Benzo[a]pyrene (BaP) is an extremely potent carcinogen. It may cause forestomach tumor and squamous cell papillomas.
- Long-term studies of workers exposed to mixtures of PAHs and other workplace chemicals have shown an increased risk of skin, lung, bladder and gastrointestinal cancers.
- Mouse tests show PAHs can cause birth defects.

Memphis PAHs Study

- Overall objective:
  - Delineate the concentrations and distributions of PAHs in ambient air in Memphis Tri-state Area
  - Identify major sources and apportion the contributions
  - Characterize near-source PAH profiles, and
  - Assess non-carcinogenic and carcinogenic risks.





Dr. Jia's research on PAHs

Environmental Pollution 220 (2017) 1171–1179

Contents lists available at ScienceDirect

Environmental Pollution

journal homepage: www.elsevier.com/locate/envpol

Long-term trends (1990–2014), health risks, and sources of atmospheric polycyclic aromatic hydrocarbons (PAHs) in the U.S.☆

Bian Liu [a], Zhuqing Xue [b], Xianlei Zhu [c], Chunrong Jia [b, *]

Science of the Total Environment 743 (2020) 140774

Contents lists available at ScienceDirect

Science of the Total Environment

journal homepage: www.elsevier.com/locate/scitotenv

Impacts of Independence Day fireworks on pollution levels of atmospheric polycyclic aromatic hydrocarbons (PAHs) in the U.S.

Chunrong Jia [a,*], Zhuqing Xue [a], Xianqiang Fu [a], Fariha Sultana [a], Larry J. Smith [b], Yueqian Zhang [c], Ying Li [d], Bian Liu [e,*]

Int Arch Occup Environ Health (2016) 89:123–135
DOI 10.1007/s00420-015-1057-7

ORIGINAL ARTICLE

Effects of profession on urinary PAH metabolite levels in the US population

Bian Liu[1] · Chunrong Jia[2]

Environmental Research 274 (2025) 121325

Contents lists available at ScienceDirect

Environmental Research

journal homepage: www.elsevier.com/locate/envres

Exposures to polycyclic aromatic hydrocarbons among adults and children: Contributions from multiple pathways and sources

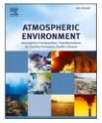
Namuun Batbaatar, Xianqiang Fu, Debra Bartelli, Abu Mohd Naser, Chunrong Jia *

Atmospheric Environment 302 (2023) 119735

Contents lists available at ScienceDirect

Atmospheric Environment

journal homepage: www.elsevier.com/locate/atmosenv



Spatiotemporal variability and measurement uncertainty in atmospheric polycyclic aromatic hydrocarbons (PAHs): A quantitative variance component analysis

Chunrong Jia [a,*,1], Xianqiang Fu [a,1], Yu Jiang [a], Adam Nored [a], Larry Smith [b]

Atmospheric Pollution Research 14 (2023) 101780

Contents lists available at ScienceDirect

Atmospheric Pollution Research

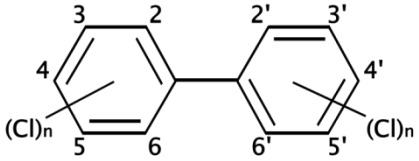
journal homepage: www.elsevier.com/locate/apr

Comparison of generic Tenax and specialized PAH tubes for monitoring polycyclic aromatic hydrocarbons in the ambient air

Chunrong Jia [a,*,1], Xianqiang Fu [a,1], Adam Nored [a], Namuun Batbaatar [a], Larry Smith [b]

3. PCBs, dioxins, and furans

- PCBs are a group of synthetic organic chemicals. They are colorless, viscous liquid and are stable at high temperatures.



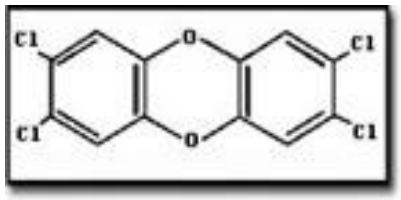
209 Possible Congeners

- Uses:
  - fire-resistant dielectric fluid in capacitors (50%) and transformers (27%);
  - plasticizer (9%)
  - hydraulic and lubricant (6%)
  - carbonless copy paper (4%)
  - Other uses (4%)

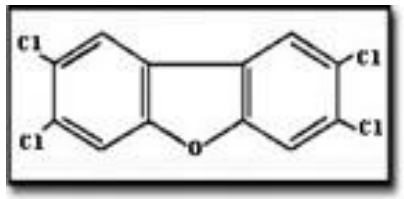
- Aroclor is a PCB mixture produced from approximately 1930 to 1979. It is one of the most commonly known trade names for PCB mixtures.
  - Commercial names: https://www.epa.gov/pcbs/table-aroclors

Dioxins and furans

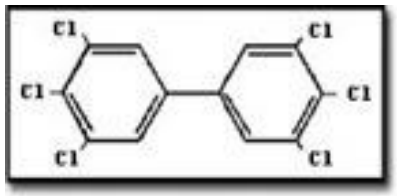
- Chlorinated dibenzo-p-dioxins (CDDs): A family of 75 chemicals.
- Dioxin-like compounds:
  - chlorinated dibenzofurans (CDFs)
  - certain polychlorinated biphenyls (PCBs)
- Sources:
  - Manufacture of PCBs created dioxins, furans as byproducts
  - Production of herbicide 2,4,5-T (part of Agent Orange)
  - Pulp and paper industry (chlorine bleach)
  - Times Beach, MO from use of waste oils to control dust



2,3,7,8-Tetrachlorodibenzo-**p-dioxin**



2,3,7,8-Tetrachlorodibenzo**furan**



3,3',4,4',5,5'-Hexachloro**biphenyl**

Fate, concentrations and exposure

- Fate
  - Persistent
  - May be transported in air long distances
  - Concentrate in food chain
- PCB concentrations

Medium	Ambient air (ng/m^3)	Indoor air (ng/m^3)	Water (ng/L)	Food (ng/g)	Fish (ng/g)
Con	0.2-0.5	6-310	0.5–20	18	~1-50

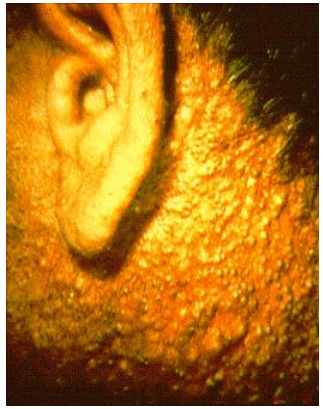
- Dioxin concentrations

Medium	Ambient air (pg/m^3)	Indoor air (pg/m^3)	Water (pg/L)	Milk (pg/g)	Fish (pg/g)
Con	0.61-78.97	1.46-4.27	19-46	15.3	~0.1-3

- Exposure:
  - Consumption of food (including human milk) is by far the most important pathway

Health effects of PCBs, dioxins, and furans

- Acute exposure leads to chloracne
  - Seveso, Italy
  - Victor Yushchenko
  - Chloracne



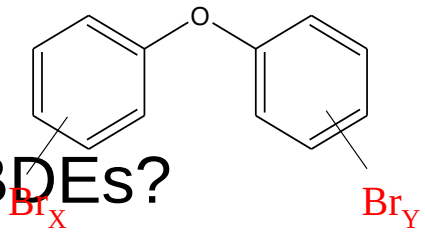
- Dioxins detectable at low levels in everyone
- Wide range of health effects in test animals
- Epidemiologic evidence suggests effects on neurologic development and cancer mortality
- Cancer: PCBs Group 2A, dioxin Group 1

4. Pesticides

- A pesticide is any substance or mixture of substances intended for preventing, destroying, repelling, or mitigating any pest.
- Four major classes:
  - Organophosphate (OP): “nerve gas”.
  - Carbamates: close relative of OP.
  - Organochlorines: associated with suppression of the immune system and cancer; banned.
  - Pyrethrins: Interfere with transmission of neural impulses via action on sodium channels.

5. Polyboriminated diphenyl ethers (PBDEs)

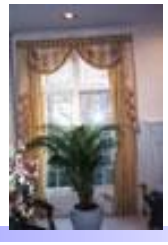
- A class of halogenated flame retardants.
- Chemical structure:



209 Possible Congeners

- Why PBDEs?
  - Flame retardants save lives.
  - Brominated flame retardants are most cost effective.
  - 3 major classes of PBDEs: penta-, octa- and deca-BDE.

Mixture	Penta-BDE	Octa-BDE	Deca-BDE
Uses	Flexible polyurethane foam (up to 30%)	Plastic housings esp. office equipment	Polymers for textile backing, electrical & electronic equipment
Comments	No longer made	No longer made	Largest volume

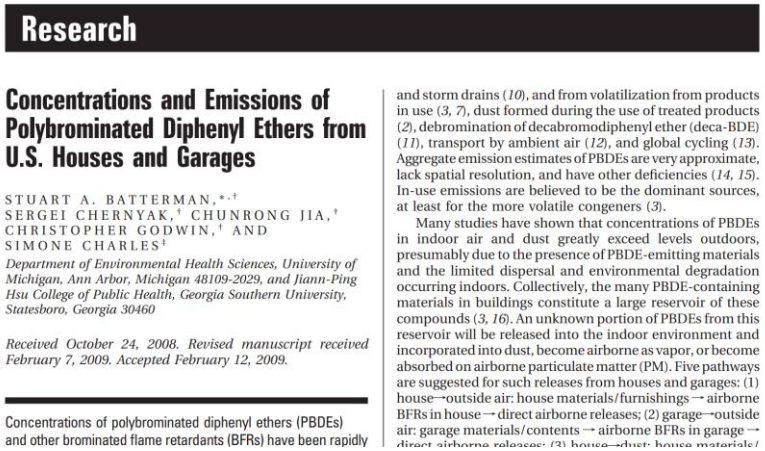




Sources, Concentrations, and Exposures

- Exposure: Food, indoor air, dust
- Average concentrations of total PBDEs:

Phase	House	Garage	Car
Dust (µg/g)	49	210	15000
Air (ng/m^3)	4.5	2.5	0.7
Airborne Particles (ng/m^3)	1.2	0.7	0.5

Note: The most abundant congeners are BDE47 (tetra), BDE100 (penta) and BDE99 (penta).



Research

Concentrations and Emissions of Polybrominated Diphenyl Ethers from U.S. Houses and Garages

STUART A. BATTERMAN,*,† SERGEI CHERNYAK,† CHUNRONG JIA,† CHRISTOPHER GODWIN,† AND SIMONE CHARLES‡

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Concentrations of polybrominated diphenyl ethers (PBDEs) and other brominated flame retardants (BFRs) have been rapidly

and storm drains (*10*), and from volatilization from products in use (*3*, *7*), dust formed during the use of treated products (*2*), debromination of decabromodiphenyl ether (deca-BDE) (*11*), transport by ambient air (*12*), and global cycling (*13*). Aggregate emission estimates of PBDEs are very approximate, lack spatial resolution, and have other deficiencies (*14*, *15*). In-use emissions are believed to be the dominant sources, at least for the more volatile congeners (*3*).

Many studies have shown that concentrations of PBDEs in indoor air and dust greatly exceed levels outdoors, presumably due to the presence of PBDE-emitting materials and the limited dispersal and environmental degradation occurring indoors. Collectively, the many PBDE-containing materials in buildings constitute a large reservoir of these compounds (*3*, *16*). An unknown portion of PBDEs from this reservoir will be released into the indoor environment and incorporated into dust, become airborne as vapor, or become absorbed on airborne particulate matter (PM). Five pathways are suggested for such releases from houses and garages: (1) house→outside air: house materials/furnishings→airborne BFRs in house→direct airborne releases; (2) garage→outside air: garage materials/contents→airborne BFRs in garage→

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Environment International

journal homepage: www.elsevier.com/locate/envint

Brominated flame retardants in offices in Michigan, U.S.A.

Stuart Batterman [a,*], Christopher Godwin [a], Sergei Chernyak [a], Chunrong Jia [b], Simone Charles [c]

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ABSTRACT

Brominated flame retardants (BFRs) are now ubiquitous contaminants with large reservoirs and high concentrations in buildings. Most of the information documenting BFR levels has been obtained in residences,

Toxicity Concerns for PBDEs

- Endocrine disruption
  - Thyroid and estrogenic effects
  - Relative potencies

    penta-BDE > octa-BDE >>> deca-BDE
- Developmental effects
  - Brain and reproductive organs
- Possibly cancer
  - Environmental conversion to dioxins/furans

6. Plasticizers - Phthaletes

- Esters of phthalic acid mainly used as plasticizers.
  - Range from one carbon to seventeen carbons
  - PVC plasticizers generally range from 4-13 carbons
  - Also used as additives in cosmetics, aspirin, and insecticides.

- Exposure
  - Anything plastic
  - through cosmetics, including hair sprays, nail polishes and perfumes

Health effects of PFAS

- Liver (cholesterol)
- Immunological (decreased vaccination response, asthma)
- Developmental (birth weight)
- Thyroid
- Reproductive (decreased fertility)
- Cardiovascular
- Cancer (testicular, kidney)

EPA Drinking Water Standards for PFAS

PFAS Compound	Maximum Contaminant Level Goal (MCLG)	Enforceable Maximum Contaminant Level (MCL)
PFOA	0	4.0 parts per trillion (ppt)
PFOS	0	4.0 ppt
PFNA	10	10.0 ppt
PFHxS	10	10.0 ppt
HFPO-DA (GenX Chemicals)	10	10.0 ppt
Mixture of two or more: PFHxS, PFNA, HFPO-DA (GenX), and PFBS	Hazard Index of 1	Hazard Index of 1

Phthaletes – Concentration and health effects

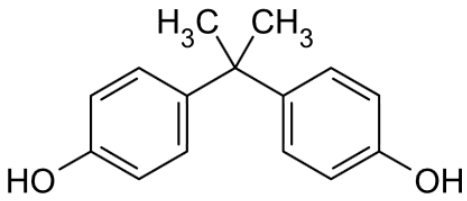
- Concentrations of diethyl phthalate (DEHP)

Medium	Ambient air ($\mu g/m^3$)	Indoor air ($\mu g/m^3$)	Water ($\mu g/L$)	Food (mg/kg)	Perfume (%)
Con	0.40 - 0.52	1.60 - 2.03	0.01	1.7–4.5	1–11%

- Health effects
  - Males: anomaly of the urethra; damage of sertoli cells; low sperm count; reductions in semen quality; DNA damage to sperm.
  - Females: Premature breast development; premature birth.
  - Possibly carcinogenic.

Bisphenol-A (BPA)

- A chemical commonly used in the manufacture of polycarbonate plastic.
- Polycarbonate plastic: A clear or tinted, unbendable plastic in which BPA is the main component.
  - Baby bottles
  - Reusable water bottles
  - Plastic baby toys
  - Microwavable food containers



- No notable levels of leaching at room temperature

- Significant levels of leaching in the range of 5-8 ng/mL when heated to 80° C

	Davis, M., et al (2008)	Gibson, R. (2007)	Polyzou, C., et al (2008)
Avent	5.64 ng/mL	8.7 ng/mL	7.07 ng/mL
Gerber	6.78 ng/mL	6.84 ng/mL	6.78 ng/mL
Playtex	4.92 ng/mL	5.44 ng/mL	4.92 ng/mL
Evenflo	6.26 ng/mL	8.41 ng/mL	
Dr. Brown's	7.08 ng/mL	6.48 ng/mL	
Disney/The First Years	6.41 ng/mL		

BPA – Health effects

- BPA is known as a synthetic estrogen.
  - Increased risk for certain cancers
  - Reproductive disorders
  - Early onset of puberty
  - Immune disorders
  - Neurological changes

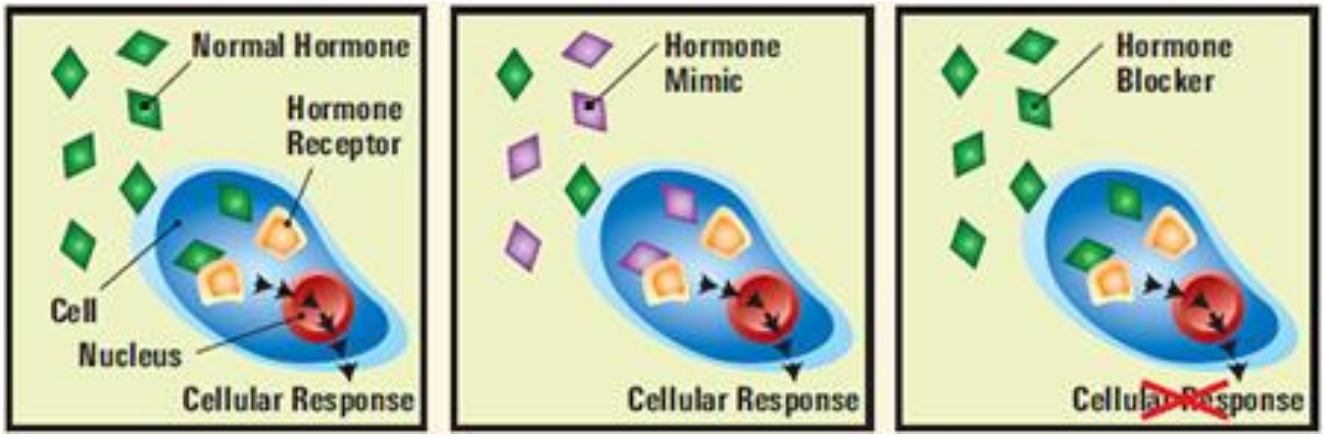
7. Per/poly-fluoroalkyl substances (PFAS)

- A very large class of synthetic chemicals
  - **Chains** of carbon (C) atoms surrounded by fluorine (F) atoms, with different terminal ends
  - **Complicated chemistry -** thousands of different variations exist in commerce
  - Perfluorooctanoic acid (PFOA) and perfluorooctane sulfonate (PFOS) are primary PFASs.

- Process chemicals in production of water- and stain-resistant coatings
  - Scotchgard
  - Gore-Tex
  - Teflon
- Released in industrial wastes
- Widespread, do not biodegrade, bioaccumulate and biomagnify

8. Endocrine Disrupting Chemicals (EDCs)

- Chemicals that interfere with endocrine (or hormone system) in animals, including humans.
- These disruptions can cause cancerous tumors, birth defects, and other developmental disorders.
- Food is the major exposure mechanism.



Common endocrine disruptors?

- **Dioxins** —byproduct in herbicide production and paper bleaching. also released into the environment during waste burning and wildfires
- **Bisphenol A (BPA)** —plastics and epoxy resins (plastic products including food storage containers)
- **Perchlorate** — a by-product of aerospace, weapon, and pharmaceutical industries found in drinking water
- **Perfluoroalkyl and Polyfluoroalkyl Substances (PFAS)** —firefighting foams and non-stick pan, paper, and textile coatings
- **Phthalates** — used to make plastics more flexible, they are also found in some food packaging, cosmetics, children's toys, and medical devices
- **Phytoestrogens** — naturally occurring substances in plants that have hormone-like activity, such as genistein and daidzein that are in soy products, like tofu or soy milk
- **Polybrominated diphenyl ethers (PBDE)** — used to make flame retardants for household products such as furniture foam and carpets
- **Polychlorinated biphenyls (PCB)** — used to make electrical equipment like transformers, and in hydraulic fluids, heat transfer fluids, lubricants, and plasticizers
- **Triclosan** — may be found in some anti-microbial and personal care products, like liquid body wash

How to avoid endocrine disruptors

- Wash your hands
- Dust and vacuum often
- Turn up your nose at fragrances
- Think twice about plastics
- Say “no” to cans
- Filter your tap water
- Rethink kids’ cosmetics
- Clean smarter

https://www.nrdc.org/stories/9-ways-avoid-hormone-disrupting-chemicals

9. Persistent organic pollutants (POPs)

- Chemicals that are stable in the environment (atmosphere, water, soil, food chain) for long periods.
  - Characterized by stability, mobility, and bioaccumulation (people, marine mammals, and other animals)
  - Harmful to human health and produce ecological damage.
  - persistent, resisting normal processes that break down contaminants
  - Mother to fetus transfer
  - Travel great distances on wind and water currents.

- The “Dirty Dozen”.
  - The Stockholm Convention, a legally binding international agreement finalized in 2001. In the Stockholm Convention, participating governments agreed to take actions to reduce or eliminate the production, use, and/or release of certain of these pollutants.

The “Dirty Dozen”

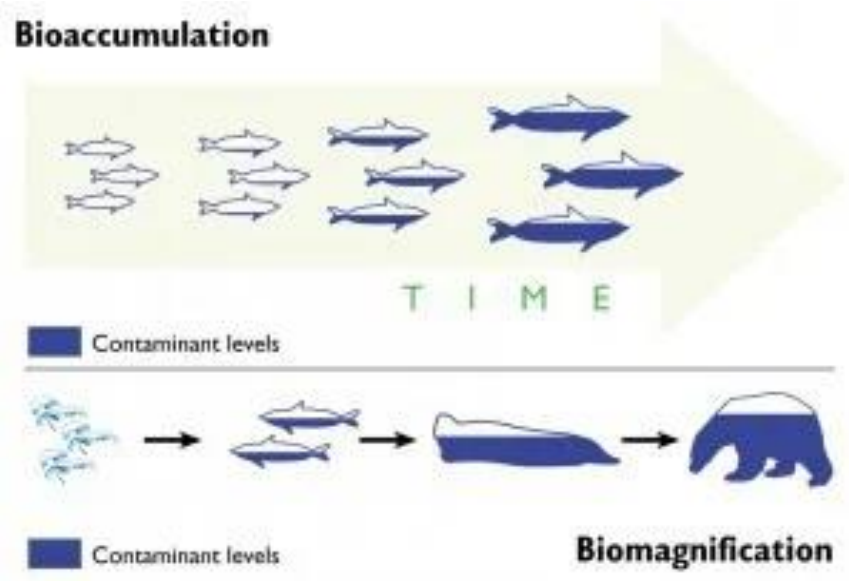
aldrin [1]
chlordane [1]
dichlorodiphenyl trichloroethane (DDT)[1]
dieldrin[1]
endrin[1]
heptachlor[1]
hexachlorobenzene [1,2]
mirex[1]
toxaphene[1]
polychlorinated biphenyls (PCBs) [1,2]
polychlorinated dibenzo-p-dioxins[2](dioxins)
polychlorinated dibenzofurans[2] (furans)

1-Intentionally Produced.
2-Unintentionally Produced - Result from some industrial processes and combustion

Bioconcentration, bioaccumulation, biomagnification

Bioconcentration is the process by which the concentration of a chemical in an organism becomes higher than its concentration in the air or water around the organism.

Bioaccumulation occurs within an organism, where a concentration of a substance builds up in the tissues and is absorbed faster than it is removed.



Biomagnification: the process by which a compound (such as a pollutant or pesticide) increases its concentration in the tissues of organisms as it travels up the food chain