

Human Health Effects of Oil Spills

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Components of Oil Spills—Petroleum

Crude oil

- Aliphatic hydrocarbons (alkanes, alkenes, alkynes)
 - Includes branched and cyclic
 - Carbon chains from 1-40+ carbons (heavy vs. light)
- Low molecular weight aromatics (benzene, toluene, xylene, cumene, phenol)
- Polycyclic aromatic hydrocarbons (PAHs) (naphthalene, anthracene, dibenzopyrenes)
- Metals
- Sulfur- and nitrogen-containing compounds (sweet vs sour)

Components of Oil Spills—Petroleum

Other petroleum products

- Refined from crude oil
- Fewer components with a more narrow chain length range
 - 7-11 carbon chain: Gasoline
 - 12-15 carbon chain: Kerosene (aviation fuel)
 - 9-25 carbon chain: Diesel fuel
 - 20+ carbon chain: **Residual oils** (residential heating oil, Bunker C oil)

All also contain variable cyclic and aromatic compounds, metals, and sulfur- and nitrogen-containing compounds.

Components of Oil Spills—Petroleum

Significance of Chain Length/Number of Carbons

- Short chains/low mass
 - High acute toxicity
 - High volatility
 - Low environmental persistence
- Long chains/high mass
 - Lower acute toxicity
 - Low volatility
 - High environmental persistence

Crude and residual oils produce the “dirtiest” spills.

Components of Oil Spills—Dispersants

What are they?

- Surfactants, hydrophilic and hydrophobic regions
- Disrupt surface tension and help disperse tiny droplets of oil into the water column
- Ideally hasten biodegradation of oil through increase in surface area

What are their health effects?

- Burning nose, throat, or lungs
- Tightness in chest
- Burning eyes

During Deepwater Horizon 1.84 million gallons of dispersants were applied.

Select Studied Oil Spills

Deepwater Horizon

- Gulf of Mexico, 2010
- 210 million gallons of crude oil

Braer

- Southwest Shetland Islands, 1993
- 25 million gallons of crude oil

Prestige

- Spain, 2002
- 17.8 million gallons of No. 4 fuel oil

Exxon Valdez

- Alaska, 1989
- 10.8 million gallons of crude oil

Tasman Spirit

- Pakistan (Karachi), 2003
- 7.4 million gallons of crude oil

Hebei Spirit

- South Korea, 2007
- 2.8 million gallons of crude oil



US. Coast Guard, public domain



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Comparison—Virginia Spills

1976, mouth of Potomac

- Barge STC-101 sank in a storm
- 250,000 gallons No. 6 fuel oil

1988, mouth of Potomac

- Barge 565 cracked in half
- 212,000 gallons diesel and gasoline

1990, Norfolk

- Columbus America collided with another cargo ship
- 30,000 gallons No. 4 fuel oil

2017, Naval Air Station Oceana, Virginia Beach just inland

- Wrong switch flipped during tank refueling
- 94,000 gallons of JP-5 jet fuel

In Virginia large crude oil spills are unlikely
(for now?)

Exposure—Immediate vs Delayed

Immediate

- Direct contact with petroleum products on water or shoreline
- Direct contact with dispersants

Delayed

- Dietary exposure from fish or shellfish
- Contact with deposits on shorelines



Health Effects—Direct Exposure

Most common in people exposed to large amounts of petroleum products during cleanup, less common in coastal residents.

Short-term

- Headaches, dizziness
- Nausea, vomiting
- Cough, respiratory distress, chest pain
- Eye, nose, and throat irritation
- Dermatitis, dermal hypersensitivity reaction
- Back pain



A cleanup worker wearing minimal protective equipment bags oily waste on Elmer's Island, just west of Grand Isle, Louisiana, on May 21. Photo by Petty Officer 3rd Class Patrick Kelley / Digital Video and Imagery Distribution System.

Health Effects—Direct Exposure

Long-term

- **Anxiety, depression, PTSD**
 - Associated with income loss, family disruption, fear of persisting contamination, interference with traditional activities
 - Studied 4-16 months after the spill
- **Respiratory symptoms**
 - Primarily studied in people exposed by the *Prestige* oil spill
 - Studied up to 6 years after the spill

Health Effects—Direct Exposure

Long-term

- Genotoxicity (studied 2-7 years after the spill)
 - *Braer* study found no effect
 - *Prestige* study found DNA damage
 - Medical significance unknown
- Endocrine effects (studied 2-7 years after the spill)
 - Elevated prolactin and cortisol (*Prestige* spill)
 - Altered lymphocyte ratios (*Prestige* spill)
 - Medical significance unknown

These effects are not consistent or well-studied.

Health Effects—Indirect Exposure

Contamination of Seafood

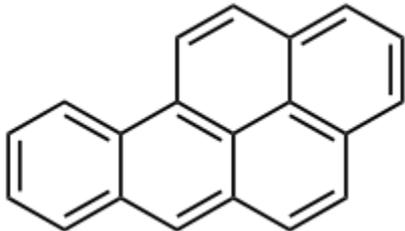
- Following a spill, petroleum components and chemical dispersants can be detected in seawater and in fish, crustaceans, and shellfish.
- FDA and NOAA have authority to close federal fisheries. States have authority over their territorial waters.
- Visible oil sheen triggers recommendation to close the sheen area plus a safety margin to harvesting.



Contaminated Seafood— How much is too much?

Deepwater Horizon

- Calculated PAH limit based upon expected cancer and noncancer health effects of 13 PAHs.
- Concentrations of 7 carcinogenic PAHs expressed as toxicity equivalents of benzo[*a*]pyrene for cancer risk.



- Noncancer risks calculated based on concentration of 6 noncarcinogenic PAHs.



Two-tier Testing Strategy

Formulated for Deepwater Horizon

Sensory

- Smelling and taste-testing!
 - Raw odor
 - Cooked odor
 - Cooked flavor
- Seven trained sensory experts
- 5/7 had to find no smell or taste of petroleum or dispersants
- Samples that pass are evaluated chemically

Chemical

- PAHs
 - Liquid chromatography/fluorescence detection (LC/FLD) screening
 - Gas chromatography/mass spectrometry (GC/MS) for identification
- Dispersant (dioctyl sodium sulfosuccinate)
 - Liquid chromatography/tandem mass spectrometry (LC-MS/MS)

Health Effects—Indirect

Post-cleanup Exposure

- Likelihood depends on the petroleum product spilled—product with longer chains and more cyclic and aromatic compounds persists longer.
- Weathered oil forms tar balls and mats that can be repeatedly buried and uncovered.
- Residual oil deposits can last for years.
- Even after a beach is cleaned residual oil can wash up.
- If someone contact residual oil they should wash their skin with soapy water or baby oil.

Incidental exposure to residual oil does not pose a significant health hazard.

Summary—Effects of Direct Exposure

- Exposure to petroleum products and dispersants during a spill can have a variety of acute health effects including eye, nose, and throat irritation and dermatitis.
- Long-term health effects prominently include anxiety and depression, primarily due to economic stress and lifestyle disruption.
- Other long-term health effects include respiratory symptoms.
- More study is needed to determine if there are genotoxic or endocrine effects and what the medical significance of these is.

Summary—Effects of Indirect Exposure

- Contaminated seafood can pose non-cancer or cancer health risks, so fisheries may need to be temporarily shut down.
- Oil residues can persist for years on beaches after cleanup, but incidental contact does not pose a significant risk to human health.

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Health Risks of PAH Ingestion

Cancer

- Based upon extrapolation from animal studies.
- Benzo[*a*]pyrene ingestion associated with leukemia and tumors of forestomach and lung in mice.
- Benzo[*a*]pyrene ingestion associated with mammary tumors in rats.

Noncancer

- Neurobehavioral effects observed in people with occupation exposure to PAH mixture.
- Short-term memory or digit span test deficits.

Responsible Agencies in Virginia

- Virginia Department of Environmental Quality
- Virginia Department of Health
 - Shellfish Sanitation
 - Waterborne Hazards Control
- Virginia Marine Resources Commission
- Virginia Department of Agriculture and Consumer Services