Anatomy of an Oil Spill
Gulf of Mexico 2010

Satellite Conference and Live Webcast
Tuesday, June 29, 2010
12:00 – 1:30 p.m. Central Time

Produced by the Alabama Department of Public Health
Video Communications and Distance Learning Division

Faculty

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Goals and Objectives

- Part 1
  - Describe the incident, characteristics of oil, and dispersants

- Part 2
  - Address public health issues
    - Exposure to air contaminants
    - Seafood
    - Beach advisories
    - Worker safety

Explosion and Fire on the Deepwater Horizon

On April 20, 2010 the Deepwater Horizon exploded, and sank 2 days later

Eleven people died and many others injured

Explosion and Fire on the Deepwater Horizon

The well began leaking oil from 5,000 feet below the surface of the water

Deepwater Horizon Site
### What is Crude Oil?

<table>
<thead>
<tr>
<th># Carbons</th>
<th>Product</th>
<th>Health Effects</th>
<th>Physical State</th>
<th>Fate</th>
</tr>
</thead>
<tbody>
<tr>
<td>C₁–C₂</td>
<td>Natural gas; Propane and Butane</td>
<td>Few</td>
<td>Gas</td>
<td>Evaporates from oil in or on surface of the water</td>
</tr>
<tr>
<td>C₃–C₄</td>
<td>Gasoline; Kerosene; Jet and Turbo fuel</td>
<td>Moderate</td>
<td>Volatile Liquids</td>
<td></td>
</tr>
<tr>
<td>C₅–C₁₀</td>
<td>Mineral Oil; Lubricating oil</td>
<td>Few</td>
<td>Heavy Liquids</td>
<td></td>
</tr>
<tr>
<td>C₁₁–C₁₄</td>
<td>Heavy Liquids</td>
<td>Few</td>
<td>Gooey Liquid</td>
<td></td>
</tr>
<tr>
<td>C₁₅–higher</td>
<td>Paraffin; Asphaltene</td>
<td>Few</td>
<td>Solids</td>
<td>Tar Balls</td>
</tr>
</tbody>
</table>

**LMRP Cap**

**What is Crude Oil?**

Beneath the oil slick:
- Weathered crude
- Crude oil
- Process could take 23 months
What is Crude Oil?

Type of Oil: Light Sweet Crude

- Light crude
  - More of the smaller mol. wt. compounds including more gas
  - Deepwater Horizon oil is very light with a large amount of gas and few heavy hydrocarbons

- Heavy crude
  - Less gas and more of the larger mol. wt. compounds
    - Exxon Valdez
  - Sweet crude
    - Does not have $\text{H}_2\text{S}$
    - Deepwater Horizon crude is sweet

- Sour crude
  - Contains $\text{H}_2\text{S}$ and has a bad odor

Toxicology of Petroleum Hydrocarbons

- In general, hydrocarbons have a low degree of toxicity to humans
  - That means, it takes a large amount to cause adverse effects
  - Most common effects: irritation, headache, nausea
    - Symptoms get better when removed from exposure

- The aquatic and ecological toxicity of oil is different than human health toxicity
  - Ecological effects are most frequently related to the physical coating of marine life and birds
**Gases: C1 to C4**

- Methane, Ethane, Propane, Butane
  - May compose up to 40% of leaking crude
  - Fire and explosive hazard
  - No direct chemically toxic effects
  - Asphyxiation by displacement of O2 in confined spaces

**Volatile Liquids: C5-C14**

- Commonly known as VOCs
  - Volatile Organic Compounds
- Products from this component of crude oil include
  - Gasoline, kerosene, jet fuels
  - Many solvents are derived from this fraction
  - Contains both aliphatic and aromatic compounds

**Volatile Liquids: C5-C14**

- Health effects associated with the VOCs
  - Dermal, eye, and mucus membrane irritation
  - Volatile liquids cause respiratory irritation
  - Benzene: carcinogen

**Volatile Liquids: C5-C14**

- Do not bioaccumulate
  - Readily metabolized and excreted
- The volatile compounds readily evaporate from the crude oil
  - Analysis of surface oil does not detect BTEX
- Air sampling is conducted along the coast to monitor for VOCs

**Volatile Liquids: C5-C14**

- Aliphatic compounds (straight or branched chain) hydrocarbons have a low degree of toxicity
- The aromatic compounds are the most toxic fraction of crude oil
  - Includes Benzene, Toluene, Ethyl Benzene, and Xylenes (BTEX)

**Gases: C1 to C4**

- Ecological
  - Question
  - Have large amounts of methane remained in the Gulf waters?
Heavier Liquids: C16- C22

- Long chained hydrocarbons
  - Aliphatic: straight and branched chains
    - Very low toxicity to humans
    - Physical coating of aquatic life and birds

Heavier Liquids: C16- C22

- Polycyclic Aromatic Hydrocarbons (PAH)
  - Common PAHs
    - Pyrene, phenanthrene, benzo(a)anthracene, benzo(a)pyrene, benzo(a)fluoranthene, fluoranthrene, fluorene

Heavier Liquids: C16- C22

- Carcinogenic activity
  - Benzo(a)pyrene is the most carcinogenic
  - PAH do not bioaccumulate
  - Metabolized via CYP (cytochrome P-450) enzymes
  - PAHs being monitored in seafood

Solids: C22-C45+

- Heaviest components of crude oil
  - Asphaltenes
  - Parafins
  - Tars
  - Practically non-toxic
  - Components of the tarballs

Solids: C22-C45+

Can be messy and ugly, but not toxic to people

What is Weathered Crude???

- Once on the water's surface, crude oil changes
- Since the site of the leak is 50 miles offshore, the oil “weathers” or “ages”
  - The smaller molecular weight compounds breakdown
  - Volatile compounds evaporate
What is Weathered Crude???

- Contains primarily long chained compounds
- PAH may be present, but not always

- Weathered oil is thicker or more solid
  - Mousse
  - Tarballs

Oil in the Gulf

- The oil is not evenly distributed across the spill area
  - Sheen
    - Very light layer of oil that is seen floating on the water

Oil in the Gulf

- Mousse
  - Heavier layers of emulsified oil
    - Oil is emulsified with water as it rises to the surface at the leak
    - Contains more heavy hydrocarbons

Oil in the Gulf

- Tarballs
  - Largest hydrocarbons that are solids
    - Tarballs are not likely to have toxic effects, but should be avoided

Analysis of Weathered Oil

Analysis of oil and water near Grand Isle and in Barataria Bay, Louisiana

<table>
<thead>
<tr>
<th></th>
<th>Weathered oil</th>
<th>Mousse</th>
<th>Tarball</th>
<th>Water</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total Petro Hydrocarbons C6-C10</td>
<td>ND</td>
<td>ND</td>
<td>ND</td>
<td>ND</td>
</tr>
<tr>
<td>Total Petro Hydrocarbons C10-C20</td>
<td>YES</td>
<td>YES</td>
<td>YES</td>
<td>YES</td>
</tr>
<tr>
<td>Total Petro Hydrocarbons &gt;C20-C35</td>
<td>YES</td>
<td>YES</td>
<td>YES</td>
<td>YES</td>
</tr>
<tr>
<td>PAH</td>
<td>YES</td>
<td>ND</td>
<td>ND</td>
<td>ND</td>
</tr>
<tr>
<td>BTEX</td>
<td>ND</td>
<td>ND</td>
<td>ND</td>
<td>ND</td>
</tr>
</tbody>
</table>

Most common PAH detected: Cryene, Phenanthrene, pyrene
Occasionally detected: Fluoranthene, Fluorene, benzo(a)anthracene
In one sample: Benzo(a)pyrene

Containing an Oil Spill
**Containing an Oil Spill**

1. VOCs evaporate
   - Up to 40% of total volume
2. Booms along the coast
3. Burning
4. Skimming
5. Dispersants
6. Biodegradation

**Booming and Burning of Oil**

- In situ burning destroys the oil and less reaches shore
  - Occurs off-shore and not along the coast

**Booming and Burning of Oil**

- Particulates are generated
- Air monitoring for particulates along the coast
  - Have measured increases in PM on some days, but below health concerns

**Booming Along the Coast**

- Worker exposure issues and need for appropriate safety equipment

**Booming Along the Coast**
Dispersants

• Have become quite controversial

Issues

– Why put more chemicals into the Gulf?
– Amount of dispersants used – over 1 million gallons
– Unknown factors with deep sea use

Dispersants

– Ecological effects on aquatic life
– Possible human exposure

Points of confusion

– Aquatic toxicity data is confused with human health effects
– Human exposure issues
  • Workers exposure
  • Dilution when used in water
  • Does not accumulate in food chain

Dispersants

How Dispersants Work

• Dispersant mixes with both water and oil
• Dispersant is sprayed onto the oil

How Dispersants Work

• Dispersant mixes with the oil

How Dispersants Work

• Dispersant makes the oil mix with water
How Dispersants Work

- Small oil droplets move below the surface of the water and are broken down by micro-organisms in the water

Dispersants: Corexit 9500

- Components of Corexit are commonly used in household products
  - Surfactants
  - Petroleum distillates
  - Propylene glycol

Will the Oil Make Me Sick?

- For the oil to cause a health effect, you must come into contact with it

Dispersants: Coreexit 9500

- Dispersants do not change the amount of oil
  - Tool to manage the oil spill
  - Keeps oil from reaching the coast by moving to water column
  - The small droplets are more easily biodegraded by microorganisms

Dispersants: Coreexit 9500

- Dispersants involve trade-offs
  - Dispersants move the oil to the water column
  - Keeps oil from reaching the coastline
  - Coreexit breaks down in the environment
    - Half-life: 2 days to 2 weeks
    - Does not bioaccumulate in the food chain
Will the Oil Make Me Sick?  
- Compounds in the oil have different types of effects  
- Possible routes of exposure  
  - Inhalation: Breathing air with contaminants  
  - Ingestion: Eating food with contaminated oil  
  - Dermal: Direct contact with the skin

What Could Be in the Air?  
- Gases, volatile compounds and particulates may be in the air  
  - Air sampling is designed to sample for components in crude oil that could be in the air  
- Compounds of concern  
  - Volatile organic compounds (VOCs)

What Could Be in the Air?  
- Including BTEX  
- Particulate Matter (PM) - PM10 and PM2.5  
  - Occurs from the burning of the oil off-shore

Odors: What Do I Smell?  
- People along the coast occasionally smell an “oily” odor, particularly if the wind is from the direction of the spill  
- Some people can smell hydrocarbons at very low levels, far below those that would cause short-term health effects
Odors: What Do I Smell?
• It is possible, but not common, for the odors to cause short-lived effects like headache, eye, nose, throat irritation, or nausea
• Air sampling monitors for VOCs, BTEX, PM

How Is the Air Monitored?
• Air toxics
  – Air sampling canister, Plaquemines Parish, LA

How Is the Air Monitored?
– Air monitoring station in Grand Isle, LA

How Is the Air Monitored?
– EPA measures two sizes of particulate

How Is the Air Monitored?
• Daily reports at:
  – http://www.epa.gov/bpspill/air.html

Real-time Air Monitoring
• Trace Atmospheric Gas Analyzers (TAGA)
• The TAGA bus analyzes the air along the Gulf Coast
  – Levels found so far are well below those likely to cause health effects
Real-time Air Monitoring

Putting It Together: Air and VOCs
1. VOCs evaporate quickly in hot weather
2. Air sampling above the leak show low levels of VOCs
3. Air sampling along the coast line detect background levels of VOCs, including the BTEX

Keeping Seafood Safe
• With all the oil in the Gulf, people are naturally concerned about seafood
• Two issues with seafood in oil contaminated waters
1. The long chain hydrocarbons get on the fish, shrimp, crabs, and oysters and taints the taste
2. PAHs in the crude may be taken up by oysters
   • Cannot see or taste
   • Chemical analysis for PAH conducted

Keeping Seafood Safe
• Oil has an odor that can be readily smelled
• Seafood with oil will taste nasty

Real-time Air Monitoring

Putting It Together: Air and VOCs
4. Analysis of the oil, mousse and tar balls do not detect BTEX
   – Exposure to BTEX or VOCs from the oil spill to the general public along the coast is not likely
   – Off shore workers should be monitored to prevent possible exposure to VOCs
Is the Seafood that Gets to Market Safe?

• Absolutely!!

• Seafood monitoring program
  1. Close areas with visible oil to fishing, shrimping and oystering
  2. Sensory analysis at docks and processors
  3. Chemical testing for longer-term components

Is it Safe to Go on Beaches??

• Once a fishing area is closed,
  – No visible oil must be present
  – The seafood must be chemically tested to be reopened

• There may be shortages of seafood, but the quality will be the same, or maybe even better

Seafood Monitoring

• Areas have been closed to fishing based on the presence of oil

• Personnel are being trained in sensory analysis

• In Louisiana, baseline testing for Aliphatic and PAHs did not detect these contaminants

May 12, 2010 - Louisiana Department of Wildlife and Fisheries Recreational and Commercial Fishing Closure

• Issues
  – Laboratory capacity
    • Approved labs
  – Use of approved standard methods for analysis
  – Limits of detection for some PAHs

Seafood Monitoring

• Issues
  – Laboratory capacity
    • Approved labs
  – Use of approved standard methods for analysis
  – Limits of detection for some PAHs

• Oil has reached the coast in Louisiana, Alabama and Florida and the barrier islands in Mississippi
  – Beaches have different warnings depending on the presence of oil and form (mousse or tarball)
  – The oil is constantly moving so the warning may change from place to place or at different times
Is it Safe to Go on Beaches??

– Guidelines for closing beaches or issuing warnings vary from state to state and even county to county

Beach Safety

- The oil on the beaches will vary from very heavy mousse-like oil to minimal sheen
- Tarballs may be present without other forms of oil
- Beaches may be closed when large amounts of heavy oil reaches shore
- Swimming warnings may be posted for sheens or tarballs

Should I Bring My Family to the Beach?

- Avoid direct contact with oil if found on a beach
- Do not swim in areas with visible oil
- Pregnant women and small children should stay away from oil on beach

Should I Bring My Family to the Beach?

- Will direct contact with the oil make me sick?
  – It is not likely, but avoiding contact with the oil is recommended

What Should I Do if I Come in Contact with Oil?

- Wash the oil off with soapy water
- Baby oil or a similar oil may help to remove the oil
- Do not use a solvent as it may promote the absorption of the oil
- Remove contaminated clothing or shoes before entering home/condo
What Should I Do if I Come in Contact with Oil?

- Wash contaminated clothing separately from the family laundry
- Throw away anything that cannot be cleaned well

Workers

- Most likely group to be exposed to toxic components in oil
- The exposure depends on their jobs, location, type of oil and duration

Workers

- Requirement for PPE depend on the hazard and the type of exposure
  - Respirators
    - High levels of particulates
    - VOCs above health standards
  - Protective clothing
    - To prevent dermal contact

Aquatic Life and Birds

- The oil is impacting marine life and birds in the affected areas

Toxicity of Oil to Birds

- The harmful effects are due to the coating of the birds
  - The oil coats birds’ feathers decreasing their ability to fly, eat or drink
  - Effects are predominantly due to the physical effects of oil, rather than chemical toxicity
Toxicity of Oil to Birds

- If found in time, the birds can be cleaned and rehabilitated and released

Oil Spill and Hurricanes

- Wind and flood waters will drive water and oil deeper into the estuaries and the coast line
  - Oil will follow flooding and spread over a wider area
  - Oil will be diluted

Oil Spill and Hurricanes

- The turbulence will break up the oil
- At the well head, work will stop and vessels will be removed
  - Oil collection will stop and will spew out
- Myth: not likely to “rain oil”
  - Several myths on the Internet

Lingering Issues

- Unprecedented situation
  - Each action a new research project
- There is much we do not know about the health effects of oil
  - What are the long-term effects on workers?

Lingering Issues

- What mental health issues will emerge and how can we best address them now?
- How long will it take the oil to biodegrade or remediate?
- What will the health surveillance show us in the long-term?