

**Chesapeake Bay Watershed....largest estuary in the U.S.**

**What anthropogenic and natural pollutants impact the aquatic ecosystems....solutions pg. 381??**



**Chapter 14  
Water Pollution**

# What anthropogenic and natural pollutants impact the aquatic ecosystems....solutions??

## Anthropogenic (chemicals)

- **Sewage treatments** from human waste
  - **Animals wastes** from feeding operation lots
- **Pesticides & fertilizers** used for agricultural harvest and residential land
  - **Pharmaceutical drugs**
  - **Oils, metals, acids**

## Natural (non-chemicals)

- **Algal bloom** from the high levels of nutrients (*nitrogen and phosphorus*) explosion of population growth
- **Sediments** from soil washed away from fields...suspended in the water *preventing sunlight to penetrate*
- **Noise, thermal (heat), solid waste**

## Consequence:

In 2009, U.S Fish and Wildlife Services announced due to the abundance of 'chemicals' discharging into the Bay...**largemouth bass became hermaphrodites** with male sex organ that could grow female eggs. Affecting fish populations and also the consumption by humans due to their endocrine systems (hormones).

## Solution:

**Chesapeake Bay Action Plan**...*reduce the impacts of nutrients sediments and chemicals coming into the Bay...*

1. reduction in nitrogen and phosphorus
2. increase in water quality (water test)
3. increase in blue crab (reduce in over-harvesting)

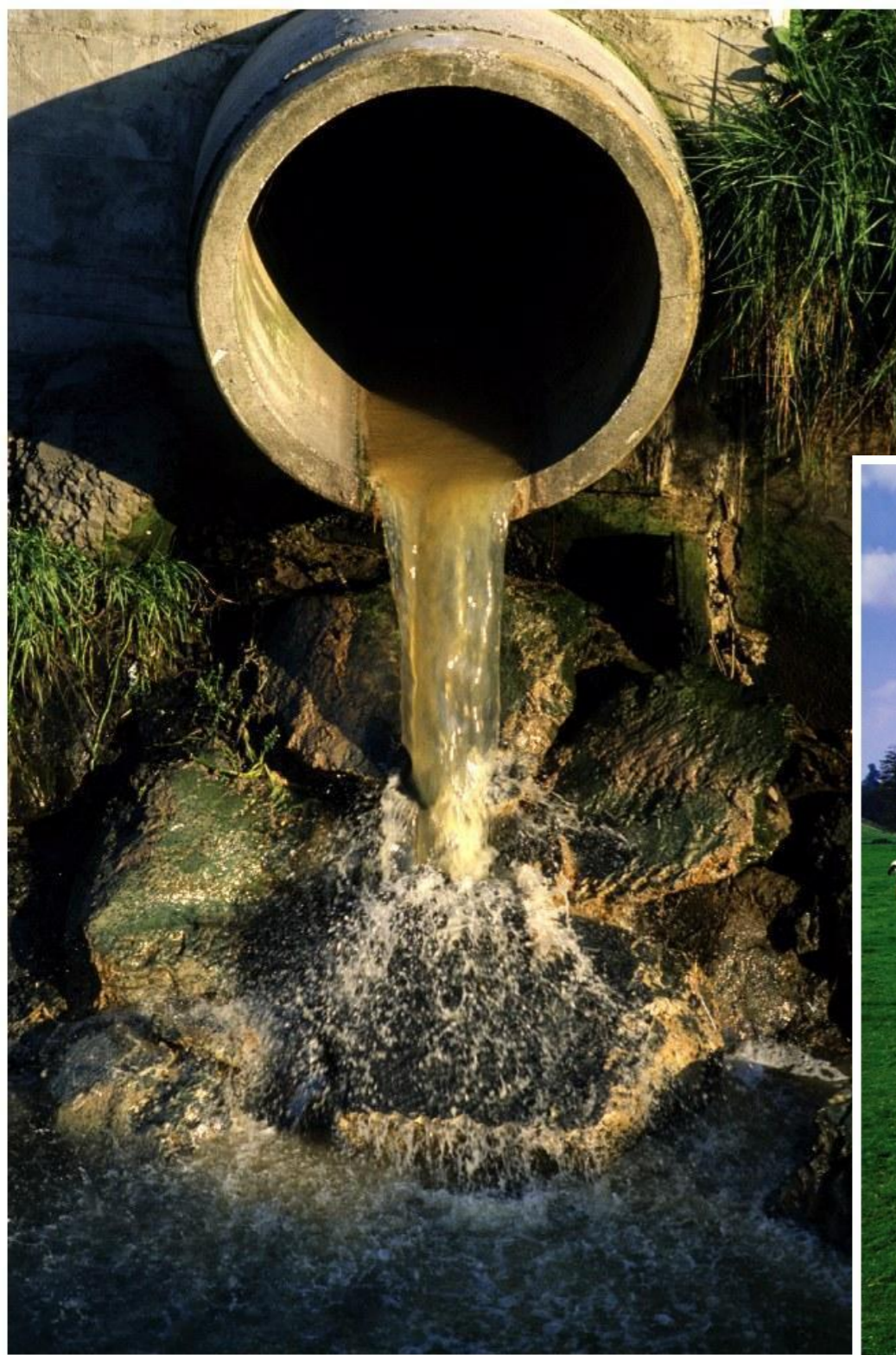
# Water Pollution

- **Water pollution**- the **contamination** (*human & animal wastes, inorganic & organic compounds, synthetic and nonchemical pollutants*) of streams, rivers, lakes, oceans, or groundwater with substances produced through **human activities** and that negatively affect organisms (*aquatic & terrestrial*).

## Pollution can come from either....

1. **Point sources**- **distinct locations** (i.e. particular factory or sewage treatment plant) that pump waste into a waterway.
2. **Nonpoint sources**- **diffuse areas** such as an entire farming region that pollutes a waterway (**coming from multiple known/unknown sources** – more difficult to control)





**Non-Point Source** – rainwater that runs off hundreds of square kilometers of agricultural fields and into streams.



**Point Source** – coming out of sewage pipes.

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# Human Wastewater

- Water produced by human activities such as **human sewage** from toilets and **gray water** from bathing and washing clothes or dishes.



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**Nutrients from  
wastewater  
decomposition  
& leached  
from  
agricultural  
lands during  
periods of  
precipitation**



# Three reasons scientists are concerned about human wastewater:

1. Wastewater in bodies of water naturally undergo decomposition by bacteria that put a large demand for oxygen in the water
2. Nutrients that are released from wastewater decomposition can make the water more fertile causing eutrophication (*a body of water becomes rich in nutrients*)
3. Wastewater can carry a wide variety of disease-causing organisms.

# Biochemical Oxygen Demand (BOD)

- **Oxygen-demand waste** – organic matter that enters a body of water & feeds the growth of microbes (decomposers), in turn, require more oxygen to decompose, the more waste, the more microbes grow (cycle)
- **BOD**– the amount of oxygen a quantity of water uses over a period of time at a specific temperature (natural standard).
- **Lower BOD** values indicate the water **is less polluted**
- **Higher BOD** values indicate it is **more polluted** by wastewater, **consumes that much more oxygen.**
- High oxygen demand due to microbe decomposition (*byproduct of nitrogen & phosphorus*), amt. of oxygen remaining for other organisms is very LOW...can be lethal for many organisms (especially stationary marine life), they DIE...

Little oxygen, little life – **Dead Zones**



# Eutrophication

- Byproduct of Decomposition are **Nitrogen & Phosphorus**, elements that **limit the abundance of producers in aquatic ecosystems**.
- The addition to these elements causes **Eutrophication** – is an abundance of *fertility* to a body of water.
- Eutrophication is caused by an increase in nutrients, such as fertilizers.
- Eutrophication can *cause a rapid growth of algae* (**Algal Bloom**) which eventually dies, causing the *microbes to increase the BOD. (leads to lack of oxygen...dead zones)*
- **Cultural Eutrophication** – anthropogenic inputs of nutrients into body of water (human activities)
  - To decrease this, sewage plants may have a **tertiary treatment removal of nitrogen and phosphorus**

## Dead Zones

- In 2006, United Nations estimated nearly **200 dead zones caused by pollution around the world.**
- *For example*, raw sewage is dumped directly into bodies of water, decomposition by microbes can consume nearly all the oxygen causing dead zones...leading to massive aquatic deaths.
- Most impressive dead zone is the **Mississippi River, dumps into the Gulf of Mexico.**

## Common Diseases from Human

### Wastewater

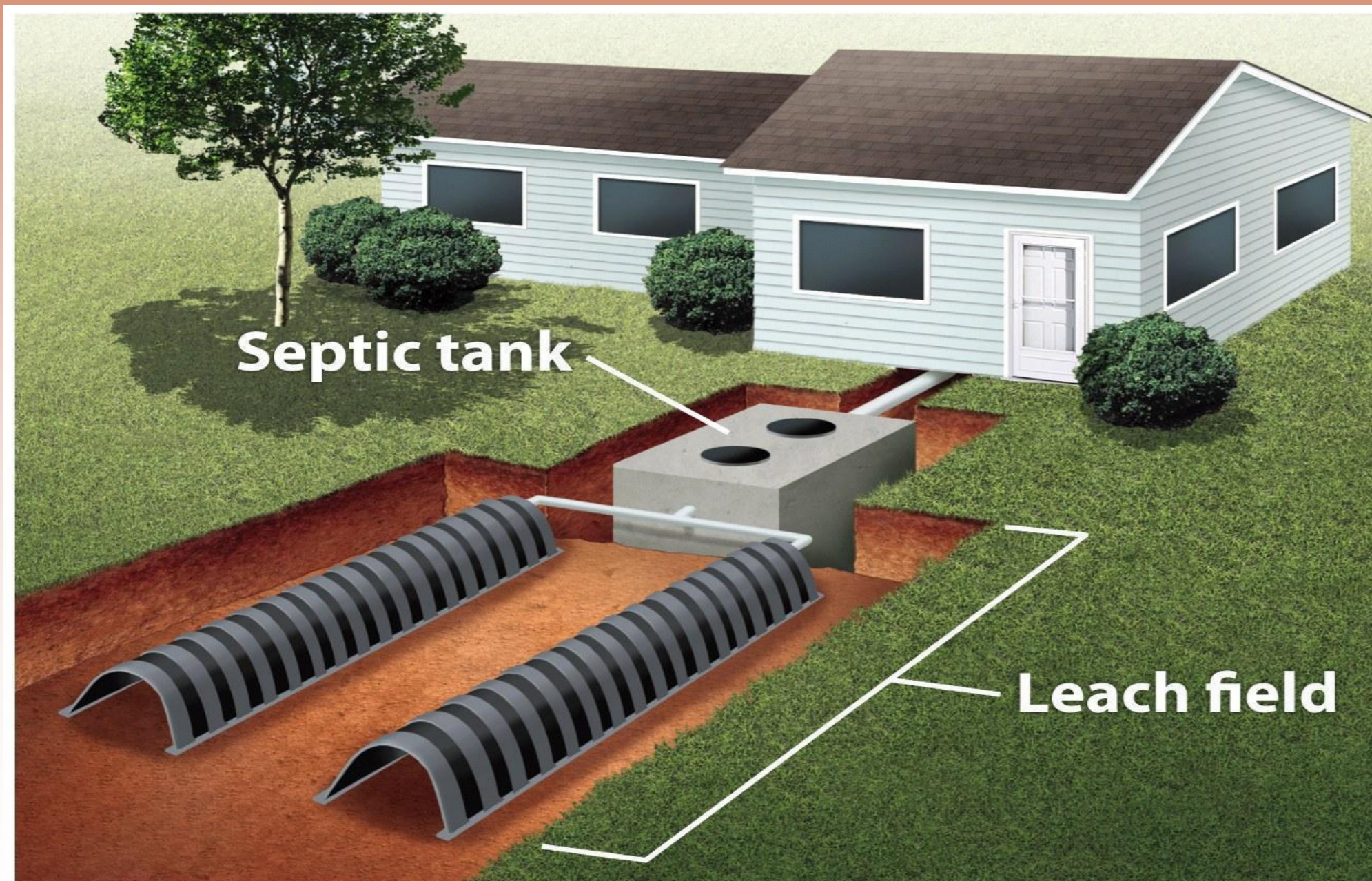
- Pathogens (viral/bacterial) in the wastewater are responsible for...
  - fecal coliform bacteria (indicator for human wastewater contamination)
  - Cholera
  - Typhoid fever
  - Stomach flu
  - Diarrhea
  - Hepatitis
  - *E. Coli*



# Treatments for Human Wastewater

2 systems for treating human waste are...

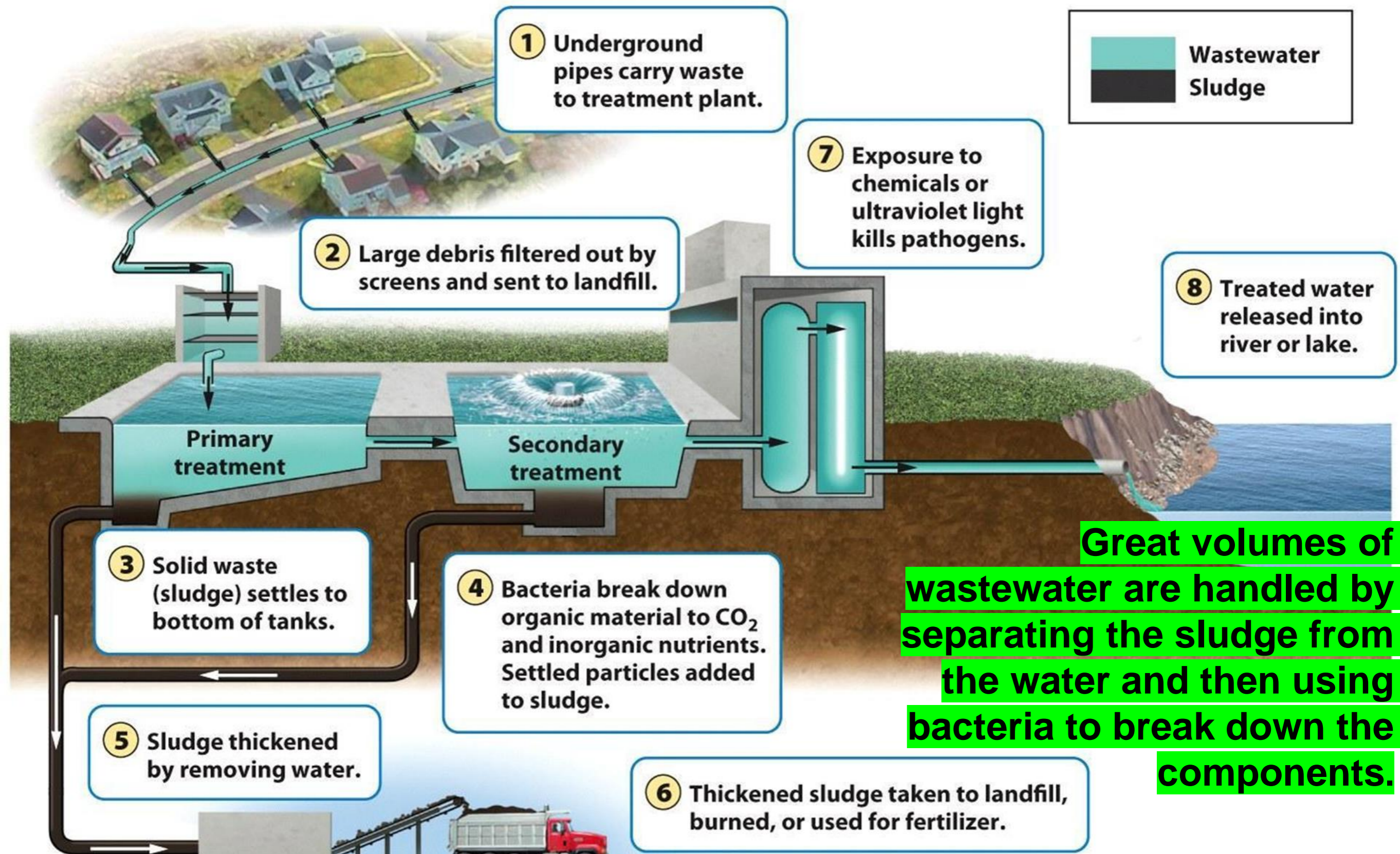
**1. Septic systems-** a large container that receives wastewater from the house.



Solids settle at bottom of tank & bacteria breaks down the sewage. The liquid moves through the filtered pipes that distribute the water through a leach field.



**2. Sewage Treatment Plants-** centralized plants in areas with large populations that receive wastewater via a network of underground pipes (*primary & secondary treatments*).





# Legal Sewage Dumping

- Raw sewage can sometimes be directly pumped into rivers & lakes (typically built to handle wastewater from local areas – not older sewage power plants)
- During periods of heavy rainstorms, this direct pumping results in overflows of raw sewage dumped right into surrounding bodies of water.
- Around the world, incidents result in the contamination of drinking water, beaches, marine life, and human illnesses (eating contaminated shellfish/fish).

Solutions.....Expensive? Modernized sewage treatment??

# Treatments for waste from large livestock operation - Animal Wastewater

**3. Manure lagoons-** large, human-made ponds lined with rubber to prevent the manure from leaking into the groundwater. After the manure is broken down by bacteria, it is spread onto fields as fertilizers.



Similar to human waste contamination, manure from the feeding lot operations not only contain **digested animal foods, but also variety of hormones and antibiotics....a leak in the liner can seep into the underlying groundwater and/or overflow into nearby bodies of water (contamination)**



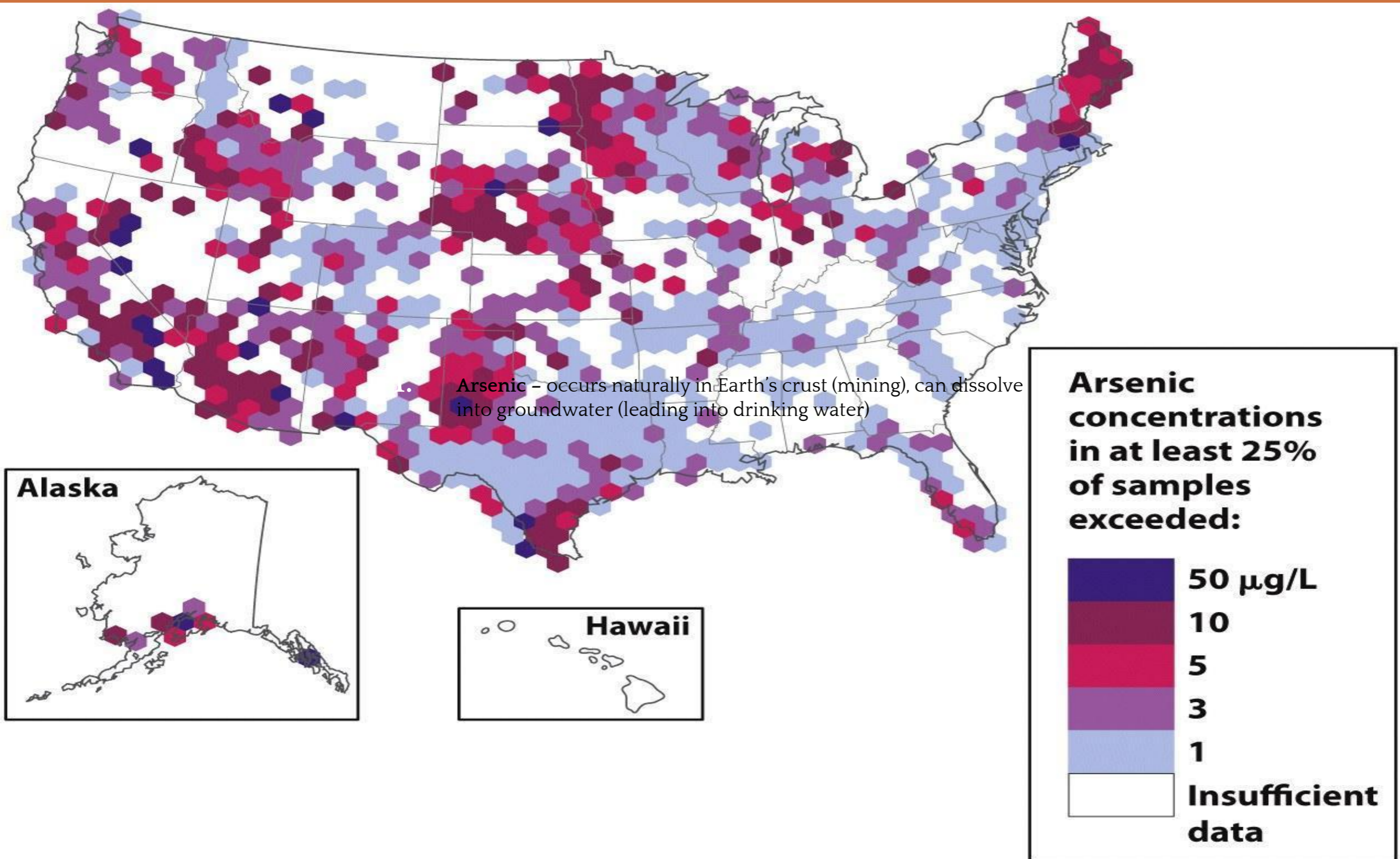
# Heavy Metals & Other Substances that can threaten human Health and the Environment

1. **Lead** – sources of drinking water

2. **Mercury** – naturally occurring in water, human activities such as burning fossil coal, incineration of garbage, hazardous waste &/or medical/dental supplies (disrupts the neural function and cognition)

3. **Nitrogen & phosphorus** cause environmental problems by overfertilizing the water  
(*Algal Bloom – BOD – dead zones*)

### 3. Arsenic – occurs naturally in Earth's crust (mining), can dissolve into groundwater (leading into drinking water)



**Figure 14.8**  
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**W/O human intervention**



**4. Acids** – industrial plants burning coal & releasing Sulfur dioxide & nitrogen dioxide into air causing forests, lakes, streams and some bodies of water to become more acidic (altering pH balance... buffers)

Low pH of water from mines mixes with low pH of streams causes iron to precipitate out of solution forming a rusty red oxidized iron





5. **Synthetic compounds** (pesticides “DDT”, military/industrial “PCB” & “PBDEs” (*flame retardant*) chemical compounds, pharmaceuticals, and hormones) – toxic, carcinogens, genetic defect, interfere with growth & sexual development (reproduction – survival of the fittest) found in the water, soil, and agricultural

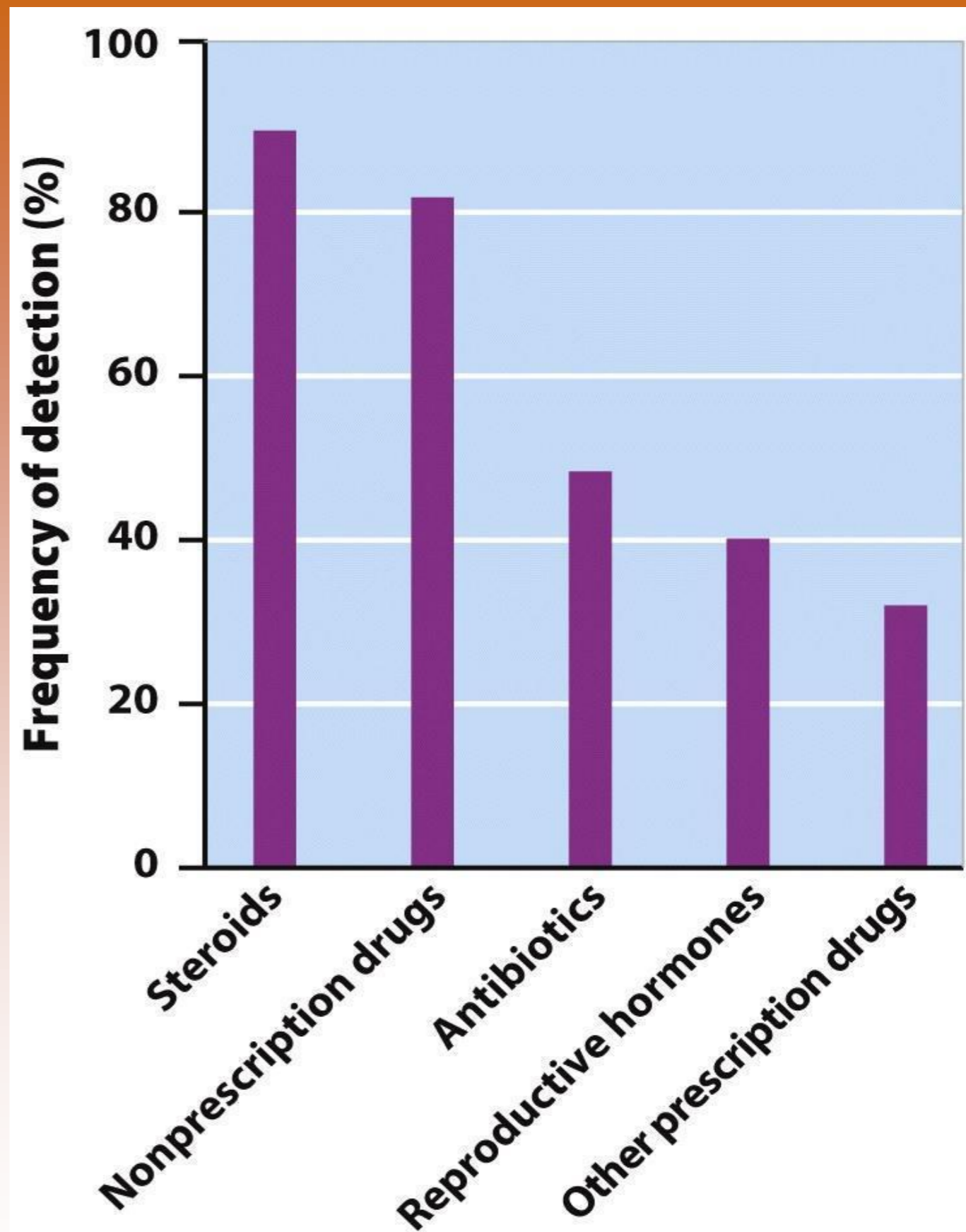


Figure 14.12  
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# Oil Pollution

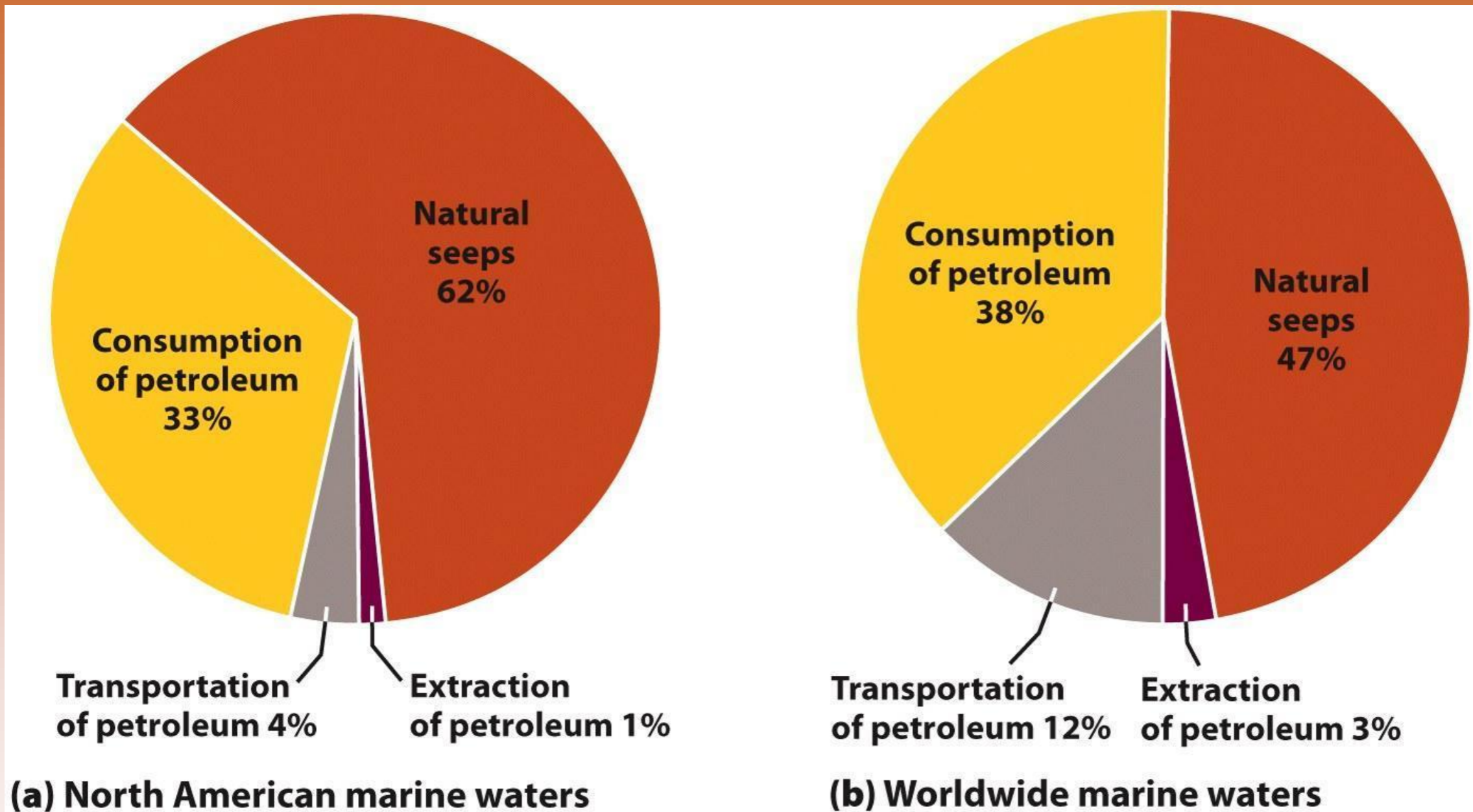


Figure 14.15

Comes from variety of sources including natural seeps, extraction of oil from underneath the ocean, transport of oil by tanker/pipeline & consumption of petroleum-based products...highly toxic to many marine organisms



**Figure 14.14**

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## Exxon Valdez oil spill of 1989

Spilled of millions of crude oil onto the shores of Alaska...killing thousands of animals.

**BP oil spill of 2010**, pipe broke on ocean floor (1 mile below the surface) form of *underwater plumes*

Oil can spread below and across the surface of the water for hundreds of km and extremely difficult to remove.

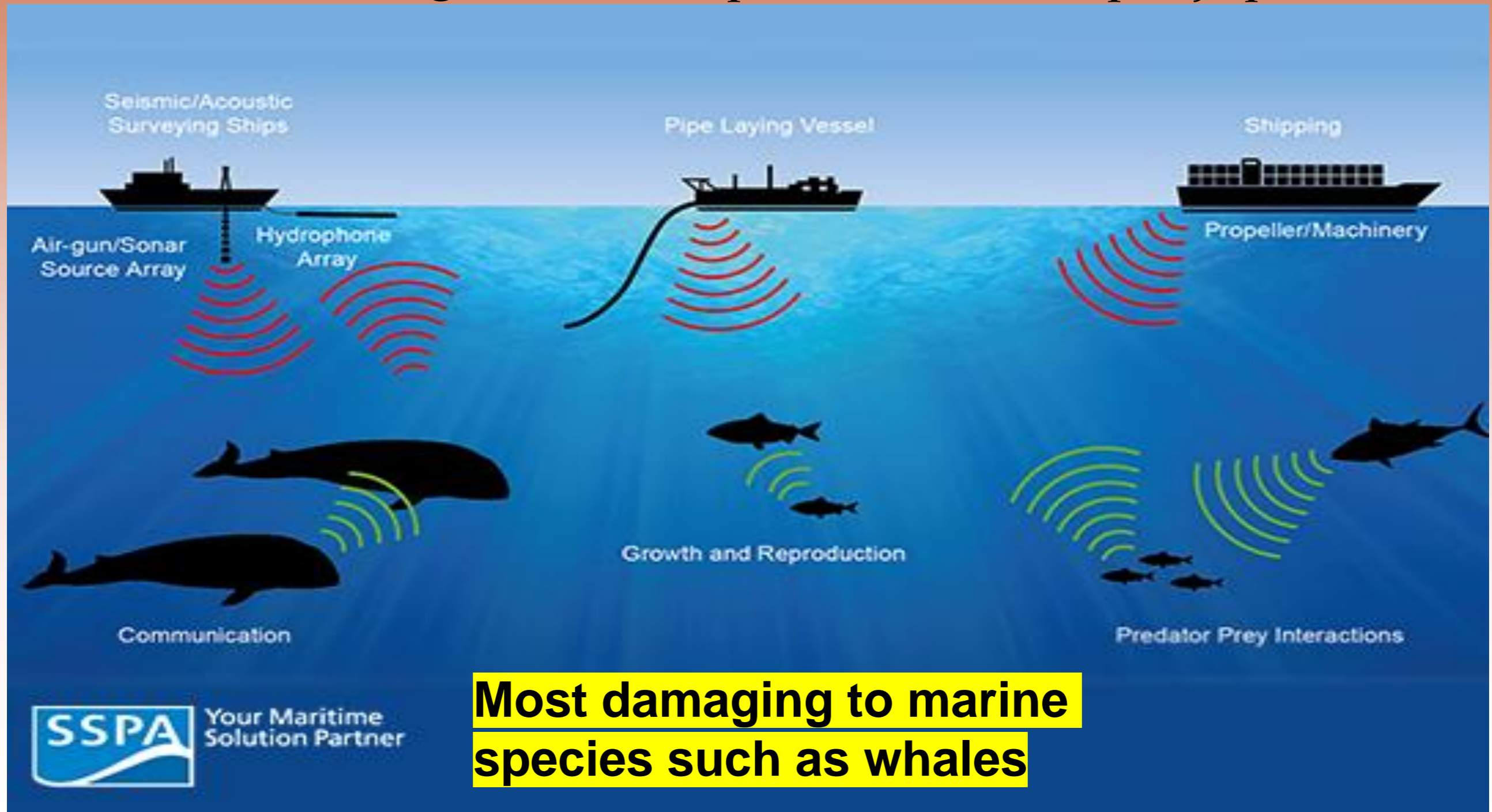


# Ways to Remediate Oil Pollution

- Cleaning organisms by hand
- Containment using **booms** (*plastic barriers*) to keep the floating oil from spreading.
- Boats equipped with giant **oil vacuums** suck up oil
- Closer to the shoreline and shallow areas, use of **absorbent material** to suck up the spill
- **Chemicals** that help break up the oil, making it **disperse** before it hits the shoreline (effective but can be toxic to marine life).
- **Bacteria** that are genetically engineered to **consume oil**

# Other Water Pollutants (Non-Chemical Based)

**1. Noise pollution** (receives least amt. of attention) Sound emitted by ships & submarines can interfere with animal communication, growth & reproduction, & prey/predator.





**2. Solid waste pollution** (*garbage, mostly plastic, coal ash/slag*) do not pose any toxic hazard, generally disposed in landfills, but some cases ends up in bodies of water.





### 3. Sediment pollution

*(sand, silt and clay)*  
carried by moving  
water in streams and  
rivers to another  
location where water is  
slow moving (*natural  
process but humans  
can increase the amt.  
by sprawling - erosion  
wind/rain*)



**Figure 14.18**

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**4. Thermal pollution-**  
human activities causes  
substantial change in  
temp. of water.

Most common cause  
occurs when cold water  
is removed from a  
natural supply, used to  
absorb heat (*part of  
industrial process*) then  
returned as heated  
water (*thermal shock* to  
organisms, kills  
organisms due to lack of  
oxygen-warmer water  
does not carry as much  
as colder water)



### **Solution**

1. cooling towers that release the excess heat into the atmosphere instead of water.
2. Closed system that cool the hot water in the tower and recycle the water to be reheated (no extraction from natural water bodies)

# Water Laws

- **Clean Water Act-** (1972) supports the “protection and propagation (breeding) of fish, shellfish, and wildlife and recreation in and on the water”.
- This is done by maintaining and, when necessary, *restoring the chemical, physical, & biological properties of natural waters.* (does not protect groundwater)
- Issued water quality standards that defined *acceptable limits of various pollutants* in U.S. waterways.
- This act allows **EPA & state governments** to issue **permits to control how much pollution industries can discharge into the water** (*pay to pollute*)



# Water Laws

- **Safe Drinking Water Act-** (1974, 1986, 1996) sets the *national standards* for safe drinking water.
- EPA is responsible for establishing **Maximum Contaminant Levels (MCL)** for 77 different elements or substances (*microorganisms, disinfectants, organic & inorganic chemicals*) in both surface water and groundwater.

**TABLE 14.1**

**The maximum contaminant levels (MCL) for a variety of contaminants in drinking water as determined by the U.S. Environmental Protection Agency, in parts per billion (ppb)**

<b>Contaminant category</b>	<b>Contaminant</b>	<b>Maximum contaminant level (ppb)</b>
<b>Microorganism</b>	<b>Giardia</b>	<b>0</b>
<b>Microorganism</b>	<b>Fecal coliform</b>	<b>0</b>
<b>Inorganic chemical</b>	<b>Arsenic</b>	<b>10</b>
<b>Inorganic chemical</b>	<b>Mercury</b>	<b>2</b>
<b>Organic chemical</b>	<b>Benzene</b>	<b>5</b>
<b>Organic chemical</b>	<b>Atrazine</b>	<b>3</b>

**MCLs are subjective to political pressure & affordability...Arsenic levels are anywhere from 10-50ppb depending upon the communities ability to afford the reduction of the arsenic in drinking water (too expensive)**



**TABLE 14.2****The current leading causes and sources of impaired waterways in the United States**

	<b>Causes of impairment</b>	<b>Sources of impairment</b>
<b>Streams and rivers</b>	<b>Bacterial pathogens, habitat alteration, oxygen depletion</b>	<b>Agriculture, water diversions, dam construction</b>
<b>Lakes, ponds, and reservoirs</b>	<b>Mercury, PCBs, nutrients</b>	<b>Atmospheric deposition, agriculture</b>
<b>Bays and estuaries</b>	<b>Bacterial pathogens, oxygen depletion, mercury</b>	<b>Atmospheric deposition, municipal discharges including sewage</b>

**Source:** Data from U.S. Environmental Protection Agency. 2004. *National Water Quality Inventory: Report to Congress.*

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Water regulations have greatly reduced contaminations of waterways for point sources of pollution; however, **nonpoint sources** (oil from parking lots, nutrients, pesticides from lawns) are not covered under existing regulations.

## Developed vs. Developing Nations

- **Developed countries** experienced industrialization for many decades and widely polluted their air & water
- **Developing countries** are in the process of industrializing (benefit economically from additional jobs), have less restrictive environmental laws, & have less money to fund water-quality improvements.
- *In some cases, contaminating industries move from developed countries to developing (cycle)*

**Solutions? Technology? Petition?** (Brazilian river polluted, government regulated the pollution, cleaner today) **Money??**