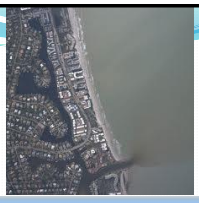
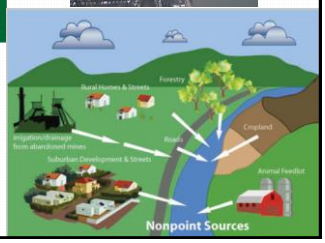
The basics…

- Pollution comes from the Latin for "defilement"
- Anything that lessens the quality or health of a system, environment, or area
  - Can be chemical, physical, or other types of pollution
- Water pollution affects all of the hydrosphere, and thus impacts aquatic AND terrestrial organisms

Sources of pollution

- Point vs. Nonpoint sources:
  - Point: specific, discrete, individual sources of pollution
    Examples: a single factory dumping, an oil spill
  - Nonpoint: broader, more spread out areas of pollution
    Examples: a farming region, a neighborhood of suburban, fertilized lawns
- Incredibly broad range of pollutants



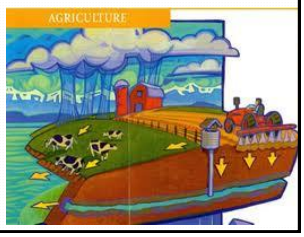


Types of Pollutants

- Pollution enters all three sectors of water use:
  - Agricultural
  - Industrial
  - Domestic

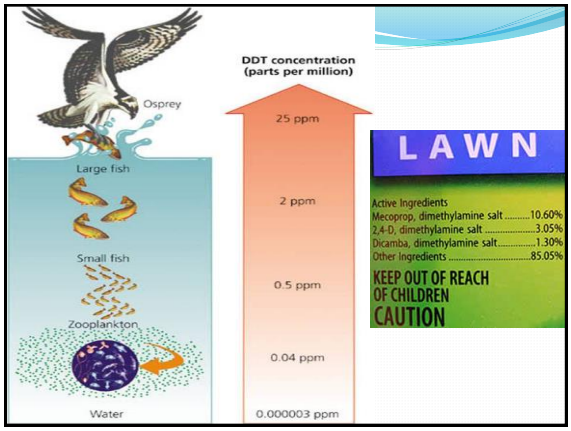
Agricultural Pollutants

- Fertilizers can lead to over-nurtifying a body of water
- Often synthetic, organic compounds: pesticides have lots of problems



Pesticides

- Typically general in their targets (harm beneficial organisms)
- Often biomagnify—build up in food chains
- Unknown side-effects when added to organisms they're not tested on
- "Inert ingredients" make pesticides more effective, but are usually trade secrets

Synergistic Interactions

- Many chemicals when added together are worse than the sum of the parts

A + B < AB

The effects of A and B together are greater than the effects of each on their own combined.

Agricultural Pollutants

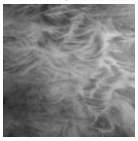
- Primarily chemical, but can include organic waste as well
- Animal feedlots produce lots of organic matter
  - Sometimes collected in manure pools (blegh!)

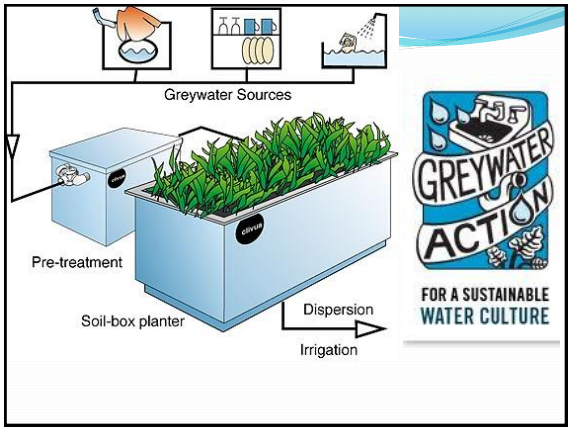

Domestic pollutants

- Anything that comes from everyday activities
- Noncommercial activities
- Primarily in the form of human wastewater


Human Wastewater

- Anything given off from daily activities
  - Human sewage: toilets or non-plumbing systems
  - Grey water: water used from washing dishes or clothes, etc.
    - Current efforts to recycle this!
- Serious issue of separating wastewater and drinking water



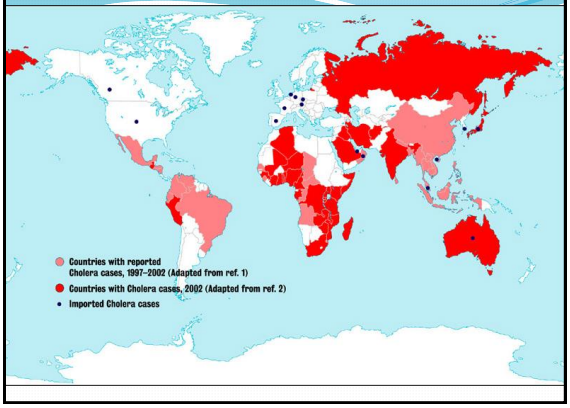



Disease Causing Organisms

- Much of human waste is fed on by bacteria and other pathogens that make people sick
- Can't test for them all, so scientists look for indicator species
  - Fecal coliform bacteria: a good indicator, especially *E. coli*

Water-borne illnesses

- Primarily hepatitis and cholera
- Rare in MEDCs, but claim thousands of lives annually in developing countries
- ~3.4 million deaths annually from malaria and diarrheal diseases—world's leading cause of death
  - More than half could be prevented by providing clean H2O (2.2 million diarrheal disease deaths annually)
  - More than 780 million people don't have adequate clean water
- More than 35% of the world doesn't have proper sanitation



Oxygen Demand

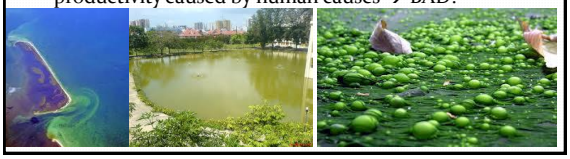
- In addition to pathogens, some waste leads to organism blooms that decrease H2O quality
- Organic matter encourages microbe growth
- Microbes need O_2 to decompose waste
- Biological O_2 Demand (BOD): how much O_2 is needed for decomposition
  - Wastewater can have a BOD 40x as high as leaf litter

Eutrophication

- Remember eutrophication:
  - Too much organic matter or nutrients
  - Increased fertility and primary productivity
  - Leads to an algal bloom
  - Algae die
  - Aerobic microbes break them down
  - High BOD leads to lowered dissolved O2
  - Other organisms can't survive
  - Body of water dies

Eutrophication 2: Algal Boogaloo

- Lesser versions of eutrophication can be seen as dead zones: entire system hasn't collapsed, but available O_2 is diminished
  - Ex.: Mouth of the Mississippi River in the Gulf
- Cultural eutrophication: extra nutrients and productivity caused by human causes → BAD!

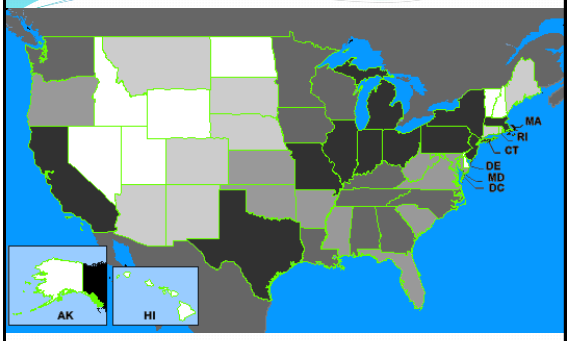


Industrial Pollutants

- Any chemical biproduct of manufacturing
- Often dumped directly, even in the US, where it wasn't illegal
- Persistent and often carcinogenic (cancer causing) or teratogenic (birth-defect causing)

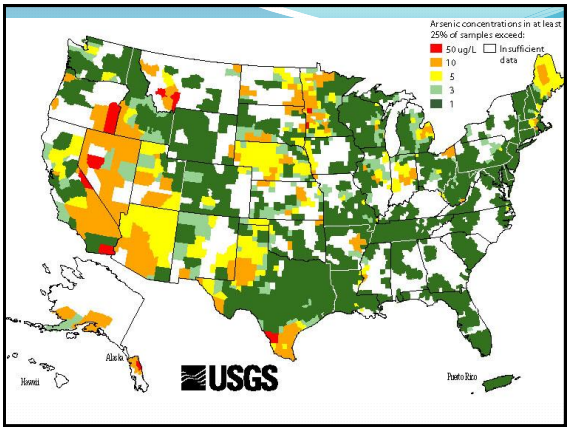
Heavy Metals

- Lead: gets in water from lead pipes and lead paint
  - Serious nervous and renal damage, especially in kids
  - Illegal now, but lots of it remains to be cleaned up



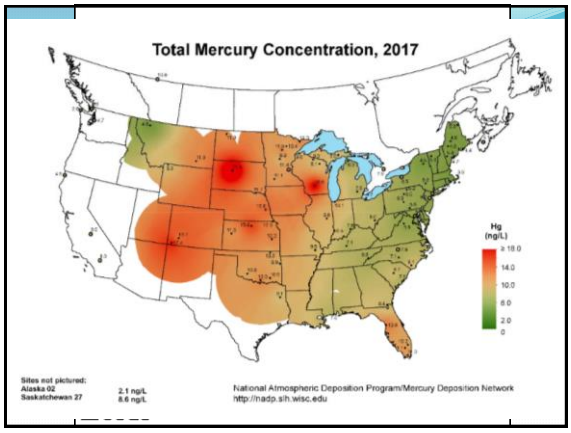
Heavy Metals

- Arsenic: naturally occurring heavy metal in rocks. Mining and deep well drilling adds arsenic to drinking H_2O
  - Carcinogenic
  - World-wide contaminant



Heavy Metals

- Mercury: naturally occurring, but gets in water through human activities
  - Burning coal/coal ash
  - Cement manufacturing (can be in limestone)
  - Converted to methylmercury by microbes
  - Methylmercury impairs senses, causes neurological damages, inhibits fetal development
  - We primarily get it by eating fish



Hill Republicans move to scrap Obama-era regulations

The Washington Post

ice President Pence, second from right, Commerce Secretary-designate ilbur Ross, second from right, and White House senior adviser Jared ushner, right, listen to President Trump during a meeting with House and enate legislators in the Roosevelt Room of the White House on Feb. 02, 017. (Jabin Botsford/The Washington Post)

By Juliet Eilperin and Steven Mufson February 2

The Senate voted to overturn an Obama administration ule Thursday aimed at preventing coal-mining operations rom dumping waste into nearby waterways, the first of early half-a-dozen rule reversals headed to President rump's desk for his signature this month.

The "stream protection rule," issued by the Interior Department's Office of Surface Mining Reclamation and Enforcement, has been a priority for repeal among GOP lawmakers since it was finalized in December.

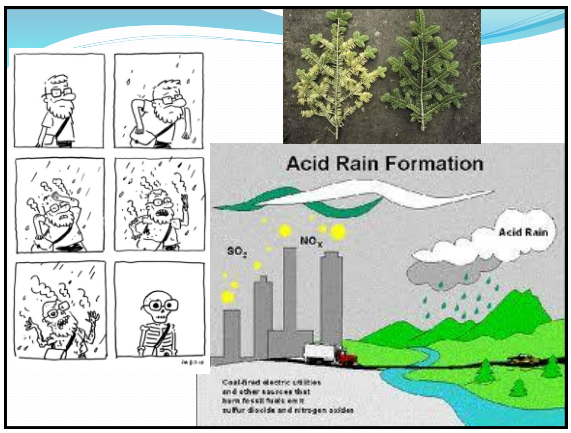
It not only stops mining firms from polluting waterways, but it also requires them to restore streams outside permit areas that have been damaged by miningerations. Companies would have to establish a 100-foot-wide corridor of native species along stream banks. While environmentalists had praised the rule, Republicans said it amounted to an effort to undermine energy companies and kill off jobs.

Sen. James M. Inhofe (R-Okla.) said Thursday in a statement that the regulation "actually creates problems, costing jobs and completely reworking regulatory programs within the agency." Reversing it, he added, was part of the GOP's broader effort "to end the War on Coal and undo eight years of burdensome regulations" adopted during Obama's tenure.

But the move has drawn sharp criticism from environmentalists, who have accused its supporters of placing the interests of the fossil-fuel industry above the health and safety of affected communities.

Acidified Water

- Drilling and mining (often for fossil fuels) releases wastes in the rocks that acidify water
- Burning fossil fuels releases pollutants that create acids (acid rain/ acid deposition)
  - Try to prevent this with coal scrubbers (clean coal air pollution)
  - Acidic water can kill organisms at multiple stages of ecosystems



Other synthetic organic compounds…

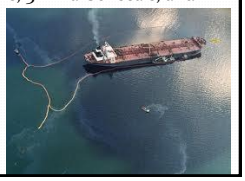
- Pharmaceuticals: prescription and nonprescription drugs (especially steroids and antibiotics) found in most US water
  - Mostly low concentrations
  - Don't understand effects, though!
  - Bacterial resistance?
- Hormones: birth control and hormone replacement
  - Low conc's, but work at low levels
  - Males developing eggs (fish)
  - Other potential effects

Oil

- Oil along shorelines and in oceans from several sources
  - Shoreline refineries as in Texas
  - Offshore oil drills: 1500 world wide—many hundreds of which are in the USA (214 in the Gulf of Mexico alone!)
    - Currently about 30% of our crude oil production worldwide
    - >20 million barrels of crude per day
    - We leak 146,000 kg of oil per year in ocean from USA
    - Leaks of 0.3-1.4 million kg from other parts of the world
  - Oil spills from tankers

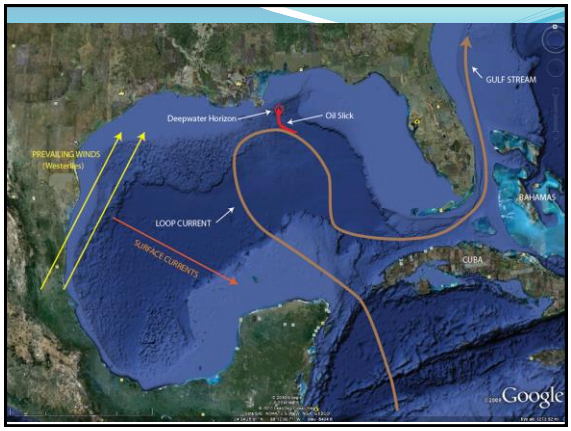
Oil Spills: Case studies

- Exxon Valdez Oil Tanker: 1989
  - Exxon tanker ran aground in Alaska
  - Spilled 11 million gallons of oil across several km of ocean surface and shoreline
  - Killed 250,000 birds, 2,800 otters, 300 harbor seals, and 22 killer whales
  - Clean-up efforts still ongoing



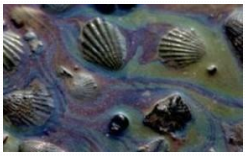
Oil Spills: Case studies

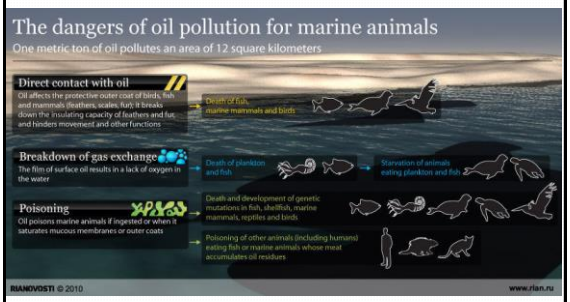
- Deep-water Horizon BP Gulf Oil Spill: 2010
  - Explosion caused a pipe to break due to failed safety observances
  - Leaked from April until August
  - Estimated 206 million gallons spilled
  - Not quite sure where this oil went… Potential for disaster



Issues with Oil

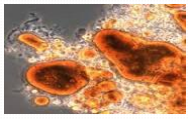
- Extremely toxic to animals—carcinogenic in nature
- Exxon Valdez spill still not cleaned up– several populations (otters and whales) never rebounded
  - Won't know full effect for a while
- Can take many decades – 100 years to break down





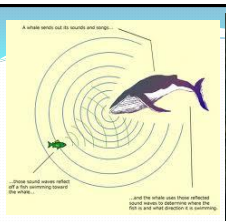
Cleaning Up Oil

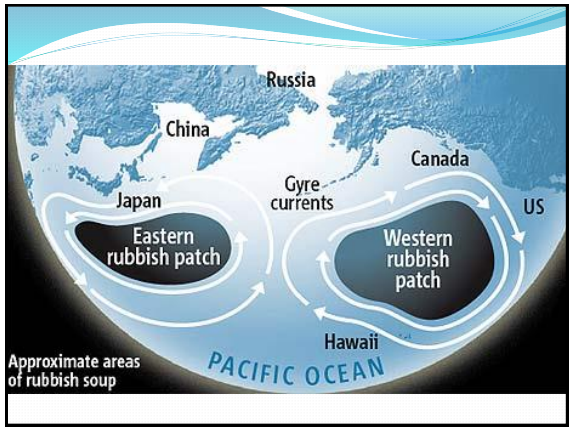
- Much has to be done by hand
  - Animals in particular are washed
  - Too much washing damages fragile ecosystems, though
- Floating oil can be siphoned off or broken down with chemicals
- GMO bacteria can eat oil



Water pollution… Not always chemical!

- Solid waste: trash, recyclable goods, medical waste, coal ash
- Sediment: fine particles increased by human activities like construction and damming
- Thermal pollution: use water to cool and dump hot water back (especially power plants)
  - Can shock organisms
- Noise pollution: can interfere with animal communications, especially mammals (whales)
  - Sonar beaching whales



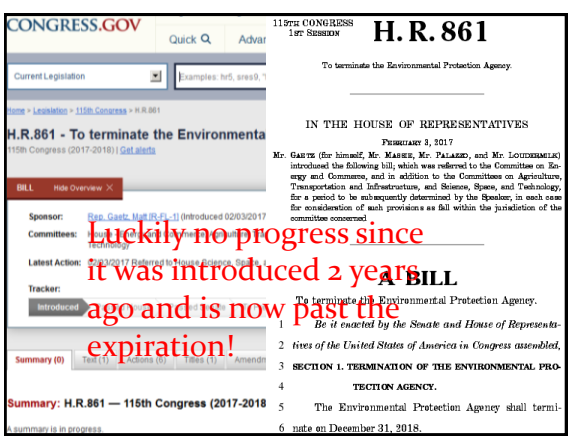


What to do? What's been done?

- Clean Water Act: 1972
  - "Protection and propagation of fish, shellfish, and wildlife and recreation in and on the water"
  - First just regulated chemicals, also now focused on biological richness
  - Controlled by EPA—allows EPA to act
- Safe Drinking Water Act: 1974, 1986, 1996
  - Established maximum contaminant levels

National Primary Drinking Water Regulations

Contaminant	MCL or TT[1] (mg/L)[2]	Potential health effects from long-term[3] exposure above the MCL	Common sources of contaminant in drinking water	Public Health Goal (mg/L)[2]
OC Acrylamide	TT[4]	Nervous system or blood problems; increased risk of cancer	Added to water during sewage/ wastewater treatment	zero
OC Alachlor	0.002	Eye, liver, kidney or spleen problems; anemia; increased risk of cancer	Runoff from herbicide used on row crops	zero
R Alpha/photon emitters	15 picocuries per Liter (pCi/L)	Increased risk of cancer	Erosion of natural deposits of certain minerals that are radioactive and may emit a form of radiation known as alpha radiation.	zero
IOC Antimony	0.006	Increase in blood cholesterol; decrease in blood sugar	Discharge from petroleum refineries; fire retardants; ceramics; electronics; solder	0.006
IOC Arsenic	0.010	Skin damage or problems with circulatory systems, and may have increased risk of getting cancer	Erosion of natural deposits; runoff from orchards; runoff from glass & electronics production wastes	0
IOC Asbestos (fibers >10 micrometers)	7 million fibers per Liter (MFL)	Increased risk of developing benign intestinal polyps	Decay of asbestos cement in water mains; erosion of natural deposits	7 MFL
OC Atrazine	0.003	Cardiovascular system or reproductive problems	Runoff from herbicide used on row crops	0.003
IOC Barium	2	Increase in blood pressure	Discharge of drilling wastes; discharge from metal refineries; erosion of natural deposits	2
OC Benzene	0.005	Anemia; decrease in blood platelets; increased risk of cancer	Discharge from factories; leaching from gas storage tanks and landfills	zero
OC Benzo(a)pyrene (PAHs)	0.0002	Reproductive difficulties; increased risk of cancer	Leaching from linings of water storage tanks and distribution lines	zero
IOC Beryllium	0.004	Intestinal lesions	Discharge from metal refineries and coal-burning factories; discharge from electrical, aerospace, and defense industries	0.004
R Beta photon emitters	4 millirems per year	Increased risk of cancer	Decay of natural and man-made deposits of certain minerals that are radioactive and may emit forms of radiation known as photons and beta radiation	zero
DBP Bromate	0.010	Increased risk of cancer	Byproduct of drinking water disinfection	zero
IOC Cadmium	0.005	Kidney damage	Corrosion of galvanized pipes; erosion of natural deposits; discharge	0.005



Luckily no progress since it was introduced 2 years ago and is now past the expiration!

MEDCs vs LEDCs

- MEDCs have had longer to pollute and are just now starting to clean up
- LEDCs still industrializing, fewer laws, and less money for cleanup and enforcement
- More affluence usually means more interest in cleaning the environment, though, which is good!

Making Water Clean For All…

- Remember that a major problem with water pollution is that it prevents people from accessing the most important substance for life on Earth…
- Take notes on the following:
- http://www.ted.com/talks/sonaar_luthra_meet_the_water_canary.html?quote=1503
- http://www.ted.com/talks/michael_pritchard_invents_a_water_filter.html
- Answer the following in a reflection paragraph: What is the single greatest threat to clean water worldwide? Explain using examples from lecture or the talks.