Science 10: (2.3) The Effect of Bioaccumulation on Ecosystems

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(Reference: BC Science 10 pp. 92 to 103)

- Amphibians (ex. frogs) live on both land and in the water.

- They are therefore useful indicators of the health of an ecosystem.
- They are sensitive to the effects of chemical run-off and other pollutants in the environment.
- Since the 1980s, the number of amphibians has fallen dramatically and there have been alarming increases in malformations in frogs.
- Causes of amphibian loss include:

prolonged drought, increased UV radiation due to ozone depletion, habitat loss, pollution, overhunting, parasites, diseases (viral + fungal)

  - **pesticides**: chemicals used to eliminate pests
    - **insecticides**: kill insects
    - **herbicides**: kill plants

HOW POLLUTANTS CLIMB THE FOOD CHAIN

- Human activity that has caused one of the biggest changes/disturbances to ecosystems has been the introduction of synthetic chemicals.

BIOACCUMULATION

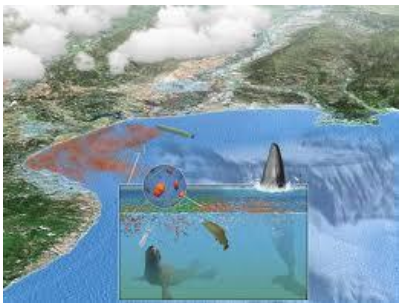
- **Bioaccumulation:** the gradual build-up of synthetic & organic chemicals in living organisms

- Occurs when decomposers cannot break down the chemicals through the biodegradation process.
- Chemicals are taken up and stored faster than they are broken down and excreted.
- These chemicals can enter the organism through food intake, skin contact or respiration and can be harmful if they are not metabolized or not excreted.
- Bioaccumulation can affect the nervous, immune, and reproductive systems of animals.
- If a keystone species suffers a chemical bioaccumulation, it can affect every other organism in its far reaching niches.
  - **keystone species:** species that can greatly affect population numbers and the health of an ecosystem

Ex. Salmon are a keystone species in many BC forest ecosystems in the following 3 ways:

1. important food source for bears, wolves, eagles & otters
2. after death, their decaying bodies are a rich source of nutrients
3. can retain chemicals for trees. in body fat & transfer to other organisms.

- **Biomagnification:** the process in which chemicals not only accumulate but become more concentrated at each trophic level.
  - Occurs when pollutants are stored in the plant tissues and the fat tissue of animals are eventually released when consumed at higher levels in the food chain.



  - → Red tides are an example of biomagnifications because as algae become so numerous, it produces toxic organic chemicals that can affect organisms, such as clams, mussels, and oysters. The organisms eat the algae and the toxins bioaccumulate to levels dangerous to others such as fish, and humans.

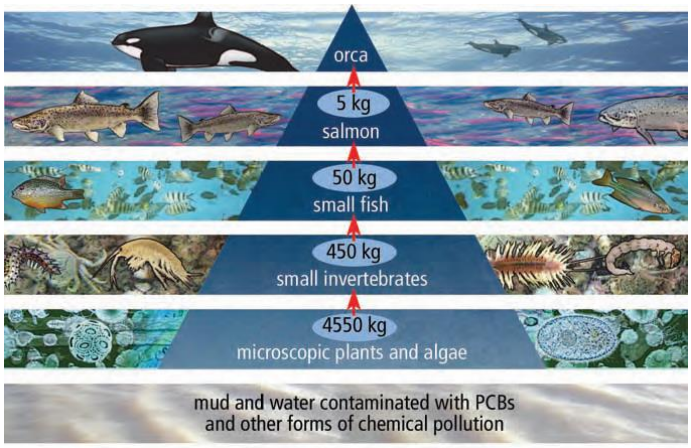
PCBs AND THE ORCA

An example of bioaccumulation in BC is the effect of PCBs on the Orca.

- **PCBs** (polychlorinated biphenyls): synthetic chemicals widely used from the 1930's - 70's in industrial products, such as heat exchange fluids, paints, plastics + lubricants for electrical transformers

  - become stored in the tissues of animals, and also persist in the environment.
  - banned in 1977 because of concerns about their impact on the environment + human health.

- PCBs bioaccumulate and biomagnify, and also have a long half-life.
  - → **half-life**: the time it takes for a living tissue, organ organism or ecosystem to eliminate one half of a substance
  - PCBs will affect the reproductive success of orcas until at least 2030 because by the time they make it up the food chain they are highly concentrated in the blubber.
    - → Magnification is increased when salmon stocks are low because blubber is burned for energy
    - → PCBs enter the orca's bloodstream and interfere with immune function.



PERSISTENT ORGANIC POLLUTANTS (POPs)

- **Persistent Organic Pollutants (POPs)**: carbon-containing compounds that remain in water and soil for many years.

Many POPs are introduced to ecosystems as insecticide sprays

- Ex. **DDT** (dichlorodiphenyl trichloroethane): an insecticide introduced in 1941 to control disease-carrying mosquitoes.
  - → Like PCBs, DDT also biomagnify, has a long half-life and persists in the environment.
  - → At even low levels (5 **ppm**), DDT in animals can cause nervous, immune and reproductive system disorders.
    - **ppm** = parts per million.

Table 2.2 Bioaccumulation of DDT in a Food Chain

Consumer	Bioaccumulation (ppm)
Plankton	0.04
Minnow	0.94
Adult fish	2.07
Heron	3.57
Osprey	13.80
Cormorant	26.40

****Complete CC p. 103 #1-11**

HEAVY METALS

- **Heavy metals:** metallic elements with a high density that are toxic to organisms at low concentrations
  - Within the biosphere they do not degrade and cannot be destroyed.
  - Some, like copper, selenium and zinc are essential in small quantities.
  - Found in water and air.
  - Are taken in through the food chain.
  - Heavy metals can also bioaccumulate and biomagnify like POPs.
  - The 3 most polluting heavy metals are lead, cadmium and mercury.

Lead:

- Environmental sources:
  - present in all soils (15-40 ppm)
  - insecticides, paints, gasoline, consumer electronics
- Effect on organisms:
  - same effects as below seen in fish + birds
- Effect on humans:
  - anemia, nervous system damage, sterility in males, low fertility in females, impaired mental development, kidney failure

Cadmium:

- Environmental sources:

- Earth's crust, trees
- plastics, nickel-cadmium batteries, zinc production, phosphate ore mining

- Effect on organisms:

- highly toxic to earthworms + other soil organisms at low levels. Higher death rates, low reproduction + grow rates in fish.

- Effect on humans:

- mainly caused by smoking → lung disease / cancer.
- cause infertility, damage to the central nervous system, immune system + DNA.

Mercury

* methyl mercury is highly toxic!

- Environmental sources:

- volcanoes, geothermal springs, rock weathering
- burning fossil fuels waste incineration, mining battery manufacturing, coal burning.

- Effect on organisms:

- circulated through the food chain, can bioaccumulate in the brain, heart + kidneys of vertebrates as methyl mercury.

- Effect on humans:

- absorbed into blood stream through digestion. Affects nerve cells, heart, kidney, lungs + suppresses the immune system.

REDUCING THE EFFECTS OF CHEMICAL POLLUTION

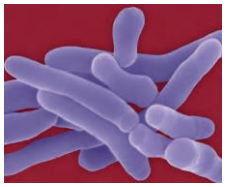
- 2 methods used to help solve the problem of chemical pollution include:

1. Trap the contaminant in the soil:

- phosphate fertilizer is added to lead-contaminated soil, causing a chemical reaction to produce lead pyromorphite (which is highly insoluble) so it can't spread easily by water & less likely to enter food chain.

2. **Bioremediation:**

bacteria



- the use of living organisms, usually micro-organisms, to do the clean-up naturally
  - only faster through biodegradation

- third way.

****Complete CC p. 103 #13-21**