Environmental Health, Pollution and Toxicology

The Basics

• Disease seldom has a one-cause, one effect relationship with the environment.

• The incidence of disease depends on several factors including:
  a. physical environment
  b. biological environment
  c. life-style

• Linkages between these factors are often related to other factors like local customs and the degree of industrialization.

Disease becomes more prevalent as feature of the landscape change in ways that favor proliferation of disease-causing organisms.

i.e.- Reforestation of the northeastern U.S. has led to the emergence of lyme disease by encouraging the proliferation of white-tailed deer, which transport ticks that harbor the Lyme bacterium.

• Developing countries (more people living off the environment) are prone to environmental health problems like cholera, dysentery and typhoid.

• Developed countries (more industrialized) are more prone to chronic and acute environmental health problems like respiratory ailments and cancer.

First we need to define some terms:

Pollution: the occurrence of unwanted change in the environment caused by the introduction of harmful materials or production of harmful conditions.

Contamination: it’s similar in meaning to pollution, and means to make an area unfit for a particular use.

Toxic: refers to materials (pollutants) that are poisonous to people and other living things.

Toxicology: is the science that studies poisons (toxins) and their effects, AND, clinical, industrial, economic and legal problems associated with toxic materials.

Often the air, water, soil, and rock around us can affect our susceptibility to environmental health risks:

On the night of August 21, 1986 a sub-aquatic landslide at the bottom of Lake Nyos in Cameroon, Africa disturbed the colder bottom waters and released carbon dioxide gas that had been trapped there (probably from the volcanic vents on the bottom). The released gas bubbled up out of the water, and being heavier than air settled down near the ground in nearby villages, killing many animals and 1700 people by asphyxiation.
Carcinogens: a toxin that causes cancer.

Synergism: the interaction of substances where the combined effect is GREATER than the sum of the individual effects.

Point Sources: a common source of pollution introduction like a smoke-stack, flowing pipe into a stream, or an accidental spill.

Area Source (Non-point pollution): more diffused source of pollution, like car exhaust, or urban runoff. Often these problems are difficult to isolate.

Measuring the Amount of Pollution

•Sometimes there is a need to measure in BIG units: Millions of gallons per day
  Millions of tons per year

•More often there is a need to measure in small units: parts per million (ppm) or parts per billion (ppb).

•These concentrations can be volume, mass, or weight.

•Often toxicology studies units used are milligrams per kilogram of body mass (1 mg/kg is 1 ppm).

•It may also be reported as a percent 100 ppm is 100 mg/kg is 0.01%.

•Concentrations of containments in Water Pollution is often measured in milligrams per liter (mg/l) or micrograms per liter (μg/l).

•If the contaminant does not significantly change the density of the water, 1mg/l is approx. 1ppm.

•Air pollutants are commonly measured in units of micrograms/cubic meter of air (μg/m³).

•1 ppm is an EXTREMELY small concentration (1 gm of salt on 1 metric ton of Pop-corn).

Categories of Pollutants

Infectious Agents:
•environmentally transmitted factors that cause disease.

•the agents are usually transmitted through food, water, air or soil.

•one of the oldest type of human health problems

•generally these can be easily controlled by manipulating the environment improving sanitation, treat the water, etc.

•the greatest mortality today in developing countries is caused by environmentally transmitted infectious diseases (AIDS in Africa, etc.)

Water-borne Illness & Food Poisoning

• In the U.S. there are 1000s of cases of water-borne illness and food poisoning each year

•Some examples of environmentally transmitted diseases are:

  1. Legionellosis (Legionnaires Disease)-bacteria found in most air conditioning units & showerheads.(pneumonia symptoms)

  2. Giardiasis- protozoan infection Small Intestines, passed by food, water, or person-to-person.

  3. Salmonella- food poisoning-bacterial infection spread via water or food.

  4. Malaria- protozoan infection transmitted by mosquitoes.

  5. Lyme borealis (Lyme disease)- bacteria transmitted by ticks.

  6. Cryptosporidosis- protozoan infection transmitted by water or person-to-person.

*This is a SMALL list. There are thousands more examples.
Toxic Heavy Metals

• Most heavy metals are extremely toxic to most life forms.

These metals are:

• Mercury
• Lead
• Cadmium
• Nickel
• Gold
• Platinum
• Silver
• Bismuth
• Arsenic
• Selenium
• Vanadium
• Chromium
• Thallium

- These have many uses in industrial processes.
- Each of these is also a by-product of mining processes.

• Heavy metals also have direct physiological effects. Some are stored in living tissue.

• The content of heavy metals in our body is known as the body burden.

• Lead (which is apparently not used by our bodies) has twice the body burden of any other heavy metal (reflects large use of lead).

Organic Compounds

• Compounds of carbon produced either directly by living things, or synthetically.

• Lots of types with lots of adverse health effects (hard to generalize).

• Used primarily in industrial processes, pest control, pharmaceuticals, food additives, etc.

• > 4 million known organic compounds, with 6,000 new ones added each week.

Radiation

Exposure to nuclear radiation is linked to serious health problems, including cancer.
Thermal Pollution
• Created when heat released by water or air produces undesirable effects.

• Can be acute or chronic.

• Heating water can change the average temperature, and concentration of Dissolved Oxygen. (this will change the species composition of the body of water)

• Lake fish are stressed at a 1.5 degree C change, River fish are stressed at a 3 degree C change.

• Stressed fish are more susceptible to disease and have a lower fecundity.

Particulates
• Small particulates of dust are released into the environment by many natural processes, and human activities.

• Modern farming, dust storms, fires, and volcanic eruptions add considerable particulates to the atmosphere.

• Many toxins enter the atmosphere as particulates.

• Sometimes non-toxins become converted to toxic forms in atmospheric chemical rxns..

Asbestos
• Small elongated mineral fragments produced from amphibole & serpentine (types of rocks).

• Industrial use in fire prevention.

• Used as heat insulation.

• Excessive contact with asbestos by industrial workers has lead to death by asbestosis and cancer.
Electromagnetic Fields (EMF’s)
•Produced wherever electricity and magnetism are used.
•High exposure to EMF’s has been linked to cancer.

Noise Pollution
•Unwanted sound
•Very loud (> 140 dB) cause pain / permanent hearing loss.(greater than 80 dB is potentially dangerous)

Voluntary Exposure
•Exposure to alcohol, tobacco, and other drugs.
"Make sure you read A Closer Look 14.2 (p292) & 14.3 (p293)

Concept of Dose & Response
•In the 1500s Paracelsus wrote “Everything is poisonous, yet nothing is poisonous.”
•All depends on the dose.
  i.e.- Copper is Required in small amounts, but poisonous in high concentrations.
•This concept is termed dose response.

Dose dependency can be represented by a General Dose Response Curve.
•Points A-F are very important.
•E & F are known for only a few substances on a few organisms.
**LD-50, ED-50, TD-50**

**Effective Dose**
ED-50 is a dose that causes an effect in 50% of the population.

**Toxic Dose**
TD-50 is the dose that is toxic to 50% of the population.

**Lethal Dose**
LD-50 is the dose that is lethal to 50% of the population.

LD-95 is useful in determining effective pesticides.

LD-0 is the dose that kills no one (still could be lethal)

• The **therapeutic index** is the ratio of LD-50 / ED-50
  the greater the index, the safer the drug is thought to be.

**Threshold effect**

• A threshold is a level below which no effect occurs, and above which effects begin to occur.

• It is difficult to evaluate the threshold for environmental pollutants.

**Ecological Gradient**

• Plants close to toxins tend to be grasses (like pioneer sp.) as the vegetation moves farther from the toxins, it changes to larger species like trees. This is known as ecological gradient. (Its change in vegetation over distance from toxins)

**Risk Assessment**

• Determining possible adverse environmental health effects following exposure to pollutants.

**Generally includes 4 steps**

1. Identification of the hazard
2. Dose response assessment
3. Exposure assessment
4. Risk characterization