Lecture 2:

1990 at least 179 confirmed air toxicants. Today it is at least 250.

If they are produced (more than 10 tons a year PER air toxicant). There are legislations on how to dispose them, how to transport them, etc.

This was not good enough, so they added: If the COMBINED emission is more than 25 tons a year. Then

EPA created a second list. […]

Acid rain first appeared around 1960.

Acid rain in Sweden source is England, Germany, Poland meaning acid rain can travel long distances. Acid rain = $NO_x + SO_2$

Great lakes were affected by the acid rain. Main source was coming from Canada.

Lots of lakes were affected in Ontario the source was Pennsylvania.

After number of years the Protocol of the great lakes was signed by USA and Canada.

Legislation was not good enough, so they redone it 2000.

Ozone layer 30-40 km from surface very, very thin 1 molecule of ozone per 100 000 molecules. Protects against sun radiation.

32% of radiation is immediately reflected upon entering the atmosphere called Albedo.

In the last centuries, the temperature of earth was stable +- 0.5 degrees.

Ozon layer destruction was caused CFCs.

The ozone destruction was noticed above the Vostok station.

Water pollution:

Surface water (70%):

Ground water (30%):

- Aquifers
- Springs

Municipal water (drinking, cooking, washing)

Clear water act 1970

Priority water Pollutants: (Page 43 book)

1) **Pathogens**: micro-organisms
   a. Virus: 1 cell smallest pathogen
   b. Bacteria: has tail and "mouth" so it can grow
   c. Protozoa: Meaning first kind of life. Has much bigger mouth and tail
   d. Parasitic worms
2) **Organics matter**: water has around 12 ppm dissolved oxygen. Organics matters reduce the oxygen in the water.
3) **Nutrients (Nitrogen, Phosphorus):** Coming from fertilizers and detergents.
4) **Toxic chemicals**: e.g. Oil (oil spills)
5) **Toxic metals**: Pb, As, Hg
6) **Sediments**:
7) **Acidity**:
8) **Salts**:
9) **Heat**:

The way to measure population of organic matter in water of is to much how much is the level of dissolved oxygen. The international community establish these means of pollution calculation:

- **BOD** (Biochemical oxygen demand): Normal this is much less than COD. Need 5 days to be measured.
- **COD** (Chemical oxygen demand): Needs 3 hours to be measured.

If the water is perfectly clean. BOD is 0:

- dumping sewers (toilet), BOD is 300.
- Can factory: BOD 1000.
- Slaughterhouses: BOD 2000.
- Coffee factory: BOD 10 000.
- Pig farms: BOD 100 000.

Legislation status that if you want to discharge water in river, BOD must be less than 30. For big BOD sequence of treatment is used.

Nitrogen and phosphorus: Very bad polluters. Come from fertilizers and detergents.

Blue baby: baby is lots of nitrogen inside.

Bad ozone: O_3 present on the surface of the each. It is extremely oxidant and destroys everything.

Clean drinking water indicators:

- Total coliforms*: We can accept 20 to 40.
- Total fecal coliforms: Must be 0.
- Streptococci.

Coliforms are microorganism that transport diseases (comes from extract of animals and humans)

Ground water is polluted through:

- fertilizers.
- Leakage from gas stations (12% of gas stations leak, most of them change tanks 2 times a year).

Chapter 3 :

Problems caused by cars:

- Traffic congestions
- Air population
- Petrochemical smog
- Urban sprawling (urbanisation)

Ways we tried to resolve that problem:

- Not everybody is allowed in downtown.
- Not allowed in specific hours or days.

Biggest negative about cars: Air population.

The increase of car population is exponential which gives birth to a number of different problems.

Exhaust of car:

Produces CO_2 CO NO_x Hydrocarbons. The problem is huge because of the number of cars present and sold each year.

Petrochemical smog: This is present in mega cities and caused by number of factors. Such as:

- Presence of gases of exhaust pipes
- Sunlight
- Presence of NO_x VOC and Hydrocarbons

This produces bad ozone on the surfaces of the earth.

Consequences start on:

- Pregnant women
- Taxi drivers
- Kids

Another effect of cars, urban sprawling, urbanisation. Phenomenon of 20th century. Never happened before.

The more a country is developed the high the percentage of paved roads.

Parameters:

- Change of unpaved roads to paved roads.
- Diminution of pollutants.
- Weight of car

Car piston 1/66 s for 1 move

If you have more fuel than air, you will produce much more pollutants.

Dirty engine produces more pollutant compared to clean engine.

Clear engines have perfect fuel to air ratio.

Air pollution control unit: Uses catalytic converters to take pollution out before it goes to the atmosphere. Up to 1970, was very simple and not effective.

2 kinds of catalytic converters:

- Using platinum takes care of CO and hydrocarbons.
- Using Rhodium takes care of NO_x

A double air pollution control unit. More of cars today have 2 air control units.

Today we want to add a third one to take care of the rest (but only expensive cars have it).

Chapter 7:

Life cycle analysis:

A study done for any thing produced or built. Go and study what raw material do I need to produce. Are they best to use? Is there a possibility to change to something better for the environment? Also study the other end, how will the product be wasted?

Life cycle also includes the price of wasting product in the product price.

- **Disadvantages**: Expensive, consumes resource time.
- **Advantages**: it is used in any kind of

Step 1: Inventory Analysis (biggest part):

- Listing of all inputs and outputs
- Qualification of each input and output

Step 2: Impact Analysis:

- Listing of effects on the environment for each input and output identified in inventory analysis.
- Qualitative and/or quantitative description of impacts: adverse effects on human health and welfare, ecosystems, and material as well as resource depletion.

Step 3: Improvement Analysis:

- Listing of needs and opportunities to reduce adverse effect identified in impact analysis and inventory analysis.
- Qualitative and/or quantitative description of improvements.

If we don't arrive to the first step that means we don't have an concrete result from out lifecycle analysis

Chapter 10:

Stone age: Discovery of smelting metals (metals when smelt change property)

Antient Babylonia: iron was 8 times more valuable than silver.

Antient Egypt: Copper was more valuable than gold.

Iron age starts 1000 B.C. the application of iron in a way we never seen before.

500 B.C. first time isolation of 1 metal (Mercury in golden age Greece)

Roman period, masters at transporting water.

Steam engines because of new usage of iron.

1820 is the first time we have report about metals and their isolation. We know there exists 40 metals on earth.

1900 we realize there are 70 metals identified.

Today 73.5 (the 0.5 because we are not sure if it is a metal or not when isolated)

Airplane: discovery of mixture (Chromium and nickel). Discovery of alloys

Lead, Arsenic and mercury very toxic, very dangerous and very poisonous

4 Ways of absorbing these toxic metals:

- **Inhalation**: different settling happening depending on the diameter of the particles. They go to alveolar sac and deposit there.
- **Drinking**
- **Food**
- **skin**

To figure the total absobtion of a body of a heavy metal:

$$C_{air} \cdot U_{air} \cdot f_{air} + C_{water} \cdot U_{water} \cdot f_{water} + C_{food} \cdot U_{food} \cdot f_{food} + C_{dust} \cdot U_{dust} \cdot f_{dust}$$

Chapter 12 (Soil contamination):

Waste is the main contaminator. Biggest part is solid waste. The more I separate them at the source the better.

Waste is sent to landfill or incendiary.

We must separate waste from Hazardous waste. Transported and disposed differently. In 1970 started to identify the hazardous waste. Hazardous waste is defined by:

- Ignitability
- Corrosivity
- Reactivity
- Toxicity

EPA found more than 1200 contaminated sites in USA only in the 20th century. For that they created big fund and CERCLA in 1980 (1.6 billion dollars). It was not enough and then increased to 8 billion dollars.

In Canada, most of contaminated sites were North.

2kg of waste per person per day. To reduce we try to:

- Recycle
- Recover
- Reuse
- Reduce

Radioactive waste has:

- Radiation emission
- Half life.

Uranium is extracted from uranium ore.

Plutonium: 94 Atomic number. Very dangerous. Because it produces gamma radiations

Yuka mountains in Nevada to dispose nuclear waste:

- Far from any population
- Soil is rocky
- Desert
- No roads, no railways, etc.

Uranium mile tailing:

2000 Kg of ore 1 KG is enriched uranium. The reset still has traces of uranium. This piles up to a hill and then leaks to ground water.

Every planet has a unique black body.

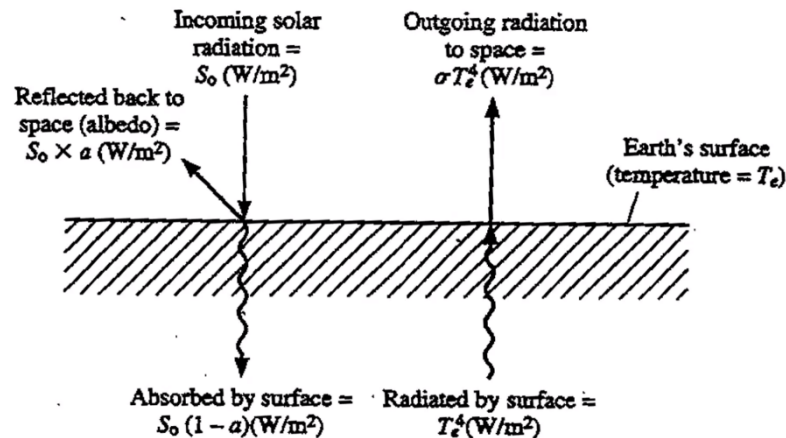**Atmospheric window**: area between 8 to 12 not much of an absorption that happens.

Figure 12.4   A simple energy balance model for the earth, assuming no atmosphere.
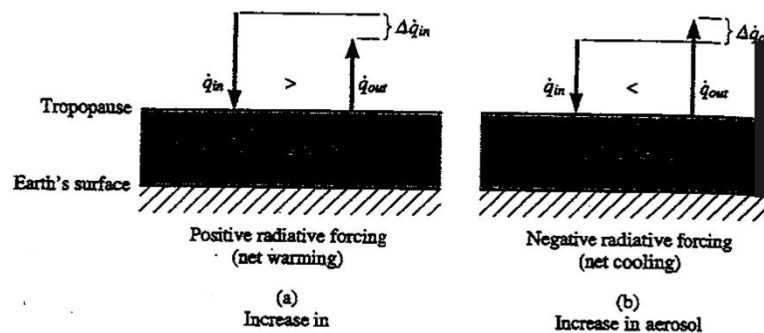

Figure 12.10   Additional modes of radiative forcing. An increase in solar energy input (a) produces a positive forcing, whereas increased aerosol particles in the atmosphere (b) produce a negative forcing.

First big changes in climate will first appear on extreme locations like Antarctica, Sahara, etc.

Vostok, Antarctica: They drilled 3.3km deep and took a core of ice that corresponded to 420000 years ago. They analyzed the bubbles inside the ice core. This is called Paleoclimatology which is study of the climate many years ago.

Using this station they discovered when did we have the last huge change in temperature?

Chapter 14:

Risk:

- Voluntary risk
- Non-Voluntary: volcano, earthquake, etc.

Risk is related to parameter safety level.

Hazard assessment

- **Cancerogenic**:
    - CDI (Chrononic daily intake): $\frac{avrage\ dose\ exposition}{weight}$
    - PF: (incremental risk of a given CDI)
    - Then they are multiplied to get lifetime cancer
    - If risk is above 1 in a million you must do something
- **Non cancerogenic**

Schematic of alternative risk management options:

- Reduce or eliminate source of contaminates.
- Modify or eliminate exposure pathway.
- Reduce or eliminate human exposure.
- Treat or compensate damage from exposure.

Chapter 15:

Forecasting is a very risky business. There are lots of unknowns. However, forecasting helps us identify trends that will help us predict the future.

Pure scientists use Experimentation and Observation. They try to fit up the theories they get with the results they get.

For **engineers**, they also use mathematical models. By using those we gain insight of the problem which gives better idea of trends.

The object is to find a way to get as good of a forecasting as we can.

After 1970 lots of forecasting has been done.

The main concern is the health and welfare of humans.

2 types of forecasting:

- General forecasting: Depends on projections and predictions.

- Building scenarios: Which is "What if this happens" and "What if this other thing happens". This gives a range of answers not only one. Then we organize the answers from worst to best.

For any kind of forecast:

I am to specify at least 2 parameters:

- Time (e.g., what will happen in the next year)
- Space (is it a regional, national, or global problem?) (Spatial scale)

Any type of forecasting beyond 30 years is not to be trusted. So, we do forecast up to 30 years

3 most important factors of forecasting (drivers):

- Population growth.
- Economic growth.
- Technology change.

Population growth:

We start to evaluate the options:

- Population will continue go up linear.
- Population will continue go up as curve.
- Population will stable at some point.
- Population will decline.

Engineers use mathematical models as follow:

$$P = P_0(1 + r)^t$$

Where P_0 is the population at $t = 0$ and r is the growth rate.

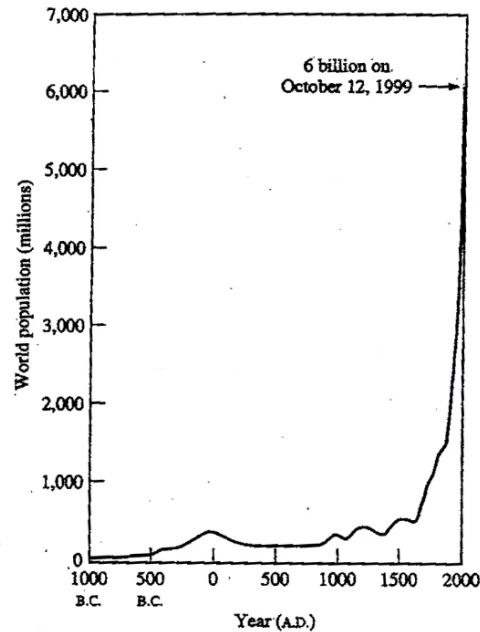**Demographic models:** are models with more parameters inside (age, gender).

Figure 15.2 World population growth, 1000 B.C. to 2000 A.D. (*Source:* Based on USDOC, 1999a)

GDP is used for economic growth

- Input-output model are as part of lifecycle analysis. Extract information apart from forecasting.
- Macroeconomic model: In general economy is divided in firms, households, and government. The more advanced this model is, the more I understand the relation ship between this 3 and the other 3. The more we understand the relationship the more we have an extra insight into the process.