Lecture #25

ERDM

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Waste to Exposure

(from Bishop)

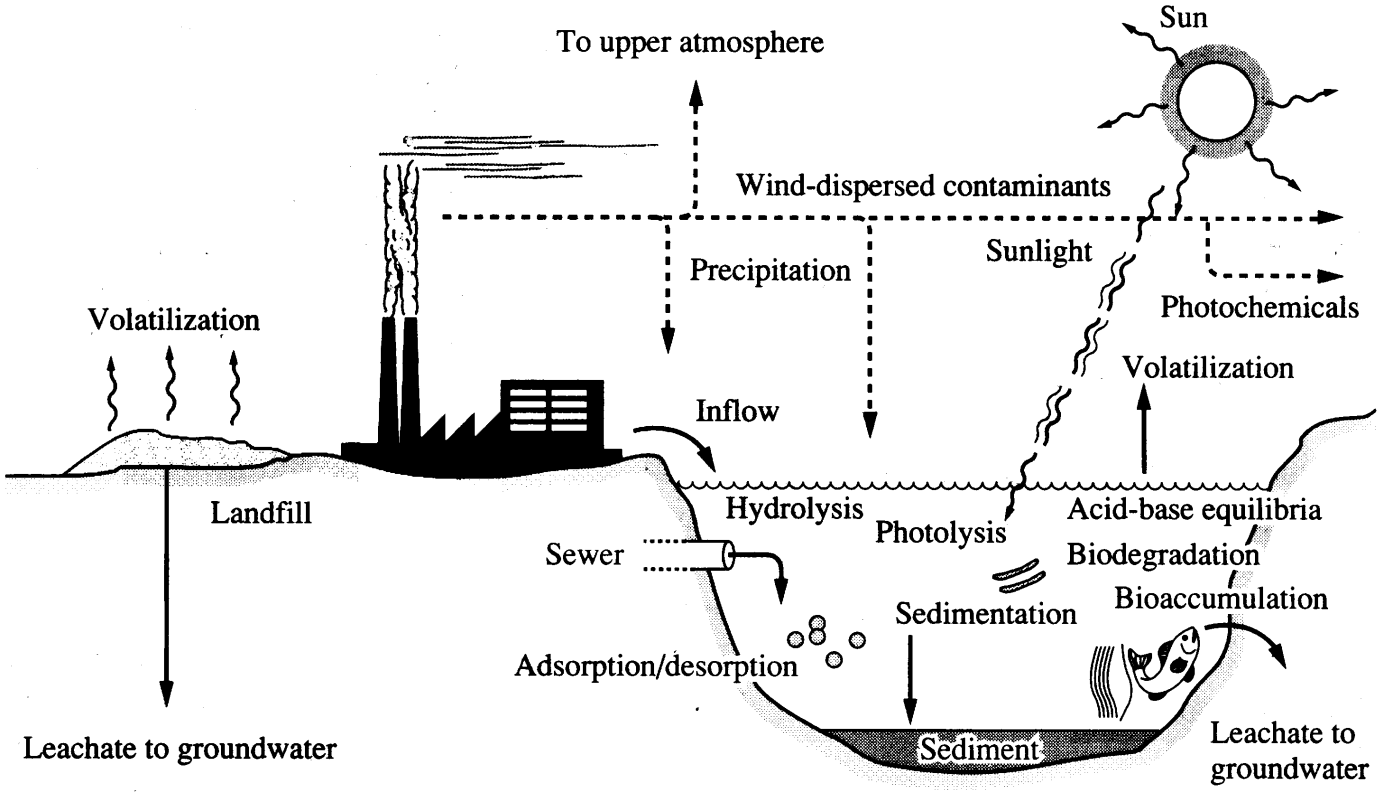
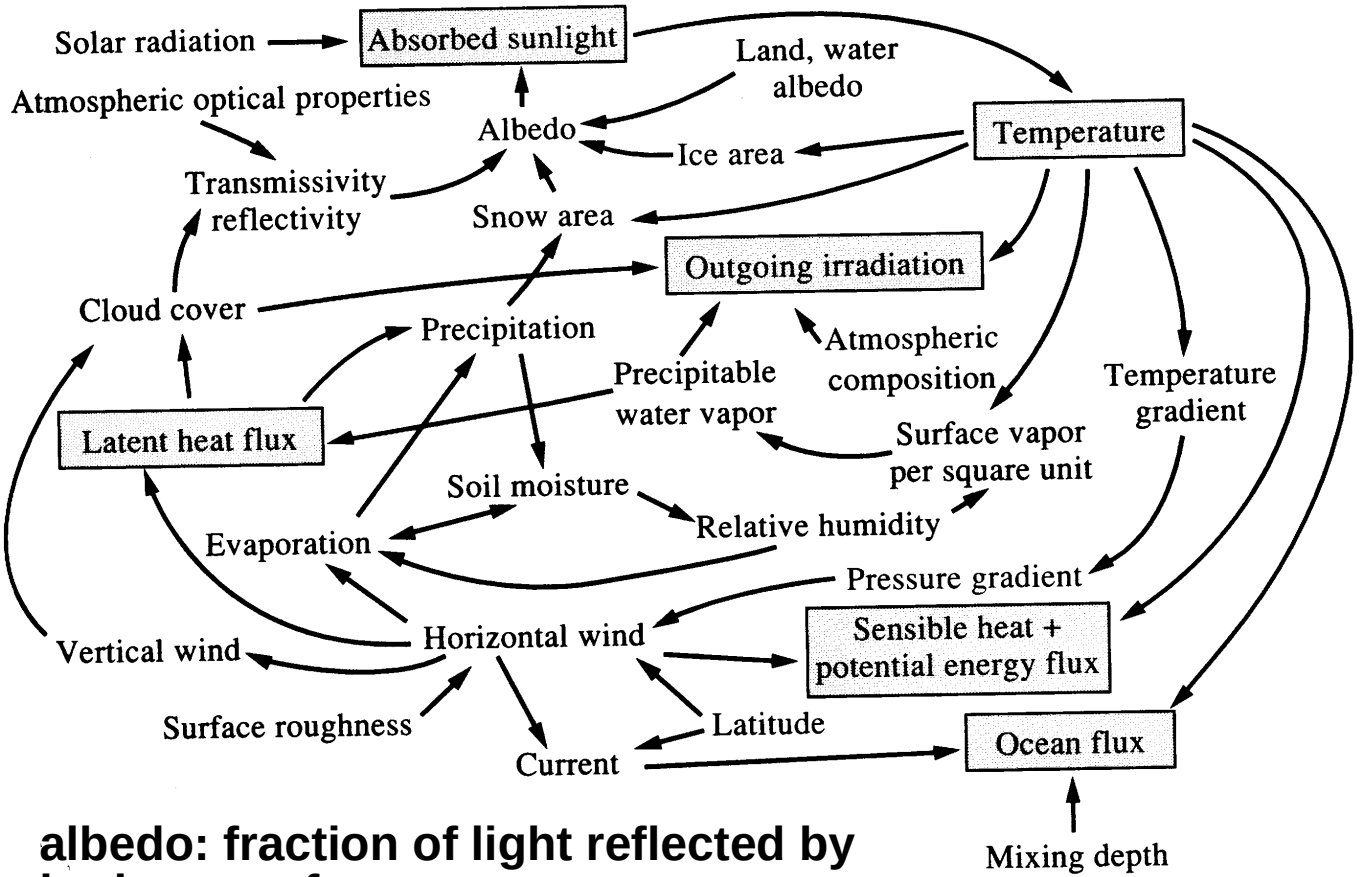


FIGURE 2.1
Fate of industrial contaminants in the environment.

Interactions are Complicated

(from Bishop) -- Global climate dynamics



albedo: fraction of light reflected by body or surface

Types of Risk
(from Graedel & Allenby)

Table 4.3 The Division of Major Areas of Environmental Concern into Types of Risk

Damage to Biological Systems	Aesthetic Degradation	Damage to Planetary Systems
Acid rain (aquatic effects)	Acid rain (Corrosion of materials)	Biodiversity loss
Air toxics (including smog)	Oil spills (visual effects)	Changes in ocean circulation
Groundwater degradation	Visibility loss	Global warming
Hazardous waste sites	Loss of opportunity for wilderness experiences	Ozone depletion
Herbicides, pesticides		Loss of arable land
Oil spills (wildlife effects)		
Surface-water degradation		
Radionuclides		
Toxics in sediments		
Toxics in sludge		
Loss of habitat		

Assessing Risk

1. **Hazard Identification -- does a non-trivial risk exist?**

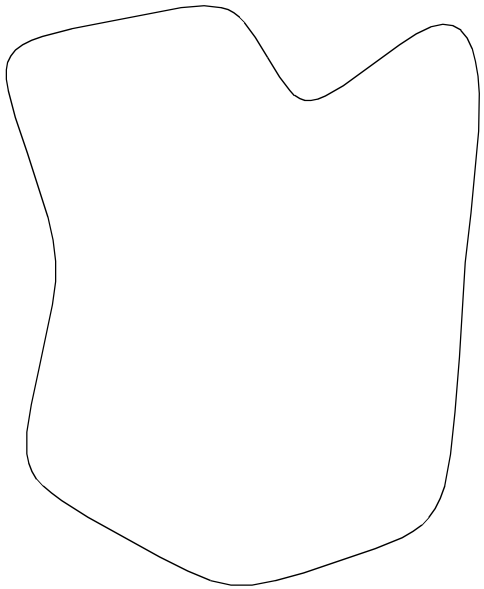
2. **If there is a risk, evaluate the dose. There may be some work to do this.**

3. **Probability of an undesirable impact as a result of the dose**

4. **Determine the exposure**

5. **Characterize the risk. Need statement that quantitatively summarizes risks posed by agent (confidence level).**

Getting Risk Data



At the left is a group of animals - Type X.

They are exposed to a concentration of 0.010 mg/L of Chemical Y -- 10% die.

They are exposed to a concentration of 0.015 mg/L of Chemical Y -- 20% die.

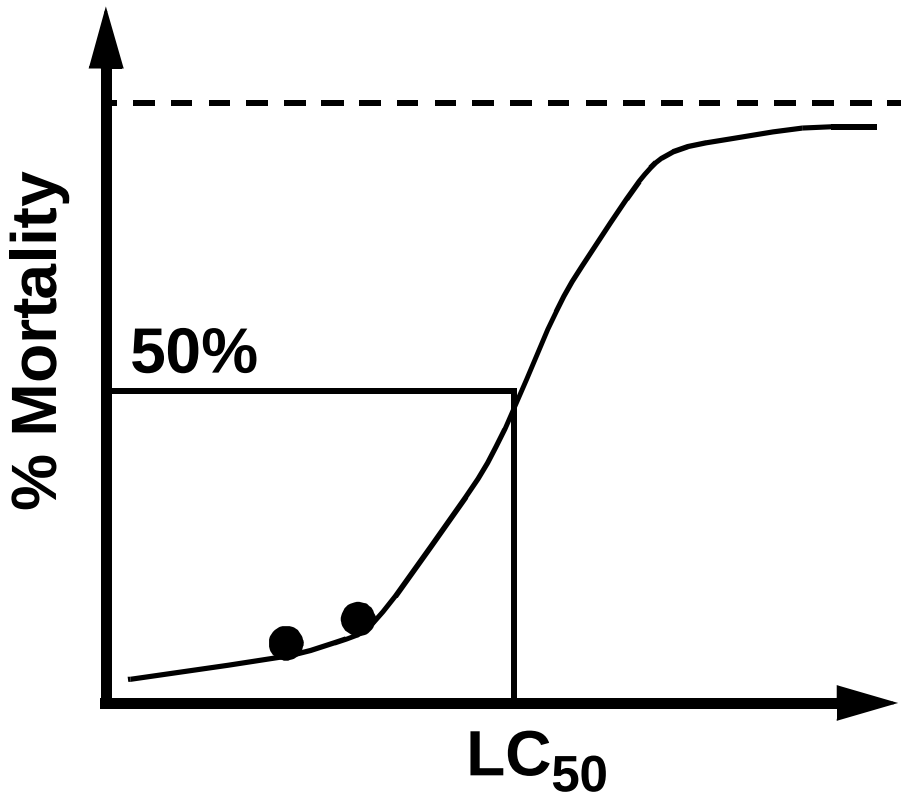
More on Risk Data

- **Assume no interaction between exposures of different types.**

- **What we learn in studying the mortality of Animal Y is transportable to study of other animals or humans.**
  - **Need to select correct animal type**
  - **Need to scale the data based on animal size**
  - **Role of animal behavior**

- **Other?**

Still More on Data



LC_{50}: concentration that kills 50% of the organisms.

LD_{50}: dosage that kills 50% of the organisms.

What dosage or concentration is safe?

Extrapolation!?!?!

Uncertainty

(from Graedel & Allenby)

Table 4.4 Contributions to Uncertainty from Toxicology Studies

Source	Estimated contribution
Extrapolation of animal toxicology data from high doses to low doses	Factor of 10^5–10^6
Basing risk estimate on a curable cancer, such as skin cancer	Factor of 10^4
Relating animal data to human impact	Factor of 10^3–10^4
Effects of doses of more than one chemical at once	Factor of 10^1–10^2
Basing risk estimate of response in animal tissue with no corresponding human tissue	Factor of 1–10
Statistical noise—extrapolating from only a few animal impacts in a large test animal population	Factor of 2

Source: Abstracted from C. R. Cothern, Uncertainties in quantitative risk assessment—Two examples: Trichloroethylene and radon in drinking water, in C. R. Cothern, M. A. Mehlman, and W. L. Marcus, eds., *Risk Assessment and Risk Management of Industrial and Environmental Chemicals*, pp. 159–180, Princeton: Princeton Scientific Publishing Company, 1988.

Determining Risk

- **We are interested in the very lowest levels of concentrations & doses. We don't want to be anywhere near LD 50 or LC 50.**

- **We collect data on what happens at high doses/ concentrations -- we want to extrapolate to what happens at low doses/concentrations.**

- **Different models used to describe situation, P(d)=?:**
  - **Multistage**
  - **Log**
  - **Linear**

Multiple Exposures

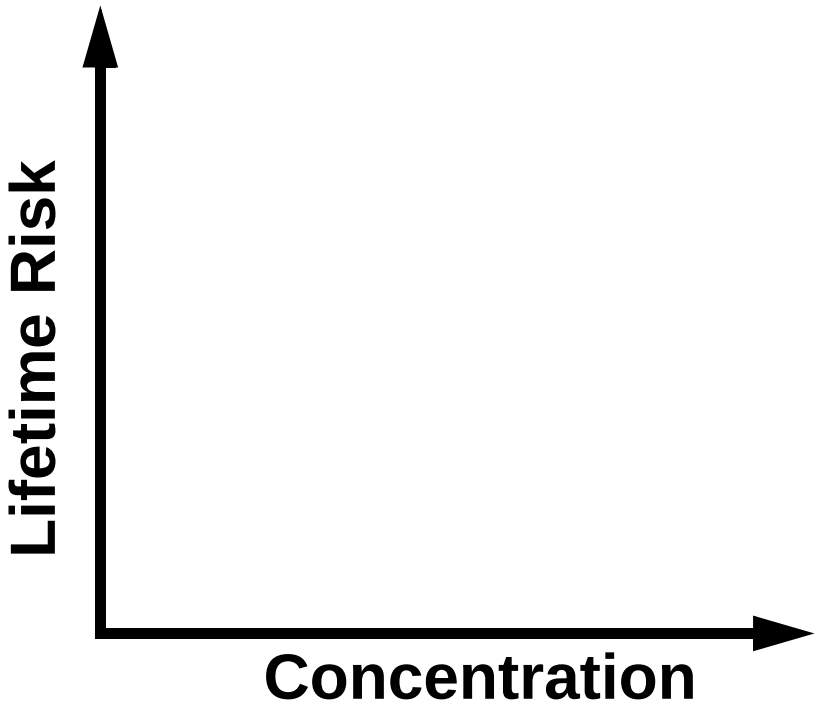
(from Graedel & Allenby)

Table 4.5 Average Exposures to Natural and Synthetic Pesticides

HERP (%)*	Average Daily Human Exposure	Human Dose Produced
0.1	Coffee (3 cups)	Caffeic acid (24 mg)
0.03	Spices	Safrole (1.2 mg)
0.03	Orange juice (0.8 glass)	d-Limonene, 4.3 mg
0.002	DDT	DDT (13.8 μg)
0.0009	Brown mustard (68 mg)	Allyl isothiocyanate (63 μg)
0.0008	DDE	DDE (6.9 μg)
0.0006	Celery (0.4 stalk)	8-Methoxypsoralen (13.2 μg)
0.0002	Toxaphene	Toxaphene (600 ng)
0.00009	Mushroom	p-Hydrazinobenzoate (28 μg)
0.000001	Lindane	Lindane (32 ng)

* HERP is the human exposure/rodent potency index. It represents the percentage of the rodent potency dose received by a human being during a given lifetime exposure.

Models



Exposure: Total Risk = N * P(d) -- other models available

Drinking Water Contaminants

(from Bishop)

TABLE 4.4
National Primary Drinking Water Standards

Contaminant	MCLG, mg/L	MCL, mg/L	Contaminant	MCLG, mg/L	MCL, mg/L
Fluoride	4.0	4.0	Organics		
Microorganisms			Acrylamide	0	TT
Giardia lamblia	0	TT	Adipate [di(2-ethylhexyl)]	0.4	0.4
Legionella	0	TT	Alachlor	0	0.002
Standard plate count	N/A	TT	Aldicarb	0.001	0.003
Total coliform	0	<5%+	Aldicarb sulfone	0.001	0.002
Turbidity	N/A	TT	Aldicarb sulfoxide	0.001	0.004
Viruses	0	TT	Atrazine	0.003	0.003
Inorganics			Carbofuran	0.04	0.04
Antimony	0.006	0.006	Chlordane	0	0.002
Arsenic (interim)	0.05	0.05	Chlorobenzene	0.1	0.1
Asbestos (>10 μm)	7 MFL	7 MFL	Dalapon	0.2	0.2
Barium	2	2	Dichloromethane	0	0.005
Beryllium	0.004	0.004	2,4-D	0.07	0.07
Cadmium	0.005	0.005	*o*-Dichlorobenzene	0.6	0.6
Chromium (total)	0.1	0.1	1,2-Dichloroethylene	0.07	0.07
Copper	1.3	TT**	Dibromochloropropane	0	0.0002
Cyanide	0.2	0.2	1,2-Dichloropropane	0	0.005
Lead	0	TT*	Dinoseb	0.007	0.007
Mercury (inorganic)	0.002	0.002	Diquat	0.02	0.02
Nickel	0.1	0.1	Dioxin	0	0.00000003
Nitrate	10	10	Endothal	0.1	0.1
Selenium	0.05	0.05	Endrin	0.002	0.002
Sulfate (proposed)	400/500	400/500	Epichlorohydrin	0	TT
Volatile organics			Ethylbenzene	0.7	0.7
Trihalomethanes	0	0.10	Ethylene dibromide	0	0.00005
Benzene	0	0.005	Glyphosate	0.7	0.7
Carbon tetrachloride	0	0.005	Heptachlor	0	0.0004
p-Dichlorobenzene	0.075	0.075	Heptachlor epoxide	0	0.0002
1,2-Dichloroethane	0	0.005	Hexachlorobenzene	0	0.001
1,1-Dichloroethylene	0.007	0.007	Hexachlorocyclopentadiene	0.05	0.05
Trichloroethylene	0	0.005	Lindane	0.0002	0.0002
1,1,1-Trichloroethane	0.2	0.2	Methoxychlor	0.04	0.04
Vinyl chloride	0	0.002	Oxamyl (Vydate)	0.2	0.2
Radioactive			PAHs (benzo[a]pyrene)	0	0.0002
Beta/photon emitters	0	4 mrem/yr	PCBs	0	0.0005
Alpha emitters	0	15 pCi/L	Pentachlorophenol	0	0.001
Combined radium 226/228	0	5 pCi/L	Phthalate, [di(2-ethylhexyl)]	0	0.006
Radium 226 (proposed)	0	20 pCi/L	Picloram	0.5	0.5
Radium 228 (proposed)	0	300 pCi/L	Simazine	0.004	0.004
Uranium (proposed)	0	0.02	Styrene	0.1	0.1
			Tetrachloroethylene	0	0.005
			1,2,4-Trichlorobenzene	0.07	0.07
			1,1,2-Trichloroethane	0.003	0.005
			Toluene	1	1
			Toxaphene	0	0.003
			2,4,5-TP	0.05	0.05
			Xylenes (total)	10	10

Key: TT = treatment technique required; MFL = million fibers per liter; pCi = picocurie; mrem = millirems.

Environmentally Responsible Design & Manufacturing (MEEM 4685/5685)
Dept. of Mechanical Engineering - Engineering Mechanics
Michigan Technological University
MichiganTech

Regulatory Levels for Toxins
(from Bishop)

TABLE 4.5
Toxicity characteristic constituents and their regulatory levels

Constituent	Regulatory level, mg/L	Constituent	Regulatory level, mg/L
Arsenic	5.0	Hexachlorobenzene	0.13
Barium	100.0	Hexachloro-1,3-butadiene	0.5
Benzene	0.5	Hexachloroethane	3.0
Cadmium	1.0	Lead	5.0
Carbon tetrachloride	0.5	Lindane	0.4
Chlordane	0.03	Mercury	0.2
Chlorobenzene	100.0	Methoxychlor	10.0
Chloroform	6.0	Methyl ethyl ketone	200.0
Chromium	5.0	Nitrobenzene	2.0
o-Cresol	200.0	Pentachlorophenol	100.0
m-Cresol	200.0	Pyridine	5.0
p-Cresol	200.0	Selenium	1.0
Total cresol	200.0	Silver	5.0
2,4-D	10.0	Tetrachloroethylene	0.7
1,4-Dichlorobenzene	7.5	Toxaphene	0.5
1,2-Dichloroethane	0.5	Trichloroethylene	0.5
1,1-Dichloroethylene	0.7	2,4,5-Trichlorophenol	400.0
2,4-Dinitrotoluene	0.13	2,4,6-Trichlorophenol	2.0
Endrin	0.02	2,4,5-TP (silvex)	1.0
Heptachlor (and its epoxide)	0.008	Vinyl chloride	0.2

The Story So Far...

- **Motivation, General Issues, Life cycle concept**
- **Product design**
  - **Features**
  - **Materials**
  - **Assembly**
- **Post-use**
  - **Reuse / Remanufacturing / Recycling**
  - **Demanufacturing**
- **Now turn our intention to Manufacturing**

Manufacturing Considerations

- **Which processes to use?**
- **In what order should processes be performed?**
- **On which machines should the processes be performed?**
- **Machine settings**
- **Tooling**
- **Fixturing**
- **Coolant, Lubricant**
- **Transportation of Work in Progress (WIP) between machines**
- **Assembly**
- **Inspection**

Manufacturing Decision-Making

Establish plans to respond to specifications

- **Operations planning: focus on a single operation on a single part (machine settings, tool geometry, etc.)**
- **Process planning: focus on the manufacture of a single product (process selection, process sequencing, etc.)**
- **Production planning: focus on whole manufacturing facility (job sequencing, inventory decisions, facility planning, etc.)**

Manufacturing Process Classifications

- **Solidification Processes**
  - **Casting**
  - **Polymer processing operations**
- **Forming Processes (Bulk Deformation & Sheet Working Operations)**
- **Particulate Processing Operations**
- **Material Removal Processes**
  - **Cutting Processes**
  - **Non-Traditional Material Removal Operations**
- **Joining Processes**
- **Surface Treatment Processes**