TABLE OF CONTENT:

KEY:

1. Table Key

Overarching Topic
Large Element
Component
Global Perspective or Australian Perspective
Equations/Steps

2. Content Key:
    a. Specifically mentioned as important in a lecture
    b. Definition
    c. Example

Data Acquisition

Costs of Data Acquisition Determination:

1. Number of Sampling Sites
2. Number of Sampling Occasions
3. Replication
4. Cost of Collecting Samples (Staff, Transport, Consumables)
5. Costs of Analysis
6. Cost of Data Processing

Management of Activities to ensure that a process, item or service, is of the type and quality needed and expected by the user Activities include:

1. Objectives of the studies are developed before any activities begin
2. The study design is statistically sound (sampling sites are representative of the environment, number of samples have appropriate power, etc)
3. Proper sampling, equipment, and analytical procedures are used
4. Field crew staff are properly trained

Background Level

Background Level: The geochemical or natural background is a relative measure to distinguish between the natural element or compound concentrations and anthropogenically influenced concentrations.

- Varies in space and time
- Examples: Heavy metals, polyaromatic hydrocarbons

Determination of Background Levels

1. Determination of pre-anthropogenic or background contaminant concentrations
   a. Required for quality assessment schemes, legal purposes, establish the severity of impact, estimate the regional and vertical extent of contamination, determine loading to an area, and estimate total inventories
2. Identification of a pristine area
   a. Identifying the potential area of influence
   b. Basis of bio-indicators
3. The use of deep sediment/soil samples are not affected by human influence:
   a. Sediment/ soil properties may vary with depth complicating the background assessment
4. Use of Global Mean Concentrations:
   a. It may not be meaningful to identify local background levels

Contamination Factor: Once background levels have been estimated, the most straightforward way of expressing the degree of contamination is by means of contamination factors (CF)

CF= CL/BL

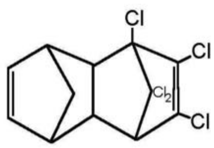
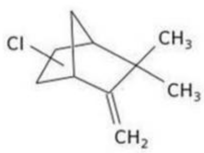
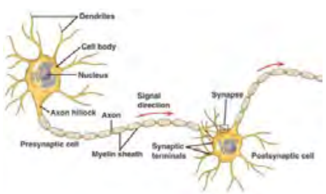
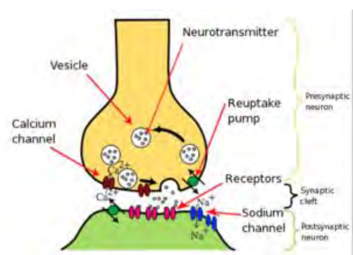
- CL is the current level and BL is the background level of contamination

For heavy metals, this might sometimes be expressed as enrichment factors (EF)

– $EF = (CL/R_{CL})/(BL/R_{BL})$

Where R_{CL} and R_{BL} are reference elements (or conservative elements that are usually not affected by humans, e.g., Al, Ca, Fe, Mn, Sr)

Organo-metallic insecticides	- 19th Century
	  - Arsenic (As) and copper (Cu)
	    - Copper arsenate
	    - Paris Green (Copper Acetoarsenite)
	  - Inhibitors of cellular respiration
	  - Broad-spectrum biocides
	  - Bioaccumulation
	  - Persistent- Residues still present
	NOT USED IN AGRICULTURE ANYMORE

Insecticides: Organochlorines	
Origin:  Aldrin The University of Sydney  Toxaphene	- Developed during and after World War II - Initially thought to be biodegradable, but not found to be true in many cases - Chlorination increases resistance to degradation
The action of OC: Neurotoxins: 	- Bind to the voltage-gated Sodium channels increasing the permeability of sodium - This increased permeability facilitates the uncoordinated discharge of signals causing hyperexcitation 
Organochlorine Insecticides Characteristics: - 12 persistent organic pollutants (POPs) listed by the United Nations Environmental Programme (All of the organochlorines)	- Slow decomposition or degradation in the environment - Generally low solubility in water - High solubility in a hydrocarbon like environments (fatty material in living organisms, soil organic matter) - Relatively high acute toxicity to insects, but low to humans
Organochlorines in biological systems:	**Bioconcentration:** the process by which chemicals concentrate in organisms through selective diffusion - **Bioconcentration factor (BCF)**: represents the equilibrium ratio of the concentration of a specific chemical in an organism relative to that in the surrounding water - Can be predicted with the octanol-water partition coefficient: KOW =C octanol / C water - **Biomagnification**: the increasing concentration of a substance in the tissues of organisms at successively higher levels in a food chain. As a result of biomagnification, organisms at the top of the food chain generally suffer greater harm from a persistent toxin or pollutant than those at lower levels - In crocodiles

Chemical Kinetics :

1. Bimolecular Reactions:

$$A + B \rightarrow C + D$$

The rate of reaction is : $-\frac{d}{dt}[A] = -\frac{d}{dt}[B] = \frac{d}{dt}[C] = \frac{d}{dt}[D] = k[A][B]$

Where k is the rate constant for the reaction (cm^3 $molecule^{-1}$ s^{-1} if number densities are used)

In a self reaction:

$$A + A \rightarrow C + D$$

$$-\frac{1}{2}\frac{d}{dt}[A] = \frac{d}{dt}[C] = \frac{d}{dt}[D] = k[A]^2$$

2. Three body reactions

$$A + B \rightarrow AB^* \qquad \text{(R1)}$$

$$AB^* \rightarrow A + B \qquad \text{(R2)}$$

$$AB^* + M \rightarrow AB + M^* \qquad \text{(R3)}$$

$$M^* \rightarrow M + heat \qquad \text{(R4)}$$

- Overall

$$A + B + M \rightarrow AB + M \qquad \text{(R5)}$$

a. M can be any inert molecule in the atmosphere, usually N2 or O2

$$\frac{d[AB]}{dt} = k[AB^*][M]$$

The complex AB* has a short lifetime so we can assume it is in a quasi-steady state

$$k_1[A][B] = k_2[AB^*] + k_3[AB^*][M]$$

Rearranging and replacing gives us:

$$-\frac{d}{dt}[A] = -\frac{d}{dt}[B] = \frac{d[AB]}{dt} = \frac{k_1k_3[A][B][M]}{k_2 + k_3[M]}$$

3. Reverse reactions and chemical equilibria

$$A + B \rightarrow C + D$$

- From a mass conservation perspective we can also write

$$C + D \rightarrow A + B$$

- So:

$$A + B \leftrightarrow C + D$$

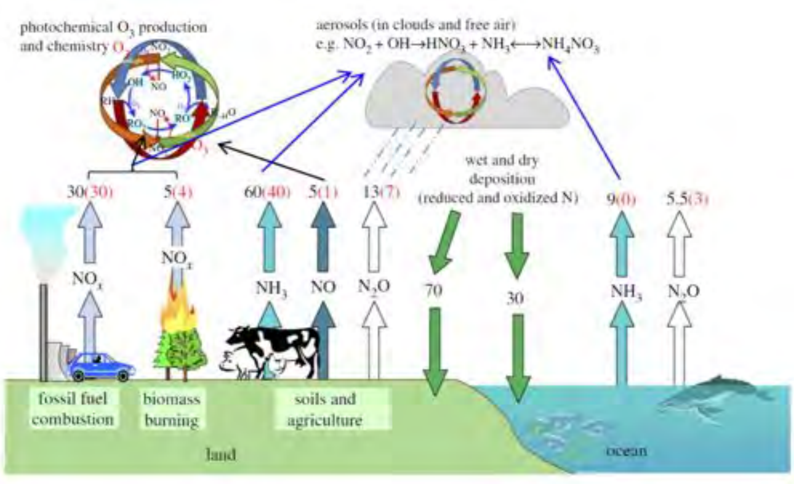
- Hence:

$$k_1[A][B] = k_2[C][D]$$

- And we can define an equilibrium constant K

$$K = \frac{k_1}{k_2} = \frac{[C][D]}{[A][B]}$$

<table>
<tr><th colspan="2">Atmospheric Chemistry of Sulfur and Nitrogen</th></tr>
<tr><td>Reactive Nitrogen</td><td>



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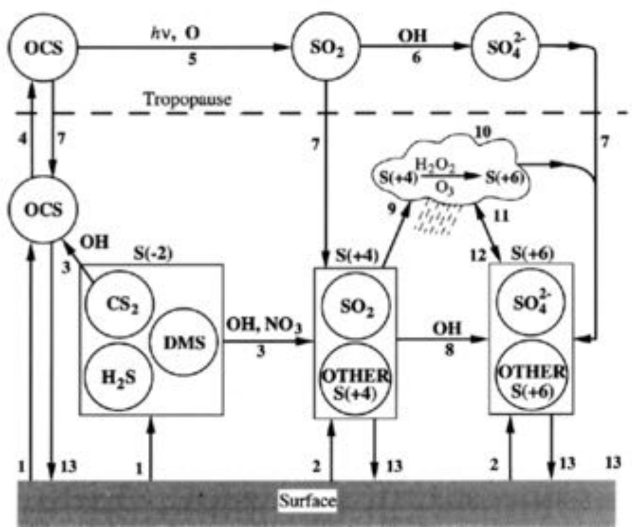
<tr><td>Reactive Sulfur</td><td>



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Ammonia and Sulphate:
The products that are formed are dependent on the molar ratio of NH3 and SO2 and their vapour pressure

$$NH_3 + SO_2 \leftrightarrow NH_3SO_2$$
$$2NH_3 + SO_2 \leftrightarrow (NH_3)_2SO_2$$

- In the presence of moisture, most of SO2 is converted to SO42-

1. Sulfuric Acid H2SO4 is very soluble and will condense onto pre-existing particles or even new ones
2. It is neutralised by Ammonia NH3
3. Ratios of Ammonia and Sulfuric acid give different products

   − 1:1 we get NH_4HSO_4
   − 1:1.5 we get $(NH4)_3H(SO_4)_2$
   − 1:2 we get $(NH_4)_2SO_4$

   a. Ammonium bisulfate
   b. Tri Ammonium hydrogen sulfate

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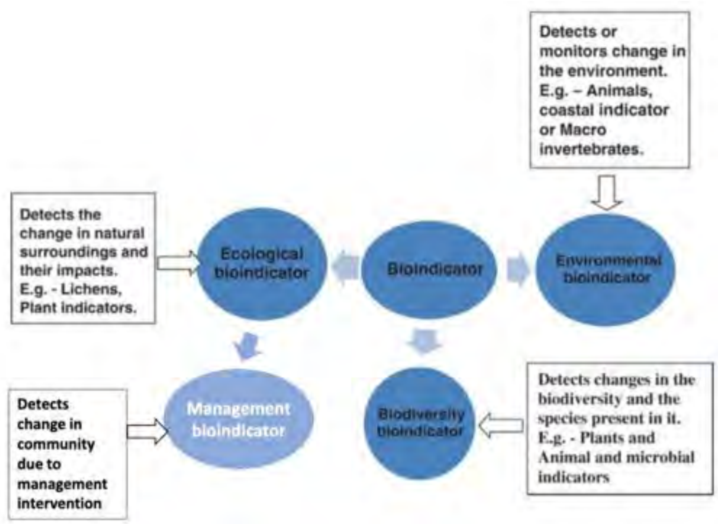
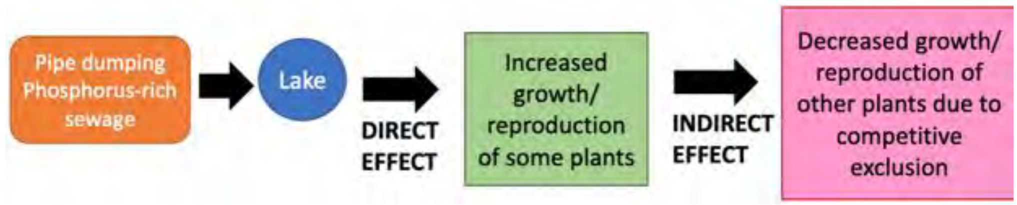
</table>

Classification of bioindicators species based on their target (what they represent)	1. **Environmental Indicators (eg. Lichen)** Respond predictably to environmental disturbance/change (eg. accumulators). Sets of environmental indicators are used to diagnose the state of the environment. 2. **Biodiversity Indicators** Represent species richness of a community. May also represent other measurable parameters of biodiversity including endemism, genetic parameter, population-specific parameter and landscape parameter. 3. **Ecological Indicators** Known to be sensitive to ecological or threatening processes such as pollution, habitat fragmentation. The response of the indicator represents the response of the community. 4. **Management Indicators (A subset of Ecological Indicators)** Population changes track the effects of management of resources (eg. fisheries) or threatening processes (eg fire) on selected biological components (other species)
Examples: Environmental Bioindicator: Caddisflies larva Biodiversity Bioindicator: Owl and Butterfly Ecological Bioindicator: Frog, and Lichen Management Bioindicator: Fish and Mussels	

Why are Bioindicators Better than Direct Monitoring of Disturbance/Stress?

1. Bioindicators add a **temporal component corresponding to the lifespan or residence time of an or residence time of an organism in a particular system**
   a. Integrate current, past, or future environmental conditions
   b. Many chemical/physical measurements only characterize conditions at time of sampling,increasing probability of missing sporadic pulses of stress
2. Sensitivity and tolerance range means that even very small disturbance/stress levels may be detected
   a. Bioindicators are often cheaper than thee costly analyses with highly sensitive technologies required to detect low contaminant concentrations (e.g chemiluminescence for nitrous oxides, pulsed fluorescence spectrophotometry for sulphur dioxide)
3. Indicate **indirect biotic effects of disturbance/stress or management** when many physical or chemical measurements cannot



Advantages and Disadvantages of Bioindicators	
Advantages:	Disadvantages:
Link to human impacts allow **management actions to be made quickly and iteratively** to improve environmental conditions before too late.	Indicator species influenced by factors other than the disturbance or stress (e.g., disease, parasitism, competition, predation) → may be hard to discriminate change due to human impacts from natural variability, limiting applicability in heterogeneous environments.
Representative indicators can be employed at a **range of scales** (from cellular to ecosystem) to track ecosystem health.	Indicator ability is scale-dependent. → a large vertebrate indicator (e.g., a fish) may fail to indicate the biodiversity of the local insect community.
Cost - effective way of sampling part of the ecosystem to inform on fitness, population density, community composition, ecosystem processes.	Bioindicator habitat requirements differ from other species in the ecosystem. Managing ecosystem according to habitat requirements of a bioindicator may fail to protect rare species with different requirements.
Allow measurement of properties of ecological systems that are **too complex to measure directly** or in their entirety	Indicators may oversimplify the complexity of the System. Simple targets are often readily identified and can be measured and managed directly (e.g., the concentration of a heavy metal in the atmosphere).