Environmental chemistry and biology
HSLU, Semester 1

Matteo Frongillo

September 18, 2024

Contents

Preamble (Week 0)

1 Agenda

1.1 Environmental concepts and definitions

- Definition of Environment and the exchange of materials and energy;
- Definition of Environmental chemistry;
- Definition of Environmental biology;
- Environmental chemistry, biology and related fiels.

1.2 Chemical processes in the environment

- Chemical structure and environmental behavior;
- Partitioning of organic substances in the environment;
- Chemical transformations under environmental conditions.

2 Learning objectives

We should be able to:

- define the term “Environment”;
- define the term “Environmental chemistry”;
- define the term “Environmental biology”;
- know the physical and chemical properties, defining the environemntal behavior of a substance;
- apply the concept of partitioning to analyze and understan the behavior of an organic substance in the environment, with the provided values.

3 Keywords

Environment, Environmental Chemistry, Environmental Biology, Partitioning, Structure (of a molecule), Chemical Transformation, biotic, abiotic

4 Introduction SW 0

4.1 Chemical structure and Environmental behavior

We consider two groups of properties of chemicals:

4.1.1 Physical properties

- Vapor pressure (mp, bp);
- Solubility (H_2O, ...);
- Acid / Base strength (pK_a, pK_b);
- Partition coefficients (e.g. K_{OW}).

These properties describe **Dispersion** in different compartiments ⇒ Mobility and Toxicity.

4.1.2 Chemical properties → Reactivity

- Functional groups (-OH, -NH_2, ...);
- Electronic substituent effects (push/pull of electrons);
- Reaction mechanisms.

These properties describe **Transformation** of products ⇒ Degradation

4.2 Partitioning of organic substances in the environment

It explains how easily a chemical can spread in the environment:

1. air ↔ water:
    - vapor pressure ("evaporation rate");
    - water solubility.

1. air water: vapor pressure (evaporation rate) water solubility 2. water soil: adsorption (sticking to particles) water solubility 3. soil air: adsorption vapor pressure 4. all phases biota: fat solubility (lipophilicity)

4.3 Chemical transformations under environmental conditions

There are two fundamental pathways:

4.3.1 Abiotic

In compartments Air, Water, Soil → **Energy source: temperature, light**

1. Hydrolysis;
2. Oxidation;
3. Reduction;
4. Photochemical reactions.

4.3.2 Biotic

In organisms → **Catalyst: enzymes**

1. Oxidation;
2. Reduction;
3. Hydrolysis;
4. Secundary reactions.

Part I

Week 1

5 Agenda

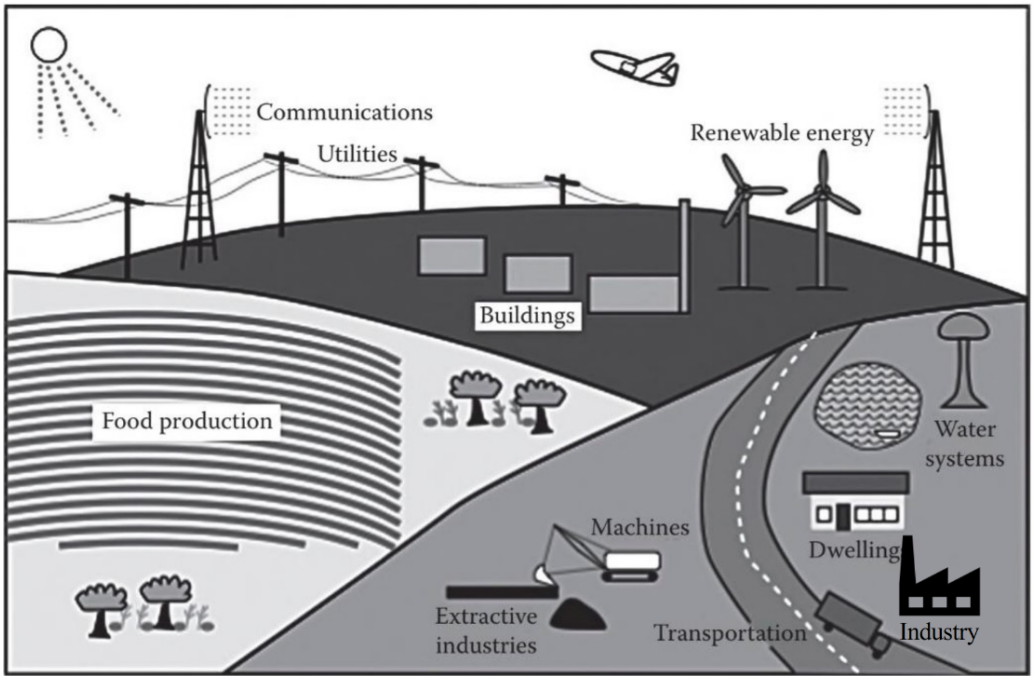
1. **Overview of the Anthrosphere and Environmental Impact**
    - Anthrosphere: definition and impact;
    - Pollutants and hazardous waste;
    - Anthrosphere: primary source of pollutants;
    - Pollutants overview;
    - Point sources vs. Nonpoint sources;
2. **Earth system and pollution dynamics**:
    - Earth system and chemicals;
    - 5-key aspects of pollutants;
3. **Important pollutant categories**
    1. Heavy metals;
    2. Greenhouse gases;
    3. Particulate matter (PM);
    4. Persistent organic pollutants (POPs);
    5. Chlorofluorocarbons (CFCs);
    6. Polycyclic aromatic hydrocarbons (VOCs);
    7. Environmentally persistent pharmaceutical pollutants (EPPPs);
    8. Plastics.

6 Anthrosphere

Definition:

Impact:

6.1 Human primary sources



1. Industrial activities:
2. Transportation:
3. Agriculture:
4. Energy production:
5. Urban development:
6. Deforestation and Land Use changes:
7. Household activities:
8. Waterwaste and Sewage:

7 Pollutants and hazardous

7.1 Pollutants

...

7.2 Hazardous waste

...

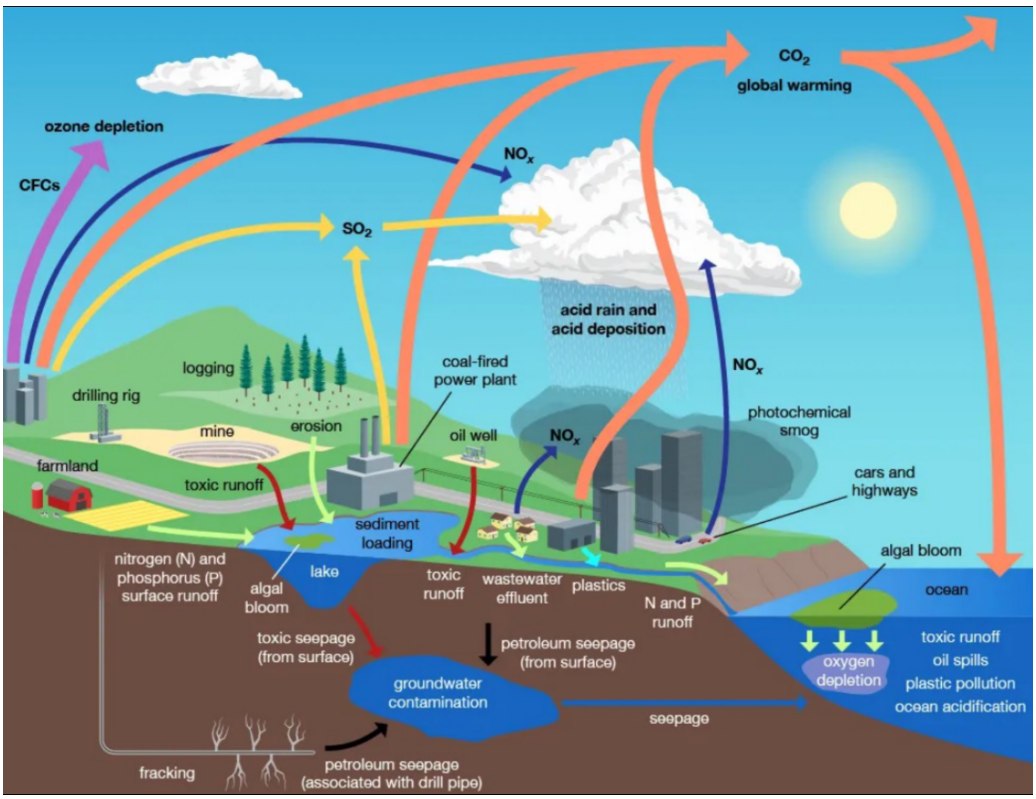
7.3 Pollution overview

Air pollution and climate changes: ...

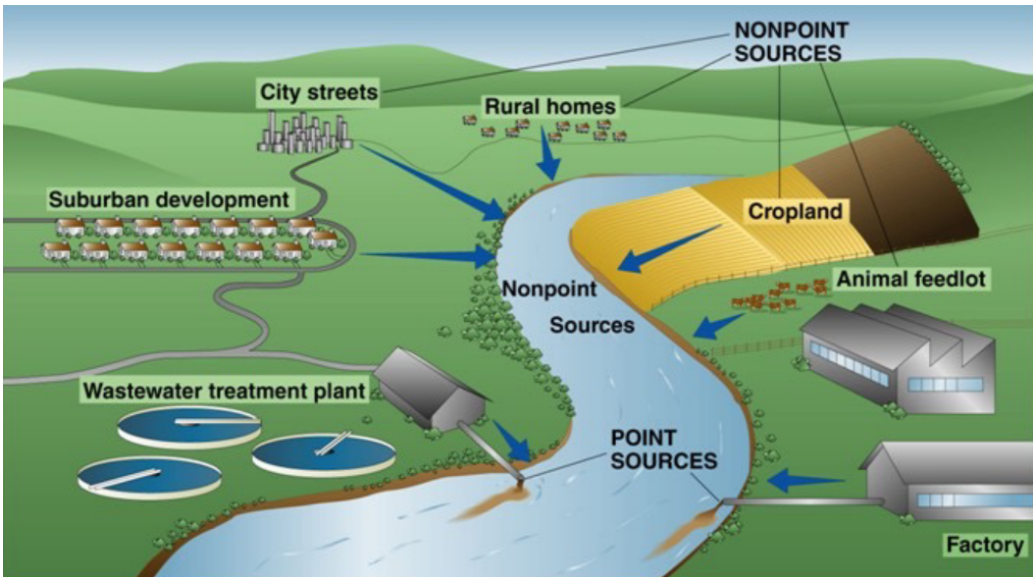
Water pollution and Ecosystem impact: ...

Land degradation: ...

Forests and Farmland: ...



8 Point sources vs. Nonpoint sources



...

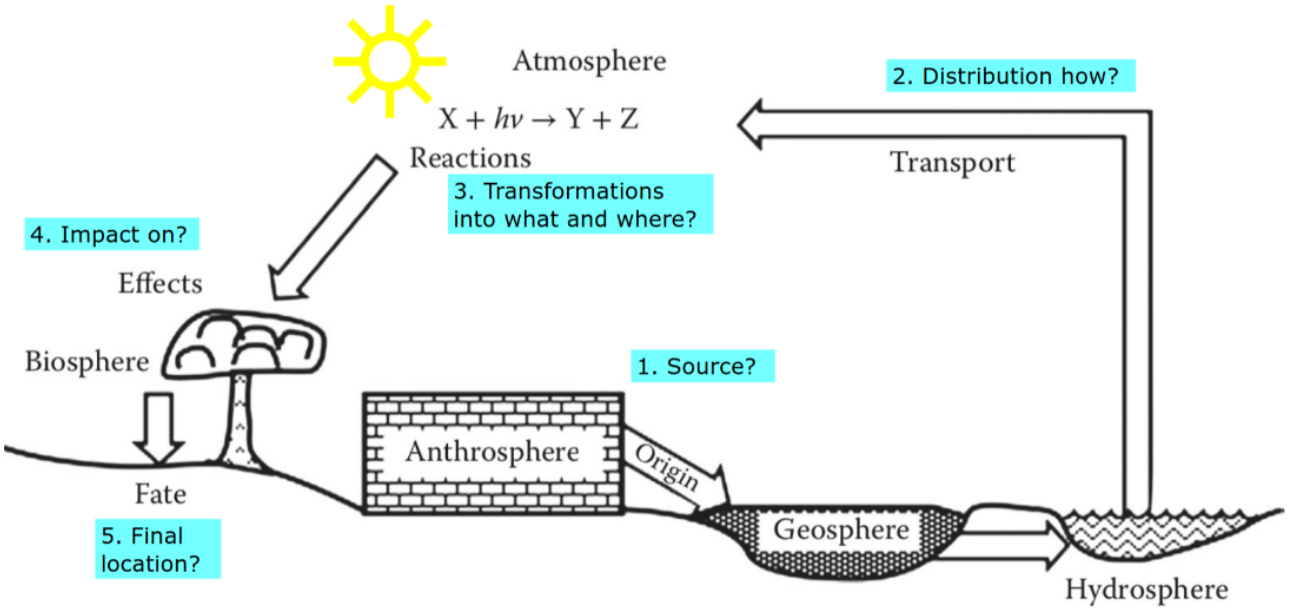
9 Earth system and Pollution dynamics

9.1 Earth system and chemicals

...

9.2 5-key aspects of pollutants

1. Origin: source of the chemical or pollutant;
2. Transport: distribution of the pollutant;



3. Reactions: trasformation of the pollutant;
4. Effects: impact of the pollutant;
5. Fate: whereabouts of the pollutant.

10 Important pollutant categories

10.1 Heavy metals

Heavy metals are material with very high densities.

10.1.1 Sources

...

10.1.2 Reactions

...

10.1.3 Effect

...

10.1.4 Fate

...

10.2 Greenhouse gases (GHGs)

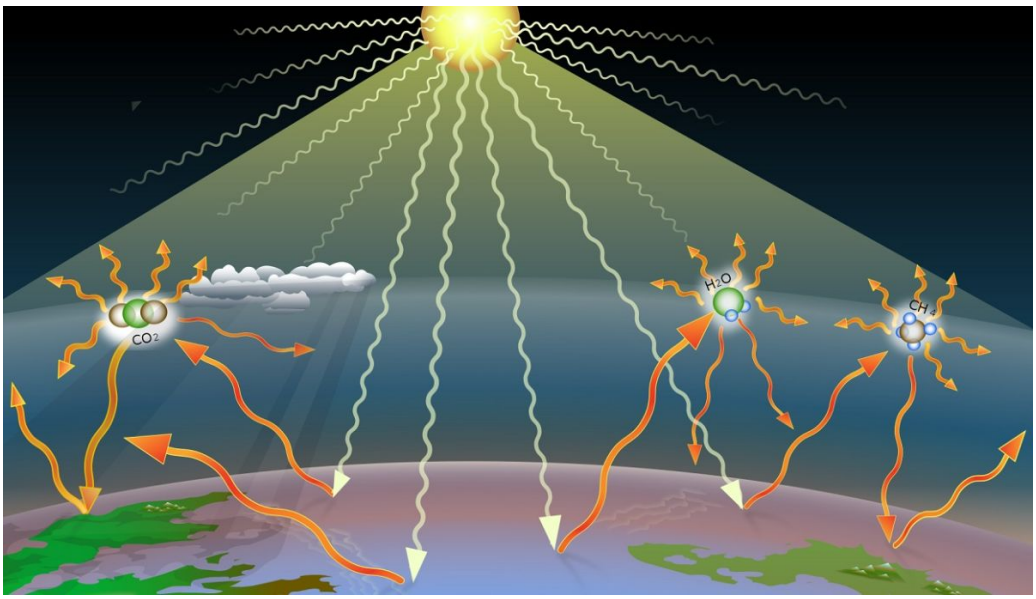
GHGs are gases which reflects UVs, impeding them to exit from the ozone and therefore dissipate their heat in it.

10.2.1 Sources

...

10.2.2 Reactions

...



10.2.3 Effect

...

10.2.4 Fate

...

10.3 Particulate matter (PM)

PM is made by microscopic particles which can depositate inside the respiratory system of animals and create health problems, such as asthma or cardiovascular issues.

10.3.1 Sources

...

10.3.2 Reactions

...

10.3.3 Effect

...

10.3.4 Fate

...

10.4 Persistent organic pollutants (POPs)

POPs are chemicals which have a very long degradation time. They are called “forever chemicals”.

10.4.1 Halogenated organic compounds (HOCs)

...

10.4.2 Per- and Polyfluoroalkyl substances (PFASs)

...

10.4.3 Both categories

- Reactions:
- Effect:
- Fate:

10.5 Chlorofluorocarbons (CFCs)

CFCs are gases ...

10.5.1 Sources

...

10.5.2 Reactions

...

10.5.3 Effect

...

10.5.4 Fate

...

10.6 Polycyclic aromatic hydrocarbons (PAHs)

PAHs are gases created by incompleted combustions, such as tobacco smoke or grilled food.

10.6.1 Sources

...

10.6.2 Reactions

...

10.6.3 Effect

...

10.6.4 Fate

...

10.7 Volatile organic compounds (VOCs)

VOCs are gases with a low molecular weight which can evaporate at room temperature.

10.7.1 Sources

...

10.7.2 Reactions

...

10.7.3 Effect

...

10.7.4 Fate

...

10.8 Environmentally persistent pharmaceutical pollutants (EPPPs)

EPPPs are pharmaceutical chemicals with a complex structure, which gives to molecules a big stability and a slow biodegradability.

10.8.1 Sources

...

10.8.2 Reactions

...

10.8.3 Effect

...

10.8.4 Fate

...

10.9 Plastics

Plactics are chemicals made by long chains of carbon...

10.9.1 Sources

...

10.9.2 Reactions

...

10.9.3 Effect

...

10.9.4 Fate

...