Water quality

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Why we care of water quality?

- **Prevent risk** to human health
- **Prevent pollution** of water bodies (aquatic life)
- **Resource recovery** (Treated effluent use, Sludge use)

Water pollutant

- **Pathogens**
  - Disease causing microorganism
- **Oxygen demanding wastes**
  - draw oxygen from water body, have serious impacts on aquatic life
- **Nutrients**
  - Lead to eutrophication have serious impacts on aquatic life and human health
- **Salts**
  - High salinity leads to loss of soil fertility
- **Heavy metals**
  - Persistent in environment , bioaccumulation, have serious chronic health impacts (carcinogens)
- **Pesticides**
  - Persistent in environment, bio-accumulate and cause serious health impacts in human and animals (carcinogens)
- **Emerging pollutant**
  - any synthetic or naturally occurring chemical or any microorganism that is not commonly monitored in the environment but has the potential to enter the environment and cause known or suspected adverse ecological and(or) human health effects
  - Pharmaceuticals, Nanomaterials, (New Delhi metallo-beta-lactamase 1(superbug)

Sources

Anthropogenic sources

Point sources

- **Domestic wastewater**
  - Pathogens
  - organic matter
  - POPs
  - Household cleaning products (Emerging pollutants)
- **Industrial wastewater**
  - Heavy metal
  - POPs
  - Organic matter

Non-point sources

- **Agricultural runoff**
  - Nutrients (N and P)
  - Fertilizers
  - pesticides
- **Urban runoff**
  - Suspended solids
  - Organic matter
  - nutrients

Geogenic sources

- Metals-Iron, Manganese, Arsenic
- Others- fluorides

Fate and transport

Conservative - the pollutant does not change form over time; no reactions

- Heavy metals
- Pesticides (DDT, endosulphan)
- Priority organic pollutants
- Emerging pollutant

Non-conservative-the pollutant changes form over time due to chemical, physical, or biological reactions

- Organic matter
- Nutrients
- Pathogens

Processes governing fate and transport

Conservative pollutant

Heavy metals

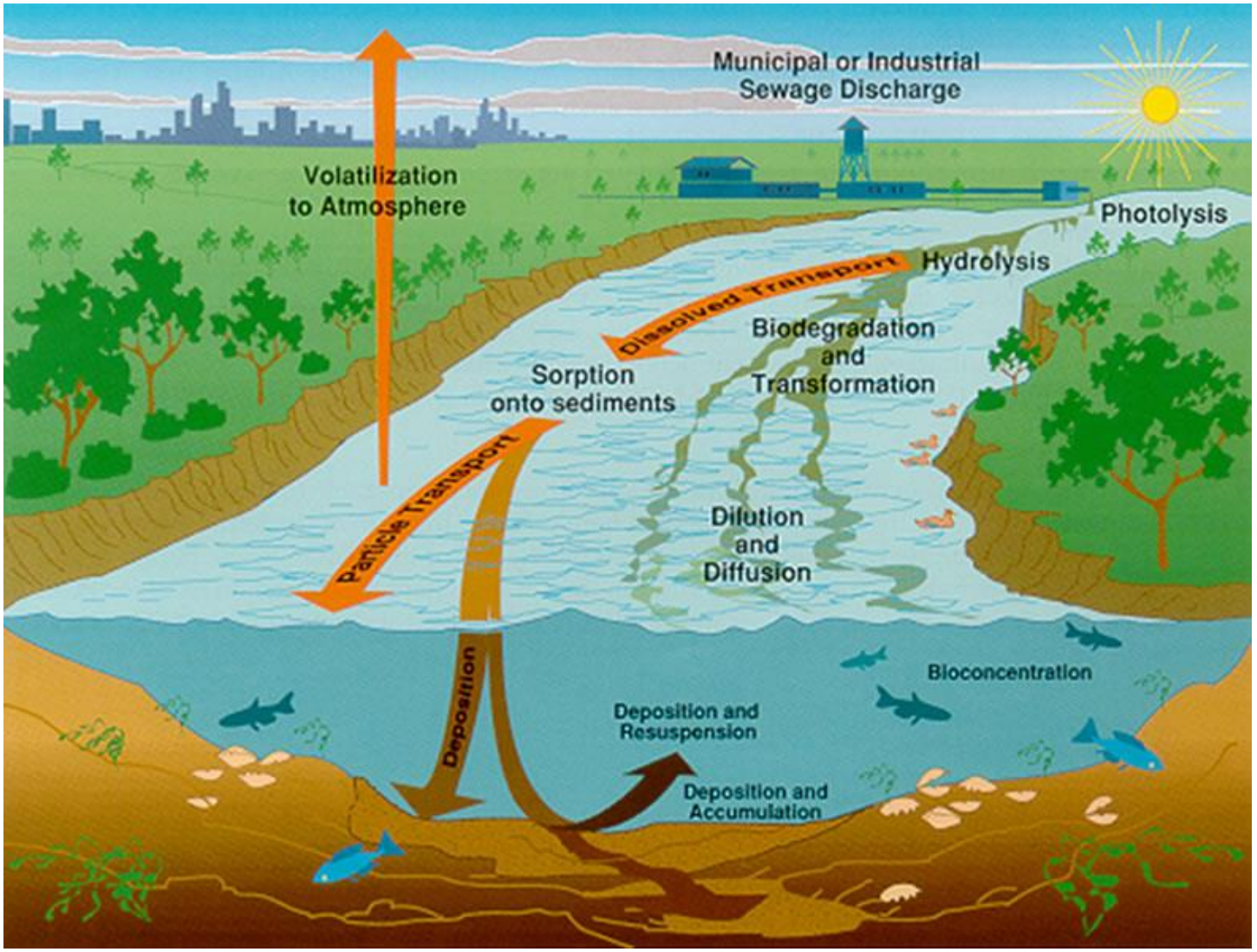
- Sedimentation
- Adsorption to suspended particles/soil media

Non- conservative pollutant

Organic matter and pathogens

- Chemical reactions
- Natural growth/Decay

Fate and transport of contaminant in environment



Exposure pathways

Exposure pathway is defined as a process by which an individual is exposed to contaminants that originate from a specific source

1. Source of contaminant release into the environment

2. Environmental media (including groundwater, surface water, air, soil, sediment, household dust, biota)

3. Point of exposure

4. Route of exposure

5. Receptor population

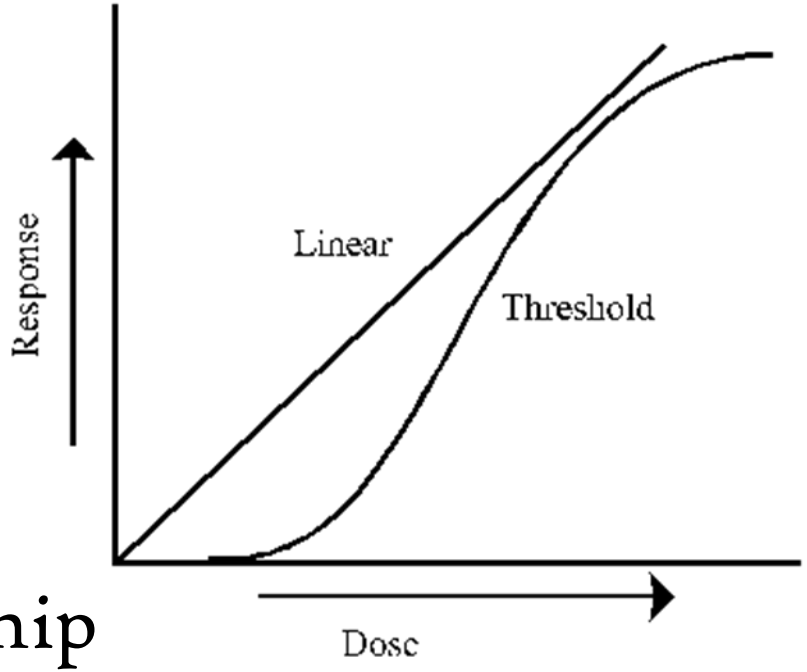
To measure exposure variables such as intensity, frequency, and duration of the contact with the polluted media are crucial

Risk assessment of chemical substances

Hazard	capability of a substance to cause an adverse effect
Risk	probability that the hazard will occur under specific exposure conditions
Risk assessment	the process by which hazard, exposure, and risk are determined
Risk management	the process of weighing policy alternatives and selecting the most appropriate regulatory action based on the results of risk assessment and social, economic, and political concerns

Risk

- Nature and level of Response
  - Non-carcinogenic
    - Pb, Zn, Mn, Cu, Ni, Cd
  - Carcinogenic
    - As, Pb, Cd, Cr



- Dose response relationship

Risk estimation

Carcinogenic risks

- Linear Model-Any level of exposure pose a cancer risk
- Carcinogenic risk = (potency factory) X (chronic daily intake))
- USEPA acceptable cancer risk $=10^{-6}$(One person getting an additional cancer over a period of 70 years

Non carcinogenic Risk

- Non Linear Model
- Health Index= Average daily dose/reference daily dose
- HI>1 in indicate non carcinogenic risk to the exposed population
- HQ = Σ HI

Human Intervention to prevent risk

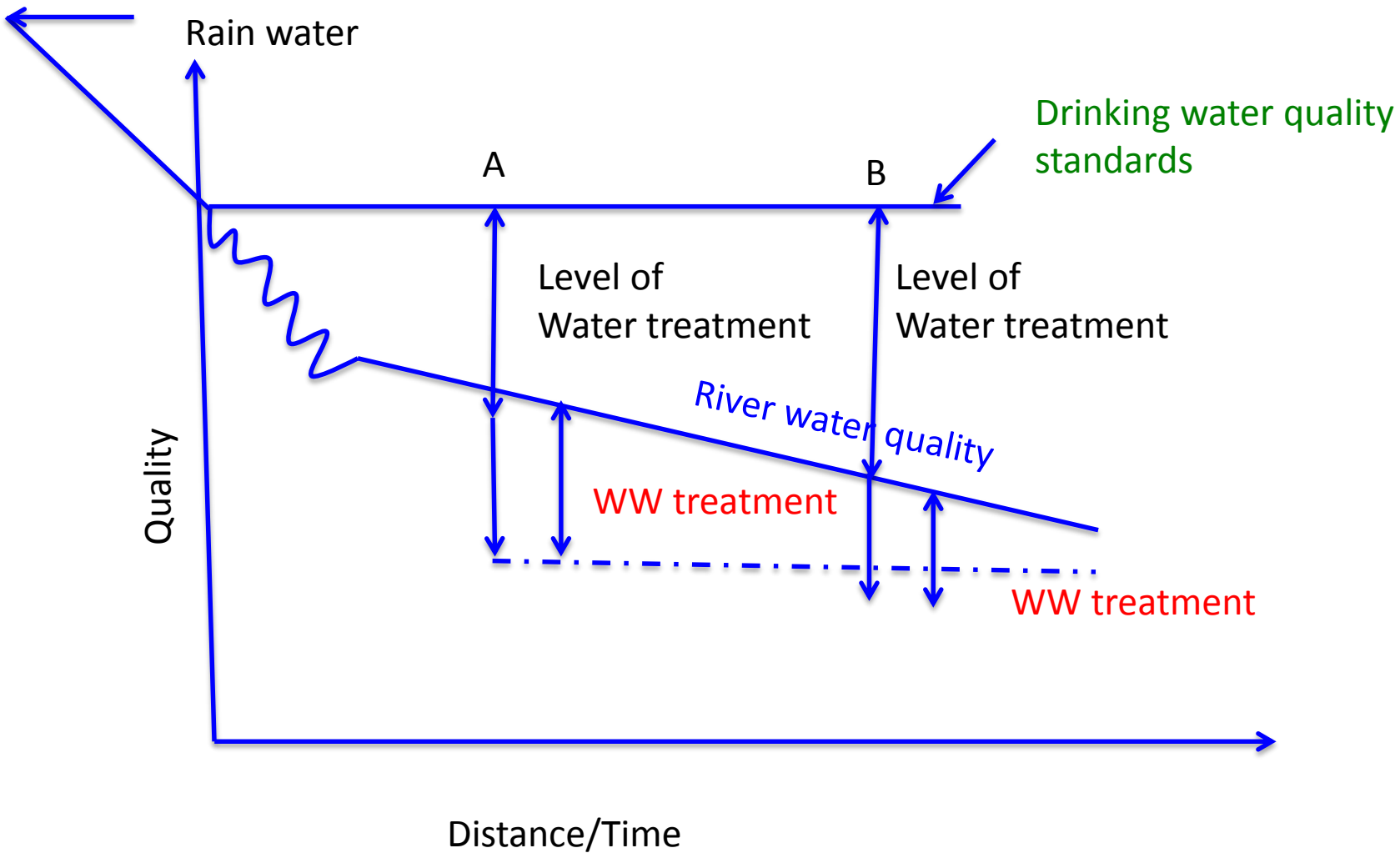
- Laws/policies to regulate pollutant levels in surface water and groundwater
  - Effluent discharge standards to control discharges from point sources
    - Wastewater treatment plants
  - Surface water quality criteria for designated use
    - Drinking water source
    - Outdoor bathing
    - fisheries
    - Irrigation /control disposal

Water and wastewater quality Enhancement: Philosophy of Treatment

- Before water is supplied to the community the water quality should be enhanced to meet the **drinking water quality standards**

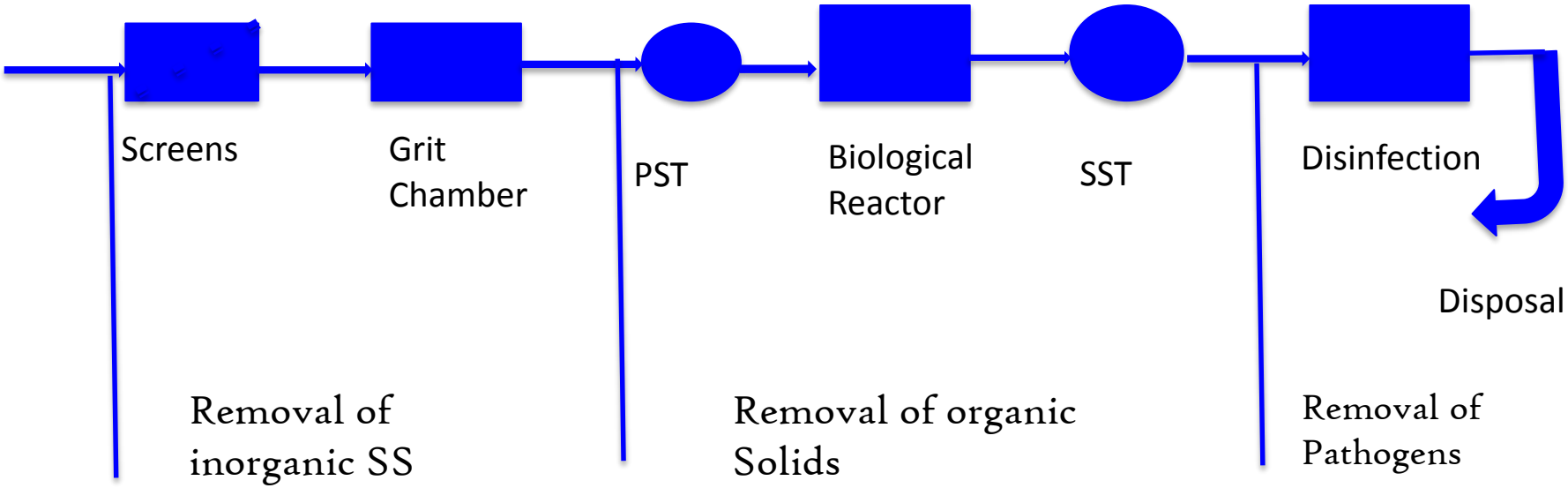
- The wastewater quality should also be enhanced since untreated effluent cause **deterioration of water quality** (source protection)

- Source protection is an effective method of reducing the **water treatment cost**


Rain water
Drinking water quality standards
A
B
Level of Water treatment
Level of Water treatment
River water quality
WW treatment
WW treatment
Quality
Distance/Time

Wastewater Treatment

- To remove Suspended solids
- To remove biodegradable organic matter
- To kill Pathogens



Wastewater Treatment

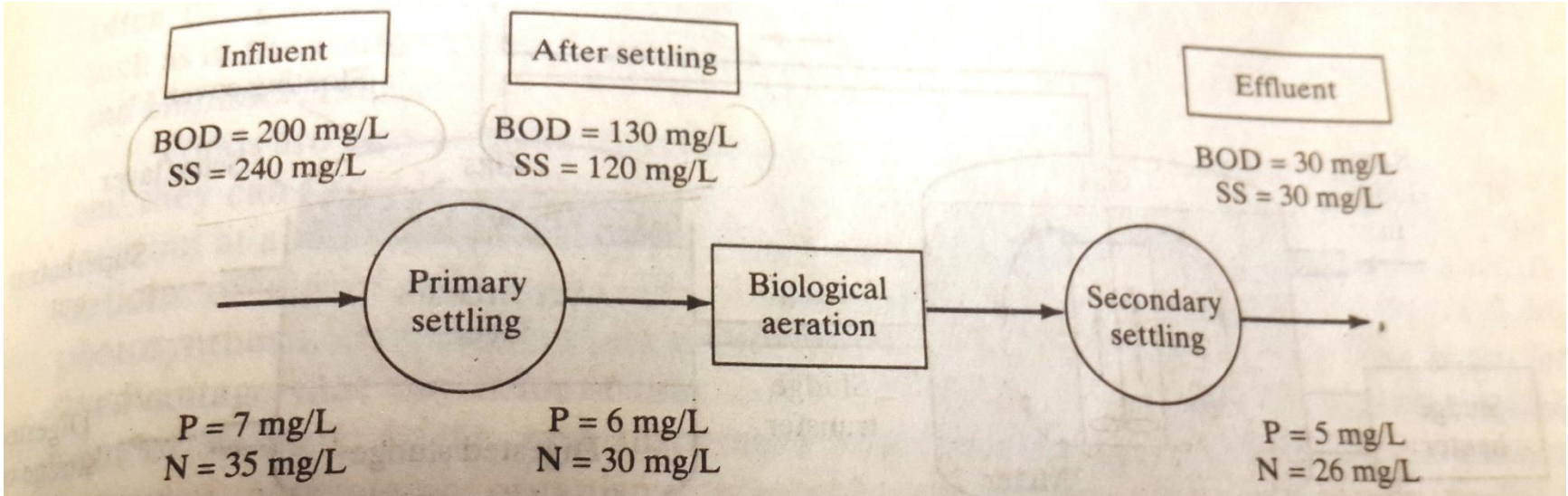


FIGURE 6.10 Approximate concentrations of BOD_5, suspended solids, total nitrogen, and total phosphorus as wastewater passes through a secondary wastewater treatment plant. (*Source: Water and Wastewater Technology* 3/E by Hammer and Hammer, © 1996. Reprinted by permission of Prentice-Hall, Inc., Upper Saddle River, NJ.)

Wastewater Treatment Plant

Sludge treatment

- Sludge –mix of solids and water

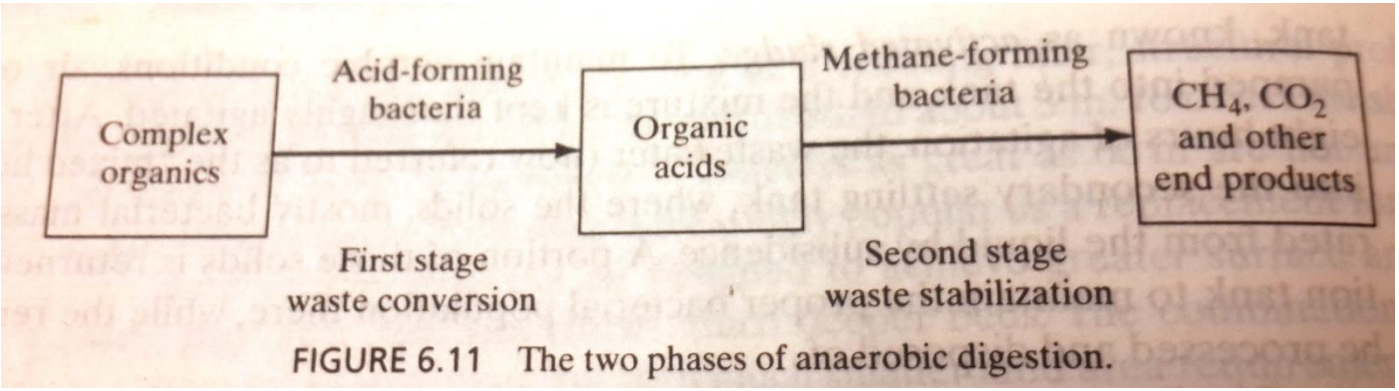
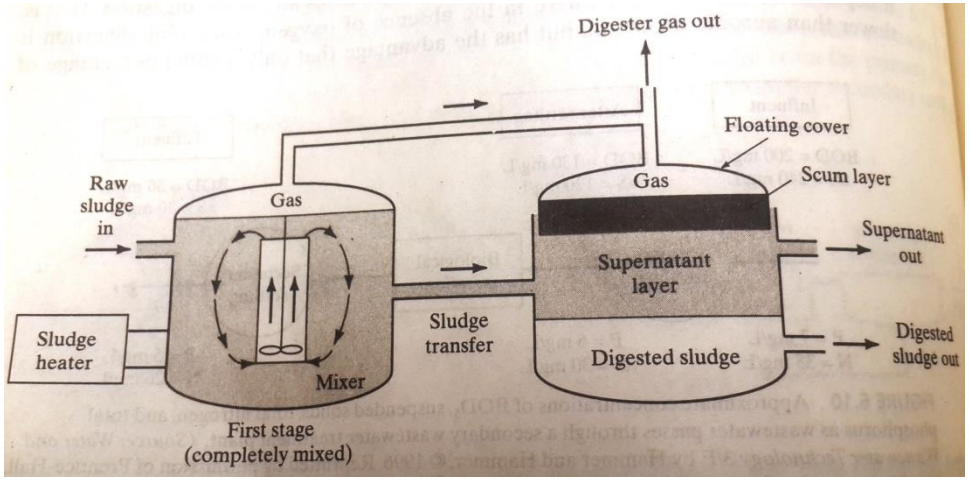
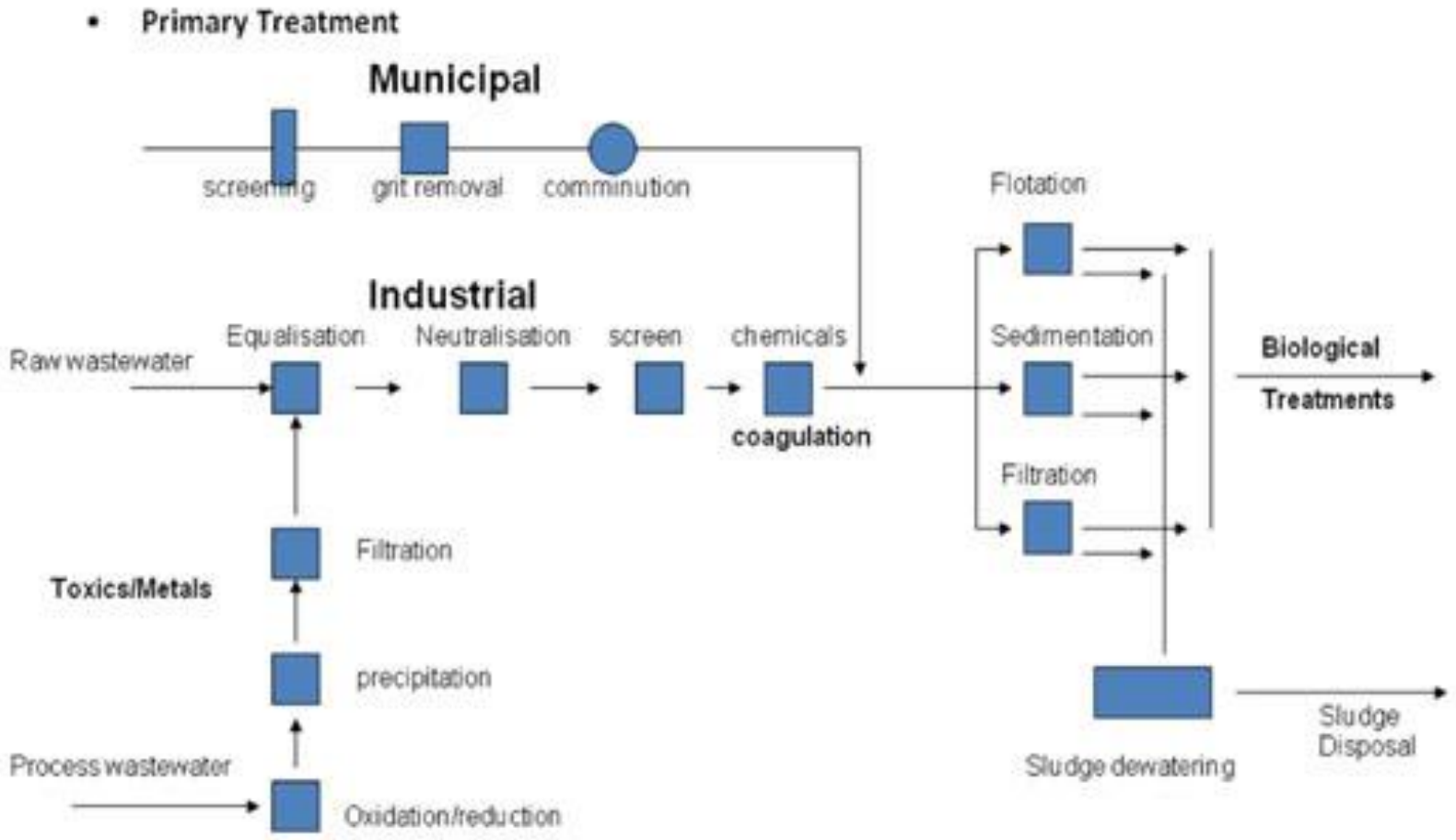


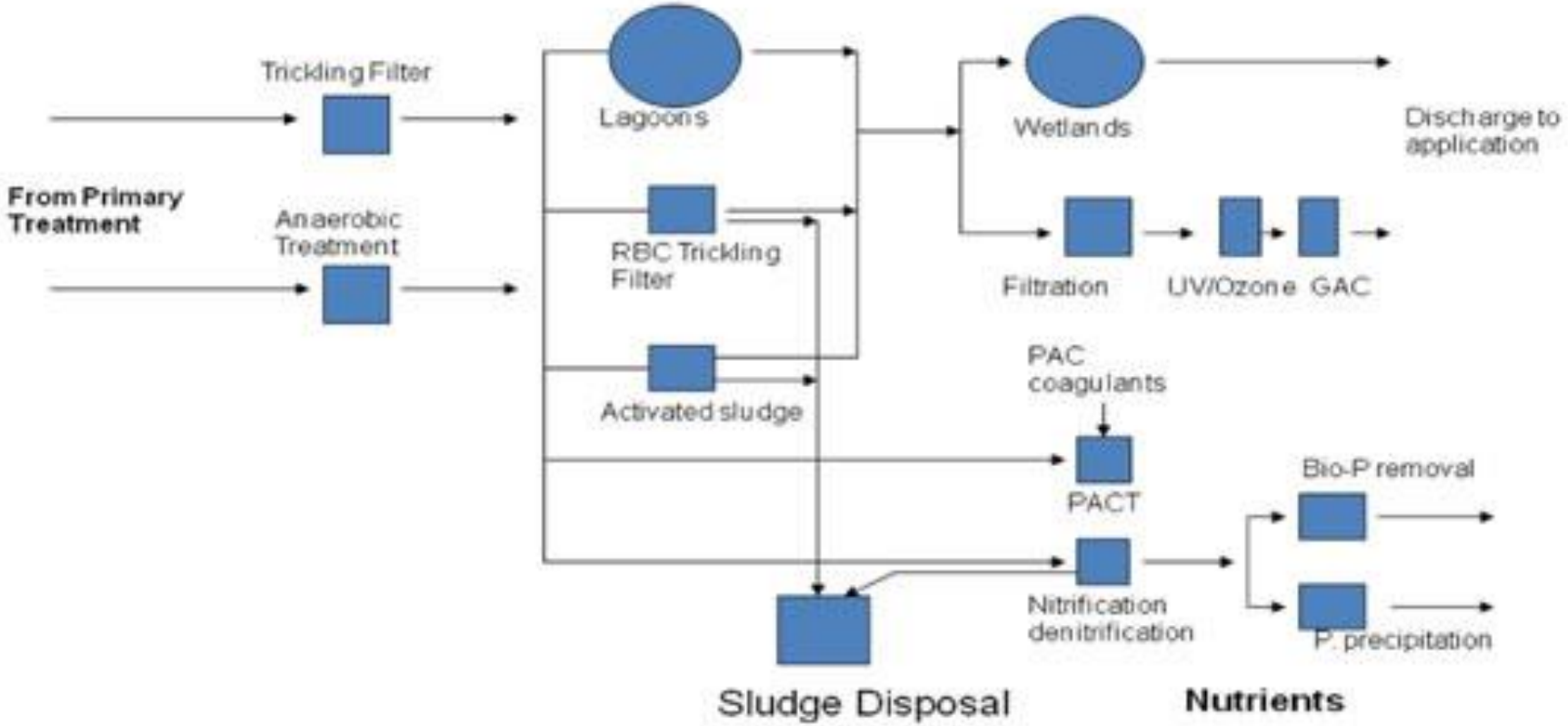
FIGURE 6.11 The two phases of anaerobic digestion.



Industrial wastewater treatment



- **Secondary Treatment**



Measure and model fate of pollutants

Conservative pollutant

Non- Conservative pollutant

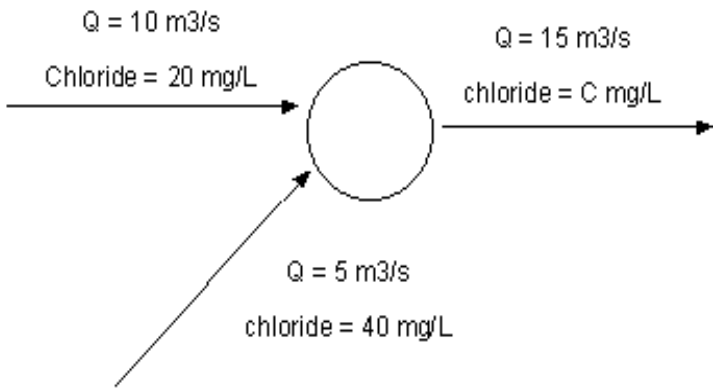
Mass Balance

input rate = output rate + reaction rate

The reaction rate is equal to 0 if the pollutant is conservative. The reaction rate can be + or – if the pollutant is non-conservative.

Conservative pollutant

EXAMPLE: Two streams enter a lake in the system shown below. The main stream has a flow of 10 m^3/s, and a chloride concentration of 20 mg/L. The tributary stream has a flow of 5 m^3/s and a chloride concentration of 40 mg/L. What is the chloride concentration leaving the lake system? Note that chloride is a conservative pollutant. The answer is obtained by balancing the sinks and sources of pollutants to the lake system as follows:



Non- conservative pollutant

The decay rate is often modeled as a first order reaction

$$Ct = [C_0]*e^{-[k*t]}$$

For steady state non-conservative pollutant, the equation needs and additional term to account for the decay as follows:

$$\text{Decay rate} = -[k*C*V]$$

k = reaction rate
C = concentration at time
V = volume of the system modeled

Assume the lake system has a volume of $10*10^6$ m^3, and the pollutant is non-conservative with a decay rate of 0.2 1/day. Flow and concentrations in the streams are as in the figure below. What is the concentration of the pollutant leaving the lake system?

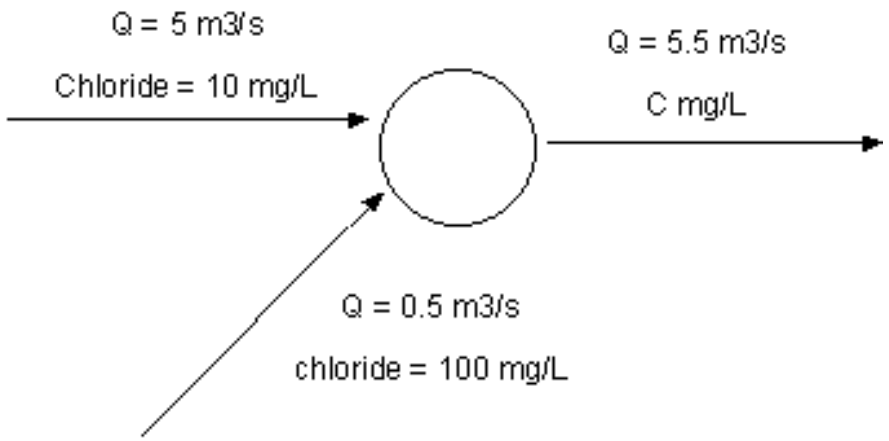
Input = [5 m^3/s]*[10 mg/L] + [0.5 m^3/s]*[100 mg/L] = 100 [m^3.mg/L.sec]

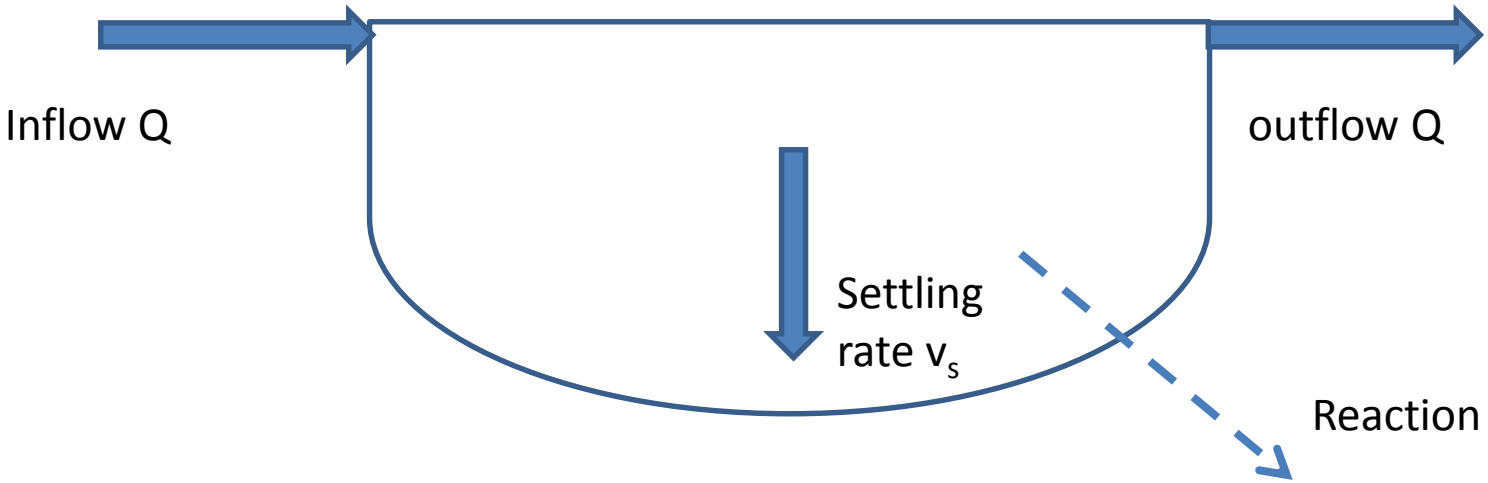
Output = [5 m^3/s + 0.5 m^3/s]* [C] = 5.5 * [C]

Decay = -[0.2 1/day] * [C] * [10 * 10^6 m^3] = -23.1 * [C]

Input = Output + Decay

C = 3.5 mg/L




Inflow Q
outflow Q
Settling
rate v_s
Reaction

Emerging pollutants

- Emerging contaminants" can be broadly defined as any synthetic or naturally occurring chemical or any microorganism that is not commonly monitored in the environment but has the potential to enter the environment and cause known or suspected adverse ecological and(or) human health effects.

- In some cases, release of emerging chemical or microbial contaminants to the environment has likely occurred for a long time, but may not have Household products related to emerging contaminants been recognized until new detection methods were developed. In other cases, synthesis of new chemicals or changes in use and disposal of existing chemicals can create new sources of emerging contaminants.

(1) develop **analytical methods** to measure chemicals and microorganisms or their genes in a variety of matrices (e.g. water, sediment, waste) down to trace levels,

(2) determine the **environmental occurrence** of these potential contaminants,

(3) characterize the myriad of **sources and source pathways** that determine contaminant release to the environment,

(4) define and quantify processes that determine their **transport and fate** through the environment

(5) identify potential **ecologic effects** from exposure to these chemicals or microorganisms.