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Environmental Engineering

INTRODUCTION

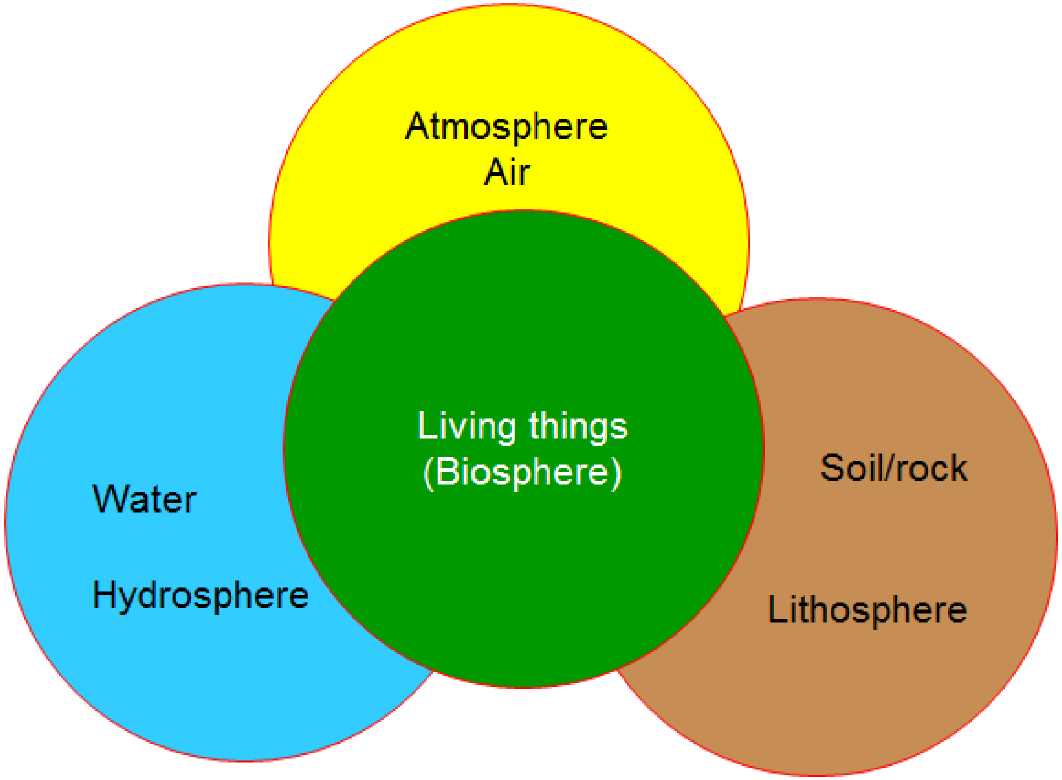
- ❑ Concepts & definitions.
- ❑ Environmental science & environmental engineering.
- ❑ Introduction to Microbiology.
- ❑ Overview of ecological and environmental systems.
- ❑ Environmental ethics, regulations, and standards.
- ❑ Environmental impact assessment and sustainable development.

Dr. Ahmad AbuYaghi Feb. 2022

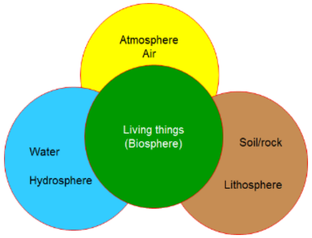
CONCEPTS & DEFINITIONS

Environment: Environment is French word "**Environner"**, which mean to encircle or surround. That is all the physical and biological surroundings of an organism, along with their interactions such as: atmosphere, hydrosphere and lithosphere, which surround us is known as our "**environment**".

The Earth's Great Spheres



CONCEPTS & DEFINITIONS



The following concepts and definitions are important in the understanding the objectives and contents of this Course:

Ecology:
Branch of biology covering relations among living systems as well as between these and their surroundings – Provides knowledge on ability of natural systems for self-purification.

Environment:

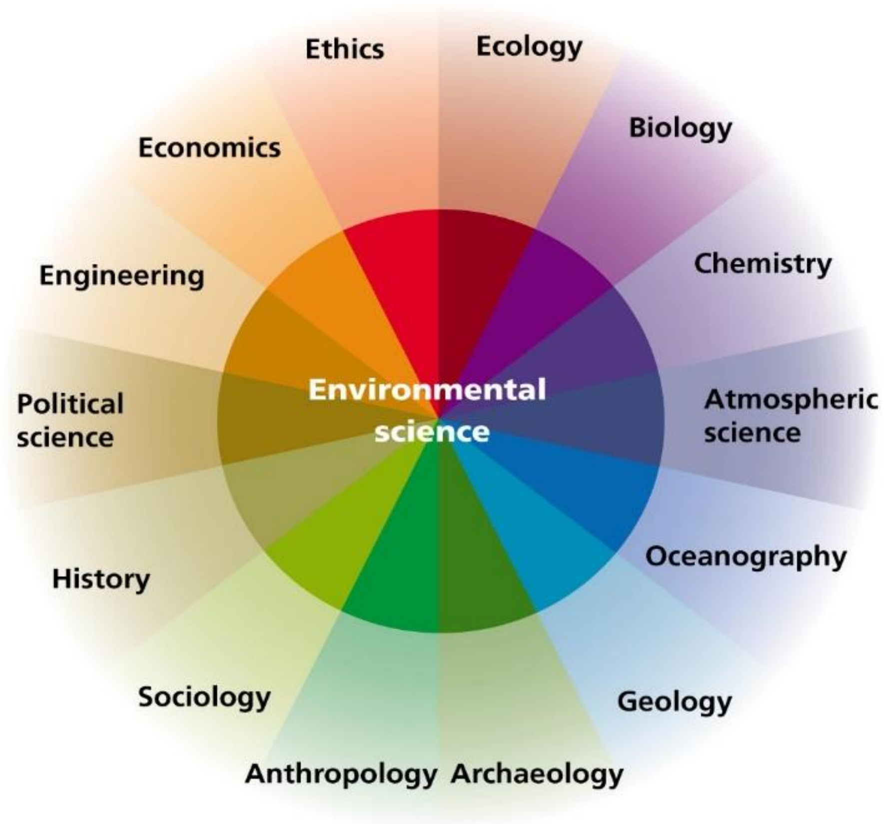
- Global: Sphere in which the life-sustaining resources of the earth are contained.
- Local: region or area where a specific problem is being addressed.

Pollution: Undesirable change in the physical, chemical and / or biological characteristics of air, water or land that can harmfully affect the health, survival or activities of humans or other living organisms.

Environmental Quality: Degree of pollution of one or more of the elements of the physical environment (air, water, land) which is measured quantitatively or expressed qualitatively.

ENVIRONMENTAL SCIENCE & ENGINEERING

Environmental Sciences:
Interdisciplinary field that involves both natural and social sciences; used to improve our understanding of natural processes and their interaction with and impacts on human society.



Environmental Engineering:
Utilizing the above knowledge and understanding to develop and apply technologies that will maintain or improve environmental quality for the benefit of human society.

ENVIRONMENTAL ENGINEERING

- ***Environmental engineering*** uses environmental science principles, along with *engineering concepts and techniques**,
  1. To assess the impacts of societal activities on the environment and the impact of the environment on people, and
  2. To protect both human health and environment.

** Engineering techniques involve design, operation, control and maintenance of engineering units (structures, equipment).*

- *Design involves material selection, sizing, connection, networking and layout.*

- ***Environmental engineering*** is concerned with the design, manufacture, installation and operation of the engineering systems that sustain and control the environments required by people and processes.
- The ***environmental engineer*** is the one who solves environmental problems using scientific tools (concepts of environmental science and engineering techniques).

SCOPE of Environmental Engineering

The mission of environmental engineering

Real-World Problems

Use of Earth's Resources

Release Contaminants to Environment

Environmental Impacts

Apply scientific knowledge

Technologies

Minimize adverse effects of contaminants

ENVIRONMENTAL ENGINEERING

❑ **Environmental engineering** is problem-focused, rather than tool-based field. It operates at four different levels:

1) Remediation of contaminated sites (= fixing the past),
2) Treatment of effluents (= dealing with present),
3) Pollution prevention, and
4) Sustainability policy (= care for future generations).

❑ Environmental engineering is an ***interdisciplinary field*** due to the wide range of science and sources of knowledge involved in environmental issues.

For examples:

❖ 1) Groundwater contamination by leaking gasoline storage tanks: Material science/corrosion, hydrogeology, geochemistry, microbiology, hydraulics AND environmental (chemical/ civil) engineering.

❖ 2) Urban air pollution: Meteorology, chemistry, environmental (chemical/ mechanical) engineering.

KEY ELEMENTS OF MODERN ENVIRON ENG.

1. Systems approach – includes multiple processes and interactions between these processes , defined by system boundaries (Systems can be structural and/or functional). Also, interactions of pollutants across environmental components is unavoidable.

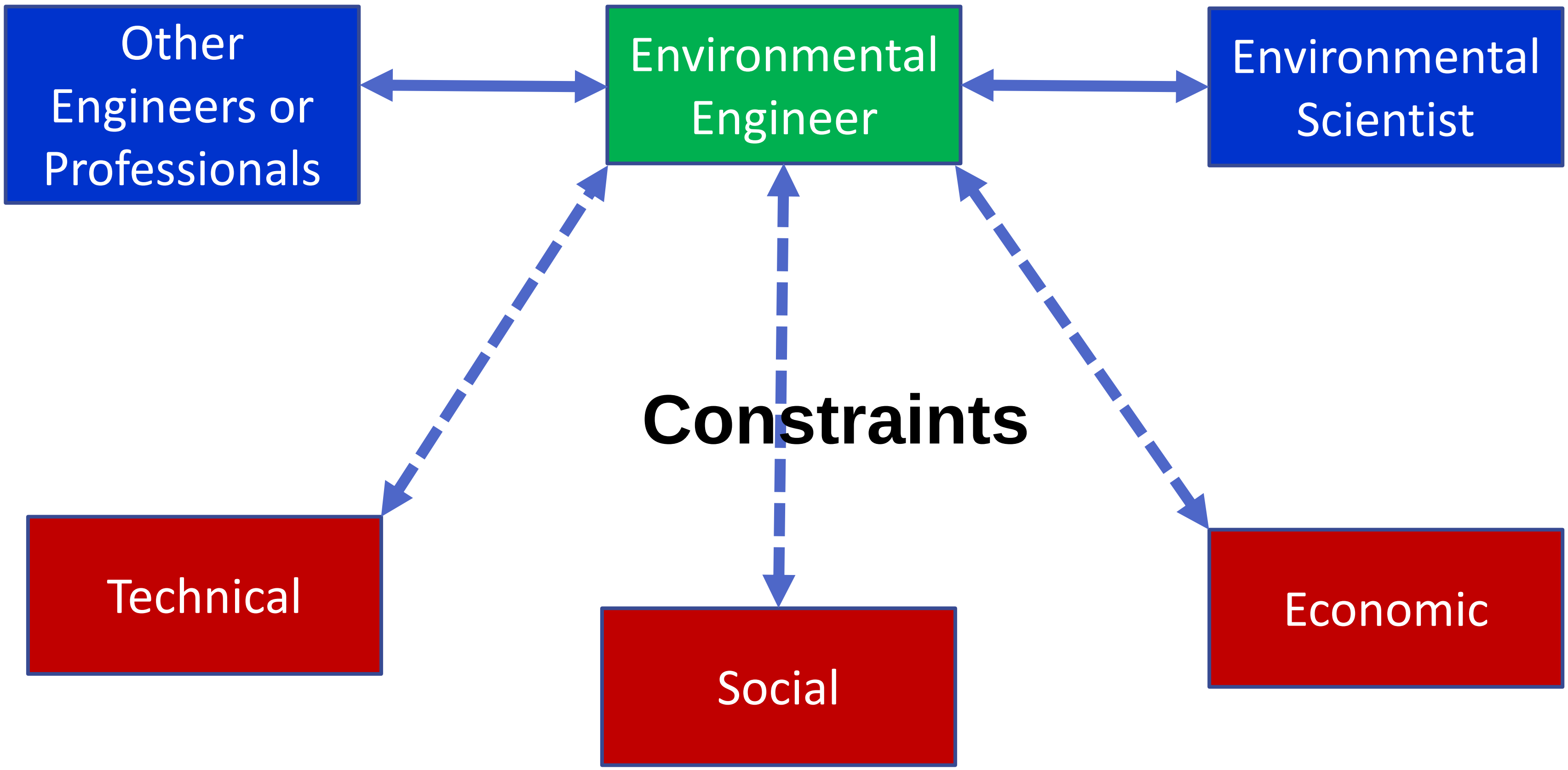
2. Based on chemistry – environmental quality described by chemical composition of the system (substances, stoichiometry, concentrations, mass balance).

3. Quantitative – magnitude of the problem and feasibility of the solution are described numerically.

4. Driven by government policy (regulations and standards), which is increasingly set on the basis of risk.

Definition of Risk: Possibility of loss or injury, AND
The chance of loss; the degree of probability of such loss.

Handling of Environmental Problems



Analysis Environmental Problems

- Analysis is crucial for understanding and solving environmental engineering problems. Both natural (ecological) systems and built engineered systems need to be analyzed.
- The purpose of analysis to predict how they do behave, and to explain why.
- **Steps:**
  1) *Translate the physical system into a mathematical representation. This includes physics laws, transformation (chemical, biochemical, electrochemical) processes, and transport (fluid flow, heat transfer, mass transfer) processes.*
  2) *Solve the mathematical problem to obtain the result.*
  3) *Interpret the significance of the result for the physical system.*

Analysis Environmental Problems

Examples of mathematical representation of natural processes:

- Chemical reaction kinetics:

$$\frac{d[C]}{dt} = k[C]^n$$

$$\ln\frac{C}{C_0} = -kt \quad or \quad \frac{C}{C_0} = e^{-kt} \;->\; C = C_0\, e^{-kt}$$

$$k = Ae^{-\frac{E}{RT}}$$

$$k_{T2} = k_{T1}\theta^{(T2-T1)}$$

- Biological:

$$\frac{dX}{dt} = \mu X$$

Ecological & Environmental Systems

- **Ecological systems:** Natural systems, e.g., coast, forest, desert, valley, etc.
- **Environmental systems:** Built or human made systems, including water supply, pollution control and waste disposal.

We study EES To learn:

1. how nature works.
2. how the environment affects us and how we affect the environment.
3. how humans can live ***sustainably*** on Earth.

Ecological systems

- **Ecosystem** is a system of living things that interact with each other and with the physical world.

- Ecosystem:
  - Includes abiotic and biotic components
  - Energy flows and matter cycles among these components
  - Biological entities are highly intertwined with chemical and physical entities.
- Ecosystems have many ***biogeochemical cycles*** operating as a part of the system, e.g., the water cycle, the carbon cycle, the nitrogen cycle & the phosphorus cycle. All chemical elements occurring in organisms are part of biogeochemical cycles.

Ecological systems

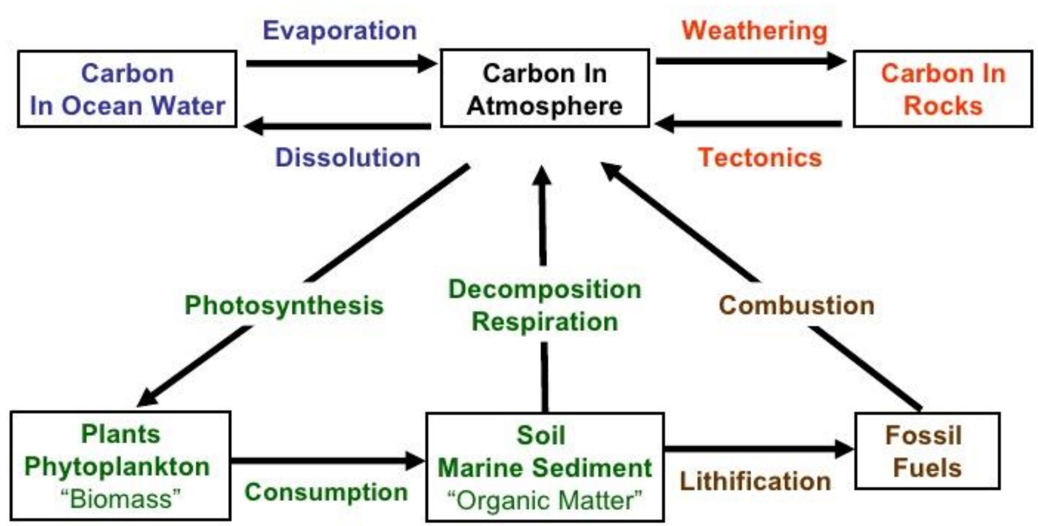
A typical natural ecosystem is divided into:

1. Biotic components:
    a) Producers: green plants, algae
    b) Consumers: herbivores, carnivores, omnivores
    c) Decomposers: ***microorganism***
2. Abiotic (physical) components:
    a) Soil
    b) Water
    c) Nutrients (includes C, O2, CO2, N2, P, etc.)
    d) Climate elements: heat, humidity, wind
    e) Physical elements: gravity, radiation, light

- Interactions occur between abiotic and biotic component, such as transfer of materials and energy.
- Pollutants, in the form of substances &/or physical effects, are foreign components to the natural ecosystem.

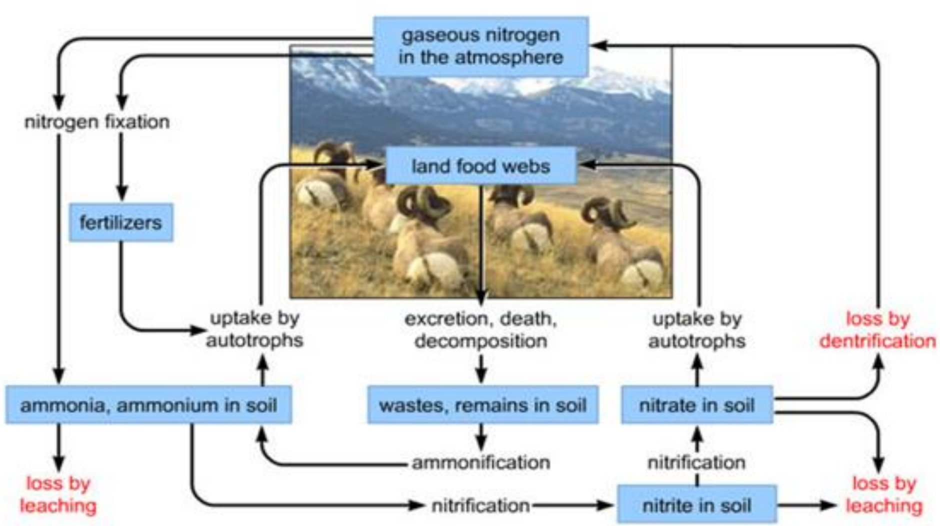
BioGioChemicalCYCLES

The Carbon Cycle

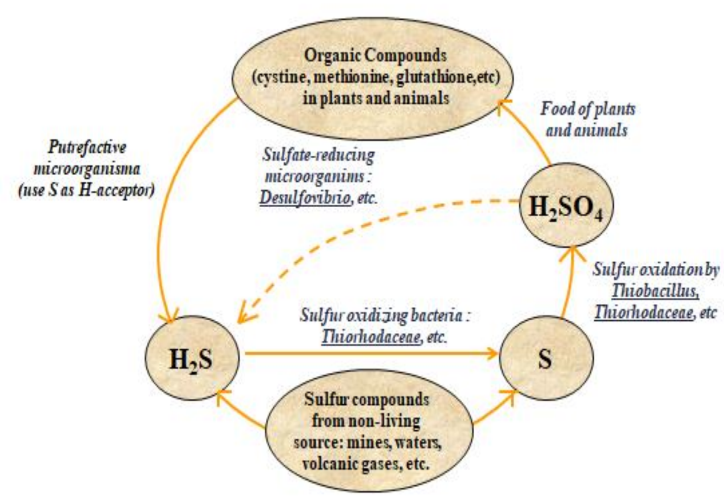


Boxes are carbon sinks Arrows are carbon fluxes

The Nitrogen Cycle



The Sulfur Cycle

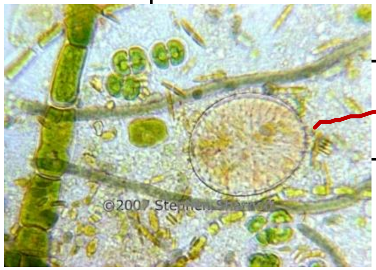


Classification of Microorganisms

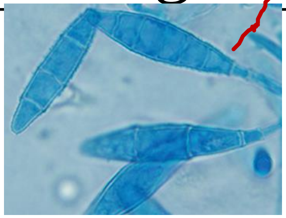
Plants
Mosses Ferns

Animals
Rotifers Crustaceans

Eucaryotes

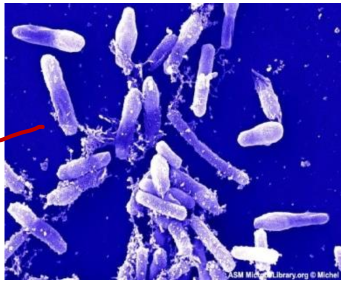


Algae	Fungi	Protozoa



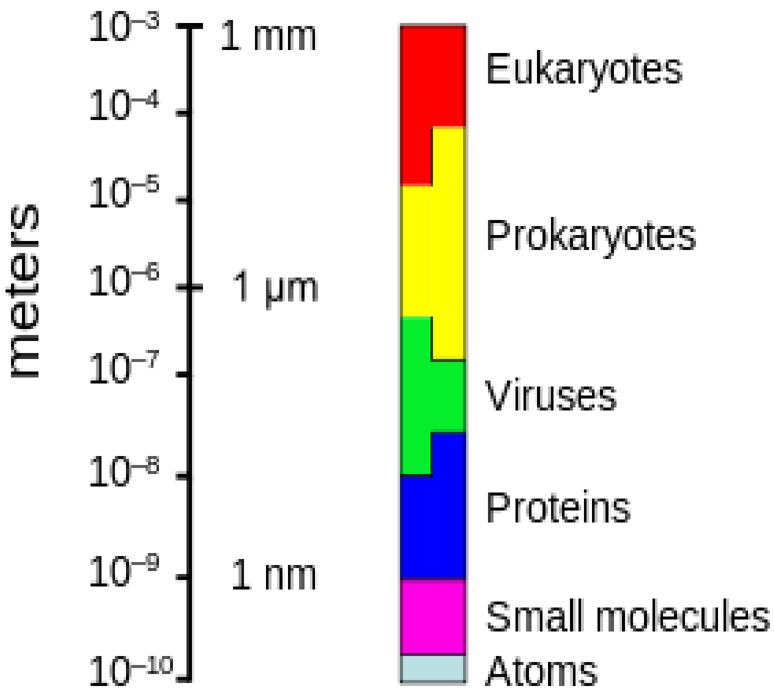
Procaryotes

Archea	Bacteria



Classification of Microorganisms

- **By carbon source**
  - ✓ autotrophs (use inorganics)
  - ✓ heterotrophs (use organics)
- **By energy source**
  - ✓ Phototrophs (use sunlight)
  - ✓ chemotrophs :
    *chemo**organo**trophs or*
    *chemo**litho**thotrophs*



- **By their relationship to oxygen**
  aerobic, anaerobic, facultative
- **By optimum growth temperature**
  psychrophiles (4-25°C), mesophiles (20-45°C), thermophiles (40-75°C)
- **By ecological habitat**
  terrestrial (soil), aquatic (fresh water), marine (sea water)

Metabolism

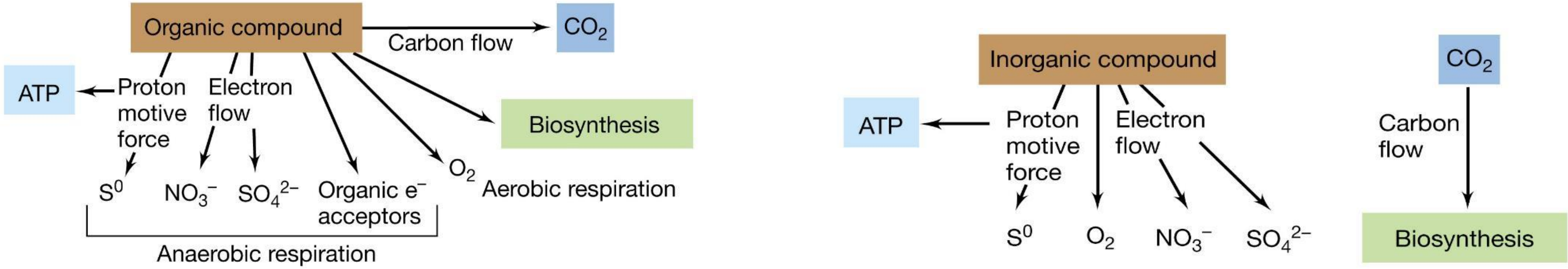
A series of energy conversion processes by performed by a cell

Catabolic

Dissimilation: substrate breakdown
Respiration: use of D.O. as electron acceptor
Fermentation: use of compounds as electron acceptors
Oxidation

Anabolic

Assimilation: utilization of substrate breakdown products
Biosynthesis: cell building
Motion
Repairing and replacing cell materials



(a) **Chemoorganotrophic metabolism** (b) **Chemolithotrophic metabolism**

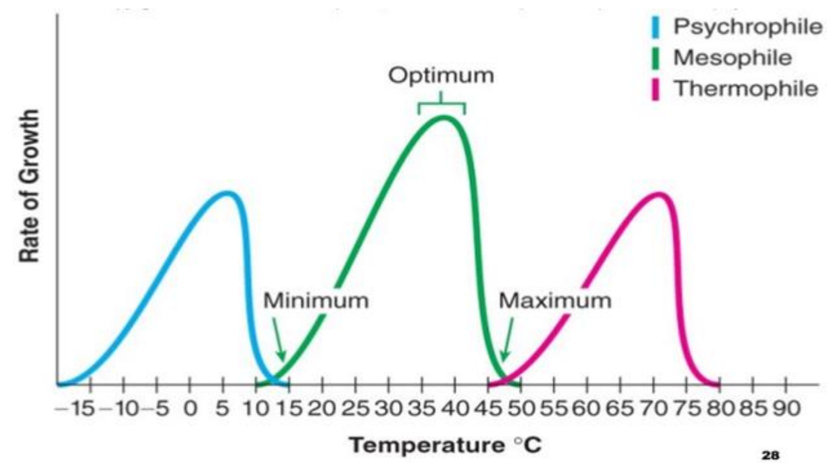
BACTERIAL GROWTH REQUIREMENTS

1. A terminal electron acceptor (O2, NO3-, organic)

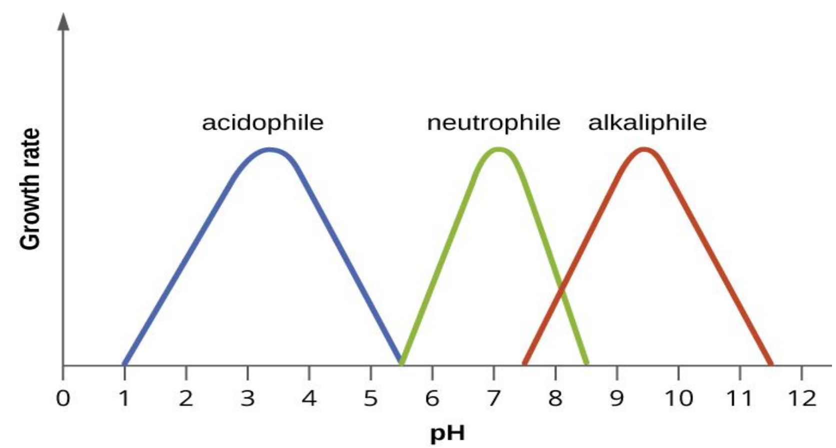
2. Macronutrients
   - Carbon to build cells
   - Nitrogen to build cells
   - Phosphorus for ATP and DNA

3. Micronutrients
   - Trace metals
   - Vitamins

4. Appropriate environment
   - Moisture:
     (water availability to cell)
   - Temperature
   - Medium pH



EFFECTS OF TEMPERATURE

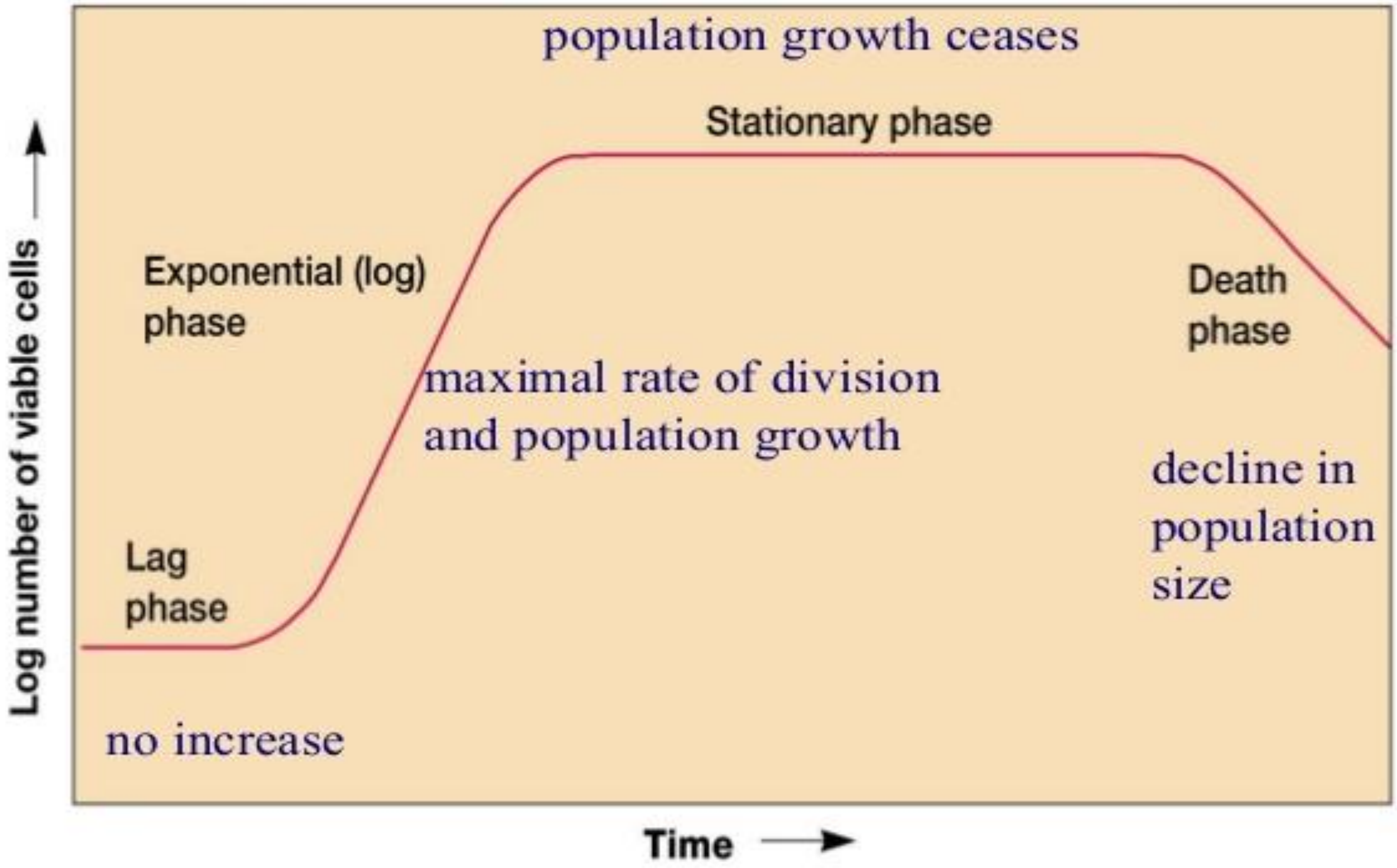


EFFECTS OF PH

KINETICS OF BIOLOGICAL GROWTH

- If you inoculate bacteria into a fresh sterilized medium and measure the cell number versus time and plot it, you may find that there are four main phases of growth and death.

4 Stages of Bacterial growth Curve



ENVIRONMENTAL SYSTEMS

I) The water resource management system

1. ***Water supply sub-system***
2. ***Wastewater disposal sub-system***

II) The air quality management system

III) The solid waste management system

1. ***Municipal solid waste***
2. ***Hazardous waste***

Water resource management system

Water supply sub-system

System Components:

- Planning
- Design
- Operation of processes: *collection, treatment (purification), transmission, distribution.*

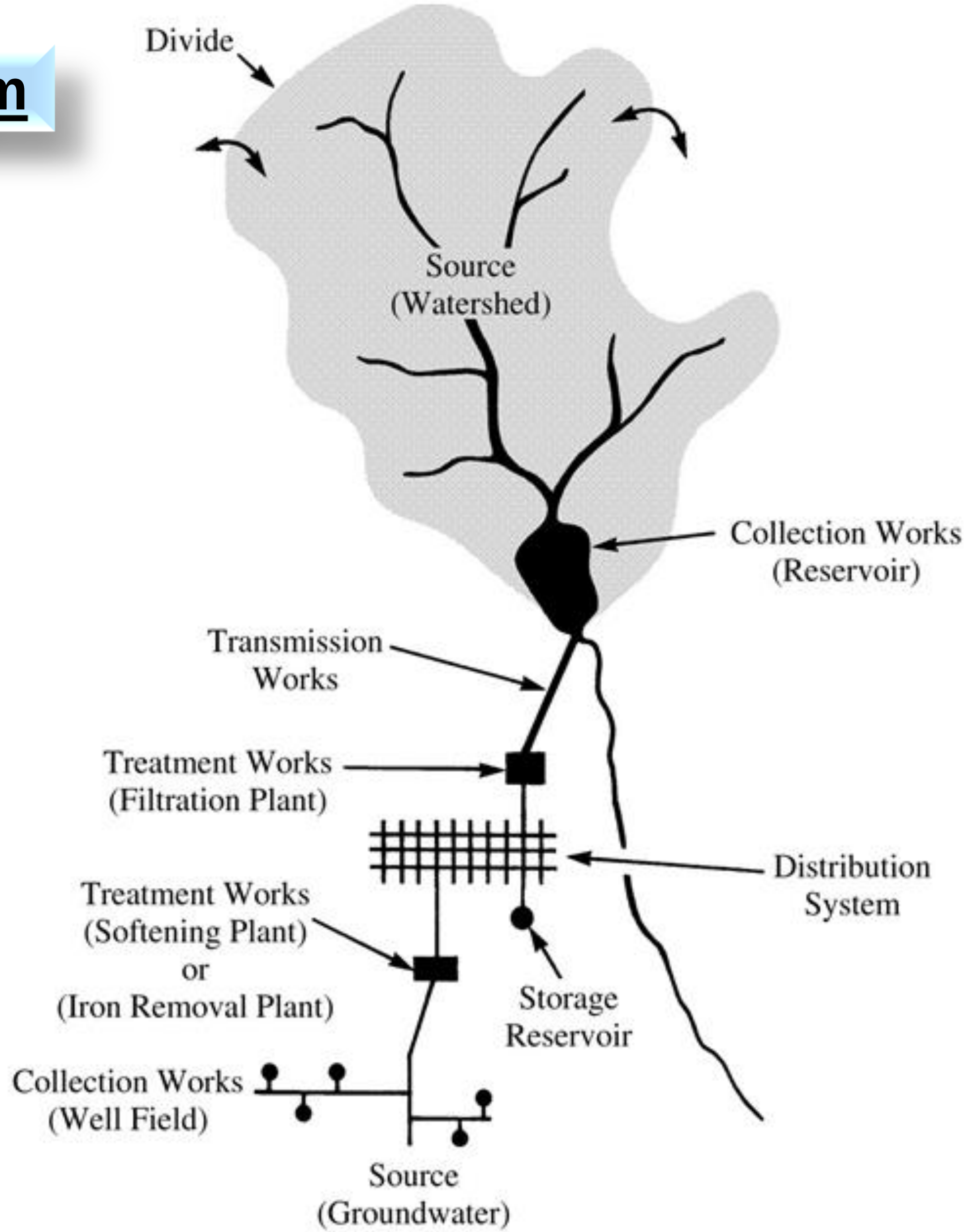
Water Sources:

1. Meteorological water: rain, snow
2. Ground water: springs, wells
3. Surface water: rivers, lakes, oceans

Water supply sub-system

FACTORS THAT INFLUENCE PER CAPITA WATER CONSUMPTION:

1. Climate
2. Industrial Activity
3. Meterage & System Management
4. Standard of Living & Attitude



Ref. Davis & Cornwell:
Intro. To Environ. Eng., McGraw-Hill

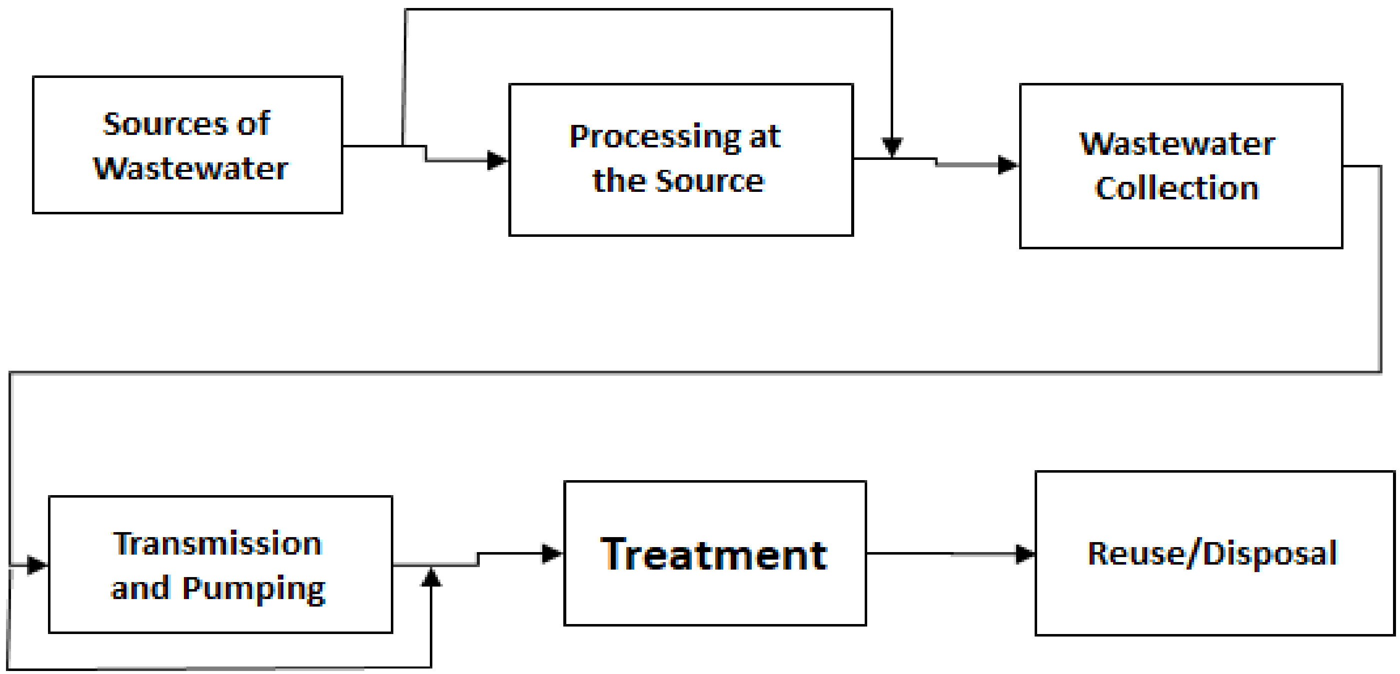
Wastewater Disposal Sub-system

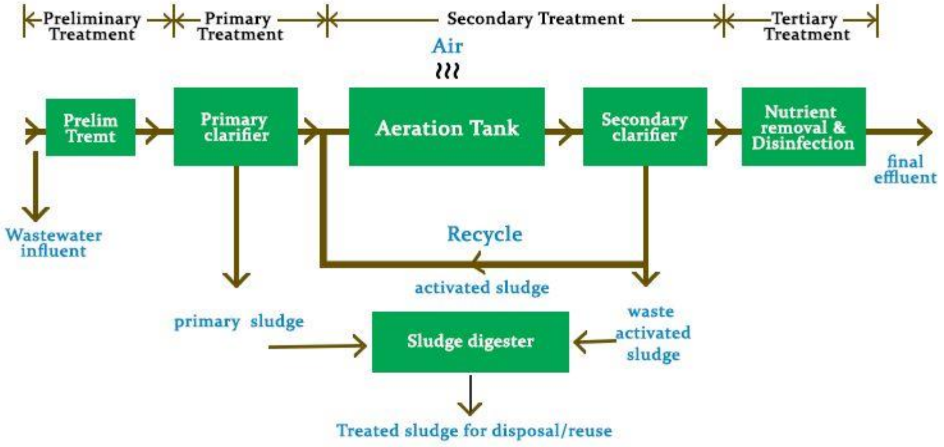
- Wastewater Sources:
  1. Domestic sewage
  2. Industrial effluents
  3. Agricultural runoff
  4. Storm runoff

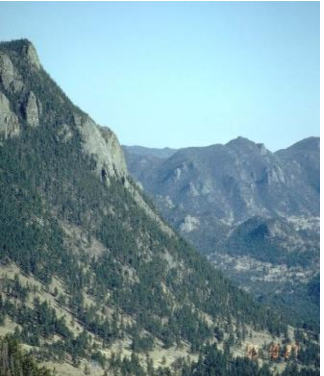
- Collection: 2 types of sewers:
  A. separate sanitary & storm,
  B. combined

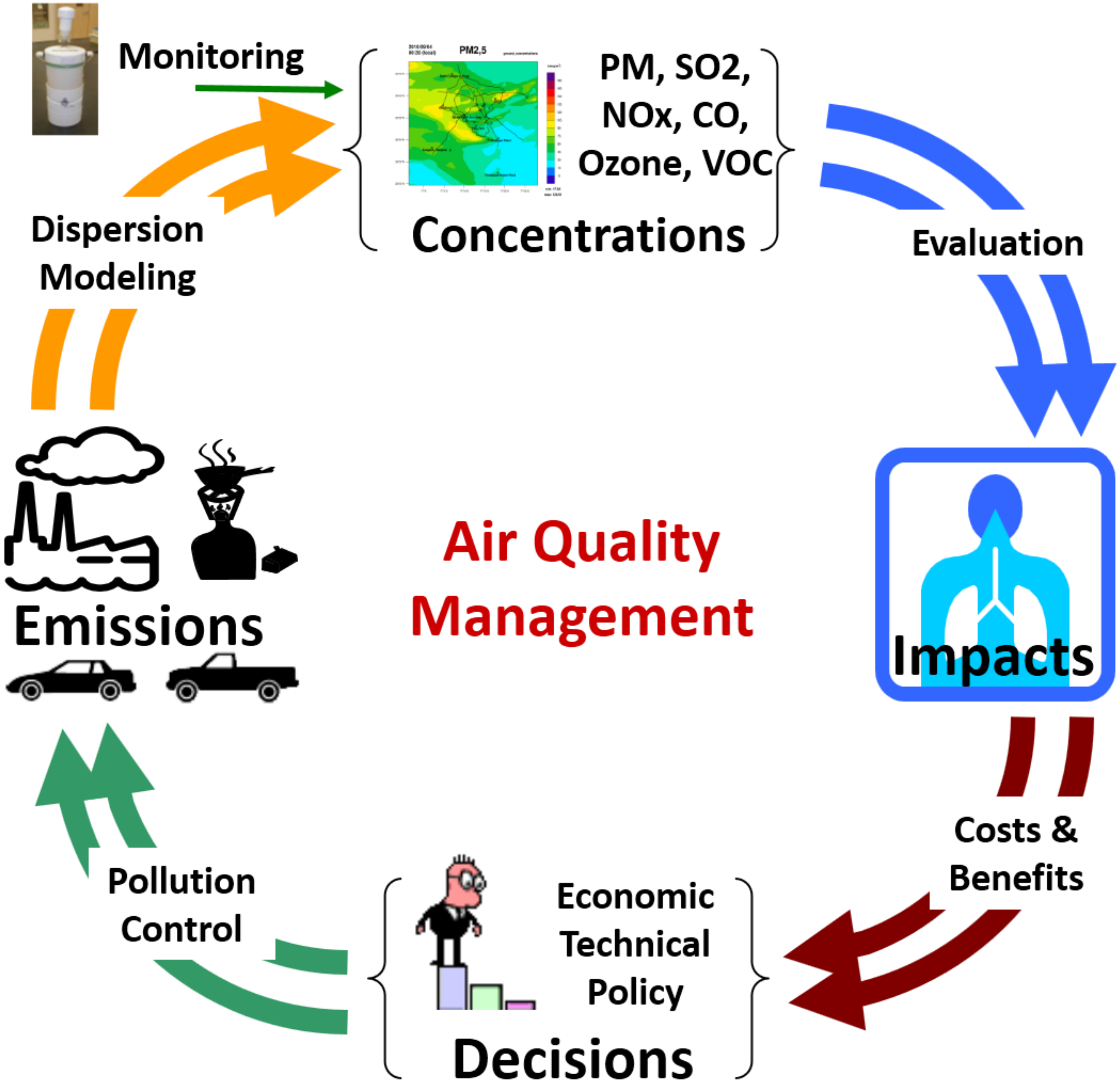
- Treatment: Stabilization of waste material or pollutant so that it will not be harmful to humans or the environment when disposed of.

Wastewater Disposal Sub-system

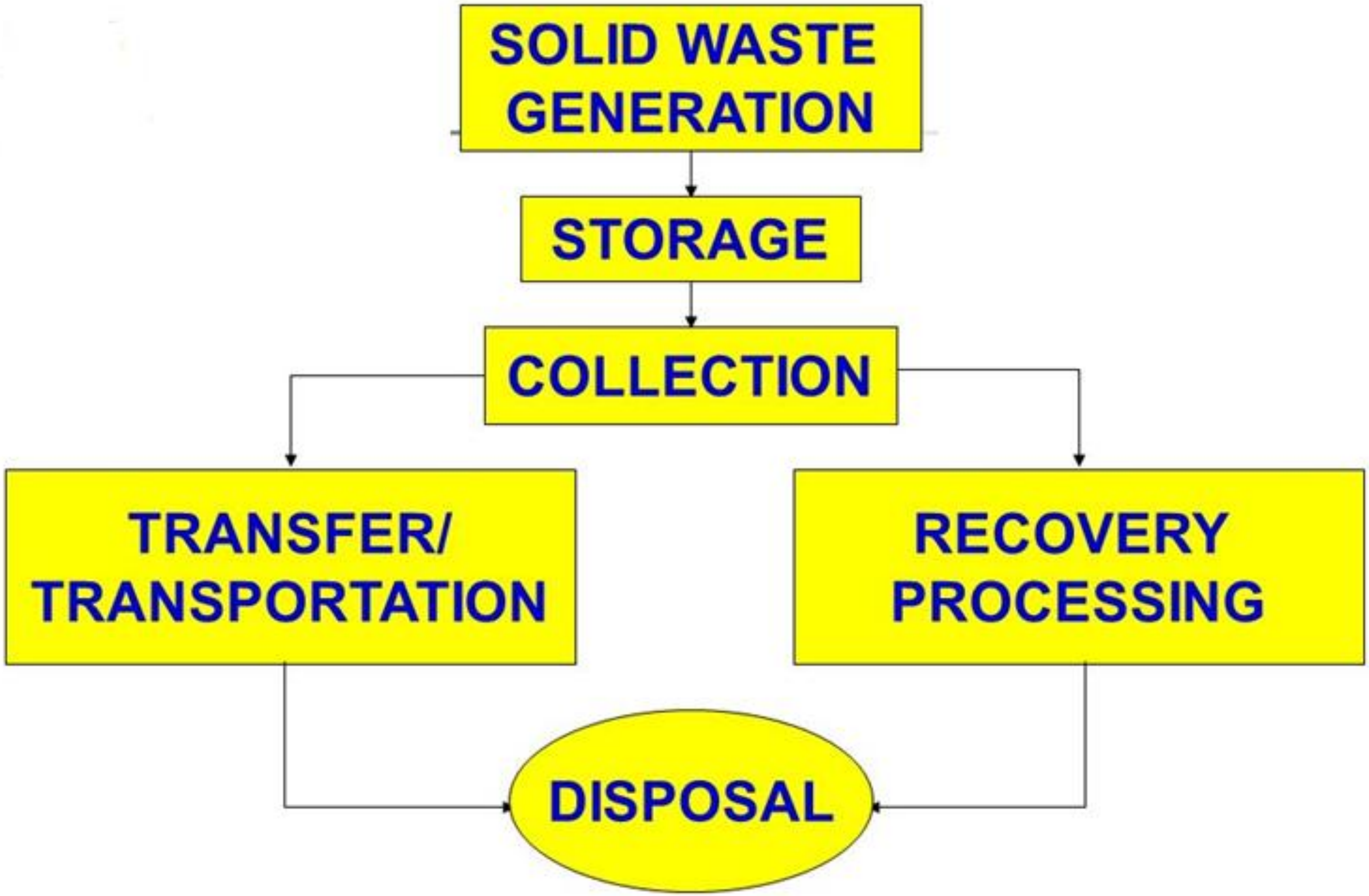







Monitoring
PM2,5
PM, SO2, NOx, CO, Ozone, VOC
Concentrations
Dispersion Modeling
Evaluation
Emissions
Air Quality Management
Impacts
Costs & Benefits
Pollution Control
Economic
Technical
Policy
Decisions

solid waste management system



Hazardous Waste Management

- Hazardous waste is "any waste of combination of wastes that poses a substantial danger, now or in the future, to human, plant or animal life and that therefore must be handled or disposed of with special precautions."
  - Sources can be Industrial, Commercial, Agricultural & Household.
  - Chemical composition: can be organic, inorganic or mixture.
  - Physical state: can be solid, liquid or gas.

Main Classes of HazWaste:

1) *corrosive & reactive,*
2) *ignitable or flammable,*
3) *toxic or poisonous,*
4) *infectious,*
5) *radioactive*

Examples on Important categories:

1) **Persistent organic pollutants (POPs)**
2) **Polychlorinated biphenyls (PCBs)**
3) **Polycyclic aromatic hydrocarbons (PAHs)**
4) **Medical waste**
5) **Heavy metals sludge**

MULTIMEDIA SYSTEMS

- Many environmental problems cross the air-water-soil boundary, e.g.
  A. Acid rain that results from the atmospheric emission of sulfur oxides and nitrogen oxides into the atmosphere.
     - These pollutants are washed out of the atmosphere, thus cleansing it but in turn polluting water and changing the soil chemistry that ultimately results in the death of fish and trees.
  B. Disposal of solid waste by incineration results in air pollution, which in turn is controlled by scrubbing with water, resulting in a water pollution problem.
- In multimedia pollution problems, environmental engineers must use a multimedia approach, and work with a multidisciplinary team to solve environmental problems.
- The best solution to environmental pollution is waste minimization.

Global Environmental Problems

Most Important

1. Habitat destruction, degradation and loss of species biodiversity
2. Depletion of renewable and non-renewable resources
3. Pollution of air, water & soil
4. Land use and land cover change
5. Climate change

Causes

1. Human population growth
2. Wasteful use of resources as well as poverty
3. Poor environmental accounting or auditing
4. Lack of environmental education and awareness

SUSTAINABILITY

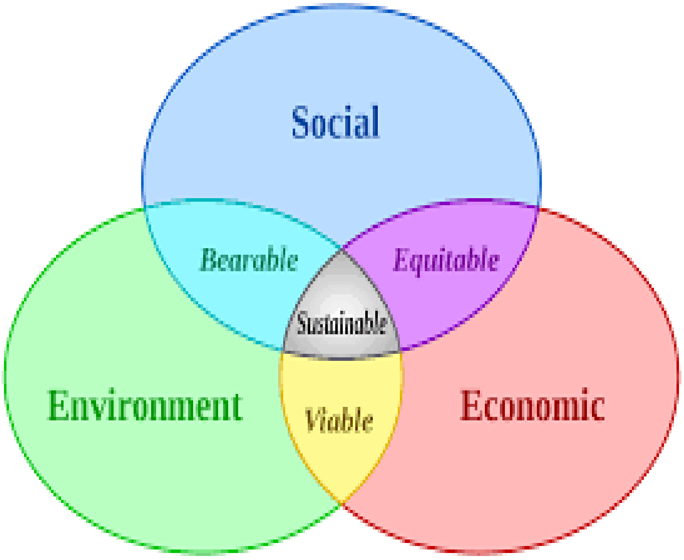
- **Sustainability** establishes and maintains the conditions under which humans and nature can **exist in productive harmony**, that permit fulfilling the social, economic and other requirements of present and future generation.

- A system is **sustainable** if it can continue indefinitely without depleting material or energy resources.

- Use the Sun as a source of energy is a key issue.

- **Sustainability** involves:

1) Soil conservation,
2) Renewable energy sources;
3) Pollution reduction & waste recycling
4) High-efficiency irrigation
5) Organic agriculture
6) Habitat and species protection
7) Fighting global climate change.



SUSTAINABLE DEVELOPMENT

- A **sustainable society** is in balance with the natural world:
  1. Continues for generations
  2. Does not deplete its resource base
  3. Does not produce more pollution than nature can absorb
- Many of our interactions with nature are **not sustainable**:
  - Declining biodiversity and ecosystems
  - Greenhouse gases
  - High rate of energy and resource consumption in developed countries
- **Sustainable development:**
  - development or progress that meets the needs of the present without compromising the ability of future generations to meet their needs

PROFESSIONAL ETHICS FOR ENGINEERS

❑ Engineering ethics:

- A set of ethical standards that applies to the profession of engineering.
- There are several important characteristics of professional ethics.
  - ➢ Unlike common morality and personal morality, professional ethics is usually stated in a formal code.
  - ➢ There are usually several such codes, promulgated by various components of the profession.
  - ➢ Professional societies usually have codes of ethics, referred to as ''code of professional responsibility,'' or ''code of professional conduct''.

CODE OF ETHICS FOR ENGINEERS

Fundamental Principles

Engineers uphold and advance the integrity, honor and dignity of the engineering profession by:

1. Using their knowledge and skill for the enhancement of human welfare and the environment;
2. Being honest and impartial and serving with fidelity the public, their employers and clients;
3. Striving to increase the competence and prestige of the engineering profession; and
4. Supporting the professional and technical societies of their disciplines.

CODE OF ETHICS FOR ENGINEERS

Canon 1. Safety & Environment

Engineers shall hold paramount the safety, health and welfare of the public and shall strive to comply with the principles of sustainable development in the performance of their professional duties.

A). Engineers shall recognize that the lives, safety, health and welfare of the general public are dependent upon engineering judgments, decisions and practices incorporated into structures, machines, products, processes and devices.

B). Engineers shall approve or seal only those design documents, reviewed or prepared by them, which are determined to be safe for public health and welfare in conformity with accepted engineering standards.

C). Engineers whose professional judgment is overruled under circumstances where the safety, health and welfare of the public are endangered, or the principles of sustainable development ignored, shall inform their clients or employers of the possible consequences.

D). Engineers who have knowledge or reason to believe that another person or firm may be in violation of any of the provisions of **Canon 1** shall present such information to the proper authority in writing and shall cooperate with the proper authority in furnishing such further information or assistance as may be required.

ENVIRONMENTAL REGULATIONS IN JORDAN

1. Environmental Protection Law, No. (6) of 2017

(http://moenv.gov.jo/AR/Documents/law_ar/)

1. Other laws: Public Health Law, Agriculture Law, Water Authority Law, Municipalities Law.

2. <u>REGULATIONS:</u>
   - Regulation No. (37) of 2005 : Licensing / Environmental Impact Assessment.
   - Regulations No. (25) of 2005 Soil Protection
   - Regulations No. (29) of 2005 :Natural Reserves & National Parks.
   - Regulations No. (27) of 2005: Management of Solid Waste
   - Regulations No. (29) of 2005: Air Protection
   - Regulation No. (24) of 2005 : Management, Transport and Handling of Harmful and Hazardous Materials.
   - Regulation No. (85) of 2002: Groundwater Monitoring

ENVIRONMENTAL REGULATIONS IN JORDAN

4. Instructions:
   - *Instruction of Management and Handling of Hazardous wastes, 2003.*
   - *Instructions for disposal of industrial wastewater to sewers public sewer of the year 1998 /Water Authority of Jordan.*
   - *Instructions of Noise Control, 2003/Ministry of Environ.*

5. Jordanian Standards *(Technical Regulations).* These standards are issued by the "*Jordan Institution for Standards and Metrology*":
   - JS 286/2008: Water- Drinking Water Standards
   - JS893/2007: Water – Reclaimed Domestic Wastewater.
   - JS202/2006: Water – Reclaimed Industrial Wastewater.
   - JS 1176/2008: Water - Reclaimed gray water in rural areas
   - JS1145/2006: Sludge – Reuse of treated sludge in agriculture.
   - JS 1140/2006: Environment- Air quality-Ambient air quality.
   - JS 1145/1996: Sludge: Uses of treated sludge in agriculture

JS 202/2006: WATER – INDUSTRIAL RECLAIMED WASTEWATER

Characteristic	Unit	Limit, according to crop irrigated		
		A*	B**	C***
BOD	mg/L	30	200	300
COD	mg/L	100	500	500
DO	mg/L	> 2	--	--
TSS	mg/L	50	100	150
PH	pH units	6-9	6-9	6-9
Turbidity	turbidity units	10	--	--
NO_3	mg/L	30	45	45
Total nitrogen	mg/L	45	70	70
E. coli	MPN/100mL	100	1,000	--
Helminth	eggs/L	1	1	1

* Cooked vegetables, parks, playgrounds, urban landscaping

** Fruit trees, highway landscaping

*** Field crops, industrial crops and timber trees

ENVIRONMENTAL IMPACT ASSESSMENT

Regulation No. (37) of 2005 : Licensing / Environmental Impact Assessment. (http://moenv.gov.jo/AR/Documents/)

The procedure of environmental licensing of new projects is summarized below:

1) Submitting project application for environmental licensing to M of Environ.
2) If comprehensive EIA required, Licensing Dept. provides project proponent with all information and guidelines needed.
3) A technical committee of experts and government officials is responsible of reviewing the EIA report.
4) Inspection Department in the M of Environ is responsible to ensure activities compliance with standard environ conditions of approval and EIA contents including monitoring and mitigation plans.
5) Decision by Minister: approval, initial approval with presentation to the Supreme Council of Organizing (Land use), requiring EIA or rejection the request.

ENVIRONMENTAL IMPACT ASSESSMENT

The EIA Regulation #37, 2005 has provided a classification of development projects based on the need for EIA study as follows:

Category 1: includes the projects referred to in **Annex 2** of these Regulations and which require a ***comprehensive EIA*** (e.g. oil refineries, power stations, mining and extractive industry, chemical and petrochemical industry, hazardous waste disposal sites and others).

Category 2: includes the projects referred to in **Annex 3** of these Regulations and which require a ***preliminary EIA***, based on which the need to conduct a comprehensive environmental impact assessment will be determined (e.g. metal processing, food industry, textile and fabric industry and municipal solid waste landfills).

Category 3: includes the projects that require neither a preliminary nor a comprehensive environmental impact assessment. The Ministry periodically supervises and monitors these projects to ensure that they are executed correctly.

CONTENTS OF THE "EIA" REPORT

The Regulation also requires that the final EIA report includes the following content:

Non-technical summary of results and recommendations; Legal & administrative framework policy and guidelines by which the assessment has been conducted; Description of the project; Baseline data: geographic, environmental & economic assessment of the project's location; Environmental impacts: Assessment of the positive & negative impacts identifying measures to mitigate negative impacts on environment; Analysis of alternatives: including design, location, technologies, environmental impacts, fixed and operational costs; Mitigation plan: description of all measures needed to minimize negative impacts on environment, including costs & administrative requirements as well as compensation if measures fail to reduce negative impacts; Monitoring plan; Appendices: names of team members, references and record of meetings and contacts.

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