Water Pollution

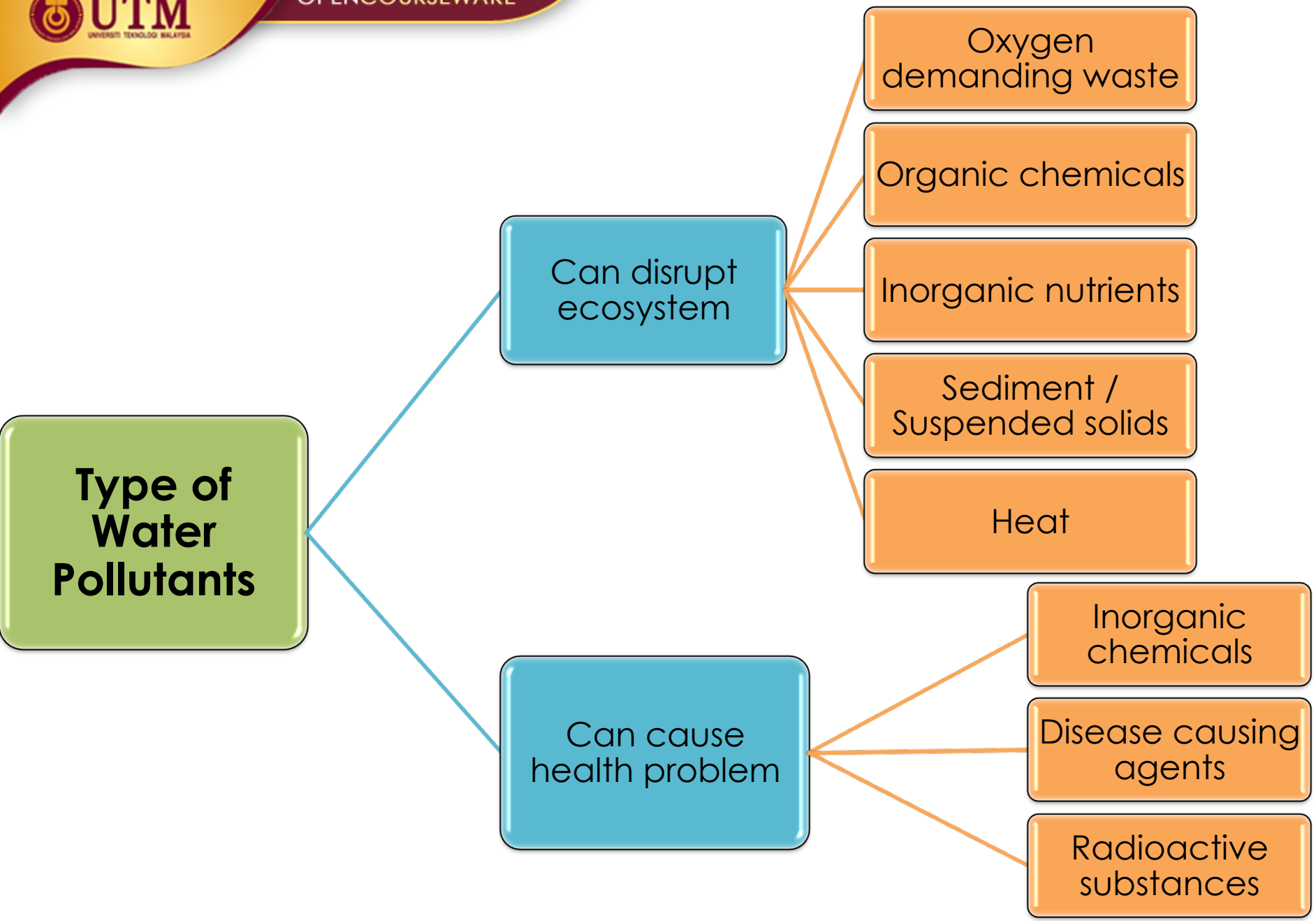
Khalida Muda (Ph.D) &
Shamila Azman (Ph.D)
Dept. of Environmental Engineering
Faculty of Civil Engineering

Introduction

This topic covers on the causes and consequences of water pollution occurrence. It also highlights on the types and sources of water pollutants as well as proper mitigation measures that can be done to minimize the impact of water pollution.

Definition of Water Pollution

"water pollution" means…the presence in water of harmful and objectionable material obtained from sewers, industrial waste and rainwater runoff in sufficient concentration to make it unfit for use


Type of Water Pollutants
Can disrupt ecosystem
Oxygen demanding waste
Organic chemicals
Inorganic nutrients
Sediment / Suspended solids
Heat
Can cause health problem
Inorganic chemicals
Disease causing agents
Radioactive substances

Water Pollutants: Oxygen Demanding Waste

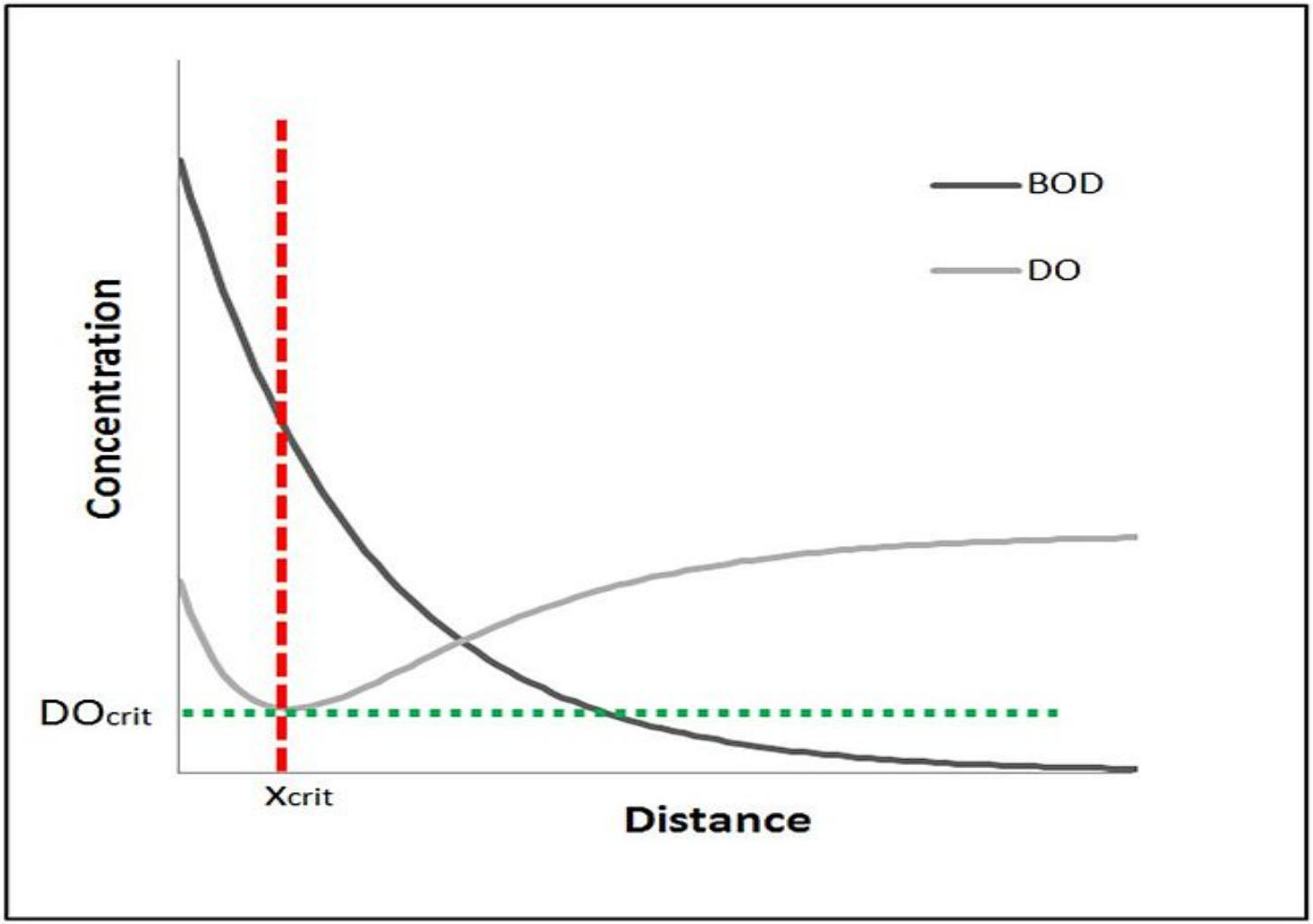
- Definition: Organic matter that accumulates in an aquatic environment
- Decomposed by aerobic bacteria using oxygen in the water during process of degrading this matter
- Caused oxygen that dissolved in water reduce

Water Pollutants: Oxygen Demanding Waste (Cont')

- Large population of bacteria supported by oxygen demanding waste can deplete the level of **dissolved oxygen (DO)**

- Effects of oxygen demanding waste in the river depends on volume, velocity, distance from effluent entrance point and temperature of water

Oxygen Sag



Oxygen Sag (Cont')

- Oxygen levels start high in clean zone, and the levels start decreasing in decomposition zone create oxygen sag curve until septic zone
- Oxygen levels decline downstream from a pollution source as decomposers metabolize oxygen demanding waste materials
- Effect of oxygen sag is the death of oxygen-breathing animals
- Oxygen concentration begins to increase further downstream at recovery zone

Water Pollutants: Organic Chemicals

- Oil, gasoline, plastic, pesticide, detergents and many water soluble and insoluble chemicals that threaten human and aquatic life

- Improper disposal of industrial and household wastes and runoff of pesticides

Water Pollutants: Inorganic Nutrients

Soluble nitrate and phosphate compounds that can cause excessive growth of algae

Water Pollutants: Inorganic Nutrients (Cont')

- Algae are vitally important to marine and fresh-water ecosystems, and most species of algae are not harmful.

- However, **ALGAL BLOOM** exhibited adverse effect.

Water Pollutants: Inorganic Nutrients (Cont')

- Effects of algal bloom:
  - ❖ Destroy aesthetics of lake / river
  - ❖ Bad taste and odor thus, increase the expense of purifying water for drinking purposes
  - ❖ Some algae release poisons
- Excessive levels of nitrate in drinking water reduce oxygen carrying capacity of human blood

Water Pollutants: Sediment / Suspended Solids

- Effects of sediment / suspended solids:
  - ❖ Reduce the ability of some organism to find food
  - ❖ Reduce photosynthesis
  - ❖ Disrupts food webs
  - ❖ Carries pesticides and other harmful substances

Water Pollutants: Sediment / Suspended Solids (Cont')

- Harmful effects:
  - ❖Loss of soil quality for farming
  - ❖Toxic compound are adsorbed onto particle surface
  - ❖Buries breeding ground for fish
  - ❖Shortens life spans of reservoirs

Water Pollutants: Heat

- Release of heated water from industries / power plants (use water as coolant) into rivers

- Urban runoff can also become source of thermal / heat pollution – i.e. storm water passes over hot parking lots / roads and flow into rivers

Water Pollutants: Heat (Cont')

- Effects of heat in rivers:
  - ❖Decreases dissolved oxygen level in river water bodies
  - ❖Interferes with reproduction of organisms in river
  - ❖Increase vulnerability to disease

Water Pollutants: Inorganic Chemicals

- Can be from natural or man made source
- Natural source: released from rocks by weathering, carried by runoff into lakes or rivers, or percolate into groundwater aquifers
- Man made source: through the mining, processing, using and discarding minerals

Water Pollutants: Inorganic Chemicals (Cont')

- Effects of high levels of dissolved inorganic chemicals in the river cause:
  - ❖Water unfit for drinking
  - ❖Harm aquatic life
  - ❖Accelerate corrosion of equipment that uses water

Water Pollutants: Disease Causing Agents

- Also known as Pathogens: any organism that causes a disease

- Most of pathogenic organism are microscopic or just barely visible to unaided eye including bacteria, viruses, protozoa and parasitic worms

Water Pollutants: Disease Causing Agents (Cont')

- Examples: Bacteria, viruses, protozoa and parasitic worms that enter water from domestic and human/animal waste

- Effects: Water borne diseases such as Cholera, Hepatitis A, Leptospirosis, Typhoid Fever

Water Pollutants: Radioactive Substances

- Radioactive wastes move through various trophic levels / food chain in an ecosystem
  - ❖**Bioaccumulation**: how pollutants enter a food chain
  - ❖**Biological magnification**: the process certain substances such as pesticides or heavy metals move up the food chain

Water Pollutants: Radioactive Substances (Cont')

- Effects of radioactive substances:
  - ❖ Can cause birth defects such as Itai-itai disease (caused by contamination of cadmium) and Minimata disease (caused by contamination of mercury)
  - ❖ Cancer
  - ❖ Can cause genetic change

Sources of Water Pollution

POINT SOURCE

- Wastewater that are discharge from known sources at an identifiable point
- Can be reduced or eliminated through proper wastewater treatment prior to discharge

NON-POINT SOURCE

- Characterized by multiple discharge points (i.e.: urban and agricultural runoff)
- Reduction generally requires changes in land use practices

How To Control Non-point Source Water Pollution

- Reduce fertilizer runoff
  - ❖ Not using excessive amount
  - ❖ Using none on steeply sloped land
  - ❖ Apply pesticides only when needed
  - ❖ Reducing the usage of fertilizers and pesticides on golf courses and public parks

How To Control Non-point Source Water Pollution

- Planting of permanent vegetation as buffer zone between farmland and rivers/lakes
- Reforestation of logged forest to control soil erosion
- Use of sedimentation basins or silt traps at construction sites

How To Control Non-point Source Water Pollution

- Road cleaning practices
- Efficient solid waste management
- Installation of waste traps at drainage system and rivers

Water Quality Parameters

- Dissolved Oxygen - Significant in protecting aesthetic qualities and maintenance of aquatic life
  - ❖ Concentration of 2 mg/L: Minimum to support normal aquatic life in the tropics
  - ❖ Concentration above 5 mg/L: Propagation of fish and aquatic wildlife
  - ❖ Concentration above 4 mg/L: Desirable for drinking water

Water Quality Parameters

- Lead
  - ❖ Toxic to human, animals and plants
  - ❖ It is recommended that concentration in domestic water supplies should not exceed 0.05 mg/L

Water Quality Parameters

- Mercury
  - ❖ High toxic potential
  - ❖ A level of 0.05 µg/L is recommended as a safe concentration for freshwater aquatic organisms
  - ❖ For domestic water supply mercury levels should be less than 0.002 mg/L

Water Quality Parameters

- Cadmium
  - ❖ High toxic potential
  - ❖ Factors such as pH affect the toxicity of cadmium
  - ❖ Cadmium in domestic water supply should not exceed 0.01 mg/L
  - ❖ Certain fishes can tolerate a limit of 0.02 mg/L

Water Quality Parameters

- Iron
  - Essential trace element required by plants and animals, however, can become toxic when present in high levels
  - Recommended iron concentration in water supply is 0.3 mg/L with a minimum limit of 0.05 and maximum limit of 1.0 mg/L

Water Quality Parameters

- Manganese
  - ❖ Vital nutrient for plants and animals
  - ❖ Desirable concentration in drinking water: 0.01 to 0.05 mg/L
  - ❖ Cause brownish color to water and washed cloth
  - ❖ Undesirable taste in drinking water at high concentration

Water Quality Assessment and Monitoring

BIOLOGICAL ASSESSMENT

- Most aquatic organism are sensitive to changes in their environment whether natural caused or human caused.

- Different organism response in different ways may include:
  - ❖Death
  - ❖Inhibition certain physiological process

Types of Biological Assessment

1. Ecological methods

- ❖ Analysis of communities in the water body
- ❖ Presence or absence of specific species
- ❖ An indicator organism will be selected for its sensitivity or tolerance to various kinds of pollution or its effects
  - i.e.: Typical effects on water quality and the associated biota which may be observed downstream of a sewage outlet

Types of Biological Assessment (Cont')

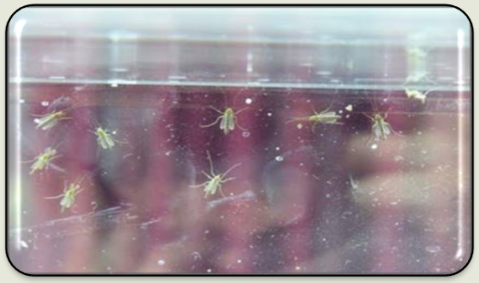
1. Ecological methods (Cont')

CLADOPHORA:

To detect high phosphorus levels in the water

TUBIFICIDAE:

Aquatic sludge worms that presence in most polluted areas



CHIRONOMUS: Commonly used in acute toxicity tests

Types of Biological Assessment (Cont')

2. Physiological and biochemical methods

- Respiration and growth of organism suspended in water
  - To determine the quantity of biodegradable organic compounds and the tendency for eutrophication

- Oxygen production and consumption, stimulation and inhibition.
  - i.e.: Measurement of oxygen production potential (OPP) that can be carried out in the lab or on-site

Types of Biological Assessment (Cont')

3. Use of organism in control environment

- Assessment of the toxic effects on organism under defined laboratory conditions (bioassays)

- Biological assessment results are used to answer the question of whether water bodies support survival and reproduction of desirable fish and other aquatic species

Lake Pollution

Differs from river or stream pollution due to physical characteristics of the water mass

- Water in **RIVERS** is constantly moving thus providing flushing action for incoming pollutants.

- Water in **LAKES** does not move much and retained for long time. Largely influenced by nutrients.

Lake Pollution (Cont')

- The predominant source of lake pollution is through nonpoint source which is generated from urban runoff or simply blow into the water.

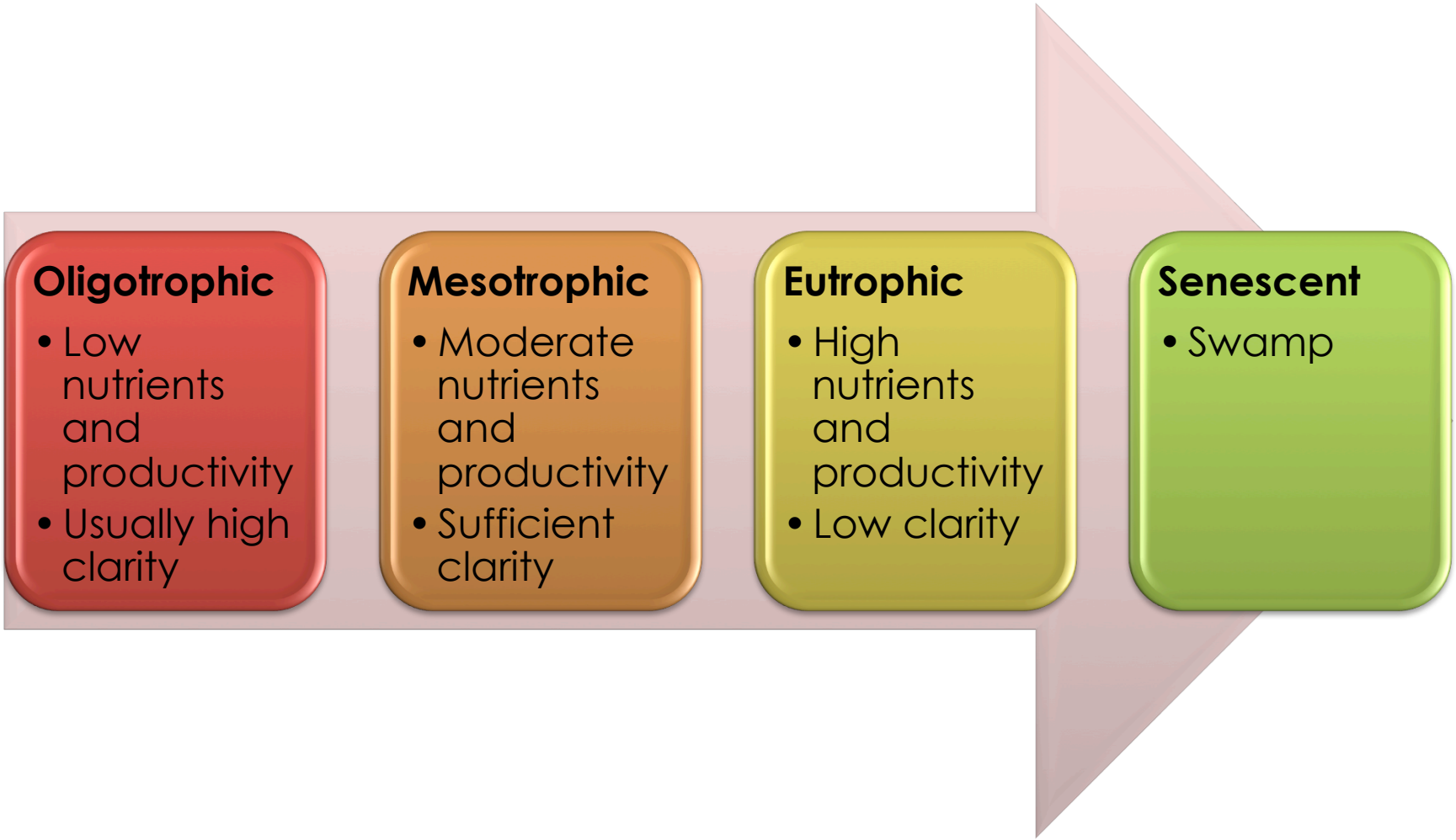
- Lake eutrophication is one of the most widespread environmental problems of inland waters, and is their unnatural enrichment with two plant nutrients, phosphorus and nitrogen.

Eutrophication….

- A process of increasing anaerobic decomposition caused by algal bloom due to accumulation of nitrates and phosphates in water, thus disturbing life of water habitat.

- It is a natural ageing process of lakes caused by sediment input and nutrient enrichment through runoffs that contain overused fertilizers and/or discharged human waste.

Stages of Lake Eutrophication



Nutrients as Algal Growth Requirement

Carbon

- Algae can obtain carbon from CO_2 dissolved in the water. The largest source of CO_2 is **from atmosphere**.

Nitrogen

- Usually in the form of nitrate and comes from **external sources.**

Phosphorus

- Phosphorus in lakes originates from **external sources** and is taken up by algae in the organic form.

Wetlands

Ramsar Convention 1971

- Areas of marsh, peatland, or water, whether natural or artificial, permanent or temporary, with water that is static or flowing, fresh brackish or salt, including areas of marine water the depth of which at low tide does not exceed 6 meters

Biological definition

- Transition zone between terrestrial and aquatic environments

Criteria of Wetlands

- The area must be permanently or seasonally inundated
- The area must support hydrophytic vegetation
- Soil in the area must be water logged for a sufficient time to become anaerobic

Wetlands in Malaysia

- Malaysia has an extensive area of wetlands.
- The lowlands of Malaysia constitute vast areas of alluvial and coastal plains that slope very gently down to the coasts.
- It spread across 3.3 million hectares or 10% of Malaysia's total land area, and are diverse in character.

Wetlands in Malaysia (Cont')

- Lowland flood plains and coastal plains are rich in natural resources, with important habitats like:
  - ❖ Mangroves (i.e. Mangrove forest at Kuala Selangor Nature Park)
  - ❖ Peat swamp forests (i.e. Sungai Bebar)
  - ❖ Intertidal mud flats (i.e. Mud flats at Gurney Drive Penang)

Natural Function of Wetlands

- Biodiversity functions
  - ecosystem diversity
  - link between terrestrial and aquatic ecosystem
  - high species and population diversity
  - highly diverse microbiological activity
- Habitat functions
  - wildlife habitat

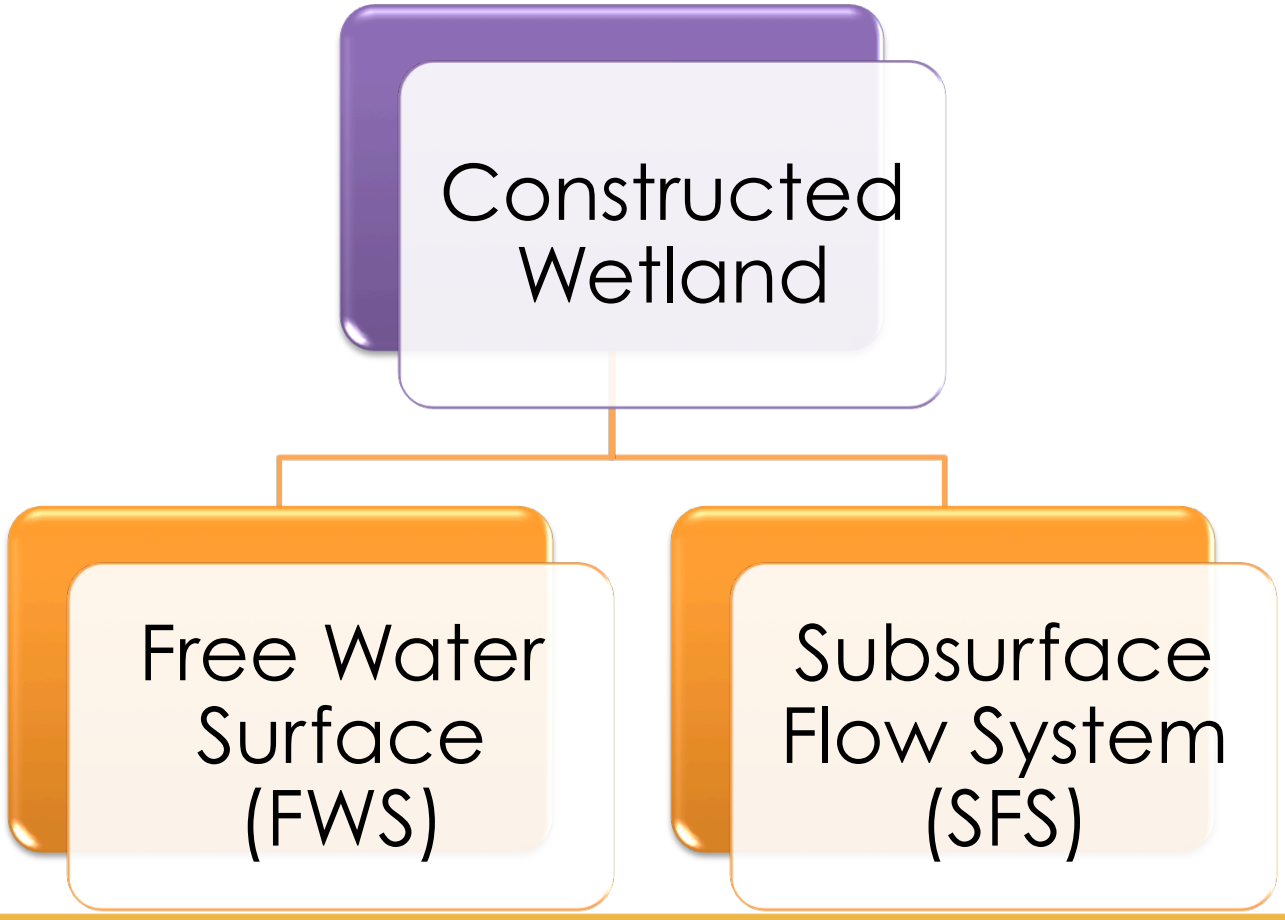
Natural Function of Wetlands (Cont')

- Climatic effects
  - carbon fixation and CO_2 balance
  - rainfall and humidity effects
- Water quality functions
  - particulate filtration
  - nutrient stripping
  - biodegradation of toxic compounds
  - heavy metal removal
  - water and wastewater treatment

Natural Function of Wetlands (Cont')

- Hydrological & hydraulic functions
  - storm protection
  - coastal erosion protection
  - water holding capacity (water catchment

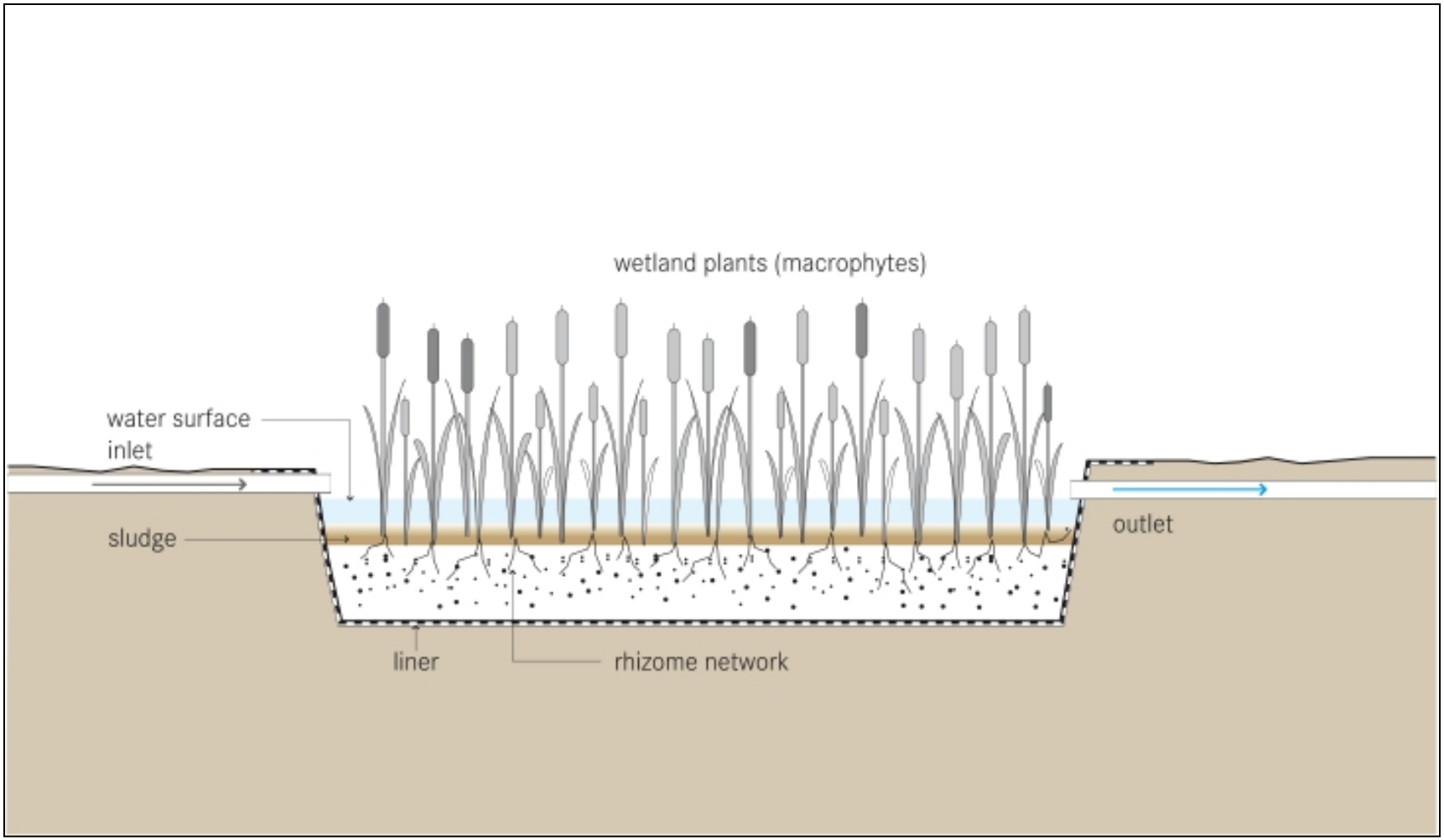
Constructed Wetlands



Free Water Surface (FWS)

- Surface flow wetlands are divided into several compartments parallel at low permeability nature of soils
- The sections allow for different amount of oxygen to be present in the water, which then works to optimize various processes for water cleanup
- Inlet pumping water in horizontal flow into wetland treatment area and discharging into receiving water
- There are a large variety of physical and biological processes that contribute to the removal of nutrients, pathogens, and metals from wetlands

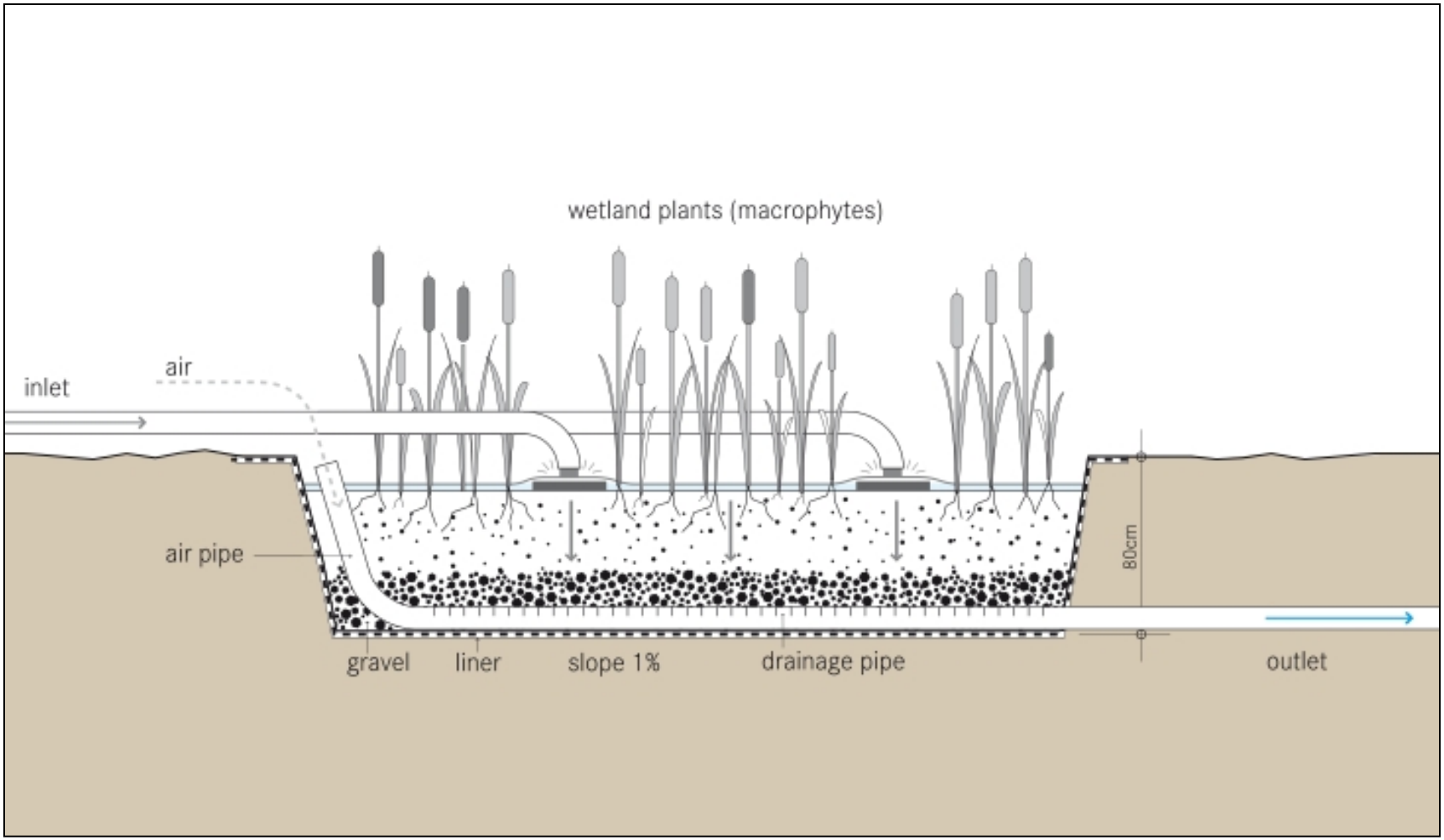
Free Water Surface (FWS)



Subsurface Flow System (SFS)

- It can be further classified as horizontal flow and vertical flow constructed wetlands.
- This wetland move effluent through a gravel (i.e. limestone or volcanic rock lay stone or sand medium) on which plants are rooted.
- Inlet distribution move either horizontally parallel to the surface, or vertically, from the planted layer down through the substrate and out.

Subsurface Flow System (SFS)



Treatment Process in Wetland System

Biodegradable organic matter removal

- Providing support medium for microbial degradation
- Conveying oxygen for aerobic degradation to occur

Solids removal

- Settleable solids are removed easily via gravity sedimentation as wetland systems generally have long hydraulic retention time.
- Filtering of solids by plant stems

Treatment Process in Wetland System (Cont')

Nitrogen removal	Phosphorus removal	Heavy metal removal
• Nitrification / denitrification • Uptake by plants	• Uptake by plants • Microbial degradation • Adsorption and precipitation onto soil	• Uptake into roots, rhizomes and leaves of wetland vegetation.

THE END