

# Lecture 2

CE 433

Excerpts from Lecture notes of Professor M. Ashraf Ali, BUET.

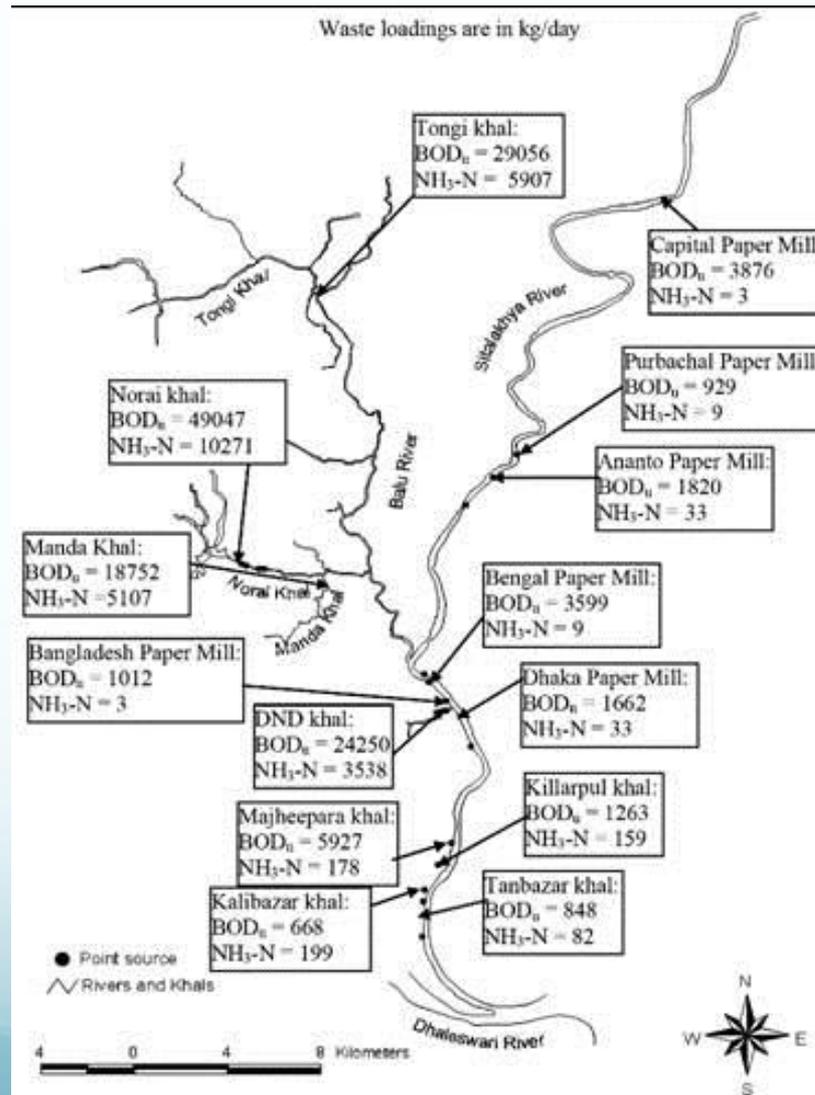
# Water Pollution

- Surface Water Pollution
- Ground Water Pollution

# Types/Categories of Pollutants

- Nature of Origin
  - Point Sources: Have well defined point of discharge
    - Types: i) Municipal point sources
      - ii) Industrial discharges
  - Non-point Sources: Origin of discharge is diffuse; not possible to relate discharge to a well defined location.
    - Types: i) Agriculture ii) Silviculture iii) Atmosphere iv) urban and suburban runoff v) groundwater vi) drainage from abandoned mines and construction activities, leaching from land disposal and solid waste.

# Point Source Loadings (in kg/day) in Shitalakhya and Balu Rivers



# Types/Categories of Pollutants

- Group of Substances
  - Oxygen demanding wastes
  - Nutrients
  - Pathogens
  - Suspended solids
  - Salts
  - Toxic metals
  - Toxic organic compounds
  - Heat
  - Radioactive substances

# Major Pollutant Categories and Principal sources of Pollutants

Pollutant Category	Point Sources		Non-Point Sources	
	Domestic Sewage	Industrial Waste	Agricultural runoff	Urban run off
Oxygen-demanding waste	X	X	X	X
Nutrients	X	X	X	X
Pathogens	X	X	X	X
Suspended solids/sediments	X	X	X	X
Salts		X	X	X
Toxic metals		X		X
Toxic organic chemicals		X	X	
Heat		X		

# Oxygen Demanding Wastes

- Substances that oxidize in the receiving body of water with the consumption of dissolved oxygen



# Oxygen Demanding Wastes

- Major Sources:

Biodegradable organic substances contained in

- i) Municipal wastewater (mainly human waste and food residue )
- ii) Industrial wastewater (e.g. from tannery, textile, paper & pulp and food processing industries)

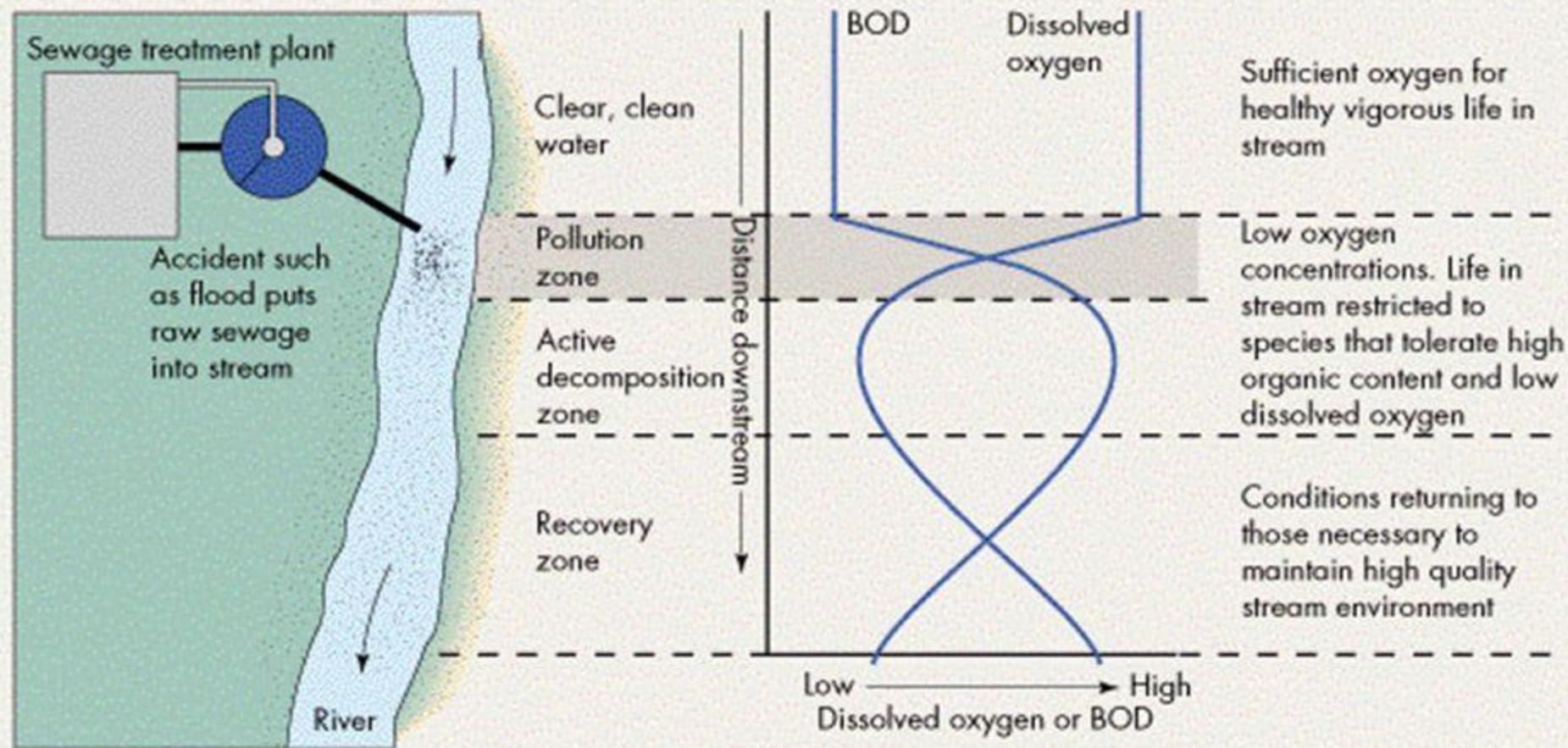
- Minor Sources:

Crop residue, decaying plants and leaves, animal droppings, oxidation at certain inorganic compounds

# Oxygen Demanding Wastes

- Measurement of strength of oxygen demanding wastes:
  - BOD (Biochemical Oxygen Demand)
  - COD (Chemical Oxygen Demand)

# BOD Effects on Water Quality



All streams have some capability to degrade organic waste. Problems occur when stream is overloaded with biochemical oxygen-demanding waste.

# Oxygen Demanding Waste

- Effects:
  - Causes depletion of dissolved oxygen (DO) in water
  - Saturation value of DO in water: 8-15 mg/L (depending on temperature and salinity. Minimum DO required for healthy fish population: 4-8 mg/L; 3 mg/L for certain species
  - If DO drops below the level necessary to sustain normal life. Then the aquatic system is classified as “polluted”
  - Oxygen demanding wastes also cause color, taste and odor problem

# Pathogens

Disease-causing organisms that grow and multiply within the host

- Source: Human and animal excreta
- Pathogens associated with water include:
  - Bacteria: responsible for cholera, bacillary dysentery, typhoid and paratyphoid fever
  - Virus: responsible for hepatitis, poliomyelitis, respiratory and eye infections
  - Protozoa: responsible for amoebic dysentery, giardiasis
  - Helminths (parasitic worms): Hookworm, ascariasis

# Pathogens

- Classification of infections diseases associated with water:
  - Waterborne disease: Oral ingestion of pathogens in water contaminated by urine or feces
  - Water-washed disease: Disease spread enhanced by scarcity of water making cleanliness difficult
  - Water-based disease: water provides the habitat for intermediate host organisms, transmission to humans through water contact
  - Water-related disease: Insect vectors (e.g., mosquitoes) rely on water to habitat, but human water contact not needed

Pathogen Indicators: - Total Coliform

- Faecal Coliform
- Thermotolerant coliform
- E coli

# Nutrients

- Chemicals that are essential for the growth of living things (N, P, C, S, Ca, P, Fe, Mn, B, Ca, etc.)
- Nutrients are pollutants when their concentrations are sufficient to allow excessive growth of aquatic plants, particularly algae.
- The process of nutrient enrichment, leading to excessive growth of algae, is called eutrophication (algal bloom). This phenomenon is particularly important for lakes

# Nutrients: Problems

- Algae eventually die and their decomposition removes DO from water
- Algae and decaying organic matter add color, turbidity, odor and objectionable taste to water, making it less attractive as a source for domestic water supply, recreational and other uses.
- Notice the greenish (sometimes reddish) color of pond, lake, river water, especially during dry season

# Bangladesh's Scenario of Eutrophication



Gulshan Lake,  
located at Dhaka City

A village pond, located  
at Manikganj



# Nutrients: Sources

- Major sources of nitrogen and phosphorus include municipal wastewater discharges, runoff from animal feedlots, chemical fertilizers and phosphorus based detergents
- In addition, there are also natural sources that may add nitrogen to the water bodies. Certain bacteria and blue-green algae can directly obtain nitrogen from the atmosphere. These life forms are abundant in lakes and have high biological productivity.
- Certain form of acid rain can also contribute nitrogen to the lakes.



# Suspended solids

- Organic or inorganic particles that are carried by the wastewater into receiving waters are termed suspended solids
- Many of these particles settle to the bottom of as sediment
- Colloidal particles that do not settle readily are the cause of turbidity found in many surface waters
- Organic suspended solids may exert an oxygen demand
- Inorganic suspended solids are discharged by some industries, result mostly from soil erosion

# Suspended solids

- Problems:
  - An excessive sediment loads deposited into lakes and reservoirs reduce their usefulness
  - In rapidly flowing streams, sediments can disrupt ecological habitats of many aquatic species
  - For domestic water supply, excessive suspended solids necessitate water treatment at an increases cost

# Salts

- Water naturally accumulates a variety of dissolved solids and salts as it passes through soils and rocks.
- Certain industrial discharges also contain significant dissolved salts (eg. Tannery effluent)

Typical cations:  $\text{Na}^+$ ,  $\text{Ca}^{2+}$ ,  $\text{Mg}^{2+}$ ,  $\text{K}^+$

Typical anions:  $\text{Cl}^-$ ,  $\text{SO}_4^{2-}$ ,  $\text{HCO}_3^-$

Effects: Taste, odor

# Salts

- Commonly used measures of salinity:
  - TDS (Total Dissolved Solids)
  - Cl<sup>-</sup> (Chloride)
  - Electrical Conductivity (EC)
- Freshwater: TDS <1500 mg/L
- Seawater: TDS ~ 30,000 – 34,000 mg/L
- Drinking water standard (Bangladesh): 1000 mg/L
- Agriculture: TDS upto 1500 mg/L can be tolerated by most crops. Concentrations above 2100 mg/L generally unsuitable for irrigation

# Thermal Pollution

- Impact of Climate change
- Primarily from industrial cooling water that is discharged into river (typically from power plants)
- Adverse impacts:
  - Sudden change in temperature can make it difficult for local ecology to ever acclimate
  - Adverse impact on dissolved oxygen

# Thermal Pollution

- Adverse impact of heat on dissolved oxygen
  - As temperature increases, metabolic rate of aquatic life increases – usually by a factor of 2 for each 10degreesC rise in temperature. As a result, oxygen demand of aquatic organisms increases
  - As temperature increases, waste assimilation capacity becomes quicker (ie, bacteria decomposes organic matter at a faster rate), drawing down dissolved oxygen at a faster rate
  - As temperature increases, O<sub>2</sub> holding capacity of water goes down -> O<sub>2</sub> demand goes up and O<sub>2</sub> availability goes down. As a result O<sub>2</sub> level in water goes down quickly and water quality becomes worse
    - Example: River water quality

# Thermal Pollution

The U.S has created the clean water act that regulates water quality standards and makes ways to implement these controls

Approximately one-half of all water used in U.S. is used for cooling by power and manufacturing industries



Thermal pollution is the degradation of water quality by any process that changes ambient water temperature.



Power plants use water from the environment as a coolant and then is returned to the environment at a high temperature. This extremely heated water causes a decrease in oxygen levels

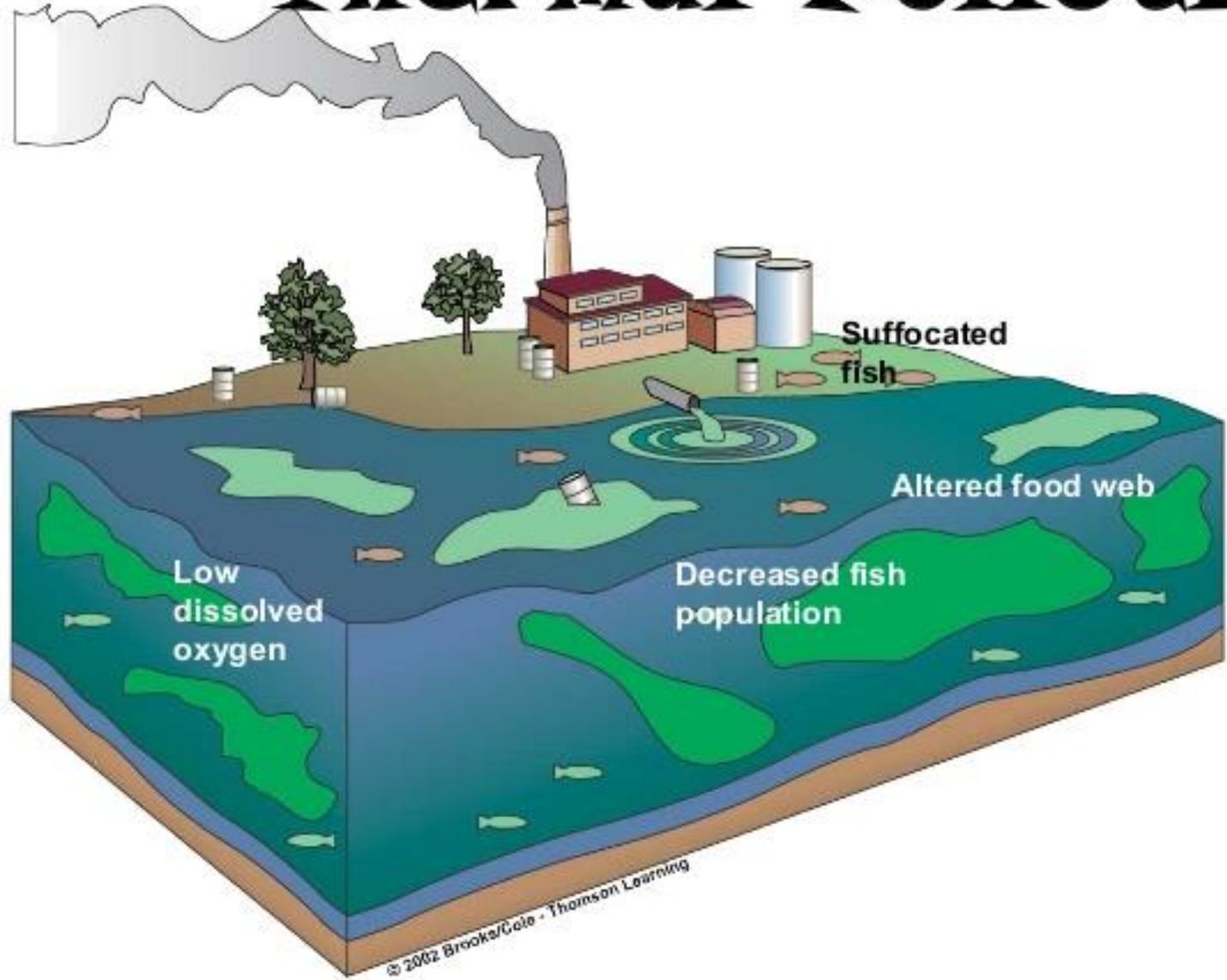
Thermal Pollution most greatly affects slow moving rivers and lakes



The elevated water temperatures can cause fish and amphibians metabolic rate to increase causing them to eat more resources in a short period of time. These changes will greatly affect an areas food chain



# Thermal Pollution



# Heavy Metals

- Usually it simply denotes metals that are toxic. Toxic metals include: Al, As, Be, Bi, Cd, Cr, Co, Mn, Hg, Pb, Se etc.
- Adverse Impacts:
  - Nervous system and kidney damage – creation of mutation and induction of tumor
  - Source: Industrial discharges, natural (eg. As in groundwater of Bangladesh)
  - Often referred to as “Persistent” (inorganic) pollutant (ie, remain in the environment for long without degradation)
  - Heavy metals of concern in Bangladesh groundwater:
    - As and Mn

# Pesticides

- Chemicals that kill undesirable organisms:
  - Categories:
    - Insecticides – most widely used
    - Herbicides – destroy plants, weeds, etc.
    - Rodenticides – kill rats, mice, etc.
    - Fungicides – kill fungi or their spores
  - The main groups of synthetic organic insecticides include:
    - Organochlorine (chlorinated hydrocarbons)
    - Organophosphates
    - Carbamates

# Pesticides

- Organochlorines:
  - e.g., DDT, aldrin, endrin, heptachlor, methoxychlor
  - Often referred to as “persistent organic compound” (POC)
  - Accumulates in lipid or fat cells
- Effects: Liver cancer, birth defects
- Not widely used now. Has been replaced by organophosphates and carbamates.

# Pesticides

- Organophosphates:
  - e.g. Parathion, diazinon, tetraethyl phosphate
  - Not very persistent
  - Effects: Tremor, confusion, muscle twitching, convulsions
  
- Carbamates:
  - e.g. aldicarb, carboxyl
  - Effects: nausea, vomiting, blurred vision, convulsions

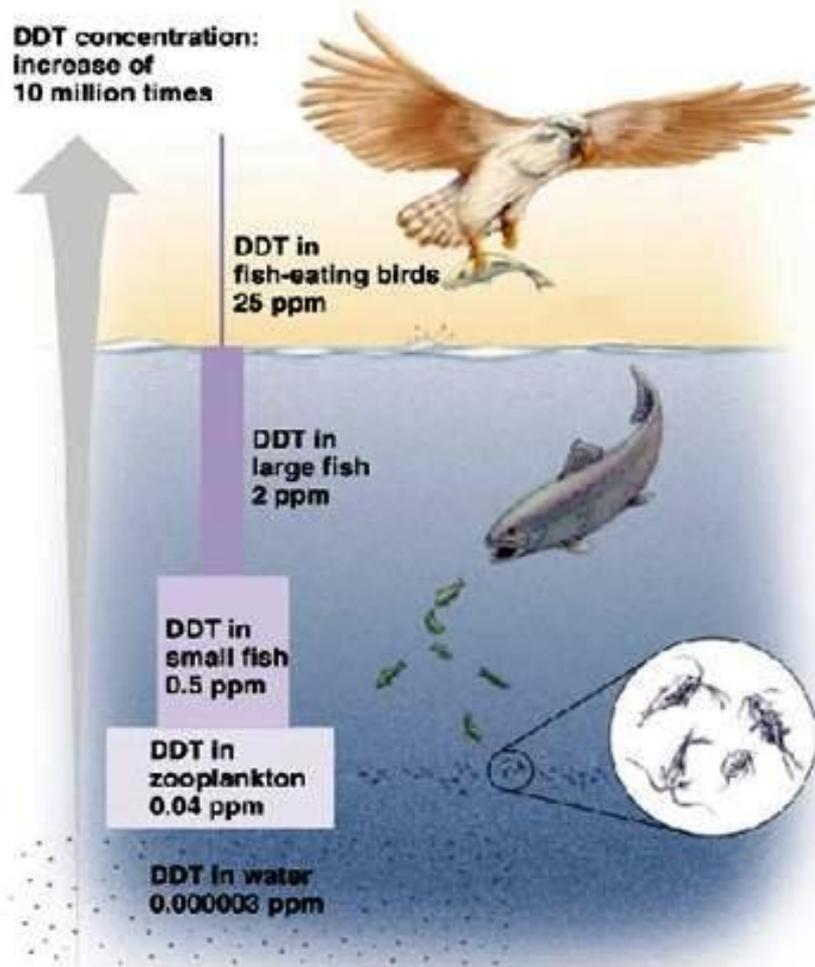
# Volatile Organic Compounds (VOC)

- Often used as solvents in industrial processes
- Most commonly found contaminant in groundwater
- “Persistent Organic Compound” (POC)
  - 5 VOCs are specially toxic and persistent and their presence in drinking water is a cause of special concern. These are:
    - Vinyl Chloride: human carcinogen
    - Tetrachloroethylene: suspected carcinogen
    - Trichloroethylene: suspected carcinogen
    - 1,2 – Dichloroethane: causes injury to central nervous system, liver and kidneys
    - Carbon Tetrachloride: Very toxic if ingested. A few mL can cause death

# Persistent Organic Pollutants (POPs)

- Organic substances that:
  - possess toxic characteristics;
  - are persistent;
  - Bioaccumulate;
  - are prone to long-range trans-boundary atmospheric transport and deposition;
  - are likely to cause significant adverse human health or environmental effects near to and distant from their sources

# Biological magnification of DDT in a food chain



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# Persistent Organic Pollutants (POPs)

- Government of Bangladesh has signed the Stockholm Convention on POP on 23 May 2001. As a Party and signatory to the Convention, Bangladesh is required to take actions to generate general awareness of harmful consequences of POPs, to reduce their releases, and their ultimate elimination.
- The Stockholm Convention identifies 12 substances as POPs, which include:
  - 9 substances used as pesticides
  - Polychlorinated biphenyl (PCBs), and
  - Dioxins and Furans

# Persistent Organic Pollutants (POPs)

- POPs Pesticides
  - There are 9 pesticides namely Aldrin, Chlordane, Dieldrin, Endrin, Heptachlor, Mirex, Toxaphene, DDT and Hexachlorobenzene

# Persistent Organic Pollutants (POPs)

- POPs – Polychlorinated biphenyl (PCBs)
  - PCBs are chlorinated hydrocarbons that have been widely used as industrial chemicals since 1930. There are 209 varieties of PCBs. Large quantities of PCBs were produced for use as a cooling and dielectric fluid in electric transformers and in large capacitors.
  - PCBs are linked to reproductive failure and suppression of the immune system in various wild animals, severe human intoxication occurred due to accidental consumption of PCB-containing oils.
  - IARC (International Agency for Research on Cancer) classified PCB into Group 2B (possibly carcinogenic to human). International production of PCBs was ended in most countries by 1980

- Video
- <https://www.youtube.com/watch?v=RMyCcWECbNE>