

CE 435 (January 2018 Semester)

**Environmental Pollution and Management:
Water Pollution**

**CN-2: Sources and Categories of Water
Pollutants**

**Dr. M. Ashraf Ali
Professor of Civil Engineering, BUET**

Water Pollution: Major Sources

- Municipal/domestic wastewater
 - Industrial wastewater
 - Urban and suburban runoff
 - Agriculture, silviculture runoff
 - Drainage/leaching from land disposal and solid waste
 - Atmospheric deposition
 - Natural, etc.
- Major sources in most cases

Classification of Pollutant Sources

According to nature of their origin/input:

(a) Point Sources

(b) Non-point/dispersed sources

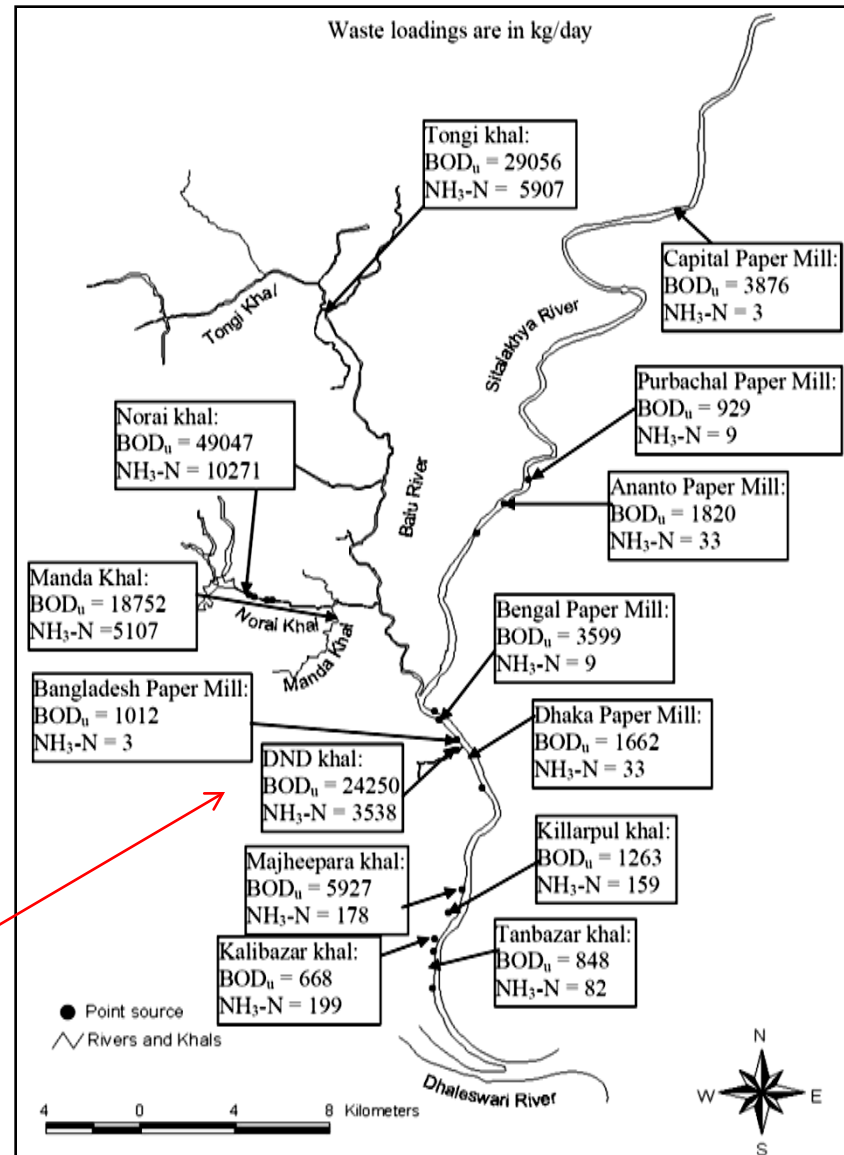
(a) Point Sources

Have well-defined point of discharge, usually continuous

Types:

- (a) Municipal point sources
- (b) Industrial discharges

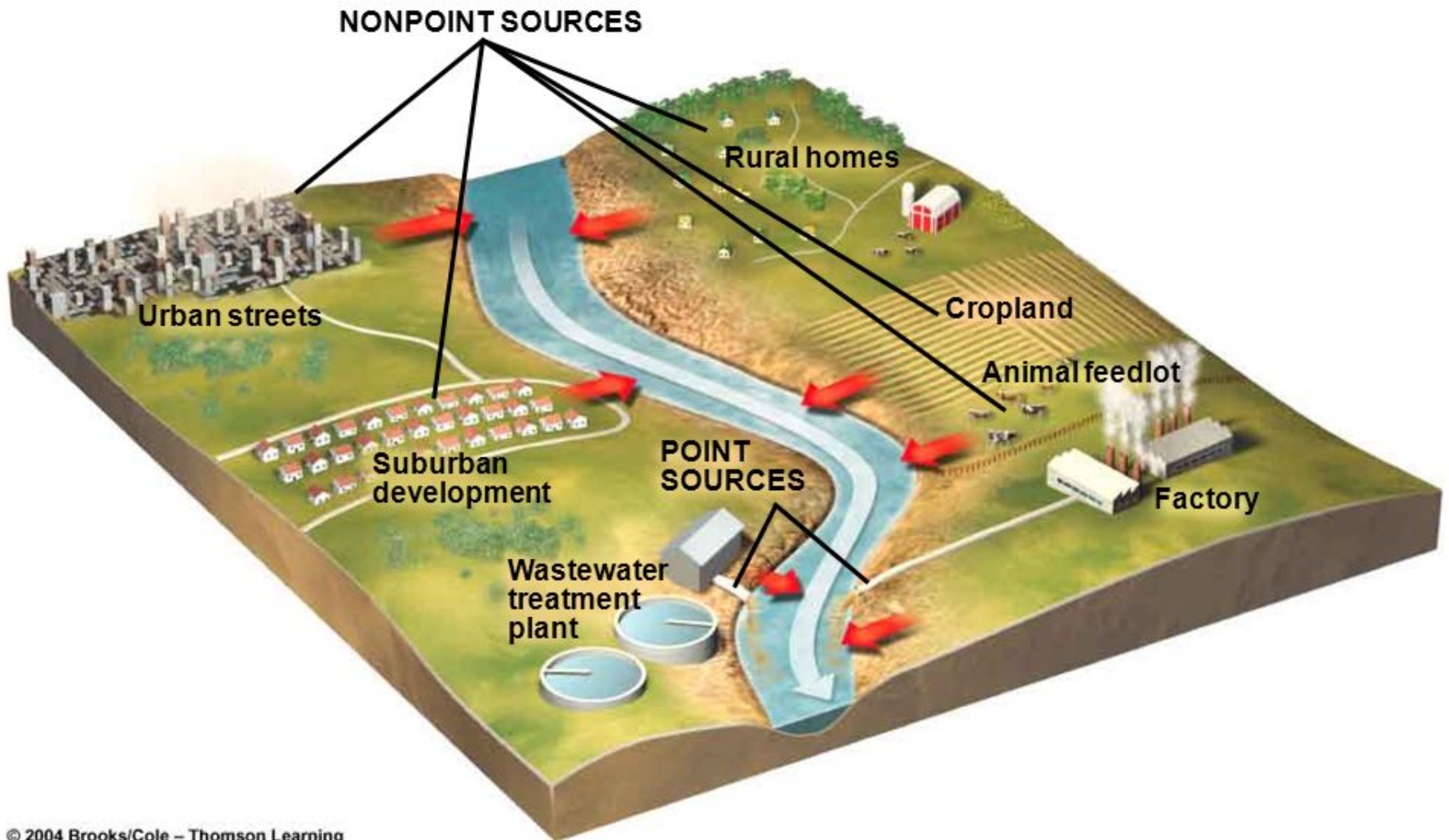
Major point sources Balu-Sitalakhya river system
(Alam et al.,2011)



(b) Non-point Sources

- **Have no defined points of discharges and are scattered**
- **Difficult to monitor, regulate and treat (often restriction on land-use required)**
- **Examples of non-point sources: Pollutant input from**
 - Agricultural
 - Forestry
 - Atmosphere
 - Urban run off
 - Ground water
 - Leachate from landfills, etc

Point and Nonpoint Sources



Nature of Pollutants

Pollutants that enter the water environment may belong to one of the following three groups:

- (i) Bio-degradable
- (ii) Non-biodegradable (conservative)
- (iii) Biologically accumulative

(i) Bio-degradable Pollutants

- Bio- degradable pollutants include a large number of complex, organic substances that undergo biological degradation through the activity of various types of decomposers, yielding simpler, inorganic end products such as CO₂, nitrates etc.
- Microbial population also undergo reduction with time owing to natural die-off; when they die, they become degradable organic matter.
- Plants, fish and higher animals similarly undergo biological degradation after death.

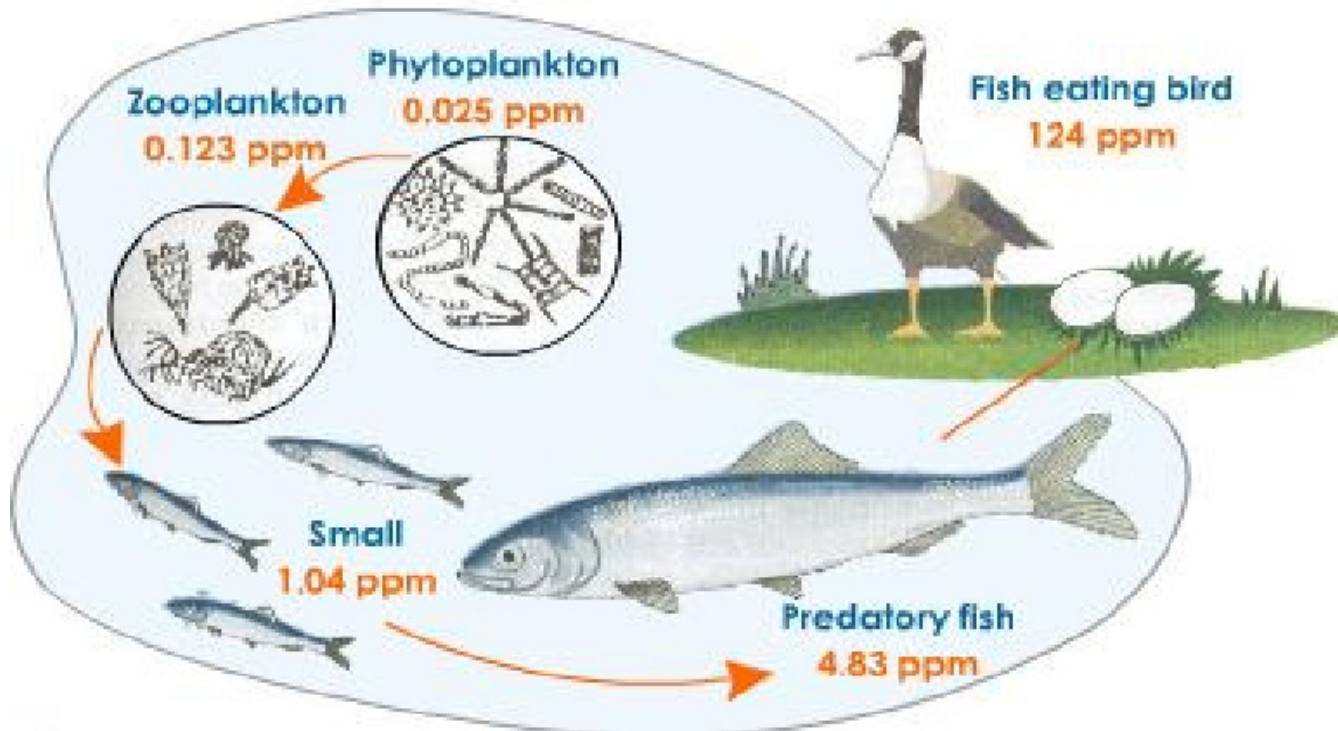
(ii) Non-degradable Pollutants

- Non -biodegradable pollutants are inert to biological action, and are also called conservative pollutants.
- Chlorides and various salts fall in this group.
- Persistent Organic Pollutants (POP_s) e.g., Pesticides (organo-chlorine compound) are also resistant to biodegradation.
- Various metals are also non-degradable.

(iii) Biologically Accumulative Pollutants

- These are pollutants (e.g., pesticides, certain heavy metals) tend to accumulate in organisms.
- **Bioconcentration**: the process by which aquatic organisms accumulate chemicals from water. Toxins that are dilute in water can be highly concentrated inside cells and tissues through this process.
- **Bioaccumulation**: if they accumulate chemicals from both water and food
- Bioaccumulation is a cause for concern if aquatic species are consumed by members higher order in the food chain (Example: **case study of DDT**).

- **Biomagnification**: the concentration of some toxic organic chemicals (e.g. DDT) increases at higher levels in the food chain; this is referred to as **biomagnification**.

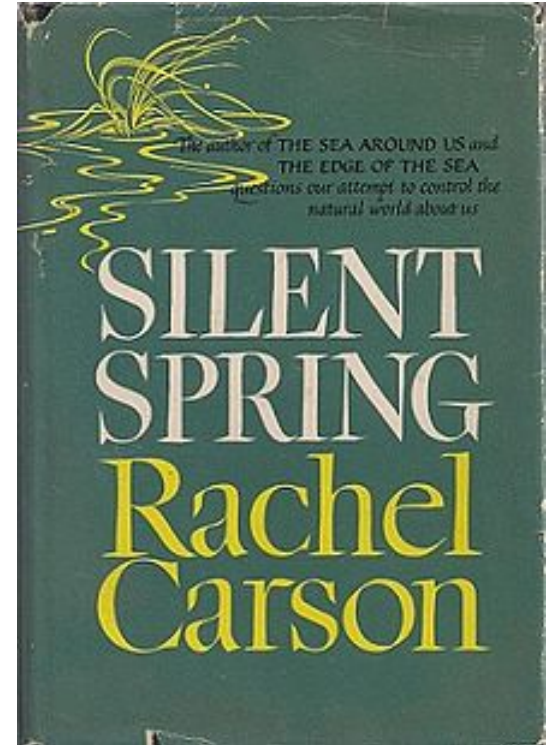


“Silent Spring” by Rachel Carson

An environmental science book published in 1962 documenting the detrimental effects on the environment of the indiscriminate use of pesticides.

Carson accused the chemical industry of spreading disinformation and public officials of accepting industry claims unquestioningly.

It led to a nationwide (US) ban on DDT for agricultural uses and inspired an environmental movement that led to the creation of the U.S. Environmental Protection Agency.



Categories of Water Pollutant

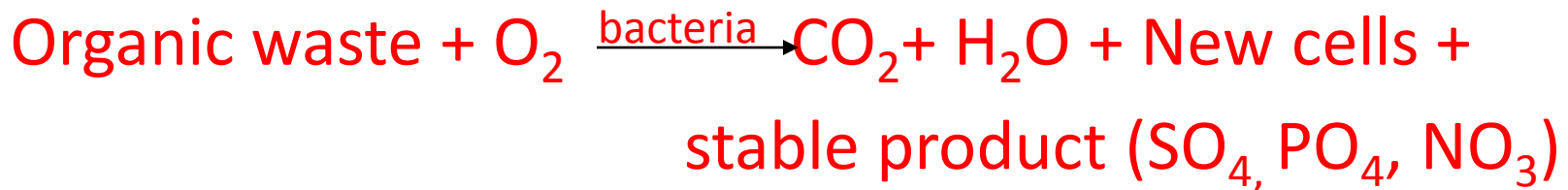
- 1) Oxygen-demanding wastes
- 2) Pathogens
- 3) Nutrients
- 4) Suspended solids
- 5) Salts
- 6) Heavy metals
- 7) Toxic and Persistent Organic Compounds (POPs)
- 8) Heat
- 9) Radioactive waste

Pollutant Categories and sources

Pollutant category	Point sources		Non-point sources	
	Domestic Sewage	Industrial wastes	Agricultural runoff	Urban runoff
Oxygen-demanding wastes	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		

(1) Oxygen demanding wastes

Oxygen demanding wastes are substances that are easily broken down or oxidized in the receiving water by bacterial activity, in presence of oxygen.



The available DO is consumed by bacterial activity leading to depletion of DO in water.

Sources of Oxygen Demanding Wastes

Major sources: Bio-degradable organic substances contained in

- Domestic waste water (human waste & food waste)
- Industrial wastewater (from tannery, textile, pulp & paper & food processing industries etc.)

Minor Sources: Crop residue, decaying plants and leaves, animal droppings etc.

Strengths of oxygen demanding wastes are measured in terms of:

- BOD (Biochemical oxygen demand)
- COD (Chemical oxygen Demand)

Effects of Oxygen Demanding Wastes

- Cause depletion of dissolved oxygen (DO) in water; saturation value of DO in water may vary from less than 8 to about 15 mg/L, depending on temperature and salinity of water.
- As DO drops, fish and other aquatic lives are threatened and in extreme cases, killed, and the aquatic system may be classified as grossly polluted; (minimum DO for healthy fish population may be as high as 5-8 mg/L; Certain fish species may survive at lower DO e.g., 3mg/L).
- Excessive fall in DO levels results in undesirable odors, tastes and colors and makes the water unsuitable for domestic supply and recreational uses.

(2) Microbial Wastes (Pathogens)

Most serious water pollutants in terms of human health worldwide are pathogenic organisms that cause a variety of waterborne diseases.

- Bacteria:** responsible for diseases like cholera, bacillary dysentery, typhoid and Para-typhoid fever
- Viruses:** responsible for enteritis, hepatitis, poliomyelitis
- Protozoa:** e.g., amoebic dysentery
- Helminthes (Parasitic worms):** worm infections, e.g., schistosomiasis

Main Sources of Pathogens

- Untreated or improperly treated human wastes
- Animal wastes from feedlots or fields near waterways
- Food processing factories without treatment facilities.

Altogether, at least 25 million deaths each year are blamed on water pollution related diseases

Natural Die-off of Organisms

- Coliforms and other micro-organisms of intestinal origin exhibit natural die-off or decrease in numbers when exposed to adverse environmental conditions, e.g., temperature, pH, physical forces, that differ from those within the human system, and when exposed to predators
- Die- off may be accelerated by the presence of toxic substances and bactericidal agents, e.g., chlorination.

Indicator Organism

- Detecting specific Pathogens in water is difficult, time-consuming, and costly.
- Usually, water is analyzed for the presence of Fecal Coliform bacteria, one of the many types that live in the intestines of humans and other animals.
- If large numbers of these organisms are found in a water sample, recent contamination by untreated wastes is indicated.
- It is usually assumed that if Fecal Coliform bacteria are present in a water sample, pathogens are also present.

Coliform tests:

- Total coliform (TC)
- Faecal coliform (FC)

(3) Nutrients (N, P, C, S, Ca, K, Fe, Mn, B, Co, etc)

- **Nutrients are an important limiting factor in the growth of plants and animals.**
- **Nutrients can be considered pollutants, when their concentrations are high enough to allow excessive growth of aquatic plants, particularly algae. This is referred to as “algal bloom” or “eutrophication”.**

Major Sources of Nutrients: (C,N,P)

- **Municipal wastewater** discharge that may be in the form of treated or untreated sewage.
- **Agricultural activities**, especially animal wastes, and chemical fertilizers.
- **Sediments** too are an important source of nutrients in many water bodies.

Effects of Nutrient Enrichment

- Nutrient enrichment leads to blooms of algae (**eutrophication**), that eventually die and decompose resulting in depletion of oxygen in water.
- **Algae and decaying organic matter add color, turbidity, odors, and objectionable tastes to water** that are difficult to remove and therefore, reduce its acceptability as domestic water source, recreational and other uses.

Controlling Eutrophication

- ① By controlling nutrient level:
Can be controlled by identifying
and reducing the supply of
"limiting nutrients" (nutrient that is
least available).

most important nutrients: C, N, P

Carbon (C): comes from dissolved CO_2
(from air), decaying organic matter
— usually not limiting

Controlling Eutrophication

Nitrogen (N) and Phosphorus (P): comes from municipal discharges, chemical fertilizer, etc. These two could be limiting nutrients.

However, certain bacteria and algae can obtain N directly from atmosphere. Hence, N is often not the limiting nutrient.

Thus, P is often the limiting nutrient and targeted for controlling eutrophication. An important source of P is detergent.

Other Control Measures:

(B) Other Control Measures:

(i) Mechanical control: Filamentous algae can be controlled by physically removing large floating clumps with a rake.

(ii) Biological control: may involve introduction of a vegetation-eating fish in water.

(iii) Chemical control: Commonly accomplished by addition of copper sulfate. Alkalinity of water is an important parameter in determining dose of CuSO_4 .

Blue-baby Syndrome:

Methemoglobinemia/Blue Baby Syndrome:

Certain bacteria in the intestinal tract of infants (< 6 mo.) converts NO_3 to NO_2 . NO_2 has greater affinity for hemoglobin than O_2 and replaces O_2 . The resulting O_2 starvation causes bluish discoloration of infants and children and may cause death.

(4) Suspended Solids

- ❑ Organic SS → can exert BOD
- ❑ Inorganic SS → from surface runoff, industrial activity, soil erosion
- Excessive SS
 - reduces the usefulness of lakes and streams
 - causes turbidity
 - disrupts ecological habitat
 - increase the cost of water treatment facilities

(5) Salts

- Water naturally accumulates a variety of dissolved solids or salts, as it passes through soils and rocks on its way to sea.
- These salts typically include
 - Cations: Na^+ , Ca^{2+} , K^+ , Mg^{2+}
 - Anions: Cl^- , SO_4^{2-} , HCO_3^-
- Certain industrial discharges also contain significant amount of dissolved salts, e.g., Tannery effluents.
- Effects of dissolved salts: **Taste, odour**
- Commonly used measure of salinity: TDS (total Dissolved solids), Electrical Conductivity (EC)

Typical Values of TDS in Water:

- Freshwater: TDS < 1500 mg/L
- Brackish water : TDS up to 5000 mg/ L
- Saline water : TDS > 5000 mg/L
- Sea water : TDS 30000-35000 mg/L
- Drinking water : TDS 500 – 1000 mg/L
- Most crops can tolerate, TDS upto 1500 mg/L
- Water with TDS > 2100 mg/L is generally unsuitable for irrigation.

Effects of Excessive Salt in Water

- **High salt concentration can cause water to become unsuitable for drinking, damage crops, cause soil pollution.**
- Salt water intrusion in surface water and groundwater in the coastal areas of Bangladesh due to reduced upstream flows and climate change related impacts (e.g., sea level rise, cyclone) is a major concern.
- **Excessive salinity is the major drinking water quality problem in the coastal areas of Bangladesh.**

(6) Heavy Metals

The toxic properties of heavier metallic elements are well established. Some of these toxic metals have desirable properties and so are routinely manufactured.

The most toxic, persistent, and abundant of these metals in the environment include:

Hg, Pb, As, Cd, Cr, and Ni

Characteristics, Sources and Effects of Heavy Metals:

Characteristics:

- Accumulate in the bodies of organism,
- Remain for long periods of time, and
- Behave as cumulative poisons

Major sources:

- Industrial discharges
- Natural (e.g., As, Mn in groundwater)

Effects on Human:

- **Kidney, liver, and brain damage**
- **Carcinogenic**
- **Hypertension**

(7) Toxic and Persistent Organic Pollutants (POPs)

Natural and synthetic organic compounds are being increasingly used in chemical industries to produce pesticides, plastics, plasticizers, solvents, detergents, paints and pharmaceuticals.

- Many of these chemicals are highly toxic to organisms that ingest them.
- Some are persistent in the environment because they are resistant to degradation

Two important sources of POPs in water are:

- 1) Improper disposal of industrial and household wastes, and
 - 2) Runoff of pesticides from farm lands, forests, and other places where they are used in large quantities.
- **Exposure to very low concentrations of these pollutants can cause:**
 - **Genetic disorders (Mutagens)**
 - **Birth defects (Teratogens)**
 - **Cancer (Carcinogens)**

(8) Thermal pollution

- Thermal pollution originates primarily with the practice of using water as a coolant in many industrial processes, particularly in power plants,
- Petroleum refineries, metal smelters, paper mills, food processing industries, chemical plants, all use and release large amounts of cooling water.



*Discharge outlet of Siddhirganj
210 MW Power plant*

Two major problems associated with thermal discharge:

- 1) The metabolic rates of aquatic lives tend to increase with temperature, generally by about a factor of 2 for each 10 °C rise in temperature. This causes an increased demand for oxygen by organisms.
- 2) The available supplies of DO are reduced both because waste assimilation is quicker – drawing down DO at a faster rate, and because the amount of DO that water can hold decreases with temperature.