**Chapter-III**

**HYDROSPHERE**

The hydrosphere is that part of the earth which contains water. It includes frozen surface water, groundwater held in soil and rock, the oceans, seas, lakes, ponds, rivers and the atmospheric water vapour. The hydrosphere covers about 70% of the surface of the Earth and is the home for many plants and animals.

**Important properties of water:**

* + It is vital for life.
  + It is the only substance which is present in all the three states of matter i.e. solid, liquid and gaseous form.
  + Water has a maximum **density at 4oC**.
  + It has highest surface tension amongst all other liquids.
  + Most large cities (depends on rivers for their water) are located on rivers.
  + It constitute 65-95% of the body weight of any living organism (70%of human’s body weight).
  + Regular supply of water is maintained through its circulation in the atmosphere through hydrological cycle (water cycle).
  + In **evaporation** water changes from liquid to vapour state from any open water source like ocean, well, river etc.
  + In **transpiration** also water changes from liquid to vapour state but from the stomata pores of leaf and stem tissues of growing plants.
  + **Condensation** is responsible for the formation of liquid from water vapours.

**Types of water:**

* **Sea/marine/oceanic water**: In this type of water salt content is more than 3.5mg/l
* **Brackish water:** Here salt content is 0.5-3.5mg/l.
* **Fresh water:** Salt content is less than 0.5mg/l in this type of water.

**Aquatic Ecosystem:**

Aquatic ecosystems are composed of living organisms and non-living elements interacting in a water system or a community of plants and animals that primarily depend on water.

**Types of Aquatic Ecosystems**

1. **Marine Ecosystems:** While terrestrial ecosystems cover only about 28 percent, marine ecosystems cover approximately 71 percent of the earth’s surface. Examples are,

* **Oceans:** These contain salty water. Major oceans include the Pacific Ocean, Indian Ocean, Arctic Ocean, Atlantic Ocean and Southern Ocean.
* **Intertidal zones:** This is the area which remains underwater at high tide and remains terrestrial at low tide. Wetlands, rocky cliffs and sandy beaches fall under intertidal zones.
* **Estuaries:** These refer to areas between river and ocean environments that are prone to tides and inflow of both freshwater and saline water. Due to this inflow, [estuaries](http://www.brighthub.com/environment/science-environmental/articles/33956.aspx) have high levels of nutrients and are also known as inlets, lagoons, harbours etc.
* **Coral Reefs:** Often referred as the “rainforests of the sea”, coral reefs are mounds found in marine waters as a result of accumulation of calcium carbonate deposited by marine organisms like corals and shellfish. Around 25 percent of marine animals including different types of fishes, sponges and mollusks are found in coral reefs.

Common species found in marine ecosystems include marine mammals such as seals, whales and manatees; different species of fish and organisms such as the tiny planktonic, brown algae, corals etc.

1. **Freshwater Ecosystems:** Only 0.8 percent of the earth’s surface is covered by freshwater ecosystems. Approximately 41 percent of the earth’s fishes are found in freshwater ecosystems. Examples are,

* **Streams and rivers (Lotic):** Lotic ecosystems refer to systems with rapid flowing waters that move in a unidirectional way. Best examples are rivers and streams, which have several species of [insects](http://www.brighthub.com/guides/insects.aspx), crabs, fishes and mammals such as beavers, otters and river dolphins.
* **Lakes, ponds and pools (Lentic):** Lentic ecosystems are still waters such as lakes and ponds that have a community of biotic (living organisms) and abiotic (physical objects) interactions. Ponds and lakes have a diverse variety of organisms including algae, rooted and floating-leaved plants, invertebrates such as crabs, shrimps, crayfish, clams; amphibians such as frogs and salamanders; and reptiles like alligators and water snakes.
* **Wetlands:** The best examples of wetlands include swamps and marshes, where the water is completely or partially shallow. Wetlands are known to be too diverse as it has numerous animals and plant species like black spruce, water lilies, mangrove, tamarack and sedges.

Freshwater and marine ecosystems are in danger because of the rapid extinction rates of several invertebrates and vertebrates, mainly because of overfishing, climate change and other activities that pollute the ecosystem.

**Major sources of water:**

**Precipitation** of water vapour in the form of rain, snow, dew, hail etc is the chief source of water in environment.

**Water cycle:** The water from oceans reaches the land through a natural process called **‘Hydrological Cycle’.** Water evaporates from oceans, ponds, lakes; ground etc. water vapours condense and form clouds which precipitate to produce both rain and snow.

90%of ocean evaporation returns to it via rain while 10% extra falls on land surface. This forms lakes, rivers and ground water. Man uses this fresh water for various purposes.

**Fresh Water Shortage**

* **Total water (100%)**
  + **Fresh water (2.5%)**
    1. Ice (69.4%)
    2. Liquid (30.6%)
       1. Ground water (98.7%)
       2. Lakes (0.96%)
       3. Soil (0.16%)
       4. Rivers (0.02%)
       5. Atmosphere (0.12%)
       6. Biological (0.01%)
  + **Saline water (97.5%)**
* India receives 2750Km3 of rainfall per year. Out of these 600 Km3 water seeps into ground, 900Km3 evaporates and the remaining goes to soil, lakes, river, ponds etc.
* Only 2.5%of the water present on this earth is fresh water and we can use only 31%of this 2.5%as it is available in liquid form.
* Total 1, 36,000 Km3 drinking water is present on earth. Out of this 14000 Km3water is already used up.
* A person in his life span drinks 61,000litres of water.
* In our country 2000million gallon water is needed for the printing of newspaper.
* For the production of 1KWH electricity, 4000 gallon water is needed.
* Only 4%of total drinking water of the world is available with India which is a good thing but per capita availability is least as shown below.

Indian = 2200m3/year.

Japanese = 6500m3/year.

American = 6200m3/year.

**Water Pollution:**

Alteration in physical, chemical and biological characteristics of water due to the addition of excess of undesirable substances that make it harmful to man, animal and aquatic life or otherwise cause significant departure from the normal activities of various living communities in and around water.

**Contamination:** It is specific term to indicate pollution. It makes water totally unfit for the best use/human use.

**What is the cost of pollution?**

* Loss of resources by unnecessary wasteful exploitation.
* Cost of pollution control-money, fund, manpower etc. for disposal of pollutant.
* Cost of human health.
* Damage to crop production.
* Damage to wildlife.

**Pollutants:** It is a physical or biotic component which adversely alters the environment by altering growth rate of species, interferes with the food chain, health, comforts, amenities or property value of man.

Pollutant is harmful solid, liquid or gaseous substance present in such concentration in the environment which tends to be injurious for the whole living biota.

Pollutants are the residues of things we use and throw away. These are the products of man’s action. e.g.

**Solid waste:** garbage, dead animals.

**Liquid waste:** oil

**Gaseous waste:** ozone, carbon monoxide etc.

**Classification of Pollutants:**

* **Primary pollutant**: Emitted from identifiable sources.
* **Secondary pollutant:** Derived from primary pollutants.
* **Non-biodegradable :** These are the pollutants which are not degraded by the micro-organisms in the soil e.g. DDT
* **Biodegradable:** These are the pollutants which are degraded by the micro-organisms in the soil e.g. paper.

**Sources of water pollution:**

* **Surface water pollution:**
  1. Domestic waste and sewage.
  2. Industrial effluents.
  3. Surface run-off (Farm run-off)
  4. Solid silt particles
  5. Oil
  6. Thermal Pollution (heat)
  7. Radioactive wastes.
* **Underground water pollution:**
  1. Sewage and industrial effluents.
  2. Fertilizers and pesticides used in fields percolate.
  3. Refuse dumps, septic tanks, seepage pits, mining activities etc.

These pollutants filter through the soil and enter the underground water.

* **Sources of marine water pollution:**
  1. Dumping of industrial wastes directly by coastal industries or indirectly through river by inland industries.
  2. Discharge of fertilizers and pesticides from inland run-off through rivers.
  3. Discharge of sewage of coastal cities and distant place via rivers.
  4. Oil, grease, petroleum products, garbage, sewage and detergents from ships.
  5. Oil spillage.

**Consequences of fresh water pollution:**

* + 1. **Deoxygenation:** Microorganisms causing decomposition of sewage take up most of the **Dissolved Oxygen (DO)** present in water. Low level of oxygen in water is injurious to aquatic life.
    2. **Diseases**: Cholera, Jaundice, Typhoid, Dysentery, Hepatitis etc.
    3. **Foul Odour/ Deterioration Of Quality**
    4. **Blooming/Eutrophication (Dead Sea):** It is the process of nutrient enrichment and gradual filling of water body. It stimulates algal growth. This adds to depletion of oxygen. This is caused by **Nitrates and Phosphate**. Fertilizer rich water of streams and lakes give rise to blooming of aquatic plants (more growth), generally on surface. This cuts off light to submerged plants which generally produce oxygen inside water (for use by aquatic animal life). This reduces DO and aquatic animals die. Their death increases organic loading of water body that further depletes oxygen.
    5. **Biomagnification**: It is increase in the concentration of non-biodegradable toxic material at each trophic level of food chain e.g. DDT.

**Effects of Water Pollutants:**

1. DDT: Cerebral hemorrhage, hypertension, cancer, liver problems.
2. Mercury: **Minamata disease** (Japan 1952 from fishes of Minamata bay), impaired speech, sense of hearing, blurred vision, death, genetic disease..
3. Lead: **Anemia**, headache, mutagenic, paralysis.
4. Cadmium**: Itai-itai disease**(kidney damage, emphysema, amemia etc.)
5. Arsenic: Mental disturbance, liver cirrhosis, ulcers in gastrointestinal tract, lung cancer etc.
6. Selenium: Fever, nervousness, vomiting, dental caries.
7. Chromium: Cancer, nephritis, gastrointestinal ulceration, liver damage.
8. Nitrates: **Metahaemoglobinomea (blue-baby syndrome).**
9. Fluoride: Mottling of teeth, weak bones, **Fluorosis,** dental caries.

**Permissible Limits for Drinking Water:**

* + **Physical:**

1. Colour: 5-25 units.
2. Turbidity: 5-10 units
3. Taste and odour: unobjectionable:
4. Temperature: 10-15oC.
5. pH: 6.5-8.0. it has no unit.
   * **Chemical:**
6. DO: 5-6mg/l
7. Dissolved solids: 500-1000mg/l
8. Chloride ion: 200-1000mg/l
9. Sulphate ion: 200-400mg/l
10. Fluoride ion: 0.1-1.5mg/l
11. Copper: 0.05-1.5mg/l
12. Iron: 0.1-1.5mg/l
13. Lead: 0.1mg/l
14. Cadmium: 0.1mg/l
    * **Biological:**
15. Coliform organisms: 100 No./l
16. E.Coli: 1-5 No./l

**Prevention and Control of water pollution.**

* + Avoiding bathing and washing clothes directly in ponds, tanks and streams that supply drinking water.
  + Separate ponds and tanks should be reserved for cattle’s and other animals.
  + Treatment of domestic, farmyard and industrial wastes should be done before releasing them into water bodies.
  + Avoiding overuse of fertilizers and pesticides reduces water population.
  + Cooling hot water that is released from industries.
  + Recycling of solid wastes wherever possible.
  + Growing water hyacinth in polluted water purifies it by taking heavy metals (lead, mercury, cadmium and nickel) and toxic materials.

**Treatment of polluted water**

W[ater pollution](http://science.jrank.org/pages/7312/Water-Pollution.html) treatment methods can be subdivided into physical, chemical, and biological treatment systems.

**Physical methods**

These processes rely on physical forces to aid in the removal of pollutants.

* 1. Screening and filtration are similar methods used to separate coarse solids from water.
  2. Sedimentation devices utilize gravity to remove the heavier particles suspended in the water stream. The wide array of sedimentation basins slow down the water velocity in the unit to allow time for the particles to drop to the bottom.
  3. Floatation process is used to remove particles with densities lower than water. Fine gas bubbles are often introduced to assist this process; they attach to the particulate matter, causing them to rise to the top of the unit where they are mechanically removed. For instance aeration of water with oxygen helps remove nitrates.

**Chemical treatment**

[Chemical reactions](http://science.jrank.org/pages/1389/Chemical-Reactions.html) can be utilized to remove water pollutants or to form other, less toxic, compounds. Typical chemical treatment processes are:

1. Chemical precipitation processes utilize the addition of chemicals (lime, ferric chloride or alum) to the water in order to bring about the precipitation of dissolved solids. The solid is then removed by a physical process such as sedimentation or filtration. These are often used for the removal of heavy metals and [phosphorus](http://science.jrank.org/pages/5141/Phosphorus.html) from water streams.

2. Adsorption processes are used to separate soluble substances from the water stream. Activated carbon is the most widely used adsorbent. Water may be passed through beds of granulated activated carbon (GAC), or powdered activated carbon (PAC) may be added in order to facilitate the removal of dissolved pollutants.

3. Disinfection processes selectively destroy disease-causing organisms such as [bacteria](http://science.jrank.org/pages/714/Bacteria.html) and viruses. Boiling the water is a simple example of disinfection. Typical disinfection agents include [chlorine](http://science.jrank.org/pages/1440/Chlorine.html), [ozone](http://science.jrank.org/pages/4972/Ozone.html), and ultraviolet [radiation](http://science.jrank.org/pages/5636/Radiation.html).

**Biological Methods**

Biological water pollution control methods are used for the control of biodegradable organic chemicals, as well as nutrients such as [nitrogen](http://science.jrank.org/pages/4687/Nitrogen.html) and phosphorus. In these systems, [microorganisms](http://science.jrank.org/pages/4305/Microorganisms.html) consisting mainly of bacteria convert carbonaceous matter as well as cell tissue into gas. There are two main groups of microorganisms which are used in biological treatment, [aerobic](http://science.jrank.org/pages/93/Aerobic.html) and [anaerobic](http://science.jrank.org/pages/323/Anaerobic.html) microorganisms. Aerobic processes occur in the absence of [oxygen](http://science.jrank.org/pages/4970/Oxygen.html). Both processes may be utilized whether the microorganisms exist in a suspension or are attached to a surface. These processes are termed suspended growth and fixed film processes, respectively.

**Ganga Action Plan (GAP):**

* Largest and very important river.
* Drains 9 states: H.P, Panjab, Haryana, U.P, Rajasthan, M.P, West Bengal, Delhi and Uttaranchal.
* There **are 3 types of pollutants**:
  + Silt,
  + Biological (organic matter) due to sewage from cities and
  + Towns and chemicals from industries.
* GAP started in 1985 to control the level of pollution of Ganga water by Ganga project directorate in MoEF.
* Rs. 550 Crore project planned to install sewage treatment plant in 27 cities on the banks of Ganga was launched.
* Under GAP-II (1993), Pollution Control Research Institutes of Bharat Heavy Electricals Ltd. At Haridwar has been conducting monthly studies to analyze the quality of water. This institute is now controlling the sewage treatment plant at Rishikesh and Haridwar and has set up a pilot plant for sewage disinfection at Jagjitpur near Haridwar.
* GAP-II phase of Ganga project includes clear “Yamuna and Gomati” which will cover 15 cities on Yamuna and 3 cities on Gomati.

**Yamuna Action Plan:**

On the 10th Dec 1997, the central pollution control board submitted a Rs. 480 crore action plan to Delhi high court to cleanse the polluted water. It involves following measures:

* Construction of 14 sewage treatment plants in various parts of Delhi.
* Proper treatment of Panipat cooperative sugar and distillery units before their discharge.
* To ensure that no effluents from NFL, Panipat flow into the river.
* Ensuring the Panipat refinery treats its effluents and then uses them for irrigation.

**Important Definitions:**

**DO (Dissolved Oxygen):** Amount of oxygen dissolved in water and is usually measured by an Oxygen Probe (DO electrode) or **Wrinkler Dissolved Oxygen Test**. **DO show 8.0mg/l indicates pollution and below 4.0mg/l heavy pollution.**

**BOD (Biological Oxygen Demand):** Amount of oxygen in milligrams required by microorganisms to decompose organic matter for 5days at 20oc.

**COD (Chemical Oxygen Demand):** Amount of oxygen in milligrams required by chemicals like potassium dichromate and potassium permanganate to decompose organic matter for 2days at room temperature.

**Presence of Coliform Bacteria in water sample alerts to food contamination.**