



WATER POLLUTION

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Definition of Water Pollution

Water pollution occurs when harmful substances—often chemicals or microorganisms—contaminate a stream, **river**, lake, ocean, aquifer, or other body of **water**, degrading **water** quality and rendering it toxic to humans or the environment.

Water pollution is a large set of adverse effects upon water bodies such as [lakes](#), [rivers](#), oceans and [groundwater](#) caused by human activities.

Types of Water Pollution

□ Surface Water Pollution

Surface water pollution includes pollution of rivers, lakes and oceans.

□ Marine Water Pollution

A subset of surface water pollution is [marine pollution](#).

□ Ground water Pollution

Interactions between [groundwater](#) and [surface water](#) are complex. Consequently, groundwater pollution, also referred to as groundwater contamination, is not as easily classified as surface water pollution. By its very nature, groundwater [aquifers](#) are susceptible to contamination from sources that may not directly affect surface water bodies.

Sources of Water Pollution

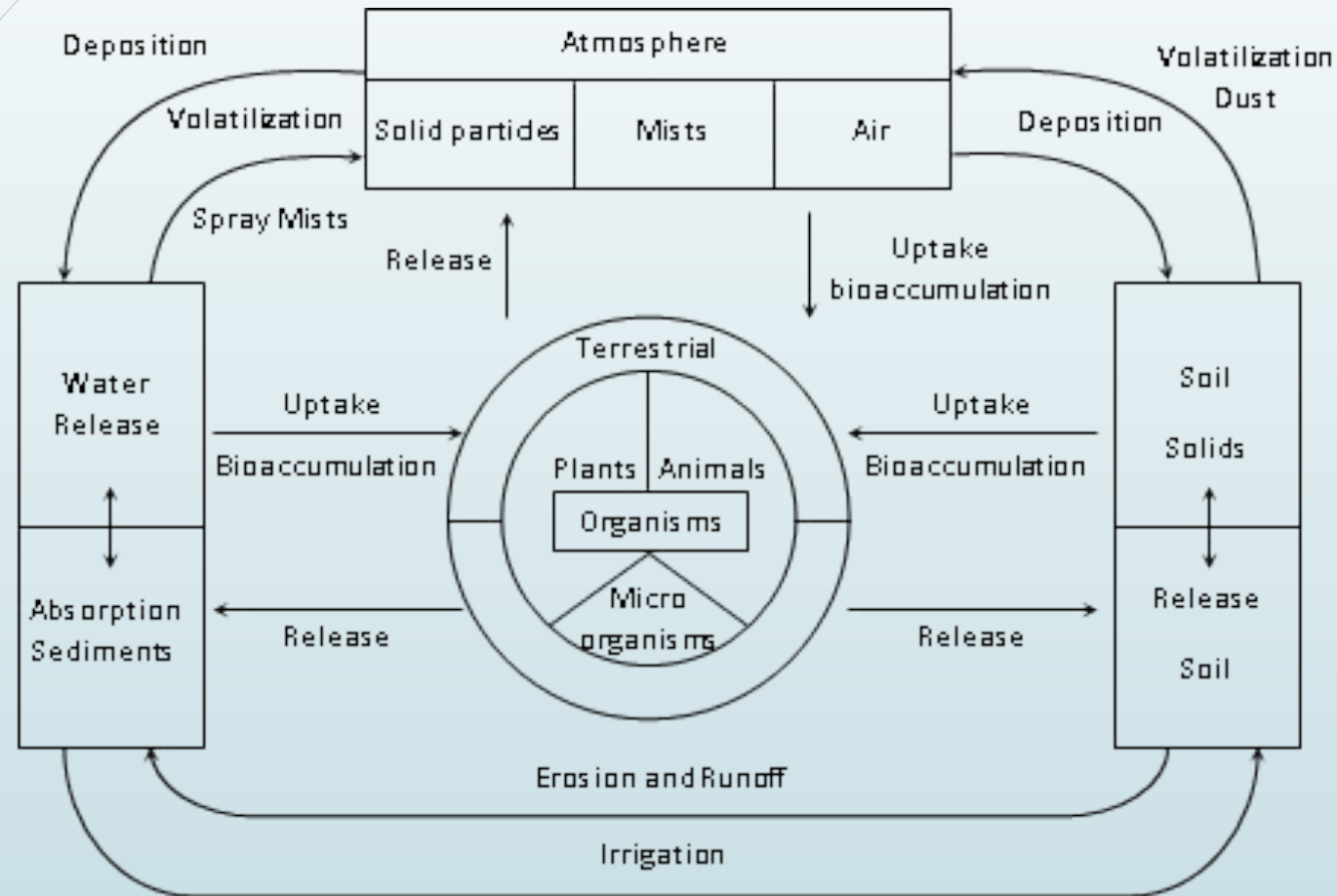


Fig: 4.3 Water pollution cycle

Oxygen demanding waste

Oxygen demanding wastes are substances that oxidize in the receiving body of water. These wastes are decomposed by bacteria (if they are biodegradable). During the process of degradation, the oxygen which is present in water in dissolved form i.e., **Dissolved Oxygen (DO)**, is utilized by the bacteria. It reduces the DO of water. DO is the one of the important water quality parameters. Its saturated value is **8 mg/L to 15 mg/L**. As DO drops, fish and other aquatic life are threatened and in extreme case, killed. In addition, as dissolved oxygen levels fall, undesirable odors, taste and colour reduce the acceptability of that water as a domestic supply and reduce its attractiveness for recreational uses.

As oxygen is demanded for the degradation of these wastes, they are known as **oxygen demanding wastes**. Usually biodegradable organic substances contained in municipal waste water as well as industrial effluents are considered as oxygen demanding waste.

Pathogen

The disease causing organisms, usually micro organism that grow and multiply within the host are called **pathogen**. Some of the living organisms such as bacteria, viruses and protozoa are infectious to human and are responsible for the serious outbreak of fatal water born diseases and so they are known as **pathogen**.

Pathogens are either macroscopic or microscopic. But some organisms are so small that they can not be seen even by the microscope. The presence of such organisms is detected by means of minutely observing their reactions in various positions.

□ Following are the different main pathogen present in water:-

- **Bacteria:** Cholera, bacillary dysentery, typhoid, paratyphoid fever etc. are caused by different bacteria present in water.
- **Algae:** Different types of skin diseases are caused by algae present in water.
- **Protozoa:** Disease like amebic dysentery, giardiasis etc. are caused by protozoa.

Volatile Organic Compound (VOC)

Volatile Organic Compounds (VOC) are among the most commonly found pollutants in ground water. They are often used as solvents in industrial processes and many of them are either known or suspected as **carcinogens** or **mutagens**. Their volatility means they are not often found in concentrations above a few $\mu\text{m/L}$ in surface water, but in ground water their concentrations can be hundreds or thousands of times higher.

- i) Vinyl chloride
- ii) Trichloro- ethylene
- iii) Tetrachloro-ethylene
- iv) Carbon –tetrachloride
- v) 1,2, - Dichloro ethane

Pesticide

Pesticides are the organic chemicals used to control unwanted species of plants and animals. These are economic poisons employed to regulate the impact of various pest (harmful organisms to plant / crops) upon our life and economy.

- ***Classification of Pesticides:***

- **On the basis of target species, the pesticides may be classified into following categories –**

- i) Herbicide (used to kill undesirable weeds)
- ii) Fungicide (used to kill unwanted fungi)
- iii) Insecticide (used to kill insects)
- iv) Rodenticides (used to kill rats)
- v) Nematicides (used to kill nematodes)
- vi) Piscicide (used to kill undesirable fish and other aquatic species)

- **On the basis of the chemical composition, pesticides are classified as –**

- i) Organochloride
- ii) Organophosphate
- iii) Carbamates.

Pesticide Pollution

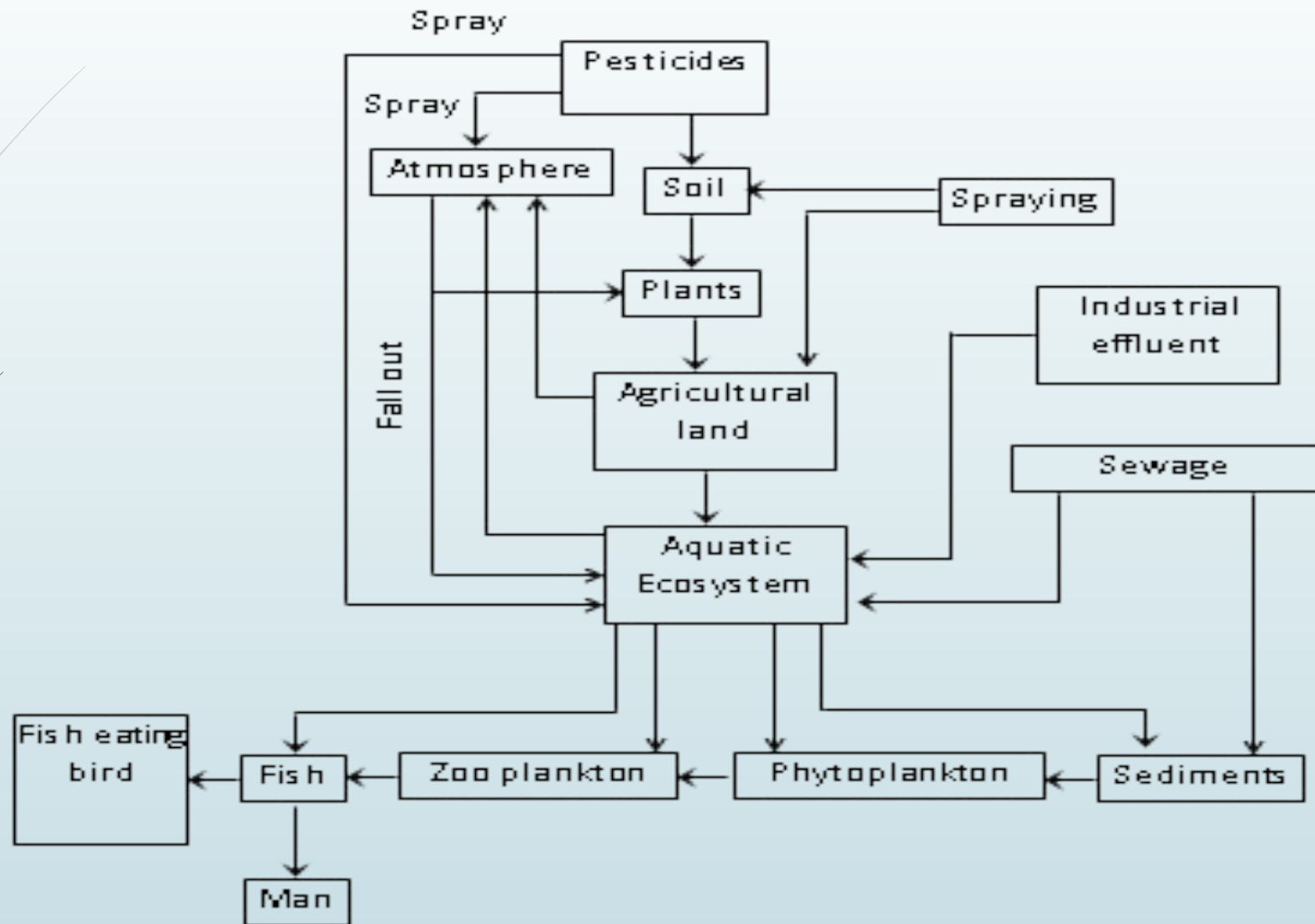


Fig. 4.4 Spread of pesticide in environment

Heat (Thermal Pollution)

Thermal pollution can be defined as an accumulation of unstable heat from human activities that disturbs the natural ecosystem.

Effect of thermal pollution:

- *Physical effects*
- *Chemical effect*
- *Biological effect*

Control of thermal pollution

Thermal pollution is one of the outcomes of the thermal power plant. In thermal power plant, water is used to cool the condenser and then again release to the stream from where it was collected. This water is known as **cooling water**. To maintain the natural ecosystem, heat must be removed from the cooling waters prior to their disposal into the water bodies.

There are different methods of removal of heat from the cooling water, these are –

- Cooling ponds
- Spray ponds
- Cooling towers

Different methods of removal of heat

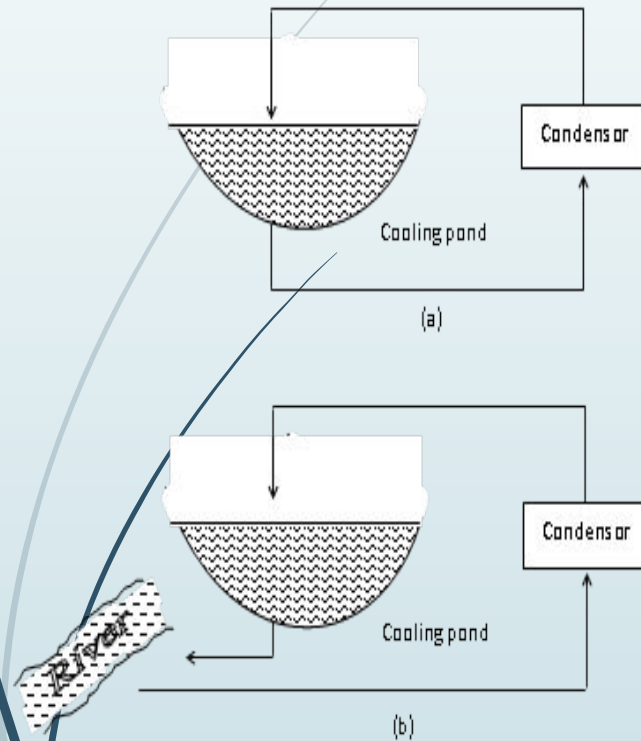


Fig. 4.5 (a) & (b) Cooling ponds

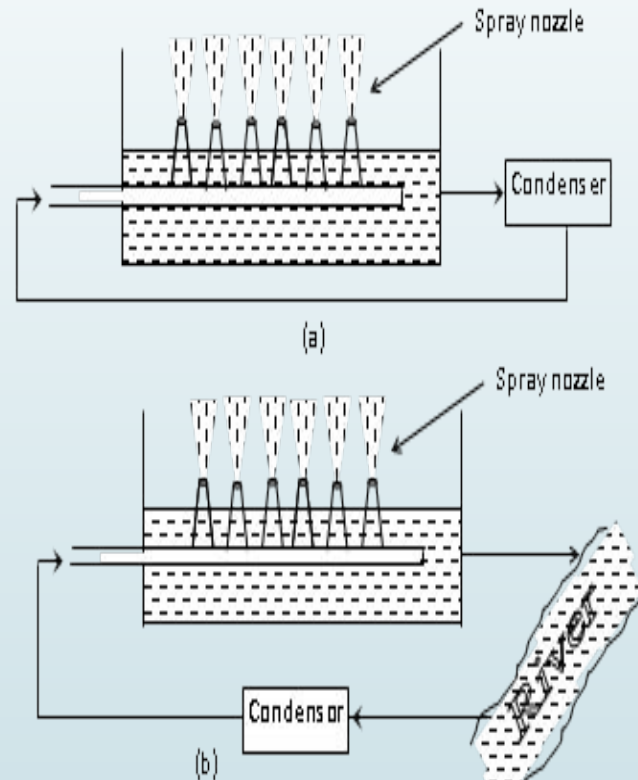


Fig. 4.6 (a) & (b) Spray ponds

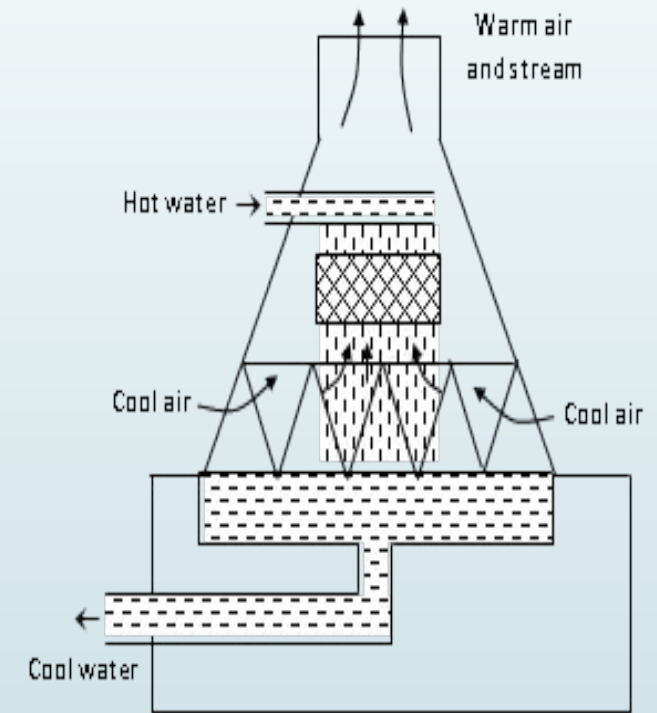


Fig. 4.7 Wet Tower

Nutrients

Nutrients are chemicals such as nitrogen, phosphate, carbon, sulphur, Ca^{++} , K^+ , Fe, Mn, B and Co that are essential to the growth of living organisms. In terms of water quality, nutrients can be considered as pollutants when their concentrations are sufficient to allow excessive growth of aquatic plants, particularly algae. As a result attractiveness of water body for recreational purposes, drinking water supply and as a viable habitat for other living organism can be adversely affected. The nutrient enrichment to the lake ultimately leads to **Eutrophication**.

Presence of excess amount of nitrogen in water is harmful because it is not only responsible for eutrophication i.e., aging of lake, but also creates public health threat when present in drinking water. Nitrogen, usually, present in water in the form of nitrate salt (NO_3^-) is itself not dangerous. However, certain bacteria commonly present in **intestinal tract** of infants can convert nitrate salt (NO_3^-) to highly toxic nitrite (NO_2^-). Nitrites have a greater affinity for hemoglobin than oxygen. As a result, due to **oxygen starvation**, **bluish discolourisation** of infant takes place. This is known as '**blue baby syndrome**'. This disease is called 'methemoglobinemia'.

Heavy metal

Usually we use the term 'heavy metal' to refer the metals which are very much toxic and harmful to the ecosystem. These heavy metals have a specific gravity of 4-5 times greater than that of water and usually belong to atomic numbers 22-34 and 40-52. They are usually members of **lanthenides** and **actinides** of the **periodic table**.

In general, toxic chemicals attack the active sites of enzymes, inhibiting essential enzyme function. Heavy metal ions act as effective **enzyme inhibitors**. They have affinity for sulphur containing ligands of different compounds present in enzyme structure.

Metalloenzymes contain metal in their structures. Their action is inhibited when one metal ion of a metalloenzyme is replaced by another metal ion of similar size and charge. If the new metal is toxicant, then it will show the toxicity and inhibits the actual activities of enzyme.



Fig. 4.9 Attack of heavy metal to enzyme

Toxicity

Toxicity is a relative potential of a substance or combination of different substances for producing injury or harm to living organism. When different chemical substances are responsible for the toxicity, then it is called **chemical toxicity** and the chemical substances are **chemical toxicants**.

- The transmission of toxic substances through the body of living organism follow a definite path. This flow of toxic substance is called '**Pharmoco-kinetics**'

Types of Toxicity

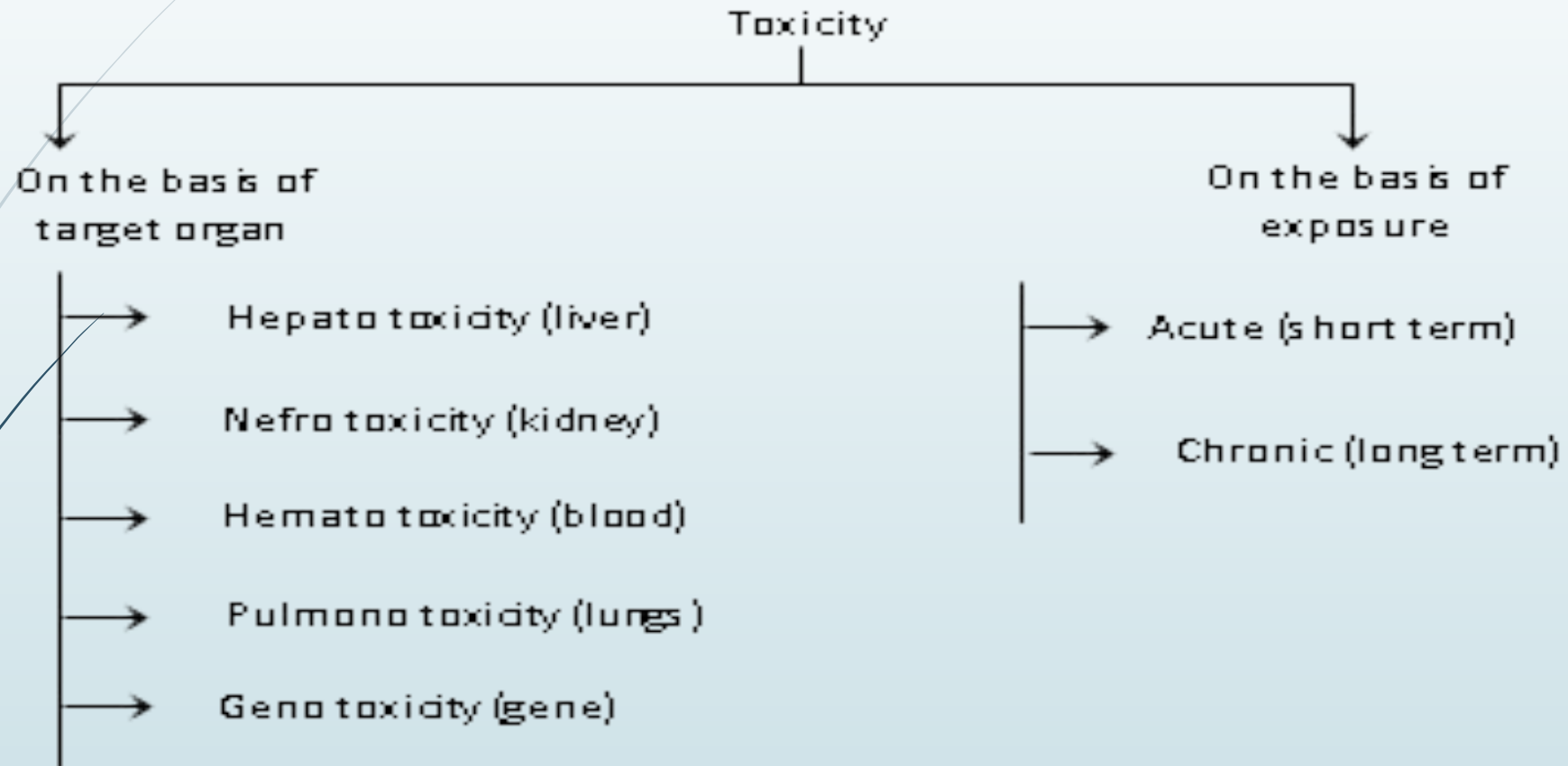


Chart: 4.2 Classification of toxicity

Mutagenesis and Mutagen

Deoxyribonucleic acid (DNA) is an essential component of all living things and a basic material in the chromosomes of the cell nucleus. Certain chemical agents as well as ionizing radiation are **capable of altering DNA**. This is called **mutation** and the process of mutation is called **mutagenesis**. The substances or an agent of mutation is called **mutagenic substances or mutagen**.

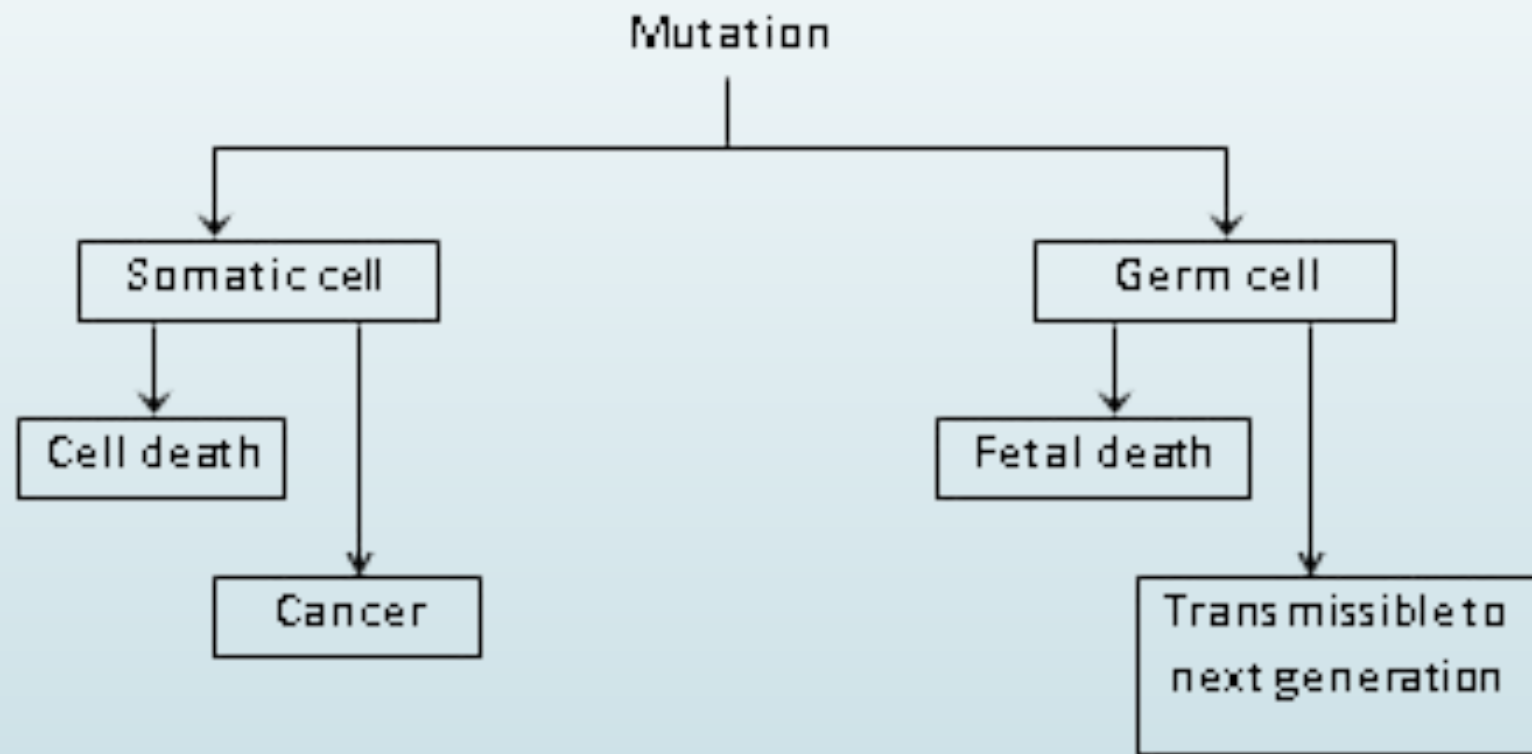


Chart: 4.3 Possible consequence of mutagenic event

Carcinogenesis and Carcinogen

The abnormal growth and activities of a cell is known as cancer. Cancer may be initiated by different substances. These substances are known as **carcinogen**. The process of cancer is known as **carcinogenesis**.

There are two stages of carcinogenesis –

- (i) Initiation
- (ii) Promotion

□ In the **initiation stage**, a mutation alters a cell's genetic material in a way that may result the uncontrolled growth of cells that characterizes **cancer**. In the **promotion stage** which is known as **stage of development, tumor develops**. This is also known as **Oncogenesis**. Tumor may be of two types – **Benign & Malignant**. Benign tumor is less harmful and **non-cancerous**. Its growth is limited within its own boundary. But when a tumor undergoes **metastasis** – i.e., it breaks apart and portion of it enter other areas of body – is said to be malignant tumor. **Malignant tumor** is much harder to treat or remove, and it is **cancerous**.

Example of Carcinogen: Benzene, Vinyl chloride, 2-Naphthylamine, Hydrozine, Arsenic trioxide, Hexavalent chromium (Cr^{6+})

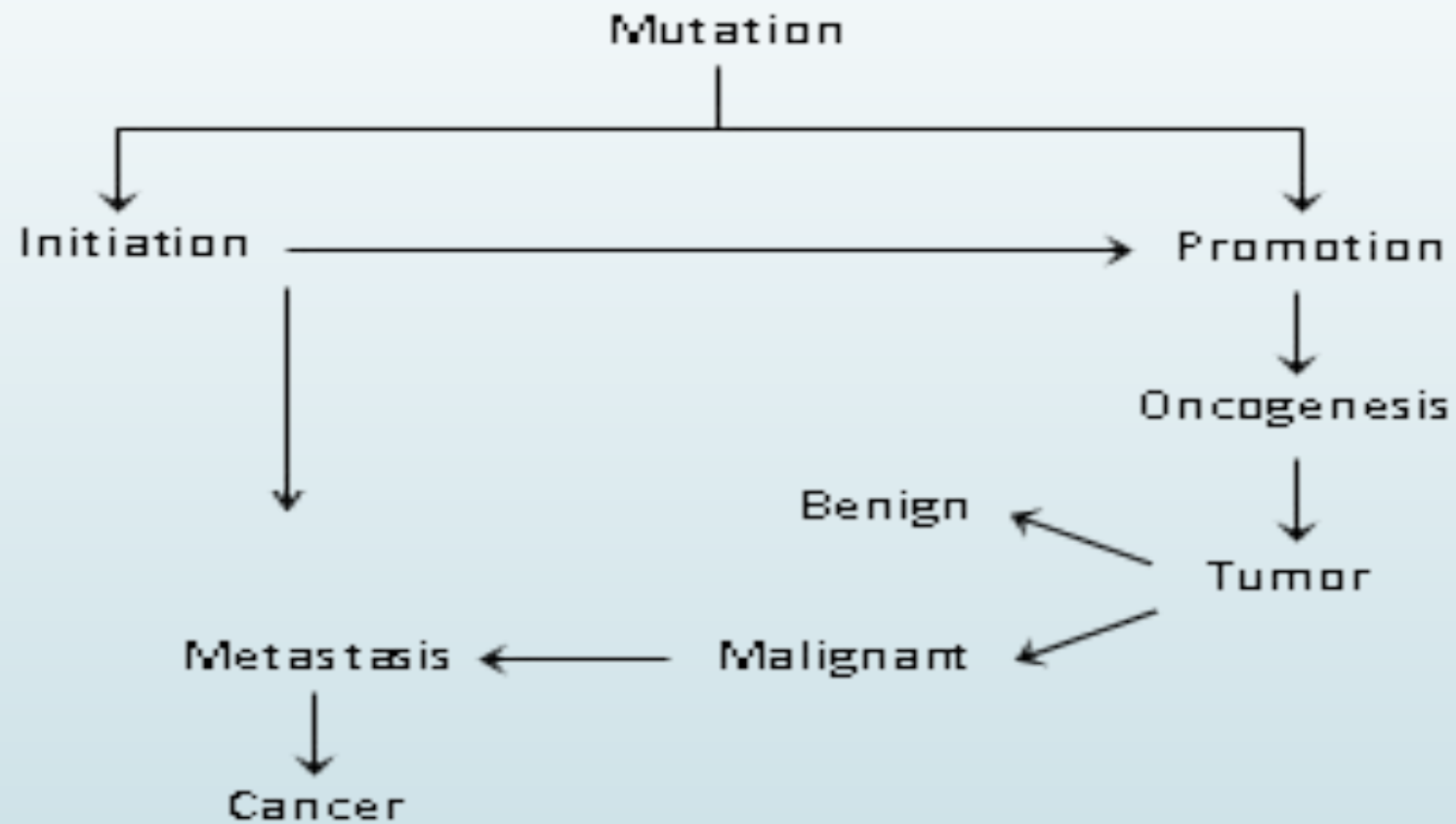


Chart: 4.4 Steps of Carcinogenesis

Heavy Metal Pollution

Elements	Sources	Effects & significance
i) Arsenic (As)	Mining by product, pesticides, chemical waste	Toxic, possibly carcinogenic
ii) Cadmium (Cd)	Industrial discharge, mining waste, metal plating, water pipes.	Replaces Zn bio-chemically, causes high blood pressure, damage of kidney, toxicity on aquatic biota also.
iii) Chromium (Cr)	Metal plating tannery. Normally found as Cr (VI) in polluted water.	Essential trace elements, possibly carcinogenic.
iv) Lead (Pb)	Industry, mining, plumbing, coal, gasoline.	Toxic, responsible for anaemia, kidney failure, nervous disorder, wild life destroyed.
v) Mercury (Hg)	Industrial waste mining, pesticides, coal.	Highly toxic

Pollutants	Major sources	Effects
Oxygen demanding Waste	Sewage effluent, agricultural run off, including animal waste, industrial waste	Decomposition by aerobic bacteria depletes level of dissolved oxygen in water, flora and fauna perish; further decomposition by anaerobic bacterial produces foul smelling toxic substances such as hydrogen sulfide.
Nutrient	Sewage effluents including phosphates from detergents, agricultural run off, especially nitrogen from fertilizers	Algal blooms: death of submerged vegetation; production of large amount of dead organic matter with subsequent problems of oxygen depletion.
Acids	Acid rain. Mine drainage; planting of extensive areas of coniferous forests, which acidify the soil	Acidification of natural waters, sharp decline species richness; fish loss; contaminant increase in level of toxic metals in solution
Heavy metal	Ore mining: associated industries; lead from vehicle exhaust emissions	Biomagnifications of toxic metal with each successive stage of food chain; threat to consumers including humans.
Oil	Drilling operations; oil tankers –pills; natural seepage; waste disposal	Contamination of the aquatic environment, death of birds and mammals
Pesticides	Direct application: agricultural run off , sewage effluent	Biomagnifications: top carnivores at risk; very persistent in environment
Heat	Coolant waters from industry, principally the electricity generating industry	Change in species composition usually accompanied by a decrease in species richness; fish may migrate or be killed by suffocation; reproductive cycle of fish