SEM IV
Paper DSE
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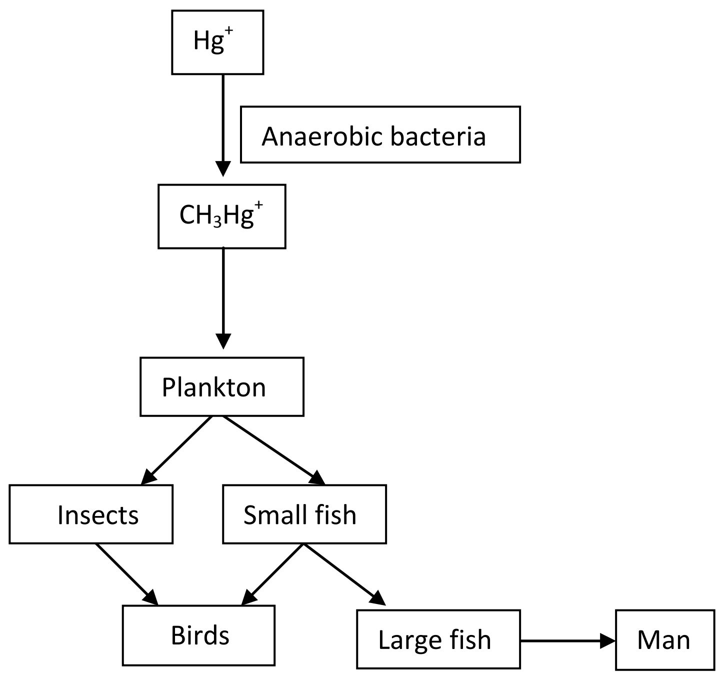
5.3.1 Biomagnification

- When a living organism cannot metabolize or excrete ingested substance that substance gradually accumulates in the organisms. This phenomenon, called biological accumulation (or bioaccumulation), refers to the process by which a substance first enters into a food chain.
- The extent to which bioaccumulation will occur depends on an organism's metabolism and on the solubility of the substance first enters a food chain. If the substance is soluble in fat, it will typically accumulate in the fatty tissues of the organism. Bioaccumulation is of particular concern when the substance being concentrated is a toxic environmental pollutant and the organism is of a relatively low trophic level in a food chain.
- When many contaminated organisms are consumed by second organism that can neither metabolize nor excrete the substance, the concentration of the substance will build to even higher levels in the second organism. This effect is magnified at each successive trophic level, and the process is called biological magnification (or biomagnificaon) or bioamplification, In other words, biomagnification is the steadily increasing concentration of a substance as it moves from one level of a food chain to the next (for example, from plankton to fish to birds or to humans). Biomagnification is of particular importance when chemicals are concentrated to harmful levels in organisms higher up in the food chain. Even very low concentrations of environmental pollutants can eventually find their way into organisms in high enough doses to cause serious problems.
- Biomagnifications occurs only when the pollutants are environmentally persistent (last a long time before breaking down into simpler compounds), mobile, and soluble in fats. If they are not persistent, they will not last long enough in the environment to be concentrated in the food chain (persistent substances are generally not biodegradable). If they are not mobile, that is, not easily transported or moved from place to place in the environment, they are not likely to be consumed by many organisms. Finally, if they are soluble in water rather than fatty tissue, they are much more likely to be excreted by the organism before building up to dangerous levels.
- Some examples are as under:
    - **Mercury biomagnifications (Minimata Incident)**
      Mercury is a well known toxic metal came in limelight only after the incidence of Minimata Disease in 1953 to 1960 in Japan. At Minimata Bay in Japan more than 100 people lost their lives and many thousands were permanently paralysed from

eating mercury contaminated fish. In a particular village facing the Bay (population 1100) 15% of the villagers were either killed or permanently crippled. Genetic defects were observed in nearly 50 babies whose mother had consumed the contaminated fish from the bay. The sea fish in the Bay were found to contain 27 to 102ppm of Hg in the form of methyl mercury. The mystery of the existence of methyl mercury in sea fish was a baffling at first since the source was inorganic mercury compound discharged into the Bay by Minimata Chemical Plant. The missing link between between the inorganic mercury in Bay water and methyl mercury in sea fish was bridged only after extensive research since 1950s. This was the first known case where natural bioaccumulation (in fish) of a toxic material (methyl mercury) killed hundred people and genetically damaged a large polulation.

Biological methylation (Amplication in food chain)

Hg or its salts can be converted to methyl mercury by anaerovic methane synthesizing bacteria in water. This conversion is facilitated byCo(III)- containing Vit.B-12 coenzyme. A methyl group bonded to Co(III) on coenzyme is transferred enzymatically to methyl cobalamin to Hg^{+2}, yielding CH_3Hg^+ or $(CH_3)_2Hg$.. An acidic medium promotes the conversion of dimethyl mercury which enters the food chain through plankton and is concentrated in fish by a factor 10^3



Mechanism of Propagation of mercury in food chain

DDT:

- DDT, an abbreviation for the organic chemical dichlorodiphenyltrichloroethane.
- It is a type of chemical known as chlorinated hydrocarbon, and it takes a long time to break down in the environment. With a "half-life" of 15 years, if 10 kg of DDT were released into the environment in the year 2000, 5 kg would still persist in the year 2015, about 2.5 kg would remain in 2030, and even after 100 years had elapsed, in the year 2100, more than 100 g of the substance would still be detected in the environment. Of course, long before that time span elapsed, some of the DDT could be inadvertently consumed by living organisms as they forage for food, and thereby enter a food chain.
- DDT is toxic to insects, but not very toxic to humans. It was much used in World War II to protect U.S. troops from tropical mosquito – borne malaria as well as to prevent the spread of lice and lice-borne disease among civilian populations in Europe. After the war, DDT was used to protect food crops from insects as well as to protect people from insect-borne disease. As one of the first of the modern pesticides, it was overused, and by the 1960s, the problems related to biomagnifications of DDT became very apparent.
- Many other substances in addition to mercury and DDT exhibit bioaccumulation and biomagnification in an ecosystem. These include copper, cadmium, lead, and other heavy metals, pesticides other than DDT, cyanide, selenium and PCBs.
- Although sometimes used interchangeably with 'bioaccumulation,' an important distinction is drawn between the two, and with bioconcentration, it is also important to distinct between sustainable development and overexploitation in biomagnification.
- Bioaccumulation occurs within a trophic level, and is the increase in concentration of a substance in certain tissues of organisms' bodies due to absorption from food and the environment.
- Bioconcentration is defined as occurring when uptake from the water is greater than excretion (Landrum and Fisher, 1999)
- Thus , bioconcentration and bioaccumulation occur within an organism, and biomagnification occurs across trophic (food chain) levels.

Substances that biomagnify

- There are two main groups of substances that biomagnify. Both are lipophilic and not easily degraded. Novel organic substances are not easily degraded because organisms lack previous exposure and have thus not evolved specific detoxification and excretion mechanisms, as there has been no selection pressure from them. These substances are consequently known as 'persistent organic pollutants' or POPs.

- Metals are not degradable because they are elements. Organisms, particularly those subject to naturally high levels of exposure to metals, have mechanisms to sequester and excrete metals. Problems arise when organisms are exposed to higher Environmental Science www.AgriMoon.Com 159 4 concentrations than usual, which they cannot excrete rapidly enough to prevent damage. These metals are transferred in an organic form.
- These metals are transferred in an organic form. those organic substances are
  - DDT
  - PCBs
  - Toxaphene
  - Monomethylmercury Inorganic substances
  - Arsenic
  - Cadmium
  - Mercury

  One can explain different chemicals which cause biomagnifications from books of environmental chemistry.

5.3.2 Eutrophication

- Enrichment of a water body by nutrients is called "eutrophication".
- The word eutrophication originated from two greek words-'eu' means good or well and 'trophes' means food.
- A newly formed water body possesses a very low concentration of plant nutrients and hence little plant life grows in such water. Low primary production limits animal communities too.
- The nutrient content in it slowly increases due to surface run off, wind borne dust and organic debris, excreta and exudates of animals which use the water. Bacteria and blue green algae fix atmospheric nitrogen. Phosphates present in the rocks and detritus at the bottom are solubilized by the microbial activity. Thus, the nutrient status of the water body gradually increases. At this stage, a moderate population of plants, animals and microbes now develops in the system, which furtherincreases withincreasing nutrient enrichment with passage of time. Eventually, dense population of plants, phytoplanktons and animals appears. At this stage, the aquatic sustem becomes highly productive in terms of fish etc.
- On the basis of nutrient status and productivity, anaquatic systems may be classified into following types:
  (i) Oligotrophic: water with poor nutrient status and productivity
  (ii) Mesotrophic: water with moderate nutrient status and productivity
  (iii) Eutrophic: water with rich nutrient status and high productivity
- A comparative account of Oligotrophic and Eutrophic lakes is given below:

Eutrophication thus denotes the enrichment of a water body by input of organic material of surface run off containing nitrates and phosphates. This may happen naturally but very slowly, often over a period of hundreds of years. Human activity generally responsible for rapid eutrophication as domestic waste, agricultural and land drainage and organic industrial waste or their decomposition products reach the water bodies and induce the productivity and composition of aquatic life. Eutrophication leads to increase in the growth of aquatic plants and often to algal blooms. The extensive algal growth have resulted in killing of fishes by interfering with recreation, excluding light intensity necessary for photosynthesis by other aquatic plants and thereby preventing the release of oxygen into the water or depleting the oxygen through decay or respiration with bloom. Some algal bloom release toxic substances that kill fishes, domestic animals and birds and water begins to shrink. The silt and organic debris accumulates at the bottom and the system turns a shallow muddy pond, then to a marsh and finally into a dry land.

- Lake washington and Lake Mendota have undergone rapid eutrophication due to anthropological activities. Similarly, the recreational value of lake in Kashmir is reduced. Nainital lake is undergoing accelerated eutrophication due to loading with sewage.
- . The various measures suggested to stop eutrophication are as follows:

1. Treatment of waste water in order to minimize nutrient inputs.
2. Reduction in the amount of nutrient solubilized in water through stimulation of bacterial multiplication.
3. Harvesting and removal of algal blooms to check recycling of nutrients into the water.
4. Removal of dissolved nutrients from water physically or chemically. Phosphorus can be removed by various methods of precipitation. Nitrogen can be removed by

(a) ion exchange, (b) electrodialysis, (c) reverse osmosis and (d) denitrification

- Undesirable effects of eutrophication

1. Algal blooms
2. Decrease in dissolved oxygen
3. Restrict the penetration of light and prevent atmospheric regeneration of water
4. Foul smelling due to decay of algae, fish, planktons and other organisms
5. Anaerobic bacteria flourishing in such environment generate toxins which are fatal to livestock, birds etc.
6. Pathogenic microbes bacteria, viruses, protozoa which flourish under the prevailing anaerobic conditions may result in causing water bornes diseases such as diarreah, dysentery, typhoid, viral hepatitis etc.
7. On depletion of oxygen and an exhausting nitrate oxygen, sulphates are reduced to hydrogen sulphide which result in foul smell and bad taste.
8. Growth of very long filamentous weeds reduce the stream velocity and also trap solid particles along with them.
9. High population densities of hydrilla , potamogeton, myriophyllum, ceratophyllum and other macrophytes render the water body unsuitable for any useful purpose.
10. Prolonged eutrophication conditions lead to “dystrophic” conditions when big flora and large quantities of humic acid are produced while drastically reducing plankton productivity.