

Water pollution: Causes, effects and control measures

Water pollution is defined as the presence of foreign substances or impurities (organic, inorganic, biological or radiological) in water, thus degrading its quality and rendering it toxic to humans or the environment.

According to Water pollution act (1974) contamination of water or such alteration of the physical, chemical or biological properties of water or such discharge of any sewage or trade effluent or of any other liquid, gaseous or solid substance into water (whether directly or indirectly) as may, or is likely to, create a nuisance or render such water harmful or injurious to public health or safety, or to domestic, commercial, industrial, agricultural or other legitimate uses, or to the life and health of animals or plants or of aquatic organisms. Water is polluted by both natural (volcanic eruptions, earthquakes, tsunamis, underground rocks and soils etc.) as well as man-made activities (sewage, industrial effluents, fertilizers etc.). They are known to alter water and contaminate it.

Water pollution can occur due to pollutants which can be classified into following categories:-

- 1) Biological pollutants:-It includes pathogens like bacteria, viruses, worms, protozoans etc.
- 2) Chemical pollutants:-It includes Organic waste (dyes, pesticides etc.), heavy metals (Mercury, cadmium, chromium etc.), nutrients (nitrogen, phosphorus, chlorides, fluorides etc.)
- 3) Physical pollutants:- Physical pollution is change in physical properties of water e.g. temperature, colour, turbidity, suspended solids etc. It is caused due to waste heat, construction, eroded stream banks, mining sites etc.

Types of water pollution

Surface water:- Water resources like huge oceans, lakes, and rivers etc. are called surface waters. Contaminants such as chemicals, nutrients, and heavy metals are carried from farms, factories, and cities into streams and rivers and then to seas and oceans. Our seas are also sometimes spoiled by oil spills.

Ground water:- Water stored underground in aquifers is known as groundwater. Groundwater gets polluted when contaminants (pesticides, fertilizers) or waste leached from landfills and septic systems make their way into an aquifer, rendering it unsafe for human use. It is virtually impossible to remove contaminants from groundwater. Groundwater can also spread contamination into streams, lakes, and oceans.

Sources of Water Pollution

Point source: When contamination originates from a single source such as a pipe, such as a discharge pipe attached to a factory.

Nonpoint source: When contamination is derived from diffuse sources. This type of pollution is often the cumulative effect of small amounts of contaminants gathered from a large area. These may include agricultural runoff or debris from land into waterways.

Transboundary: When contaminated water from one country enters into waters of another country e.g. radioactive waste from reprocessing plant in England is carried by the Gulf Stream to

the Norwegian coast; traces of PCBs have even been found in birds and fish in the Arctic. They were carried there through the oceans, thousands of miles from where they originally entered the environment.

Causes of water pollution:

1) Waste water:- With billions of people on the planet, disposing of waste water is a major problem. According to a new report released by the World Health Organisation (2017), more than two billion people lack access to clean and safe drinking water. Used water is wastewater. It comes from our sinks, showers, and toilets (sewage) and from commercial, industrial, and agricultural activities (metals, solvents, and toxic sludge). It also includes storm water runoff, which occurs when rainfall carries road salts, oil, grease, chemicals, and debris from impermeable surfaces into our waterways. Over 30 billion tons of urban sewage discharged into lakes, rivers and oceans each year. Wastewater also harbors pathogenic organisms.

2) Nutrients: Nitrogen and phosphorus are the most valuable **nutrients** in **sewage** sludge. Chemical fertilizers used by farmers also add nutrients to the soil, which drain into rivers and seas. Rain washes fertilizers, pesticides, and animal waste from farms and pathogens into our waterways. Together, **sewage and fertilizers** can cause a massive increase in the growth of algae or plankton.

3) Industrial waste: Industrial waste contains pollutants like asbestos, heavy metals (lead, mercury, cadmium etc.) and petrochemicals which are extremely toxic to both people and environment. Leather and chemical industries are major contributors of water pollution. Around 70% of the industrial waste is dumped into the water bodies.

4) Radioactive waste:- Radioactive substances are used in nuclear power plants, industrial, medical and other scientific processes. They can be found in watches, luminous clocks, television sets and x-ray machinery. There are also naturally occurring radioisotopes from organisms and within the environment. If not properly disposed of, radioactive waste can result in serious water pollution incidents.

5) Oil Pollution: Oil Pollution is contamination of environment due to the introduction/presence of oil in excessive quantity. Marine water is especially affected by this form of pollution. Oil spill occurs due to the release of a liquid petroleum hydrocarbon into the aquatic environment. They are caused by *breakage of oil tankers, oil pipe leakage, human transport or recreational activities cleaning of tanks*, refineries, drilling rigs and storage facilities.

6) Solid Waste: Dumping of solid wastes and litters in water bodies' cause huge problems. Litters include glass, plastic, aluminum, Styrofoam etc. Every day, humans are generating millions of tons of solid waste, some of it ends up in landfills, and some enters the waterways by accident or through illegal dumping. Most of that litter (approximately 70%) is plastics,

with metal and glass contributing to the remainder. About 80% of the water pollution is caused due to domestic sewage like throwing garbage on open ground and water bodies.

7) **Alien species:** Alien species (sometimes known as **invasive species**) are animals or plants that have been introduced into a different ecosystem where they do not belong. Outside their normal environment, they have no natural predators, so they rapidly run wild, crowding out the usual animals or plants that thrive there. Common examples of alien species include zebra mussels in the Great Lakes of the USA, which were carried there from Europe by ballast water. In the Black Sea, an alien jellyfish called *Mnemiopsis leidyi* reduced fish stocks by 90 percent after arriving in ballast water.

8) **Thermal pollution:-** is the degradation of water quality by any process that changes ambient water temperature. It includes warm water from cooling towers, floating debris, foam, and garbage. In nuclear plants, water is used in large quantity to cool reactors. Warmer water is also generated in power plants. The discharge of high-temperature water into a natural body of water can affect the downstream habitats, therefore altering the ecological balance. Unsafe removal of could increase water temperature by 18°F. Due to global warming, there is also an increase in water temperature.

9) **Air pollution:** When cars, trucks, and power plants etc. burn fossil fuels, they emit particulates into the air. These particulates eventually settle into waterways and head for the sea. Rain becomes acidic due to air pollution and falls on land and water bodies.

Effects of Water Pollution

1) **Water related Diseases:-**On an average 250 million people worldwide succumb to diseases related to water pollution.

Pathogens are responsible for causing following diseases:

- **Waterborne diseases:** including cholera, typhoid, and dysentery etc. are caused by drinking water containing infectious viruses or bacteria, which often come from human or animal waste.
- **Water-washed diseases:** such as trachoma and scabies, are caused by lack of clean water.
- **Water-based diseases:** such as schistosomiasis, dracunculiasis etc. spread by organisms that develop in water and then become human parasites.
- **Water-related:** insect vectors, such as mosquitoes, black fly breed in or near water and spread diseases, including dengue, malaria, filariasis etc.

Besides pathogens contaminated water also contains toxic heavy metals:

Mercury: It may have toxic effects on the nervous, digestive and immune systems, and on lungs, kidneys, skin and eyes. It is a threat to the development of the child in utero and early in life. A significant example of mercury exposure affecting public health occurred in Minamata, Japan, between 1932 and 1968, where a factory producing acetic acid discharged waste liquid into Minamata Bay. The discharge included high concentrations of methylmercury. The bay was rich in fish and shellfish, providing the main livelihood for local residents and fishermen from other areas. For many years, no one realised that the fish were contaminated with mercury, and that it was causing a strange disease in the local community and in other districts. At least 50 000 people were affected to some extent and more than 2000 cases of Minamata disease were certified. Minamata disease peaked in the 1950s, with severe cases suffering brain damage, paralysis, incoherent speech and delirium.

Cadmium: It causes nausea, vomiting, diarrhea, muscle cramps, salivation, sensory disturbances, liver injury, convulsions, shock and renal failure. **Itai-itai disease** was the name given to the mass cadmium poisoning of Toyama Prefecture, Japan, starting around 1912. The cadmium was released into rivers by mining companies in the mountains. The cadmium and other heavy metals accumulated at the bottom of the river and in the water of the river. This water was then used to irrigate the rice fields. The rice absorbed heavy metals, especially the cadmium. The cadmium accumulated in the people eating contaminated rice. Cadmium poisoning causes weak and brittle bones, pain in spine and legs, coughing, anemia and kidney failure.

Nitrate: Nitrate fertilizers used on soil enter our water bodies. It not only makes water unfit for drinking but also causes diseases. In human body, the nitrates are converted to nitrites by microbial flora of intestine. These nitrites then combine with the hemoglobin of blood to form methaemoglobin, which interferes with the O₂ carrying capacity of the blood. The disease produced is called methaemoglobinaemia or Blue Baby Syndrome. Symptoms include shortness of breath and blue coloration of skin. Nitrate poisoning is frequent in Rajasthan due to hard and saline water. Several children have died due to this problem.

Fluoride: Ingestion of excess fluoride, most commonly in drinking-water, can cause fluorosis which affects the teeth and bones. Chronic high-level exposure to fluoride can lead to skeletal fluorosis, include stiffness and pain in the joints. Acute high-level exposure to fluoride causes abdominal pain, excessive saliva, nausea and vomiting. Seizures and muscle spasms may also occur. Many people in Rajasthan have humped back due to high fluoride content in water sources .

Arsenic: The immediate symptoms of acute arsenic poisoning include vomiting, abdominal pain and diarrhoea. These are followed by numbness and tingling of the extremities, muscle cramping and death, in extreme cases. Long-term exposure to high levels of inorganic arsenic include pigmentation changes, skin lesions, hard patches on the palms and soles of the feet (hyperkeratosis), skin cancer, cancers of the bladder and lungs. In China (Province of Taiwan), arsenic exposure has been linked to “Blackfoot disease”, which is a severe disease of blood vessels leading to gangrene.

Lead: Lead poisoning leads to nausea, vomiting, anemia, damages nervous system and kidneys.

2) Eutrophication (Gr. *eutrophos*= well-nourished): Although phosphorus and nitrogen are necessary for plant growth but in excess levels they overstimulate the growth of aquatic plants and algae. This process of nutrient enrichment is called as eutrophication. It may also trigger toxic algal blooms like red tides,

brown tides, and the growth of *Pfiesteria*. *Pfiesteria* is a single-celled organism that can release very powerful toxins into the water, causing bleeding sores on fish, and even killing them. Some algal blooms are toxic to plants and animals. When the algae die or are eaten, neuro- and hepatotoxins are released which can kill animals and may pose a threat to humans e.g. shellfish poisoning. Biotoxins created during algal blooms are taken up by shellfish (mussels, oysters) and poisoning humans on consumption of shellfish. Toxic algal blooms disrupt tourism due to foul odors and unsightly views, and poisoned fish affect recreational and commercial fisheries. Decomposition of blooms also leads to depletion of oxygen in water. Thus in a poorly oxygenated water with higher CO₂ levels, fish and other animals begin to die and clean water body turns into a sinking drain. Eutrophication is induced by the discharge of nitrate or phosphate-containing detergents, fertilizers, or sewage into an aquatic system.

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3) Biomagnification: It is also known as bioamplification or biological magnification. It is increase in concentration of a substance, such as a toxic chemical, in the tissues of tolerant organisms at successively higher levels in a food chain. Persistent organic pollutants or POPs like DDT (dichlorodiphenyltrichloroethane), hexachlorobenzene (HCB), PCBs (polychlorinated biphenyls), monomethylmercury etc. show biomagnification.

E.g. DDT when enters an aquatic ecosystem, it keeps on moving from water to different living components of the aquatic system and its concentration continuously increases in successive trophic levels in a food chain

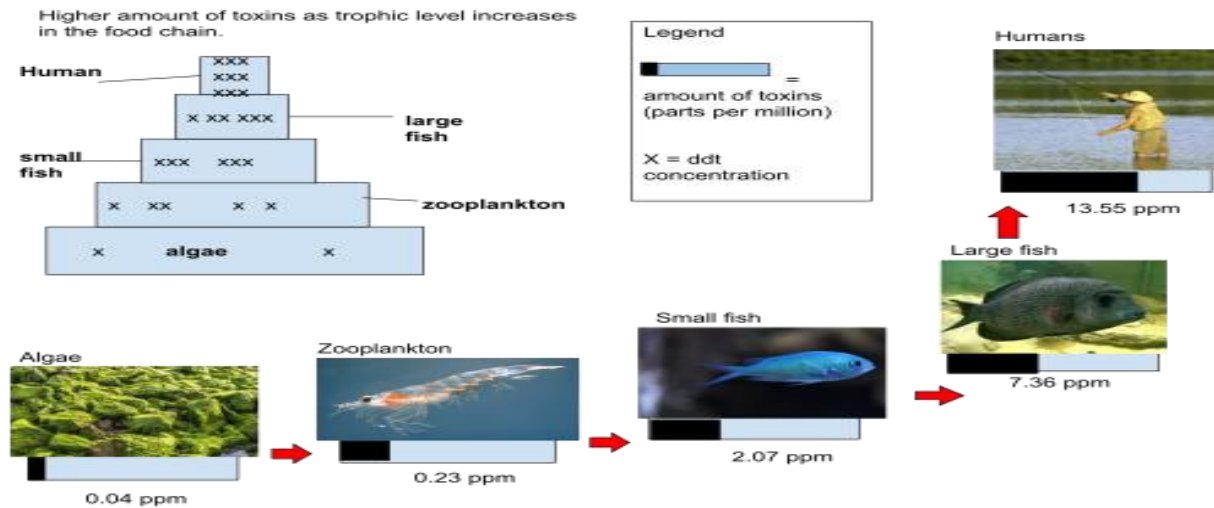


Fig. Biomagnification in food chain

Besides POPs, heavy metals and radionuclides (strontium-90) also show biomagnification. If bioaccumulators destroy keystone species in an ecosystem, it can lead to extinction of many species. In addition, in the 1960s, scientists discovered that overusing of DDT led to its accumulation in soil, water and organisms. It affected predatory birds, including fish eating bald eagles, by thinning their egg shells, leading to drop in their population. Some heavy metals adversely affect the nervous

system, liver, kidneys and circulatory system. Some can cause reproductive problems or cancer. Many POPs are capable of endocrine disruption within the reproductive system, the central nervous system, or the immune system.

4) Thermal pollution has adverse effects on aquatic life. It leads to early hatching of fish eggs, failure of trout eggs to hatch, failure of salmon to spawn, increase in BOD, change in diurnal and seasonal behaviour and metabolic responses of organisms, significant shift in algal forms and other organisms towards more heat-tolerant forms leading to decrease in species diversity, changes in macrophytes and migrations of some aquatic forms. Warmer water causes deoxygenation of water bodies leading to death of aquatic animals.

5) Marine ecosystem is also under threat due to following:

Marine debris:-Marine ecosystems are also threatened by marine debris, which can strangle, suffocate, and starve animals. Marine plastic pollution has impacted at least 267 species worldwide, including 86% of all sea turtle species, 44% of all seabird species and 43% of all marine mammal species. The impacts include fatalities as a result of ingestion, starvation, suffocation, infection, drowning, and entanglement.

Oil spill destroys the insulating ability of fur-bearing mammals, such as sea otters, and the water repellency of a bird's feathers, thus birds and mammals will die from hypothermia. Many birds and animals also ingest oil when they try to clean themselves, which can poison them. When exposed to oil, adult fish may experience reduced growth, enlarged livers, changes in heart and respiration rates, fin erosion, and reproduction impairment. Oil also adversely affects eggs and larval survival.

Ocean acidification:-Oceans are becoming more acidic due to increase in carbon pollution. This has made it harder for shellfish and other species to build shells and may impact the nervous systems of sharks, clownfish, and other marine life. It has also lead to bleaching of corals.

6) Suspended sediment reduces the amount of light penetration into the water column and hence reduces the energy available for photosynthesis by aquatic organisms. A reduction in algae results in a major loss of food for invertebrates hence affecting the whole food web. Under extreme or prolonged exposure to sediments, there is physical damaging and clogging of gills of fish ultimately causing its death.

Control Measures

Following are some of the measures to control water pollution:

1) Recycling and Reuse of water: Re-cycling and re-use are other ways to prevent water pollution which can improve the availability of fresh water. The use of low quality water, such as treated wastewater in the industries water can be used for washing vehicles and we should use only good quality water for drinking

purposes. The reclaimed polluted water can be used in making fertilizers as it is rich in phosphorous, potassium and nitrogen. It can also be used for the irrigation and factories purposes.

2) Preventing soil erosion: To prevent water from getting polluted, we should prevent soil erosion. We have to plant more trees to stop soil erosion. We must adopt soil conservation techniques and manage catchment areas.

3) Cleaning of water ways and the beaches: Cleaning is required on a regular basis. Travel through sea, residence near sea shores and tourism has resulted into pollution of water bodies.

4) Adopting organic farming: Overuse of fertilizers and pesticides should be avoided. In fact, organic manure should be used as it will control runoff of harmful chemicals into water bodies. States like Sikkim and Kerala are totally doing organic farming.

5) Industries should behave more responsibly: Most of industries throw their wastes into the rivers which are toxic to living organisms. To prevent water pollution from industrial wastes, these wastes should be disposed of properly. Industries are also required to modify their methods of manufacturing or develop techniques to prevent water pollution. . For example, Roorkee-based Central Building Research Institute has successfully tried to transform the ash from the thermal power stations into bricks.

6) Avoiding hazardous material: It is also extremely important to adopt the correct methods of the disposal of toxic wastes. Oil leak from the automobiles, ships and other machines poses bigger threat and have become major contributors for water pollution. Safe disposal and clearance of the oil should be done. At the international level, there should be ban on nuclear tests in the ocean. Plants like water hyacinth, salvinia etc. can be used to treat the polluted water.

7) Cooling towers, cooling ponds and spray towers can be used to control thermal pollution.

8) Compliance with all the laws regarding water pollution: Effective implementation of established laws could reduce water pollution effectively.

9) Sewage treatment plans: We should set more and more sewage treatment plans as they convert pollutants into non-toxic substances. The presence of radioactive wastes in the water can also be removed by oxidation ponds.

10) Educating people and Media involvement: People should be educated on the harmful effects of water through environmental communication. Like immersion of idols during religious ceremonies to be done at appointed places only. Garbage in the cities and towns should be classified and thrown into the designated dustbins only. Dead bodies should not be thrown in the river.

