WATER POLLUTION

INTRODUCTION

Water is abundantly available in nature. It is an essential constituent of all animal and vegetable matter and form about 75% of the matter of Earth's crust. It is also an essential ingredient of animal and plant life. Water is distributed in nature in different forms, such as rain water, river water, spring water and underground in aquifers. Rain water is the purest form of naturally occurring water. Water pollution is the contamination of natural water present in lakes, rivers, streams, oceans, and groundwater due to inflow or deposition of pollutants directly or indirectly into the water systems. Any modifications or change in the chemical, physical and biological properties of water that can cause any harmful consequences on living things and the environment is known as water pollution. Water pollution is very often caused by human activities. In most of the developing countries the major cause of death is consumption of polluted water. Water pollution affects all living species, populations and the complete functioning of the ecosystem that lives in the waters.

SOURCES OF WATER POLLUTION

Classifications of water pollution according to identifiability, can be either a Point or a Nonpoint Source. Point source refers to the pollutants that belong to a single identifiable source. The ources are called point sources because in mathematical modeling, they can be approximated as a mathematical point to simplify analysis. Nonpoint source pollution can include:

- ➢ on-site septic systems
- ➢ leaky tanks or pipelines containing petroleum products
- ➢ municipal landfills
- ➢ livestock wastes
- ➢ industrial/factory wastewater
- ➢ municipal sewage treatment plants

Non-point source on the other hand are pollutants emitted from multiple scattered sources. Nonpoint sources of pollution are often termed 'diffuse' pollution and refer to those inputs and impacts which occur over a wide area and are not easily attributed to a single source. Nonpoint source pollution is a combination of pollutants from a large area rather than from specific identifiable sources . Different spatial land uses and runoff is generally associated with nonpoint source of pollution.

Nonpoint source pollution can include:

➤ Excess fertilizers, herbicides and insecticides from agricultural lands and residential areas

➤ Oil, grease and toxic chemicals from urban runoff and energy production

➤ Sediment from improperly managed construction sites, crop and forest lands, and eroding stream banks

➤ Salt from irrigation practices and acid drainage from abandoned mines

➤ Bacteria and nutrients from livestock, pet wastes and faulty septic systems

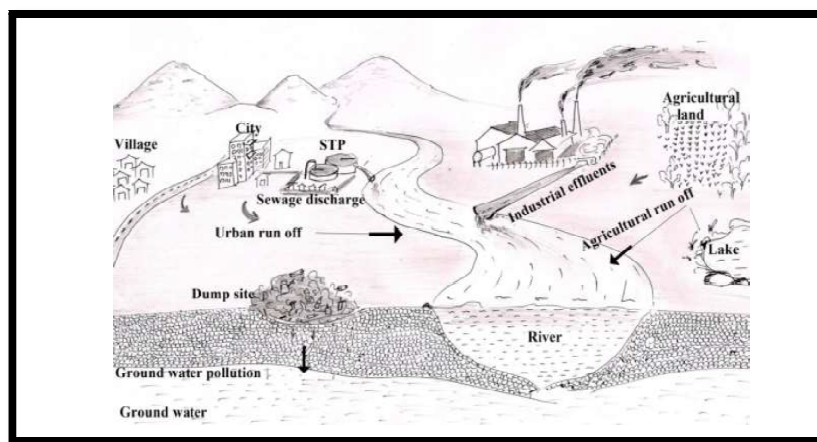➤ Atmospheric deposition and hydro modification

Figure: Examples of potential sources of contamination for surface and ground water

According to the activities, the sources of water pollution can be described as follows

1. Industry

Most industries generally produce wastes containing toxic heavy metals along with hazardous organic and inorganic effluents. These chemicals contaminate the ground water and severly pollute it. These pollutants ultimately find their way in effluents discharged by industries, which cause water pollution and damage to us and our environment. They contain pollutants such as lead, mercury, sulphur, asbestos, nitrates and many other harmful chemicals. Many industries do not have proper waste management system and drain the waste in the fresh water which goes into rivers, canals and later in to sea. The toxic chemicals have the capability to change the color of water, increase the amount of minerals, change the temperature of water and pose serious hazard to water organisms.

2 Sewage and waste water

Every day wastewater from sinks, dishwashers, clothes washers and toilets flows into sewer pipes containing pathogenic organisms, nutrients and solids from domestic wastes. Leakage from the sewer lines can contaminate the underground water and make it unfit for t drinking. Also, when not repaired on time, the leaking water can come on to the surface and become a breeding ground for insects and mosquitoes. The sewage water carries harmful bacteria and chemicals that can cause serious health problems. Pathogens are known as a common water pollutant; the sewers of cities house several pathogens and thereby diseases (Table) Microorganisms in water are known to be causes of some very deadly diseases and become the breeding grounds for other creatures that act like carriers. These carriers inflict these diseases via various forms of contact onto an individual. A very common example of this process would be malaria.

3 Mining activities

Mining is the process of crushing the rock and extracting coal and other minerals from underground. These elements when extracted in the raw form contain harmful chemicals and can increase the amount of toxic elements when mixed up with water, may result in health problems. Mining activities emit several metal waste and sulphides from the rocks and is harmful for the water. Acid mine drainage causes the acidity of water, which in turn disturb the chemical composition of water source by dissolving and freeing some harmful substances.

4 Agriculture run-off

The water leaving from agricultural land is known as agricultural runoff. Runoff could be due to drainage by rain or by irrigation. Fertilizers , pesticides , insecticides , processing wastes and animal wastes etc. are constantly added to the water. Leachates from agricultural land containing nitrates, phosphates and potash , move horizontally as into surface water posing danger. For generations, thousands of acres of farmland have been cultivated throughout. Nutrient-rich water from farm fields is drained or pumped into natural water bodies without treatment which the impact water quality. This overabundance of nutrients encourages algal blooms i.e. overgrowth of aquatic weeds, that deplete oxygen from the water and block sunlight from reaching underwater vegetation, critical to fish and wildlife habitats. Nitrogen pollution comes from many sources, including from the fertilizers used on lawns and in landscaping. This nitrate-rich water makes its way to surface waters as runoff during rainfall or over-irrigation, or it may drain slowly from the soil over time.

5 Marine dumping

In some countries the garbage produce by each household in the form of paper, aluminum, rubber, glass, plastic, food if collected and deposited into the sea. These items take from 2 weeks to 200 years to decompose. When such items enter the sea, they not only cause water pollution but also harm animals in the sea. Also waste from recreational activities and waste from travelling vessels are thrown into the oceans, causing ocean pollution.

6 Accidental leakage

Marine pollution: Oil spill pose a huge concern as large amount of oil enters into the sea which does not dissolve with water; there by opens problem for local marine wildlife such as fish, birds and sea otters etc. For example, a ship carrying large quantity of oil may spill oil if met with an accident and can cause varying damage to speciein the ocean depending on the quantity of oil spill, size of ocean, toxicity of pollutant.

7 Burning of fossil fuels

Fossil fuels like coal and oil when burnt produce substantial amount of ash in the atmosphere. The particles which contain toxic chemicals (often of sulfur, which is present in coal) when mixed with water vapor result in acid rain. Also, carbon dioxide is released from burning of fossil fuels which result in global warming which in turn affect the global water cycle.

8 Facilities handling radioactive materials

The element that is used in production of nuclear energy is Uranium which is a highly toxic chemical. Nuclear waste can have serious environmental hazards if not disposed-off properly. Few major accidents have taken place in Russia, USA and Japan. Nuclear research centers and medical sector also handles radioactive materials. From such sources negligence or accidental release of radioactive material causes water pollution. Mining also expose the environment to the radioactive materials.

9 Urban development and run off

Growing population demands more for housing, food and cloth. As more cities and towns are developed, they have resulted in increased use of fertilizers to produce more food, soil erosion due to deforestation, increase in construction activities, inadequate sewer collection and treatment, landfills as more garbage is produced, increase in chemicals from industries to produce more materials. Runoff from urban areas contains large concentration of oils, greases, nutrients, heavy metals and detergents. The detergents being soluble can pass through the soil

and pollute ground water. Raw sewage dumped in shallow soak pits and seepage from polluted lake, pond or stream also pollutes water.

CLASSIFICATION OF WATER POLLUTANTS

Water pollutants can be divided into four major categories- Chemical, Physical, Physiological and Biological. Though the physical and physiological pollutions are mainly outcomes of chemical pollutants, they are categorized separately because of their nature.

1 Chemical Pollutants: Chemical pollutants can further be divided into Organic pollutants and inorganic pollutants.

Organic pollutants: Organic pollutants are the compounds those contain carbon atom in them and mainly of biological origin. These are the oxygen depleting substances in water. They are carried to the water course from different sources like sewage, animal and human excreta, refineries, distillery, pulp and paper industry, tanneries, diary industry, textile industry, slaughter houses etc. BOD and COD is common indicator of high organic content of waste water. The organic pollutants could be further subdivided into two.

Biodegradable organic pollutants

These are the organic materials which can be easily degraded by microorganisms. Most of the naturally occurring organic compounds (originated from plants and animals) are biodegradable. Examples are given in the table below.

Non-biodegradable organic pollutants

These are the organic materials which are resistant to biological degradation. Most of these are synthetic organics, which are of high concern. Examples are given below in table. Some naturally occurring organic compounds biodegrade so slowly that they are considered refractory. For example, lignic acid, tannic acid, cellulose, and many of the organics associated with petroleum.

Table: Examples of some organic pollutants

Types of Organic pollutants	
Biodegradable organic pollutants	**Non-biodegradable organic pollutants:**
Proteins, fats, carbohydrates, alcohols, acids, aldehydes, esters, soaps etc.	Pesticides (DDT, aldrin, dieldrin, endrin, endosulfan, lindane, toxaphene, mirex, heptachlor etc.), polychlorinated biphenyls (PCB's), polyaromatic hydrocarbons (PAH's), plastics, dioxins, furans, phenols, dyes, detergents etc.

Inorganic pollutants:

Inorganic pollutants include inorganic acids, alkalis, salts, anions, cations, free chlorine, ammonia etc. They are added a result of industrial effluents, sewage, household cleansers and surface run-off from urban and agricultural field etc. They affect the physical and chemical quality of water. Some common inorganic pollutants are given below in table:

Table: Common inorganic pollutants found in water

Pollutant	Examples
Acids	Phosphoric acid, sulfuric acid, hydrochloric acids etc.
Alkalis	Sodium hydroxide, lime etc.
Cations	Calcium, magnesium, sodium, potassium, ammonium, iron, manganese, aluminium, mercury, lead etc.
Anions	Phosphates, sulphates, chlorides, nitrites, nitrates, cyanides, carbonates, bicarbonates etc.

2 Physical Pollutants

These are the pollutants which deteriorate the physical parameters of water quality. These include color, turbidity, suspended matter, radioactivity, froth and thermal pollutants

Color: Colour affects the aesthetic value of water body. It may or may not be harmful for health e.g. green color of water body due to humic acid (vegetable origin). Harmful color producing chemical includes various dyes, toxic colored compounds of iron and chromium etc. Color is also produced by pigments like that of microalgae.

Turbidity: Turbidity is due to colloidal particles which do not settle in standing water. It may be due to presence of inert and harmless material like clay or due to presence of chemicals like hydrated iron oxide, aluminum hydroxide and organic substances etc. Greater turbidity means presence of greater amount of pollutants in water, but absence of turbidity does not mean that water is unpolluted.

Suspended matter: These are coarse and insoluble matter suspended in water. Natural suspended matters which are not harmful for health include silt, clay, sand and rock particles etc. The suspended matter of sewage and industrial origin are particularly harmful to health.

Radioactivity: Radioactive pollution occurs due to presence of radionuclides. Radioactive elements are naturally present in earth crust particularly in granite rocks and responsible for background radioactivity. It is very low. Problem arises when radionuclides of high radioactivity

are released into water by human activities. Some radioactive elements include plutonium, uranium, thorium, radon, iodine, neptunium, americium, cesium, curium, strontium-90, radium- 226, cesium-137, phosphorus-32 etc.

Froth: Froth formation occurs due to presence surfactants like soaps, detergents, fatty acids and saponins etc. these lower the surface tension of water. Sodium lauryl sulfate and Sodium lauryl ether sulfate are common surfactants found in personal care products. Blowing agents like gases (e.g. carbon dioxide), baking powder, isocyanate etc. help in foam formation.

Thermal pollution: Thermal pollution is increase in temperature of water body due to discharge of heated water or wastewater into the watercourse. Waste heat is mainly discharged into water by nuclear and thermal power plants, and by industries involving water as coolant in industrial manufacturing. Increased water temperature leads to depletion of oxygen and increased respiration.
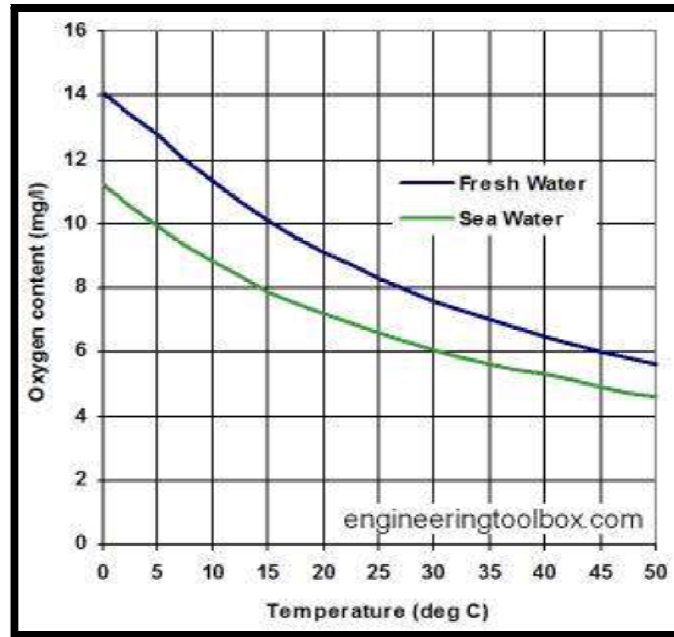
Fig.: Effect of thermal pollution on dissolved oxygen in water

3 Physiological Pollutants

Physiological pollution, as said earlier, is caused by presence of some chemicals. Physiological pollutions are of two types- taste and odour.

Taste: Many chemical compounds are released by industrial waste, which impart unpleasant taste to the water.

Odour: Odour in water is mainly produced by presence of volatile organics or due to metabolites produced by microorganisms.

Table: Physiological pollutants imparting characteristics taste or odour to water

	Pollutants	Characteristics
Taste	Synthetic detergents	Mouldy taste
	Phenols	Phenolic taste
	Chlorophenols	Intense, objectionable taste
	Aromatic nitro derivative	Bitter almond taste
Odour	Indole, skatole	Unpleasant fecal odor
	Methyl/dimethyl amines	Fishy odour
	Organo sulfur (methyl/ethyl mercaptans)	Putrid smell
	Hydrogen sulfide	Rotten egg smell
	Organo phosphorus	Fishy smell
	Aldehydes, cyano derivatives	Bitter almond smell
	By-products of microorganism metabolism	Various smells like fishy to grassy

Biological Pollutants

The biological pollution occurs due to introduction and growth of micro and macro organisms in water body, which adversely affect the quality of water, human health and ecosystem. Various biological pollutants include bacteria, algae, weeds, viruses, protozoa and worms. Table shows the various biological pollutants found in water.

Table: Some common biological pollutants

Biological pollutants	Examples
Bacteria	*E. coli, Salmonella, S. typhi, Vibrio cholera, Clostridium botulinum* etc.
Algae	Various macro and micro algae, some produces toxins
Virus	Hepatitis A virus, Poliovirus etc.
Protozoa	*Entamoeba histolytica, Naegleria fowleri, Cryptosporidium parvum, Cyclospora cayetanensis, Giardia lamblia* etc.
Worms	Round worms, tape worms, flukes etc.
Weeds	Hydrilla, potamogeton, ceratophyllum etc

Table: Water borne pathogens and diseases caused by them

Disease	Pathogens
Amoebiasis	*Entamoeba histolytica*
Giardiasis	*Giardia lamblia*
Botulism	*Clostridium botulinum*
Cholera	*Vibrio cholera*
Dysentry	*Shigella dysenteriae*
Typhoid fever	*Salmonella typhi*
E.coli infection	*Escherichia coli*
Hepatitis A	*Hepatovirus A*
Polio	*Poliovirus*

Groundwater pollution

Groundwater is is found underground in soil or under rock structures called aquifers. About 25% of the planet's overall fresh water supply is groundwater, while surface water stored in rivers, lakes and soil moisture accounts for less than 1%. Groundwater and surface water are often closely interconnected, so when surface water becomes polluted, groundwater can become contaminated as well. lot of the Earth's water . Humans often use aquifers as a means to obtain drinking water, and build wells to access it. When this water becomes polluted it is called groundwater pollution.

Groundwater pollution is often caused by pesticide contamination from the soil, this can infect our drinking water and cause huge problems. Spilling gasoline, oil, paint thinners, etc. onto the ground can contaminate groundwater. Groundwater pollution is a low-risk ecological problem but high-risk health problem. Contaminated water in the aquifer will slowly flow, creating a plume of contaminated water. Contaminants in groundwater are not diluted or dispersed because this water moves usually less than 0.3 meter per day, polluted groundwater has very slow cleansing rate due to the low dissolved oxygen and low bacterial count. It can take hundreds of years to cleanse degradable wastes and non degradable wastes are there permanently.

Factors affecting ground water pollution

The extent of ground water pollution depends on the following factors:

1. Rainfall pattern
2. Depth of water table.
3. Distance from the source of contamination and
4. Soil properties such as texture, structure and filtration rate.

Figure: Point and non point sources of ground water pollution

SOME MAJOR INCIDENCES OF WATER POLLUTION

1. Minamata episode

In Minamata city of Japan, disastrous effects of mercury poisoning, was observed in 1956. Chisso coporation, a chemical manufacturing company of Minamata, discharged huge amount of pollutants including mercury into the Minamata bay, which causes the disease known as Minamata disease. The symptoms of this disease include numbness in hands and feet, general muscle weakness, lack of coordination in muscles (ataxia), damage to vision, hearing or speech, paralysis, coma and death in extreme cases. This disease claimed thousands of death of humans and other animals. The researchers took 2 to 3 years to find out the reasons of Minamata disease, since the mercury released by chemical company was inorganic and had relatively low toxicity. But a high level of organic form of mercury (methyl mercury) was reported in fish and shellfish of Minamata bay. Actually inorganic mercury was enzymatically converted into methyl mercury. by methane synthesizing anaerobic bacteria. Acidic medium facilitates this conversion. Methyl

mercury is very toxic, soluble in water and has ability to bioaccumulate through food chain. It enters the food chain through phytoplankton and concentrates thousands of times in fishes on higher trophic level. Consumption of such fish causes disease in man and other animals. This incidence of Minamata is the best example of how one type of pollutant can be converted into other types by environmental factors.

2. Itai itai disease

This disease, due to cadmium poisoning, was first reported in 1912 in Toyama, Japan. Cadmium was released into the rivers as a result of mining activities in Toyama region and continued for years. The water of Jinzu river and its tributaries was used as drinking water, fishing and other general purposes but mainly in rice fields. Rice absorbs heavy metal, Cadmium. On consumption of contaminated rice the cadmium got accumulated in peoples and manifested its ill effect. Cadmium poisoning causes softening of bones and kidney failure. Symptom of cadmium poisoning that is weakness of bones results in spinal and leg pain. Painful screams of victim "Ouch-ouch" is the literal meaning of itai itai.

3. Exxon valdez oil spill

It was one of the largest oil spills. It occurred on 24 March 1989, in the gulf of Prince William Sound, Alaska by oil tanker Exxon valdez. From it about 11 million gallons of crude oil was spilled which heavily polluted about 200 miles of area. The spilled oil caused the death of more than a lakh of seabirds, thousands of sea otters and harbor seals, hundreds of bald eagle and very high number of solmon and herring.

4. Torry canyon oil spill

It occurred off the south west coast of United Kingdom on 18 March, 1967. The Torry canyon oil tanker struck the rocks near Isles of Scilly. The gounding and breaking of oil tanker spilled 25-36 million gallon of oil and it is worst spill in UK history. It contaminated hundreds of km of French and Cornish coast. It claimed life of 15000 seabirds and huge number of other marine organisms. Heavy detergents used to mitigate the problem also caused the damage.