CHAPTER 2

TYPES OF WASTEWATER AND ITS TREATMENT

2.1 Sources of Wastewater

As discussed in Chapter 1, wastewater is an umbrella term used to describe all liquid wastes generated due to human activities. It refers to all discharges from household, commercial establishments, institutions, industries and so on. See Figure 2-1

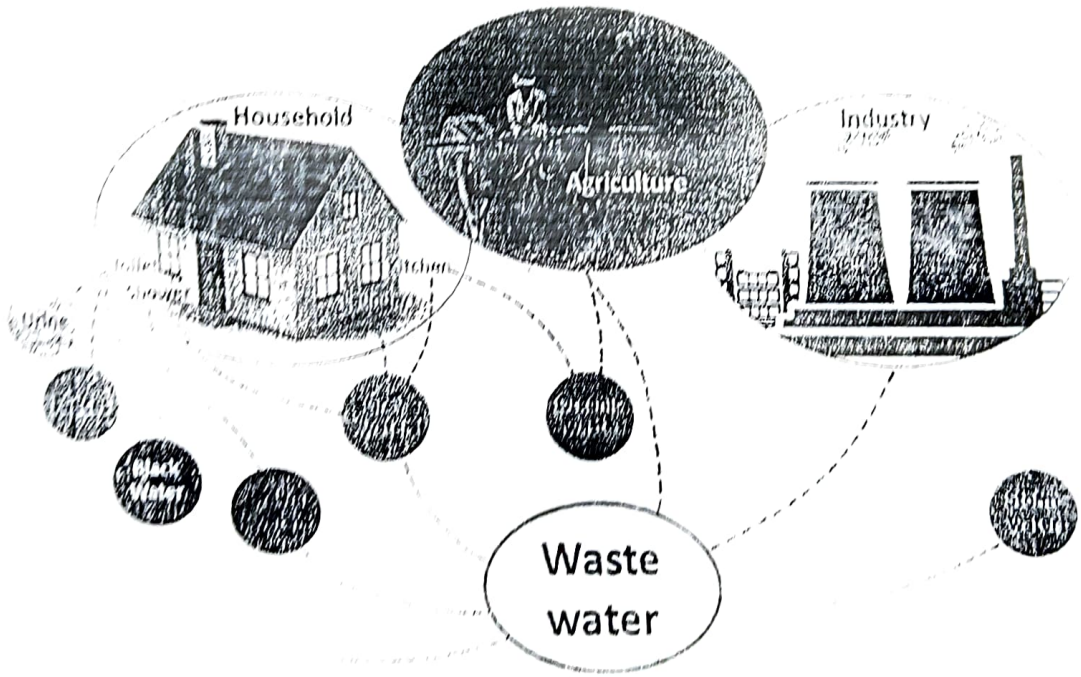

Figure 2-1: Sources of Wastewater

Other sources of wastewater include, storm water and surface runoff, agricultural runoff water used to irrigate fruit and gardens, water from swimming pools etc. Of these agriculture irrigation, livestock watering and cleaning, etc. pose fresh water and the soil at risk associated with added nutrients and contaminants to the local waterbodie

Domestic sources	Industrial sources	Agricultural sources
• Residential buildings • Commercial complexes and Small businesses	• Industrial and manufacturing activities such as chemical, pharmaceutical, oil, mining, and metal industries	• Run-off from agricultural fields and farms

Considering the issues related to collection and treatment, the wastewater from agricultural sources are difficult to manage and are therefore not considered for wastewater treatment. Hence wastewater from agriculture is not discussed further.

2.2 Types of Wastewater

The point sources of wastewater can be divided into two main types depending on the source of generation, i.e. Domestic Wastewater and Industrial Wastewater. These sources of wastewater can further be sub-divided on the basis of the resultant activity from which they are generated. **In this manual, we will understand Domestic and Industrial Wastewater in detail.**

2.2.1 Domestic Wastewater

The wastewater generated from variety of domestic uses such as washing, bathing & flushing toilets is termed as Domestic Wastewater. Washing involves the washing of utensils used in cooking, washing vegetables and other food items, bathing, washing hands, and washing clothes. Similar wastewater also emerges from commercial complexes and small businesses in urban areas and are considered under the heading of domestic wastewater for simplicity of understanding.

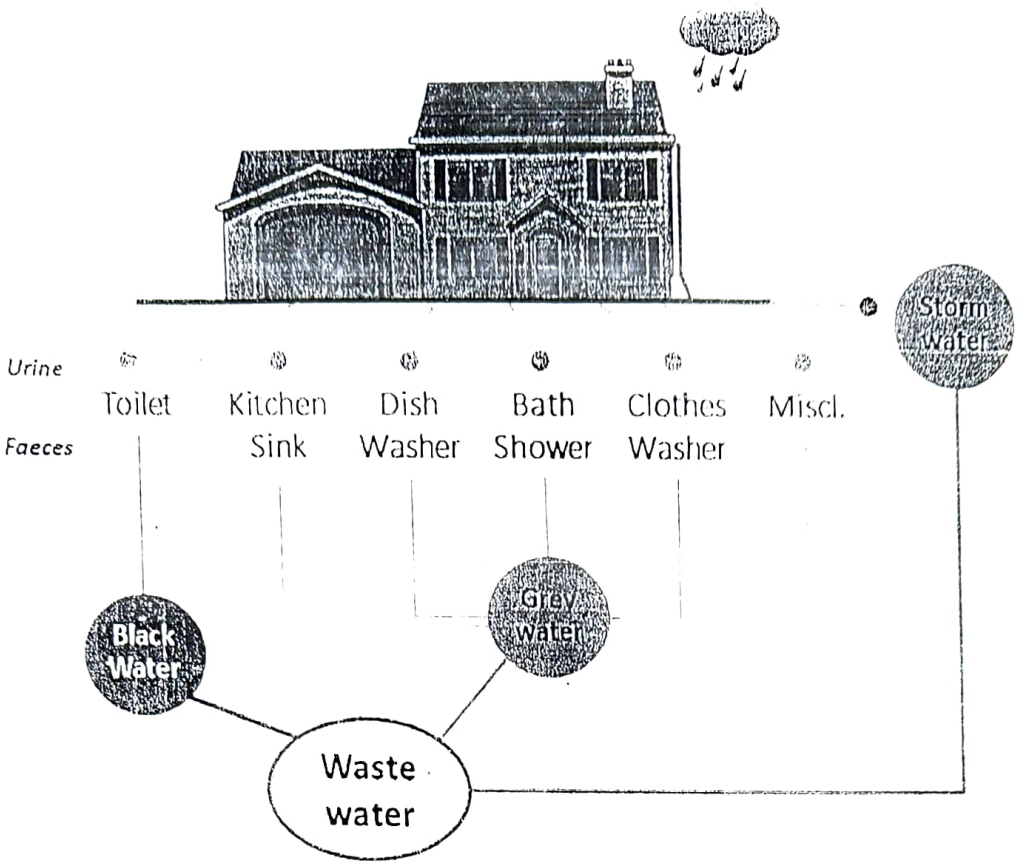

Figure 2-2: Domestic Wastewater - Types and Sources

The domestic wastewater can be further distinctly divided into two categories.

Sewage	Sullage
The wastewater generated due to flushing of toilets to evacuate human excreta and faecal matter along with body liquids is called "Black Water" or Sewage	All other domestic wastewater emerging from other activities are referred as "Grey Water" or Sullage. Sullage, therefore, is water mixed with vegetable matter, oils used in cooking, oil in hair, detergents, dirt from floors that have been washed , soap used in bathing along with oils/greases washed from the human body, etc.

Grey water is easier to purify as compared to black water i.e. sewage. However, the practice predominantly followed in India is to combine these two forms of wastewater to discharge into a public sewer (or into a sewage treatment plant in a residential community/ building that has no access to a public sewer). The mixed wastewater (black water and grey water) is termed as sewage in India.

2.2.2 Industrial Wastewater - Process Wastes and Chemical Wastes

The wastewater discharged from industries vary widely in the quantity and quality depending on the type of processes employed by the industry, the raw materials processed and end product. Further, other sources of wastewater resulting from a wastewater treatment plant, other than the effluent treated water and water from the manufacturing processes also are part of the industrial wastewater. These include

- Thickener supernatant
- Digester supernatant
- Reject water from sludge dewatering
- Drainage water from sludge drying beds
- Filter wash water
- Equipment cleaning water

In general, industrial wastewaters may contain suspended, colloidal and dissolved (mineral and organic) solids. In addition, they may be either excessively acidic or alkaline and may contain high or low concentrations of colored matter. These wastes may contain inert, organic or toxic materials and possibly pathogenic bacteria.

2.2.3 Constituents of Wastewater

Post discussing the types and sources of wastewater, it is important to understand the constituents of wastewater. The constituents of wastewater can be broadly classified under the following categories

- suspended and dissolved inorganic solid substances
- suspended and dissolved organic solid substances

The sewage and industrial wastewater are distinctly different in terms of the constituents that is present in these wastewater. As shown in **Table 2-1**, the wastes include organic, inorganic, and gaseous substances, some of which may be highly toxic, such as lead, mercury and other heavy metals. They will also contain microbial constituents which if untreated has a potential to cause harm to human health and environment

Table 2-1: Constituents of Wastewater

Domestic	Industrial
• Carbohydrates	• Carbohydrates
• Fats, oils and grease	• Fats, oils and grease
• Proteins	• Proteins
• Surfactants	• Surfactants
• Volatile organic compounds	• Volatile organic compounds
• Chlorides	• Chlorides
• Nitrogen	• Nitrogen
• Phosphorus	• Phosphorus
• Sulfur	• Sulfur
• Methane	• Phenols
• Hydrogen sulfide	• Pesticide residues
• Microorganisms such as coliforms, viruses etc.	• Heavy metals • Suspended and Dissolved Solids

While constituents of domestic wastewater do not vary by a large extent, industrial wastewater can have varied composition based on the source of generation. The Table 2-2 and

Table 2-3 highlight the various substances generally found in industrial wastewater in relation to the type of industry generating the wastewater.

Table 2-2: Substances present in industrial effluents

Substances	Activity Sources
Acetic acid	Acetate rayon, beet root manufacturing
Acids	Chemical manufacturing, mines, textile manufacturing
Alkalies	Cotton and straw kiering, wool scouring
Ammonia	Gas, coke and chemical manufacturing
Arsenic	Sheep dipping
Cadmium	Plating
Chromium	Plating, Chrome tanning, alum anodizing
Citric Acid	Soft drinks and Citrus food processing
Copper	Copper plating, cop[per pickling
Cyanides	Gas manufacturing, plating, metal cleaning
Fats, oils, grease	Wool scouring, laundries, textile industry
Fluorides	Scrubbing of flue gases, glass etching
Formaldehyde	Synthetic resins and penicillin manufacturing

Substances	Activity Sources
Free chlorine	Laundries, paper mills, textile bleaching
Hydrocarbons	Petrochemical and rubber factories
Mercaptans	Oil refining and pulp
Nickel	Plating
Nitro compounds	Explosives and chemical works
Organic acids	Distilleries and fermentation plants
Phenols	Gas and coke manufacturing, chemical plants
Starch	Food processing, textile industries
Sugars	Dairies, breweries, sweet industry
Sulfides	Textile industry, Tanneries, gas manufacturing
Sulfites	Pulp processing, viscose film manufacturing
Tannic acid	Tanning, sawmills
Tartaric acid	Dyeing, wine, leather, chemical manufacturing
Zinc	Galvanizing, zinc plating, rubber processing

Table 2-3: Heavy Metals in Wastewater from Major Industries

Industry	As	Cd	Cr	Hg	Pb	Ni	Zn
Pulp and Paper Mills			X	X	X	X	X
Organic Chemicals	X	X	X	X	X		X
Alkalis, Chlorine	X	X	X	X	X		X
Fertilizers	X	X	X	X	X	X	X
Petroleum Refining	X	X	X		X	X	X
Steel Works	X	X	X	X	X	X	X
Aircraft plating, finishing		X	X	X		X	
Flat glass, Cement			X				
Textile mills			X				
Tanning			X				
Power Plants			X				

2.3 Key Monitoring Parameters

Before understanding the effects of untreated wastewater, it is important to understand the key monitoring parameters and how the quality of water is affected by them

There are various parameters through which wastewater is monitored. These parameters (e.g. Hardness, Chemical Oxygen Demand) can either be a resultant of a particular type of compound (e.g. salts, acids) or can be the constituent or pollutant directly (e.g. heavy metals). These parameters can further be divided into physical, chemical and biological parameters. The **Table 2-4** below lists the key monitoring parameters for wastewater

Table 2-4: Key Monitoring Parameters

Characteristics	Monitoring Parameters
Physical	• Dissolved solids • Suspended solids • Color • Odor • Temperature • pH • Turbidity • etc.
Chemical	• pH# • Organic matter measured by - Biochemical Oxygen Demand (BOD)## - Chemical Oxygen Demand (COD)### • Inorganic Matter - Chlorides - Nitrogen - Phosphorus - Heavy metals - Nickel, Manganese, Lead, Chromium, Cadmium, Zinc, Copper, Iron Mercury • Dissolved oxygen • Alkalinity, Hardness, Trace metals, Heavy Metals
Biological	• Fungi • Algae • Protozoa • Viruses • Pathogenic organisms - Coliforms, Faecal Coliforms, Faecal Streptococci, Clostridium perfringens, Salmonella spp., Enteroviruses Rotaviruses

Notes on Monitoring Parameters

#pH - The hydrogen-ion concentration is an important parameter in both natural waters and wastewaters. It is a very important factor in the biological and chemical wastewater treatment process. Water and wastewater can be classified as neutral, alkaline or acidic according to the following pH ranges.

- pH = 7 neutral
- pH > 7 Alkaline
- pH < 7 Acidic

Biochemical Oxygen Demand (BOD) - BOD is a measure of the biodegradable organic matter in the wastewater. It is determined by measuring the dissolved oxygen used by microorganisms during the biochemical oxidation of organic matter in 5 days at 20°C.

Chemical Oxygen Demand (COD) - COD is a measure of the organic matter in the wastewater. It is determined by measuring the dissolved oxygen used during the chemical oxidation of organic matter in 3 hours.

2.4 Environmental Effects of Untreated Wastewater

In certain parts of the world, especially in developing countries, wastewater is pumped directly into the sea or into fresh waterbodies without any form of treatment. In certain cases, the wastewater may also be used for irrigation or discharged onto land. In other parts of developing countries, lack of adequate wastewater treatment infrastructure, maintenance and outdated systems heavily compromise wastewater treatment efforts. The effects of this either untreated or partly treated wastewater can be classified in the following manner

Effect on Man

On a worldwide scale, polluted water is probably responsible for more human illness than any other factor of influence. These diseases transmitted through water are caused majorly by micro-organisms and other small organisms such as worms. Thus sewage and polluted water are responsible for several water-borne diseases such as cholera, typhoid, diarrhea, dysentery etc. It is believed that millions of people including children die each year globally from diarrheal disease. Guin a worm is another disease caused by drinking polluted water. In India alone, it is estimated that about 18 lakh people suffer from this disease

Industrial wastewater carry along with it large number of chemical constituents. These constituents if discharged directly into the freshwater bodies or used for irrigation has the potential to enter the food chain and thus get consumed by man. For example, pesticide residues, heavy metals can over a period of time get accumulated inside the human system and eventually lead to poisoning of the body and can even result in death. In India, a large number of people are dependent on rivers and lakes as the main sources of drinking water. Thus discharge of untreated wastewater into rivers and lakes can affect a large population.

Effect on Aquatic Life and Animals

The effect of water pollution is seen the most on aquatic life, as their existence depends on water. Hence, if there is any disturbance in their ecosystem, there is a direct impact. It is estimated that during the last 20 years, there is a decrease of about 40% in aquatic life. Irregular growth of algae reduces oxygen content in the water by affecting the process of photosynthesis eventually causing the death of fishes and other organisms. Mass killing of fish was among the earliest and most dramatic result of indiscriminate pollution of water. Another type of fish killer is pollution from domestic wastewater. Thermal pollution from industries caused due to increase in the temperature of water is also known to be a major cause of death of marine life. Apart from aquatic life, farm animals are also affected due to water pollution. In India, farm animals are bathed in rivers and lakes, they are also used as sources for drinking water. The animals are exposed to harmful chemicals and microorganism and can be lethal for them. The industrial wastes may pose serious problems on receiving waterbodies, e.g. oxygen depletion, emission of noxious gases, fish kills and change in flora and fauna.

Other Effects

Water pollution: The physical and physiological nature of water undergoes changes due to influx of pollutants. The colour of water changes, mainly due to organic dyes. The colour in itself is not harmful; however, aesthetic considerations make coloured water unsuitable for any purpose.

The turbidity caused by the presence of colloidal or suspended matter is the characteristic trait of sewage and industrial effluents. Generally, more the turbidity, higher is the sewage or effluent and the effects are worse. Foam is the product of water mixed with soaps and detergents. It consists of a suspension of air bubbles in water medium.

Industrial effluents containing chemical substances such as iron, chlorine, phenols, etc., affect the taste of the water. The decomposition of organic matter and algae, fungi and filamentous bacteria also imparts peculiar tastes. Similarly, the odour of water also changes due to the presence of pollutants.

Oil spills have their effect over evaporation. The industrial effluents, which contain several types of chemicals, are also responsible for the loss of soil fertility. In fact, the effects of water pollution are multidimensional in nature.

Groundwater pollution: A great deal of water is held in underground rock structures known as aquifers, which we cannot see and seldom think about. Water stored underground in aquifers is known as groundwater. Aquifers feed our rivers and supply much of our drinking water. When it rains, water seeps into the ground. This water if contaminated with chemicals and nutrients, can contaminate the groundwater resources. In India, groundwater is a major source of water for drinking and irrigation and thus this polluted water can get consumed by humans.

Water Security: Most parts of the world are facing issues arising from water scarcity. Wastewater discharged on lands can trickle into groundwater and contaminate groundwater aquifers. If discharged into freshwater bodies, it may render water sources unsuitable for use.

Ecosystem Services: All ecosystems are connected and they all ultimately depend on water. Similarly, all water surface and underground is connected. This means careless wastewater discharge can have some serious ripple effect. One common effect of wastewater is the eutrophication of fresh waterbodies and oceans. If one part of the ecosystem chain is destroyed, it can upset its entire food chain.

Agriculture/ Fisheries/ Tourism: Wastewater for irrigation may contain unsuitable chemicals and higher concentrations of nutrients needed for crops. This can result in delayed and poor crop yields. Wastewater used for animal farming may also contain harmful substances and chemicals dissolved in them. Animals may die, and there is a chance that humans that consume such animals may be harmed too. In some places, faecal loaded wastewater is discharged directly into the sea. The discharge contains pathogens and harmful dissolved chemicals which can affect fishing in that area. The smell and such behavior do not encourage tourism to that area.

2.5 Significance and Benefits of Wastewater Treatment

Wastewater treatment is a process to improve and purify the wastewater, removing some or all of the contaminants, making it fit for reuse or discharge back to the environment.

A water contaminant is any undesirable substance (physical, chemical, biological) present in water.

Discharge may be to surface water, such as rivers or the ocean, or to groundwater that lies beneath the land surface of the earth. Appropriate treatment of wastewater ensures that acceptable water quality is maintained.

The discharge of untreated or inadequately treated wastewater into water bodies is called water pollution. The pollution of water has a serious impact on all living creatures, and can negatively affect the availability of water for drinking, household needs, recreation, fishing, transportation, and commerce.

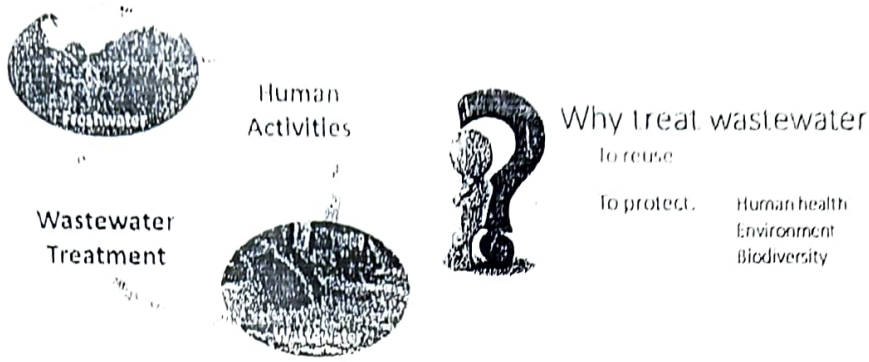

Figure 2-3: Wastewater Usage Cycle

Across the world, there continues to be huge volumes of wastewater pumped directly into rivers, streams and the ocean itself. The impact of this is severe. Apart from the damage to the marine environment and to fisheries it can cause, it does little to preserve water at a time when many are predicting that a global shortage is just around the corner.

As it stands this method of disposing of wastewater, any form of water that has been contaminated by a commercial or domestic process, including sewage and byproducts of manufacturing and mining is largely an issue in developing nations.

The better the treatment process, the higher the percentage of wastewater that is reclaimed and reused before it is released into the ocean. There are a number of industries that are just doing the bare minimum in order to meet the regulatory requirements. This is not the right approach. As the world's population grows and develops, it is important that the right measures are taken to make sure contaminated water is treated properly and recycled wherever possible.