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# WASTEWATER CONTAMINANTS AND TRATMENT

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***Abstract*** - Due to increase in industrialization, population and urbanized societies, the world is facing problem of wastewater management. Every day, effluent generated from various activities from various wastewater generating sources and these are the main cause of pollution in receiving body. Contaminant, which is usually present in wastewater in many forms, is known to be toxic for aquatic life as well as human life. Some of these pollutants are pathogenic microorganisms, phosphorus and nitrogen, heavy metals, organic matter. The main sources of microbial contaminants in wastewater are human and animal wastes. Also, the presence of these phosphorus and nitrogen in excess amount could lead to the eutrophication of water sources. As there are many negative effects of untreated wastewater on aquatic life, environment, ecology and human life, a number of processes are in place for the treatment of wastewater effluents before discharge into receiving water bodies.

***Index Terms*** **– Wastewater, contaminants, wastewater treatment, and Treated wastewater**

## I. INTRODUCTION

Wastewater is any water that has been contaminated by human use. Wastewater is "used water from any combination of domestic, industrial, commercial or agricultural activities, surface runoff, or storm water, and any sewer inflow or sewer infiltration. Therefore wastewater is byproduct of domestic, industrial, commercial or agricultural activities. Wastewater may be conveyed in a sanitary sewer that conveys only sewage. Alternatively, wastewater can be transported in a combined sewer that conveys both storm water and sewage, and possible also industrial waste. After treatment at a wastewater treatment plant, treated wastewater (effluent) is discharged to a receiving water body. When wastewater is used for another purpose than treated wastewater is termed as "wastewaters reuse" and "water reclamation". The two fundamental reasons for treating wastewater are to safeguard public health and prevent the pollution of receiving water bodies. The wastewater that is discharged to the environment without suitable treatment can cause water pollution. A variety of substances in untreated or improperly treated wastewater effluents are known to be toxic to plants and animals, including humans and pose negative impacts on the environment.

**Figure 1 Wastewater**

➢ **Sources of wastewaters:**

Four main sources of wastewaters are:

- Domestic sewage: Households may produces wastes from flush toilet, sinks, dishwashers, washing machines, bathrooms, showers etc.
- Industrial wastewater: industrial site drainage (silt, sand, oil, chemical residual), cooling water, organic and biodegradable waste from hospitals, food factories.
- Agriculture runoff: Agricultural runoff carrying fertilizers and pesticides.
- Storm water and urban runoff: urban runoff from highways, roads, railway track, car park, roofs, and pavements (contains oil, animal feces/ manure, food waste, litter, petrol, diesel, rubber residues from tyres etc.)

## II. MAJOR CONTAMINANTS IN WASTEWATER

### 2.1 Nitrogen and phosphorus:

The two major eutrophic nutrients in wastewater effluents are nitrogen and phosphorus. It is indicated that over 47% and 53% of streams have medium to high level of phosphorus and nitrogen, respectively. In untreated wastewater, nitrogen is primarily in the form of ammonia and organic nitrogen, while phosphorus may exist as soluble orthophosphate ion, organically – bound phosphate, or other phosphorus/oxygen forms.

**Effects:**

- The recognizable effect of eutrophication is the occurrence of algal blooms, which in turn leads to the depletion of dissolved oxygen concentration in receiving water bodies. A low DO in water bodies is known to the death of aquatic life, muddy water and drastic reduction of the desirable flora and fauna.
- Another impact of eutrophication is an increase in the amount of chlorine required for the disinfection of water bodies, which could increase the increasing the risk of cancer.
- Excessive nutrient proliferation in wastewater effluents may leads to the stimulation of harmful microbes like Pfisteria. The presence of Pfisteria in a water body id identified to cause eye and respiratory irritation, headache, and gastrointestinal complaints.

The presence of remarkably high nitrate content above a maximum contaminant level of 10 mg/L in water is known to lead to methemoglobinemia (blue baby disease) in infants and other susceptible individuals. During methemoglobinemia in infants, nitrate is reduced to nitrite in the digestive system, which attacks the hemoglobin.

### 2.2 Heavy metals:

Heavy metals refer to any metallic element that has a relatively high atomic mass (> 5 $g/cm^3$) and are toxic or poisonous even at a low concentration. Heavy metal ions which are toxic to humans are important contaminants. Heavy metals, which are significantly toxic to environmental ecology, mainly include cadmium(Cd), chromium(Cr), nickel(Ni), mercury(Hg), lead(Pb), manganese(Mn), copper(Cu), and zinc(Zn). Even their presence in trace quantities (i.e. minimum detectable concentrations) causes serious problems.

**Sources of heavy metals in wastewater:**

Industrial activities are significant sources of heavy metals. Mining operations and ore processing, textiles, metallurgy and electroplating, dyes and pigment, paper mi, tannery, and petroleum refining are the main sources of heavy metals in wastewater.

**Effects:**

- Some studies have indicated zinc poisoning to be a cause of stomach cramps, skin irritation, vomiting, nausea, anaemia, damaged pancreas, disturbed protein metabolism, arteriosclerosis, respiratory disorders. The presence of zinc has been shown pose great danger to infants and unborn, especially when large concentrations of it is absorbed by their mothers during pregnancy.
- The presence of zinc in wastewater is indicated to cause an increase in water acidity, which could affect the cultivation and yield of crops.
- The presence of lead in humans and animals is revealed to have effects on hemoglobin synthesis, which could lead to anaemia. Some of its effects are reported to be irreversible, chronic exposure may lead to sustained decrease in kidney function, which could lead to possible renal function
- In case of mercury, its organic forms are known to be more toxic to aquatic organisms than the inorganic forms. Although aquatic plants are affected by mercury in water concentrations approaching 1 mg/L for inorganic mercury, the effect is grater even at much lower concentrations of organic mercury.

- Chromium is necessary for the metabolism of insulin and essential for animals, at high concentrations it is known to be toxic to organisms. On animals, chromium is known to cause skin irritation and cancer.

**2.3 Organic waste :**

Organic wastes consist of carbon, hydrogen, oxygen, nitrogen and other elements, and could either be carbohydrate, protein or fat which are biodegradables. The majority of organic materials in wastewater originate from plants, animals or synthetic sources. The presence of organic matter in water lead to imposes an oxygen demand on the microorganisms that helps in degradation, hence depleting the level of dissolved oxygen that is available for other aquatic organisms. A decrease in dissolved oxygen below certain point will have adverse effect on the physiology and metabolism of aquatic organisms, which leads to their death. The death of aquatic organisms, such as fish will deplete the recreational value of such waters due to the release of odours and the overall degradation of water quality.

**2.4 Endocrine Disruptors:**

Endocrine-disrupting compound refers to "exogenous substances that alter functions of the endocrine system and consequently cause adverse health effects in an intact organism". Endocrine disruptors are said to be chemicals or natural by-product in the environment that mimic hormones in the body. They are also known as exogenous agents that interfere with the synthesis, secretion, transport, binding, action, or elimination of natural hormones in the body that are responsible for the maintenance of homeostasis, reproduction, development and behavior.

The presence of endocrine disruptors in receiving water bodies is indicated to threaten reproductive success and long term survival of sensitive aquatic populations.

**Sources of EDCs in wastewater:**

The source of EDCs categorized as pesticide is generally agricultural areas and surface runoff. In addition, in nonagricultural crops such as commercial forestry and horticulture and plant nurseries, pesticide can also be wide used and discharged into wastewater. For EDCs like hormones, pharmaceutical factories are an important point source. In addition, hospital wastewater and human and animal excretion are also important source.

**2.5 Hydrocarbons:**

Although petroleum hydrocarbons are toxic to all forms of life, environmental contaminants due to crude oil is relatively common because of its widespread use and associated disposal operations and accidental spills. The presence of hydrocarbon pollutants in wastewater effluents is known to lead to several health and environmental impacts, which are of great concern.

**Effects:**

- Since petroleum consists of highly toxic chemicals, its presence in water can cause significant damage to body organs(liver and kidney) and systems, such as nervous, respiratory, circulatory, immune, reproductive.
- A host of other diseases and disorders could be caused to humans and animals by the presence of hydrocarbons in water.

**2.6 Bacteria**:

Bacteria are single-celled prokaryotes, which have several shapes (including spheres, rods, and spirals) according to their morphology. The size of most of the bacteria range from 0.3 to 3$\mu$m. Bacteria pathogens feed on organic and chemical heterophs that grow in the intestine. They generally cause diarrhea, and some emit toxins that may pauncture that intestinal lining. Some of the most harmful gastrointestinal bacteria are salmonella, campylobacter, and shigella.

Salmonella typhi are bacteria that are spread in water and cause typhoid fever. They colonize on organ surfaces. Their favorite location is the gall bladder.

Typhoid fever can causes fever, rashes, headache, joint pain, and even death.

**2.7 Viruses**:

Viruses are the noncellular form, which are composed of the protein and nucleic acid molecule (DNA or RNA), and they are organic species that are parasitic in the living and nonliving body. They are neither biological nor abiotic, and are not attributed to the five kingdoms (including prokaryotes, protists, fungi, plants, and animals).

A variety of viruses that are directly harmful to human health are present in wastewater. Viruses are still widely spread and are disseminated in the environment by discharging untreated or treated water to the receiving water environments and food productions.

**2.8 Protozoa**:

Protozoa are the same as multicellular animals, with physiological functions including metabolism, exercise, reproduction, reaction to an external stimulus, and adaptability to the environment. Some protozoa have a hazardous effect on human health, which can cause clinical diseases and also are responsible for outbreak of waterborne diseases. Some of the most harmful protozoa are malaria, amebiasis, chagas diseases, cyclospora, cryptosporidium, and microsporidia.

**2.9 Pathogens**:

Disease causing organisms are called pathogens including nonliving viruses and organisms from four of the kingdoms of life. Some pathogens are spread through wastewater by the fecal oral route. The process begins when pathogens multiply in the intestinal systems of humans and animals and are then excreted. Pathogens vary in size.

**2.10 Other Pollutants:**

Some other contaminants, such as disinfection by-products (DBPs), microplastic, and nanomaterial, present in wastewater have also raised peoples concern. DBPs refer to series of by- products produced by disinfectant and some organic and inorganic substances in water during disinfection with disinfectant. Microplastic, often define as plastic particles <5mm, have aroused increasing concern.

## III. TREATMENT OF WASTEWATER

### 3.1 TREATMENT OF DOMESTIC WASTEWATER

1. **SCREENING:** Screening is employed for removal of suspended solids of various sizes.it is used to trap and remove the floating matter, such as pieces of cloth, paper, wood, cork, hair, fiber etc. If these floating materials are not removed, will chock the pipes.

2. **GRIT CHAMBER:** Grit removal basins, such as grit chamber or Detritus tanks are the sedimentation basins placed in front of the wastewater treatment plant to remove the inorganic particles (specific gravity about 2.65), such as sand, gravels, grit, egg shells, bones, and other nonputresible material that may clog channels or damage pumps.

3. **SKIMMING TANK:** Skimming tank are sometimes employed for removing oils and grease from the sewage, and placed before the sedimentation tank. This material may enter into the sewage from kitchen of restaurants and houses, from motor garages, oil refineries, soaps and candle factories.

4. **SEDIMENTATION:** Sedimentation is utilized in wastewater treatment to separate suspended solids from wastewaters. Removal by sedimentation is based on the difference in specific gravity between solid particles and the bulk of the liquid, which results in settling of suspended solids. Sedimentation is also utilized in one or more steps of a treatment sequences.

5. **FILTRATION:** The filter units used for secondary treatment consist of open beds of coarse aggregates over which sewage (i.e. effluent from the primary clarifier) is sprinkled intermittently. The necessary contact surface for the growth of aerobic bacteria is provided by the aggregate in the bed, and the aeration is provided by nature. The effluent from filter units is settled out in secondary clarifiers.

   There are various kinds of filter that are commonly employed either singly or in combinations, for giving secondary treatment of sewage. The different types of filters that may be used in sewage treatment are:

   1) Contact beds (used at very small plants, and have becomes almost obsolete these days).
   2) Intermittent sand filter.
   3) Trickling filters.
   4) Miscellaneous types of filters.

6. **ACTIVATED SLUDGE PROCESS:** The activated sludge process provides an excellent method of treating either raw sewage or more generally the settled sewage. The sewage effluent from primary sedimentation tank, which is, thus normally utilized in this process, is mixed with 20 to 30 percent of own volume of activated sludge. The mixture enters an aeration tank, where the microorganisms and the sewage, are intimately mixed together, with a large quantity of air about 4 to 8 hours. Under this condition, the moving organisms will oxidize the organic matter, and the suspended and colloidal matter tends to coagulate and form a precipitate, which settles down readily in the secondary settling tank. The settled sludge (containing microorganisms) called activated sludge, is then recycled to the head of the aeration tank, to be mixed again with the sewage being treated.

7. **OXIDATION PONDS:** Oxidation ponds, also called lagoons or stabilizing ponds are large, shallow ponds designed to treat wastewater through the interaction of sunlight bacteria and algae. Algae grow using energy from sun and carbon dioxide and inorganic compounds released by bacteria in water. During this process of photosynthesis, the algae release oxygen needed by aerobic bacteria. Sludge deposits in the pond must eventually be removed by dredging.

8. **ROTATIONG BIOLOGICAL CONTACTER:** in this treatment system a series of large plastic disks mounted on a horizontal shaft are partially submerged in primary effluent. As the shaft rotates, the disks are exposed alternatively to air and wastewater, allowing a layer of bacteria to grow on the disks and to metabolize the organic in the wastewater.

9. **DISINFECTION:** Disinfection is done to kill the pathogens in the wastewater, so that it cannot harm the environment after discharge or dispose in environment. Sewage may be disinfecting by adding chlorine to it, either before the treatment or after the treatment, as it done for disinfecting waster. When chlorine is added to the treated sewage as a final step in the treatment, it is called post- chlorination.

10. **OTHER METHODES USED IN TERTIARY TREATMENT OF WASTEWATER:** Tertiary treatment consists of processes which are designed to achieve higher effluent quality than conventional secondary treatments. The other methods are:
    - Suspended solids removal
    - Carbon adsorption.
    - Ion exchange.
    - Reverse osmosis.
    - Nutrients removal methods
    - Electrodialysis.
    - Chemical oxidation.
    - Sonozone wastewater treatment process.

### 3.2 TREATMENT OF INDUSTRIAL WASTEWATER.

1) **Equalisation:** Equalisation consists of holding the wastewater for some pre-determined time in a continuously mixed basin, to produce a uniform wastewater. Such an arrangement will, of course be necessary when the wastewater produced by the industry varies in characteristics and quantity over the entire day.

2) **Neutralisation**: Neutralisation means neutralizing the excessive acidity or alkalinity of the particular wastewater, by adding alkali or acid, respectively, to the wastewater. This may be achieved either in equalisation tank, where possible, or a separate neutralisation tank may be used.

3) **Physical treatment**: Physical treatments consist of separating the suspended inorganic matter by physical processes, like sedimentation and floatation.
    - Sedimentation: sedimentation is used to separate heavy settable solids, and hence sedimentation tank may be provided only when the wastewater contains a high percentage of such heavy inorganic solids.
    - Floatation: floatation consists of crating of fine air bubbles in waste tank, by introduction of air into the tank from the bottom. The rising air bubbles, attach themselves to the fine suspended particles, increasing their buoyancy, and finally lifting them to liquid surface for consequent removal by skimming.

4) **Chemical treatment**: chemical treatment is often necessary before biological treatment, though sometimes, it may not be required at all. Sometimes, it may however, serve as final stage of treatment. The chemical treatment consists of:
    - Reverse osmosis.
    - Electrodialysis.
    - Chemical oxidation.
    - Chemical coagulation.
    - Adsorption.
    - Deionization
    - Thermal reduction
    - Air stripping.

5) **Biological treatment**: Biological treatment of industrial wastewater is necessary, when they contain large quantities of biodegradable substances. Such biological treatment may be used with or without acclimatisation.
Acclimatisation: it consists of the gradual exposure of the wastewater in increasing concentration to the seed or initial micro biological population under a controlled condition.

### 3.3 SOME OTHER METHODS TO TREATE WASTEWATER.

1. Constructed wetlands: constructed wetlands are engineered systems that have been designed and constructed to utilize the natural processes involving wetland vegetation, soil, and their associated microbial assemblages to assist in treating wastewater. Constructed wetlands consist of a lined cell, which the water flow into. Plants are planted in cell and the roots filter the contaminants out of the water.

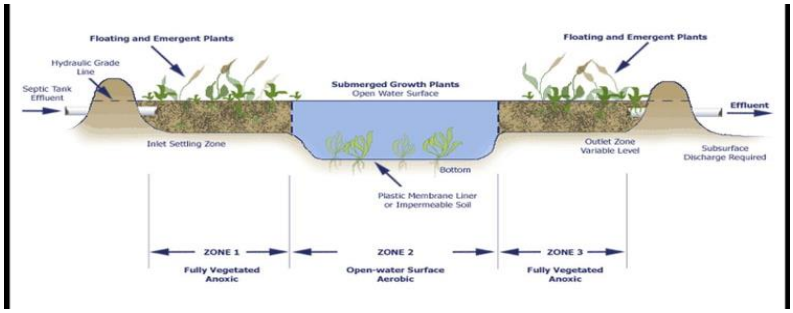


**Figure 2 CONSTRUCTED WATELAND**

2. Rapid infiltration: Another natural method is called rapid infiltration, which is a process where basin is filled with wastewater, which has already gone through a pre- treatment. The ground acts as a filter and removes the pollutants from the water. This method is similarly to what happens in a septic system.

3. Membrane filtration technologies: membrane filtration can be broadly defined as a separation process that uses semipermeable membrane to divide the feed stream into two portions: an infiltrate that contains the material passing through the membrane, and a retentate consisting of the species being left behind. More specifically membrane filtration can be further classified in terms of the size range of permeating species, the mechanisms of rejection, the driving force employed, the chemical structure and composition of membranes, and the geometry of construction. The most important types of membrane filtration are pressure driven processes including microfiltration (MF), ultrafiltration (UF), Nano filtration (NF), and reverse osmosis (RO).

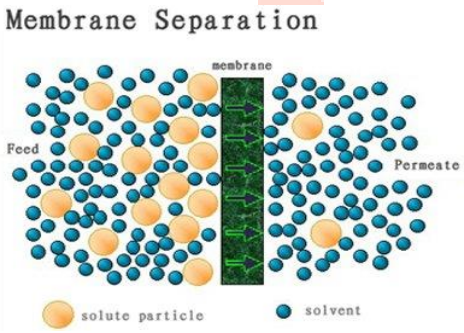


**Figure 3 MEMBRANE FILTRATION**

4. Advanced oxidation technology: Advanced oxidation processes (AOPs) have been broadly defined as near ambient temperature treatment processes based on highly reactive radicals, especially the hydroxyl radical (OH), as the primary oxidant. Clearly, the .OH radical is among the strongest oxidizing species used in water and wastewater treatment and offers the potential to greatly accelerate the rates of contaminant oxidation.
   The generation of .OH radicals is commonly accelerated by combining ozone ($O_3$), hydrogen peroxide ($H_2O_2$), titanium dioxide ($TiO_2$), heterogeneous photocatalysis, UV radiation, ultrasound, and (or) high electron beam irradiation.

### 3.4 USES OF TREATED WASTEWATER

The treated wastewater effluent from municipal sewage system is characterized as renewable, cheap, and attractive as a non-conventional water sources. The treated wastewater can be used for several purposes including:

- Agriculture.
- Domestic application (e.g., flushing of toilets).
- Firefighting.
- Parks and golf course watering.
- Use of wetlands for wildlife habitats.
- Recreational impoundments.
- Industrial use (for cooling water make up, boiler feed water etc.)

The potential reuse of wastewater depends on its characteristics, which determines the methods and degree of required treatment.

Treated wastewater can use for non-potable purposes. Non potable reuse can reduce water consumption from other sources and decrease the waste water flow rate.

## IV. CONCLUSION

Now a day there is continuously increasing worldwide concern for the wastewater contaminants and wastewater treatment technologies and new technologies used for treatment. If the wastewater is not treated or insufficiently treated then the presence of contaminants in wastewater disrupts the eco balance of aquatic life and poses threat to human life. Some of these problems including eutrophication, metal poisoning, irritations, and several water related infections. To safeguard ecosystem and public health, there is need to treat wastewater effluent before discharge. The remediation of wastewater can be achieved by various treatment processes

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