DOMESTIC WASTE WATER TREATMENT

Introduction

- Wastewater is the water which is disposed from:
  - homes
  - offices and
  - industry.

- It comes from toilets, sinks, showers, washing machines and industrial processes and was historically called sewage.

- Wastewater treatment, also called sewage treatment, the removal of impurities from wastewater, or sewage, before it reaches aquifers or natural bodies of water such as rivers, lakes, estuaries, and oceans.
- Since pure water is not found in nature (i.e., outside chemical laboratories), any distinction between clean water and polluted water depends on the type and concentration of impurities found in the water as well as on its intended use.
- In broad terms, water is said to be polluted when it contains enough impurities to make it unfit for a particular use, such as drinking, swimming, or fishing.
- Although water quality is affected by natural conditions, the word pollution usually implies human activity as the source of contamination.

- Water pollution, therefore, is caused primarily by the drainage of contaminated wastewater into surface water or groundwater, and wastewater treatment is a major element of water pollution control.

Toilet

Urine

Faeces

Blackwater

Washing

Bathing

Kitchen

Greywater

Cont..

- Wastewater produced due to human activities in households is called **domestic wastewater** i.e. wastewater from the kitchen, shower, wash basin, toilet and laundry.
- It is defined as follows:

- **yellow water:**	human urine
- **brown water:**	human faeces with flushed water (can include paper if used)
- **black water:**	human faeces (brown water) mixed with urine (yellow water), in general: wastewater from toilets. It contains human waste and can be a public health risk if not treated properly. (Sometimes, water used in kitchen is also classified as black water)
- **grey water:**	water used in the kitchen, bathroom including sinks, baths, showers and laundry, etc. or any water that has been used at home, except water from toilets

- The strength and composition of the domestic wastewater changes on hourly, daily and seasonal basis, with the average strength dependent on per capita water usage, habits, diet, living standard and life style.
- The main reason is variation in water usage in households.
- Households in developed countries use more water than those in developing countries.

Waste water component

- Wastewater components can be divided into different main groups
- They can adversely affect the aquatic life if discharge them into environmental.

Components	Of special interest	Environmental effect
Microorganims	Pathogenic bacteria, virus and worms eggs	Risk when bathing and eating shellfish
Biodegradable organic materials	Oxygen depletion in rivers and lakes	Fish death, odours
Other organic materials	Detergents, pesticides, fat, oil and grease, colouring, solvents, phenols, cyanide	Toxic effect, aesthetic inconveniences, bioaccumulation in the food chain
Nutrients	Nitrogen, phosphorus, ammonium	Eutrophication, oxygen depletion, toxic effect
Metals	Hg, Pb, Cd, Cr, Cu, Ni	Toxic effect, bioaccumulation
Other inorganic materials	Acids, for example hydrogen sulphide, bases	Corrosion, toxic effect
Thermal effects	Hot water	Changing living conditions for flora and fauna
Odour (and taste)	Hydrogen sulphide	Aesthetic inconveniences, toxic effect

- Physically, domestic wastewater is usually characterised by a grey colour, musty odour and has a solids content of about 0.1%.
- The solid material is a mixture of faeces, food particles, toilet paper, grease, oil, soap, salts, metals, detergents, sand and grit.
- The solids can be suspended (about 30%) as well as dissolved (about 70%).
- Dissolved solids can be precipitated by chemical and biological processes.
- From a physical point of view, the suspended solids can lead to the development of sludge deposits and anaerobic conditions when discharged into the receiving Environment.

- Chemically, wastewater is composed of organic (70%) and inorganic (30%) compounds as well as various gases.
- Organic compounds consist primarily of carbohydrates (25 %), proteins (65 %) and fats (10 %), which reflects the diet of the people.
- Inorganic components may consist of heavy metals, nitrogen, phosphorus, pH, sulphur, chlorides, alkalinity, toxic compounds, etc.
- However, since wastewater contains a higher portion of dissolved solids than suspended, about 85 to 90% of the total inorganic component is dissolved and about 55 to 60% of the total organic component is dissolved.

- Gases commonly dissolved in wastewater are hydrogen sulphide, methane, ammonia, oxygen, carbon dioxide and nitrogen.
- The first three gases result from the decomposition of organic matter present in the wastewater.

- Biologically, wastewater contains various microorganisms but the ones that are of concern are those classified as protista, plants, and animals.
- The category of protista includes bacteria, fungi, protozoa, and algae.
- Plants include ferns, mosses, seed plants and liverworts. Invertebrates and vertebrates are included in the animal category.
- In terms of wastewater treatment, the most important category are the protista, especially the bacteria, algae, and protozoa.

- Also, wastewater contains many pathogenic organisms which generally originate from humans who are infected with disease or who are carriers of a particular disease.
- Typically, the concentration of faecal coliforms found in raw wastewater is about several hundred thousand to tens of million per 100 ml of sample.

Types of sewage

- There are three types of wastewater, or sewage:
- ✓ Domestic sewage,
- ✓ Industrial sewage, and
- ✓ Storm sewage.
- Domestic sewage carries used water from houses and apartments; it is also called sanitary sewage.
- Industrial sewage is used water from manufacturing or chemical processes.
- Storm sewage, or storm water, is runoff from precipitation that is collected in a system of pipes or open channels.

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- Domestic sewage is slightly more than 99.9 percent water by weight.
- The rest, less than 0.1 percent, contains a wide variety of dissolved and suspended impurities.
- Although amounting to a very small fraction of the sewage by weight, the nature of these impurities and the large volumes of sewage in which they are carried make disposal of domestic wastewater a significant technical problem.

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- The principal impurities are putrescible organic materials and plant nutrients, but domestic sewage is also very likely to contain disease-causing microbes.
- Industrial wastewater usually contains specific and readily identifiable chemical compounds, depending on the nature of the industrial process.
- Storm sewage carries organic materials, suspended and dissolved solids, and other substances picked up as it travels over the ground.

Historical Background

- **Direct discharge of sewage:**

- Many ancient cities had drainage systems, but they were primarily intended to carry rainwater away from roofs and pavements.
- A notable example is the drainage system of ancient **Rome**. It included many surface conduits that were connected to a large vaulted channel called the Cloaca Maxima (“Great Sewer”), which carried drainage water to the Tiber River.
- Built of stone and on a grand scale, the Cloaca Maxima is one of the oldest existing monuments of Roman engineering.
- There was little progress in urban drainage or sewerage during the Middle Ages.
- Most wastes were simply dumped into gutters to be flushed through the drains by floods.

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- Toilets (water closets) were installed in houses in the early 19th century, but they were usually connected to cesspools, not to sewers.
- In densely populated areas, local conditions soon became intolerable because the cesspools were seldom emptied and frequently overflowed.
- The threat to public health became apparent.
- In England in the middle of the 19th century, outbreaks of cholera were traced directly to well-water supplies contaminated with human waste from privy vaults and cesspools.

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- It soon became necessary for all water closets in the larger towns to be connected directly to the storm sewers.
- This transferred sewage from the ground near houses to nearby bodies of water.
- Thus, a new problem emerged: surface water pollution.

Developments in sewage treatment

- It used to be said that “the solution to pollution is dilution”
- When small amounts of sewage are discharged into a flowing body of water, a natural process of stream self-purification occurs.
- Densely populated communities generate such large quantities of sewage, however, that dilution alone does not prevent pollution.
- This makes it necessary to treat or purify wastewater to some degree before disposal.

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- The construction of centralized sewage treatment plants began in the late 19th and early 20th centuries, principally in the United Kingdom and the United States.
- Instead of discharging sewage directly into a nearby body of water, it was first passed through a combination of physical, biological, and chemical processes that removed some or most of the pollutants.
- Also beginning in the 1900s, new sewage-collection systems were designed to separate storm water from domestic wastewater, so that treatment plants did not become overloaded during periods of wet weather

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- After the middle of the 20th century, increasing public concern for environmental quality led to broader and more stringent regulation of wastewater disposal practices.
- Higher levels of treatment were required. For example, pretreatment of industrial wastewater, with the aim of preventing toxic chemicals from interfering with the biological processes used at sewage treatment plants, often became a necessity.
- In fact, wastewater treatment technology advanced to the point where it became possible to remove virtually all pollutants from sewage. This was so expensive, however, that such high levels of treatment were not usually justified.

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- Wastewater treatment plants became large, complex facilities that required considerable amounts of energy for their operation.
- After the rise of oil prices in the 1970s, concern for energy conservation became a more important factor in the design of new pollution control systems.
- Consequently, land disposal and subsurface disposal of sewage began to receive increased attention where feasible.
- Such “low-tech” pollution control methods not only might help to conserve energy but also might serve to recycle nutrients and replenish groundwater supplies.

Sewerage Systems

- A sewerage system, or wastewater collection system, is a network of pipes, pumping stations, and appurtenances that convey sewage from its points of origin to a point of treatment and disposal.
- **Combined systems:**

➢ Systems that carry a mixture of both domestic sewage and storm sewage are called combined sewers.

➢ Combined sewers typically consist of large-diameter pipes or tunnels, because of the large volumes of storm water that must be carried during wet-weather periods.

Combined Systems

- They are very common in older cities but are no longer designed and built as part of new sewerage facilities.
- Because wastewater treatment plants cannot handle large volumes of storm water, sewage must bypass the treatment plants during wet weather and be discharged directly into the receiving water.
- These combined sewer overflows, containing untreated domestic sewage, cause recurring water pollution problems and are very troublesome sources of pollution.

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- In some large cities the combined sewer overflow problem has been reduced by diverting the first flush of combined sewage into a large basin or underground tunnel.
- After temporary storage, it can be treated by settling and disinfection before being discharged into a receiving body of water, or it can be treated in a nearby wastewater treatment plant at a rate that will not overload the facility.
- Another method for controlling combined sewage involves the use of swirl concentrators. These direct sewage through cylindrically shaped devices that create a vortex, or whirlpool, effect.
- The vortex helps concentrate impurities in a much smaller volume of water for treatment.

Separate systems

- New wastewater collection facilities are designed as separate systems, carrying either domestic sewage or storm sewage but not both.
- Storm sewers usually carry surface runoff to a point of disposal in a stream or river.
- Small detention basins may be built as part of the system, storing storm water temporarily and reducing the magnitude of the peak flow rate.
- Sanitary sewers, on the other hand, carry domestic wastewater to a sewage treatment plant.
- Pretreated industrial wastewater may be allowed into municipal sanitary sewerage systems, but storm water is excluded.

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- Storm sewers are usually built with sections of reinforced concrete pipe.
- Corrugated metal pipes may be used in some cases.
- Storm water inlets or catch basins are located at suitable intervals in a street right-of-way or in easements across private property.
- The pipelines are usually located to allow downhill gravity flow to a nearby stream or to a detention basin.
- Storm water pumping stations are avoided, if possible, because of the very large pump capacities that would be needed to handle the intermittent flows.

Wastewater Treatment Categorization

Primary	Secondary	Advanced
• Primary clarification • Chlorination	• Activated sludge • Trickling filter • Rotation biological contractor	• Unit operations • Unit processes • N, P, SS, etc

Secondary Wastewater Treatment Plant

- TSS
- BOD

Advanced Wastewater Treatment Plant

- Remove N & P
- Remove additional BOD & TSS that secondary treatment cannot remove
- AWT utilizes chemical, biological & physical

N removal by AWT

- Nitrification
- Denitrification

Nitrification

- Nitrification is an aerobic process that transforms ammonium nitrogen (reduced state) into an oxidized form (NO^-_3)
- This process is carried out by autotropic bacteria of the genera *Nitrosomonas* & *Nitrobacter*
- The overall reaction
- $NH^+_4 + 2O_2 \longrightarrow NO^-_3 + 2H^+ + H_2O$

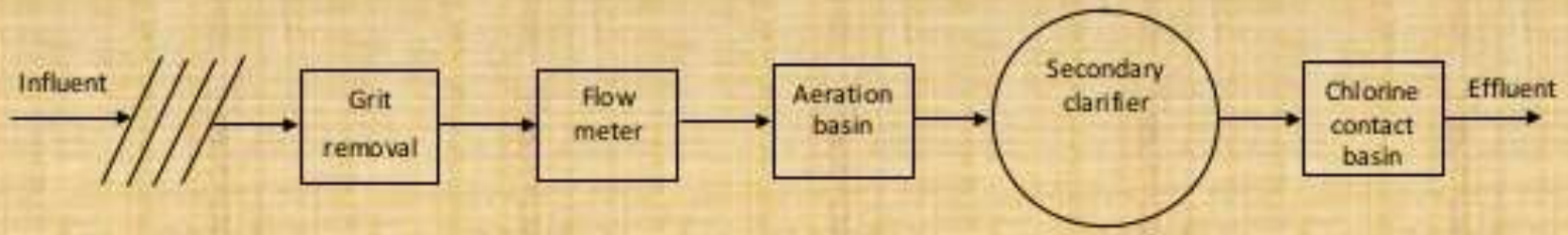
Denitrification

- To remove the nitrate that formed during nitrification , a second biological process known as denitrification must be used in an anoxic environment (void of dissolved oxygen)
- Denitrifying , heterotrophic microorganisms reduce nitrate into nitrogen gas, which is released into the atmosphere
- The equation is
- $6NO_3^- + 5CH_3OH \longrightarrow 3N_2\uparrow + 6OH^- + 5CO_2 + 7H_2O$

P removal by AWT- EBPR

- Biological phosphorus removal may be accomplished by providing alternating anaerobic/aerobic treatment of the waste water.
- Such systems promote the growth of phosphorus accumulating organisms (PAOs) such as *Acinetobacter.*
- PAOs takes up excess amount of P from wastewater during the aerobic phase of biological treatment.
- These process is known as enhanced biological phosphorus removal (EBPR)

Overview of Wastewater Treatment System



Primary Treatment

- Primary treatment is clarification, or separation of suspended solids from the wastewater.
- Primary Treatment follows preliminary treatment, settling of SS & removal of oil, grease, and scum that floats on surface of wastewater.
- Since these species contain organic matter, BOD removal is accomplished.
- Primary Treatment does not remove organics soluble or colloidal organic materials. Light weight organics that floats to the surface are skimmed off & pumped to the digesters for treatment

Primary Treatment (continued)

- The sludge that accumulates at the bottom of a primary clarifier is normally stabilized by anaerobic digestion before disposal.
- Primary sludge is is called “raw” sludge and contain pathogens and organics that produces odors

Primary Treatment (continued)

- Primary clarifier:

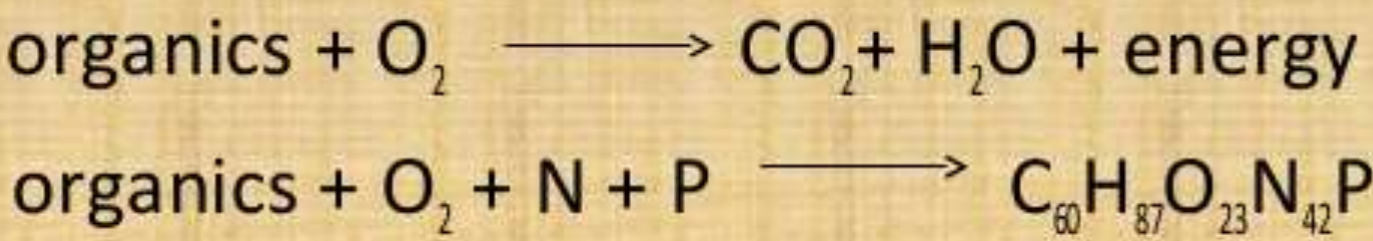
Sl	Particulars	Specifications
1	Size	Circular/ Rectangular
2	Depth	10-16 ft
3	Length	50-300 ft
4	Width	10-80 ft
5	Dia	10-200 ft
6	Detention time	1.5-2.5 hrs
7	Avg. over flow rate	800-1200 gpd/ft^2
8	Weir loading rate	10000-40000 gpd/ft^2

Secondary Treatment

- Secondary wastewater treatment implies that a biological process is being used for treating the wastewater.
- Microorganisms indigenous to the wastewater use organic carbon, along with N & P, to grow more microorganisms, primarily bacteria.
- Bacteria use the organic matter as measured by BOD & COD for their energy and carbon source.
- Oxidation of the organic matter produces energy that is captured in the microbe's biochemical pathways, while a portion of a organic material is used in the synthesis of biomass.

Secondary Treatment (continued)

- The following equations shows the organic materials is being oxidized for energy and organic materials is being synthesized into new microbial cells respectively-



Disinfectants used in Wastewater Treatment

- -Disinfectants-Cl_2, O_3 & ultraviolet (UV) radiations.
- -These disinfectants offer the advantage of eliminating the production of trihalmethanes (THMs), which are chlorinated organic species and suspected carcinogens that result when chlorine is added to water containing organic compounds.

Chlorination of Wastewater

- -Chlorine is delivered to wastewater treatment facilities in pressurized containers, which range in size from 150-lb to 1-ton cylinders.
- -Chlorine is liquefied under high pressure & withdrawn as a gas or liquid, depending on the withdrawal rate.
- - At large waste water treatment plant, chlorine is withdrawn as a liquid & must pass through an evaporator to be converted to a gas.

Chlorine Contact Basin

- -When chlorine is added to secondary effluent, it must have sufficient contact with the wastewater to kill pathogens.
- -Long, rectangular serpentine channels simulating the plug flow regime are used in the design of chlorine contact basins.