Course : Wastewater Management

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Module 1 : Introduction

Lecture 1 : Introduction

1.1 BACKGROUND

Urbanization has encouraged the migration of people from villages to the urban areas. This has given rise to a number of environmental problems such as, water supply with desirable quality and quantity, wastewater generation and its collection, treatment and disposal. In urban areas for domestic and industrial uses the source of water is generally reservoir, river, lake, and wells. Out of this total water supplied, generally 60 to 80% contributes as a wastewater. In most of the cities, wastewater is let out partially treated or untreated and it either percolates into the ground and in turn contaminates the ground water or it is discharged into the natural drainage system causing pollution in downstream water bodies.

The importance of water quality as a factor constraining water use has often gone unacknowledged in the analyses of water scarcity. Water scarcity is a function not only of volumetric supply, but also of quality sufficient to meet the demand. The drinking water demand is perhaps the largest demand for high quality water apart from many industrial uses which also require high quality water. Agriculture, by far the largest consumer of water, also suffers when water supplies become saline. In India, water pollution comes from the main sources such as domestic sewage, industrial effluents, leachets from landfills, and run-off from solid waste dumps and agriculture land. Domestic sewage (black water) and sullage (grey water) is the main source of water pollution in India, especially in and around large urban centers. The regular monitoring of the water quality in the rivers and wells in the country revealed that the total coliform counts far exceeds the desired level in water to be fit for human consumption [CPCB, 1997].

In the past disposal of waste from water closets was carried out manually and wastewater generated from kitchen and bathrooms was allowed to flow along the open drains. This primitive method was modified and replace by a water carriage system, in which these wastes are mixed with sufficient quantity of water. This waste is carried through closed conduits under the conditions of gravity flow. This mixture of water and waste products is known as sewage.

The **advantages** offered by the water carriage system are:

- The carriage of wastes on head or carts is not required.
- Bad smell, which was unavoidable during open transport of sewage, is not occurring due to transport of this polluted water in closed conduits.
- The old system was posing the health hazards to sweepers and to the nearby residents, because of the possibilities of flies and insects transmitting disease germs from the accessible carts to the residents food eatables. This is avoided in water carriage system because of transport of night soil in close conduits.
- The human excreta is washed away as soon as it is produced in water carriage system, thus storing is not required as required in the old system of manual disposal. Thus, no bad smells are produced in closed conduit transport.
- In the old system, the wastewater generated from the kitchen and bathrooms was required to be carried through open roadside drains for disposal. This is avoided in sewerage system as the open drains could generate bad odours when used for disposal of organic wastes.
- The water carriage system does not occupy floor area, as the sewers are laid underground.
- In addition, the construction of toilets one above the other is possible in water carriage system and combining latrine and bathrooms together as water closets is possible. This is one of the important advantages of water carriage system.

However, this water carriage system also has certain **drawbacks** such as:

- A large network of pipes is required for collection of the sewage; hence, the capital cost for water carriage system is very high.
- In addition, the operation and maintenance of sewerage system is very expensive.
- Large wastewater volume is required to be treated before disposal.
- Assured water supply is essential for efficient operation of the water carriage system.

1.2 DEFINITIONS

Industrial wastewater: It is the wastewater generated from the industrial and commercial areas. This wastewater contains objectionable organic and inorganic compounds that may not be amenable to conventional treatment processes.

Night Soil: It is a term used to indicate the human and animal excreta.

Sanitary sewage: Sewage originated from the residential buildings comes under this category. This is very foul in nature. It is the wastewater generated from the lavatory basins, urinals and water closets of residential buildings, office building, theatre and other institutions. It is also referred as domestic wastewater.

Sewage: It indicates the liquid waste originating from the domestic uses of water. It includes sullage, discharge from toilets, urinals, wastewater generated from commercial establishments, institutions, industrial establishments and also the groundwater and stormwater that may enter into the sewers. Its decomposition produces large quantities of malodorous gases, and it contains numerous pathogenic or disease producing bacteria, along with high concentration of organic matter and suspended solids.

Sewage Treatment Plant is a facility designed to receive the waste from domestic, commercial and industrial sources and to remove materials that damage water quality and compromise public health and safety when discharged into water receiving systems or land. It is combination of unit operations and unit processes developed to treat the sewage to desirable standards to suit effluent norms defined by regulating authority.

Sewer: It is an underground conduit or drain through which sewage is carried to a point of discharge or disposal. There are three types of sewer systems that are commonly used for sewage collection. Separate sewers are those which carry the house hold and industrial wastes only. Storm water drains are those which carry rain water from the roofs and street surfaces. Combine sewers are those which carry both sewage and storm water together in the same conduit. House sewer (or drain) is used to discharge the sewage from a building to a street sewer. Lateral sewer is a sewer which collects sewage directly from the household buildings. Branch sewer or submain sewer is a sewer which receives sewage from a relatively small area. Main sewer or trunk sewer is a sewer that receives sewage from many tributary branches and sewers, serving as an outlet for a large territory. Depressed sewer is a section of sewer constructed lower than adjacent sections to pass beneath an obstacle or obstruction. It runs full under the force of gravity and at greater than atmospheric pressure. The sewage enters and leaves the depressed sewer at atmospheric pressure. Intercepting sewer is a sewer laid transversely to main sewer system to intercept the dry weather flow of sewage and additional surface and storm water as may be desirable. An intercepting sewer is usually a large sewer,

flowing parallel to a natural drainage channel, into which a number of main or outfall sewers discharge. Outfall sewer receives entire sewage from the collection system and finally it is discharged to a common point. Relief sewer or overflow sewer is used to carry the flow in excess of the capacity of an existing sewer.

Sewerage: The term sewerage refers the infrastructure which includes device, equipment and appurtenances for the collection, transportation and pumping of sewage, but excluding works for the treatment of sewage. Basically it is a water carriage system designed and constructed for collecting and carrying of sewage through sewers.

Stormwater: It indicates the rain water of the locality.

Subsoil water: Groundwater that enters into the sewers through leakages is called subsoil water.

Sullage: This refers to the wastewater generated from bathrooms, kitchens, washing place and wash basins, etc. Composition of this waste does not involve higher concentration of organic matter and it is less polluted water as compared to sewage.

Wastewater: The term *wastewater* includes both organic and inorganic constituents, in soluble or suspended form, and mineral content of liquid waste carried through liquid media. Generally the organic portion of the wastewater undergoes biological decompositions and the mineral matter may combine with water to form dissolved solids.

1.3 SOURCES OF SEWAGE

The wastewater generated from the household activities contributes to the major part of the sewage. The wastewater generated from recreational activities, public utilities, commercial complexes, and institutions is also discharged in to sewers. The wastewater discharged from small and medium scale industries situated within the municipal limits and discharging partially treated or untreated wastewater in to the sewers also contributes for municipal wastewater.

1.4 SEWAGE DISCHARGE

The quality of sewage and its characteristics show a marked range of hourly variation and hence peak, average and minimum discharge are important considerations. The process loadings in the sewage treatment are based on the daily average characteristics as determined from a 24 hours weighted composite samples. In the absence of any data an average quantity of 150 LPCD may be adopted for design. The hydraulic design load varies from component to component of the treatment plant with all appurtenances, conduits, channels *etc.*, being designed for the maximum discharge, which may vary from 2.0 to 3.5 times the average discharge. Sedimentation tanks are designed on the basis of average discharge, while consideration of both maximum and minimum discharge is important in the design of screens and grit chambers. Secondary treatment is generally designed for average discharge, with sufficient safety margin to accommodate the peak discharge.

1.5 EFFECT OF UNTREATED WASTEWATER DISPOSAL

The daily activities of human beings produce both liquid and solid wastes. The liquid portion of the wastewater is necessarily the water supplied by the authority or through private water sources, after it has fouled by variety of uses. The sources of wastewater generation can be defined as a combination of the liquid or water-carried wastes removed from residences, institutions, and commercial and industrial establishments, together with groundwater, surface water, and storm water as may be present.

If the untreated wastewater is allowed to accumulate, it will lead to highly unhygienic conditions. The organic matter present in the wastewater will undergo decomposition with production of large quantities of malodorous gases. If the wastewater is discharged without treatment in the water body, this will result in the depletion of Dissolved Oxygen (DO) from the water bodies. Due to depletion of DO, the survival of aquatic life will become difficult, finally leading to anaerobic conditions in the receiving waters. The nutrients present in the wastewater can stimulate the growth of aquatic plants, leading to problems like eutrophication. In addition, the untreated domestic wastewater usually contains numerous pathogenic or disease causing microorganisms, that dwell in the human intestinal tract or it may be present in certain industrial wastewaters. Apart from this, the wastewater contains inorganic gritty materials. The continuous deposition of this inorganic material may reduce the capacity of water body considerably over a period.

Generally domestic sewage does not contain any inorganic matter or organic compounds in highly toxic concentration. However, depending upon the type of industries discharging into the public sewers and the dilution that is offered by sewage; the municipal wastewater may have these inorganic substances or toxic organic compounds with the concentration more than the discharge limits stipulated by the authorities. Certain compounds, such as sulphates, metals such as chromium, etc., if presents in higher concentration, may disturb the secondary treatment of the sewage.

1.6 OBJECTIVES OF SEWAGE COLLECTION AND DISPOSAL

The objective of sewage collection and disposal is to ensure that sewage discharged from communities is properly collected, transported, treated to the required degree so as not to cause danger to human health or unacceptable damage to the natural environment and finally disposed off without causing any health or environmental problems. Thus, efficient sewerage scheme can achieve the following:

- To provide a good sanitary environmental condition of city protecting public health.
- To dispose the human excreta to a safe place by a safe and protective means.
- To dispose of all liquid waste generated from community to a proper place to prevent a favorable condition for mosquito breeding, fly developing or bacteria growing.
- To treat the sewage, as per needs, so as not to endanger the body of water or groundwater or land to get polluted where it is finally disposed off. Thus, it protects the receiving environment from degradation or contamination.

1.7 WASTEWATER TREATMENT

The treatment and safe disposal of wastewater is necessary. This will facilitate protection of environment and environmental conservation, because the wastewater collected from cities and towns must ultimately be returned to receiving water body or to the land or reused to fulfill certain needs. The sewage treatment plants constructed near the end of nineteenth century were designed to remove suspended matter alone by the principal of simple gravity settling. It soon became apparent that primary treatment alone was insufficient to protect the water quality of the receiving water body. This was mainly due to the presence of organic material, in colloidal and dissolved form, in the sewage after settling. Thus, in the beginning of twentieth century several treatment systems, called secondary treatment, were developed with the objective of organic matter removal. For this secondary treatment, biological methods are

generally used. The aerobic biological treatment processes were popularly used as a secondary treatment, and these processes are still at the first choice.

In the second half of twentieth century, it became clear that the discharge of effluents from even the most efficient secondary treatment plant could lead to the deterioration of the quality of receiving water body. This could be attributed partly to the discharge of ammonia in the effluent. In the receiving water body this discharge exerts an oxygen demand for the biological oxidation of ammonia to nitrate, a process called nitrification. However, even when nitrification is carried out at the treatment plant itself, the discharge of effluent can still be detrimental to the water quality due to introduction of nitrogen in the form of nitrate and phosphorus as phosphate. The tolerance limits of nitrates for the water when used as raw water for public water supplies and bathing ghats is 50 mg/L as NO_3. The availability of nitrogen and phosphorous tends to cause an excessive growth of aquatic life notably, autotrophic organisms such as algae, that can use carbon dioxide rather than organic material as a sources for cell synthesis. Thus, explosive development of biomass may occur when nitrogen and phosphorus are abundantly available. Although, this biomass may produce photosynthetic oxygen in the water during daytime, after sunset it will consume oxygen, so that the dissolved oxygen concentration will decrease and may reach to the levels that are too low to sustain the life of other (macro) organisms. This phenomenon of eutrophication has led to the development of tertiary treatment systems. In these, nitrogen and/or phosphorus are removed, along with solids and organic materials.

Once the minimum effluent quality has been specified, for maximum allowable concentrations of solids (both suspended and dissolved), organic matter, nutrients, and pathogens, the objective of the treatment is to attain reliably the set standards. The role of design engineer is to develop a treatment scheme that will guarantee the technical feasibility of the scheme, taking into consideration other factors such as construction and maintenance costs, the availability of construction materials and equipment, as well as specialized skilled personals for operation and maintenance of the treatment plant.

Primary treatment consists of screens (for removal of floating matter), grit chamber (for removal of inorganic suspended solids) and primary sedimentation tank (for removal residual settleable solids which are mostly organic). Skimming tanks may be used for removal of oils; however, in conventional treatment plant no separate skimming tank is used and oil removal is

achieved by collecting the scum in primary sedimentation tank. This primary treatment alone will not produce an effluent with an acceptable residual organic material concentration. Almost invariably biological methods are used in the treatment systems to effect secondary treatment for removal of organic material. In biological treatment systems, the organic material is metabolized by bacteria. Depending upon the requirement for the final effluent quality, tertiary treatment methods and/or pathogen removal may be included.

Today majority of wastewater treatment plants uses aerobic metabolism for the removal of organic matter. The popularly used aerobic processes are the activated sludge process, oxidation ditch, trickling filter, and aerated lagoons. Stabilization ponds use both the aerobic and anaerobic mechanisms. In the recent years, due to increase in power cost and subsequent increase in operation cost of aerobic processes, more attention is being paid for the use of anaerobic treatment systems for the treatment of wastewater including sewage. Recently the high anaerobic process such as Upflow Anaerobic Sludge Blanket (UASB) reactor is used for sewage treatment at many places.

Depending on the mode of disposal the tertiary treatment may be given for killing pathogens, nutrient removal, suspended solids removal, etc. Generally secondary treatment followed by disinfection will meet the effluent standards for disposal into water bodies. When the treated sewage is disposed off on land for irrigation, the level of disinfection needs will depend on the type of secondary treatment and type of crops with restricted or unrestricted public access.

Questions

1. Describe advantages and disadvantages offered by the water carriage system.
2. What are the possible adverse effects when untreated or partially treated sewage is discharged to the environment?
3. Why it is necessary to treat wastewater before disposal? What is the objective of the sewerage works?
4. Define sewage, sullage, sewer, and sewerage.