

WASTEWATER DISPOSAL INTO NATURAL WATERBODIES

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- This topic discusses up the setting of standards for disposal of water as well as receiving water quality to preserve the natural water quality of the region ,the various methods of disposal and processes involved , the concept of initial dilution and dispersion, and the basic concepts relating oxygen sag eutrophication , reoxygenation and deoxygenation



LEARNING OBJECTIVES ON THIS TOPIC

- - explain various factors that should be considered while setting the standards;
- -discuss decay of pollutants in lakes
- -explain reaeration and deoxygenation processes in a river
- -assesses ocean outfall working.
- -explain dilution, dispersion and diffusion processes of an outfall operation
- -explain environmental hydraulics.



EFFLUENT DISPOSAL STANDARDS

- Wastewater after treatment needs to be disposed of appropriately to avoid the pollution of the waterbody. The ultimate disposal of wastewater effluents can be by dilution in receiving waters ,by discharge on land, by evaporation into atmosphere as well as seepage into the ground.



Receiving Water and Discharge Standards

- The fundamental guidelines for up standards include the following;
- 1. Oil ,grease and floating solids should be removed form wastes before discharge to receiving water.
- 2 Solids that may settle and form sludge banks should be removed.
- 3. The minimum dissolved oxygen necessary for fish life must be assured by the setting of proper standards.



- 4. In canals, exclusively for drainage, dissolved oxygen should not be dropped down to zero.
- 5. In case of water supplies and bathing beaches, bacterial numbers are reduced by initial dilution a relatively rapid death rate with the passage of time and distance from the point of discharge.
- 6. Conservative pollutants should be reduced in concentration mainly by dilution.
- 7. Dilution necessary for the discharge of toxic components should be assessed.



- 8. Discharge of nutrients promotes excessive growth of algae and other forms of microscopic life resulting in undesirable turbidity and floating scum. As the organism die, odour is produced and the nutrients returned to watercourse, thus nutrient content of wastewater should be reduced before discharge.
- 9. Heated water discharges should not increase the temperature of the main body of receiving waters 5° C above the ambient temperature of waterbody.



EFFLUENT DISPOSAL BY DILUTION

- To describe the effects of a waste discharge on a waterbody, it is necessary for us to understand the physical phenomenon occurring in that body of water. Disposal processes where dilution is involved, concept of mass balanced need to be understood well, which forms the basis of all the dilution processes in all the waterbody system.



- The mass balanced equation is a simple formulation of mass of wastewater constituent in a stationary volume of fixed dimension. The simple mass balanced equation shall be:
 - $$\text{Rate of mass increased} = \text{Rate of mass entering} - \text{Rate of mass leaving} + \text{Rate of mass generated inside} - \text{Rate of mass lost inside}$$



Disposal into Lakes

- In locations where nearby streams are not available, it may be necessary to discharge treated wastewater into lakes or reservoirs. Lakes and reservoirs are often subjected to significant mixing due to wind induced currents.



- For bringing out the dilution estimate for the waste disposal, we need to understand the mass balanced equation of the effluent disposal in a lake. A mass balanced equation around the lake can be written as
- $$C = \frac{W}{V} (1 - e^{-Bt}) + C_0 e^{-Bt}$$
- $$V$$
- **Where:**
- $B = 1/t_0 + k'$ and C_0
- k' = first order decay constant
- C_0 = concentration in the lake at time $t=0$
- As discussed above, it is important to understand various other conditions of the lakes where treated wastewater discharge.



Stratification in Large Lakes

- Water such as lake is called stratified , when mixing in a waterbody is incomplete, allowing two or more distinct layers to developed for a considerable period. Stratification can occur with temperature or salinity , and the stratification can be vertical or horizontal
- Stratification of lakes is the result of an increased in water density with depth caused by a decreased in temperature. The maximum density occurs at 4°C.



Three Zones of Stratified Lake

- **1. Epilimnion**—maybe 9-15 m deep and fairly uniform in temperature because
 - of mixing by wind action.
- **2. Thermocline** -- is a zone of significant temperature changes and is extremely resistant to mixing.
- **3 Hypolimnion**--The lower layers in a body of water which are marked by low temperatures and insufficient light for photosynthesis. Levels of dissolved oxygen are low.



Eutrophication in Large Lakes

- **Eutrophication** is frequently a result of nutrient pollution. It generally promotes excessive plant growth and decay, favors certain weedy species over others, and is likely to cause severe reductions in water quality. Lakes and rivers becomes foul smelling and can no longer support many fishes and other animals.



- **Eutrophication** is a major pollution problem in lake ecosystem worldwide. The major causes of eutrophication are the ff.
- **A Excess nutrients that enter bodies of water come from the sewage plant.**
- **B. The use of detergent that contain phosphate greatly increases the quantity of phosphate entering the waterbodies.**
- **C. Nitrates comes from the fertilizers and automobile exhaust which enters the waterbody through rain and snow .**



Disposal into Rivers

- Rivers are subjected to natural pollution as they serve as drainage channels for large areas of the countryside. Rivers are capable of absorbing some pollution caused by humans, as they possess the ability to purify themselves through the action of living organisms.



- There are some natural processes, which are responsible for the rivers to self purify which include the following;
- **A. Dissolved Oxygen (DO) in Water Bodies** --when a pollutant is introduced into a water source, the DO typically decreases to a minimum level and then gradually recovers to reach back to its normal saturation levels. Decreased DO levels may also be indicative of too many bacteria and excess amount of biological oxygen demand .
- **B .DO Percentage Saturation** is a relative measure of the amount of oxygen
- **C. Reoxygenation** is a result reaeration from the atmosphere and photosynthesis of aquatic plants and algae are also the sources of oxygen replenishment in a river.
- **D. Deoxygenation** is a chemical reaction involving the removal of molecular oxygen (O_2) from a reaction mixture or solvent, or the removal of oxygen atoms from a molecule.



- The oxygen in rivers depleted by the following two processes.
 1. The bacterial oxidation of organic matter.
 2. The oxygen demand of sludge and benthic deposits.



Design of River Diffusers

- **Diffusers**--is a pipe with holes drilled in it at equal or varying spacing.

The design of this facility used for introducing waste into a river is important as that of the effects on oxygen resources of domestic waste.



RIVER DIFFUSERS



Disposal into Estuaries

- **Estuary**---defined as the zone in which a river meets with the sea.
- The analysis of estuaries in general is more complicated than the analysis of rivers and lakes. The ebb and flow of tides may cause significant lateral mixing
- Some estuaries are so large that complex-mix models are clearly inadequate. Where the physical processes are extremely complicated, it may be necessary to resort to physical rather than purely mathematical models of the basin. In any case, a physical understanding of the flow processes in a estuary is necessary before any rational analysis.



DISPOSAL IN OCEAN

- Ocean disposal is typically accomplished by submarine outfalls that consist of a long section of pipe to transport the sewage some distance from shore and in the best examples, a diffuser section to dilute the waste with seawater. Diffusers are one of the most efficient methods of providing initial dilution of a waste in a waterway. But most design parameters for diffusers originated from work done on ocean outfalls.



- At the end of the outfall, treated on untreated wastewater is released in a simple stream or jetted through a manifold-port diffuser .At this point the sewage mixes with surrounding seawater, and mixture ,which is called the sewage field. This drift or movement of current is term advection.



- The design of outfall should meet applicable receiving-water standards.
- Due to the initial dilution from an efficient diffuser is so large that the reduction in dissolved oxygen is usually of no significance.
- **Bacterial, floatable material, nutrient , and toxicity** requirements will govern the design and location of most outfalls. Accurate estimation of the number of coliform bacteria requires taking into account their reduction due to **die-off, flocculation and settling.**



- There are three major phases of mixing when the waste is released through an outfall diffuser,
- **1 Mixing effected by the buoyancy and momentum of the discharge or initial dilution.**
- **2. Far-field mixing or dispersion.**
- **3.Waste Decay**



OUTFALL DESIGN

- The outfall is used to convey the waste to the diffuser section. Its size is determined by the **velocity, headloss, structural considerations and economics situations**. Velocities of **0.7 to 0.9 m/s** at average flow are normally recommended in pipeline design to avoid excessive headloss.
- Lower velocities will not be a problem provided the waste received preliminary treatment to reduce the amount of settleable solids. On the other hand, velocities higher than **2.5 to 3 m/s** should be avoided because of excessive headloss.

