Urban Utilities Planning: Water Supply, Sanitation and Drainage
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Module - 11
Sewage treatment
Lecture - 53
Artificial Sewage Treatment Part I: Primary Treatment

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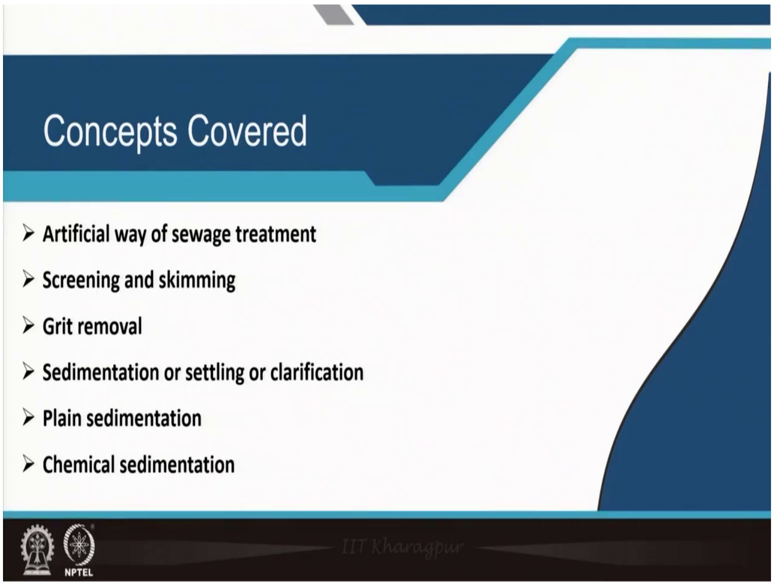

In lecture-53, Artificial Sewage Treatment (part 1) will be covered. The different concepts to be covered includes

- Artificial way of sewage treatment
- Screening and skimming
- Grit removal
- Sedimentation or settling or clarification
- Plain sedimentation, and
- Chemical sedimentation.

Artificial method of sewage treatment

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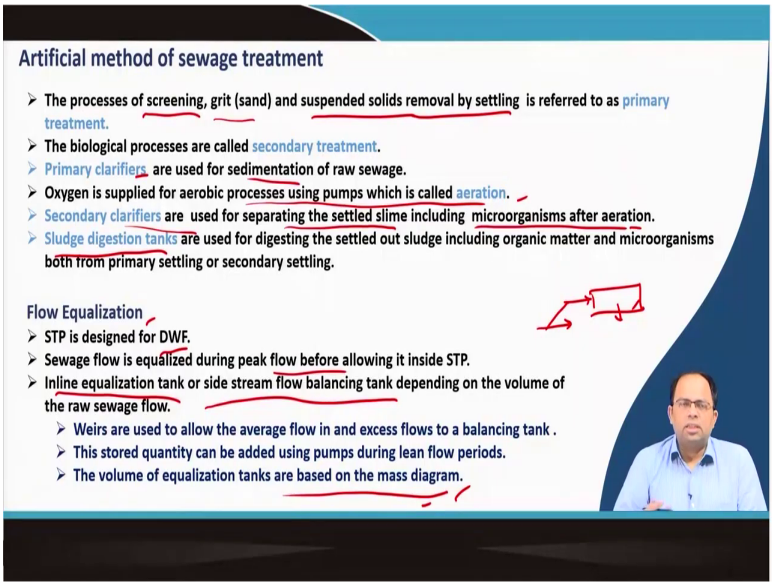

Artificial method of sewage treatment involves primary, secondary and tertiary treatment. Primary treatment involves the screening of the wastewater, removal of suspended solids by settling or sedimentation. Then Aeration is done which involves the supply of Oxygen for aerobic processes using pumps which enables the action of aerobic organisms. Biological processes are known as secondary treatment. Secondary clarifiers are employed after biological treatment which removes the slime which has formed upon the action of biological organisms. Sludge digestion tanks (can take sludge from both the primary and secondary clarifiers) are used for digesting the settled out sludge including organic matter and microorganisms both from primary settling or secondary settling. Sometimes, sewage is let out after the primary treatment stage because of financial constraints. The final discharge standard should be considered to decide on these matters.

Another important step is flow equalization; this has to be done before any treatment is done.

Flow Equalization

Flow equalization tank is built in the sewage treatment plant to handle the difference in volume over different days or seasons. The sewage treatment plant is primarily designed to handle dry weather flow, DWF. During the rainy season, excess flow occurs in the sewers and the excess volume is usually left untreated and sent to the outfall point by employing jumping weirs etc. As the STP is designed for a standard sewage inflow amount, it is important to maintain a standard volume sent to the plant. Flow equalization tank helps in storing the sewage during peak flow and allows the excess volume to the STP during the lean period.

There are two kinds of flow equalization tanks.

Inline equalization tank - the sewage first comes equalization tank first from where it is taken to the clarifiers.

Sidestream flow balancing tank - In this system, a certain amount of sewage goes to the primary clarifier such as the sedimentation tank and the rest goes to the equalization tank where it gets stored, at the same time. This excess sewage can be channelled to the primary clarifier as per requirement. Weirs can be used to allow excess flows to the balancing tank. This stored quantity can be added using pumps during lean flow periods. The volume of equalization tanks is based on the mass diagram (discussed previously under the section – design of reservoir capacity).

Screening and Skimming

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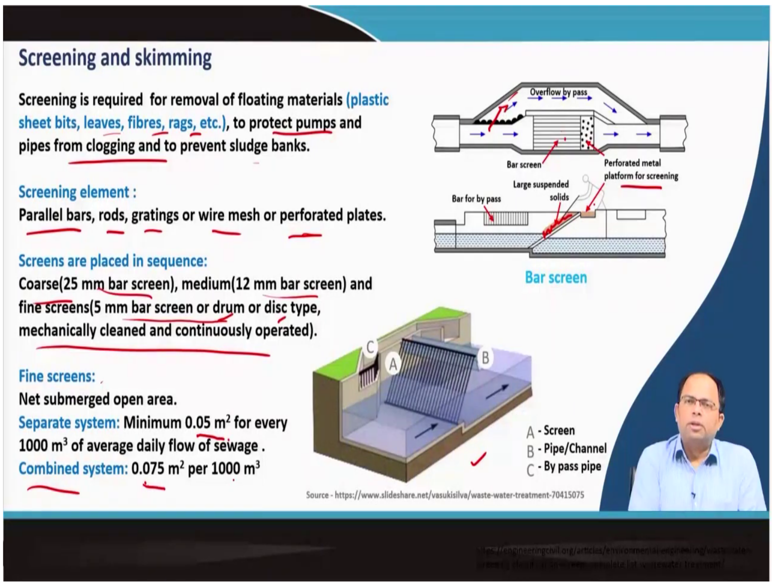

Screens are required to remove floating materials particularly. In the case of a combined system or the case of an open channel, a huge amount of solid waste gets deposited in the sewers and has to be cleaned before the treatment. Components such as plastic bits, leaves, fibres, rags etc which does not undergo sedimentation has to be removed initially. This is done to protect the pumps and the pipes from clogging and to prevent the formation of sludge banks. Screening is done by employing parallel bars, rods, gratings, wire mesh, perforated plates etc.

As shown in the figure, the excess water if it is not intended to get screened can be diverted to the overflow bypass. Screens such as a bar screen, and a perforated metal screen, ie, a coarse screen and a fine screen is installed together. The screen is installed with an inclination to trap the garbage which is to be cleaned by mechanical means or by workers.

3D view of the screens shows the different components involved. Coarse screens (25 millimeter bar screen), medium screens (12 millimetre bar screen), and fine screens such as a perforated plate (5 millimeter bar screens), and drum screens or disc type screens are placed in sequence. This gets mechanically cleaned and continuously operated. It is essential to determine the area of a particular screen that should be submerged because that corresponds to the area through which the wastewater will pass through.

In a separate system, around 0.05 meter square of screen area is provided for every 1000 meter cube of the average daily flow of sewage. This can be considered to determine the size of screens or the number of screens that has to be installed. In a combined system, the size of screens is relatively more because there is a need to filter different kinds of solid and floating matter; it is given as 0.75 meter square per 1000 meter cube.

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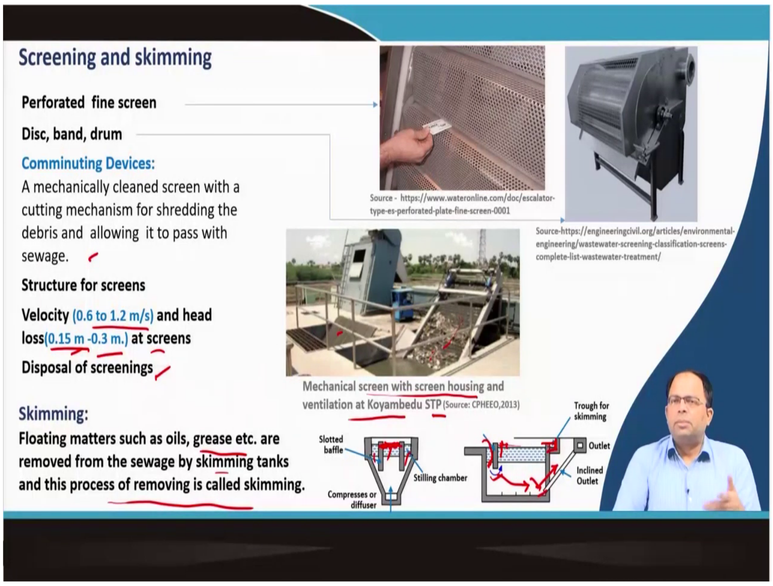

The images of a perforated fine screen and a disc band or drum screen is given in the above image. Apart from such screens, *comminuting devices* are employed, which is a mechanically cleaned screen with cutting mechanisms for shredding the debris and allowing it to pass through the sewage; It involves a rotating drum with teeth attached to shred the garbage. In the above image, the image of a mechanical screen attached with screen housing and ventilation is given; the two screens can be seen involving the mechanical screen which has provision for the scrapping off of the garbage can be noted.

While designing the STP, and to know the space requirement, it is important to know the velocity at which water has to be passed through the particular unit and the volume of waste that has to be handled. The amount of time involved and the number of units to be given should also be considered. The velocity of 0.6 to 1.2 meter per second is considered; head loss due to friction is around 0.15 meter to 0.3 meter at the screens. This is important because the movement of water from one unit to other occurs because of the head and if it becomes inadequate, the movement will not happen. Garbage after being collected from the screen is taken to the landfill site.

Along with screening, skimming is also employed as a pretreatment process which involves the removal of garbage and the floating matter such as oil, grease etc. Removal is done in skimming tanks (similar to the processes which involve sewer appurtenances to remove oil, sand, and grit) to ensure that oil does not enter the STP. The above figure shows the profile of the skimming tanks and the different components involved such as the baffle, a trough where the floating matter and oil gets removed, inclined outlet which allows the wastewater collected at the lower level of the tank towards the outlet.

Grit Removal

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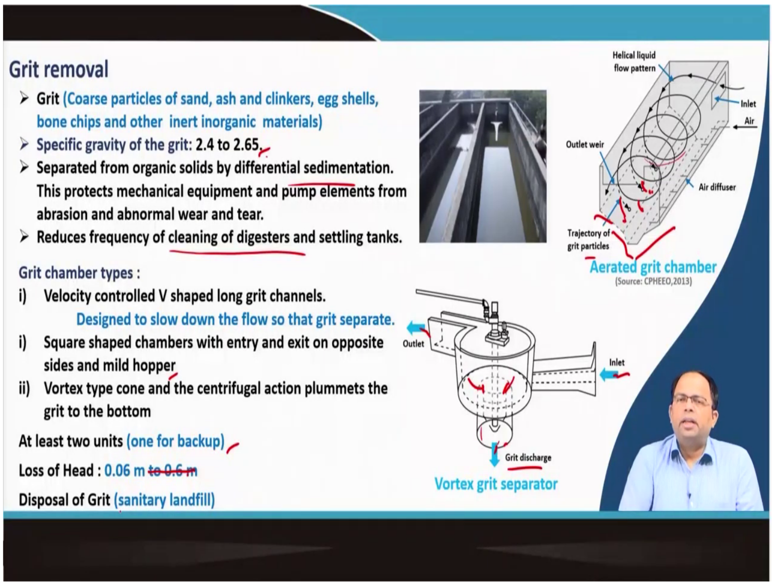

Multiple grit removal chambers are involved in the removal of grit in a sewage treatment plant. This step is important because the presence of coarse particles such as sand, clinkers, eggshells, bone chips, other inorganic materials etc with high specific gravity can cause damage (abrasion, etc) to the mechanical equipment involved. The various materials with different specific gravity can be settled with differential sedimentation which allows sedimentation of specific constituents in specific grit chambers. Grit removal reduces the frequency of cleaning digesters and settling tanks. This also reduces the volume of sludge to be digested. There are different types of grit chambers.

Velocity controlled V-shaped long grit chamber – This involves slowing the flow to allow grit removal. The system is shown in the above figure. Air is allowed inside the chamber. The trajectory of liquid flow in a helical pattern allows the grit to fall and get separated and collected at the V-shaped bottom of the chamber, *Square shaped chamber* – with entry and exit on the opposite sides. A mild hopper is involved which gathers the material to a point from where it can be taken out.

Vortex grit separator - Vortex type cone and centrifugal action plummets the grit to the bottom. The inlet and the outlet is shown in the figure. The centrifugal action involved brings down the grit to the bottom from where it can be removed.

At least two units of grit chambers are provided (one for backup). Loss of head occurs and is around 0.62 meter. The grit is then disposed of in sanitary landfills.

Sedimentation or settling or clarification

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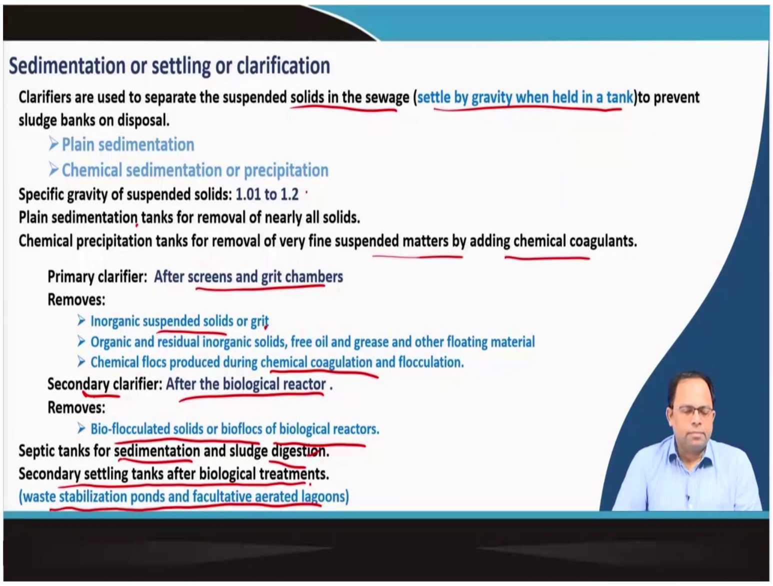

This step is exactly the same as in water treatment. *Plain sedimentation* (for all solids), and *chemical sedimentation or precipitation* (for removing fine suspended matter particularly colloids with the addition of chemical coagulants) are involved. Clarifiers are used to separate the suspended solids (with specific gravity 1.01 to 1.2 – is higher than that of water enabling settling) in the sewage which settles by gravity when held in a tank to prevent sludge banks on disposal.

Primary clarifiers are involved after the screens and grit chambers. This removes inorganic suspended solid or grits (if separate grit chambers are not provided). Similarly, organic and residual organic-inorganic solids, free oil, grease and other floating material could also be reduced to some extent. Chemical flocs produced during chemical coagulation and flocculation is also removed.

Secondary clarifiers are employed after biological reactors. Secondary clarifiers remove the bio flocculated solids or bio floc of biological reactors.

Septic tanks for sedimentation and sludge digestion – Sludge left after sedimentation is digested in septic tanks.

Secondary settling tanks after biological treatment (the secondary clarifier).

Waste stabilization ponds and facultative aerated lagoons instead of secondary settling tanks for the removal of suspended solids.

Plain sedimentation

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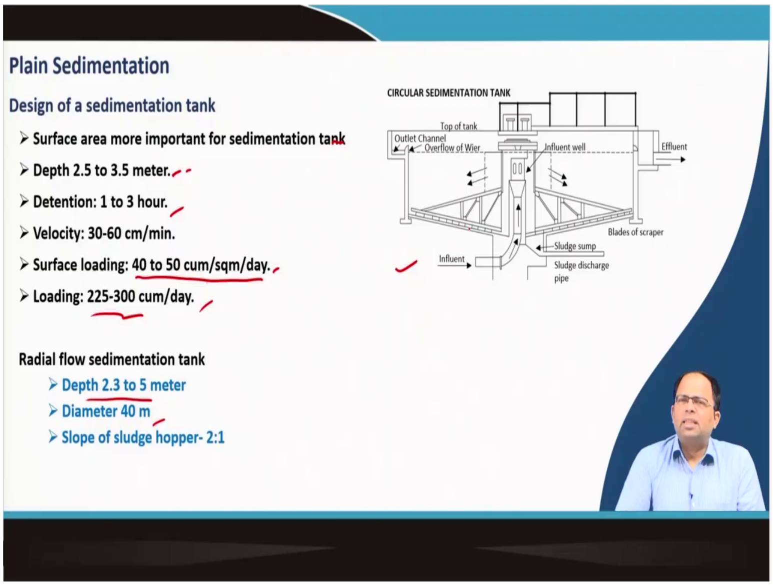

<u>*Design of a plain sedimentation tank*</u>

- Surface area is more important for sedimentation tanks because waves may get formed if the size is too large which can increase turbulence, and thereby reduce sedimentation.

- The depth of this tank is around 2.5 to 3.5 meter
- The detention period is 1 to 3 hours
- The velocity of movement within is 30 to 60 centimeter/minute
- Surface loading is around 40 to 50 cubic meter per square meter per day.
- The overall loading based on the volume of the tank is 225 to 300 cubic meter per day.

Both the loading values have to be considered in the design of the sedimentation tank. The above-mentioned points correspond to that of rectangular tanks.

In the case of a radial flow sedimentation tank such as the circular sedimentation tank shown in the above figure:

- Depth is 2.3 to 5 meter
- The diameter is around 40 meters
- The slope of the sludge hopper is 2:1

Chemical sedimentation

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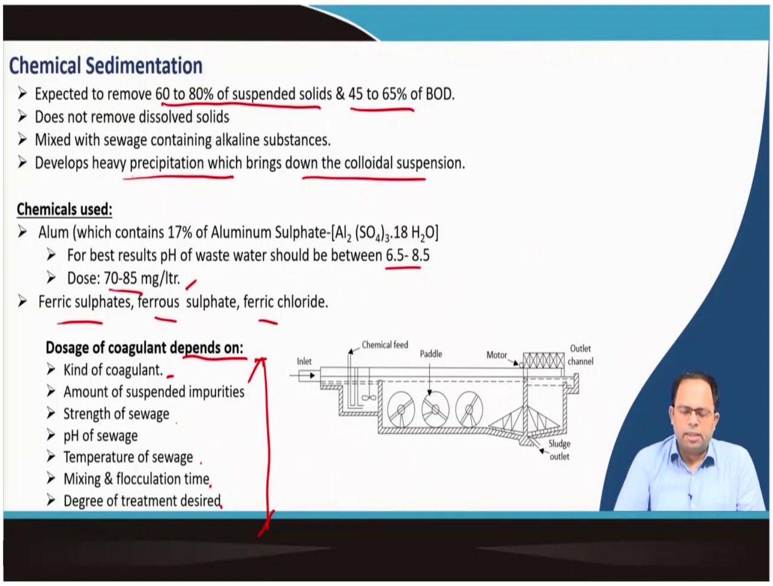

- Expected to remove around 60 to 80 percent of suspended solids and 45 to 65 percent of BOD.
- Does not remove dissolved solids which can only be removed through filtration.

- Sewage is mixed with alkaline substances which helps in developing precipitation to bring down the colloidal suspension.

Chemicals used:

- Alum (which contains 17% of Aluminum Sulphate-[$Al_2 (SO_4)_3.18 H_2O$]
    - For best results pH of wastewater should be between 6.5- 8.5
    - Dose: 70-85 mg/ltr (dosage is different from water treatment)
- Ferric sulphates, ferrous sulphate, ferric chloride are the other chemicals that could be also used instead of alum (aluminium sulphate and water).

Dosage of coagulant depends on:

- Kind of coagulant
- Amount of suspended impurities in the wastewater
- The strength of sewage
- Ph of sewage
- Temperature of sewage
- The mixing and flocculation time
- The degree of treatment desired.

Conclusion

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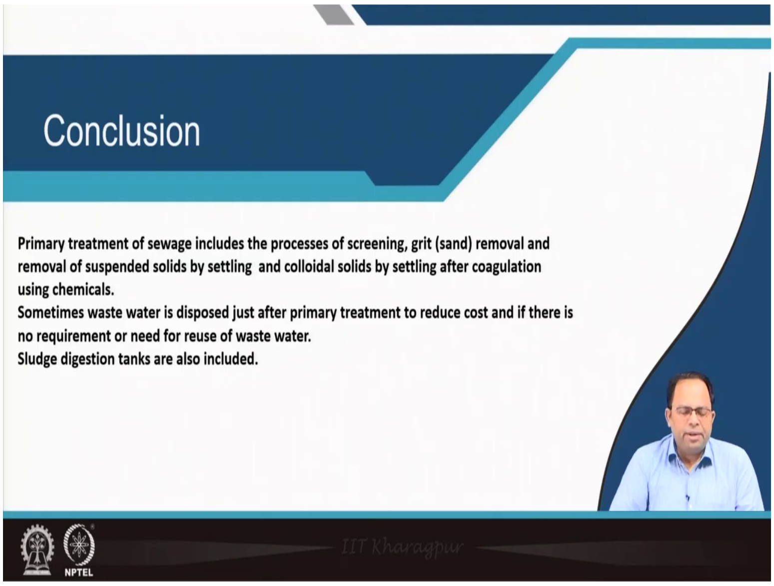

- Primary treatment of sewage includes the processes of screening, grit, or sand removal, and removal of suspended solids by settling and colloidal solids by settling after coagulation using chemicals.
- Sometimes wastewater is disposed just after primary treatment to reduce cost and if there is no requirement or need for reuse of wastewater.
- Sludge digestion tanks are also included in primary treatment if there is no further secondary treatment.

References

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