Building Services I

Lecture 10

Primary Treatment Unit

- Its main purpose to separate the floating materials and also the heavy settable organic and inorganic solids
- It also helps in removing the oils and grease from the sewage
- It reduces the BOD of the wastewater by about 15 to 30% by primary treatment itself

The operation used in the primary treatment

- screening
- grit chambers
- skimming tanks
- primary settling tank

So if you see this is the primary treatment plant of the sewage treatment plant, so this is the first step were raw sewage enters we have a bar screen where it will have filter, the most you know big solids and then it goes to the grit chambers which then flows to your primary settlement tankNow this screening for removing floating papers, rags and clocks.

- Grit chambers are detritus tank we call it, it is for removing the grit and sand and any other fine substances.
- Skimming Tanks we use it's for removing oils and grease.
- The primary settling tank is provide to remove the residual suspended matter if any is there

Now coming to the first part that is Bar Screens

Bar Screens

- The screening process we have bar screens it is a set of inclined parallel bars, so this is your bar screens inclined parallel bars it is fixed at a certain distance, it is neither close to the channel or close to the grit chamber
- Now this is to remove the large particles we saw earlier which is floating and suspended
- Now the waste water enter the screening channel, it should have a minimum self-clearing velocity of 0.375m/sec
- The velocity we have to maintain so that the screening should not be dislodge from the bars
- The slope the screen not perpendicular to the it is slope to a 30° to 45°

- Horizontal and the mechanically cleaned screens, so if it is mechanically screened the slope can be 45° to 80°

Grit Chamber

This Grit chamber it is to remove the contents like sand, gravel, cinders or any other inert solid materials which have specific gravity of 2.65 specifically, so why we mention the specific gravity is it should not again filter the organic solids also in this process so only to remove the sand, gravels and cinders. So if you maintain this specific gravity we can achieve this, now this is the chamber particles settle as individual entities so there is no interaction with the neighboring particles that is no type of digestion and any reaction will happen. It's also free settling or zone I settling it's just settles that's all then the velocity can also pass through it should not be alert to change in spite of the change in flow. So whatever velocity is coming in weather it is increases or decreases it has to be constant. So automatic velocity is achieved by providing a proportional weir at the outlet of the grit chamber where it has from the bar screen. Now the horizontal flow grit chamber should be designed under the most adverse conditions all the particles of size 0.2mm or more in diameter, it should reach the bed of the channel prior to reaching the outlet. So the sludge water when it is going to move from the inlet to outlet it should be capable to settle 0.2mm in more in diameter any particles is 0.2mm or more should settle the bottom of the grit chamber. Now the length of the channel depends on the depth required the amount of the thing that is going to enter and the settling velocity and the depth required will be designed by the length of the channel. So minimum allowance of approximately twice the maximum depth so whatever depth you have twice the depth should give the length of the channel because we told that settling has to happen before it reaches the output of particles 0.2mm and more. If we have very large plant then you will have two or more grit chamber because the quantity will be more and everything will not settle in one grit chamber itself. The grit chambers recommended detention time is 30 to 60 seconds, so the water should flow through the channel for about 30 to 60 seconds to have an effective settlement.

Skimming Tank

- The floating solid materials like soap, vegetables, debris, fruit skins, pieces of corks all this things will be removed but oil and grease will be removed only by the skimming tanks because oil and grease which cannot be filtered by this grit chambers or Bar screens
- So skimming tank is a chamber it is designed so that the floor of floating material rises and reminds on the surface of the waste water until it is removed so when this happens continuously so this is the top view, this is the inlet, your bar screen and here happens here skimming and skimmed oil to the sump, the skimmed whatever is floating here taken to the sump and this is here outlet. So if you see here this is the section we have

your inlet here and the sewage water is flowing through your chamber. Now this will be a continuous process it will be May to flow from the top to bottom. So it will create a skimming effect so when it is skimming it will the float the oil and grease to the top so that can be removed effectively. So while the liquid flows continuously through outlet or partition below the water lines

- So here the skimming tanks the detection time is 3 minutes
- So to prevent heavy solids from settling so when this skimming process the heavy solid should not settle to prevent that compressed air is blown through the diffusers placed in front of the tank. So when air is kept on blowing through it the solids will not settle there
- So due to compress the supply the oil matter rise support and are collected so this also helps in the skimming process the air that is supplied inside

Primary Sedimentation Tank

- Effluent of the grit chamber, containing mainly lightweight organic materials will be settled in the primary sedimentation tank.
- So if you look at this pictures so here is where the Fat and float to top are removed skimmed off and then it is fed into your primary settling tank

So the objective of this sedimentation is

- To remove the readily settle able solids, whatever solids we have here everything will not be settle able so whatever can settle at this point will be removed here and the floating material also will be removed
- When settling happens some solids might float on top and to reduce the suspended solids contents which when they are used as a preliminary step to biological treatment
- So there is a design criteria for the amount of BOD and the amount of suspended solids that can be present when the treated water released to the natural waters. So to bring down the BOD and suspended solids this sedimentation tank will help in that
- Now this biological treatment that is happening here in this tank will reduce the load on the biological treatment units,
- when the suspended solids is reduced so when it goes to the next process the load also will reduced
- Now the primary sedimentation tanks it is designed for the velocity of 1 cm/sec this is the average rate of flow.
- The detention period for year is 90 to 150 minutes that may be used for the design and also depending on the volume it may vary.

- So you can see a slope in this tank so what happens if the slope of the sludge it is generally 2:1 (Vertical to horizontal if you take the slope) the ratio is 2:1 which is necessary because whatever the sludge is being deposited it will kept and accumulated here by gravity

Secondary Treatment Units

Whatever collected in the primary treatment plant now that has to be taken to the secondary treatment whatever is remaining

- So the effluent from the primary treatment is treated further for removal of dissolved and colloidal organic matter so which not able to settle which is already dissolved in the water and which is a colloidal organic matter it has to be treated only in a secondary treatment.
- This is generally accomplished through biochemical decomposition of organic matter which can be carried out either under aerobic or anaerobic conditions. So from the primary sedimentation tank the sludge move on to your secondary treatment, the secondary treatment we have various one trickling filter which will take to the oxidation ponds or you also have the activated sludge process. So depending on the type of treatment unit we have it can be either aerobic or anaerobic.
- Now this is the biological unit where the bacteria will be decomposed to the fine organic matter to have a more clearer effluent, so if you see the color of the effluent here if you see its more brown here and its becomes the brown is gone down and the blue is coming up so as it progresses you see the so the blue color means it's more clear the effluent is more clear.
- The end product is aerobic decomposition is mainly carbon-di-oxide and the bacterial cells, and about in anaerobic process you will get CH_4, CO_2 and bacterial cells
- Now this biological reactor where the organic matter is decomposed that is we have three things like your
    1. Filters which is called trickling filters
    2. Activated sludge Process are ASP
    3. Oxidation Ponds

Now the bacterial cells will be separated out in secondary settlement tank and there is the another settlement tank in this unit they were the separate the bacterial cells and then you dispose of them after you stabilize the bacterial cells under the aerobic or anaerobic process along with the solids settled in the primary sedimentation tank

Trickling Filters

Now this is how a trickling filters looks like

- This is used for the complete treatment for the domestic waste, so this is the circular thing where it is a bed of which is of various media can be small bricks and bats. So many media's are available then you have the booms were the water is being trickled down like it is actually done as a spring irrigation kind of thing. So this is the treatment of domestic waste and as a roughing filter for strong individual waste, so it as an application like trickling filters cannot be used in all applications. So this happens prior to your activated sludge process now what happens is primary sedimentation tank is the previous step for your trickling filter so as that the settle able solids is settled here otherwise if there is no primary settling tank this filter will get cloaked because we have very minute pores for this
- So it is followed by secondary settling tank for removal of settle able bio solids in the filtration process. So after this is being trickled or settled down so the trickling happens now there is another settlement happening here so whatever is settle down this is been taken to your secondary settling plant and the clear water will be removed
- So when the water is trickles through the filter media, so this is the filter media was talking about it is generally like rocks of 40 to 100mm size or any other plastic media can be used, a biological slime consisting of aerobic bacteria and other biota builds up so around this because the water is flowing through the media around the media there will be a layer of slime will be formed. So the organic material in the sewage is observed in the biological slime it is partly degrade here itself, so it increases the thickness of the biofilm.
- So there is the scouring the biofilm has to be scoured is you have to scrape it out and fresh bio film again it starts to come in and that will grow on the media like this it will keep on growing in
- Now this bed of the trickling filter is again has to be sloped to take out the effluent so that slope will be 1 in 100 or 1 in 50
- So the under drainage system consist of 'V' shaped or half round channels, cast in concrete floor during its construction.
- Revolving distributors are provided in the top, this spray head they what shown in it will be revolving it can be either two or four horizontal arms, so this arms will have the perforations from where your sludge water will be trickling down you see this are the pores that will have, so the rotating arms remain about 15 t0 25cm above the top surface of the media.
- The distribution arms will be rotated by an electric motor or by back reactions on the arms y waste water like when the flow of the water itself it is about two rpm and it will be in automatic process, the head of 30 to 80cm of water is required to rotate the arms

so if it as to rotate it by itself the head as to be the head means the incoming pipe it as to be 30 to 80 cm

- Now this trickling filters can be classified as low rate and high rate depending on the organic, what is the type of loading that is coming inside, so if it is low rate filters the hydraulic loading will be 1-4m^3/m^2 .d and the organic loading will be 80 -320 g of BOD for every m^2 diameter and recirculation is not adopted as low rate filter the depth of the media will be from 2m to 3m. If it is a high rated one the hydraulic loading will be about 10 – 30 m^3 and the BOD will be 500 -1000g and the recirculation is again possible here which is again 0.5 to 3 so the depth of the media here will be very less which is 1m to 1.8m, so depending on the type of or the amount of flow it can be determined whether it is a low rate filter or a high rate filter

ACTIVATE SLUDGE PROCESS

- This is an aerobic biological treatment system.
- The settled water is aerated in an aeration tank, so this is your aeration tank where you have pores where you will have the air going inside so the air will be treating it so this will be kept for a few hours in the tank
- During this aeration, the microorganisms will stabilize the organic matter.
- Now in this process the organic matter is synthesized into new cells and a part of it is oxidized to derive energy. So we already saw anaerobic process will always give out energy.
- So the synthesis reaction followed by subsequent separation of this biological mass and oxidation reaction so that mechanical BOD removal is happening in the activated sludge process it's a mechanical process where the BOD is removed
- Now the biomass is generated in the aeration tank is generally flocculent and it is separated from the aerated wastewater, this happens in a secondary settling tank and is recycled partially in aeration tank once it done it goes to the secondary settling tank but again sometimes a recycling also happens it again done in a aeration tank.
- The mixture of recycled sludge and wastewater it is called as a mixed liquor.
- The recycling of sludge out it helps in the initial built up of a high concentration of active microorganism, so this microorganism that is present in only helping in this process, so when you recycle this sludge it will increase the concentration so the BOD removal will be accelerated that is faster
- Once the required concentration is reached further increase we have to prevent that is done by regulating the quantity, so the recycling sludge is coming inside will be you know regulated and then the excess sludge will be removed from the system.

- The aeration units are main units of activated sludge process, so the aeration is main unit in this whole process the main aim to supply oxygen to the wastewater to keep the reactor content and to mix up the return sludge with wastewater thoroughly, so only by supplying aerobic reaction its more oxygen supply, so the oxygen supply to the waste water must be more only that will keep the process more alive and content so the return sludge will be help in this process
- The usual practice is to keep the detention period is between 6 to 8 hours, so few hours I told you is kept between 6 to 8 hours it is more efficient, the volume of aeration tank is also decided by the returning sludge, see how much return sludge you required to do have a better efficiency depending on that you have to design not only in flow of the system but also the return sludge has to be calculated in the design so that is usually 25 to 50% of the waste water volume, how much ever volume comes inside from that volume 25 to 50% additionally you have to take into consideration for designing this aeration tank
- The mood of air supply can be either diffused by air aeration or by supplementing compressed air from tank bottom or by mechanical aerators so you can either way bring air into the aeration tank. So it can be either provided at surface by are compressed air from the bottom by diffused aeration so both the process are used.
- Depending on the flow regime like the flow of water, this process can be classified as conventional and completely mixed activity sludge process the modification is extended in such as extended aeration is possible only used in treatment of waste water the modified version is the return of the sludge. So that is the modified process it is extended aeration we call it this is used in the treatment of waste water process.

SECONDARY SETTLING TANK (SST)

- It is somewhat different than you are primary settling tank here the function is so here this is similar to your primary but the function is doesn't not only settles but it also make the thickening of the sludge happening here
- This is takes place in followed by compression.
- It has a detention period of 1.5 to 2.5h, so the sludge that is coming here will thickened the sludge so that settling will happen faster.

OXIDATION PONDS

- Oxidation Ponds are the stabilization ponds, what happens is the partially treated sewage is sent to these oxidation ponds. It is actually pond which is dug into the ground it is very shallow depth.

- This is the heterotrophic bacteria degrade organic matter in the sewage, the sewage that has come to this level will have heterotrophic bacteria degrade organic matter. So that will production of cellular materials and minerals will be produced
- The production of this will support the growth of algae and oxidation in the pond. If you see here you can see it's just a regular pond that is dug in the ground the depth is very less, so the partially treated things comes here now the bacteria which is present here in help in growth of the Algal growth.
- So this algal populations also they further decompose organic matter by producing oxygen because when plants are there it will give of oxygen
- So these production of oxygen replication oxygen used by the bacteria, so whatever the oxygen bacteria uses it will be again replaced by the alkyl growth so these as to be at least 1m deep to discourage growth of aquatic weeds and it should not go beyond 1.8m
- The detention period is usually 1 to 4 weeks depending on the sunlight and temperature

So the most final stage in a secondary treatment unit is a sludge treatment

SLUDGE TREATMENT

- In a Sludge treatment, the drying beds are commonly used in small water plants treatment and to dewater the sludge before it is sent to the final disposal.
- So in this you have two mechanisms
    1. You filter the water through the sand
    2. You evaporate water through the surface

From the primary settling tank from the sludge is coming here and from the secondary settling tank also the sludge comes here so from the sludge is digested is through the digested passes through to the sludge drying bed. The water will pass on to the other systems

- The drying beds it consists of perforated or open joint pipes laid with the gravel base covered with the layer of sand
- So the sludge is placed on top of this and allow to dry so they will have a bed like this you have the gravel bottom, sand on top the sludge is placed here, so the just placed and let it dry so what happens is whatever is present here it will trickle down and time in the waters taken out here, the dry sludge will be here now this water whatever is coming out it can be removed through evaporation process also or an by gravitational like this trickling mechanism
- So the filtered water is again returned to the plant for treatment
- So the cracks develop know when the sludge as it dries the cracks will develop and evaporation is occur faster so that is also easier to discharge the sludge. So it is also this

process well suited sludge which is under proper aerobic or anaerobic digestion after those process is done this kind of treatment is effective

TERTIARY TREATMENT

- This is the final or advanced treatment, it consists of removing the organic matter left after the secondary treatment, if there is any organic matter left it will be removed by this method, this infection in this method is normally carried out by chlorination, this actually a chemical treatment use chemical to remove clean the sludge. So it is further removal or organic matters, suspended solids, nutrients and total solids happen in this treatment.
- The sewage treatment is generally confined only to secondary treatment only
- Various physical chemical and biological processes are available for treatment depending on the particular requirements. So the choice of the treatment matters different on several factors including the disposable facility available should be consider to when you design the sewage treatment plant process

Pumps & Motors

Now moving onto the equipment's used in the management of water and waste water. So basically equipment are pumps and motors, motors to drive the pumps. So what is the pump

- It is the mechanical device or arrangement by which the water is cost to flow at increased pressure it is known as the pump. The process if using a pump is known as called Pumping

The purpose of pumping

- To increase or boost the pressure to certain points
- To clear water after treatment, to lift the clear water is treated
- To lift the raw water from the lakes, reservoirs or any rivers and to take the available water from the well and to elevated tank and to take the water
- To make the available water at higher pressure
- To take the water out from basins, sumps and all those things
- If you want throw directly into a distribution system then you use pumps

Types of Pumps

So when you take pumps the major types will be positive Displacement and Centrifugal pumps. So these positive displacement it is operated by alternating there will be a cavity which will be filled and then so this is how it works there is a cavity here and this is your inlet, so when you

move by the section the water enters here and then moves here it is to discharge here but in a centrifugal pump there is a impeller here, so the water as it is comes inside the impeller moves it as speed and it will push the water to the discharge. So this is the basics of the Positive Displacement and Centrifugal Pump. So when you use a centrifugal pump can vary the flow depending on the pressure or head because that is controlled, in positive displacement it will be very constant flow, the flow in centrifugal pump is reduced when the viscosity increases the flow will be reduced but when the viscosity increase the positive displacement from the flow is more. So the changing system pressure head will have a major effect in the flow rate in a centrifugal pump it is not so effective in a positive displacement pump it's a constant one.

SUBMERSIBLE PUMPS

This is the type of centrifugal pump it is also called as multistage centrifugal pumps, this will be submerged in a liquid that's why we called as submersible pump whatever liquid you want to take if it is going to be a bore well it will be inside the well and then the water will be pumped out. The main advantage is it prevents pump cavitation, pump cavitation we say air lock, air seal happening in the pump that will be prevented and higher elevation difference between the pump and the fluid surface is not a problem for this pump.

APPLICATIONS

Now the application if you see, you have single stage and multistage

- Single stage pumps are for drainage, sewage pumping, general industrial pumping and slurry pumping
- Multistage is typically used in your residential, commercial, municipal and industrial water extraction and water wells and oil wells.

The other uses will be

- Sewage treatment plants
- Seawater handling
- Firefighting
- Offshore drilling
- Artificial lifts
- Irrigation systems

Now reciprocating pumps it's a type of positive displacement pump so we know we saw it is a pumping action actually

- Priming is not required for this type of a pump, this is generally used in hilly areas it is lower efficiency when you compared to your centrifugal pumps that is your submersible pumps, the application is it is not recommend for city water supply schemes its initial cost is very high, so if we can justify the cost you can use it in those places, these small types of reciprocating pumps suitable for private wells. So it will give a it is best when you have a higher pressure

MOTORS

So you required a motors for to power the working of the pumps, so some of the types of motors are

- Steam Engine
- Gasoline Engine
- Diesel Engine
- Electric Motor

Steam Engine

It is practically out of dated and it is old fashioned and the setup is very clumsy, it also consumes more fuel takes more time to work to come to start. It has construable loss of energy when it is stopped and started; the efficiency is only 60 -70%

Gasoline Engine

Gasoline means it is using gasoline or petrol as the fuel, this is not as clumsy as steam engine, so it is very reliable and it takes only less quantity of fuel and the efficiency is about 70-80. This engine is very noisy

Diesel Engine

This is the gasoline engine, the gasoline engine is very costly and rarely adopted and it is suitable for stand by units if electric motor or something is there fails you can use the gasoline engine as the stand by unit. Diesel engines are very noisy and also used as a stand by units

Electric Motor

This is the modern motors that we used, it can be used in small and medium plants, it is very compact in design we just switch it on and the motor starts immediately. So it is also it addresses very smoothly and is free from dust, there is no dust no smoke and it is advantages in everywhere efficiency is about 90 to 95%

SIZING OF THE MOTORS

How do you select a motor, how do you size the motor it is basically from the horse power, horse power is nothing but the torque and produced by the thing so generally it is done as a H.P = (W×H)/75 where the W is the weight of water in Kg per second and H is the total head in meters. So the standard efficiency will be used when choosing the equipment, 65% to 100% is the best one and motor generally as we used the efficiency will go below 50% then will have to replace the motor.

Another point is during **start up** the motor starts what happens is should be able to it already stopping so it should be able to start and then pick up speed and then maintain the speed so that is something have to look for a motor

Duty Cycle is when it starts runs and stops, there is a cycling that is happening, so that will be happening frequently so when there is the frequent thing happening it becomes you know it will detoriate the life of the motor so that as also be considered.

The we comes to pumps, how do you select the pumps

- Solids handling – you have to consider what is the type of solid, water is going to handle, so what is the solids present it is a clear water or it is going to have some clear water with some junks like you know leaves and twigs or it's going to spherical solids which we find in a sewage treatment, sewage water.
- Shut off – Shut off is the highest point, the pump can take the water can lift the liquid actually so beyond that point the water will not go so that has to be considered
- Performance curve and GPM – there is the chart which says the how many gallons per minute of water or how many liters of water can be taken to what kind of a height depending on the pipe size. So there is the chart we chart we have called performance curve chart from that we get select the required pump
- Horsepower – we already saw that is the measurement of the amount of energy necessary to do the work is also there
- Amps and Volts – So if the lower amp pump is selected the rating will be better because lower amp is lower energy and the energy is used to run the pumps so it is more economical so these points have to be consider when sizing the pumps.