Water Quality Management Practices

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Week-08

Lecture-36

Trickling Filter- Physical Overview, Types and Process Description

Hello everyone, welcome to this NPTEL online certification course on Water Quality Management Practices. My name is Gourav, Professor Gourav Bhowmick. I am from the Department of Agriculture and Food Engineering of Indian Institute of Technology, Kharagpur. In this particular module we will continue with the discussion on the Aerobic Waste Water Treatment Systems and today we will start with the discussion on the trickling filter. The concepts that I will be covering today is the overview of trickling filter, its process descriptions, physical descriptions of trickling filter, the types of trickling filter, the advantages and disadvantages and some design equations and one numerical as well. To start with we all know that there are like two different types of in terms of attachment of bacteriological parameters and also we have attached growth biological systems and biological treatment systems and suspended growth biological treatment system.

We already designed one suspended growth biological treatment system that is what activated sludge process. So, today we will start with the attached growth biological treatment system. In case of attached growth biological treatment system it can also be subdivided into three categories. First is unsubmerged attached growth where the fixed bed support is provided and the bed is actually stationary, but it is not submerged completely.

Then we have submerged attached growth process. It is also stationary bed and the fixed bed support is provided. However, the whole process the whole growth bed is in submerged condition. And the third one is the moving bed attached growth process. In this case the media is keep on moving inside the reactor.

So, there is one example I will share you in like you know in next to next slide also next to next I mean like the lecture module also lecture material also it is about the moving bed bar frame reactor. So, there you will get to know about this moving bed attached growth systems and you will also design it by yourself and you understand how it performs. So, today our motto is to understand this unsubmerged attached growth reactor which is also known as the trickling filter. So, trickling filter it is a type of unsubmerged attached growth process where the wastewater is distributed from the top of the filter media and it slowly trickles down. So, that is why it is called the trickling filter.

So, you can see in this picture you can see this distribution arms. In this distribution arms the wastewater is trickled or does like you know sprayed over the surface of this biomedia. And this biomedia is actually a useful for like you know for forming the micro biofilm layer small biofilm slime layer on top of it. So, this biofilm only now consume let us start consuming the organic matter present in the wastewater and it starts growing on itself. So, this what is happening there? There are this wastewater all whenever it is when it is sprayed over the top of this biomedia those biofilm present in the biomedia or the surface of this biomedia consume those nutrient present in the wastewater and by the time it will reach to the bottom it is or it is theoretically there are will be some amount of removal of organic matter nitrogen phosphorus etcetera.

We will discuss about it in more in detail. So, this is like overall picture that I want to share with you like how it looks like and this biofilm which normally comprises it is majorly the active aerobic microorganism of bacteria protozoa fungi and also it major role is to remove the ammonia or the nitrogen compound and as well as the organic matter present in the wastewater. So, if you see the physical description so, in general what are the different components that it has first one is the filter media. Filter media is you can see in the middle we provide the filter media that main motto is to provide some space for the microorganism to grow as easy as that you understand. So, this microorganism will start growing on the surface of this biomedia and it will start to catalyze the oxidation reaction on the of the organic matter in the wastewater.

In case of conventional low rate and high rate trickling filter this filter media has around 3 meter of a media depth. In case of super rate trickling filter we will discuss about all these things low rate high rate as well as the super rate trickling filter. In case of super rate trickling filter the media depth is around 8 millimeter 8 meter and with the minimum clearance of 15 centimeter has to be provided in the distribution arms because this rotary distribution arms it spread the wastewater on top of this filter media. The gap between this top surface of this filter media and the spraying nozzle of individual distribution arms this should be the gap should be at least 15 centimeter ok. Now, this rotary distributor systems rotary distribution system is nothing, but it consists of a central feeder pipe and then supports two or more horizontal arms with a number of nozzles through which the wastewater is sprayed over the surface of this filter media ok.

Now there is this under drainage system you can see in the bottom there is this under drainage system. It has a couple of purposes first of all it is all the after the treated wastewater is treated that wastewater it carries along with it along other than that it also carries the solid which discharge from the filter media because what is happening in the filter media with time the bioprimes start growing. So, when it start growing after certain millimeter of depth what happened after certain millimeter of depth what will happen it will the outer layer will keep on going, but inside layer they will die. So, with time once the inside layer they will start dying they come out of the surface of this biomedia. So, this phenomena is called the slogging of phenomena.

So, this biomedia when it come out of this surface this slime layer you will see taken one small slime layers like structure it will come out of the surface and it comes at a as a as a grow structure. So, it will directly go inside go in the bottom in the under drainage system we collect those slogged of biomedia slogged of biofilm and that also carries by in the in the secondary in the next step in the clarifier we collect those this biomass and we easily dispersed it as a sludge. Another very important job that it performs is the ventilation system because of certain gap that it provide that we provide on the under drainage system in the bottom it provides some ventilation to the filter in order to maintain the free air circulation in for the aerobic environment to prevail ok. So, in general the floor of the under drainage system has to have at least 1 to 5 percent of slope towards the main drainage channel and with a minimum velocity of 0.6 meter per second to avoid the deposition of this slogged biofilm ok.

So, it should the biofilm should keep on coming in the bottom and hopper bottom like structure. So, from there the main effluent channel is there from there we collect the this biomass and then slogged biomass and we simply separated in the next system in the clarifier and the secondary sedimentation tank called clarifier. So, what are the different types of trickling filter? First to start with the low rate or high rate trickling filter and then the super rate trickling filter is there. So, what is low rate or high rate trickling filter as you can see in this picture in this low rate simply we have trickling filter then we have a secondary sedimentation tank to collect the sludges to like you know sediment all the slogged biomass. Then the effluent will the super rate will go out it comes as effluent.

In case of high rate trickling filter what happened the after the effluent trickling filter process the some amount of effluent is we are returning and again after the secondary sedimentation tank also whatever the sludge is there the sludge also we some portion of the sludge is actually we return it back to the primary sedimentation tank for and for further treatment and from there the sludge is actually collected for in the digester in the collected for the sludge handling units and all. So, in this case this is called the high rate trickling filter and also further treatment efficiency is quite high quite efficient in case of high rate trickling filter systems. In general the circulation it helps in providing the seeding to the filter bed during the initial startup and during the normal operation also it in case normal operation it also dilutes the organic matter concentration in the influent waste water by which actually it helps actually to for like you know to reduce the influent BOD load and which is the one of the major limitation in case of trickling filter. So, that is why the super rate high rate technique filter operates much with much better efficacy. Then there comes the super rate technique filter or the roughing filter or famously known as bio tower ok.

If you see now it is bio tower is most prominently used this word is most prominently used then the super rate trickling filter. So, what is happening there we when we have a organic load of more than 1.6 kg of BOD per meter cube per day we normally provide this kind of structure bio tower. In case of bio tower what is happening what is you can see this picture both the picture the in case of low rate or high rate trickling filter we are not providing any external means of air circulation we just make some space in the bottom ok that is it and on the top that is it. So, basically from here we have a exhaust fan which purposefully pulls the air through the system and there is a vent provided on the both the side like I mean like the on its peripheral region.

So, through which the air will enter air will enter and it will pass through those biomedia and reaches to the top. So, because of that there is a active aeration taking place because of this active aeration the it generates its maintains the aerobic environment inside the trickling filter ok. Another type of system is there you can see in the next one this 3B in this figure there is in the in the in the in the peripheral structure of it there is blower placed in the bottom. So, this blower it blows the air it takes the air from outside and blows it inside and the air will and there is a vent on the top and through which the water the air will pass through this biomedia it will reach to the atmosphere. So, this way in either of this configurations are useful for making it a bio tower considering it at a bio tower or super rate trickling filter.

It normally has a diameter of around 3 to 70 meter with a air blower or exhaust fan in it and there is a normally in case of absence of external air circulation normally we provide the shallow depth, but in case of artificial air draft it can be constructed up to 12 meter depth with a 5 to 8 meter typically adapted depth. The synthetic material such as plastic modules can be used for filter media as it provide high specific surface area, high void ratio and low density on which the biofilm can be formed. In this kind of plastic media interlocking plastic surfaces are arranged to produce a honeycomb like structure which is highly porous clog resistance and this permits the application of higher organic and the hydraulic loading rates of this type of filters. In case let us discuss about more in details majorly the mechanisms like flocculation and sedimentation in the void of this bed material also assist in overall treatment process. This diameter of this trickling filter it depends on the mechanical rotary distributor we used for spraying the waste water on the top commonly more than 12 meter for single filter unit.

In case of rotary arm when it rotates it is a result of the jet reaction. What do you mean by the jet reaction means suppose it is rotating like this over a single point. Because what happens is it act like a lever action and what happen when the water will move from say one direction from the right hand side arm in the left hand side arm say it is moving from the opposite direction. So, what will happen it will literally because of the Newton's third law it will put a additional jet action on the top on the arm because the arms are almost free moving. So, it will move in the opposite direction of the flow of water.

Like you know spray the side from which the your spraying action is going taking place. So, because of that it takes it is naturally it started rotating on the top of this things because of this jet action. So, you do not have to provide any additional means of rotor or motion like energy sources to move that arm move the arms of this distribution channels. So, then this in general this technique filter with the small diameter of less say less than 6 meter we normally provide the power driven rotary arms. In case of it is more than that we do not provide it happens naturally using the jet action.

In order to avoid the filter clogging a maximum specific surface area of 100 square meter per meter cube is recommended for carbonaceous viewed removal and up to 300 meter square per meter cube for nitrification also if you want to also go ahead with the nitrification process. Because the nitrifiers are slow having a very slow growth rate ok. The overall performance of the trickling filter it depends upon the hydraulic and the organic loading rate applied wastewater pH operating temperature and air availability through the natural draft within the pores and mean time of contact of wastewater with biofilm. The mean time of contact is related to the filter depth applied hydraulic loading rate and the nature of filter packing. The contact time in general it is estimated by the equation 1

$$T = C.D/Q^n$$

where t is the mean detention time, d is the depth of filter bed and q is the hydraulic loading rate in meter cube per meter square per and C and n are the constants ok.

Please remember this equation it will be useful for us write it down it will be useful for us in coming slides t equal to C t by q to the power n for finding out the mean detention time ok. To understand more about the process biology what is happening in general the wastewater trickles down through this filter media and this biological slime layer is developed on the surface of this filter media. This biofilm which is formed over the media surfaces it consists of microorganism responsible for biodegradation of organic matter. The major population of this biofilm over this slime layer which form just right next to the bio biomedia they are majorly aerobic anaerobic or facultative nature ah bacteria ah other than that algae, fungus, protozoa, rotifiers, snails, flies, worms can also be there because of its favorable condition that we provide. Usually usually up to a depth of 0.1 to 0.2 millimeter of slime layer can have the aerobic properties beyond this the aerobic anaerobic zone started developing 0.1 to 0.2 millimeter not more than that ok. And insufficient food and limited oxygenability lead to the microorganisms in the lower portion of the in the state of starvation. So, what will happen when the lower portion I mean like the outer layer it still has some food, but the lower portion it does not penetrate that food and also it started growing like old.

So, what will happen this slime layer it becomes thicker and with time it completely get out of this surface I mean like get they die and they get out of this surface like in along with the fresh biofilm as well. So, this is called the this is called the slogging phenomena as I told you. This slogged biomass is removed from the system via this under drain system and it subsequently removed in the clarifier by settling ok. So, this is how the process looks like. So, how nitrification is taking place nitrification can be achieved in the triggering filter when operated at low organic loading rate and suitable temperature.

The process gets initiated at a BOD concentration less than 20 milligram per liter and also the total nitrogen removal efficiency of up to 35 percent can be achieved in the trickling filter systems. And nutrient removal efficiency of treatment filters depends on the operating conditions like high removal of ammonia and no capacity of trickling filter for nutrient removals it depends like you know different condition operating conditions and all. Sludge retention the sludge which is retained in the trickling filter for very long time as compared to the activated sludge process typically the mean cell residence time of almost 100 years or 100 days or more can be easily achieved. And sludge generation in the trickling filter is generally 60 to 70 percent lower than the ASP treating the same wastewater. Because in ASP the sludge generation is quite high the amount of organic matter which converted into the biomass is quite high, but in case of sludge which is generated in the over the top of trickling filter I mean like the here also actually theoretically speaking the biomass the conversion is almost the happens in the same procedure, but what happened it keeps on like you know like you know generating the slime layer on the top of this biomedia and there are huge number of biomedia with a huge number of specific surface area.

So, it takes time for the bioprim to actually reach to that state when it will be considered as sludge and then you get rid of those things ok. So, the sludge generation process is quite low in case of trickling filter compared to the ASP. Air supply in case of low rate or high rate trickling filter the natural air draft is used through the filter bed which is responsible for the air supply, but in case of super speed super in case of say like in a super air trickling filter what is happening there the you are applying some artificial additional means of air supply either through a blower from the bottom or from the blower from the top I mean like fan from the top you can have those air circulation additional air circulation on the biomedia bed ok. This design values as recommended for the design of different type of trickling filter see low rate high rate and for the super rate trickling filter and the hydraulic loading rate what it should be the depth the volumetric loading rate the recirculation ratio the power requirement the dosing interval the slugging of phenomena and the effluent quality. So, all these things actually will vary and I will request you to please go through this slide again and please write it down in your notebook to have a overall idea that which type of trickling filter is more efficient in which type of in general obviously, the super rate trickling filters are most the best performing one, but it comes with certain economic advantages and also because it involves the additional you have to employ some additional power because of the blowers and all that you need to install.

Anyway so, about the detailing about the rotary arm in general it rotates with a very slow rotational speed of 0.5 to 2 rpm that means, 0.5 to 2 rotation revolution or rotation per minute you can imagine how slow it is ok. The peripheral speed of this two arms will be 0.5 to 4 meter per minute not more than that the arm length could be as low as 3 meter and as high as 35 meter depending on the diameter of the filter bed.

The rotary arm delivers the waste water about 15 centimeter above the filter bed as I already discussed and the velocity should be more than 0.3 meter per second to prevent the deposition of solid inside this rotary arm ok, thus inside those nozzles. Minimum two arms are provided obviously, two in order to counterbalance each other and then if you can have more like instead of 4, 6, 8 number of arms. In general if you see the guidelines it is given in the table 1. What are the advantages and disadvantages of trickling filter? The major advantages are it can be operated under a wide range of organic and hydraulic loading rates.

It can resist to the shock loading it is one of the best thing about the trickling filter that it can resist the shock loading whereas, activated sludge process it cannot resist the it cannot it started performing poorly when there is a shock load ok. There is a certain problem you start facing a lot of issues when it is a there is a certain organic shock happening organic shock load is taking place inside the in the inside the treatment plant. In general it is more efficient nitrification can be achieved with a low organic loading rate and high effluent quality in terms of BOD and suspended solid removal low power requirement and not land intensive treatment system as compared to the stimulation points and all. However, it is quite intensive compared to the activated sludge process. High capital cost which is one of the major disadvantage the additional treatment may be required to meet the better discharge standards.

It requires the expert design and constructions requires constant source of wastewater flow and regular monitoring the major problem is vector and order of are the major problem in the nearby for the nearby like people who are living in the farming and plant area. Pre-treatment of wastewater is necessary and obviously, the unit to supply it need to pass it through the primary setting primary treatment units and the risk of clogging is relatively high which can drastically cause a huge problem to your systems and air to do the air flushing is possible or water flushing back flushing is possible, but it requires huge amount of bulk amount of water to do this kind of a job. So, some issues are there which needs to be we need to tackle it. The design formulation of trickling filter have been given by several famous scientists like NRC formulas, sludge formulas and they can filter formulas and all. So, in general in formula to calculate the rotational speed of rotary distributor is given by equation 2

$n = (1 + R)(q)\ (10^3\ \text{mm/m})\ /NA)(DR)(60\ \text{min/h})$

whereas, this R is nothing, but the recycle ratio q is the influent hydraulic loading rate in meter cube per meter square per hour N a is the number of arms in the rotary distributor assembly and d r is the dosing rate in millimeter of per pass of the distributor arms.

So, it will give you the value of N in rpm rotational speed in rpm. The NRC formula for design of trickling filter suppose you have a fast edge filter where this NRC equation from is given by equation 3

$$E_1 = 100/\left\{1 + 0.4432\sqrt{\left(\frac{L}{VF}\right)}\right\}$$

So, whereas, this E 1 is the efficiency of BOD removal in fast edge filter at 20 degree Celsius including recirculation and sedimentation whereas, in percentage and L is nothing, but the BOD loading at to the filter in kg of BOD per day and V is the volume of the filter media and in meter cube and f is the recirculation factor which can be easily find out by this equation 3 which is given as

Recirculation factor $F = 1 + R/(1 + 0.1R)^2$

So, this R is the recirculation ratio. In case of 2 stage trickling filter the equation becomes

$$E_2 = 100/\left\{1 + \frac{0.4432}{1 - E1}\sqrt{\left(\frac{L_2}{VF}\right)}\right\}$$

whereas, this E 2 is the efficiency of BOD removal in second stage of treatment second stage trickling filter at 20 degree Celsius and E 1 is the efficiency of BOD removal in the first stage and L 2 is the BOD loading rate in the second stage filter. So, with this equation we can easily calculate with this calculate the efficiency of the BOD removal in first stage and second stage filters. We can use the Rankine's formula also in using the Rankine's formula the BOD to the BOD of influent of the filter shall not exist 3 times the BOD required for certain effluent.

So, in this case this is the only criteria here we can it can be easily expressed by equation 5 or equation 6 is nothing, but

$$S2 + R1(S4) = 3(1 + R1)S4$$

or

$$S4 = S2/(3 + 2R1)$$

whereas, S 2 is the BOD of settled effluent, S 4 is the BOD of trickling filter effluent after SST and R 1 is the recirculation ratio and E is the efficiency of BOD removal. So, it can again be written like expressed like in equation 7

$$E = (1 + R1)/(1.5 + R1)$$

whereas, this R is nothing R is the value of recirculation which can be easily calculated by Q t minus Q by Q. So, Q t is what total flow including the recirculation Q is the wastewater flow that needs to be treated. In case of second stage second stage filter the same equation like in this the the condition can be represented by equation 9 and equation 10 whereas, the S 6 if you see

$$S6 = S4/(R2 + 3) \text{ and efficiency } = (1 + R2)/(2 + R2)$$

whereas, S 4 is the BOD of effluent ah, influent in the second stage filter and S 6 is the effluent of BOD of second stage ah, trickling filter after SST and R 2 is the recirculation ratio.

So, equations are very easy it is a very easy formula this Rankine's formula once you know those numbers ah, you can easily get the value of the unknown ones ok. In case of Ekenfeld's formula it is developed by the Ekenfeld's in 1961 for filter performance while treating the municipal wastewater the second order reaction kinetics is followed while developing the kinetics. So, the equation will become

$$-\frac{1}{X}\frac{dS}{dt} = KS^2$$

remember this is different to the first order or the pseudo first order in first order or pseudo first order ds by dt is equal to minus equal to minus ks or equal to ks, but in this case is the second order equation. So, it follows the equation 11. So, whereas, this x is the mass of organism present in the filter bit capital S is the BOD concentration k is the reaction rate constant and integrating this to ah, with time 0 to t and solving the equation 11 we will get the equation number 12 the

$$\frac{S_t}{S_0} = \frac{1}{(1 + S_0 \cdot K \cdot X.t)}$$

So, it is you can substitute

$$t = C\left(\frac{D^{0.67}}{Q_L^{0.5}}\right)$$

So, please remember that this c is can be ah, it is nothing, but ah, it is a kind of a you can the first c in the after the equation 12 the when you calculate the substitute it with the t you can easily calculate all those constant S 0 k x and also the c you can put all these things in a same constant c and the equation will become equation 12 will become ah, as you can see from the equation 13

$$\frac{S_t}{S_0} = \frac{1}{1 + C\left(\frac{D^{0.67}}{Q_L^{0.5}}\right)}$$

So, whereas, this ah S t is the BOD 5 of the effluent in milligram per liter S 0 is the BOD of the influent in milligram per liter c is the constant typical value is 5.358 and or you will be given in the in any problem or you have to find out ah, with the known ah, parameters and d is the filter depth which is provided in meter and ql is the hydraulic loading rate per unit area of the bed in meter square per meter cube per meter square per day. Later on this Echelfinter he has also again developed a performance equation of specific rate of substrate removal using the pseudo first order reaction as well. If it is like

$$-\frac{1}{X}\frac{dS}{dt} = K \cdot S$$

In this case ah, the this 1 by x into dx by dt represents the specific rate of substrate utilization that is mass of substrate divided by microbial mass into time.

dS by dt is the rate of substrate utilization only and k is the rate constant and S is the substrate concentration in mass per volume. So, if you rearrange this equation number 14 for ah, the you integrate it. So, it will become

$$\int_{S_0}^{S_t} \frac{dS}{S} = -K X \int_0^t dt$$

So, because this k is a average cell mass concentration in mass per volume and S 0 is the substrate concentration applied over the ah, filter bed that is resulting after recirculation and S t is the substrate concentration over time. If you integrate it the you will get this following equation in the equation 16 which is

$$\frac{S_t}{S_0} = e^{-K \cdot X . t}$$

Where this x is the proportional to the surface area of the media ok, which is almost ah, equal ok. And this main contact time t in this filter bed is given by this Holland's equation where ah, in the equation 1 if you remember we did it in the very beginning ah, in this equation 1 if you remember ok, t equal to C t by q into n ok. Please you remember this equation t equal to C t by q into n. So, q to the power n. So, we will use this equation here in the equation number 12 and we will replace the no sorry we will use it in the equation number ah, 16 we will replace it with it and we will become we will get the equation number 17.

$$\frac{S_t}{S_0} = e^{\frac{(-K A_S^m D)}{Q_L^n}}$$

Whereas this ah, m this A S to the power m this m is a constant ah, specific to the media configuration and type of wastewater being treated and the value of it can be experimentally determined and similarly the value of n which is q l to the power n, n depends on the flow characteristics.

So, the packing and the usually the value is around 0.5 to 0.67. For specific wastewater and filter media equation 17 can further be simplified ah, by you know combining k A S and m into 1 constant k and it will become

$$\frac{S_t}{S_o} = e^{\frac{-K D}{Q_L^n}}$$

and this value of k t can be easily find out if you know the k 20 value ah, k t is equal to k 20 into 1.35 that is the temperature correction factor to the power t minus 20. With the same we have done it for the in case of BOD modeling also in we have used the same formula for ah, in airation airation ah, system design as well. So, temperature coefficient is like you know correction factor

$$K_T = K_{20} \times 1.035^{(T-20)}$$

From there you can easily get the value of k t at any particular temperature. So, now, we have a very good idea about ah, the different equations different modeling that we can be can be used in trickling filter. So, let us solve one problem ah, for design problem. So, it will be easier for us to understand the whole concept.

So, let us design a low rate trickling filter. So, design a low rate trickling filter for secondary treatment of sewage generated from a residual academic campus with a population of 30000 residents with a rate of water supplies 130 LPCD liter per capita per day. You know LPCD right liter per capita per day of uses ok. And the BOD 5 of after pre treatment primary treatment is 110 milligram per liter and BOD 5 of final effluent should be less than or equal to 20 milligram per liter the value of C is also given. If you remember we can we can use the equation, if you remember this equation we can use it

$$\frac{St}{So} = \frac{1}{1 + C\left(\frac{D^{0.67}}{Q_L^{0.5}}\right)}$$

So, from here you already know let us say the let us take the value of D is around 0.1.5. So, average sewage flow we can easily calculate because the total number of resident in your city is 30000. So, total number of water that you supply total amount of water that you are supplying per capita per per per day is 170 liter.

So, 170 liter 2 you can convert it into meter cube, but multiplying it with 10 to the power minus 3. Then whatever the water you are you know you are supplied with there is a general thumb rule that 80 percent of that water actually goes out from your household as a waste water ok. So, as for it connects with your sewerage line. So, I mean like it goes to as a sewage and it connects with it goes to your sewerage line to the treatment plant. So, 80 percent of your total water supply so that means, water total water supply is 170 into 170 into 10 to the power minus 3 into 30000 multiplied by 0.8 you will get the total average sewage that is being generated.

Average sewage flow = $30{,}000 \times 170 \times 0.80 \times 10^{-3} = 4080\ m^3/day$

So, what is that value it is around 4080 meter cube per day ok. Now what you need to do you just simply solve this this S t is given to you final effluent final effluent BOD should be 20 initial effluent BOD is how much 110 milligram per liter you C is given to you 5.358 a D is given to you 1.5 you need to find out the value of Q L right.

$$\frac{20}{110} = \frac{1}{1 + 5.358\left(\frac{1.5^{0.67}}{Q_L^{0.5}}\right)}$$

So, value of Q L if you solve this equation you will get 2.441 meter cube per meter square per day. So, what will be the total plan plan plan area required for the trickling filter we know that flow rate is sewage flow is

$\frac{4080}{2.441}$= 1671.45 m^2

So, you will get the area as 1671.45 square meter so that means, meter square so that means, the the area of your plane area through at which the you know your waste water needs to be sprayed should be 1671 meter square.

So, what will be the diameter required for your trickling filter you just simply calculate it like you know from the equation pi r square or pi D square by 4 from there you can easily calculate the diameter the D value will come as 46.14 ok. So, either you can have the single filter with a diameter of 46.14 or you can have 2 rate filter with each having a diameter of 32.65 you just simply divided by 16.71 divided by 2 and then make it you know you know into 2 difference trickling filter you can easily calculate the diameter and so that you know the diameter and you know the depth you have chosen at 1.5 meter that is it your design is done and so now, you put up a certain amount of biomedia percentage wise and then you calculate the design the rest of the portions like you know the rotary arms and all this things ok. So, this is how you can easily design the low rate trickling filter ok very good. So, we had a very good discussion about the trickling filter and we I hope we understood the trickling filter in depth and so that we can use it in you know I mean like you can actually design it by yourself in future ok. So, in conclusion we discussed about the trickling filter physical structure we discussed about the operational aspects types and configurations the benefits of bio tower and the biological mechanism that involves and what are these advantages and disadvantages and that we also get to know that it has very good for wide range of loading rate it can resist to the shock load and it has a efficient nitrification and the low power requirement ok.

So, that is very good for us to here. So, these are the paper that I would request paper and journals that I would request you to go through it for more in depth getting a more in depth idea about the system. Thank you so much see you on the next video.