Water Supply Engineering
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Lecture-33
Rapid Sand Filters and Pressure Filters

Hi friends welcome back, so today we will be concluding the our concluding our discussion on rapid sand filters. We have started discussing about a couple of processes like coagulation flocculation earlier this week. And then in last couple of lectures we did talk about the filtration process. So, we discussed the slow sand filtration and we also discussed the basics of rapid sand filter what are the different components of it in the previous class.

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This particular class will be talking about the operation. So, primarily we will focus on the rapid and operation what are the operational challenges and troubleshooting then we will be also talking about the filter back washing, how do we estimate head loss in the rapid sand filters. And we will briefly discuss about the pressure filters and what are their advantages and disadvantages when we consider using pressure filter in the municipal water supplies.

And we will conclude this lecture with a comparison of various filters that we discussed for water treatment.

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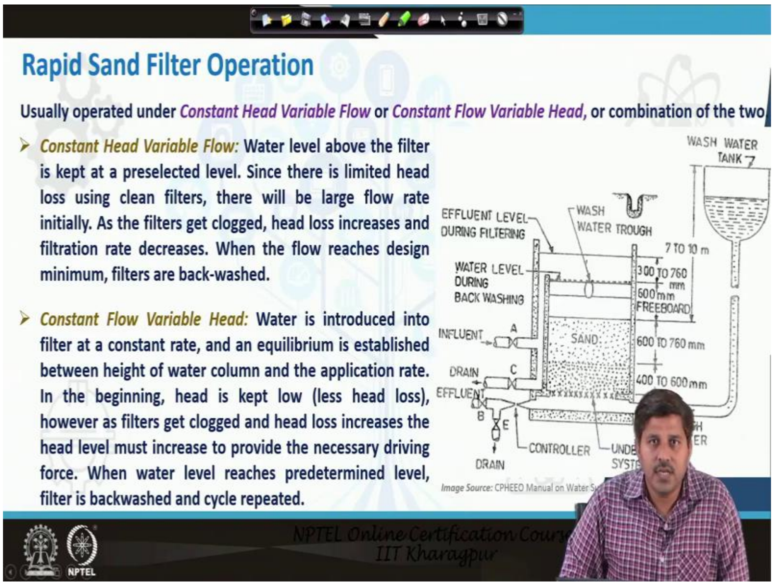

So, the rapid and operation essentially can be done in two different modes. We can operate rapid sand filters in a constant and variable flow mode or constant flow variable head mode or generally in fact these days it is more common to use a combination of these two approaches. So, filter operation is essentially like we let the influent come into the filter and then influent comes in the top.

We provide almost around a meter space for keeping the in water here and then water percolates through this sand bed and gravel bed. Removal essentially takes place in the sand bed Travel is just to support the sand bed as we discussed in the previous class as well. And then it flows through under drainage system of mostly like the perforated laterals connected to a central manifold and then the central manifold direct the flow to the outlet.

So, generally like we can have outlet coming in to filter through the central manifold that is the normal operation. During backwash we change this we change this like approach and what we do we like just based on the closure and opening of your walls. So, in fluent line will be closing in the backwash period will actually not operate the influent line we will close the affluent line as well and we will in fact push the wash water through the these laterals wash water will rise up it will make this bed fluidized.

And then the wash water is comes here it is collected through these troughs and then it is taken out through the drain. So, that is the normal operation in the back washing time. So, the constant head and variable flow means when we keep the water level more or less constant in the filter. So, if the water level is constant in the filter then the flow will essentially be based on the whatever head that water level is providing.

But the head varies because the head loss through the filter varies when the filter is new like when we are just starting the field operation of the filter. So, the head loss is very low during that period and we get like higher flow but as the operation of filter progresses further. So, as the time passes there would be more and more head loss will be occurring through the sand bed and that is primarily because it gets the impurities gets in trap reducing the pore sizes and so flow becomes more difficult and head loss is increased.

So at the head loss is increased and we are operating filter at a constant head, so obviously the flow through the filter will vary. So, that is like that is one of the point of concern here that we do get lesser and progressively lesser and lesser output from the filter. And when this flow rate decreases beyond a third level then we understand that we need to actually backwash the filter. Now the constant flow variable head concept is that we keep the flow constant.

So, we introduce water at a constant rate initially an equilibrium will be established between height of water column and the application rate. But again as the like head loss increases initially there is low head loss, so initially we will have lesser head of the water or lesser depth of the water at the top. As head loss increases we need to increase the head at the top so that it can compensate for the head losses in order to yield the constant flow.

So, that is when again we see that it is like becoming difficult and water level is reaching over a predetermined level like in order to ensure the same flow the water level is further increased to a level like we do provide free board. But like we should see that to what level we can allow the water and if it is passes beyond that then we stop the filter operation and again go for the back washing purpose.

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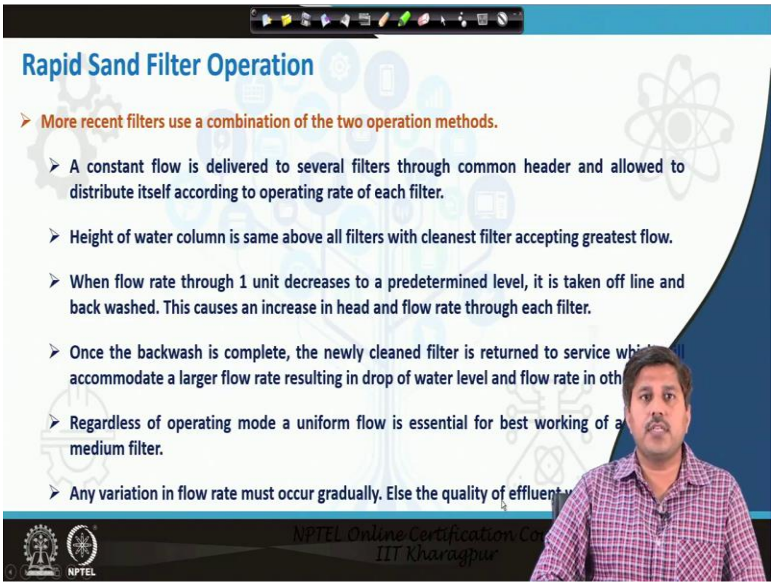

So, this is the generally like to separate mode of operation but in particularly in the recent time we use combination of these two models. So, what generally is done is a constant flow will be delivered through several filters in the common header so because we are having several filter beds it is not that we are just operating one filter bed. So, there will be several filter beds and we provide water through a common delivery head to all the filter units.

So essentially height of water column is same in all the filters but what happens that the cleanest filter which is the newest one or which is recently back washed will have the greatest flow through that whereas the filter which is aged or which is operating for say several hours will have relatively lesser flow through that. So, when flow rate through one particular unit decreases a predetermined label we take that off line and when we take that off line and put that in a back washing.

So this causes increase in the head and flow rate through the all other filter. So, let us say if you are having say n number of filters put in a battery mode over here. So, when we take say one filter off line then the head increases in all other filters. And then this filter is back washed and again put back in the line now this will have this will because it is recently back washed so it will as it will start taking higher flow rate.

So it will be basically accepting the or accommodating a larger flow rate and this will result in the drop in the water level of the other filters. So, whatever like that way we keep on when again another filter starts getting slow so we put that into the backwash until it is not that all the filter units will be backwash together we just backwash one at a time or two at a time depending on how many number of filter units are provided.

The idea is that whatever mode we operate what we need is generally a uniform flow because our system is designed to yield a certain amount of water per unit time per unit hour or per unit like whatever the unit of time you consider. So, it is designed and it should be operated in a way that the flow that is coming out of the filter or out of the treatment facilities with the desired rate. So, that how we ensure kind of a uniform flow.

We should try to make an attempt of uniform flow and any variation in flow rate if it is happening it should be gradually. It is not that we are operating filter for 250 meter cube per hour and even if it is decreasing it is coming down to say 220 this decrease all so first thing we should try that there is no decrease. But even if the decrease is happening it should be gradual it is not that there should be a sudden drop from 250 to 200.

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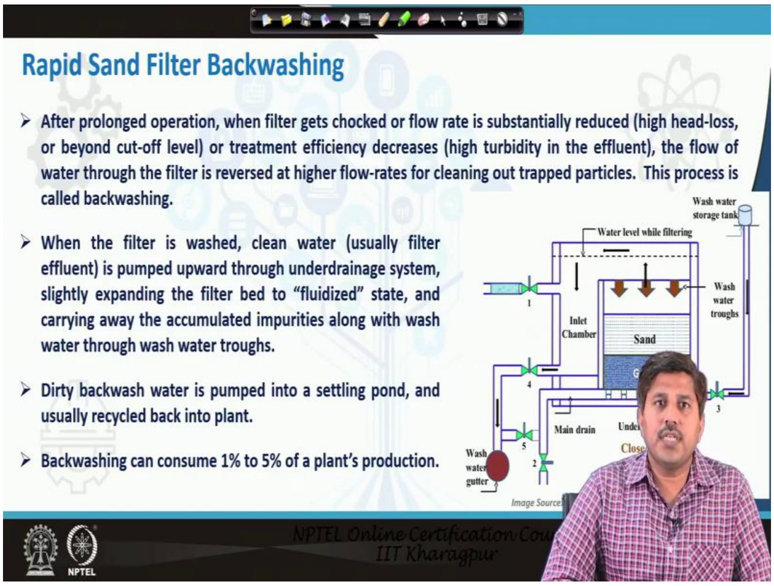

Then that means there are problems with the process so that is about regular operation during back washing again as just we discussed. So, what back washing essentially is that when we operate filter for long enough times, long enough time means, does not mean that month or year it is just 1 day, 2 day in some cases even 3 days period. So, typically 1, 2, 3 days is the operating cycle of the rapid sand filters.

So, what happens that this filter gets choked or flow rate is substantially reduced because of the high head loss or a flow rate or head loss goes beyond its cutoff level or the treatment efficiency decreases. So, in any of these cases like if it is completely choked or there is a high head loss happening or it has flow rate has substantially reduced or the affluent quality is not good. So, these indicates that we should actually put the filter through a like you know through a back washing process.

So, back washing process is essentially that we reverse the flow in the filter so that whatever impurities because when we are operating filter in a normal operation mode. So, the impurities gets untrap in the generally upper layer of the filter. So, in order to get these impurities removed from the sand bed so that the fresh filtration cycle can be started we do a backwash so basically flow direction is reversed and this bed is made in a fluidized state.

So that whatever like it comes into the suspension the bed is a expended and as a result whatever the impurities are extend like attached to these sand particles will come again into the aqueous phase will come into the suspension phase and then that water is drained as a result when water will be drained those impurities will go off and we will have like our bed will again be ready almost for the next cycle.

So when particularly the filter is washed we put clean water usually the filtered affluent. So, whatever if fluent from the filter is coming part of that we store in a wash water storage tank and this storage water is again used for the purpose of back washing. So, we will pump this water upward through a under drainage system so like in the previous class also we this we were discussing that one of the role of under drainage system is to pump the backwash water.

So we will be pumping the backwash water through this under a drainage system and gravel will distribute that water uniformly the gravel bed essentially. Now what it does it slightly expense the filter bed when because it is a sand particle and we pump it a higher rate so that these sand particles gets expanded and this bed becomes in the fluidized state. Now what the accumulated particles again will come into the water phase and then it will be drained through the wash water troughs.

So, the dirty backwash water which is collected is formed into a settling pond and in most cases it is recycled back into the plant recycled back means it is generally it might be put directly to the clarifier or many times like if you have primary clarifier you can put it to the clarifier if not we can put it to the main line. And then add through a process it through a flash mixture and coagulation unit as well.

So this back washing process typically consumes 1 to 5% of the plants production so whatever like almost 1 or 2% of plant production water is stored as a backwash and that is in fact pumped during the back was for each filter.

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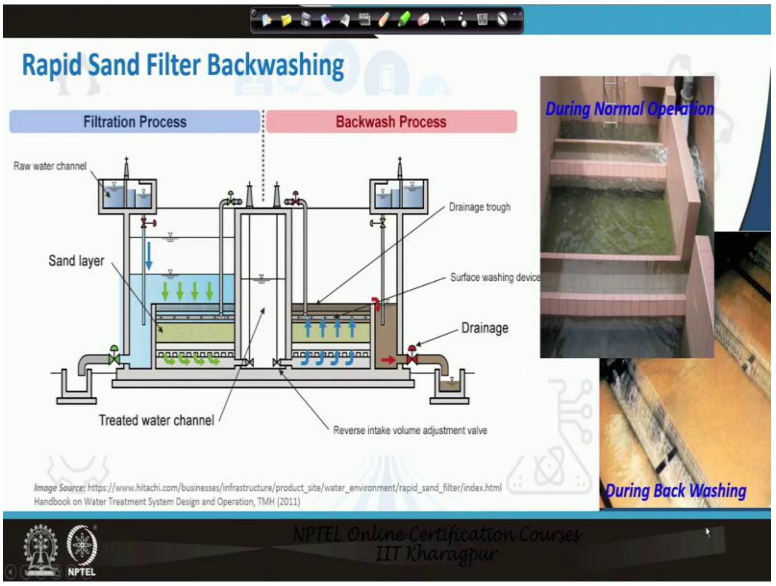

So in normal filtration we will be basically having water coming in here at the top then it will be like we allow the water flow will be this and 2 ended in a system it will be collected. Whereas in a backwash process the water will like this treated water will be pumped in this valve will actually be open and this will be pumped in and then flow takes upward and this collected water will be drained through a drainage system.

So that is the basic difference between normal filtration process and backwash process. If you see visually like this is the filter operation have happening in a normal run so these are the wash water traps but does not matter like these are major filter beds and water passes through these filter beds we are not collecting wash water through this because it is just somewhat because water level is higher than generally the wash water.

Here if there are wash water traps water level is still here, so these traps will be some much but they are not carrying water or they are not letting water go out because that valves and those things are closed here. So, water is essentially flowing downward while during back washing purpose you can see that this is actually a backwash operation. So, during back washing process one can see here that the water level is just around the wash water traps and then water actually moves to this wash water traps and needs collected.

And we can see that sand is actually expended or fluidized state over here. So, the impurities that are trapped in the sand are basically flown away through these wash water traps and then this was water traps collect the water and put them into the drain. So, this is what typically happens during the backwash cycle.

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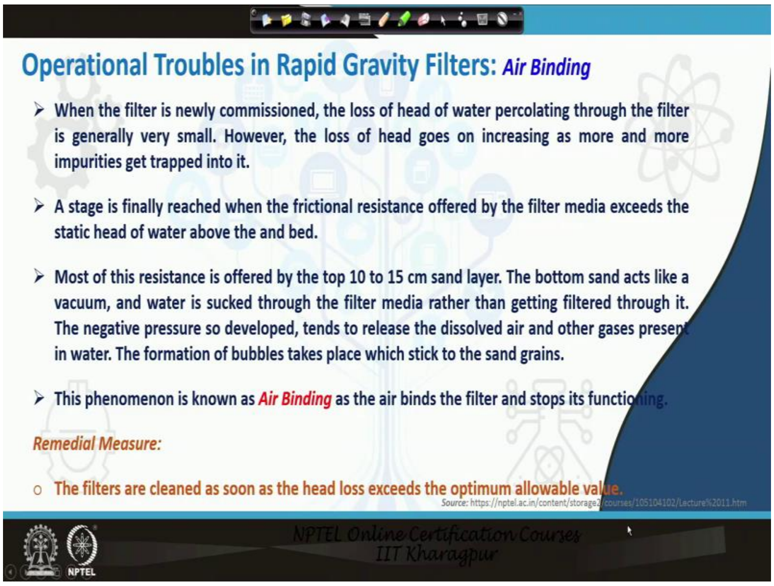

Now there are certain operational issues what we encountered during the operation of rapid gravity filters one of them is air binding. So, when filter is newly commissioned the loss of head of water which is percolating through filter is generally very small but this keeps on increasing as like filter operation filter operation takes place for a relatively longer time. So, there might stage come when the frictional resistance offered by the media exceeds the static head of the water above the bed.

So, if the like because the head loss if the head loss increases over the head which is being provided so that will completely kind of stop flow or when the flow is stopped and then air are present in the bottom. So, it kind of creates a vacuum it it make like the bottom sand may act like a vacuum bed over there and then it can suck water through the filter media. And when it is sucking water through the filter media that sucking is going to be very rapid.

It is not like it will coming with proper treatment it can just suck water due to negative pressure which can be developed and this can actually release the dissolved layer and other gases present in the water. So this fault there would be formation of bubbles which can again stick to the sand grains and this is called air binding. So, air might bind with the sand particles so this phenomenon is typically known as they are binding and it can stop the functioning of the filter.

So, in order to overcome this the remedial measure is simple that we put the filter in a backwash cycle when the head loss exceeds the optimum allowable value. Because this air binding primarily takes place because of the increased head losses only so if we see that the backward cyclist says that is it is not allowing the head loss to reach that level. So, that it can exert negative pressure and it can kind of cause the air binding problems.

So if we take care of this so then we can get away with these air binding problems. So, simple solution is just we put the backwash at the appropriate time.

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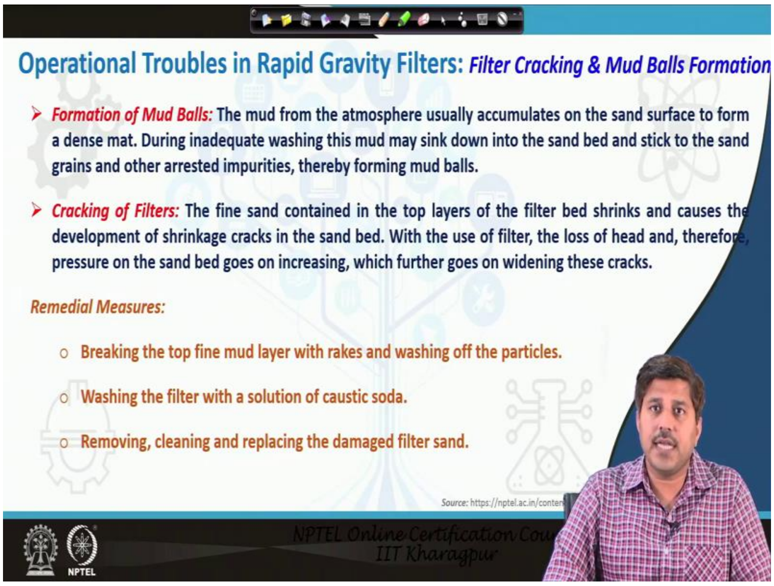

The couple of other problems are the filter cracking and the mud ball formation. So, mud ball formation is like because these filters are generally exposed to that fear so the dirt or kind of mud particles will come. And if we are not washing the filters adequately so they may come and kind of sink down they also have a specific gravity. So, they can sink down to the sand bed stick to the sand grains and like kind of interact with the other impurities or other things that are present in the top layer of the sand bed.

And thereby can form the mud balls another problem is the cracking of the filters. So, basically the top layers of the filter bed top layer of the sand bed might shrink and cause the development of shrinkage cracks in the sand beds which is known as the cracking of the sand beds. So, with the use of filter loss of head and kind of the pressure that it exerts this sand bed might like go the cracking on the sand bed might go on increasing and it can basically widen those cracks and water can quickly percolate through that so the filter efficiency will be going down as these cracks develop.

So, remedial measure for this is breaking the top fine mud layer and like the washing of the particles if we see those kinds of things. Washing of the filter with a solution of caustic soda can also be one of the option and removing cleaning and replacing the damaged filters and if it has achieved to that level. Like generally we prefer first to like clean them so either like proper washing mud layer maybe some time little stirring also helps in.

Or if we can actually wash with the solution of the caustic soda but if nothing is working if let us say these are also not reducing the like if you do not properly wash the filter for large period and the formation of hard mud balls has already taken place. Then to extend these process can be effective is only limited so if that is not working then we may need to kind of remove and clean and replace the damaged filter sand in the these rapid sand filters.

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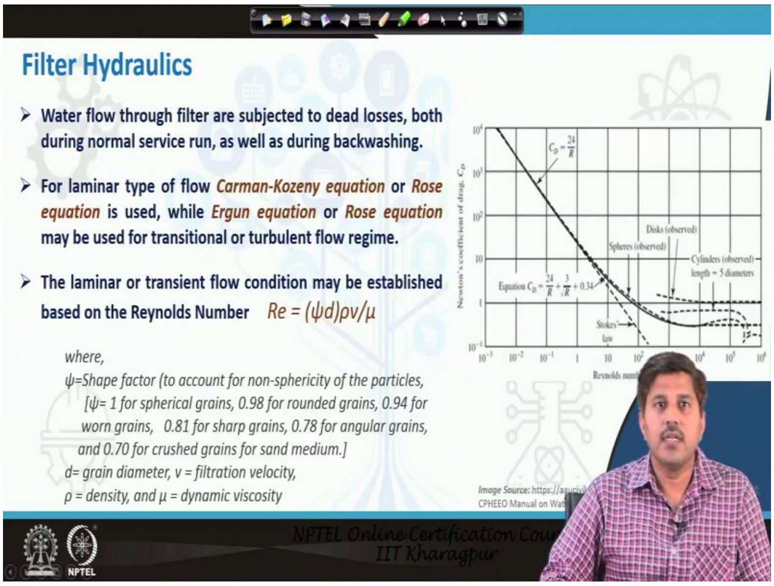

So these are like problems related to the filter operation and as we see that most of the problems are particularly like the air binding or other problems or like requirement of back washing all mostly depend on the head losses which is happening through the filter bed. So, we need to understand the filter hydraulics and how do we estimate the head losses through the filter bed so that we can fix up the appropriate washing cycle and maintenance cycle of the filters.

So, when water flows through the filter subjected to kind of these like subjected to flow through these various beds or layers. So, during normal service run there will be head losses and during the back washing also there are going to be head losses. So, for laminar type of flow the for laminar type of flow the typically Carmen Kozeny equation or Rose equation is used while if the flow regime is the transitional or turbulent then Carmen Kozeny equation or Rose equation can be used for estimating the head losses.

How do we establish whether the flow is in a laminar condition or other it is generally we do it based on the Reynolds number. So, this is how typically like Reynolds number we have so depending on the value of the Reynolds number we can see if it is falling in this particular zone roughly we call that as a laminar flow and if it is in this like somewhere here we call that transitional flow and in a very high values we call that a turbulent flow.

So, ideally Reynolds number should be less than one for laminar flow to happen but in like these kind of media even up to you can see that even up to around 6 or so the values are so we can even if a little higher than one we can accept that but it should not be like too high. If it is more than say 10 or more than this value so then there is a deviation it starts from this point forward. So, we should not be accepting that.

So, Reynolds number is again estimated as generally we know that the formula is Rho vd by mu that is the traditional formula for Reynolds number estimation. Here we are dealing with the sand particles or say other media particles whatever media particles we are considering. So, as we know that this Reynolds number is for a spherical particle but our particle may not be perfectly sphere many of the times.

So in order to avoid in order to kind of see that we replace d with a safe factor into d which is psi d. The safe factor here is to account for the non sphericity of the particles. If the particles are perfectly sphere this Psi value is 1 if it is a rounded grain it is close to 0.98 it can be considered as 0.94 for one grains 0.8 one for sharp grains 0.78 for angular grains and 0.70 for crust grains of the sand medium where d is the effective daya.

So, we mean we kind of get the effective die and apply the safe factor and instead of d we use psi d so our Reynolds number can be estimated using this way where d is the grain diameter V is the filtration velocity Rho is the density and mu is the dynamic viscosity. So, we determine the Reynolds number and see if it is falling in which range.

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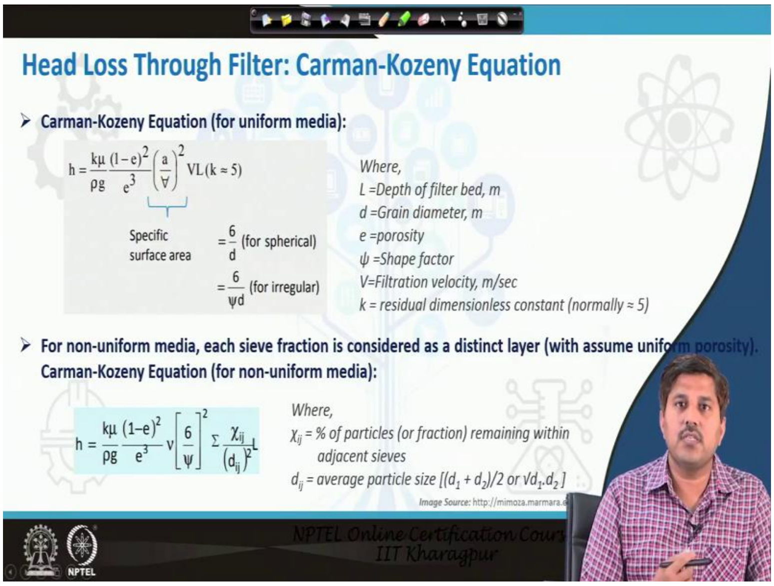

If it is falling in laminar range so we can use the Carman Kozeny or Rose equation or otherwise we can use the transient state equation. So, the Carmen Kozeny which is one of the like popular equation for estimation of the head loss so that is given as like it is in fact derived from the Darcys Westbeach equation it is a like modified version where we include for the porosity through the sand bed.

So, it is given as K mu by Rho G 1 - C square by e cube a by V ok here the L is the depth of the filter VL, so L is the depth of the filter bed d is the grain diameter epsilon or e what you can say is the porosity size the shape factor V is the filtration velocity and K is a residual dimensionless constant which is normally taken as 5. So, we can take K value as 5 and a by V is the ratio of area to volume.

So if it is for spherical particle we know that area to volume ratio is 6 by d for irregular particle it can be 6 by psi d because we need to include the safe factor along with the d. So, we can like if having known all these things we can estimate how much is going to be the head loss. This is a case for the uniform media when we consider that the entire sand bed is like the mid the particle sizes in the entire sand bed is more or less uniform.

But from non uniform media if let us say we are having media of different sizes. So, each sieve fraction is considered as a distinct layer so what we can have then we can have say different fraction of like particles so let us say we do say we estimate d10, d 20, d 30, d 40 that way with different sieve sizes then each gap is actually 10% of particles are of this size like between these size 10% of particles are between this size 10% of particles are between this size that way.

Or let us say we decide that we are going to filter it through say 100 micron sieve size 200 micron sieve size 300 micron sieve size this becomes our daya standard daya and whatever the fraction of the particles that we are collecting becomes the fraction of the particle or percentage of the particle. So, for non-uniform media when there are different layers so what we believe is that let us say there are different layers.

So, we estimate the head loss for kind of each layer and add that. Now for estimation of head loss through each layer if we assume like the like the porosity is uniform through the layer if we assume that porosity is uniform through the layer means it is not that they are assembled in this way they can be assembly if this complete sand bed is there and then different pile particle sizes are there. So, overall the porosity you can we can assume uniform through each layer.

So if like all other things the if we see here are constant the porosity becomes constant the filtration velocity becomes constant k becomes constant Rho G mu all are constant. So, this constant part is will be there and in order to add all of these what we do is we take the summation of the fraction of the particles between remaining between the adjacent sieves. So, if let us say we are as we said that if we are having say 100 micron sieve size and 200 micron sieve size, so if say the fraction entrapped between this and them is say this.

So, this becomes the fraction of the particle entrapped and d is the average particle diameter so we can take either average either arithmetic average or geometric average. So, generally geometric average can be taken because we are taking square of this also our arithmetic average can also be taken a time. So, we take the average daya we take the fraction so similarly for 200 to 300 micron we will be getting some different fraction.

So, then we will be summing the length of the particle in that fraction so how much is the length how much is the fraction. So, let us say this is or as we are saying that if we are doing it based on different if we have estimated different d values so then fraction becomes 10% say D between d-10 and d 20 the fraction is 10%. So, then we take the 10% of the particle of like 0.1 fraction of the particle of length total length we know that how much is the total length of that particular layer or even if it not layer we can take the whole filtration a whole filter layer.

Because we are anyway taking the fraction and divided by whatever the sizes we got here average of those sizes. So, that way we can take some and we can estimate the head losses. So, essentially it is nothing but like estimating the head losses through each layer and adding them.

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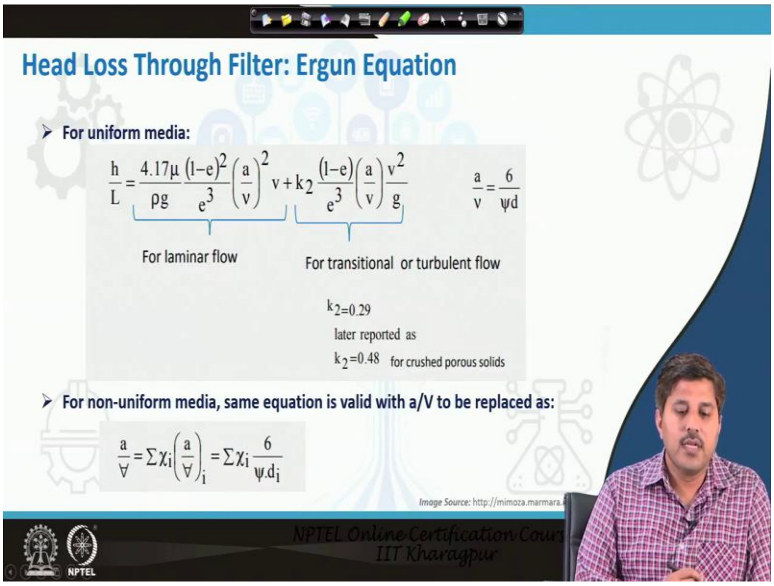

Similarly for transient state we can use the Ergun equation. So, this has a two component one is for laminar flow which is similar to the earlier one and then there is a additional component for transient on turbulent flow. So, here we have the k2 value which can be taken for crest for us what is a 0.48, a by V will be again 6 by psi d and for non-uniform media again this a by V will be replaced as this and rest of the things remains the same so similar concept is applied.

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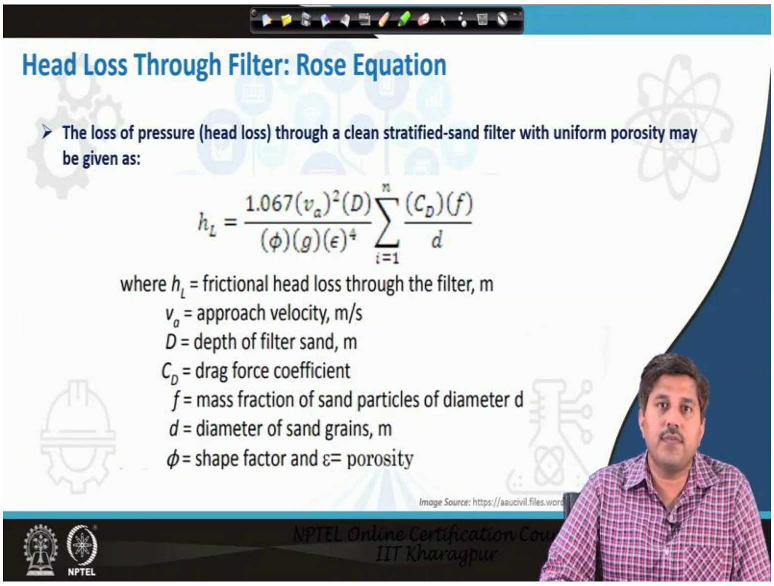

There is another equation which is Rose equation for head loss here also like we get it is a different form of equation where is based on the CD drag coefficient and as we estimated drag coefficient can be estimated based on the Reynolds number and all other things like we have known here.

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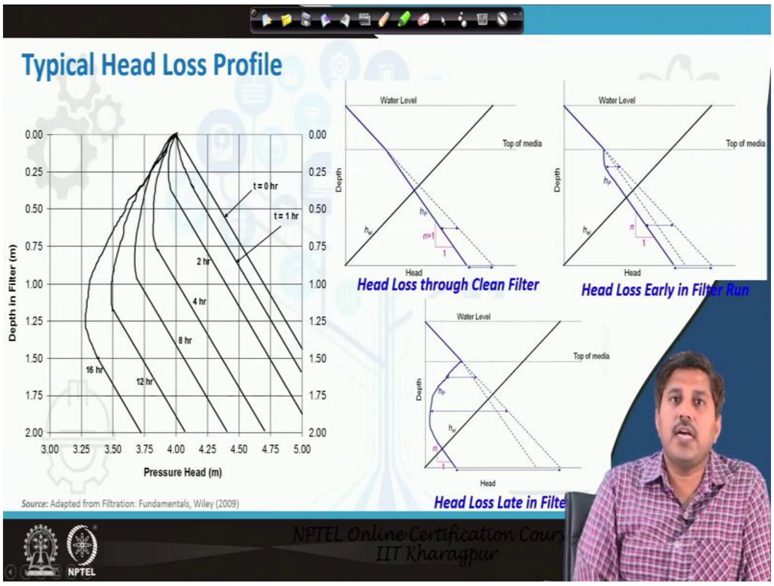

So, this is the another equation to estimate the head losses typical head losses through filtration will happen actually when we are when we are starting a new filter completely new filter so head base on the water level should be actually straight. But if we are having say this is the top of media so because of media layer we will have a reduced head. So, this is the profile of head say when the filter is started a new.

Now when filter starts in a running so during operation and during particularly the early days in the operations will so that head loss is starting building up now. So, head losses as we said that entrapment primarily take place in the upper layer of media, so we will see the more head loss happening on over here and then after that it again becomes more or less flat because head loss is in the lower part is relatively much lesser.

In a later filter run we will see that this head losses at the top is actually shooting up so it can actually increase quite a bit and to certain layer of the filter depth. And then again it will be becoming and if as just we were discussing that if we further operate this head loss can actually increase. So, what will happen that the head which is providing or like the amount the head which is available a head which is available from the water column might actually be like the head loss might increase then that.

And then we can create a negative pressure and that suction air binding issue what we are discussing can be prominent in these cases. So, typically like if you see typical profile head loss profile. So, in a clean filter at time 0, it will be like this as you progress time 1 hour 2 hour 4 hour 8 hour 12 hour 16 hours so you see that it is actually keep on increasing the head loss keep on increasing. So, this is how the kind of head loss happens in a filter.

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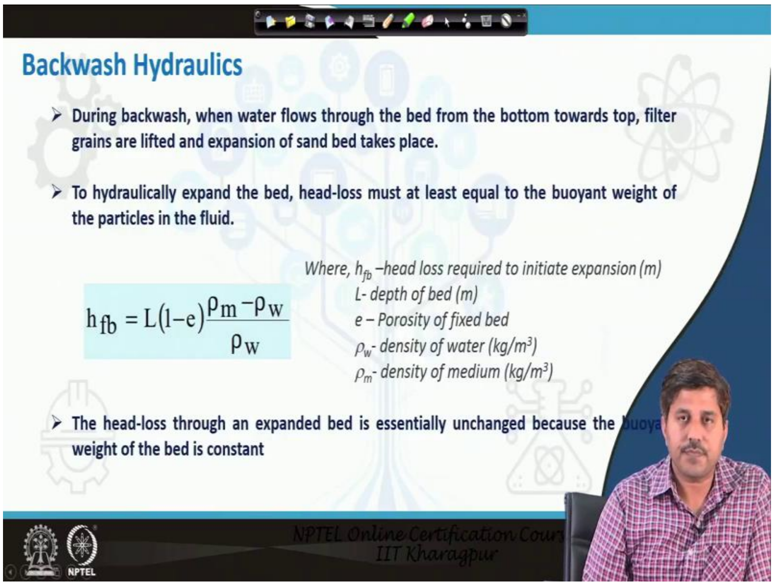

During backwash all so head loss takes place. So, during backwash when water flows through the bed from the bottom towards the top the filter drains are lifted and expansion of the sand bed will take place. We are actually lifting the filter beds we are taking making the filter bed fluidized. So, the filter bed will get expanded and when it is actually getting expanded, so all more like should have come we should compensate the head which is equal to the buoyant weight of the particles which are there in the fluid.

So, we should provide minimum head which is equal to this so the head loss must be at least equal to like whatever head we are providing must be at least equal to the buoyant weight of the particles which are there in the fluid. So, how it is determined the head loss required to initiate the expansion h fb will be equal to L 1 - e Rho m - Rho w by Rho w where Rho m is the density of the medium Rho w is the density of the water.

So, it is kind of like you can say 1 minus specific gravity minus 1 as well and then is the porosity of the fixed bed and 1 - e is the fraction of the solids that are there because e is the porosity, so 1 - e becomes the fraction of the solids and L is the depth bed. So, head loss through the extended bed is essentially unchanged because the buoyant weight of the particle is going to remain constant.

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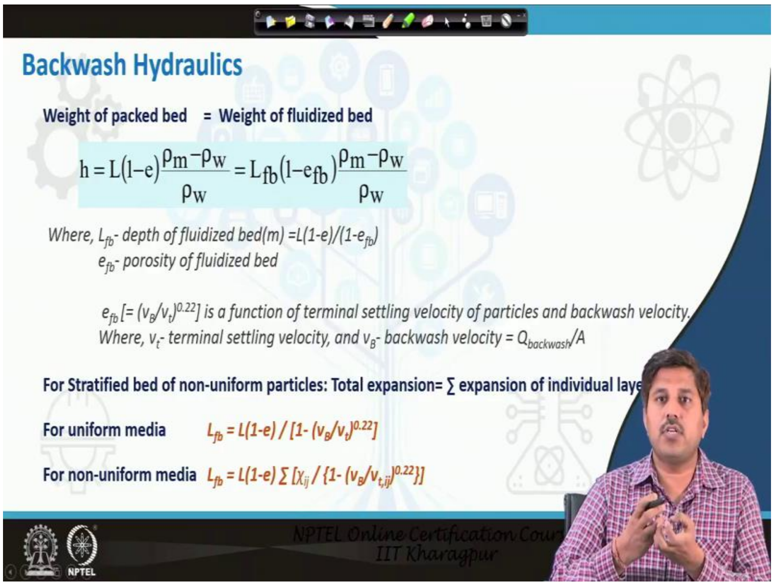

So the weight of particle is not changing so when whenever they are in the fluidized state they will have same weight. So, the weight of and that is actually going to be like weight of packed bed will be equal to the weight of fluidised bed. So, total head loss we can estimate as this or in case of fluidized it is actually this where L fb is the depth of the fluidized bed and e fb is the porosity of the fluidized bed.

The depth of the fluidized bed can be determined as this L 1 - C upon 1 – e, e fb is here which is basically the porosity of fluidized bed is considered as a like function of terminal settling velocity of the particle and backwash velocity. So, backwash velocity is nothing but simply like discharge the flow which we are using for backwash divided by the area. So, that gives us the backwash velocity and terminal settling velocity of the particle like can be determined based on the Stokes law or Newton's law.

So this is equal to the e fb essentially equal to the ratio of these velocities to the power 0.22. So, backwash velocity divided by terminal settling velocity to the power 0.22. So, that becomes the effective porosity of the fluidized bed. Again for stratified bed of non uniform particles the total expansion will be expansion of the individual layer similarly. So, if we are working with the uniform media so the length or the bed of depth of the fluidized bed expanded bed is going to given by this like it is same thing here.

So e fb we can replace as this is the same formula so L1 – e 1 minus instead of here be like determining the porosity of the fluidized bed we can determine the V B by V t to the power 0.22. And if it is a non uniform media again so it will be summation of the expansion of the individual bed so this part remains the same and then we take a summation of this. So, how many fraction of the particles are having say the settling velocity this range and depending on like if the particle size is increased the settling velocity will increased.

So, that way we can estimate the total expansion for the non uniform media as well as a summation of the individual layers.

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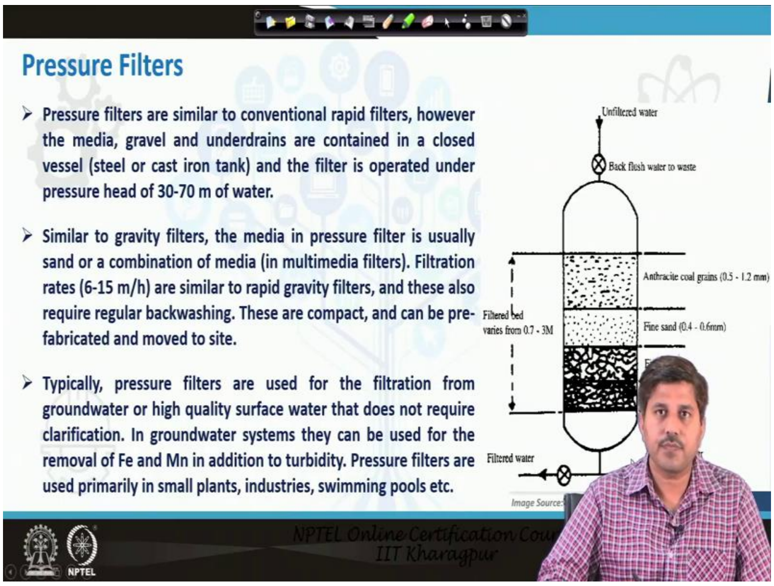

This was about the rapid sand filter, so there are pressure filters also which are very similar to the conventional rapid sand filters only difference is that the like the under drainage system the gravel system the bed everything like media bed everything will be in a closed encased container which is usually made of steel or cast iron and this will be operated under pressure. So, we can put everything in a closed container and operate the flow in the pressure.

So because let us say with the filtration system we may see head losses increasing or we can apply additional pressure to overcome that head losses and the cycle of back washing although the cycle back washing is a must in this also ok. So, similar to kind of gravity filter these also must require regular back washing these also are regularly back washed. But the back washing cycle can be increased another advantage is that we can go with the fine sand instead of the coarse sand like in rapid gravity filters we use sand.

We can use sand particles up to 1mm sizes in order to ensure the high flow rate but here we are applying pressure, so we can ensure high flow rate even with a smaller sand particle or smaller porosity however the entrapment would be more in that case. So, similar to kind of gravity filter these media in the pressure filter is sand or a combination of media in case of we can have multimedia pressure filters as well.

Filtration rate typically ranges between 6 to 15 meter per hour and which are more or less similar to rapid gravity filter of course not on the higher range though. Typically these filters will be used for filtration of ground water of high qualities ground water generally which is having less sediments so that entrapment is not that. Because if we are see the amount of flow that we are passing in a unit time or through this filter bed, if we are going for a smaller particle size smaller sand size sand particle size so the interrupt meant would be more.

Although with pressure we can let that pass through but again the entrapment is going to be higher and as a result the like required back washing cycle and those things will increase. So, we do apply pressure filter where the water quality is relatively better or the sediment load is relatively less. So, we can go for high quality surface water or ground water again in ground water for removal of iron and manganese in addition to turbidity these pressure filters are used.

These are also used only in small plants because in large plants the requirement of pressure is going to be too much, so in small plants they may be used the industries or swimming pool waters it is a pretty common. So, swimming pool is needs to be recirculated, so it is generally usually passed through these pressure filters and then recirculated.

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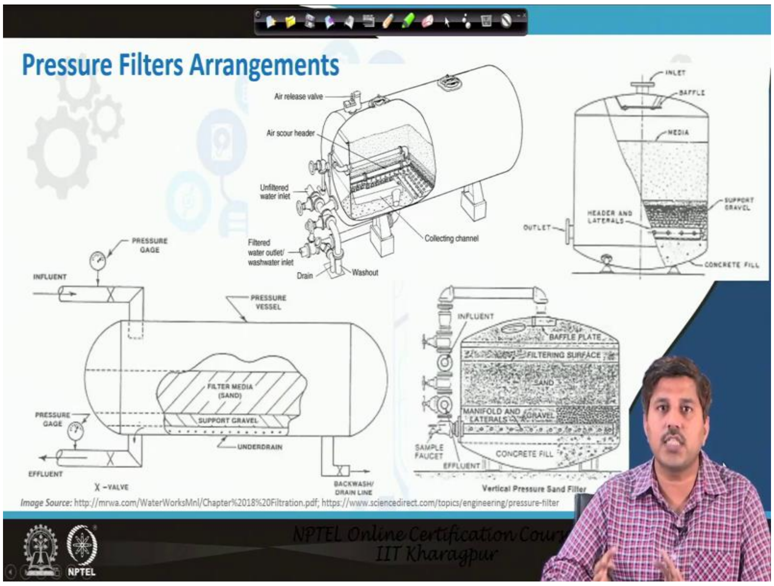

Because we need a large flow in very small amount of time in swimming pools. So, the arrangements again there are horizontal flow pressure filters vertical flow pressure filters but the basics remains the same that will allow water to pass through these beds and everything is done under pressure. So, these are some of the different arrangements of the pressure filters.

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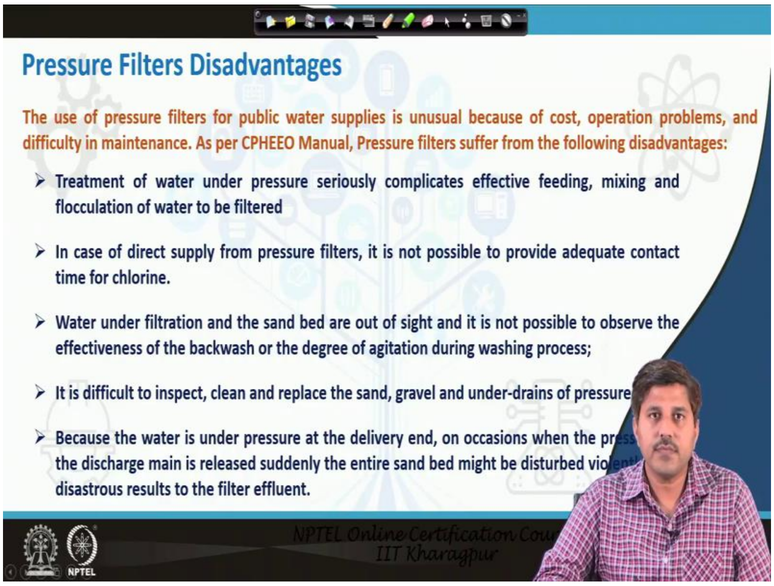

The use of pressure filters for public water supplies or the large municipal water supplies is very unusual. It is generally and not recommended to use pressure filters for large municipal supplies because of the cost we need to maintain the pressure, so the cost is going to be quite high there would be operational problems and there is difficulty in maintenance as well. So, a pressure filters suffer from various disadvantages one of like a few of them as per listed in CPHO manual are like it seriously complicates the effective feeding mixing and flocculation of water which needs to be filtered.

In case of direct supply from pressure filters providing adequate contact time becomes difficult because flow rate might be higher. The water which is subjected to the like filtration through the pressure filters in the sand bed is actually out of sight. So, everything is in a closed container and we cannot see whether the sand is good working or it has become dirty. So, like that kind of visual control is not possible to observe these things.

So what kind of degree of agitation needed during the washing process whether that is being provided or not it becomes difficult to visualize. So, it becomes difficult to inspect clean and replace the sand gravels maintenance part again becomes difficult it is all in a closed container. So, these are the problems and because water is under pressure at the delivery and on occasions when pressure on the discharge is released suddenly we can see that entire sand bed might be disturbed violently. And that can actually cause damage to the filter itself.

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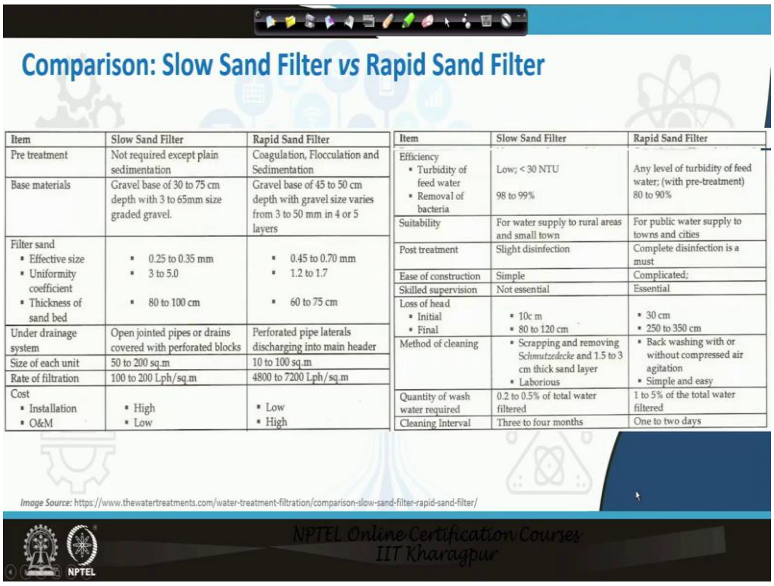

Item	Slow Sand Filter	Rapid Sand Filter
Pre treatment	Not required except plain sedimentation	Coagulation, Flocculation and Sedimentation
Base materials	Gravel base of 30 to 75 cm depth with 3 to 65mm size graded gravel.	Gravel base of 45 to 50 cm depth with gravel size varies from 3 to 50 mm in 4 or 5 layers
Filter sand • Effective size • Uniformity coefficient • Thickness of sand bed	 • 0.25 to 0.35 mm • 3 to 5.0 • 80 to 100 cm	 • 0.45 to 0.70 mm • 1.2 to 1.7 • 60 to 75 cm
Under drainage system	Open jointed pipes or drains covered with perforated blocks	Perforated pipe laterals discharging into main header
Size of each unit	50 to 200 sq.m	10 to 100 sq.m
Rate of filtration	100 to 200 Lph/sq.m	4800 to 7200 Lph/sq.m
Cost • Installation • O&M	 • High • Low	 • Low • High

Item	Slow Sand Filter	Rapid Sand Filter
Efficiency • Turbidity of feed water • Removal of bacteria	 Low; < 30 NTU 98 to 99%	 Any level of turbidity of feed water; (with pre-treatment) 80 to 90%
Suitability	For water supply to rural areas and small town	For public water supply to towns and cities
Post treatment	Slight disinfection	Complete disinfection is a must
Ease of construction	Simple	Complicated;
Skilled supervision	Not essential	Essential
Loss of head • Initial • Final	 • 10c m • 80 to 120 cm	 • 30 cm • 250 to 350 cm
Method of cleaning	• Scrapping and removing *Schmutzedecke* and 1.5 to 3 cm thick sand layer • Laborious	• Back washing with or without compressed air agitation • Simple and easy
Quantity of wash water required	0.2 to 0.5% of total water filtered	1 to 5% of the total water filtered
Cleaning Interval	Three to four months	One to two days

So, these are the major problems most of the problems are related to operational and of course another problem is the high cost high energy requirement in order to maintaining the pressures. So, for that reason these are generally not recommended for large municipal supplies only for smaller treatment systems or industrial uses or like we were giving example swimming pool uses or filtering ground water which is usually have very little sediments and comes quite clean.

So, without even going for coagulation flocculation process we can directly put ground water to pressure filters and then supply to after feeding with the chlorine or that kind of any kind of disinfectant. So, if we compare these filters like if we start looking at the slow sand filter and rapid sand filters. So, in slow sand filter typically we do not require any pretreatment in rapid sand filters generally coagulation flocculation and sedimentation is given.

Here also plain sedimentation would be recommended though because if durability high they might fail badly. The base material is gravel here like the specifications as we discuss this is the filter sand what are the effective size uniformity coefficient thickness of beds the under drainage system kind of size of each unit here we can go for 50 to 200 square meter this is 10 to 100 square meters, rate of filtration 0.1 to 0.2 meter per hour here it is 4.8 to much higher 7.2 around given.

So the different sources will give the different values though the cost here installation cost is high operational maintenance cost is low here relatively installation cost is low and operation and maintenance cost is high. The efficiency here you see that because the sand sizes are small you see the effective size here is 0.25 to 0.35 and here 0.45 to 0.7 so as a result this gives a better efficiency and then this the remodel efficiencies 98 to 99% this has 80 to 90% remodel efficiency.

Their suitability their post treatment requirements ease of construction supervision loss of head method of cleaning all things are actually compared here.

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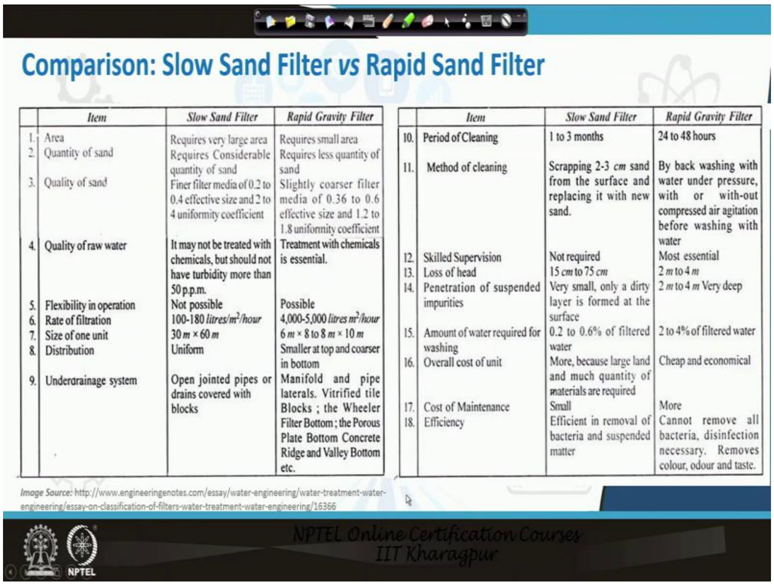

Similar comparison can be obtained from other sources as well so like this is from other sources which talks about area as well. So, area requirement is very high in slow sand filters it is much lower in the rapid gravity filters of course because of rate of flow and the more or less all other points that we were just discussing compared here.

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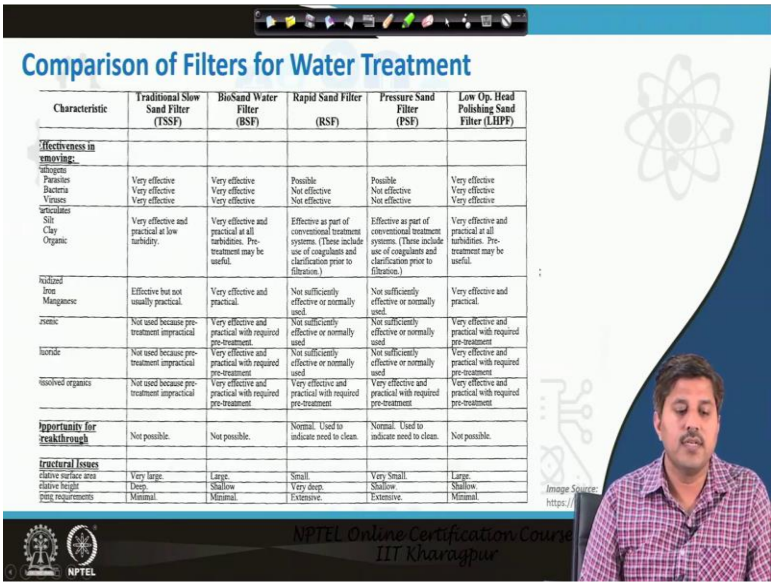

These are another comparison of various filters, so like traditional slow sand filters the rapid sand filters the pressure sand filters it has also talked about BioSand filters and some other low operating head polishing sand filters they are very rarely used or very specific cases. But majority of these are so whether like the effectivity in removing so like the pathogens removal these are very effective.

Whereas rapid sand filters is not effective in removing the bacteria and viruses. So, is the pressure sand filter some other metal? So, and then the opportunity for back through the structural issues related with these filters. So, all other various aspects related to caused volume so these are compared over here. So, we conclude this discussion on the filtration process here and effectively like the discussion for this week also.

In one more lectures in this week will be considering few practical problems practical problems as in like numerical problems practice numerical problems and post that will be basically concluding the discussion for the week 6, so thank you for joining.