Wastewater Treatment and Recycling
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Lecture – 24
Wastewater Treatment Units: Screening

Hello friends. So, earlier class, this week, we did talk about the basic concept of Wastewater Treatment. How there are set of various unit operations and unit processes are combined in order to make a complete treatment scheme or treatment setup. From this lecture onwards, we will pick the specific units and have discussion onto that and we are going to start with the very first unit which is used is Screening.

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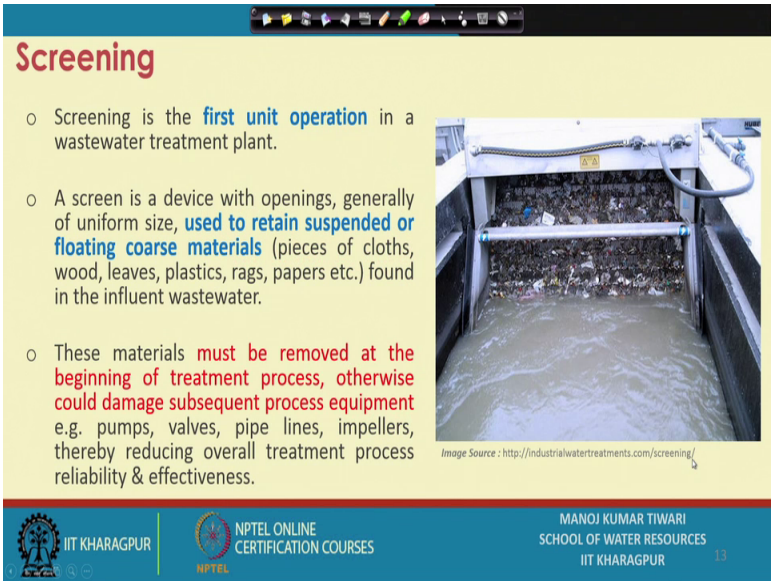

So, screening is the first unit operation in a water treatment plant. We are saying it unit operation because, it is a purely physical process, ok. There is no chemical reaction or nothing is involved in this, ok. So, screen is typically a device with opening generally of the uniform size which is used to retain this suspended and floating course materials.

So, like you can see this image over here ok, there are lot of things are trapped here. What are trapped? There could be piece of cloths, there could be piece of woods, stems flowing in then leaves, plastic, rags, papers. So, all those things which is found in the influent wastewater; you have a look at any wastewater channel and you will see that

many of these things comes along with the wastewater channel in the flow along with the wastewater.

So, these materials is easy to remove just by the filtration because, they are of much larger size. But, it is essential to remove them in the beginning itself, beginning of the treatment process itself. Otherwise, if we let them go and then when we start, let us say pumping sewage or to a reactor or those kind of stuff. So, they could damage the palms, the other channels. So, all the like process equipment's actually could be damaged by these materials, ok. So, pump, valves, pipelines, impellers, all those things could be damaged and in order to protect them, it is advisable to remove these materials at a very first stage itself, ok. So, that these does not move ahead.

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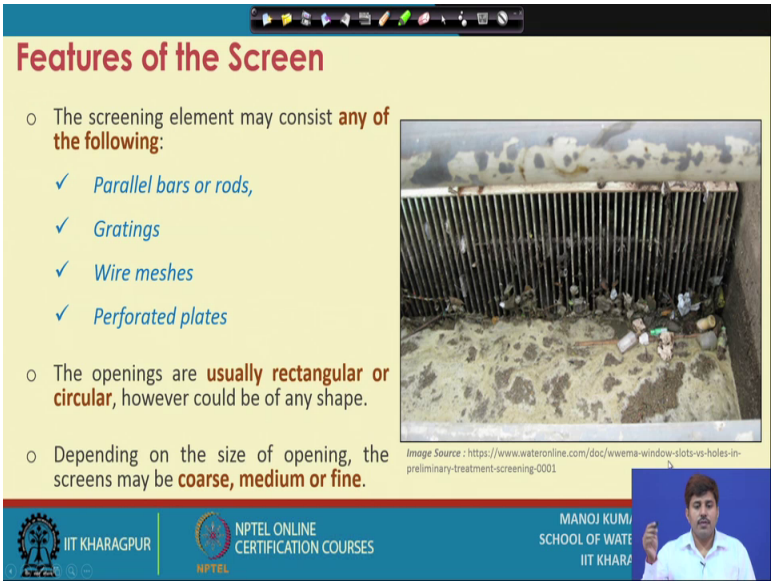

Now, if you see the features of a screen. So, the screen elements generally consist of either parallel bar or rods, it could be greetings, it could be wire mesh, it could be perforated plate. So, those kind of things can be used for the screening purpose. It is just simple physical filtration, ok. The openings of these screenings are usually rectangular or circular. However, technically it could be of any shape. It could be of hexagonal, pentagonal so, that way, like it could be of any shape.

But, for most cases, it is either kept circular or kept rectangular and depending on the size of this opening what is the opening size here through which this material can pass through or can be retained through? So, depending on the size of the opening, the screens

can be said as coarse screen, medium screen or fine screen, ok. So, there are other classifications as well.

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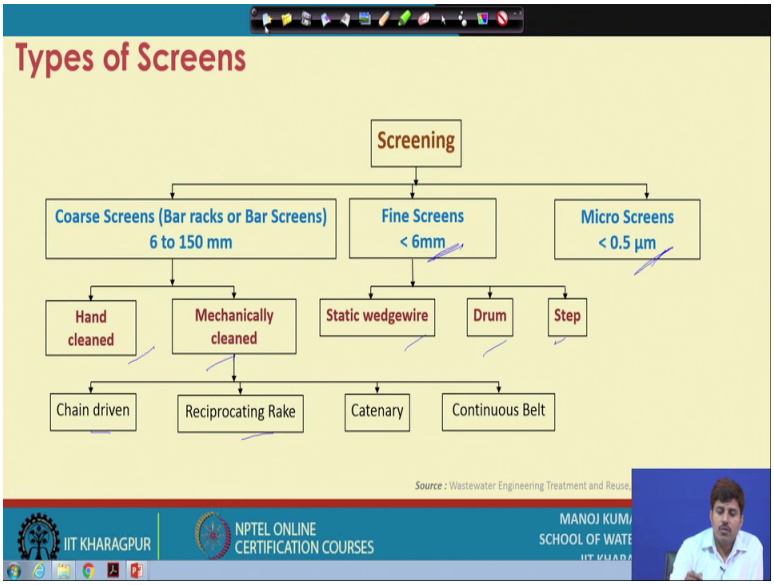

So, if you see the type of screens, the coarse screen which are bar racks or bar screens, typically are of the order of 6 to 150 mm opening size. We have fine screens which are usually of less than 6 mm and micro screen, which are less than 0.5-micron meter. Then, there could be these particularly coarse screens could be hand cleaned or could be mechanically cleaned, then mechanically cleaned. It could be chain driven reciprocating, ok so, there are variety of options. The finest cream could be of step type, drum type or static wage wire type. So, there are variety of like combinations that can be there for these screens.

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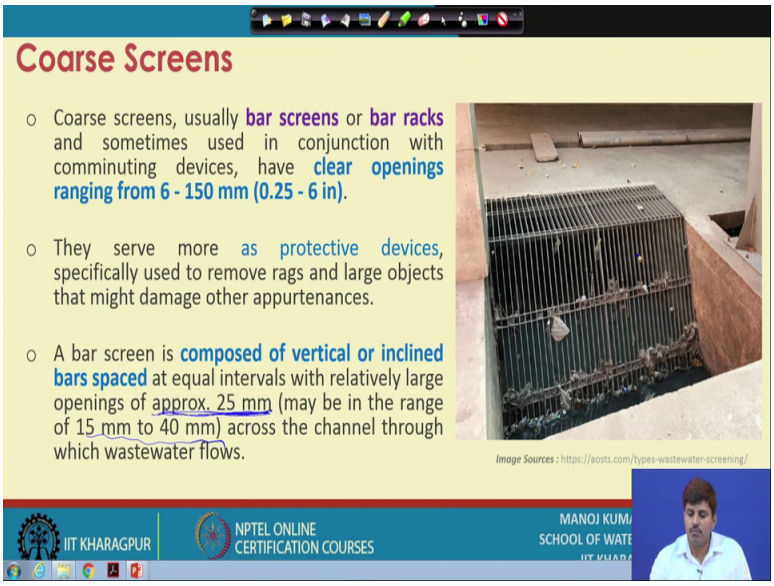

Now, if you see the coarse screen which is the first one to be used particularly in the sewage treatment plants, generally consists of bar screen or bar racks and sometime in conjunction with the comminuting devices as well. So, they typically have a clear opening ranging from 6 to 150 mm which is 0.25 to 6 inches in the size, ok. These are more as a protective devices. So, it kind of used for protecting the rest of the plant operations and these are specifically used to remove the racks and large objects.

So, because the opening size is 6 to 150 mm. So, depending on the size, it will remove only the particles which are larger than the opening size and rest can actually sneak in through. The bar screens are typically composed of vertical or inclined bar spaced at equal intervals with relatively large opening of approximately 25 mm. So, that is the approximate size.

But it could range from 15 mm to 40 mm, ok. And, it should be uniform across the channel through which the wastewater flows. So, if wastewater is, let us say, flowing through this way or through that way. So, it should basically inter intercept the path of the wastewater flow. That is what the objective of screening is.

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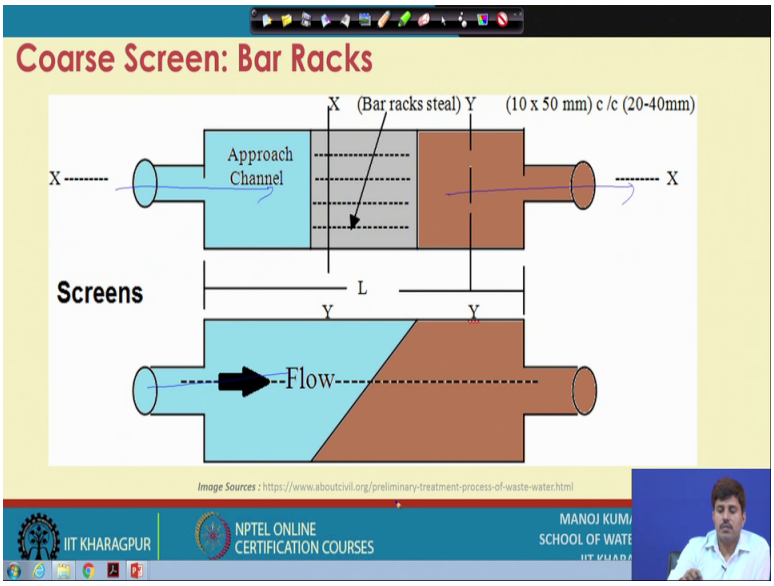

So, if we see the screenings process, so, let us say this is our approach channel, ok. The water is flowing in like this and then we have the different bar racks here kept at the stake and then the flow is in short that way. So, since it is kept typically kept on inclined and particularly the manually clean one so, if you see the front view, it will look like that where wastewater is flowing like this and if you see the top site, it will look something like that.

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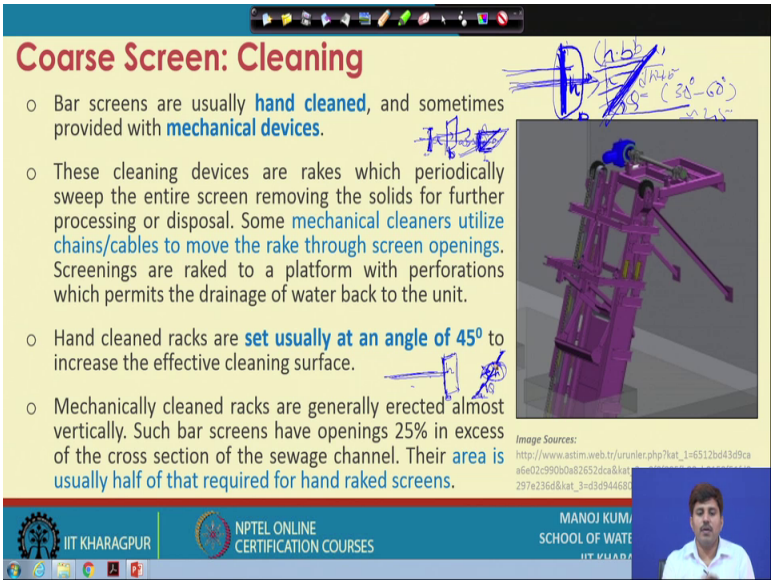

Now, the cleaning process of screens are of like very essential because it is efficiency will depend on the cleaning. Otherwise, if you do not clean and things get accumulated on the surface of screens. It could get choked and it will it may actually prevent the flow itself, ok.

So, bar screens are usually hand cleans and sometime provided with the mechanical devices for cleaning depending on the size of the plant for small plants hand cleanings are good, but for very large plants, many times the mechanical devices are preferred for cleaning purpose. So, these cleaning devices are racks which periodically sweep the entire screen removing the solids for further processing or disposal.

So, the entire screen will be taken out and it is cleaned and then it is placed back. There are mechanical cleaners which utilize chains or cables to move the read through these screen openings, screens are wrapped to a platform with operate with which should have perforations. So, whatever we are cleaning, we should keep it on a platform which has bottom perforations.

So, what? So, we when you accumulate the materials, which is typically called screenings. So, whatever is filtered out means, whatever is retained at the screen surface or these materials these paper claws these kind of things are called screenings. So, the screenings which are retained are kept on a perforated plate, it is kept on a perforated plate. Because, that should permit the drainage of water which is still holding in the screenings back to the unit.

So, whatsoever, water is still there when we are removing it, that should actually again flow back to the basic unit, hand training racks are usually set at 45-degree angle. Generally, it could vary from 30 to 60 it is not necessarily has to be 45, but 45 is the most optimum. So, let us say, like if this is your flow velocity. So, it screens are kept like this, ok. At certain angle theta, which theta is actually from 30 to 60 degree generally, 45. Now, why it is done? Because, it gives us a increase in the effective cleaning surface, right. You see when the wastewater is flowing like this.

So, the cross sectional area that we have through which the wastewater flows vertically is this, ok. So, if you put a screen like this so, this is the cross sectional area. Let us say, the height is h and width of screen is h b, ok. So, h into b is going to the cross sectional area

through which your flow will take place, but when you keep it inclined, ok. So, if this is your h and this is your b, so here you get square root of h square plus b square.

So, you get a much larger area, then actually h, and the area of the screen that will be there. So, water is exposed to a larger area and also the, with the same size of opening, you can trap even smaller particles. So, how is that possible? Let us say you have a opening size of let us say a into b is your opening size and you are allowing flow like this. Now, what happens if you incline this thing? So, your b remains same, but a has turned inclined.

So, an object of let us say, size a almost size a will pass through this, right because, your flow is taking place like this. So, an object may be little smaller than size a will pass through this, but when this is inclined. So, the projected surface that you get you are now this is a ok. This o this is still b, but your inclined surface is a. So, projected surface is actually smaller than a ok, depending on the angle that you are having. So, depending on the angle that you are having theta, let us say is actually smaller than a. So, how smaller is this? It is your depending on how you are taking the dimensions. So, it is going to be a sin theta that way, ok. So, it is a sin theta and then what you will get is the size of the particle a. Because a sin theta will generally be smaller than a if theta is of the order of let us say 45 and that.

So, a particle something of size a will get returned because, it will not be able to sneak through that. So, with the same size of opening, it can give you better removal if you keep that screen inclined, ok. The disadvantage here is, however, if you want to plant a screen vertically, so, as you see here, the area of screen needed will be let us say, you want to keep a screen vertically; so, a b thickness and b width and h height. So, area of screen needed is b into h while here if you inclined it this way for the same height h.

So now, the area of screen will be needed your depending on which angle you are considering if this is your theta. So, this will be now greater than h the side, h by sin theta that way. So, eventually, what you see here that, your area required of the screen is increased this. But again, the efficiency increases plus it is difficult to take out the manual screen. It is far more easier to handle the inclined screen.

So, it increases the effective cleaning surfaces and it increases the effective operation as well. Mechanically cleaned screens are generally sort of kept almost vertically because,

they are anyway mechanically driven we do not need to do hand operations much there. Such bar screens have opening 25 percent in access to the cross section. So, if let us say, your water is up to this. So, we will have a little higher cross sectional area, ok. But still the area is usually half in that required for the hand drag distance because, we are placing it vertically and not giving too much of angle or inclination.

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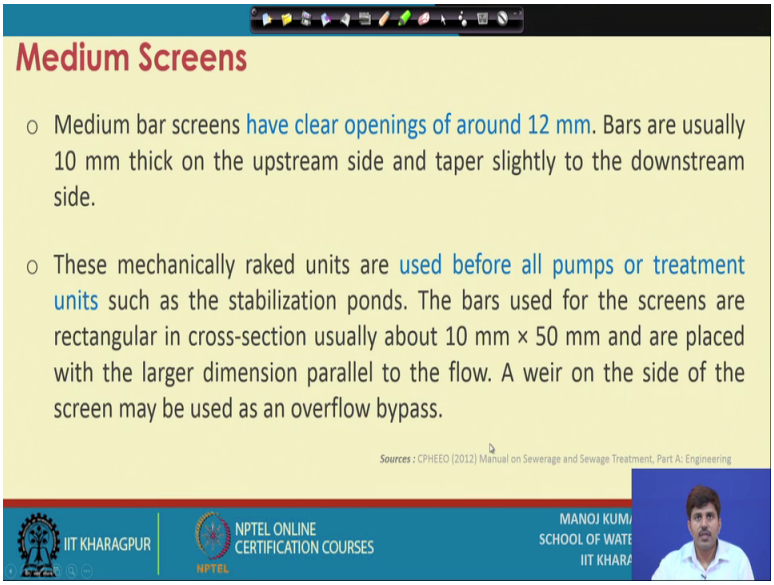

Then, we have medium screens medium bar screens have clear opening of around 12 mm very less use though these are typically 10 mm thicks on the upstream side and tapper slightly towards the downstream side. These are mechanically racked units mostly and used before all pumps or treatment unit so, as to things can get protected and should not allow to pass in through, ok.

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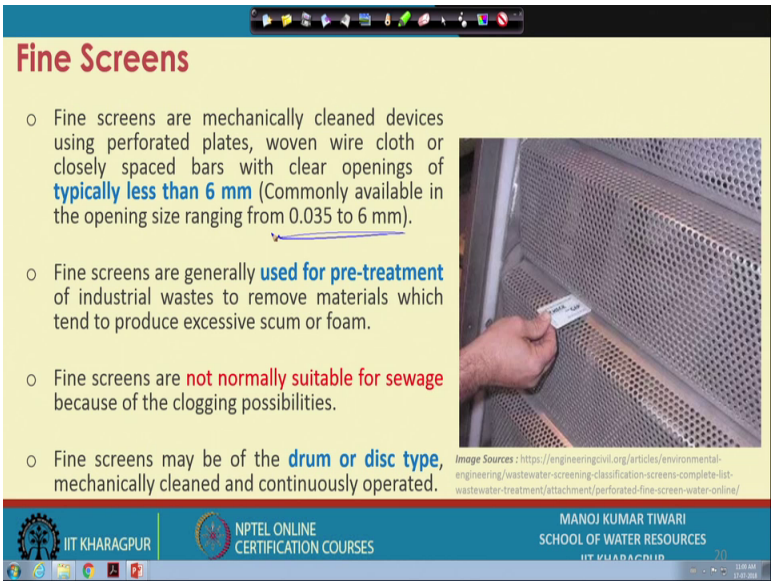

And, then the fine screens which are again mechanically clean devices. Because it is not possible to practically clean such devices manually. Depending on the size, they are typically less than 6 mm opening, but commonly available opening range is from 0.35 to 6 mm, ok. So, 35 micrometer to 6000 micrometers are the actually range of the opening, the fine screens are generally used for pretreatment of industrial waste to remove the materials which can forms come or form.

So, those kind of things in sewage they are normally not used they are not suitable for sewage because there is a huge clogging possibility, sewage flows usually have lot of such materials. So, if even if we want to use a fine screen, so, we will we should actually first put a coarse screen then, we should put these device to like ensure communicator kind of things. So, that it shreds these waste and then we can let it pass through the fine screen.

But normally, these are not suitable and not uses this could be drum or disc type. Depending on the placement and depending on the design, there are various micro screen screens which are not used as a pretreatment. But, the suspended solids are removed using micro screen from secondary effluent many times.

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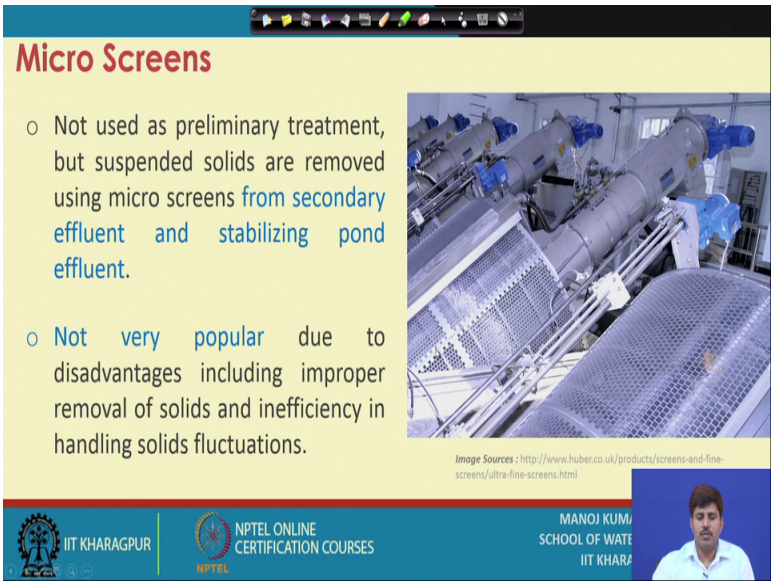

So, these are not in fact, a screen that we have been discussing so far. As a first unit, they can be used at a later scale and they are not very popular due to several disadvantages that improper removal of solid and inefficiency of holding solid fluctuations. Because, with if the solid load comes more, these screens probably will not be able to withstand that load and that is why, it is not that popular.

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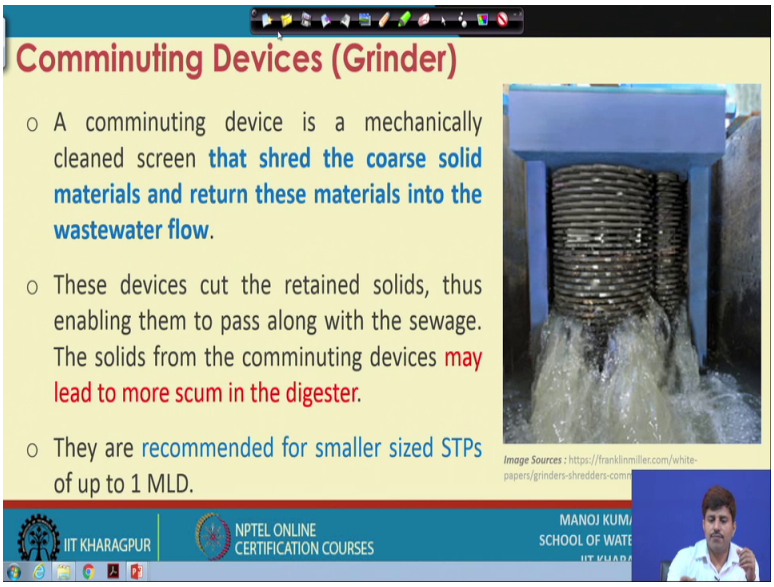

Commuting devices or grinder is actually again a mechanically cleaned screens. What it does? It shreds the coarse solid materials. So, you are seeing here these kind of setups

that are there. So, when it operates so, something which is falling in this gets completely shred and they are released in the waste water, ok.

So, these this shred that likes shred these core solid materials and return these materials into the waste water flow. These devices cut the retained solids and thus enabling them to pass along with the sewage and this solids from this comminuting devices may lead to more scum in the digester. Because, we are getting more solids coming in, they are only recommended for smaller sized STPs generally, which are of size lesser than 1 MLD, 1 million liters per day.

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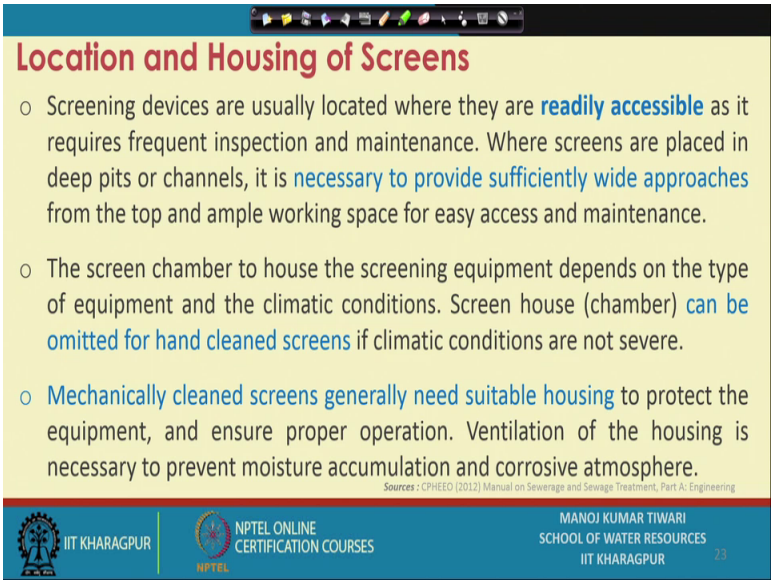

So, these are the different type of screens and we how we sort of locate or house these screens where we should keep these screens depend's on the type of screens that we are using, ok. So, screens which usually are which are is like when we try to place the screens, the first criteria is that they should be readily accessible. So, whatsoever you are placing screen should be readily accessible because screening requires frequent inspection. We must keep on seeing what kind of materials it is being what kinds of materials are being retained when it is going to be choked.

So, the it is maintenance, it is operation, its inspection is a must. And for that purpose, we should ensure that wherever we are trying to put screen units are actually very nicely accessible area, where screens are placed in deep channels. If we want to let us say, put in a deep pits or channels, then also we should ensure that there is a sufficiently wide

approach to go and assess those things assess from top. So, that from top we can go there, we can pull out the racks, we can ensure the cleaning operations. There are ample working space has to be there for easy access and maintenance of the screen.

So, that is one important point where we locate and ideally, it is located in the beginning of the treatment. So, the channel which is coming in we should put a screen and then allow the water to pass through for subsequent processing. For the like housing of this screen, whether we should provide a screen chamber or a house to a screen, depends on what kind of equipment's is there and what kind of climatic conditions it is working in.

So, for say, if it is a hand driven screen and working in a normal climatic conditions, we actually do not need any screen chamber or any screen house. It can be there in the flow through channel. So, there is a channel we can just intercept that put a screen over, there in the channel and let that pass through. So, whenever needed, we can take that outline that we do not need any specific chamber or house for that screens, ok. But, that is only if these are hand driven and good and kept in a like relatively favorable climatic conditions. Even hand driven these things if you want to keep it in a let us say very cold climatic conditions where there is trapping. When it is getting trapped, the ice is forming over there. So, your channels or your this thing screens may actually get blocked over there.

So, those kind of things need to be ensured that that are there, then mechanically cleaned screens are generally need some sort of suitable housing or we what we typically refer as screen chamber. So, mechanically clean devices because they will have mechanical equipment's and in order to ensure their proper operation and safety, we cannot expose these mechanical equipment's to the open, ok. There would be possible wear and tear those kind of things could be far more if we kept left it in open.

So, it is better to keep it in a protective environment and we should ensure whatsoever housing we are providing should have proper ventilation and should prevent the moisture accumulation as well as prevent the corrosive environment because these are mechanical equipment and if we allow if we do not put proper ventilations.

So, let us say we put a closed case and there is no ventilation. So, then it is likely that, there will be developing moisture and leading to the corrosive environment. So, in order

to avoid that we must ensure that these are kept these are placed in a nice dry environment and there should not be chances of the corrosion were there.

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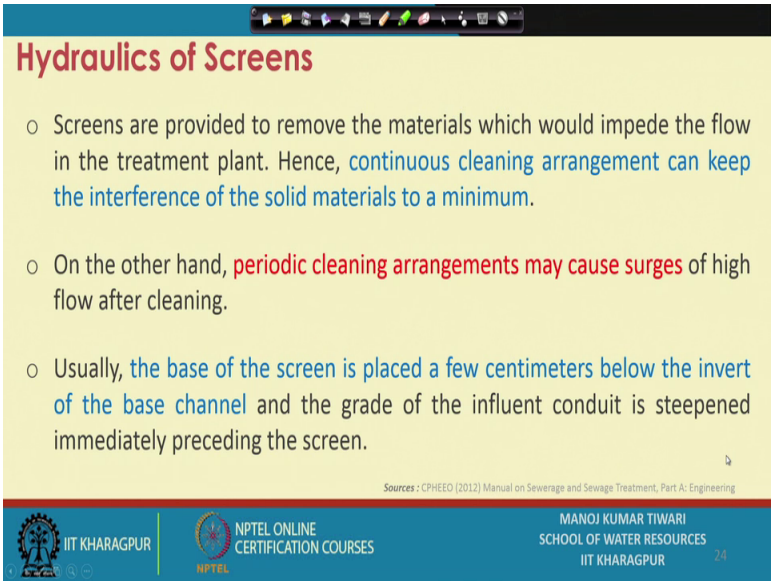

Then, when a water channel is passing through the screen there is going to be certain had hydraulic disturbances. So, his screens are provided to remove the material which would impede the flow of the treatment plant, ok. So, if we are in a flowing channel, if you are putting obstruction in the form of screen, it is obviously, going to the disturb the flow conditions, ok.

So, if we keep on as the more and more blockage or more and more retention takes place on the screen surface, it becomes more and more difficult or they are like head loss will increase that way and flow will be disturbed more. So, a continuous cleaning arrangement should means, if we make a continuous cleaning arrangement. It can keep the interferences to the solid material at a minimum level. But, the periodic cleaning arrangements may cause surges of high flow after cleaning.

So, how frequently we should clean like depend's on how much is trapped and we should ensure that the hydraulics is not disturbed. So, it is not that head loss has increased too much or the flow has stopped. So, then we should clean it and it is not that we always keep on cleaning regular cleaning even though there is no disturbances in the flow. For the purpose of minimizing the hydraulic disturbances, the base of screen is typically placed a few centimeters below the invert of the base of the channel. So, that when the

screen base is low. So, the flow gets uninterrupted like just there will be bar and screens that can be which can capture that, but from base side there is the interruption is minimized, ok.

So, that is our important aspect and grade of the infinite conduit is steepened immediately proceeding to this screen. So, that the flow is ensured. So, if it is in a steeper channel so, we get a good flow over there and because of the slope. So, we get a better flow and the bottom of a screen is kept little lower then channel itself so, that the disturbances or this thing can be minimized.

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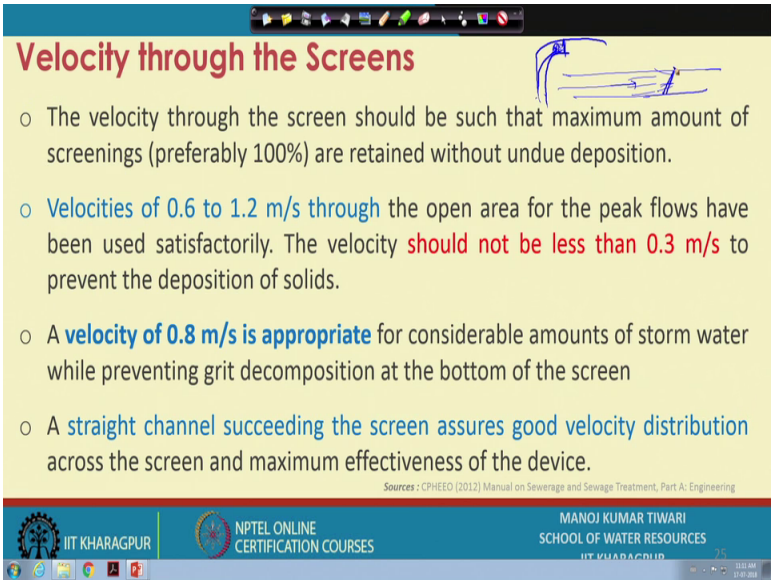

Now, we need a adequate velocity through the screens. The velocity through the screen should be such that maximum amount of screenings or solid materials are retained without undue deposition, ok. So, that is one of the essential criteria. Generally, the our C p achieve manual recommends velocities of 6 0.6 to 1.2 meter per second through the open area for the peak flow, this much should be there and velocities should not be less than 0.3 meter per second to prevent the deposition of solids. If it is less than that, so, then the solids may get deposited on the screen surface itself.

So, generally a velocity of 0.8 meter per second is considered appropriate for the considerable amount of storm water while preventing any grit decomposition at the bottom of the screen. So, because that is also not recommended, those things which can flow should actually flow through the screens straight channel which is like if the screen

is kept in a straight channel so then a good velocity distribution is like ensured. If you are having a let us say, if you are having a channel like this and try to kept a screen here.

So, because of the flow disturbances here, there is too much of turbulence and the velocity distribution through across the screen is not good. So, it is better to have a like significant amount of straight channel before they screen. So, that velocity is nicely distributed in the channel And, this sort of maximize the effectiveness of the screen in terms of the retention.

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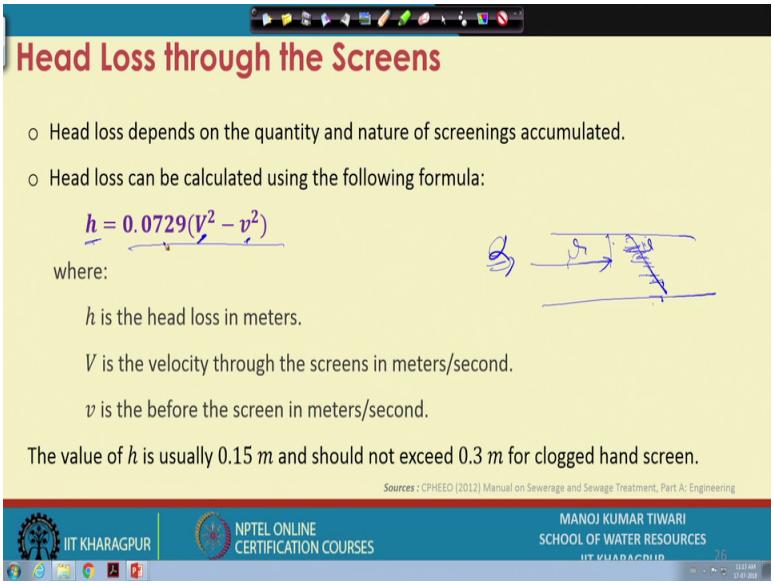

Now, when the flow goes through the screens, there will be head loss which will bound to happen, ok. So, this head loss depends on the quantity and nature of these screenings that are accumulated the head loss can be calculated using this typical formula, ok. As per recommended by the C p here, so, h which is the head loss in the meters is equal to 0.0729 V square minus small v square, where V is the velocity through the screen in meters per second and v is the before the screen in meter per second. So, in the channel, what is the like velocity and what is the velocity through the screens? So, the velocity here through these screen openings is V, ok.

So, because we are trapping some part of area over here and for a constant discharge Q the area, here is this and the area whatsoever the screen or bar thickness and those kind of things are going to be. So, the area for flow through the screens is going to get reduced and we will have velocity through the screens a little higher.

So, that is why v is little higher as opposed to v and their differences multiplied by the differences of their squares multiplied by 0.0729 gives the head loss, the value of this head loss is usually 1 point 0 0.15 meter and should not exceed 0.3 meter for clogged hand screens. So, that is the criteria if it is exceeding that, we know that it is high time to clean the screens.

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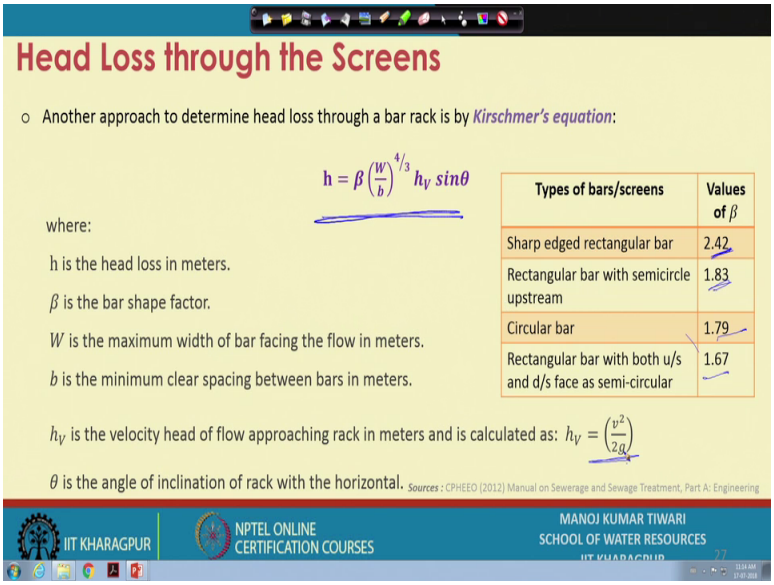

There is another approach to determine the head loss through these bar screens, from this equation. So, we have another equation over here. Here, h is the head loss in the meter beta is the shape factor of this screen, ok. And this shape factor will depend on what kind of shape it is so, it is a sharp edge rectangular bar the shape factor is 2.42. It is a rectangular bar with semicircle upstream 1.8 for circular bar 1.79 for rectangular bar with both upstream and downstream as semicircular is 1.67.

So, we take the beta value accordingly and then W is the maximum width of the bar facing the flow in meters, b is the minimum clear spacing between the bars in the meters. So, what is the minimum clear spacing h V is the velocity head of the flow approaching rack in the meters which is calculated as v square by 2 g and theta is the angle of inclination of the rack with the horizontal. So, like if it is kept at 45 so, theta becomes 45 that way. So, this is another approach for estimating head loss.

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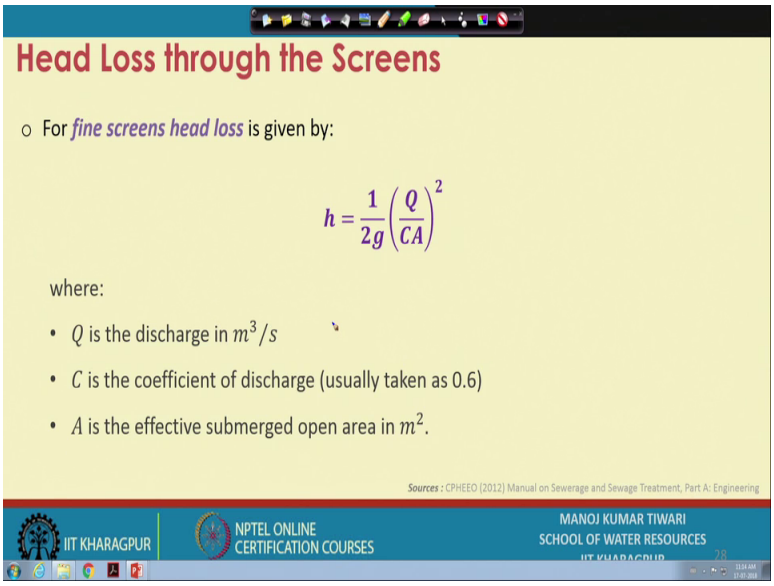

There is for fine screens, we use typically this formula for head loss estimation, 1 by 2 g cube by C A square. Here, Q is the discharge in meter cube per second, C is the coefficient of discharge which is usually taken as 0.6 and A is the effective area of the opening in meter square. So, this way, we can estimate the head loss through the screens, ok.

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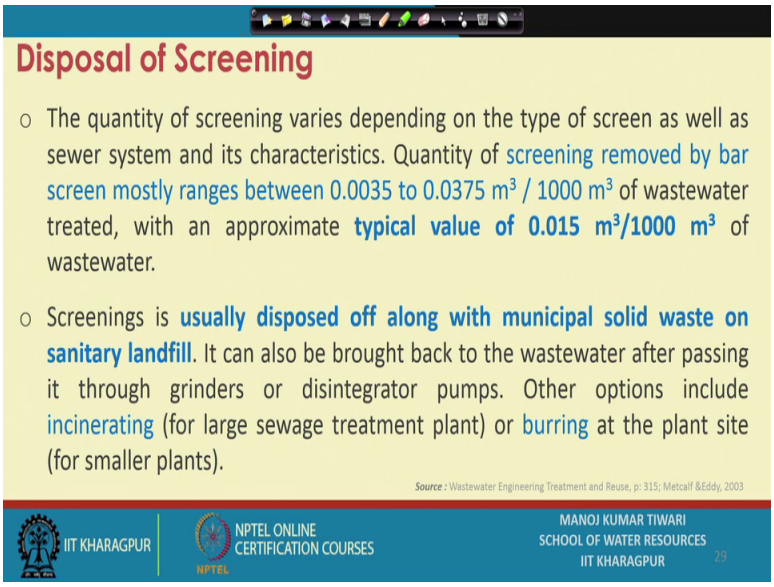

Now, at the end, when this screening is complete, we have to think about the disposal of the screenings, ok. So, whatsoever quantities which has been retained, now how much

quantity will retain will depends on what type of screen as well as what type of sewer system and what are it is characteristics, ok.

In municipal sewage, we are supposed to have high amount of screening as opposed to the industrial sewage. The quantity of screenings removed by bar screens mostly ranges from 0.0035 to 0.0375 meter cube per 1000-meter cube of the waste water treated, ok. And we then approximate typical value of 0.015-meter cube per 1000-meter cube of the waste water.

So, that is the typical value. The screening is usually disposed of along with the municipal solid waste on sanitary landfill; there are other alternate options also. So, we can brought this back to the waste water, ok. We can channelize this back to the waste water so, what if we like if we are passing the screenings through grinders or disintegrator pumps. So, it gets grinded disintegrated and then we can channelize that back to the wastewater the other options include incineration. So, if we are particularly having let us say large size of treatment plant which is generating too much of these bulks solid screen.

So, it could be incinerated although there are environmental effects of that process. So, it is not recommended, for smaller treatment plants many places, it is buried at the plant site itself, ok so dumped in the ground the plant site. But, otherwise, like because of the nature of this, it is typically the solid waste material which are coming in the water. So, they can be trapped and put back for processing along with the municipal solid waste in the sanitary land fill or whatsoever disease being done with the municipal solid waste. So, that way, we can sort of handle the screenings which has been coming from. So, we conclude this discussion on screening and in next class, we will talk about the grit removal and equalization systems followed by the sedimentation in the later classes.

Thank you.