Advanced Aquaculture Technology
Professor Gourav Dhar Bhowmick
Department of Agricultural and Food Engineering
Indian Institute of Technology, Kharagpur
Module 02: Technology of Closed Aquaculture
Lecture 09
Flow-Through System

Hello, everyone. Welcome to the advanced aquaculture technology course.

(Refer Slide Time: 0:32)

My name is professor Gourav Dhar Bhowmick I am from the agriculture and food engineering department of IIT Kharagpur. So, in this particular lecture, we will be discussing about the flow-through system, for the module 2, technology of closed aquaculture.

(Refer Slide Time: 0:44)

The concepts that I will be covering in this particular lecture is the introduction to the flow-through systems, what are the type of flow-through systems? Like, conventional one, intensive ones. And what are the merits, and demerits related to these kind of flow-through systems.

(Refer Slide Time: 1:01)

Flow-through systems, it is actually intensive land-based aquaculture systems. So, in general, we use these kind of systems is not used in semi intensive, or extensive aquaculture because it doesn't make sense to involve this much of in the design and the engineering prospects involved with this particular flow-through systems are not viable for other aquaculture units like another intensive ones. It involves rearing fishes at high stocking density in long, or narrow ponds or tanks, it requires abundant amount of continuous water flow. So, that is the reason why it is called flow-through systems.

It facilitates the high degree of control over the environment for the of the species that you we are culturing the in our aquaculture pond, or in aquaculture raceway. I mean like in aquaculture pond, or aquaculture tank whatever it is. In the flow-through systems, the most common facilities are like involved with the trout culture, different kind of trout, rainbow trouts and etcetera, etcetera. So, this is very much famous in the all the western countries in general, and also in India also we are using it now, it is in a large number.

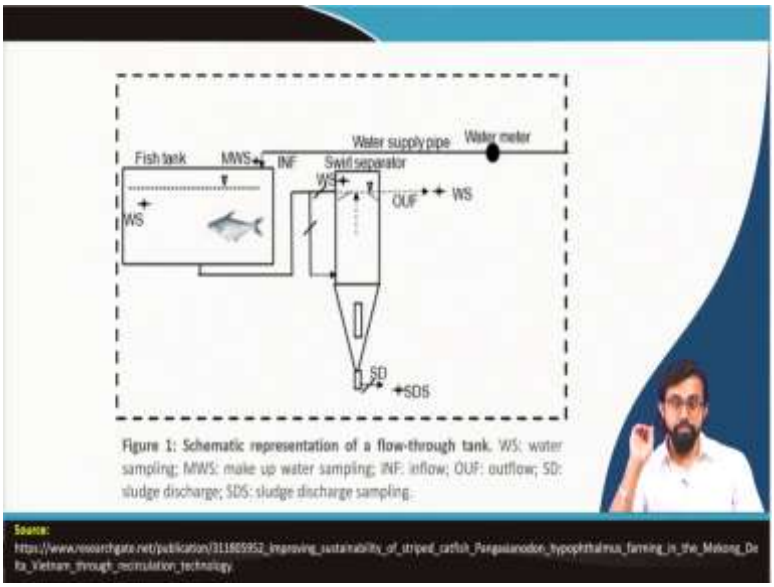
(Refer Slide Time: 2:05)

Continuous flow of this water. Actually, which is happening in this kind of flow-through systems, which actually ensure the proper oxygenation and also flushes out all the metabolic wasted, that is waste that is generated out of the aquaculture species and all. So, in general, this the systems this kind of flow-through system is usually in the shape of rectangle, definitely we try to make it in a rectangle shape in general, I will discuss you in I will show you the picture how it looks like. So, other than that, it can be circular, if there are possibility of making it in other shapes as well, but rectangular are the one which is like very famous one, and which we normally try to have it in our system in our farm and all.

It generally a design made of reinforced concrete or the earthen material with the inner surface covered with plastic or the linen material. Sometimes it can be of only plastic material, or nowadays we use this HDPEs and all. So, that can also be used, and there are possibility of using it, designing it with the FRP materials also like fibre reinforced plastics and all. Other than that, metal or wooden-based flow-through systems are also there depending upon the place of culture and all.

The water supply, it can be of two types in general, the conventional one is like, you are providing water in the same direction and just go keep on going and keep on flowing through it and there is another one intensive, where we have the intensity echo when we go for further a higher stocking density, we have to provide it with the additional amount of the water supply units, which we considered as the intensive water supply systems.

(Refer Slide Time: 4:12)



This is a standard schematic diagram of representation of the flow-through tanks, the water sampling, you can see the water meter from the water supply line through the water supply pipe the water is coming which is like INF means like inflow, the inflow is coming to the culture tank, where the no way, we normally go for this make up water sampling, that water sampling is done there.

Then in the water tank in the fish tank, the fish or whatever the cultural species we are targeting those are being those normally have been rear. There we have this water sampling units, you can see WS they are, these units, these sampling units are used for continuous monitoring of the quality of the water that you are supplying and the quality of the water that is prevailing in the tank.

So, it is very much like predominantly use, these kind of sampling techniques and all, grab sampling or. So, then from this fish tank, the water is coming out it comes to this swirl separator. So, why do we need this kind of swirl separator? So, all the actually, the amount of the waste that is generated from this intensive aquaculture units are very high. In general, they have this very huge amount of suspended solid, they can have a huge amount of nitrogen species and all, so which are also converted into the biomass and they can also be sedimented there, and those solid material, those suspended solid materials are actually being collected, and is separated using this swirl separator units.

In the swirl separator unit, you can see in the vortex region that it generate the vortex region in this hooper like structure, at the end, so, it we can get the sludge discharge, you can see SD this sludge discharge unit. So, from that we get the sludge out of it, which are in general the

thickened slurry kind of it looks like thicken slurry, and this slurry is actually very rich in different nutrients and all. So, we want sometimes to be like, with this kind of biomass this kind of I mean like the sludge actually has a very high potential to be used in for different purposes.

So, normally it is used for fertilization, bio fertilizer application, we can use it for different other purposes as well like we can get some by-products recovery also from this systems, and we can use it for fertilization and all, anyway. So, this swirl separators at the end of the getting, at the end when the system is actually getting rid of all the solids present at least like the as much as possible the solids from the water, then the clean water is going out of the from the top of it. So, you can see the supernatant of this swirl separator unit is going OUF, you can see the outflow. So, through that way, so, it is getting out.

So, all this WS is the point where the water sampling is taking place. So, based on the water sampling, earthen data that is available, so what are the data that we need normally look for? The suspended solid, so, the solid it can be of different types, suspended solid, it can be dissolved solid, etcetera. So, what is suspended solid? There are other solids material as well, in general what you need to know? What is suspended solid? The one which is in suspension all the time in the water. So, the one which is dissolved in it, we dissolve on it which is very hard to segregate from this water, it is like all we call it that dissolved solids and all.

And, the other one which is having which is in a suspended solids that we can easily take out using the simple filtration method, we can use this swirl separator method where we can make a vortex so, the centrifugal force, what will happen the stock, the material, the elements with the higher specific gravity will be in the peripheral region, and in the peripheral region and it will keep on accumulating in the bottom. Like there are like technologies you already know what is how to use this kind of physical, this phenomena to getting rid of the solid particles from the wastewater.

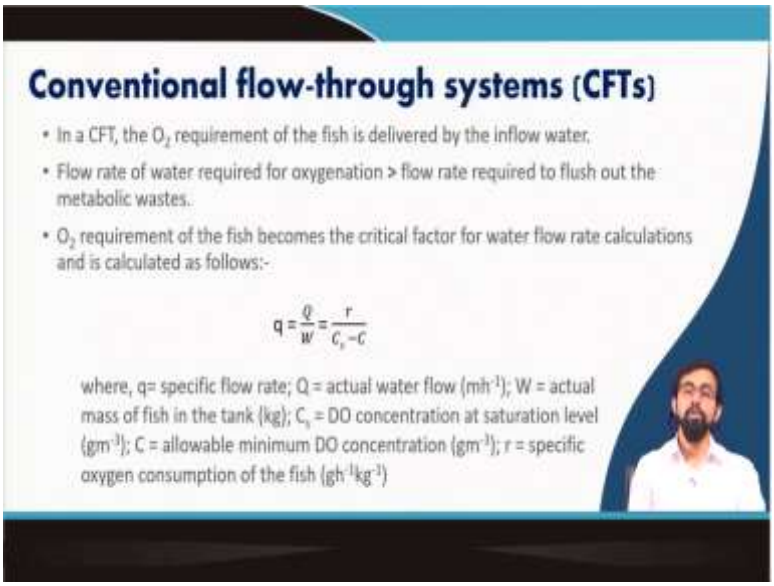
So, after the solid particle is getting, we can get rid of the solid particles the clean water that is coming out of the system is actually again be used, reused can be reused back to the tank or not. So, it is good enough to throw it to the surface water bodies, but make sure that you have checked the water quality of that before throwing into the surface water bodies, because in Indian context Central Pollution Control Board has very strict rules and regulations like related to the water, surface water discharge.

So, you have to abide by those rules and regulations you have to abide by all the parameters whether it be pH of the water, if the pH is up and down like it is not at the range that it requires you have to go for neutralization techniques and all, if the like it depends like depending upon the various parameters if the solid concentration is still very high, you cannot still throw it into the solid water into the surface water what is you have to make sure that the solid is completely removed, if the suppose the alkalinity is very high, if suppose the hardness is very high or low, so, all these parameters.

So, first of all I would like to request you to get an idea about what are the water quality parameters, pH, DO, alkalinity, hardness, nitrogen content. Nitrogen content can be different type, total nitrogen content, total ammoniacal nitrogen, total Zn nitrogen, so these are different terms that you need to understand, you need to learn, you can just simply Google it, it is very easy. Even if it is not then maybe we will discuss it in during our live session that we will be having.

So there also I will discuss with you all these parameters and how these parameters are very much needed, you need to know these parameters in order to understand or the design your aquaculture farm in future because it is related to the water, aqua is water right? The water is very important, and you need to know each and every segments of water quality parameters, and how those are related to this kind of flow-through system, or any kind of aquaculture farm that we will be designing.

(Refer Slide Time: 10:43)



So, the in case of conventional flow-through systems the oxygen requirement is delivered by the normally the inflow water, the flow rate of water required for the oxygenation has to be

higher than the flow rate required to flush out the metabolic wastes. So, that you have to make sure when you will be designing and or for your own farm or maybe you are a technology provider, or you are a consultant. So, when you will be designing for your customer and then you have to make sure that the flow rate is designed accordingly. So, there it has to be higher than the flow rate required for the flushing out of them, all the metabolic wastes from your system.

The oxygen requirement of the fish, it becomes a very critical factor for the water flow rate calculation, and we can how to do that? The specific flow rate or the q, that we can easily find out by the actual flow rate, which is in meter per hour. So, this water flow, while it is meter per hour, it is actually meter cube per meter square per hour.

So, that is why in general we say like, m^3 of water flowing through a particular within a particular hour, or particular timeframe for per m^2 of surface area of your this flow-through system and all, so m^3/m^2 / h. In short we say meter per hour, the W is the actual mass of fish in the tank kg, in kg unit. So, if you see the unit for Q the specific flow rate is meter per kg per hour, is not it? So, Q / W. So, that is equal to the DO concentration and the saturation level which is g/m^3, which is C_s.

What is that DO concentration as saturation level? You need to remember this data, this is very important, you will be asked in any kind of competitive exams there is a chance you may be asked that in general at 20 degrees Celsius DO, all the dissolved concentration in STP condition at 20 degrees Celsius it is 9.07 milligram per litre, or 9.07 PPM, parts per million. So, that is the DO concentration at saturation level, at 20 degrees Celsius, that with temperature that DO value will up and down. So, based on the temperature, sometimes the DO concentration, saturation DO concentration can be as high as 11, 12 and as it can be as low as 7, 7.5 like that, depending upon the temperature and all.

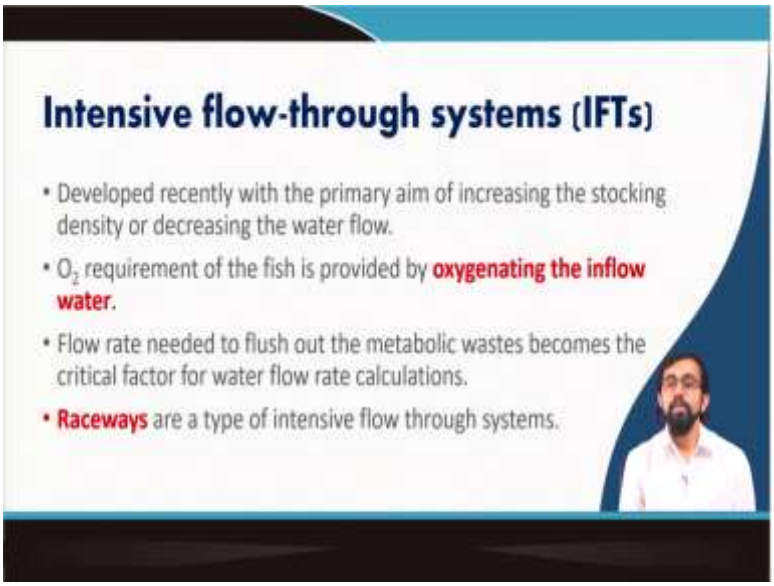
So, in general the when that warmer area that DO concentration or saturation level is much lesser, in case of colder region it is much higher, is not it? That is the reason why we go for we heat the water to get rid of all the gases, this is also standard degassing procedures from the water.

Then the C is the allowable minimum DO concentration. So, suppose we have a allowable minimum DO concentration of around say like 2 milligram per litre, or like. So, based on this value, and the based on the saturation value, and based on the specific oxygen consumption rate of the fish, which is gram per hour per kg in general.

So, that value is that value we can easily find out in the literature. So, from that equation from this equation, you can easily calculate any unknown fact from your systems you can get an idea about the actual water flow required in your system before just because when you have like while calculating when you will have the idea about the value of r, value of C_s and C. So, based on this equation and value of W also, say suppose you know that the actual mass of fish that is available, based on this factor, based on these numbers you can easily calculate the actual water flow that is required.

Suppose, the actual water flow you know and everything you know from the calculation, from the pre calculation stage. Now, all of a sudden you are asked like what is the actual mass flow, mass of fish that is available in the tank that is also doable. So, in general it is used for the actual water flow calculation, this equation and this, this you should remember. This is actually more or less same for all kinds of flow-through systems.

(Refer Slide Time: 15:04)



The second one is intensive flow-through systems, it is actually developed very recently with the primary aim of increasing the stocking density or decreasing the water flow. In general, the water, the oxygen requirement of the fish is provided by oxygenating the inflow water, what it happens, the water before it is supplied to the system, supplied to this kind of flow-through system it is oxygenated, by using the oxygenator.

What is oxygenated, what does that mean? It means we somehow increase the dissolved oxygen concentration of the inflow water. So, there are various means of doing that, simply you supply the fresh oxygen using oxygen cylinders, you can supply the fresh air, like from the air circulation, aeration units and all.

So, there are various ways of doing that. But you have to make sure that you are oxygenating your inflow water. So, to a certain level that the inflow the flow-through system has enough amount of oxygen, and so that the, even the increasing the stocking density will not cause any issue to your system. So that is why it is called intensive flow-through systems, the water flow can be minimized because water flow is for what? To addition, to supply the addition oxygen, additional oxygen, but if you can supply the minimum, like even less than the water that it requires, and if you can supply it with the enough amount of oxygen that it requires for the survival of the of your aquatic species, then that is it, that is what we need.

So that is how we take care of the oxygen requirement of the fish in the system, in this kind of intensive flow-through systems or in short, we call it IFTs. The flow rate needed to flush out the metabolic waste becomes the critical factor for water flow rate calculations. So that is very important. And we need to think we need to, we need to make sure the flow rate needed for flush out of the metabolic wastes in the design calculations and all. The raceways are actually a type of intensive flow-through systems.

(Refer Slide Time: 17:12)

So, this raceway and all that we normally have, normally we design, it is it is a type of typical example of the intensive flow-through systems. So, like, let us talk more about like we know we have an, we have a basic idea about what is the flow-through systems, what are the different types of flow-through systems?

Now, let us talk about the advantages and disadvantages, or the pros and cons part of flow-through systems. We already know, while discussing that we have to make sure that the oxygen is continuously provided. So, the continuous flow maintains the oxygen level and the

temperature and removes the carbon dioxide and the nitrogenous waste from this kind of flow-through systems.

If it is intensive one, then this is the same thing happened, but the flow the only the not only the flow, but oxygenation oxygenator involves with the before putting the water into the system, that also helps additionally, which also kind of have more advantages for this kind of intensive flow-through systems.

It can facilitate a very high production level 1000 times more than the pond culture, can you imagine like the you can just by introducing these kind of techniques by introducing some initial capital cost, which we normally as a, Indian context, we normally think like, it is not doable and all. So, but we the problem is we do not do the economic analysis, we do not do we only think about the cost that involves in the beginning, we do not think about the benefit that we will be getting in a subsequent timeframe.

So, if we can design our system optimally, if we can have our system scientifically designed and the engineering the aspects will be done properly, will definitely get very high amount of production benefits. So, it can go almost 1000 times more than the general pond culture of the same area, like suppose the same area if you can compare in a pond, like the production is can be like is 1000 times less than the this flow-through systems. It facilitates the discharge of effluent with very lower concentration of solids and nutrients, which is also very much helpful in environment perspective as well.

It relatively easier for feeding, grading, and harvesting process, because you do not have to worry about like because the feeding is done, you just put an automatic feeder you can design it accordingly it will be there will be like a you need a circuits and all, it will definitely provide you the amount of feed that is required, that it requires with time without any human involvement at all.

What are the disadvantages in it? First of all, the flow-through system and the raceways if it is not incorporated inside a pond, or inside there are there are instances where the raceways are incorporated inside a pond. So, raceway in-pond we call it, raceway in big culture pond. Other than that it requires a huge amount of water, it is a large amount of water that it requires to how to say exchange a lot.

So, that is a bad thing, that is the one of the major cons part of these kinds of technologies. It is inability to self-cleaning, because self-cleaning is only possible if we increase the velocity,

the flow velocity up to a certain level, but if you increase that flow velocity up to a certain level what will happen? The fish that they are the dwelling there they will not be able to survive in this harsh situations and all.

So, for them it is a big of a difficulty, this self-cleaning procedure is like if you want to incorporate self-cleaning then definitely for the fish to survive and go to the upstream it is really very difficult for them the dwelling in that zone will be very much they will face a lot of difficulty on it. So, that is the same thing, it poses the cleaning difficulties because it will be like continuous motion and all, but not self-cleaning. So, that means, somehow you have to get rid of all the suspended solids that is being sedimented with time on the bottom of this culture tanks.

It requires a high amount of dissolved oxygen level to, level maintenance. Definitely because once you do the intensive aquaculture, it means that there are a large number of fishes involved with it. So, when there is a large number of fishes involved in it, so definitely you have to involve, you have to make sure that dissolved oxygen level of the pond, or the tank is never below a certain threshold limit. It does not have to be saturation or it does not have to be near to saturation level, but it has to be maintained, it has to maintain a certain threshold limit based on the culture species that you are culturing in your treatment unit.

Also, the culture fishes they consume more food due to the requirement of the high energy for swimming, in general what will happen it's like, when we do more kind of more gym or more physical exercise, we need more amount of food. So, once they are in the extensive aquaculture systems, though, they have a fast area to cover, but they feel like, there is no competition they do not go fast or something.

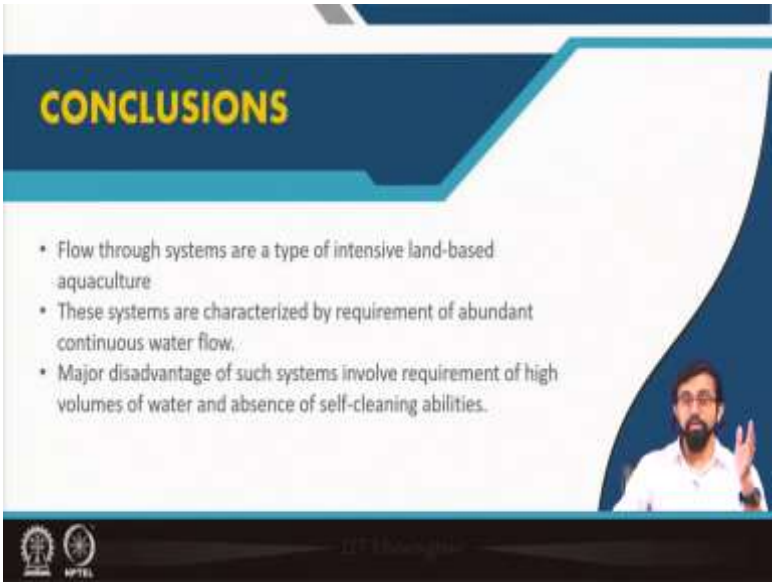
But in case of small aquaculture systems, if you if you give it a closer look, it is so surprising though it has a small area, very less area to dwell, less area to swim, but also but still it has always has a lot of neighbouring species, neighbouring fishes with it, and it always keeps on moving like here and there it is like the energy the swimming the potential is becoming much higher in case of intensive aquaculture then the extensive one.

And which actually involves with a high cost, like involves with a large amount of cost for us, how? Because of the involvement of the feed requirements, but it is somehow good, even sometimes what we do what we should do, before providing the food, you just use a small stick or something if you have a small pond, and all. And or, if you have some way to help this fish to move fast, and also anyway it is a flow-through system. So definitely the fish will

swim a lot. So, the moment the moment it will swim a lot, what will happen it needs a huge, a lot of fish feed as well.

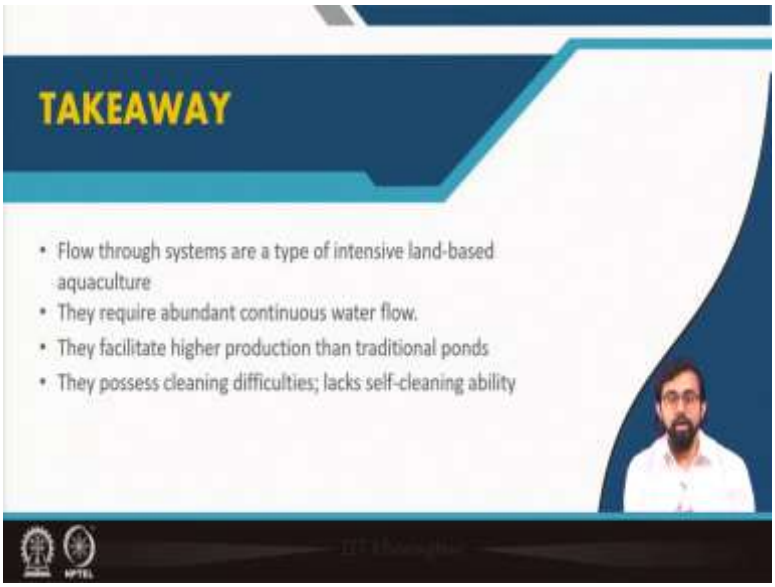
So, but the good thing about this is like it is, it will be completely it will be consumed more in much higher percentage than then in the other intensive aquaculture systems or then in the other extensive aquaculture or semi intensive aquaculture systems, because it is keep on running it is keep on moving from one place to another. And it gives them a huge amount of how to say like, like the conversion, biomass conversion this feed to conversion biomass conversion ratio is very high in this kind of systems because of that, so, the production yield will be higher, however the consumption of feed which cause you some additional economic involvement and all.

(Refer Slide Time: 24:13)



In general, the flow-through systems are a type of intensive land-based aquaculture, this system is characterized as by requirement of abundant continuous water flow, major disadvantage involves because like it involves requirement of high volume of water and the absence of self-cleaning ability, and as we discussed the feed, that is these are the only like the cons part of this kind of system.

(Refer Slide Time: 24:33)



So, what will be the takeaway message for the today's lecture, that flow-through systems in general involves with a certain like it is a an intensive land-based aquaculture systems, which involves with a continuous flow of water in your system, in the unit. It requires abundant amount of continuous water flow, the water will be keep on flowing. It facilitates the higher production than the traditional pond, I already discuss with you to discuss with you what is the reason behind it what is the scientific funda behind it.

And they possess the cleaning difficulties and lacks the self-cleaning ability, scientists are working on it, they have developed different kinds of self-cleaning raceway ponds nowadays as well. So, where the treatment unit so, there is like, proper type proper sacking mechanisms which are there those sacks are there which will clean keep on cleaning with time it will keep on cleaning the bottom of those flow-through systems and all. So, by this way you can clean the systems, you can clean the bottom and with time and not only that, if it is a very really huge.

So, what they do with time to time they the moment they do the harvesting, the amount of harvesting say like once in a year or twice a year depending upon the culture species. So, once the harvesting is done, then they keep on flow, they increase the flow rate. So, once they increase the flow rate, and somehow make certain barricator, certain restriction at certain point, what will happen?

There all the solids will keep on accumulating, then they will go for grazing process, and they collect all the like the suspended solid, all the sedimented particles which is there in, which are there in the this kind of like system, this flow-through systems and all. So, this is how it is

done, and this is the technology that is available nowadays in the market already. So, I hope you get to know some new things in today's lecture.

(Refer Slide Time: 26:45)

And these are the references that I have taken the data from so you can go through it, and if you have any difficulties definitely during the live session you can discuss with me. Thank you so much. See you in the next lecture video.