Advanced Aquaculture Technology
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Module 02: Technology of Closed Aquaculture
Lecture 10
Raceway culture

Hello, everyone. Welcome to the last lecture of the module 2, for the NPTEL online certification course, Advanced Aquaculture Technology. I am professor Gourav Dhar Bhowmick from the agriculture and food engineering department of IIT Kharagpur. So, in this particular lecture material, I will be discussing about the raceway culture, and how the raceway and the design and engineering specification of the raceway culture.

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The concepts I will be covering this particular lecture material is the introduction to the raceways, what are the advantages and disadvantages that is related to the raceway culture, the general criteria for constructing raceway, the type of raceway, the in-pond raceway systems, and these are the one that we will be discussing more in details in this particular lecture material.

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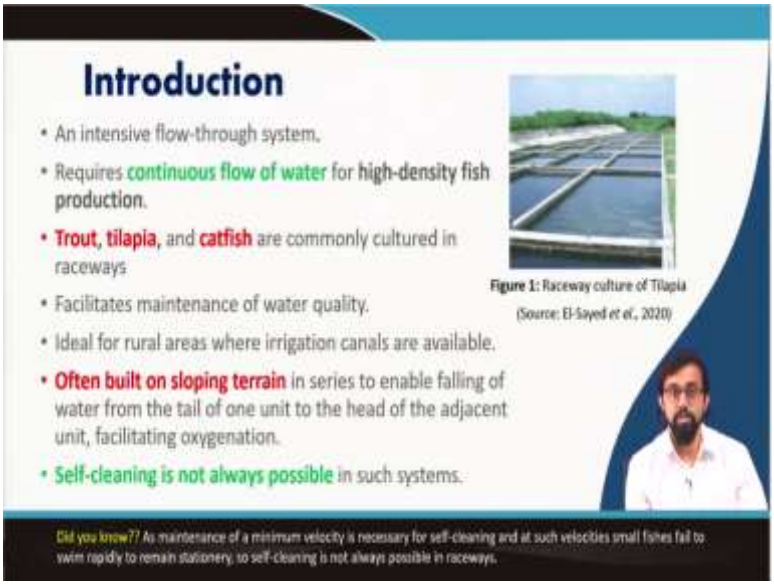

So, you know the raceway, it is actually an intensive flow through system, it requires continuous flow of water for high density fish production, as you might have remember, like in the last lecture material, we have discussed about the flow through systems. And raceway is one type of intensive flow through system.

So, it requires continuous flow of water and the trout, tilapia and the catfish are the one which are most commonly cultured in the raceway. There is one reason behind it, because these species can withstand some minor environmental changes as well, but because raceway which it has a continuous flow of water has been maintained. So, there is sometimes there is a possibility that some amount of water deterioration or there is a possibility of some amount of less amount of the quality, water quality parameters can deteriorate there is a chance.

So, in this kind of cases, the fish like tilapia, catfish can easily survive because they do not, they can withstand these kind of minor environmental changes, and that can take place in the raceways. It can facilitate the maintenance of the water quality. In general, the raceway has this raceway is still much better than the other flow through systems because it can continue the quality of the fish. So, it is ideal for the rural areas where irrigation canals are available, often build on sloping terrain, in terrace to enable the falling of water from the tail of one unit to the head of the adjacent unit, and facilitating the oxygenation.

So, you know like it is a cascade system in general we call it cascade systems, you know like one step wise. So, this because of this stepwise nature, or the because of this sloping terrain, sometimes what happened it can increase the oxygen present, the dissolved oxygen present in the water, how it can increase? If there is like more amount of splashing or more amount of

water dropping like this nappy flow also if we can maintain, the water will get more amount of specific surface area, and if the specific surface area is higher, what will happen?

The oxygen, the diffusion from the air to the, or the total air diffusion from the atmosphere surrounding atmosphere the water will be maximized. By this way we can increase the available dissolved oxygen present in the water, and this available dissolved oxygen can help in increasing the dissolved oxygen present in a raceway in general. And it will help in all the aquatic species that is being cultured, and it can even if you go for higher stocking density, they can easily survive in this kind of system.

So, that is the major advantage of these kinds of systems. And these kinds of systems are majorly being utilized all over the world nowadays. It is considered as the future of one of the futuristic model of aquaculture practice, and it has the one issue which is I already discussed in the last present lecture material as well is the self-cleaning.

Self-cleaning is not always possible in this kind of system. Because of the because if you want to go for the self-cleaning, if you want to increase the velocity. So, what will happen? This velocity, the small fishes will fail to swim rapidly. So, to remain the stationary, so if we go ahead with a self-cleaning thingy, so what will happen? It will cause our small fishes to be in a stress condition.

So, that is why we would, do not want it to be, this the water quality, the water, the flow should be as minimum as like the minimum as possible not as minimum like not so, like not so less that the water will be not in a continuous flow condition, but it has to continuity has to be maintained, but the self-cleaning velocity cannot be approached in this kind of system, that is one of the major drawbacks.

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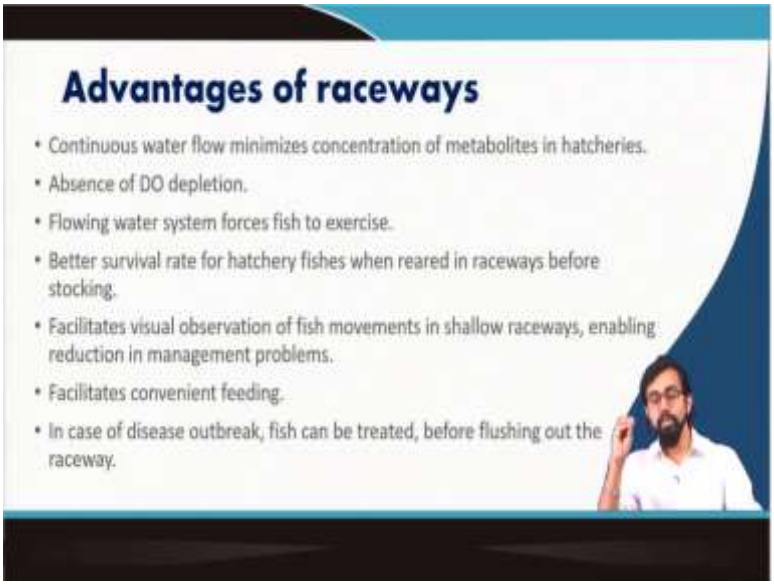

So, that drawbacks are also been somehow people from like scientists all over the world, they are working on it and there are a lot of technologies which are already available, and there are technologies which will definitely be available in sooner future. So, to get rid of these issues, the disadvantage that is related to the raceways.

What are the advantages of raceway? So, it can what is happening here, it is a continuous flow of water. So, when there is a continuous flow of water, so, what will happen? It will definitely minimize the concentration of the metabolites in the hatchery, it can absence that DO depletion, the changes of water, changes of the freshwater, or the presence of oxygenated water, what will happen?

It will, because of the oxygenation of the water bodies, which is incoming inflow of water body, inflow water, which is coming into the this kind of tank, or raceway systems. So, what will happen? This raceway, it will have a very high amount of DO concentration in the incoming water, and it will help in get rid of the DO depletion issue related to the other flow through systems.

It helps the force, it force the fish to exercise, that is the thing I discussed in the last lecture material also, that if you have this kind of flow through system, this flowing water which will help the force the fish to exercise to move rapidly, and if it will move rapidly, and if you can then provide them ample amount of feed, they will grow very fast, and they will consume the feed.

They will, while consuming the feed, this feed conversion ratio will be increased, because it is like simple like we go for exercise, we go for gym and all, then what will happen? Will become, we will be will feel more hungry, because our body needs more amount of nutrients at that moment. So, we eat food, and proper food and that food the conversion from that quote to our actual health, or the actual muscle regeneration will be much higher.

So, that is the same way it happens to the aquatic species as well. So, they once they do a lot of exercise, and if you can supply it with the ample amount of food, they will consume the food, they will consume all the nutrient present in the food, and then they convert it to the viable biomass.

This viable biomass is nothing but it will reflect in their weight. So, with time, the they grow very fast and they have a very like, this when you have this muscle rather than like, I mean like, do I mean my muscle here like, to that is biomass which are generate, which are present because of the exercise is actually much tastier it says in different by the nutrition is that it is much better, much tastier than the one which are only like as go in shallow in nature, and stays in the stagnant water bodies.

So, that is why the freshwater fish which are in the upper, upstream joint of the river, when there is like the when you just come down off the mountain, those fishes, those freshwater fishes are very tasty, and very they have much higher acceptance rate than the fish in the plane area, river area.

But okay sea is different, seawater is different, sea fish is different I am not going to compare with that, sea is different they have their own taste. And they have their own specific taste which is like different to the fish, freshwater fishes, and the freshwater aquatic species. So better survival rate for the hatchery fishes when reared in raceways before stocking, because they have already gathered enough the biomass which is good enough for them to survive for the nearest of their life. And so, that is why in raceways we go for the this, we go for this rearing, the hatchery fishes and then we go for the the stocking.

So, stocking it can be done in a very in a stagnant water body as well. Or we can go for the marketing pond, and all. Marketing pond where it is like it is a little bit smaller than the stocking ponds, where you can put the fish just in order to wait for the market demand. The moment there is market demand you just harvest it from the marketing pond, and you can provide it to the market, provide it to them, you can transport it to the market. This raceways, this it

facilitates the visual observation of fish movement in shallow raceways. And which enables the reduction in the management issues.

So, sometimes we have issues like, different kinds of disease and all it can occur and if we can have a visual observation all the time what will happen? Because of the almost clean water, which presents in the raceways we can visibly see the culture species. So, if I see if we can see that there is some issue with some plants, sorry some cultural species, we can just not that, then at that moment only just take it out and put it in in the quarantine pond, in the quarantine pond is what where we normally keep all the fishes all the aquatic species that were culturing, which are facing some issue, health related and all. We just take them, take them out so that it will not contaminate the other fishes in the or other aquatic species in that surrounding vicinity or in that tank or in the raceway.

It can facilitate the convenient feeding because low area, high stocking density, just put a feeder, automatic feeder, which is very easy to feed, like the very low amount of energy it requires to develop. And that is it, you just keep on feeding the your species, or the cultured species that you are culturing.

So, it is very easier to feed them because in a same place, or you can have a small automatic feeder in like 3 to four 4 different places in the raceways, and that is it. They will be very happy to have their food, all the time to time and it is like, it is more convenient, like it is more convenient to feed like 1000 people in a hostel than 1000 people in a market or in a bigger fairground, and all. So, it is like that.

So, in case of disease outbreak, fish can be treated before flushing out of the raceway. First of all, how disease outbreak can be minimized? Because water is continuously it is like there is a continuous flow of water, that can reduce the outbreak of the disease because of the disease-causing microorganisms can be washed out, it will not because in case of stagnant water, this spread of disease can be very high, it can be as low as in a couple of hour, it can completely spread over all over your farming species.

However, in case of raceway, that is the good thing about in case of raceway, you do not have to worry about that. You do have to worry about that if it is in a very high concentration, the amount of microbiota which is responsible for the disease outbreak, if it is very high, then it is a big of a issue.

Other than that, you do not have to worry about it because anyway, the flushing is happening time to time. And also, you can easily the moment you can visually observe that if you are the specialist, the fish specialists, they can easily identify the changes in their structure in their body mass ratio, or and they can easily take it out and put it in the quarantine pond. And so, that is how it is to be done.

So, these are the advantages, these are the positive or pros part of the raceways compared to the other flow through systems and other aquaculture techniques. So, that is why raceways are becoming very famous nowadays and that is how like that is why we are discussing about all this advanced technology right now.

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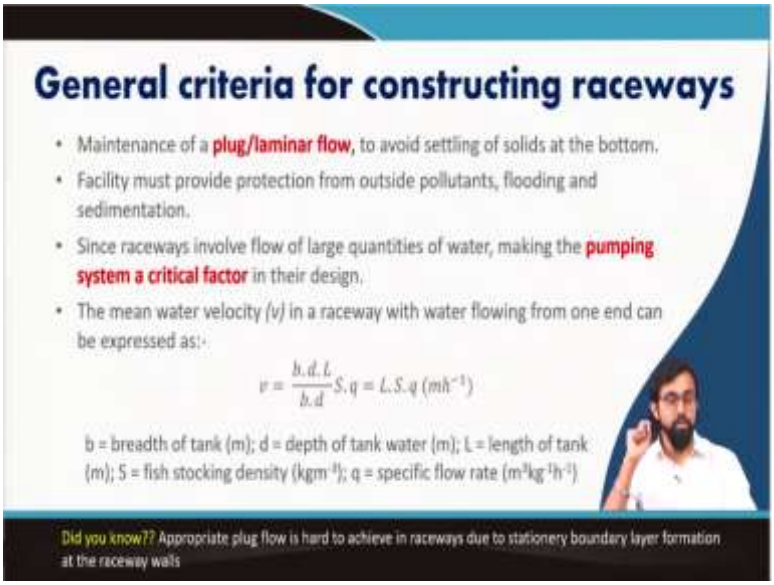

So, it maintains the laminar flow in general or plug flow. So, I hope you know what is laminar flow, what is turbulent flow etcetera, etcetera. So, based on the Reynolds number and all, so I think you have learned it in your physics, or physics subject or if it is not, you can search for it if you want I can discuss about these things in our live session, but in general the this you can easily find it in Google what is laminar flow? What is plug flow? What is this turbulent flows? So, in general it is provided to avoid the settling of solids in the bottom.

So, I can give you one example, what is a laminar flow, and turbulent flow? Just to give you a very broad perspective. When you switch on your, when you say switch on your tap so, when you switch in your water tap what will happen? The water will keep on dropping at one momentum it has a very singularity like, it is like a very homogeneous flow of water you can see, I do not know what exactly I have to mention here, like we see that there is no disruption in the water flow.

This is like it looks like a very crystal-clear water is coming out of the, or your water tap or whatever the liquid that you are targeting. That is called that is kind of laminar flow, the moment it has some disturbances like turbulence flow. It is a very gross stuff example that I have given, there if you go and Google it and you will find very details about it like what exactly are these flows.

The facility must provide the protection from outside pollutants, flooding and the sedimentation that is the one of the major criteria for constructing raceway, you have to have a proper facility designed if it is outside, outside your farm. It has to be covered properly, if it is like inside your pond, the inside your farm definitely you had to has to have a proper protection from storm, from pollutants, from flooding, or from sedimentation and etcetera, etcetera. Since raceways it involves the flow of large quantity of water making it pumping system a critical factor in this design, the pumping system that it requires it has to be properly designed it has to be supplied with a supplementary pump as well.

What do I need? Why do I need supplementary pump or kind of makeshift arrangement, or we can, that way like additional pump that we can do, we can have. Because sometimes there is a chance that pump may fail, or because of some reason or other. So, you have to have a backup pump ready with you, and that is the only one, that is the first thing that I am discussing here because like related to that there are other factors related to the pumping systems involves as well. Because, because pumping system is the one because of what the water is in keep on flowing condition, or like it is keep on flowing over the raceway.

So, that is one of the major reason, if somehow it got any issue it involves any kind of technical issues. So, it can affect your farm output, it can affect your aquatic species that is dwelling there drastically. Because it will not supply with, it may not supply with ample amount of oxygenated water. So, which will reduce the dissolved oxygen, and aquatic species will be in stress and they may die also. If it prolongs the this situation prolongs for a long period of time.

The mean water velocity in v in a raceway with water flowing from one-to-one end can be expressed as b, d, L upon a b, d this S into q, $\frac{(b.d.L)\times S.q}{(b.d)}$ So, here what is this b is the breadth of the tank, the d is the depth of the tank water in meter, L is the length of the tank in meter, S is the fish stocking density in kg per meter cube, and q is a specific flow rate. So, in general actually it is like volume by area. So, in general if you have the proper you know the length,

you know the fish stocking density, and you know the flesh specific flow rate in meter cube per kg per hour. Remember we discussed about this in last lecture also.

So, from this value, you can easily calculate if you multiply see the m multiplied by kg per meter cubed multiplied by the flow rate which is like meter cube per kg per hour. So, if you see it will come down to meter per hour. So, which is the unit of what is the velocity. So, that is how the velocity of mean water velocity in a raceway is calculated.

Remember, it cannot be as high as the self-cleaning velocity as I already discussed in the last class. So, it is just the optimum velocity that it requires for your, the target fishing density and the specific flow rate that you want to maintain in your system, and the accord based on the length of your tank. Based on this 3 factor, you decide the mean water velocity in your, in a raceway.

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So, also the water velocity should be maintained all the time to reduce the stress of the fish. And also, the energy wastage of the fish. What do I mean by the energy wastage? Water velocity, if it is not maintained continuously, first thing just remember one thing it is like when you start a start an engine and when you stop it and rather than if you have a continuous like if you keep on doing it suppose you have a vehicle which you are keep on starting it and stopping it in a very small duration, and another bike another vehicle which will start from the same A to B, it will go from A to B with only one start and with stops at the end, which will consume more amount of energy, what do you think? Definitely the one which is keep on pausing, there is regular time interval it has to start, and you know the starting of engine requires a lot of energy.

That is the same way, if you maintain the water velocity continuously, if we have a continuous flow of water, it will cause you less amount of energy, rather than if you keep on starting the pond, and starting the pump and again stop it, and again start the pond, start the pump and stop it, what will happen? It will consume a huge amount of energy, also it will cause you the huge amount lot of stress in your fish because of the less amount of dissolved oxygen present in your system.

You have to, the water velocity has to has to be maintained in order to avoid any wash away of the supplied food particles. The velocity cannot be as high as like whatever the feed material that you are providing it will not be utilized at all. Because the fish will not get enough time and because of the turbulence it creates because of the high-water velocity, the food particles will lost. So, that will cost you additional economic losses.

So, we do not want to have this kind of additional economic losses, so, you have to put your automatic feeder, or say like manual feeding system when you were doing, you have to distribute it or broadcast it at a particular place where it can utilize, it can be utilized as in a optimum way. So, that you have to identify.

The materials used for this, and also you have to make sure the generated waste always in the suspended condition, how it will help? See, you cannot go for self-cleaning velocity. Sometimes it is a big of a, it is a problem, but what you can do? What do I mean by the self-cleaning velocity? It does mean that all the wastewater all the waste, it is not getting enough time to get settled in the bottom of the pond, bottom of the trace plate. If you can make the water run in a such a way, so, the velocity will be just optimum so, that just as the all the waste will be in the suspended condition. That is what the kind of self-cleaning velocity that is how we can attain the self-cleaning velocity.

So, if these 3 can be managed somehow, because say suppose in case of long pond which are having their length is very high, you cannot attain the self-cleaning velocity it is very hard. Water velocity cannot attain the third pond, it is very hard. Because if you want to attain in that case, so, you have to increase the velocity very high, so that the suspended solids will not get enough time to get suspended, get settled on the bottom, but if it is like a small pond, if it is like a small raceway, the width, the length is very small like up to a certain limit. So, in that case the water velocity can be maintained so to attain the self-cleaning velocity. In this way, we can go for this self-cleaning we can attain the self-cleaning nature of the raceway and plus the waste can be well managed at the end of the system.

So, what the people are doing, scientists are doing nowadays? When you have a very long raceway. So, you put we distributed, we bifurcated in like 3 different small raceways, and we use the water velocity in the self-cleaning velocity level. So, like this way you can when you have a very large amount of pond, large amount of raceway you can bifurcated into 3 different systems.

By this way, this is only a means only one type of example that I am giving to get rid of the problem of self-cleaning attaining the self-cleaning velocity. So, the material used for the construction is the concrete, earth with inner plastic cover for large outdoor raceways. Plastic as I discussed the HDPE, this FRP material, the fibre reinforced plastic, these FRP materials are very famous nowadays, the metal or wood that you can use for designing this kind of raceways.

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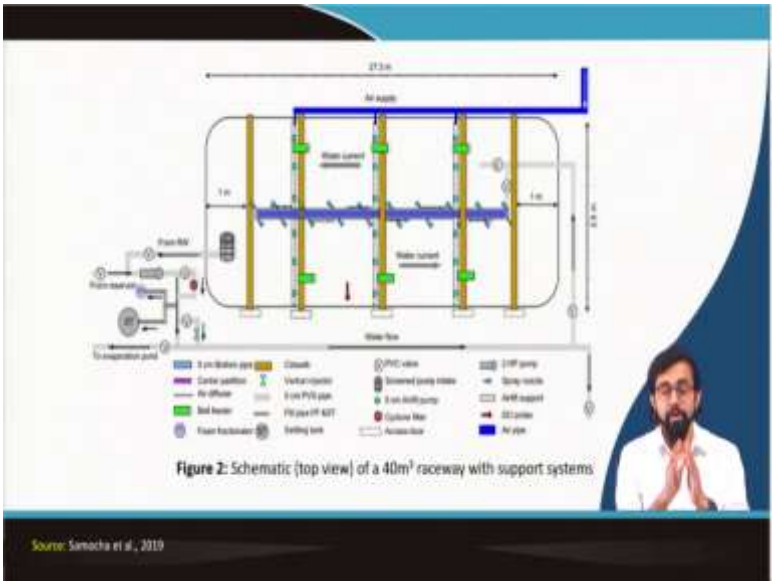

This is you can see the typical design, the schematic of a 40 meter cube raceway. Which is taken from Samocha et al., 2019. You can see the reference from there you can look into this paper, it will be give you a very broad like an idea about what exactly I am discussing here. So, if you can see those air supply line with this deep blue colour, with the air supply line is provided into the, there is 3 different channels mainline in these 3 different main as you see this is nothing but the airlift support, and the air lift pump that is there. So, in say, this green dots, green small dots where this air lift support that is provided in the main line.

There if you see the big green horizontal lines, those are the belt feeder, in the belt feeder what is happening? There is like a conveyor belt system you have the it is keep on dropping, there is like sometimes some amount of feed is dropping with time. So, it is providing, it is like the

conveyor belt is keep on moving and it is providing the feed at a certain interval, that is the belt feeder and all, that is that is provided here.

Then the water you can see this is the whole pond, which is like 2.5 meter by 27.3 meter in dimension, at each from the edge, from the both of the edge, 1 meter distance we have this catwalks, catwalks where we use, it is not the catwalks, or like it is the catwalks which we normally use it for human intervention.

Suppose the pond is very long. So, you have to have, you have reach to certain portion of the pond, certain portion of the raceway. So, then we have this kind of catwalk so where and this dotted one is the access door. You open the door you go to the catwalk, in the catwalk if you go, if you from there in the bottom 3 in the sorry in the 3 catwalks, which is present in the middle, they are having those bottom feeders they are incorporated with the bottom feeder. Also, they are attached to the airlift support. But at the end, the last and the first, they have they do have only the catwalks and all. They have only the regular catwalks and all.

If you see the middle portion, this in the middle where you have this blue lining, this is actually the air, this is actually also the this bottom pipes which are available you see this colour with the late with the light blue, with the light blue you can see this PVC, this pipes are available which this continuous systems where you can see this, the this arrow sign which you see in the arrow sign, is like the spray nozzle, you can see from in the middle the spray nozzles are also you can see from there they actually the aeration is provided, the air diffusers are there. So, this air diffusers are providing the aeration to the system, you can see the pipeline, you can see the grey line.

This grey line is the 5 centimetre PVC pipe, it is should be PVC or in general I think orbital. So, this PVC pipes so where in general the V sign is actually the one where, there are like valves are present. So, in order to redirect the flow of water to the systems. So, when we design our raceway, we design it this way. So, this is a very standard practice of designing raceway. So, to have a water current, continuous water current and in a certain direction which will this if you see there is like screened pump intake. So, at the left chamber, from this pump intake we take the raw water into the reservoir, and from reservoir and the raw water is coming to the this treatment units.

So, from in the treatment units if you can see there is like 2 HP pump which is supplying it to the this foam fractionator, and also it is going to the settling tank, and we use this treatment to go for this evaporation tank and all at the end, and then water is again after the oxidation is

happening, after the treatment is done. Then water is again to the Venturi injector, and through the normal line it is going to the going back to the pond again. And some portion of it also we take out depending upon the treatment requirement and all. Sometimes what we do we add some additional biofilters and all also. So, it requires it depending, biofilters are actually for the smaller size raceway, for bigger size raceways we do not need the biofilter essentially, it depends.

Everything that I am saying here it all depends on the design and specific requirement of your farm. So, this is actually a one standard diagram, one standard design or like the top view of the how it should look like, this raceway of this around 40 cubic meter of volume, how it should look like. So, I hope you have a better have a very, like good understanding about the system right now. Like how it should look like?

And you can see this airlift pump which are present in this airlift support after each catwalk, those are actually pushing the water forwards and this actually helping the water to make a continuous flow. So, that has other use as well. So, in general it makes this water flow possible in this kind of systems and the air supplies are there to provide the additional amount of aeration through the nozzle and through diffused aeration systems in this particular.

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So, what are the type of raceways? In general, we have linear, we have tank raceway, and we have mixed-cell raceway. In case of linear raceway, it has a separate inlet and outlet. So, made of either concrete blocks, earthen channels with a trapezoidal or parabolic cross section, it should have a bottom grid of at least 0.5 feet for per 100 feet. The length of this raceways are determined based on the site topography and along with the need of the reaeration or not.

The width is determined on the basis of the available water supply, operation or maintenance needs, and the available harvesting equipment available with us, or available in the market in our nearby vicinity. Based on that, we go for linear channels, this is the easiest one, this is the easiest one to build that you can do.

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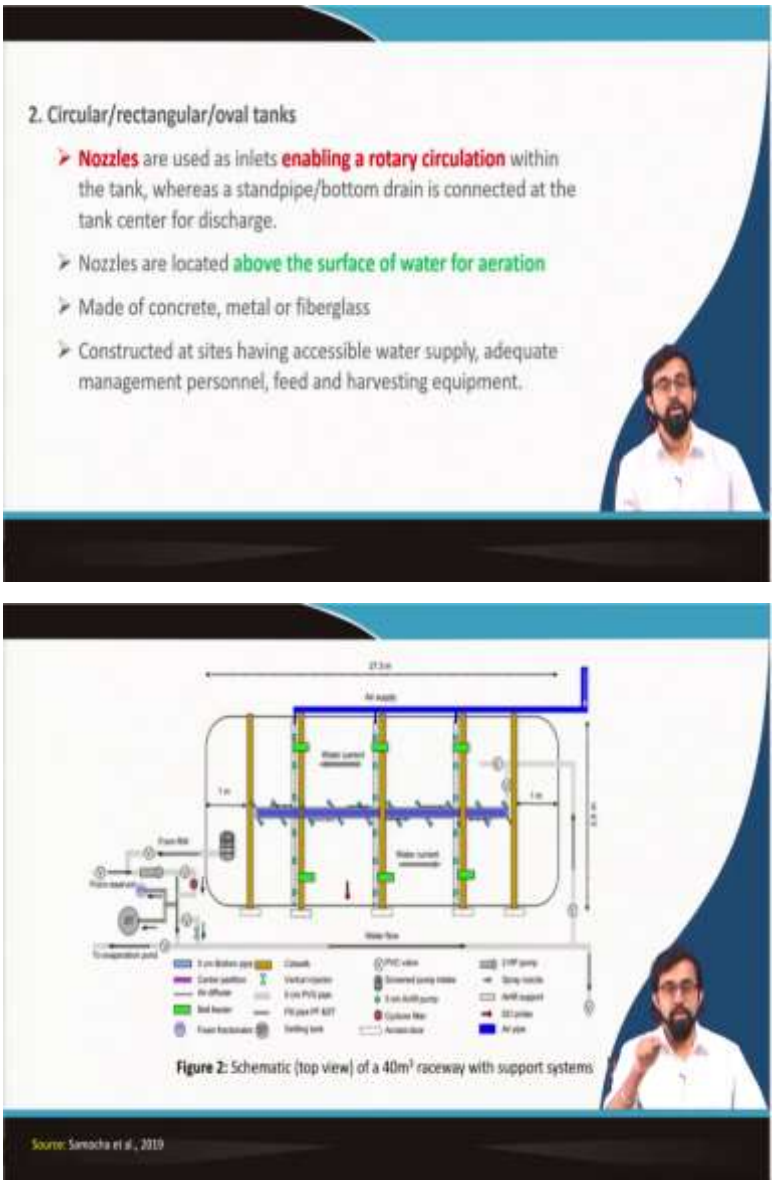

Second is the circular, rectangular, or the oval tank. The nozzles are used as inlet to enabling the rotary circulation. So, nozzles are not only providing the water, it provides the water in jet motion so, what will happen? It makes the initial flow, and which makes within the tanks and whereas the standpipe and the bottom drain is connected at the tank centre for discharge. So, in general, in circular rectangular oval tanks what will happen? We provide the water with the nozzle, and the water will come out of the system, and if the nozzles are located above the

surface of the water for aeration, and it will make a continuous flow, it makes the continuous flow possible.

If you see the earlier design also, if you see in this design also the nozzles are placed in a very certain angular way. So, it will make the water current possible. So, the in this kind of rectangular tanks and all. In general and also the I told you it is above the surface of the water. So, because the water when we come from the above the surface, so it will once it will come as a jet, it will also add the aeration, it will make a small splashing thing, and because of the splash, because of this splashing thingy what will happen? The specific surface area it is increased, more amount of air can diffuse into the water body. So, it is made up of concrete metal or the fiberglass in general. It is constructed at a sites having accessible water supply, adequate management of personnel feed and harvesting equipment.

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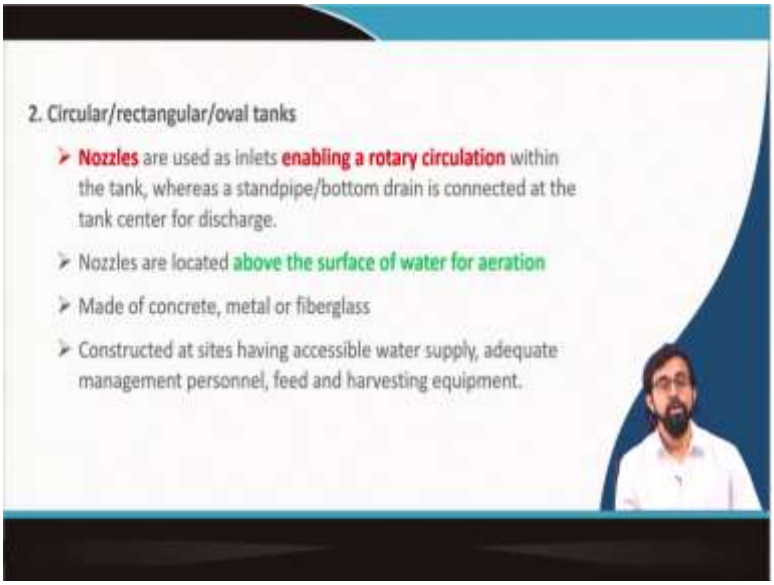

The major one, which is developed this the mixed-cell raceways, MCR, which is developed by, which was developed by Watten et al. in 2000. So, what they did? It is a mixture of structural, it is a mixture of linear channel raceways and the circular tanks within a single vessel.

It fascinated the rapid solid removal, maintenance of uniform water quality, easier maintenance and husbandry, it is like possible here. Presence of vertical jet port manifolds the MCR, converts into the linear raceways, into a series of adjacent mixed-cells, each having the hydraulically independent flow region, I discussed with you in earlier slides also. This MCRs are the one which have this hydraulically independent flow region. Because of that they are not related to other raceways which are present in its neighbouring, or in its vicinity or its adjacent

to each other. And because of that, it can attain the self-cleaning velocity as well, if it depending upon our design and all.

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You can see this is the bottom centre drain, it forces the each cell to act as an individual circular tank, and from this discharge port, or discharge jet port, or the discharge manifolds, we call it. It presents the along with the sidewalls of them MCR, on the far left, or the single sided manifold composed of 5 nozzles directed across the width of the raceway, which this middle and the far right picture actually shows the double sided manifold, composed of see 10 number of nozzles in both of the sides. So, it will give directed tangential to the this, towards the raceway wall. So, this is also one type of, this is also type of structure in MCRs we normally witness.

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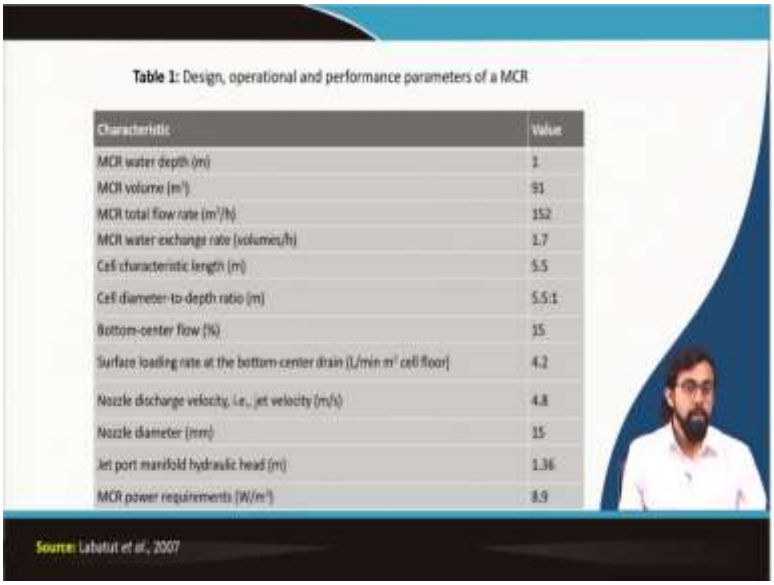

So, in general, let me give you a very brief overview of the design operation and the performance parameters related to the design of this MCRs. So, in general, this particular data is taken from the Labatut et al., 2007. It you see the paper, in the research report they have nicely designed a MCR system, and they have mentioned what can be the standard water depth in MCR? What kind of the standard volume? As you can see from the value given here, the 1 meter is a standard MCR water depth, the volume can have when to have a volume of say like 91 cubic meter, with a flow rate of around 152 cubic meter per hour, water exchange rate is also there like 1.7, the cell characteristics length is 5.5 meter, cell diameter to depth ratio 5.5 to 1.

So, these are the different parameters, which we need to focus on when we will be designing an MCR. So, the power requirement if you see almost 8.9 watt per meter cube of water treatment. So, 8.9 watt per meter, I am giving a simple idea, per meter cube means 1000 litre, so, for 1000 litre of treatment you need to have a 8.9 watt of power is required, only 8.9 watt. In general the BTU unit, or in normally the normal like the household units that we calculate for electricity for 1 unit, it is actually 1 kilowatt hour. So, suppose these MCRs are working for like 1 hour a day or something.

So, I am just giving just example. So, 1 hour, so, 1 hour per in 1 hour in MCR unit is taking like 8.9 watt per meter cube. So, in general it is taking like 8.9 watt hour for treatment of 1000 litre of wastewater, so 8.9 watt hour is almost nothing, if it was for like, another 100 hour like continuously for 100 hour, then it will take 8.9 into 100. So, this is much 890 watt hour. So, still 890 watt hour is nothing compared to like 1 kilowatt, or it is like 1 unit it will take after

running for 100 hour. So, just giving you one brief idea about how these calculations take place and all.

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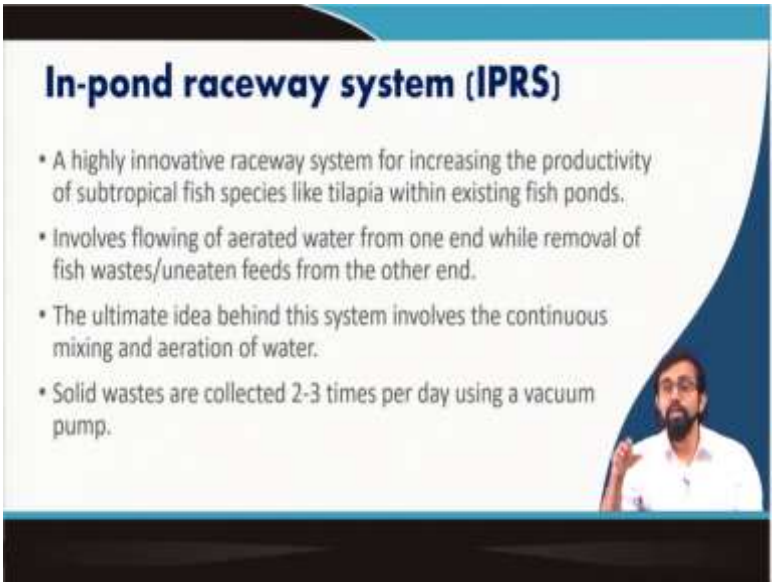

So, in-pond raceway systems, and the another one is the in-pond raceway systems, as I discussed the raceway systems when we incorporate in the pond itself, it is called the in-pond raceway systems, IPRS which are very recent and very highly innovative technologies, which are normally used nowadays all over the world.

So, in the pond itself, we have this nozzle systems, we have this water circulation units by which we provide a continuous water flow. So, it is like raceway in a pond, in a big pond. This highly innovative raceway systems for increasing the productivity of subtropical fish species like Tilapia, within the existing fish ponds are very much famous nowadays.

It involves the flowing of aerated water from one end, while removal of fish waste and uneaten food from the other end. The ultimate idea behind this system involves the continuous mixing and the aeration of water, the solid waste are collected 2 to 3 times per day using a vacuum pump.

So, at the end of the raceway, we have the installation, so, from that installations we can suck the water through it and or we can utilize some depending upon the design, we can go for this vortex collectors and all these things, by which we can easily collect the solids that is getting deposited at the end of the raceway with time.

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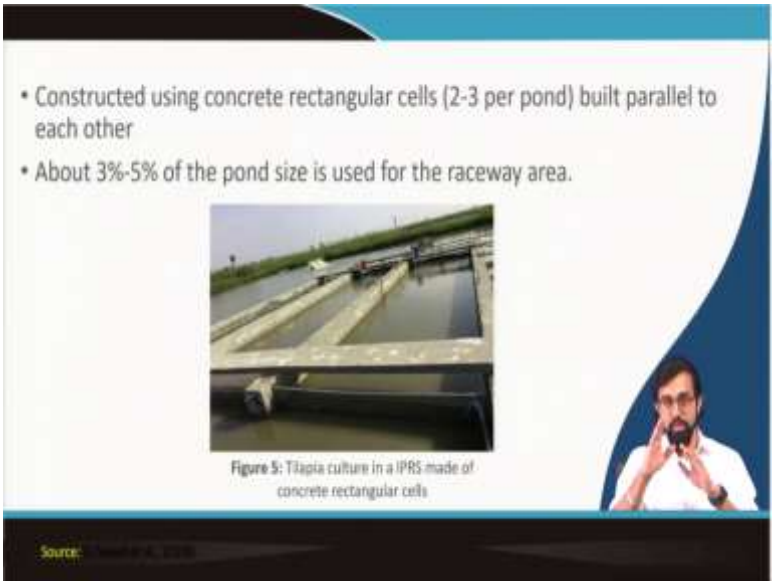

So, this is the in-pond, see this is one example of in-pond raceway systems. And so in general it is constructed using the concrete rectangular cells, like 2 to 3 per pond, and it is built parallel to each other. About 3 to 5 percent of the pond size is used for the raceway area. So, it is not more than that, in general if you have a say like 100 hectare of pond size, so you will only use like around 5 hectare of area for the raceway, this kind of raceway design. You can go for Tilapia and all these cultures.

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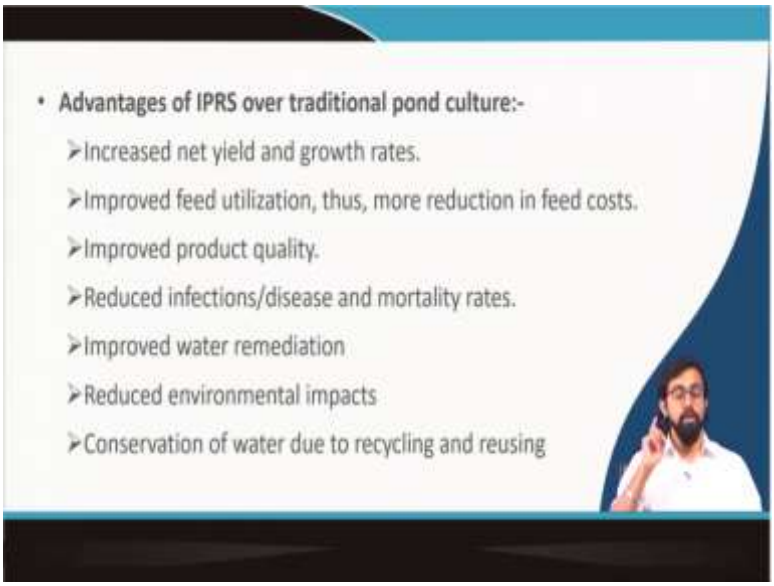

So, what is the difference between this IPRS over the traditional pond culture? It can increase the net yield and the growth rate, because see, flow through system, advanced systems it is a it has a very high amount of water circulation, because of that, it can give you more amount of

dissolved oxygen, which can help sustaining more amount of fishes, that means the stocking density can be improved, fish quality can be improved, because it is giving this exercise thingy, and also it can provide the ample amount of it just enough feed for their survival, the proper feed conversion ratio can be achieved.

Overall, it can increase the net yield and the growth rate of the fish itself, it can improve the fish utilization, more reduction in the feed, feed utilization it can like proper optimum utilization as I mentioned, it can improve the product quality, it can reduce the infection disease or the mortality rates, it can improve the water remediation as I already discussed, it can reduce the environmental impact because the water saving can be taking place. It can help us like to treat the water optimally. So, that the at the end of the water, at the end of treatment, the water can be recycled back down even if it is not, then it can be supplied to the it can be throwback to the surface water body without damaging the surrounding ecosystems. The conservation of water due to recycling and reusings.

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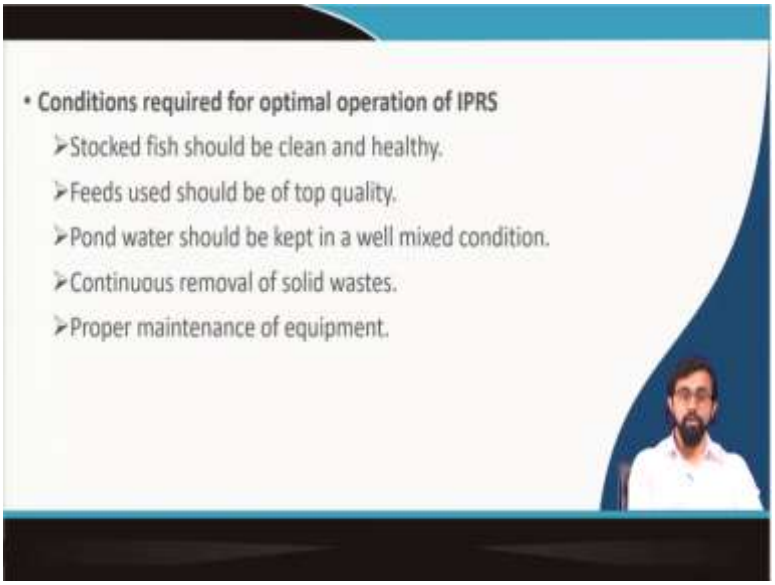

However, there are conditions required for optimal operational of IPRS. Stockfish should be clean and healthy, feed should be top quality, as I already discussed, the pond water should be kept always in a well-mixed condition, continuous removal of solid waste has to take place, or you have to make sure management of solid waste, the solid waste does not show any nuisance to the system, does not affect the system's quality and all. And the proper, the conditioning on the equipments that it has to be maintained.

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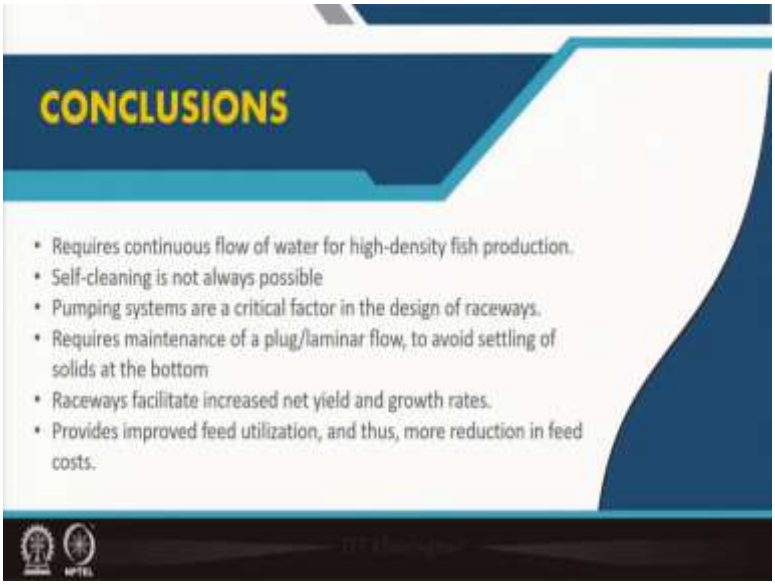

So, in general, it is though self-cleaning is not always possible, but as we discussed, there are possibilities of making it in such a way that these kind of techniques can be self-cleaned. It requires a continuous flow of water for high density fish production, it can raceways can facilitate the increase net yield and growth rate. It improves the feed utilization, thus more reduction in the feed cost.

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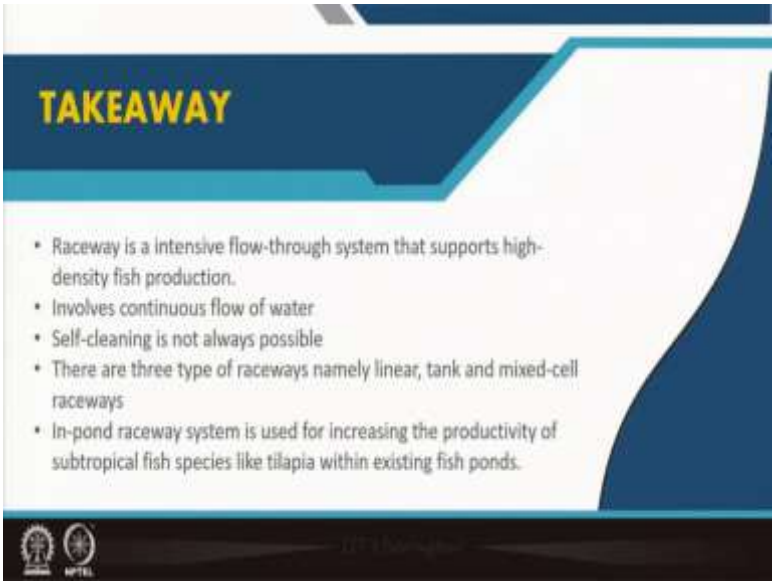

So, what will be the takeaway message for this lecture? So, the takeaway message which involves in this lecture is like the fish culture that it involves, so which like the advance level of intensive aquaculture systems, we can go ahead with this kind of raceway culture. And in

the next module, we will discuss more like this kind of advanced aquaculture technology. So, thank you so much for listening and have a good day.