Advanced Aquaculture Technology
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Lecture 32
Aeration

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Hello, everyone, welcome to the second lecture of Module 7 of the subject Adverse Aquaculture Technology. My name is Professor Gaurav Dhar Bhowmick. I am from the Department of Agriculture and Food engineering department of IIT Kharagpur.

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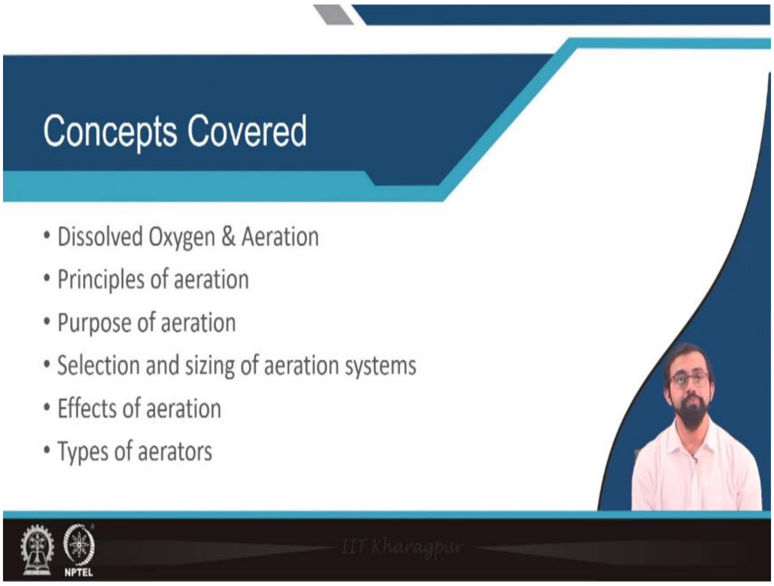

So, in this particular lecture material, the concepts that I will be covering on the dissolved oxygen and the aerational requirement and different principles of aeration, the purpose of aeration in aquaculture systems, selection and sizing are different type of aeration systems, and their affects, and what are the types of aerators.

I will be continuing this lecture with the follow up lecture materials as well, with the same topic to discuss more about the aeration systems and to solve some numericals which are very much important and when you will be designing your farm, and especially when we will be discussing about the requirement of air, requirement of aeration in particular, and what are the type of aerators that you need and what type of aeration systems that you need to provide it with what capacity. Okay!

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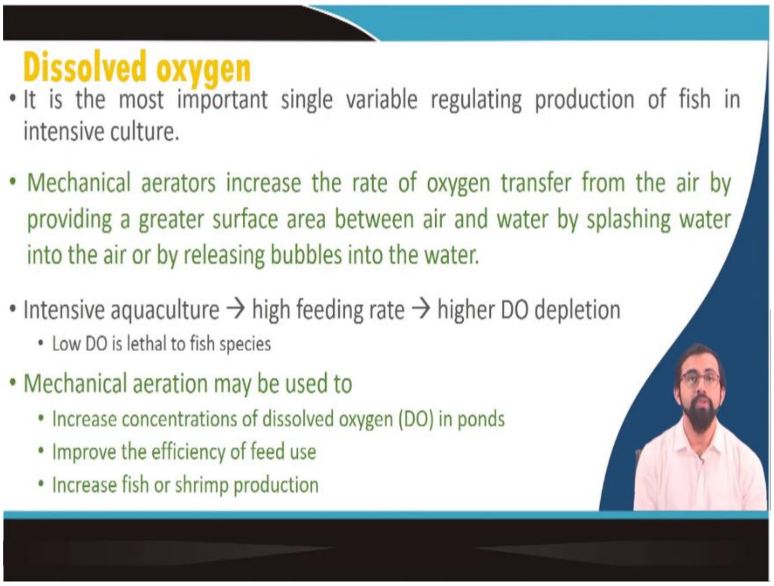

So, in general, you know that the dissolved oxygen is one of the most important variable in terms of aquaculture because this is the one of the main living index, you know for all the living organisms living aquatic organisms present in your plant or in your farm or in natural water bodies and all So, this dissolved oxygen it cannot be replenished naturally in a upto after a certain limit.

So, by means of that I I mean to say suppose in general when natural diffusion occurs oxygen from the atmosphere, it can be easily diffused to the water bodies, but it has one threshold limit, when we go for semi intensive or intensive aquaculture systems, we need we need huge amount of oxygen that needs to be supplied in higher rate also and that cannot be done naturally. Because of that reason, we sometimes provided with some mechanical aerators.

So, these mechanical aerators what they do, they simply supply the additional amount of, the surplus amount of oxygen in the dissolved oxygen form that it requires for the aquatic species to survive. So, in general, this mechanical aerator, it increases the rate of oxygen transfer from the air by providing the greater specific surface area between the air and the water by splashing the water into the air or by releasing the bubbles into the air.

What happens when it is like the other way around either you splash the water into the air, so, because of that, what happened, the water bubble, the size of the water bubble will go down and because of that, it will get enough surface area, at least it will compared to the normal water body, whatever the surface area it has, if you splash it, it will be in the air. So, the surface area will be much bigger higher. Because of that it will get more air to water interface.

And when they say air to water interface will be maximized will be somehow we can enhance the oxygen diffusion rate also we enhance. So, by using this phenomena, we normally use it in the surface aerators. There are some type of submersible aerators where we what we do we some provide the aeration from the bottom of the water body and water surface. We supplied with the air simply air in a bubble form.

So, what will happen the air which is in a bubble form when it will go out of the water surface and reach to the atmosphere during this duration like whatever the duration that it will cover and the space that it will cover in that region what happened the oxygen that it has this air because you know like almost 20.9 percent of the air is actually there in oxygen. So, this oxygen will easily get transferred to the water body.

So, by this means, we can increase the dissolved oxygen concentration. So, this is another way of transferring oxygen to the or I would say like increasing or enhancing the water oxygen transfer rate in water bodies. And the discussion in the beginning only I say it like intensive aquaculture is one of the major reason because intensive aquaculture comes with a very high feeding rate and also very high amount of stocking density and it cause a higher amount of dissolved oxygen depletion or DO depletion in short we call.

And which is very much lethal to your aquatic species any kind of aquatic species which you are rearing in your system or in your farm. So, that’s why we supply it with the mechanical aeration and it not only increase the concentration of dissolved oxygen, but also it improves the efficiency of the feed use and also it improves the fish and shrimp production in general.

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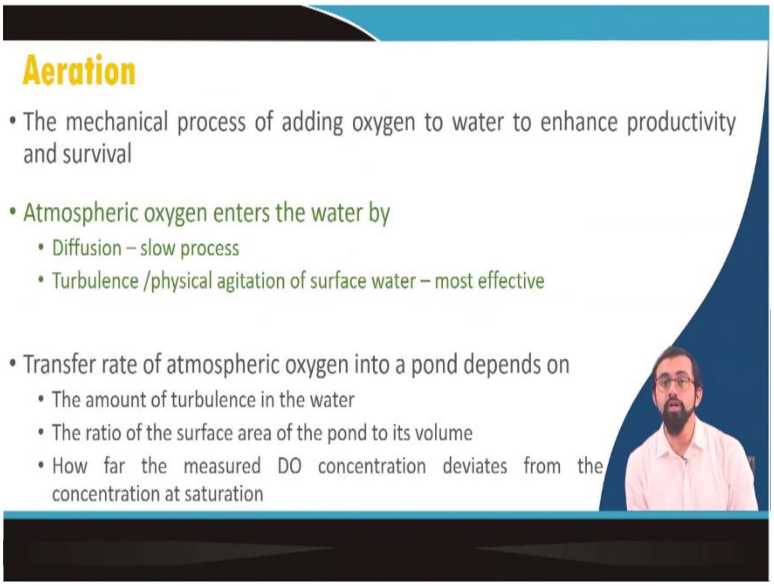

Atmospheric oxygen enters into the water by two means Okay! in general, first by diffusion, which is natural that I already discussed. And natural diffusion that I am talking about in this case, so which is a slow process. And the most effective one is like when we provide it with a turbulence and or the any physical agitation in the water surface or the or we supplied with the air bubble in the water.

So, this is the most effective way of supplying oxygen to the water. This transfer rate from the atmospheric oxygen into the pond, it depends on the amount of turbulence that we can create and also the ratio of surface area of the pond to its volume. This surface area you can enhanced by doing this turbulence by doing this surface agitation and all and also providing with the aerational amount of bubble. That should be our motto.

Somehow, we need to increase the surface area, this ratio of surface area to volume for a pond. So, that maximum amount of air-water interface can be utilized for dissolved oxygen enrichment. Okay! And second thing it also depends on the how far the measured DO concentration deviates from the concentration of the saturation. What do I mean by the concentration of saturation?

In say I am giving you one very general example I think it is better for you to remember this fact also that suppose at 20 degrees Celsius temperature at standard atmospheric pressure any water body if it does have around 9.07 to 9.09 milligram per liter of dissolved oxygen present in it. So, we can call it a saturated, it is already saturated with dissolved oxygen, saturated with oxygen the water body.

So, this value can drastically go up and down depending upon the temperature as you know, if temperature increase the oxygen diffusibility will decrease. Any air diffusibility will decrease because it depends upon the temperature, it's like the same, if you remember, I already gave this example of boiling water, when we boil the water the air bubble is coming out that means it is getting like kind of desaturated with the air any air content. And all

So, by this means we can reduce the dissolved oxygen concentration when the temperature is increasing and thus the vice versa the same the other way around, when we decrease the temperature the diffusibility will increase. So, it not only that it also depends on the altitude, it depends upon the pressure atmospheric pressure.

So, all these phenomena taken into, if you like considering all these phenomena, and this standard number I am giving you, at standard temperature and pressure say like at 20 degrees Celsius at standard atmospheric pressure 9.07 milligram per liter or 9.07 PPM parts per million is the standard value of the saturated oxygen concentration in water. Okay! So, this value and say like in a pond in a certain situation the pond has say like 3 PPM of dissolved oxygen and another pond has 6 PPM of dissolved oxygen.

So, which case do you think this oxygen diffusibility will be much higher? Definitely in the case when the deviation is much higher. What do I mean by the deviation? Deviation between the saturation concentration and the actual measured concentration, DO concentration. So, in the first case, if you remember the example that I have given from 9.07 milligram per liter to 3.3 milligram per liter,this this value is much higher, this dissolved oxygen deficit.

This value is much higher than 9.07 minus 6, because of that, in the first case, the diffusibility will be much higher and oxygen oxygen dissolved oxygen diffusion rate will be much higher from the atmosphere. So, this is the these are the all the depending criteria that the criteria on which the dissolved oxygen concentration, this transfer rate is actually depends on.

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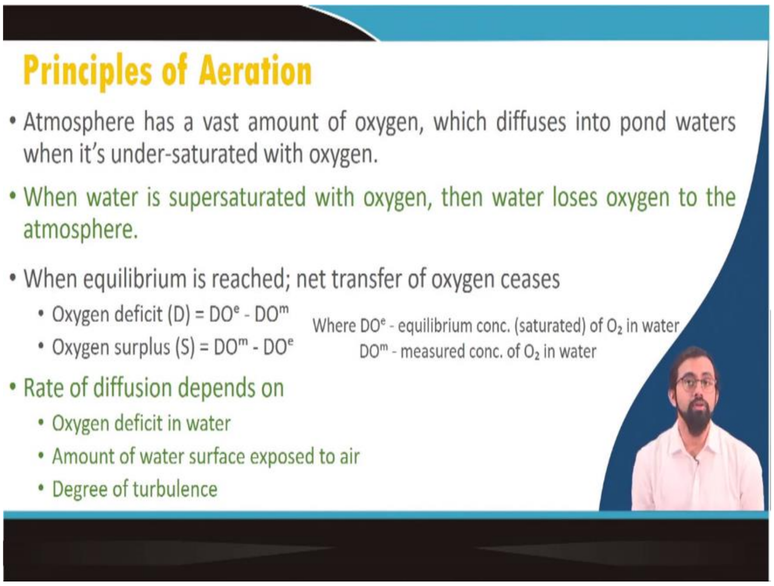

So, further to discuss about the principles of aeration which is very important for you to know. In general,the you know atmosphere has like vast amount of oxygen right. So, in general the maximum in the atmospheric air the nitrogen is at maximum then the oxygen almost 20.9 percent in standard condition right? Which diffuses diffuses into the pond bottom by any pond water or any surface water bodies in the under normal saturation condition of a normal diffusion rate condition. Okay!

But when the water is super saturated with oxygen, this water can lose oxygen as well, Okay! it is like other way around. When water has suppose oxygen concentration at 20 degrees Celsius more than 9.07 PPM say like 11 or 12 PPM that means, at that particular time and um that particular time and temperature that water is super saturated with oxygen. Okay! So, what will happen in this particular in this case, the oxygen will diffuse back to the air when any medium any liquid medium is supersaturated with a particular gas it will difffuse back to its natural prevailing zone.

So, normally it will go to the air, again it will diffuse back to the air. Okay! And when this equilibrium is reached the net transfer of oxygen completely ceases. Okay!So, how we can calculate? When I will ask you about the oxygen deficit, when we are discussing about the oxygen deficit it means the dissolved oxygen in equilibrium condition minus the dissolved oxygen in measured concentration like whatever the measured concentration of the DO in water at that particular moment of time.

Oxygen surplus it happens when supersaturation events happen, Okay! supersaturation type of event happened. In that case this DO surplus this oxygen surplus you can easily calculate by subtracting the DO equilibrium from the DO measured DO concentration.right And this rate of diffusion actually as we already discussed it will depend upon the degree of turbulence, amount of water surface exposed to air and the oxygen deficit in the water body. Okay!

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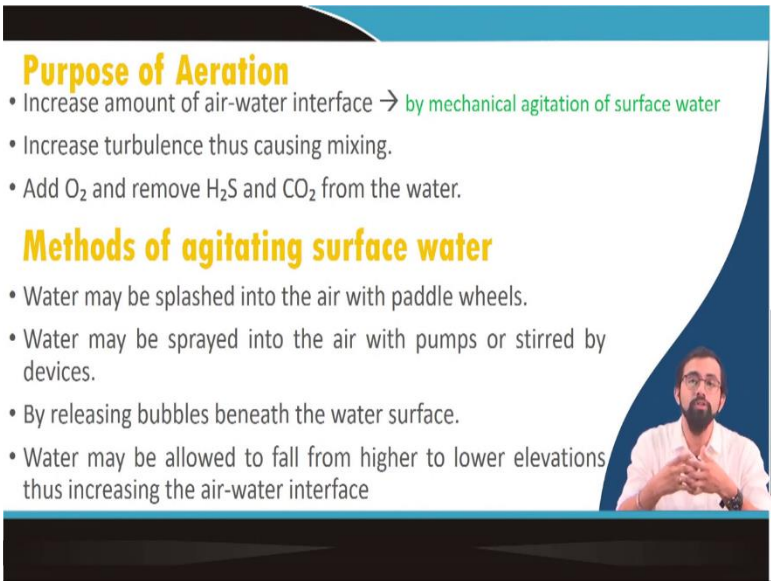

So, why we you can understand, why we need to go for this aeration, why do we need aeration in general or we need to provide the system our farm with the different types of aerators in general. First of all, to increase the air to water interface. Second thing, to increase the turbulence thus causing the proper mixing. Okay! Because sometimes what happened suppose you are only providing a very minor turbulence in a certain very limited space of your tank or very limited space of your surface water body.

So, what will happen, oxygen will definitely, the oxygen depletion rate will increase, Okay! the oxygen transfer rate from atmospheric oxygen to dissolved oxygen will increase, but it will be limited to that particular zone. How we can increase it further? If you can create a proper turbulence all around the water body then only you can you can homogeneously distribute the oxygen deficit and you are provided with the dissolved oxygen coming out from the atmosphere which is like which we are transferring from the atmosphere all around your pond or all around your tank or the water body that you are targeting.

So, this turbulence is very important. You need to create this turbulence properly. And third most important thing is to get rid of some some unwanted or like some gases like specifically if I talk about carbon dioxide, H_2S, these are the gases which are not expected to be there in your pond because that can be harmful in the long run and that can be even lethal you know if it is present in water body for a long period of time for your aquatic species.

So, what are the ways by which we can create this turbulence or agitate the surface water? First thing what we can do we can splash the water into air. So, this system when we this kind of system when we utilize we call this type of aerators paddle wheels, we have like you know specific fins the paddle wheels, they will keep on rotating they have like say like 10 or 12, 16 paddles with it like so, it will the fin it with it. So, that fin will splash into the water and it will create a very small bubbles into the air, Okay! it will spray small bubbles into the air.

Second thing water can directly be sprayed into the air with the pump you can simply use a proper pump and you can simply throw the water in a atmosphere in a at a certain altitude. And from that altitude because of through the gravitational action it will fall into the surface of the water body only and it will create two things first the water is sprayed into the air that is one thing and second thing it will splash when it will get back to the surface of any water body. So, these two means are actually working here.

Third thing we can release the bubbles beneath the water surface, you can simply supplied with air bubbles far beneath the water body and like it depends upon the size and the capacity of your compressor air compressor that you are using or the pump that you are using. Water may be allowed to fall from a very high altitude. So, what will happen, from a higher elevation to lower elevation when it will fall it will increase the air to water interface.

This phenomenon is happening naturally in most of the water body, surface water bodies. You know One famous example is any waterfalls, any waterfalls how they replenish the dissolved oxygen concentration. They replenish by means of having this small waterfalls in a different area, we call it hydraulic jump event or some subcritical to super critical event and vice versa. When these kind of events are happening, so, water will get, the surface water body will get huge amount of dissolved oxygen, it can easily replenish this DO deficit in its body.

So, this is the way of doing, this is the natural way of improvising the you know dissolved oxygen concentration in natural water bodies. So, we can also mimic these kinds of systems. You may have heard about the type of aerator, cascade aerator, in a cascade air what we do we simply pump the water and have higher elevation then we have a circular stair like structure, so one after another.

So, what will happen it will fall from the center and it will from other all the other sites, you know like a small waterfalls. And it will create a nappy flow this particular flow that we call nappy flow because of that is the first, because of this nappy flow and this water splashing that happens at each stage or each stair it will increase the dissolved oxygen concentration like anything. So, that is a very standard way and that is a very age-old practice in this any for increasing the dissolved oxygen concentration in the water. Okay

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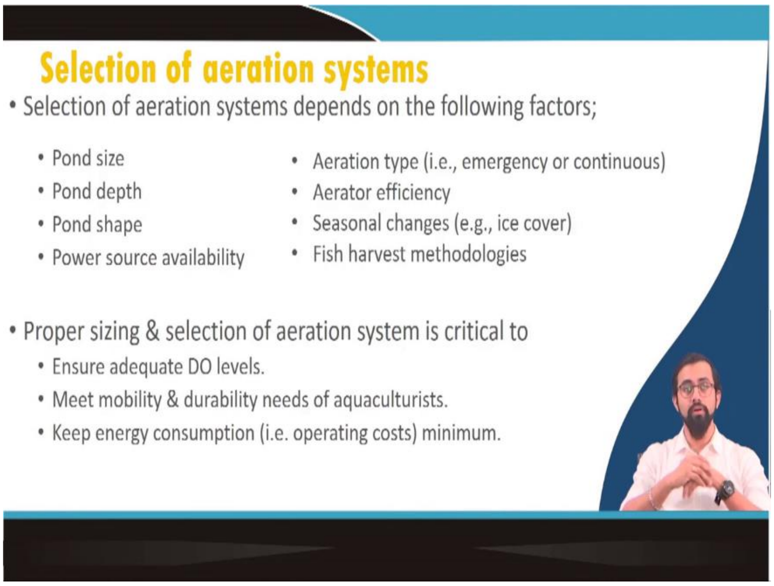

So, now we know what is the purpose of doing the aeration. Now, we know what are the fundamentals that we can utilize in this to increasing the dissolved oxygen concentration. So, now, if I ask you like Okay, so you have a farm, you are going to design a aquaculture farm or say like in any farm, so in farm where the water bodies involved. Whenever any farm where water body is involved and you are culturing any aquatic species there you have to supply it with oxygen. Okay

Unless or until you are working on some anoxic microorganisms. And all There are some anoxic microorganisms and anaerobes are there. So, which are normally microbes like different kinds of bacteria. So, they when you are culturing, just to give you an example, like suppose you are working on denitrifies, different kinds of denitrifies. And all So, these denitrifies, they do not need oxygen for their survival.

So, in this particular case only you do not supply them with any kind of oxygen. So, in that case, it is better to maintain the dissolved oxygen level below than 1 or almost 0, it will be better to have as low as possible. Okay Other than that particular case, any other cases whenever you will be culturing any aquatic species. Especially any living organisms, which do the aerobic respiration process, you need to provide it with the oxygen.

So, what are the factors that it depends on? First of all, the size of your farm, like or the water body, their depth, shape, the power source availability that you can somehow manage to have it in your farm. What are the type of aeration that you are supplying it? Is it a continuous system? Is it only for the emergency basis? What is the efficiency that you are expecting, I mean, like aerator efficiency?

We will discuss more about it how to calculate this aerator efficiency in later slides or even in later lectures as well. What are the seasonal changes that you can expect like ice covers. And all When there is ice covers depending on that you need to maybe redesign or maybe think about the retrofitting of your system. Fish harvest methodology that we will be using, suppose you using, suppose your fish harvest methodology that you are using, it is like a normal size net and all these things.

So, if you are using this kind of net, size nets and all, and all of a sudden in the middle of it, you have this paddle wheel aerator definitely you cannot go ahead with this technology, right with this method. So, while you need to harvest your aquatic species, you what you need to do, you need to simply move or it is a humongous process.

So, you do not need to go for this based on your type of harvesting or based on your harvesting procedure that you will be your targeting, you will have to choose your aeration systems, okay that is very important that people most of the times they forget they just go ahead with the design and all at the end they realized okay, so now how to harvest the fish, how to harvest our aquatic species. okay

So, you have to ensure that you are ready with the backup plan and you are ready with the proper planning or the method or choose your methodology for fish harvesting properly even before the drawing is done before the designing is done. okay Proper sizing and selection of aeration system is critical. What is the reason behind it ?

Because you have to ensure that adequate DO level is present in your water body, it will meet the mobility and durability needs for the aquaculturists you know you have to have proper dikes and all in the middle of it so that the dike also has to have a proper width so that even the aquaculture the aquaculturists or like the farmers can easily go from one place to another. Keep the energy consumptions at as minimum as possible, operating costs. okay

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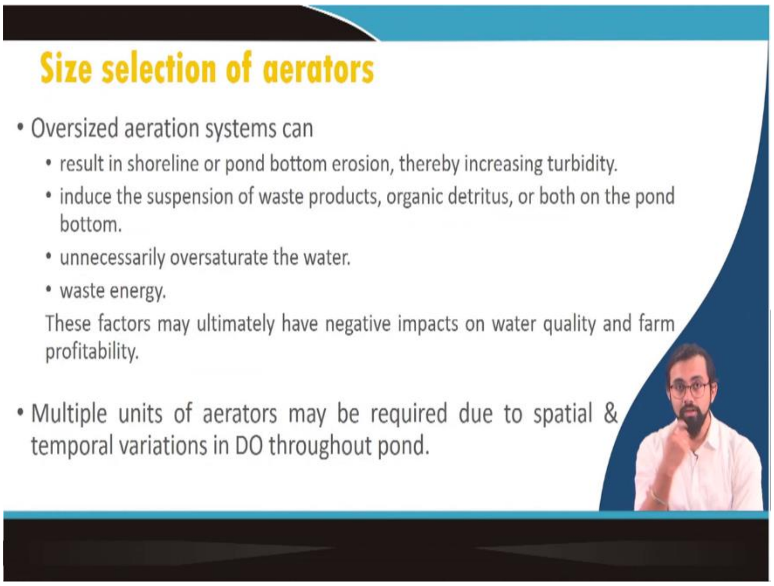

So, that is why people come up with some different fundamentals and all of what will be the design and what can be the type of aerator that can be used. Size selection, definitely oversized aeration systems doesn't make any sense. Why to go for oversized aeration? First of all, it will create a lot of nuisance if you realize.

Suppose you need a certain amount of oxygen certain amount of aeration that needs to be provided in your pond of say, like one hectare area one hectar area, but you are providing like 10 times more aeration you are providing with a 10 times more aeration, it will create enough turbulence to completely erode the pond bottom and it will increase that turbidity in your system in your pond.

When it will increase the turbidity what will happen it will cause a lot of affects lot of unwanted results in your aquatic species like suppose just to give you an example, it can cause the gill irritation for your small species and all. So, that is not acceptable. Second thing is it will induce the suspension of waste products, organic detritus which is there in the benthic region and it is definitely not acceptable as well.

Unnecessarily it will over saturate the water which is nothing but a waste of energy. Because if you are oversaturate the water definitely that oversaturated oxygen will go into the, go into it will definitely transfer to the atmosphere but it does not make sense. Second thing is like multiple unit of aerator it may require in some cases.

But it actually depends on the spatial and temporal variation of DO throughout the pond, but you make sure that the amount of aerators that you actually need is just enough to meet the oxygen requirement. No oversized aerator is acceptable and definitely it is like, if it is not meeting the oxygen demand then definitely is not good as well. okay

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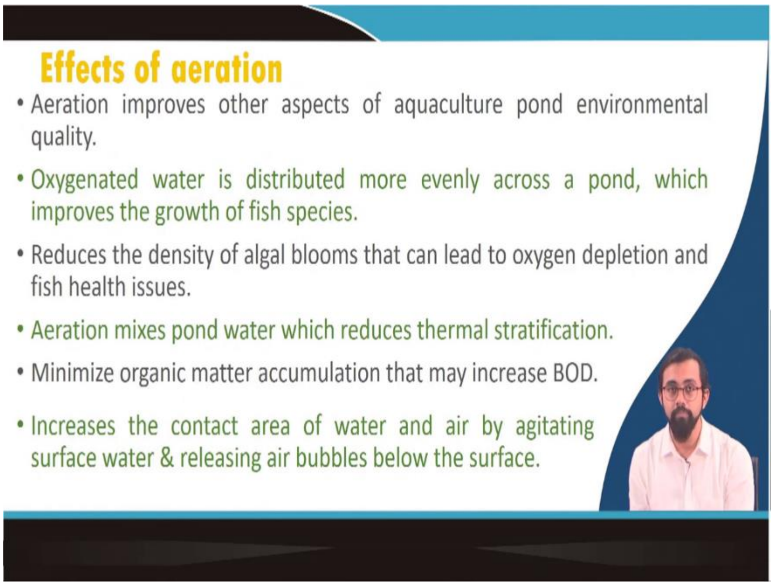

So, what are the effects of aeration? So, first of all aeration it improves the aspect of aquatic pond environment in general and also this oxygenated water is distributed. If it is distributed more evenly across the pond. It can improve the growth of fish species. It can reduce the density of algal blooms that can lead to the oxygen depletion and the fish health issues. Also, this aeration can mix the pond water which reduces thermal stratification.

Why I say thermal stratification? You If you remember in last lecture material I think we discussed about the different apilimnion zones, different limnion zones and all, remember? When in the top, when in the daytime what happened the temperature rises like anything, but even if you go further down like even I am giving you just a simple example even a 10 feet, a 10 feet height of you know, I mean the depth of pond can give you enough the temperature difference of around 10 to 15 degrees Celsius.

Remember we discussed about in last lecture. This change in temperature is not accepted, not accepted for the aquatic species which are dwelling all over it. Okay In general, suppose your culturing species like say Indian major carbs or any normal say silver carbs, carbs and all, common cups and all.

What will happen in that case, they have their specific area of dwelling, some people like to stay in the service which we call them surface feeders, then this columnar feeders and then there is bottom feeders lower the who normally like to have leave by feeding the detritus and all in the from the mythic region. However, suppose you are culturing any particular species, which needs to be which goes up and down, okay which like it is only a specific type of species that we are talking about when we discuss about IMCs and these common carbs.

In general, most of the species they love to go up to a certain height up to come sometimes in bottom sometimes, sometimes in bottom, sometimes in the surface for them, if there is a thermal stratification is happening. So, that's not accepted. What we need to do? This aeration it will mix the water so because of that, the thermal stratification event is not taking place.

So, the temperature will be evenly distributed throughout the pond throughout your tank and because of that, this event can be we can somehow managed to get rid of this even that this summer stratification even which can cause physical stress in your aquatic rearing spaces. It will also minimize the organic matter accumulation that may increase the BOD biological biochemical oxygen demand, if you remember we discussed in a couple of lectures later, in a couple of lectures, like I think 3, 2 or 3 lectures back and it also increases the contact area of air to water by agitating the surface area and it definitely help in increasing the aeration efficiency.

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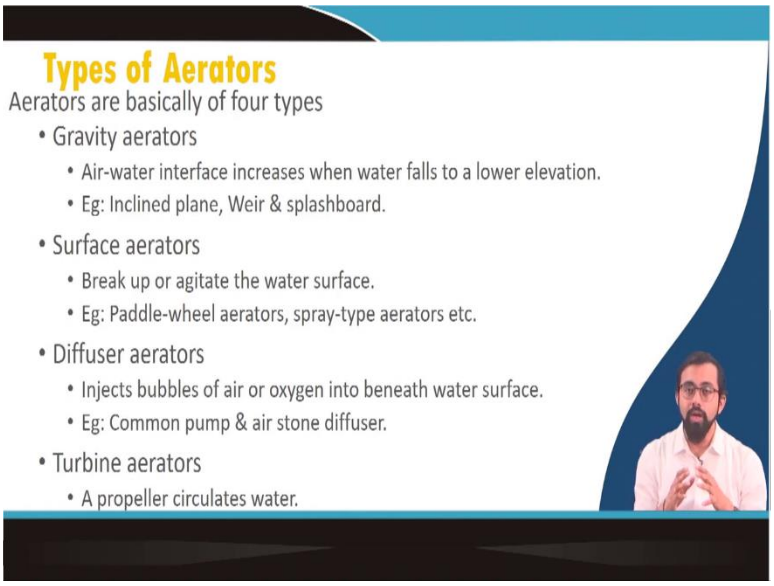

So, now we know the fundamentals, now we know the methods, now we know the requirements of aerator. And all Now, let us discuss about the types of aerator that is already available in the market, already available in the research labs. And just to give you an idea about this different type of aerators, which will definitely let you think like what can be the other options that you can make available just going through a brainstorming by yourself.

The major ones are this gravity aerators, surface aerators, diffuser and the turbine aerators. What does this gravity aerators does? I told you we, this is gravity aerators it normally follows the fundamentals of like kind of splashing the water from a higher altitude. When it does that some higher elevation to lower elevation when the water will keep on coming. What it will do it will increase the aeration efficiency we call them gravity aerators.

One of the example of this gravity aerator is the cascade aerators, I told you the example, right? Cascade aerators they are the one example of this gravity aerators. Different weir and splashboards are normally used in case of gravity aerators for increasing the aeration efficiency. The next type of it next type of aerator is surface aerators which normally break up and agitate the water surface okay like paddle-wheel, spray-type, etcetera.

Then there comes the diffuser aerators it normally injects the bubble of air or oxygen in beneath the water surface normally common pump or air stone diffuser. I think you might have seen in the aquarium, in the aquarium if you see the small diffuser stone we provide. And we provided with this small air pumps.

This air pumps what it does it will provide the air through these diffusers and because of, why we provide the diffusers, we try to break the air in like you know this air molecules as small as possible. So, what it does is small bubbles, the more the small bubbles the more the specific surface area for in between, more the interface between the air water increases. And because of that, it will help in enhancing the dissolved oxygen transfer rate between from atmospheric air to the water body. okay

So, what is the example of these kinds of diffuser aerators? This common pump and air stone diffusers which I you already just now I gave the example of aquarium aquarium diffusers. The fourth type is that turbine aerators. How this turbine aerators works? It actually, say it will have a pump and motor systems which will be there in the above of the surface and there will be a shaft going into the bottom of it or like up to a certain depth.

It will collect the air from the atmosphere and it will there is you know a spiral vein connected with it. So, this spiral vein it will just take the air from the atmosphere it will just supply it into the bottom or the certain depth of water by this means, it will provide the aeration provide the atmospheric air into the bottom of your water body.

This is done and this is normally done by means of, this is actually very standard process for the very high size like how to say like when you have a very big or higher sized pond like say like more than 10 hectares or so, so, in that case you need to have this shiftable like portable turbine aerators they are having it, so along with this wheels and all, so, they go from one place to another and then this aquaculturist they supply aeration from its bank. So, that is how it is done in case of turbine aerators. I will show you in details how it looks like.

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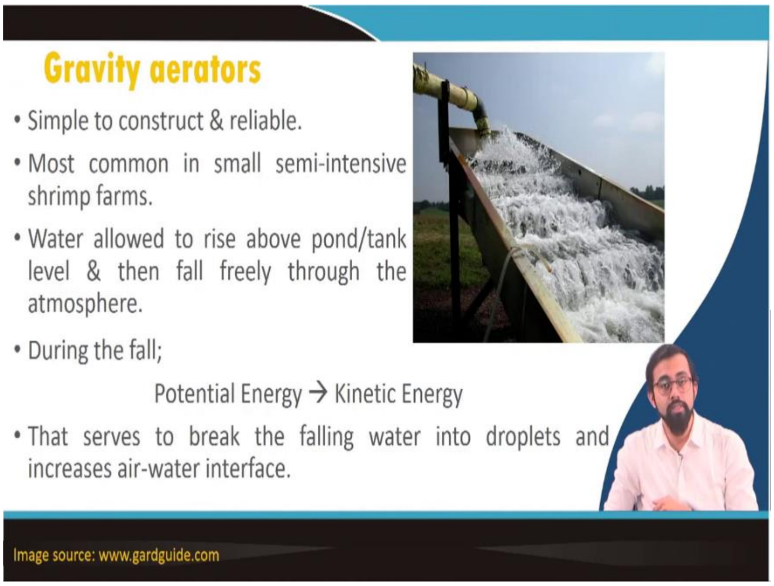

If you see, this is the standard example of this gravity aerators, you see there is like inclined stairs are provided. The stairs are, it is actually very simple and very reliable forces of supplying like increasing the aeration rate for any kind of like you know farming practices. So, it is very much useful in small semi intensive shrimps' farms.

So, this potential energy is simply converted into kinetic energy and that is this is used to in, because of that this falling water which has convert into droplets and it increases the air-water interface and by which it will increase the overall. These are the overall oxygen transport.

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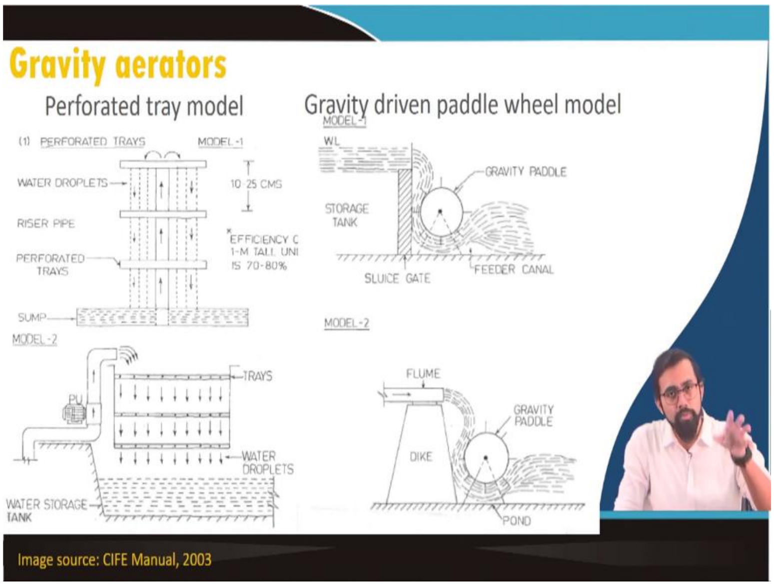

These are some of the example of how this gravity aerators. If you see the first one is perforated tray, from the center we put the water we pump the water up and then water will come through this perforated trays at a certain interval and it will independently increase the aeration efficiency.

The same way the model 1 and model 2 both are actually perforated trays only in the model 2 also, it see that there is a pump unit which will pump the water form at a certain height and then it will throw into the trays, the trays will happen, trays have this particular perforations, zig-zag way it is made so that the water will make a proper splashing into the each tray, it will increase the aeration efficiency and all okay.

So, the same thing you can see this the fundamentals a little bit different in case of gravity driven paddle wheel aerators, the water is pumped out first and then through the flume or through the in the over the storage tank the water is coming into this gravity pedals. The gravity pedals will move because of the action of the water only and it will increase the aeration efficiency. So, these are the examples of gravity aerators.

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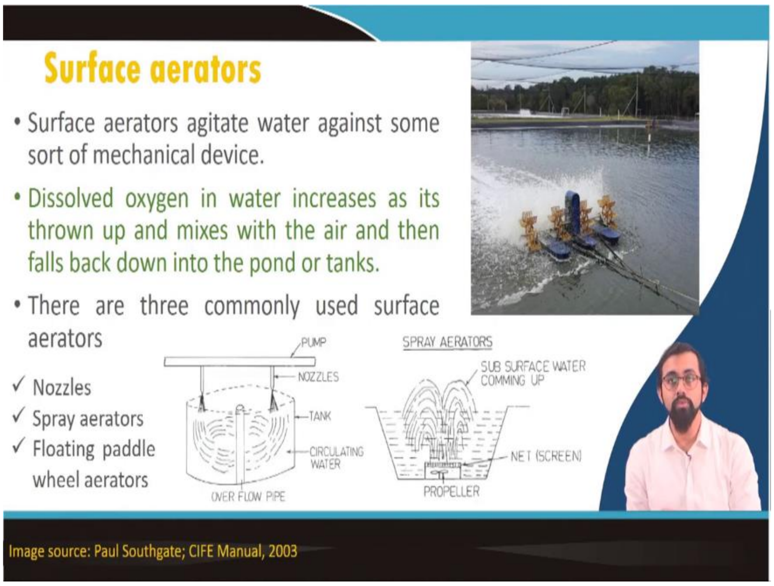

Surface aerators, this I think you have seen in general whoever having their aquaculture aquacultural pond or so, or maybe you have seen in your village area. So, this is the very standard paddle-wheel aerator that we normally use to increase the aeration efficiency. There are other types of surface aerators as well if you see in the bottom the left the figure which is shown in the left side, this is called the nozzle type aerator.

There its normally it has this circular shaped tank and the nozzles are provided at a certain angle. So,it will the the main shaft will keep on moving and it will spray the water from the above and it will increase the aeration efficiency in your system. The same way there is another type which is called spray aerator but in case of spray aerator we use the propeller from certain height below the, say certain couple of centimeters or sometimes a couple of inches below the surface of the water and we splash it.

So, it will go up it looks like a fountain so it will increase the aeration efficiency like anything. So, this is also a standard way of doing it. Not only that, it will also enhance the aesthetic point of view also. Why I am saying that? Because this looks very good, this spray aerators it looks very good, it looks it makes a fountain like structure. So, this can solve the purpose like in both ways, first of all, aesthetically it will improve that particular area and secondly it will increase the aeration efficiency.

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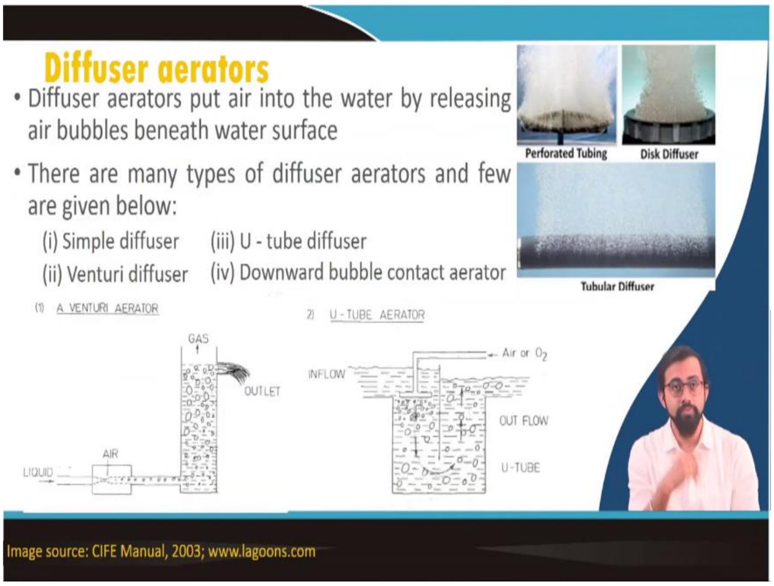

Another type of aerators is the diffuser aerator as I have already mentioned, so one there are the perforated tubing, fixed diffuser, tubular diffuser. I think this is a diffuser you have seen in your aquarium. There are some other type of diffusers as well like U-Tube aerator or like venturi aerator where liquid is normally pumped through a venturi meter where the air is getting in contact contact with water and it will increase the aeration efficiency. So, this venturi aerator is also a very like I decade old process which normally being used in specific purpose, for some specific purpose.

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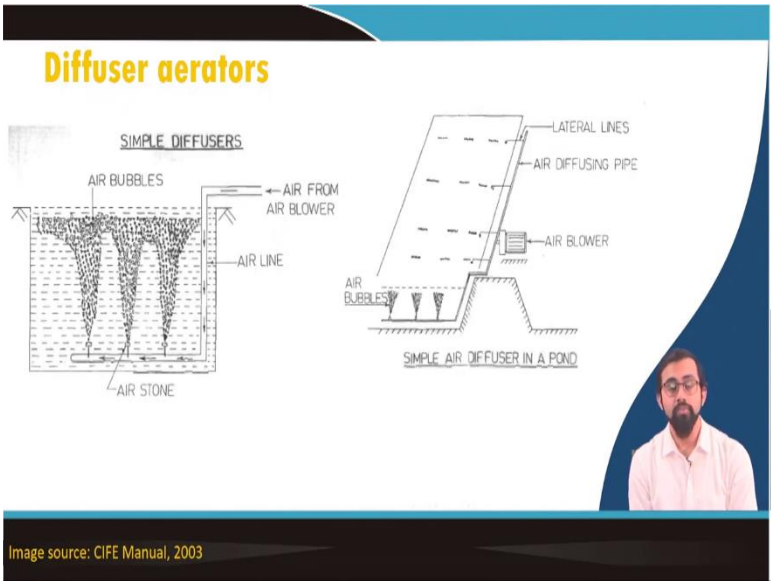

This is a very standard simple diffuser and which is used in the pond.

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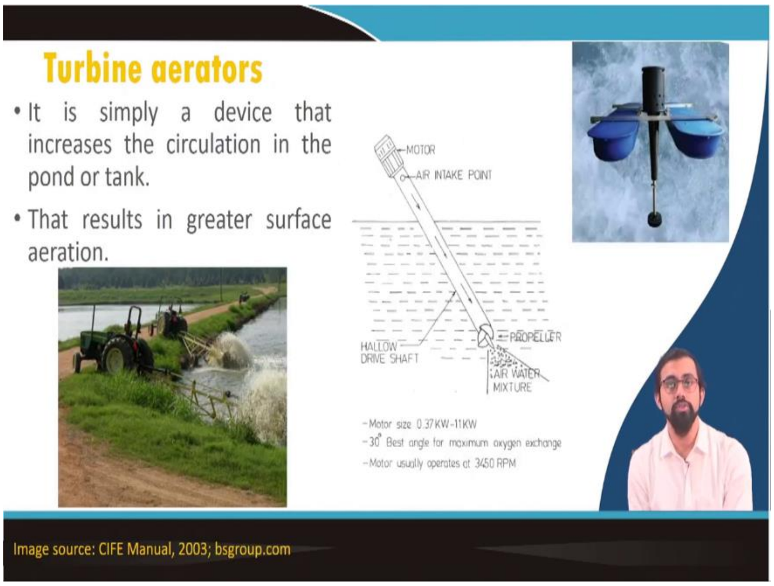

The turbine aerator as I told you see this motor and air intake point and it will go up to a certain height up to a certain depth and this air-water mixture is actually through the propeller, you will get this air-water mixture which will increase the aeration efficiency. You see in the left side the structure mounted turbine aerators are there for you know as I mentioned as I told you.

When you have a very larger area of your pond or larger area of your tank area tanks and all. So, then these kinds of proctor mountain turbine generators are used. So, you can go from one place to another and you just use it for increasing the aeration efficiency in your or increasing the dissolved oxygen rate of your pond.

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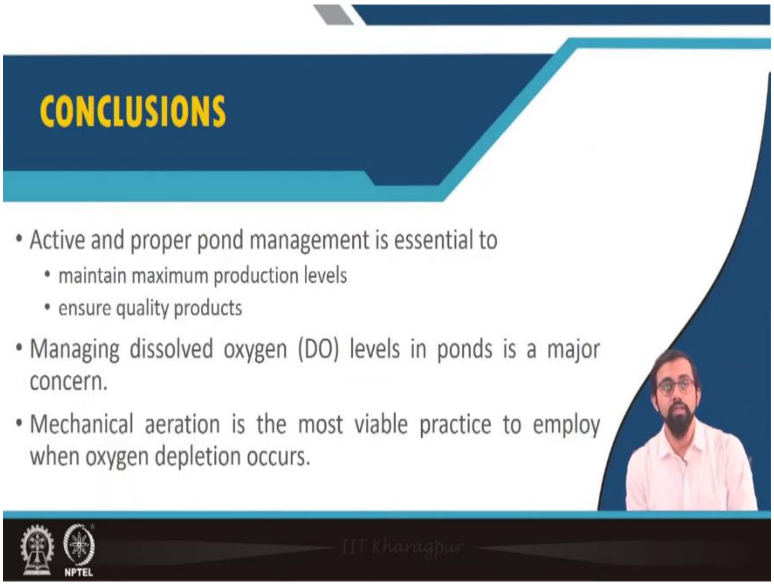

So, we will continue with these aerators in the coming lecture also. So, to give you more idea more knowledge about aerators how it works, what is the fundamentals of aeration, aeration rates and all, we will discuss about some numericals, we will discuss about the equations by which it actually it governs. And so, in general in this particular lecture, we have discussed about the essentiality of active and proper pond management based on aerators and all.

So, which will definitely provide us with the maintaining maximum production level and also ensure the quality products. And it will this managing this DO level in this sense is the major concern for us and the mechanical aeration is the most viable practice to employ the dissolved oxygen concentration in water bodies.

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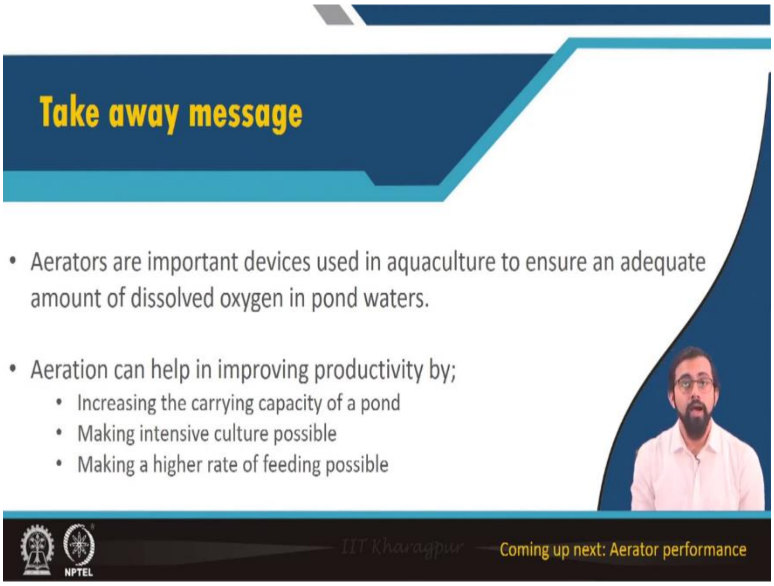

And aerators are the one by which we normally do that and this aeration can help not only not only by providing the enhance productivity, but also by other means, it will give you increase in the carrying capacity of the pond, it will make intensive agriculture practices possible and also it will help us you know when we provide it with the high rate of feeding that is also possible in this particular case.

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So, I will keep on discussing about this aquaculture practices more in details in the coming lecture. So, these are the references from which I have taken some information for this lecture material. So, will definitely continue with aerator in the aerator discussion on this aerator systems in the coming lecture. Till then, thank you.