Advanced Aquaculture Technology
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Lecture - 05
Topic - Conversation Strategies

Hello everyone, my name is Professor Gourav Dhar Bhowmick, I am from Agricultural Food Engineering department of IIT, Kharagpur.

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So, welcome to the last lecture of module 1, which is like conservation strategies that will be discussed from the module one of introduction of aquaculture for the course advanced agricultural technology.

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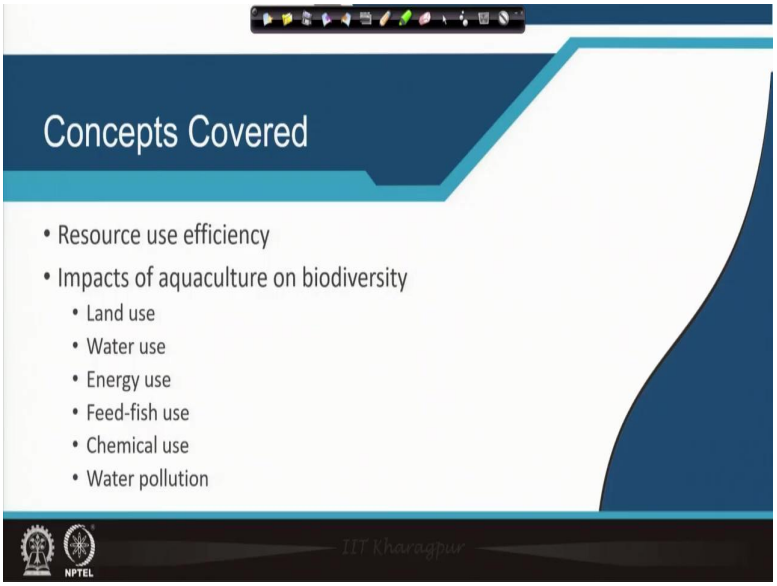

The contents that I will be covering the resource use efficiency, the impacts of aquaculture biodiversity, land use, water use, the energy use, feed fish use, chemical use and the water pollutions related to the aquaculture and its impact on the biodiversity, which is one of the major information's that we will be discussing in this particular module in this particular lecture series.

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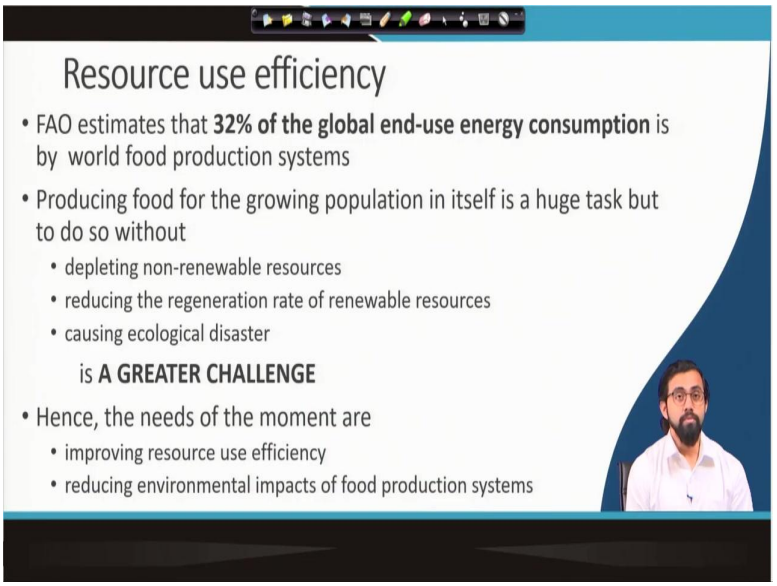

So, what is the resource use efficiency? So, in general Food and Agriculture Organization, they estimate that almost 32 percent of the global end-use energy consumption is to produce only the food for the human consumption. So, in general, it seems like we are using a lot of energy, we are consuming a lot of energy for the transportation and all, but actually, if you see

the figure almost 32 percent are actually involved with world food production systems. Producing a food for the growing populations like the now see from like, we are going to like almost more than 7.5 billion people on this earth right now, at this moment, so, and it is keeps on growing.

So, for this growing population for itself, producing food is a huge task, but we have to do it without depleting, further depleting or further utilizing any non renewable energy sources, reducing the regeneration rate of renewable sources and also, we have to make sure that it will not cause any ecological disaster because of the farming practices or the food production systems that we are adhering to produce the amount of food for the population for human consumption, which is actually a great challenge, which is one of the major reason that we need to go ahead with the proper resource use efficiency. So, that the resources or the it can energy resource, it can be the existing, it can be the material resource.

So, whatever we are utilizing, it has to be at its best and it has to be at its optimal weight. So, the need of this moments are like improving the resource use efficiency definitely and to reduce the environmental impact of this food production systems of our food production units depending like it can start from the resource utilization or the freshwater utilization in the pond to the byproduct and development from the byproduct recovery from the processing units from the processing units of all the fish or the fish feed or the say like normal food production units. So, all this processing units the final byproducts that will try to get trying to procure like somehow get out of it.

So, we have to go through a proper environmental study, we have to go through a proper economic and resource use study. So, that the whatever the amount of resources, whatever the amount of energy, whatever the amount of impact it has on the surrounding ecosystems can be reduced in a very impactful way.

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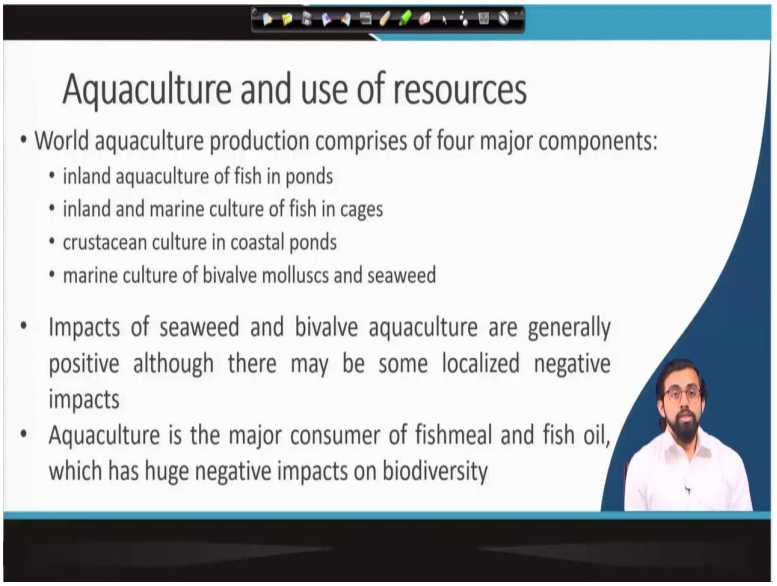

So, in general, the aquaculture production, what we normally have it comprises it can be of like major four components it has, it is not limited to it, but it is has these four major components. First of all, the inland aquaculture of fish in pond, second is the inland and marine culture of fish in cages. Third is the crustacean culture in coastal ports and the fourth is marine culture of bivalve molluscs and the seaweeds et cetera, et cetera. So, these four are the major aquaculture production in the worldwide.

So, the impact of seaweed or the bivalve, it is not much in the environment pond of view and also the economic pond of view as well because they have very little even like sometimes like there are very little negative impact, but mostly it is positive, I would say because seaweed and bivalve, they utilize a very low amount, we need a very low amount of input for them to grow in the system in the farm.

Additionally, what they do they treat the water because of their food habits. So, they actually treat the water to get rid of some amount of pollutants from the system itself and they utilize it and so somehow they can actually helping the environment to be for the pollutant free and all.

Aquaculture in general, they utilize huge amount of fish meal and fish oil, which has a very huge negative impacts on the biodiversity. In coming slides, I will be discussing about this in details and also a number that you may have this thinking like whatever the fish that we are using, is, the total amount of fish that actually called utilizing, whatever the amount of fish,

whatever the amount of aquaculture product we are producing is actually for the human consumption or the byproduct utilizations, it is actually not.

A major portion of the fish we are actually cultivating all around the globe is actually used for cultivating the other type of fish, the higher hierarchical fish or the fish which utilize those the carnivorous species, which has a much higher economic return. So, it has a very, like huge environmental impact of this kind of fish meal or the fish oil production, which is used for the consumption of like for the aquaculture benefits and all.

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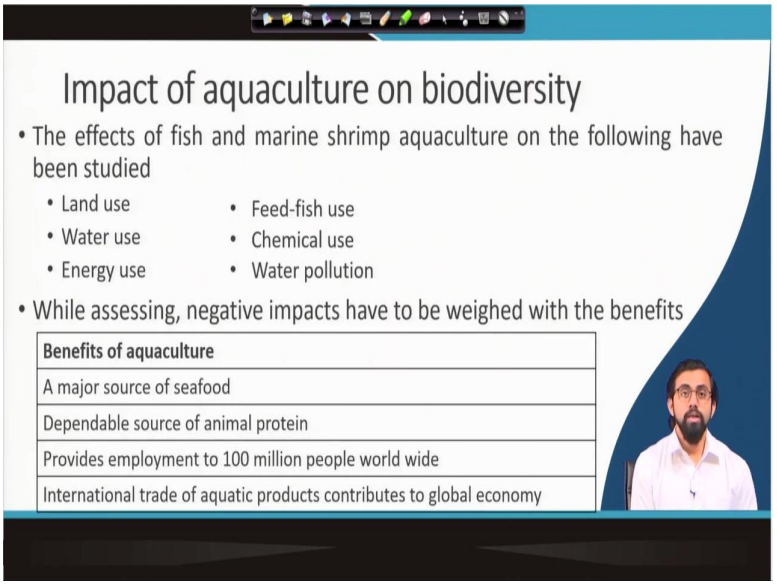

So, in general the impact of I will discuss about those fish meals in details in later slides. So, in general the impact of aquaculture on biodiversity if I discuss, so it has the impact on the land use, the water uses, the energy uses the fish feed use, the chemical use and the water pollutions. So, I will be discussing all these six ponds in details in the later slides. And though there are like when we always we cannot talk about the negative impacts only there are lot of positive impacts also associated with it. Like because the aquaculture is a major source of seafood and it is a major source of the most dependable source of animal protein that we can have to nurture and properly balance our diet, it provides the employment to the hundreds of millions of people around the world.

The international trade of these aquatic products contributes to the global economy at a very high range. So, even that some all these the country, the island West countries, for them, this aquatic product trade is one of the major source of income. And it actually gives them the major boost in their country based economy or their GDP system. So, that is this there are lot

of benefits of aquaculture as well, which are the major reasons of which we want to go for it. So, the whatever the negative impacts that it incurs. So, we have to try to find out the way to somehow minimize it or try to neutralize it if possible or like completely nullified this kind of negative impacts.

So, in order to do that, we need to understand what are the negative impacts on this different on this aquaculture processes on this land, water, energy, chemical, the water, et cetera, et cetera. So, in order to understand this, let us go ahead and find out and enhance an idea about the negative impacts of aquaculture in general.

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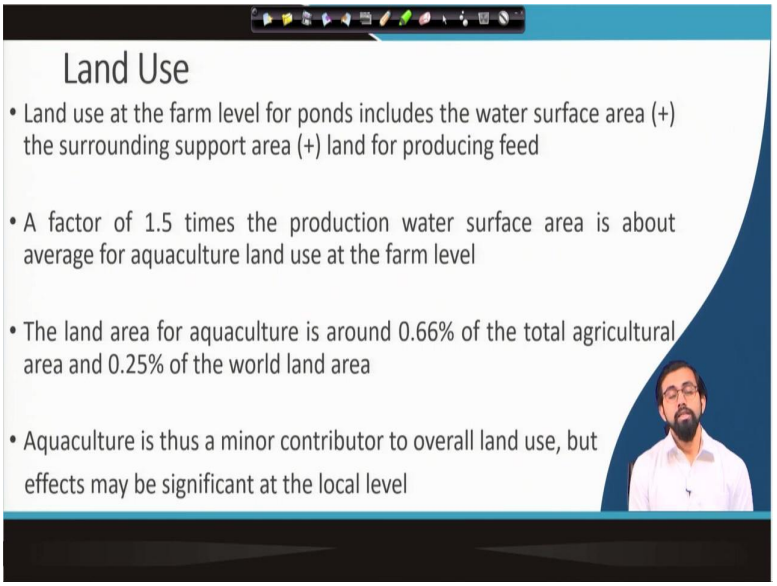

So, when we talk about the land use, so in general, the land use for a farm, if I asked you the land is for a farm, suppose you have a 10 feet by 10 feet of small aquatic pond you are developing in the backside of your farm in your house or like backyard. So, he will say what is the total amount of farm that it requires?

He will say like, it is only 100 square feet, because it is like 10 feet by 10 feet, that is it, but it is actually not. So, why it is not the actual land uses that you are actually incorporating here, when we go for lifecycle analysis of your product, you need to incorporate the supporting support area needed for producing the feed as well because your feed is not coming out of nowhere. It has to have suppose some amount of land it requires to produce the feed.

So, you may think about it is very it is hypothetical, how you can calculate that support area. You do not have to calculate that support area. There are standard practices in the if you go

for research, different research papers, there are standard practices, how we can like calculate that standard support area for a particular amount of surface area for your pond, so you can go ahead with it, this is the recent days practice, earlier we do not do that these kind of practices. But recently, we started incorporating these kind of practices also to identify the to, quantify the actual impact on the land or the water for these kind of aquatic aquaculture practices that we normally do.

The factor of 1.5 times the production of water surface area is about the average of aquaculture land use in case of farm level. So, see aquaculture farm level when we go for the actual production surface area, it is like the 1.5 times the production surface area of normally we calculate, when we talk about any aquaculture farm and all. The land area of agriculture is around 0.66 percentage of total agricultural area and 0.25 percentage of the world land area. Can you imagine the amount of land that we are utilizing for just culturing the aquaculture system?

So, what was it before? It was before maybe some mangrove area, maybe some forest, so what we are doing, we are going for the reforestation procedures, we are going for the mangrove appropriation thing, this all these procedures, all this the things that we are doing to just to have a larger amount of agricultural space has huge amount of environmental impact, so I will discuss about in detail.

So, aquaculture is considered as the minor contributor to the overall land use, but it affects significantly in the local level.

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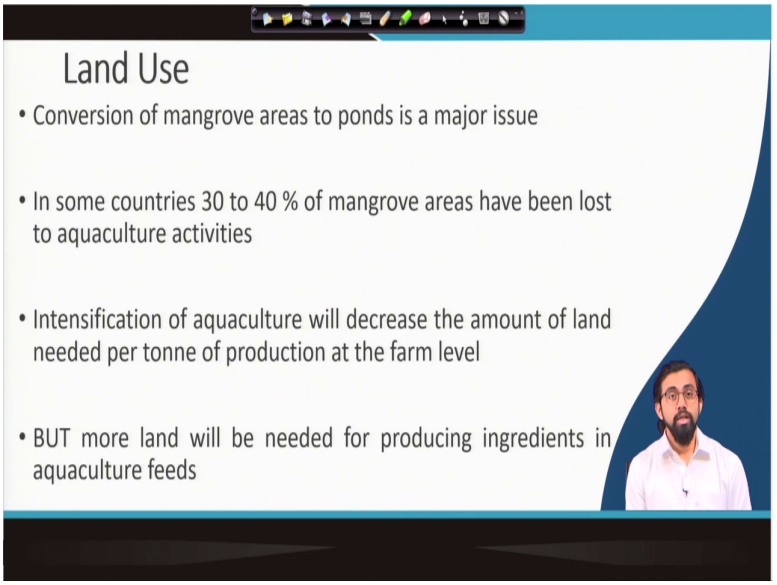

See what I mentioned like conversion of the mangrove areas to ponds, it is a major issue. Why we go for these things, in general, suppose most of them sea based products that we are sea based culture species that we try to farm in our aquaculture farm, try to culture in our aquaculture farm it needs the seawater, it needs a saline water.

So, how do we do that, we go for design the tight fit farms, say suppose we need to design a tight fit farm and we go for a proper discussion about the engineering details and all and for that we need to say like couple of hectares of land by the side of seashore. That is it, we go to the policymakers, we ask them, like we need these things. And they say like okay, let us go for it. Let us go have it have a land of this much area, so, that will increase our economics.

But before doing that, for all the for the engineers and also for the policymakers, we have to think how much of our environmental impact it will happen, it will cause when you go for developing these huge land based this aquaculture system, aquaculture pond and all which is just by the side of the seashore, because it is a rich source of biodiversity. It is a rich source of mangroves are there so those mangroves, you have to get rid of all those mangroves to or you have to cut a camel through this mangrove so to get the seawater when there is a high tide and so that all this construction actually causes a huge harm to the aquatics surrounding ecosystems.

And it is not in a very small amount, it is actually a huge amount of harm it can cause and earlier, we do not worry about it, say like 30-40 years back 100 years back, but now we need to really think about it, do we need this kind of systems and if we need how we can make it scientifically benign, more scientifically accurate and optimum so that we do not harm the eco surrounding ecosystem, at the same time, we somehow try to contribute to the ecosystem.

So, that is how our approach should be, the intensification of the aquaculture it decreases the amount of land needed per tonne of production at the farm level which is somehow good because the utilize the land that you are using in a maximum way in optimum way and you how to do that, you intensify the aquaculture product. If you intensify the aquaculture products go for the intensive aquaculture maybe it comes with some other engineering developments, go for it, the science is already developed and there are ample amount of research has already been done, people are started thinking about producing aquaculture in like outside this globe.

So, there are technologies available and it is actually available. Just go for it search for the research papers, come to the researchers like us and we will give you the idea, we will give you the proper scientific methods that we need to inculcate to utilize it to your farm to produce maximum in a least environmental with the least environmental effect on I mean like least destruction in the environment or the ecosystem. So, in order to intensify the aquaculture, we need the advanced engineering systems. But this more than this, we can say that that decreases the amount of land but actually more land is needed for producing the ingredients of the aquaculture feed. We do not think about it.

So, the moment I told you that the intensification will aquaculture will reduce the land like anything, but actually, if you see the if you do the proper lifecycle analysis, it is not. The actual amount of land that is it is needed now for the intensive aquaculture is less, but the food or the feed that is required for that aquaculture species to sustain is more. So, in order to do that because it is not at all surviving through the natural feed anymore. So, it has to be, I told you like it is a simple food chain, you supply the proper agricultural feed, you will have a good amount of yield for your culture species.

So, where to get those aquaculture feed from, it is developing somewhere, it is getting and it is this agriculture feed can we have some other type of fish as well, so, in order to develop that fish, you need to have some amount of land. So, actually, you have to do this very fine calculations like whether the intensification is actually reducing the required land or not, or where actually it is just a fake farm. So, these are some stuff we need to remember we need to understand when we go for the actual design of aquaculture farm.

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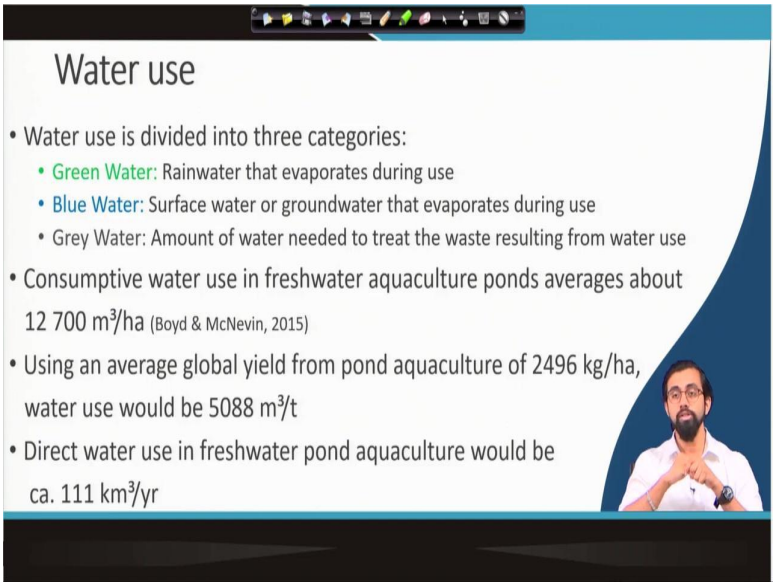

So, that is what we want for all of you like whether you are from fisheries biology, fisheries, bachelor or fisheries engineering or electrical engineering or an aquaculture enthusiastic you have to know this matters you have to know this facts, so that when you will be discussing we will be designing your own aquaculture farm or you will be consulting an aquaculture farm for your customer for your buyers, you will give them the best possible outcome with the environmentally benign way.

So, water uses when we talk about the water uses, it can be the green water the rainwater that evaporates during the uses the uses, the blue water, the surface water or the groundwater that evaporated during the uses and the grey water, it is the amount of water needed to treat the waste resulting from the water uses or the freshwater exchange that we need to do during the water uses.

So, all these type of water uses are the one which are in the negative side which we have to get rid of we have to these are the like the outcome of the aquaculture farm that we normally have. So, in general, the consumptive water using freshwater aquaculture pond, average is about around say like 12,700 meter cube per hectare according to the literature is given by Boyd and McNiven in 2015. So, using an global yield of say like pond aquaculture of around say like 2496 kg per hectare. So, total water use would be around 5088 meter cube per tonne, can you imagine the amount of water that we are utilizing; one meter cube is 1000 liter.

Now, just imagine the amount of 0 that you have to, add another three 0 that you need to put in this number to just to convert it into liter so that it will be much easier for us to understand.

So, these much liter of water is needed just to produce 1 tonne of product. So, we need to minimize these uses, we need to minimize the we need to optimize these water uses for better future. The direct water use in a freshwater aquaculture, pond aquaculture be around approximately 111 cubic kilometer per year.

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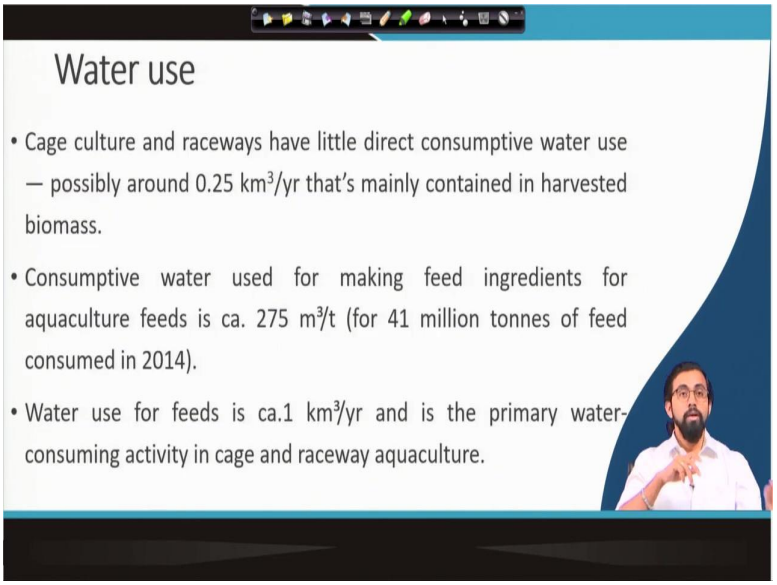

So, in general cage culture and raceways they use less amount of water they are in stream water uses they use so they are not even something around 0.25 kilometer cubic kilometer per year and that is mainly contained in the harvest at biomass that so we can go ahead with this kind of cultural processes so that we can utilize we can minimize the water users and at its maximum. Consumptive water uses for making the feed ingredients is approximately around 275 meter cube per tonne so for around say like 41 million tonnes of feed that is consumed in 2014 this data is given, 275 meters 275 multiplied by 1000 liter per tonne of production that is the amount of water that it is needed for producing the feed ingredients all over the world. It is huge.

The water use for feeds is approximately 1 cubic kilometer per year and it is the primary water consuming activity in the cage and raceway aquaculture. So, in case of race and aqua raceway aquaculture in stream water uses we can be proud about it. We are not utilizing much of a water but what about the feed water, what about the water that is needed for producing the feed and all, so that also has a huge impact on the system.

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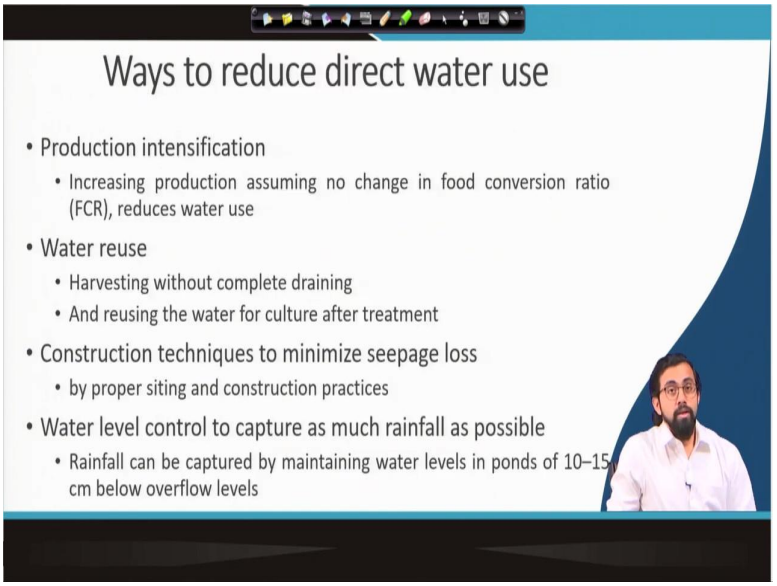

So, what are the ways to reduce this water use? The first of all the production intensification, so, it can be done by like increasing the production, go for the intensive aquaculture systems, by we can increase the production as you may no change in the food conversion ratio which reduces the water use. Water reuse that is an important thing we need to harvest without complete draining just wait for proper harvesting process to finish, reuse the water after a for culture after treatment go for the re-circulating aquaculture system, biofloc technology there are lot of technologies now a days available to treat the wastewater coming out of the aquaculture pond, to treat the water and reuse it back to the to your system.

Construction technique to minimize the seepage loss by proper setting and the construction practices. Water level control to capture as much as water as possible. So, you can develop your farm in such a way so that all its roof tops and all its available spaces land spaces are being utilized to capture the rainfall at its maximum and if you can utilize that rainfall that water users will be minimized like anything. So, in general, in order to capture the rainfall, you have to have at least maintain 10 to 15 centimeter gap in the water level below the out flow level. So, that water rainfall water can be captured and can be utilized in your pond.

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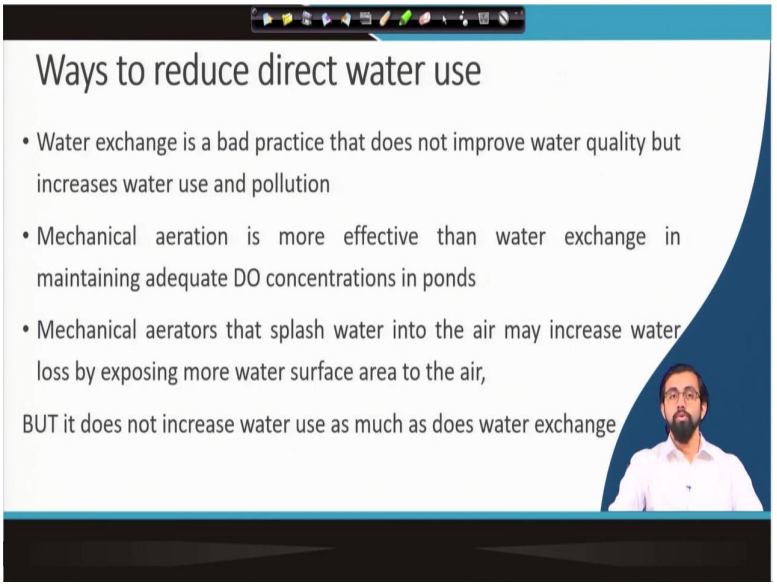

There are other ways you have to in general, water exchange is a bad practice you just go to do not go for water exchange whether you go for the treatment of water. So, because it does not improve the water quality, but it increases the water uses and the pollution occurs in general because what we do water exchange means the whatever the used water we just throw it away in the surface water bodies and we use the freshwater to use it back into your system then there is there comes the mechanical aeration which is more effective than the water exchange because it can maintain the adequate amount of the concentration. But another important thing, everything comes with the pros and cons you have to optimize the system because the mechanical aeration it will help you to get more amount of dissolved oxygen, but because of the mechanical aeration more amount of water is getting splashed out in the system in the environment in the air what will happen because of that, the evaporation loss will be maximized.

Evaporation can be happened because the evaporation it needs more amount of surface area for water to get like to vaporized into the air. So, if evaporate into the air, so, if it gets more amount of surface area, the more amount of water surface is now available for evaporation. So, because of that the evaporation losses can be very high.

So, but it is not as much as the losses that incurs due to the watershed. So, that is why we still go ahead with the mechanical aeration. But if we can do if people are still doing it all over the world, the scientists are doing they are trying to find out more optimal way to read to increase

the aeration but not doing it mechanically not doing it by splashing the water so that it will increase the evaporation losses and all.

What they started doing, they started having designing different kind of aerators which will reduce the water losses due to the evaporation as well they go for the submersible one, they go for some other aerators and all, the very advanced stage aerators systems and all where they can get rid of the evaporation loss that incurs due to the mechanical aeration systems and all.

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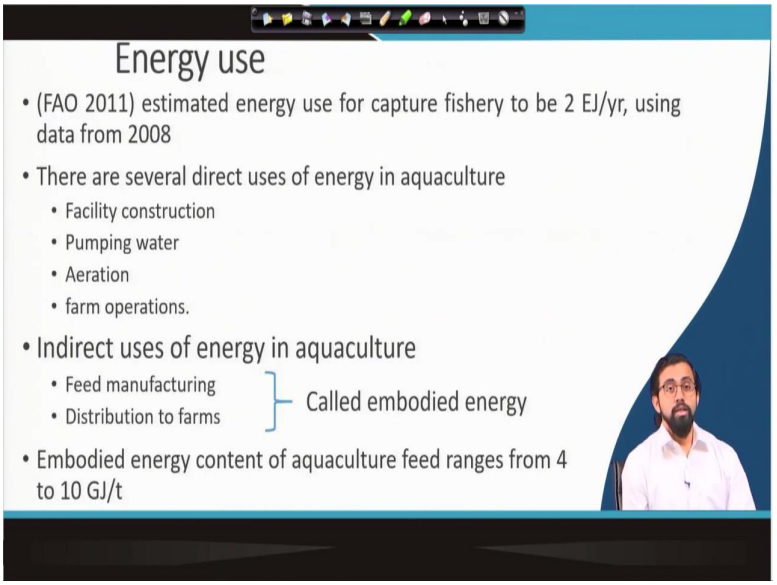

So, total energy uses according to the Food and Agriculture Organization 2011, the estimated energy use for capture fisheries around 2 exajoule per year, what is exajoule, it is 10 to the power 18, we know like 10 to the power 6 is mega, 10 to the power 9 Giga like that 10 to the power 18 we call it exajoule. So, 2 into 10 to te power 18 joule per year of energy is being utilized when we go for the capture fisheries. Let us talk about the aquaculture what will happen in case of aquaculture. Several direct use of energy is there in aquaculture, facility construction, pumping of water, aeration, farm operations like there the electricity that we use in the farm and all.

Other than that, what are the indirect uses of energy? The feed manufacturing I always tell this, this called the embodied energy. Embodied energy you have to understand, the feed manufacturing also comes with the cost of energy some energy is utilized in case of manufacturing of the feed as well, which you are utilizing. So, the cost when you calculate it is not the only cost of feed the energy losses in incurred because of the production of the feed

has also to be incorporated when you will be designing when you be doing the proper lifecycle analysis of your system, the distribution to the farm which so all these things are actually incorporated within we call it embodied energy.

So, this embodied energy it contains in aquaculture feed ranges from 4 to 10 Giga joule per tonne, what do I mean by Giga joule, 10 to the power 9, so 4 to 10 into 10 to the power 9 joule per tonne of production is the energy content of the aquaculture feed and which is really huge, but we do not talk about it, we need to start thinking about it, how it involves in aquaculture production and what are the possible consequences.

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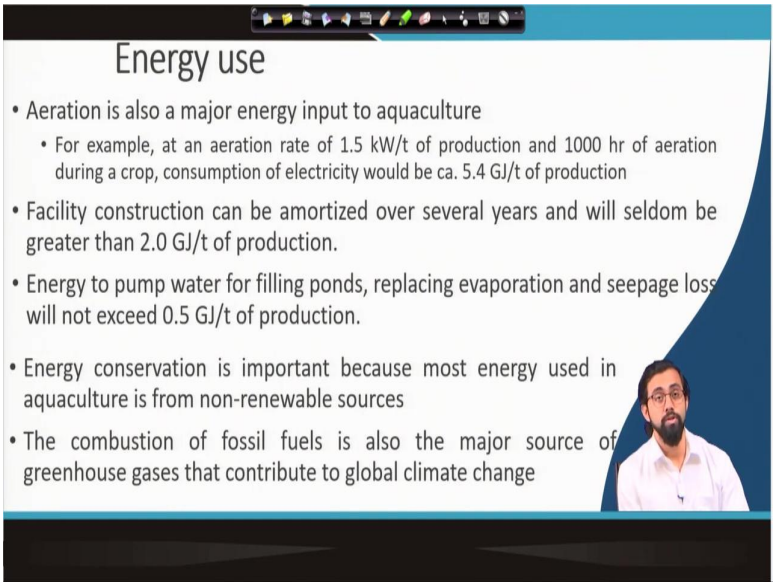

The aeration is also a major energy input to the aquaculture for example, at an aeration rate of 15, 1.5 kilowatt 1.5 into 10 to the power 3 watt per tonne of production and also say like 1000 of product aeration during a particular crop or particular season. So, the consumption of electricity would be approximately 5.4 in to 10 to the power 9 joule per tonne or 4.4 Giga joule per tonne of production. The facility construction can be amortized over several years and will seldom be greater than 2 Giga joule per tonne of a production. The energy to pump water for filling pond replacing the evaporation loss or the seepage loss will not exceed more than 0.5 Giga joule per tonne of production.

So, energy conservation is important but because most energy used in the aquaculture is coming from the non renewable sources, so, what we can do, we have provision we know how solar energy works, we know how wind energy works, we know how geothermal energy works just start utilizing those things. So, we can reduce the total energy required for this

kind of tweak for the farming for that particular aquaculture farm. The combustion on the fossil fuels, it also the major source of the greenhouse gases, so which can contribute to the global climate change.

So, that is the reason why I told you to go, let us we design nowadays our aquaculture farm with maximum non renewable sources as possible renewable sources as possible. Solar energy, wind energy, geothermal energy I told you because in the temperate region, so for us, it is very easy. In India, we can go ahead with the development of farm is very easy, but suppose in a temperate region, what they will do, in the Europe or in the northern part of America, Canada, what they will do, how do they do the aquaculture where their average temperature is very low, how they will do the production, how they can keep warm their farm, how they can keep on their greenhouse so that where they are producing the farm producing this agricultural farm. They are using the geothermal energy.

We can also utilize the geothermal energy properly to for reducing a different kind of cost involved for the farm production to reduce the air conditioning charges, to reduce the different to maintain the proper temperature inside your system to have a maximum benefit out of it. So, we need to think about all these renewable sources of energy and which can be utilized to further reduce the energy requirement from the aquaculture farms.

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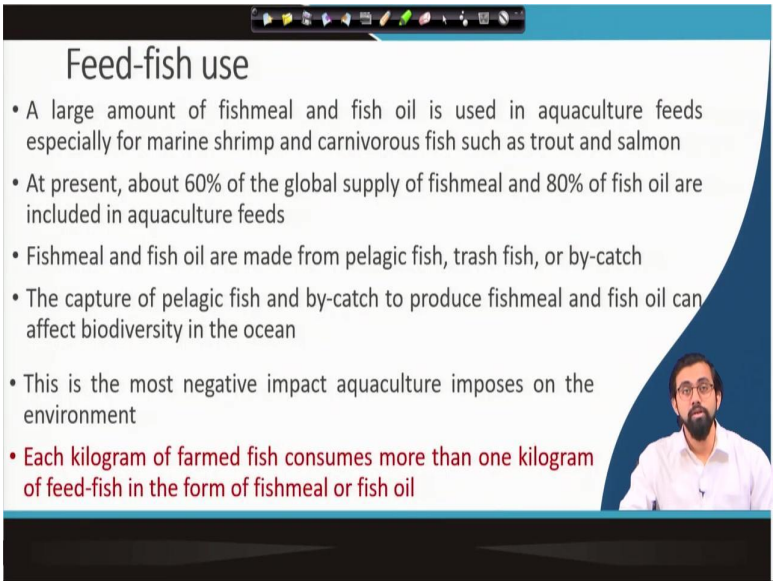

The fish feed uses, the large amount of fish meal or the fish oil is used in the aquaculture field especially for the main streams and the carnivorous fish such as trout or salmon. So, at present 60 percent of the global supply of fishmeal and the 80 percent of the fish oil are

actually included in the aquaculture feed itself. Can you imagine the total amount of it is almost 60 percent of the global supply is only utilized by the fish itself?

So, it is like in a lower tropic culture is actually utilized by the higher tropic culture and utilized and this loss we have to corporate when this consideration we have to incorporate and each and every design criterion that how this fish meal, how this lower chain like lower tropic species are involved in culturing the higher tropic species, and how they are interrelated, what are the design criteria, what are the numbers that you have to incorporate when you will be designing a farm. It is very important that is the advanced stage of agriculture practices that we are doing right now all over the world.

The fish oil or the fish meal they are made from the pelagic fish, trash fish or the by -catches, this capture of this pelagic fish, pelagic fish has the normally this column dwellers like normally they are not the benthic zone, they not dwell on the benthic or they not the surface, they normally stay in the pelagic zone, mostly in the middle size middle portion of the like they call it the column dwellers you know what is column dwellers, we have already discussed and this by-catch which are the one which somehow you go for say catching salmon you started you somehow by mistake you by not by mistake, but because of the net and all you started capturing the other sea mammals and also this is called the by-catch which you are not targeting this is non-targeted species that by mistake you have not by mistake it because of the because of that is also is normal dwelling zone. So, it can also get caught.

So, what you going to do with that, so, most of the cases they try to get it back to the ocean body, but 60 percent of the cases they cannot survive. Because one this by-catching thing happen they somehow get injured severely. And when you and they are out of the water for several moment of time, they cannot sustain most of the cases this by catches cannot sustain and this by catches end up losing their life. That is a major and horrible mistake, horrible side effect and disadvantages of the capture fisheries.

So, it also affects, so the capture of this pelagic fishes and by-catches as I already discussed, it affects the biodiversity in the ocean. And the most negative impact of aquaculture imposes in the environment is this fish feed use. Each kilogram of farmed fish consumes more than one kilogram of fish feed fish in the form of fish meal or fish oil, sounds funny, but it is true. So, the each kilogram of fish that we are consuming we are farming, it is actually can consume more than a kilogram of fish feed or as a fish meal and all.

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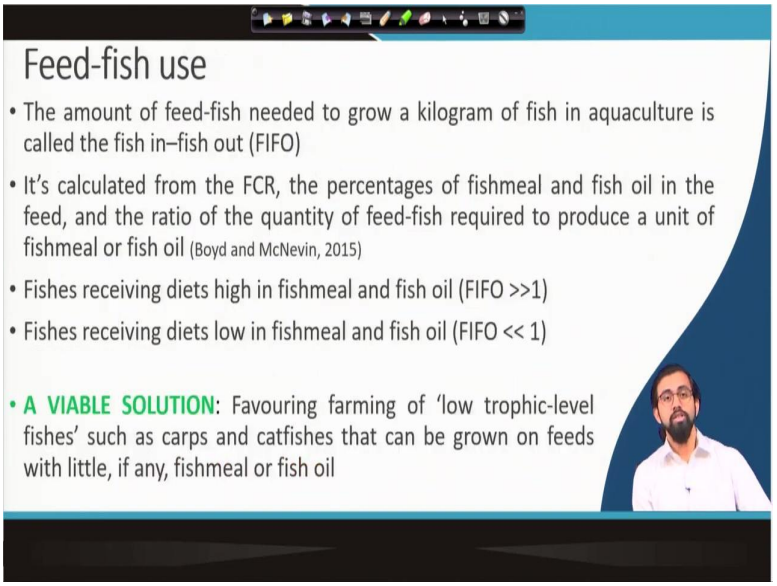

So, fish feed use the amount of fish feed fish that we needed to grow one kilogram of fish, we call it fish in fish out FIFO. So, do not confuse with FIFA, so it is FIFO. So, it is calculated from the FCR or the food conversion ratio the percentage of the fish meal or fish oil in the feed and the ratio of the quantity of the fish feed fish that is required to produce a unit of fish meal or fish oil it is called the FIFO. So, fishes required like high diet the diet which is high in fishmeal, they have FIFO of more than one and the fishes which requires less amount of fish meal likes mostly the say like the herbivorous fishes and all. So, they have a FIFO like less than one.

What is the bivalve solutions, farming of low tropic level fishes as I told you go for the herbivorous fishes they like the crabs and the cat fishes even they can grow on feed without or even a very little amount of fish meal and fish oil. So, go for culturing those fishes, which will supply the amount of protein required for the human consumption and also it will reduce the environmental impact and it will reduce the issues the water consumption at a very high rate.

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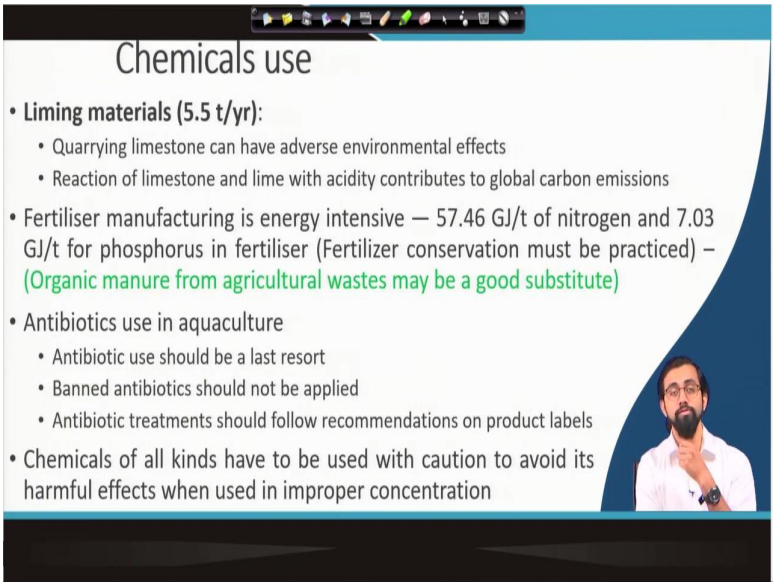

Chemical uses, the lining material we use a different type of limestone for which has the adverse effect on the environment but we use it for lining purposes, we use it for preparation or for pond and preparation or for tanks. And the reaction of this limestone has it contributes to the acidity which with the acidity which contributes to the global carbon emissions. I will discuss about the number in details. This fertilizer manufacturing is actually energy intensive, almost 57.47 Giga joule, energy is required for the production of one tonne of nitrogen and 7.03 Giga joule of energy is required for per tonne of phosphorus that is required in case of in the fertilizers.

What will be the alternate, we can go ahead with the organic manual from the agriculture wastage, use it as a that is a very best substitute for the production of your systems. Antibiotics used in aquaculture, antibiotic use is the last resort. The banned antibiotics should not be applied, antibiotic treatment should follow the recommendations on the product label then only you go ahead with antibiotics just do not use antibiotics, no matter how bad it is like either you use it, put it put the fishes in the quarantine tank and then use it a little bit but try to use it as minimum as possible chemicals if all these kinds have the very like which has the cautions to try to avoid them for its harmful effect on the environment and also the in the system.

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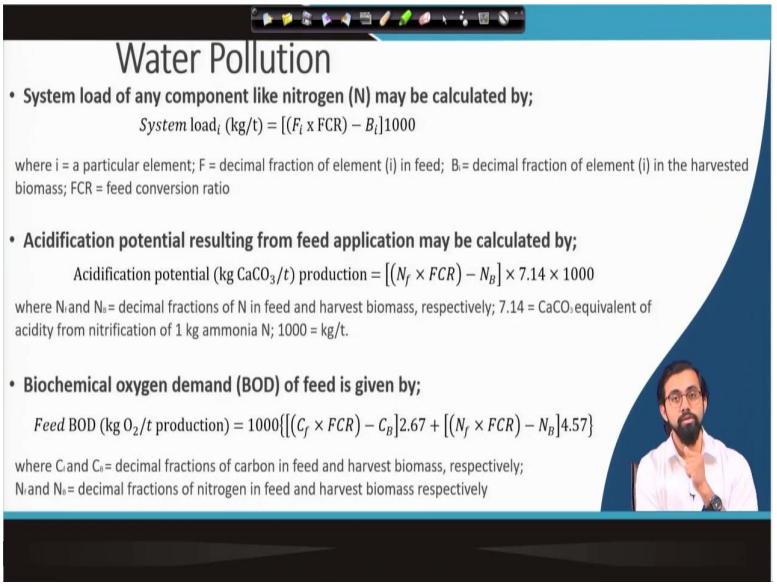

So, when we talk about the water pollutions, so, we talk about the pollution caused by the nitrogen, pollution caused by the carbon et cetera. So, major pollution caused by the nitrogen species and the carbon species. In general, the system load of any components like nitrogen it can calculate say like kg with this equation system load for a particular element i, so, in kg per t is equal to the Fi into FCR. Fi is the what is the decimal fraction of that particular element in the feed multiplied by the food conversion ratio minus the BI which is the decimal fraction of the element in the harvested biomass multiplied by the 1000 just to convert it to tonne to kg.

So, what does that mean? So, Fi is the amount of decimal fraction of the elements say like nitrogen percentage present in the feed multiplied by the food conversion ratio that means, food conversion ratio is what the amount of feed that is actually being utilized converted to the biomass of that particular fish. So, if you multiply this number you will get in the biomass in the further the final product.

What is the percentage of element that is available minus sorry that is the ratio that you can get from the beginning and minus if you do this final harvested biomass if you do the calculation of the decimal fraction, so, this difference will give you the amount of element that is lost because of the water pollution. Feed decimal fraction on the element in the feed multiplied by the feed conversion ratio minus that is that should be the total amount of feed element available in the feed but actually, when you harvest the biomass if you calculate the

total decimal fraction that will definitely be less than the actual Fi that you definitely it will be less than the decimal fraction on the element in feed.

This ratio this value you multiplied by 1000 will give you the system load or the actual loss of pollutant like the nitrogen or say like pollutant in this particular case nitrogen through the wastewater. The same way we can this will definitely cause the acidification, how we can find out the acidification caused by the feed, kg of calcium carbonate per tonne of production, Nf into FCR, Nf is the total amount of decimal fraction of nitrogen in the feed multiplied by the conversion ratio minus the harvest net amount of fraction of nitrogen harvested biomass multiplied by 7.14 which is like the calcium carbonate equivalent of acidity from nitrification of 1 kg of ammonia of ammonia nitrogen and 1000 is for the kg to tonne conversion.

So, from this calculation we can easily find out the acidification potential production. The final pollution criteria that we can go ahead with the calculation of VOD biochemical oxygen demand, it is the value it means the amount of oxygen required for the conversion of a particular biomass to a particular biomass a particular product to its N farm. So, like I mean like component of oxygen required for say like in this particular case, what is the feed BOD? That is the kg of oxygen per tonne of production is equal to 1000 into Cf into FCR, Cf is the decimal fraction of carbon increase multiplied by the FCR code conversion ratio minus the decimal of carbon in biomass multiply 2.67 plus the same way for the nitrogen 4.7.

What is this number 4.57 and 2.67, it is the amount of oxygen required for complete reduction of that nitrogen species is the number that it is standard it is a standard, you can find it in the research articles different research articles from this equation we can get the feed BOD.

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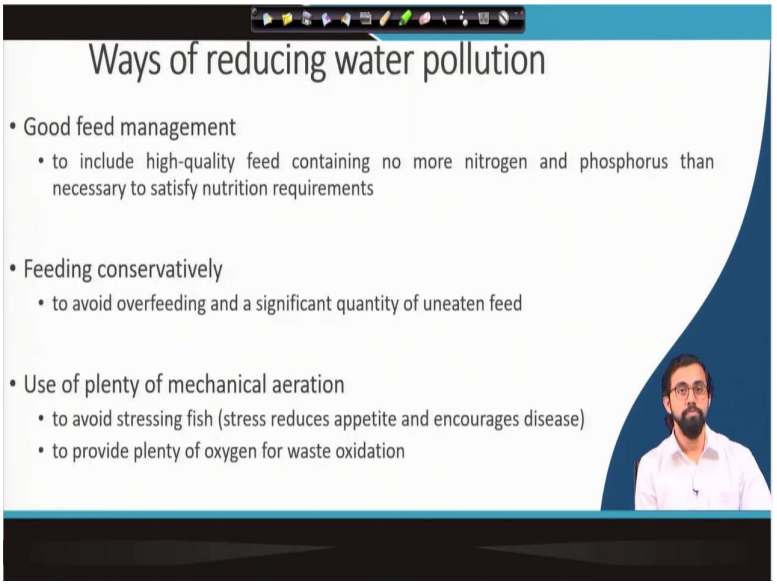

So, how to reduce the water pollution? I will discuss in details in the later lectures how we can what are the procedures, what are the treatment systems that we have to reduce the water pollutions. First of all good feed management, you have to incorporate high quality feed containing no more nitrogen and like not more amount of nitrogen phosphorus then it is required. The feeding conservatively try to not go for overfeeding or seek try to reduce the quantity of uneaten feed, go for plenty of mechanical aeration, go for proper waste treatment procedures and wastewater treatment procedures.

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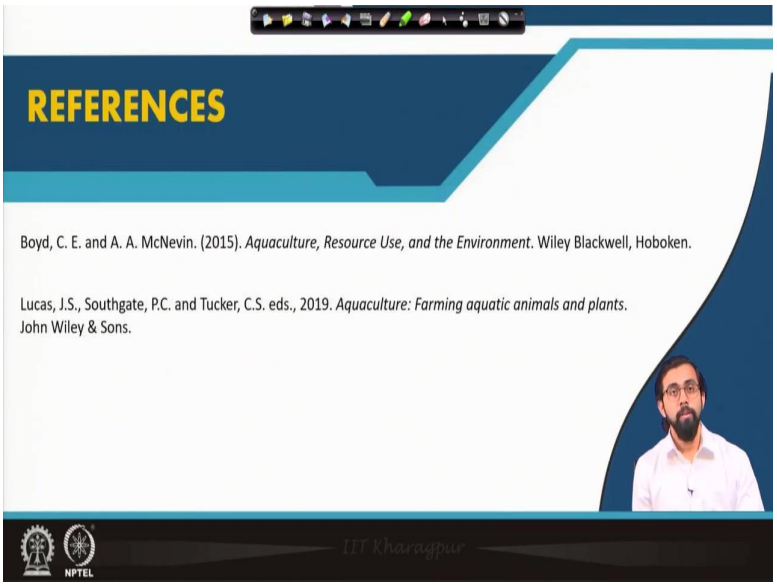

So, these are the references that I have used for this lecture material. And thank you so much. So, this is the end of this particular lecture module. So, we will discuss more in details about the advanced aquaculture technologies in the coming modules. Thank you so much.