Advanced Aquaculture Technology
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Lecture 45
Bio-floc Technology

Hello everyone, welcome to the Lecture 5 of Module 9. My name is Professor Gourav Dhar Bhowmick, I am from the Agricultural and Food Engineering of IIT Kharagpur.

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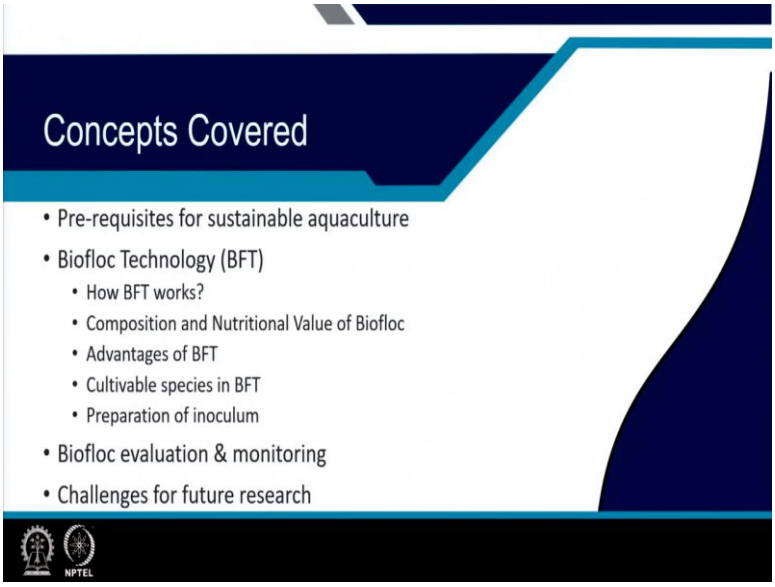

In this lecture material, the concepts that I will be covering are the prerequisites for sustainable aquaculture, the bio-floc technology, how this BFT works, what are the composition and the nutritional value of bio-floc, what are the advantages of it, what are the cultivable species in bio-floc technology, and the preparation of inoculum. Other than that we will go ahead with the bio-floc evaluation and the monitoring systems and what are the challenges for future research. I hope this particular lecture material will definitely help you with understanding the bio-floc technology, not only that but you can utilize it in your field as well.

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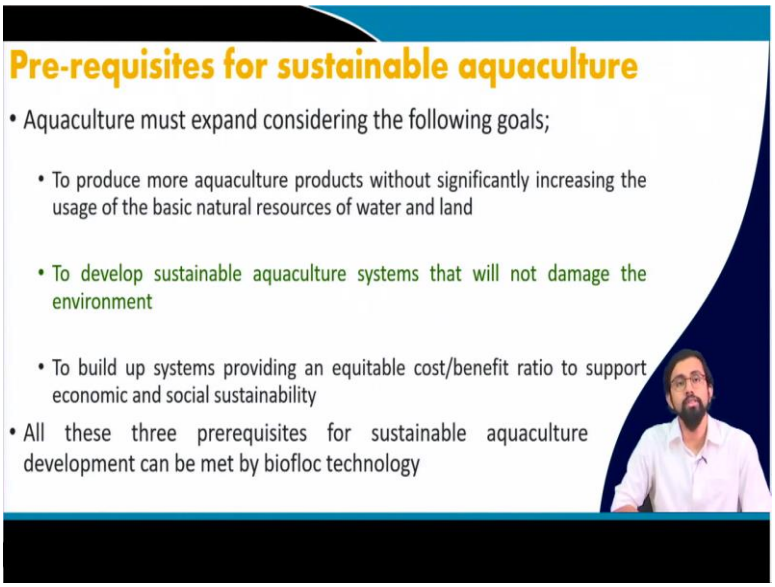

The prerequisites for sustainable aquaculture is like aquaculture must expand considering the following goals. First, to produce more aquaculture products without significantly increasing the uses of basic natural resources of water and land. Second, to develop a sustainable aquaculture system that will not damage the environment.

And the third, to build up a system which can provide an equitable cost and benefit ratio to support the economic and social sustainability. So, based on all these goals, we can go ahead with the sustainable aquaculture processes. So, if we can achieve these goals, we can call this aquaculture practice as a sustainable aquaculture practice. All these three prerequisites for the sustainable aquaculture development can be made by a technological by bio-floc.

So, that is why this bio-floc technology started becoming a very like high-end technology nowadays, people are using it very vigorously all over the world right now. And so, it is very important for you guys to know what is this bio-floc technology and how it works and what is it like in general.

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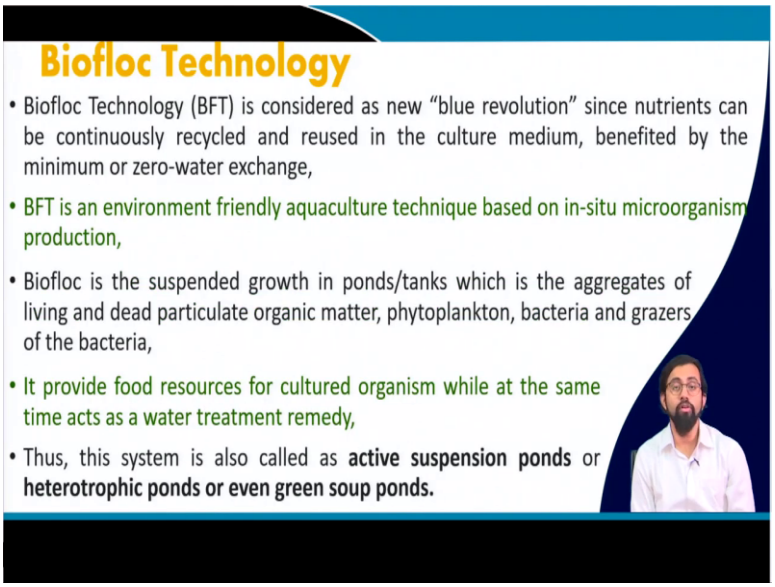

When we talk about bio-floc technology, it is considered as a new blue revolution, blue revolution just like white revolution attached to the milk, in the same way blue revolution is attached to the development of aquatic species. So, the revolution, when you are revolutionising some the production system and everything and the technologies, technological advancement is there in your aquatic species culturing, so that comes under this blue revolution.

And bio-floc technology is actually one of the major reasons behind it, which actually revolutionize this technology, this aquatic species culture, this aquaculture in general. What is the reason? Reason is, since the nutrient can be recycled and reused in the culture medium and benefited by the minimum to zero water discharge. So, how it is happening?

So, see BFT in general, it is an environmentally friendly aquaculture technique, which actually based on the in-situ microorganism production. Either these bio-flocs is normally is in the suspended growth condition, you remember we discussed about the suspended growth and the attached growth, in case of trickling filter like that kind of wastewater treatment system, it attached over the bio-media.

Whereas in case of MBR, in case of activated sludge process, the culture is actually in suspended condition. So, that is why we call them suspended growth process. Bio-floc is a suspended growth of these ponds and tanks, which is the aggregates of living and the dead particular organic matter, phytoplankton, bacteria, grazers of the bacteria. It actually, not only the, it is not only the bio-floc that we are talking about, if you are providing sufficient condition the bio-floc will definitely develop.

What is the benefit of it? So, this bio-floc, it is actually how it is helping. It is helping first of all, it is actually consuming the waste from the wastewater that is being generated from the aquaculture ponds. Second thing, this bio-flocs are actually being fed by your aquatic animals. Suppose you are culturing of fish. So, bio-floc technology is a technology where this heterotrophic growth of these organisms, these organisms are actually again can be fed by your aquatic species, the cultured species.

So, that is how, it is like a nice circle like you have an aquatic spaces, it is dwelling over there, it is doing the extractor all this extractor products, because of that the pollutant level goes high, then it is treated then it is coming to this bio-floc tanks there this heterotrophic microorganisms they work on it, they feed on this pollutants, they consume the pollutants, they use it in their biomass, this biomass is nothing but the nitrogen rich biomass, the nutrient rich biomass.

This nutrient rich biomass is again fed by the fish. So, see, you can idealize like, it is like a complete resource recovery, plus water and zero water discharge, like almost zero water discharge, it is really good, it is really high-end technology, that is if you can use it properly, it can give you a very high return, very high sustainability issues, like in terms of sustainability issues it is definitely it will reach the top, in terms of resource recovery is very high, in terms of feed application is very low, in terms of yield it will be very high.

So, all way it is like a win-win-situation for us. So, that is why bio-floc technologies are like nowadays is in very demand. So, this system sometimes called active suspension pond or heterotrophic ponds or even green soup pond also.

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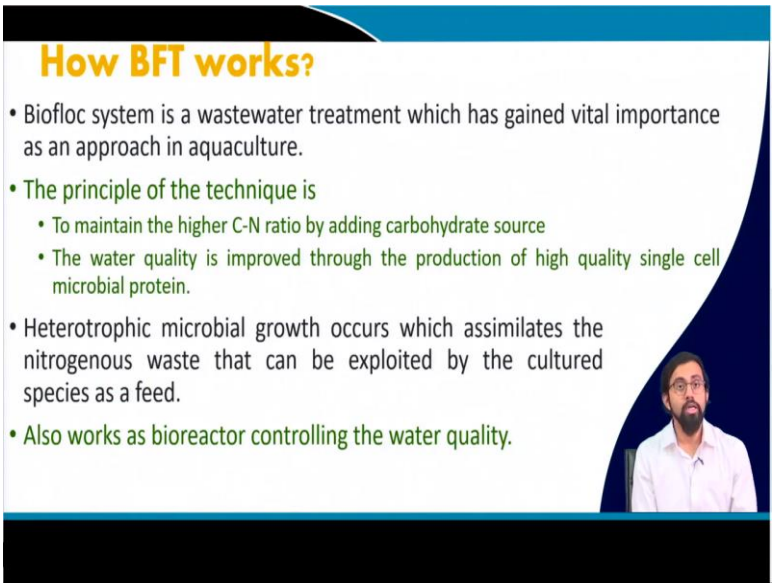

So, how it actually works? I already discussed, let me give you another round of discussion, like to make it more clear for you. This bio-floc system is actually wastewater treatment, which has gained vital importance as an approach to the aquaculture, the principle of the technique is to maintain higher carbon to nitrogen ratio by adding carbohydrate source, the only source the only thing that is required in the system is the carbohydrate source in general.

I am talking about like this carbohydrate source has to be supplied almost every day. And the water quality is improved for the production of high-quality single cell microbial proteins. This heterotrophic microbial growth occurs which assimilates the nitrogenous waste into them, and that can be exploited by the culture species as a feed. Also, it acts as a bioreactor by means of which it can control the water quality.

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How it works? We immobilize the toxic nitrogen species, immobilization of the toxic nitrogen species, which occurred very more rapidly, which occurred in your fish culture tank that you can easily immobilize it, I mean like the toxic nitrogen pieces which occurs in your tank can be very readily immobilized in your BFT because growth rate and the microbial production per unit substrate of heterotrophs are 10 times greater than that of the autotrophic nitrifying bacteria, what does that mean?

Let us see the picture again. We have a bio-floc tank, we know that toxic nitrogen species is generating in your tank in your fish culture tank. So, from fish culture tanks suppose you have a bio-floc culture tank different, in different tank. So, this fish culture wastewater is coming to your bio-floc tank, earlier we used to have either bio-floc or normal membrane bio-rectors.

In case of this membrane bio-rectors all this kind of autotrophic nitrifying bacteria is around when we culture them. What happened, we use, we need to provide them with oxygen. Second thing, this Nitrosomonas and azotobacter they actually normally they are autotropic in nature. So, for them their consumption rate the immobilization rate is much, sorry their growth rate and the microbial production rate is almost 10 times lesser than this hydrotropic growth of this substrate and heterotrophic growth of this microbial production in the BFT.

Because of that, this high production rate of microbial community they can consume more amount of pollutants like in a very feasible manner. And once they produce a huge amount of pollutants, they made these flocs in the principles of flocculation. And once they made these

flocs, then they can be easily supplied to your rearing species, they will consume it and by this way they can have a very high amount of this protein rich live feeds.

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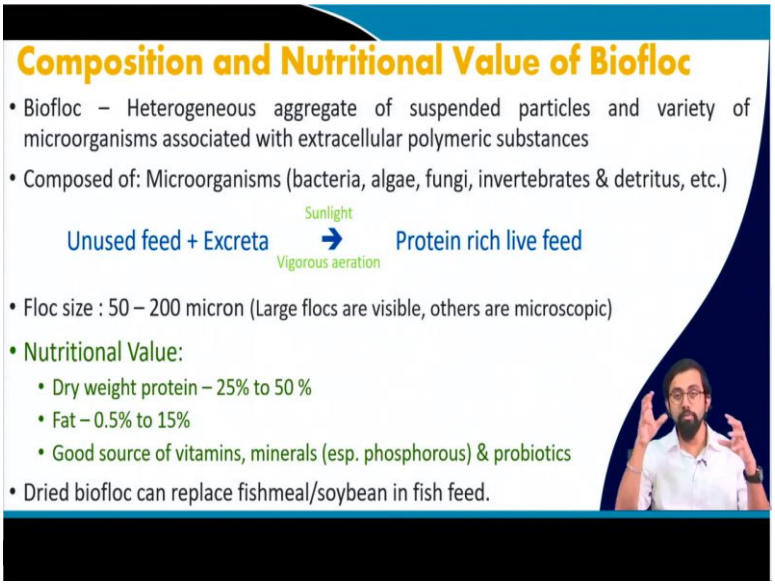

So, by a floc, it is a heterogeneous aggregate of suspended particles and variety of microorganisms associated with extracellular polymeric substances. Composed of mainly the bacteria, algae, fungi, invertebrates and detritus, etcetera. This composition of this bio-floc. So, how it happens, you see the unused feed plus excreta, sunlight and the presence of vigorous aeration if you provide enough amount of aeration, it is very important, aeration is actually very important here.

It will provide you this protein rich life feed that can this floc which is of size of around 50 to say like 200 microns, you know micron right, it is 10 to the power minus 6-meter, it is called a micrometre, in general we call them micron. These large flocs are also visible other than this microscopic, microscopic one. It has a very high nutritional value. Dry weight protein concentration of this flocs can go up to 50 percent. Can you imagine?

The fat can go up to 15 percentage. Good source, it is also a good source of vitamin, minerals, like especially phosphorus and the probiotics, the essential microorganisms. That can be very easily fed to your fish and they will be very happy to have, to consume these vitamins, minerals and these probiotics. And it can directly replace your fish meal and the soybean meals from your fish feed.

So, we discussed about it in a previous module remember that fishmeal it cost a lot and it will increase the overall the cost for production like anything for any kind of fish crops. If we can

replace it with this kind of technologies, this bio-floc technology, it can be highly beneficial for like different purposes. Say it be reduction in the production costs. Say it be higher in the yield. Say it be resource recovery. As I discussed it is like everything is good here.

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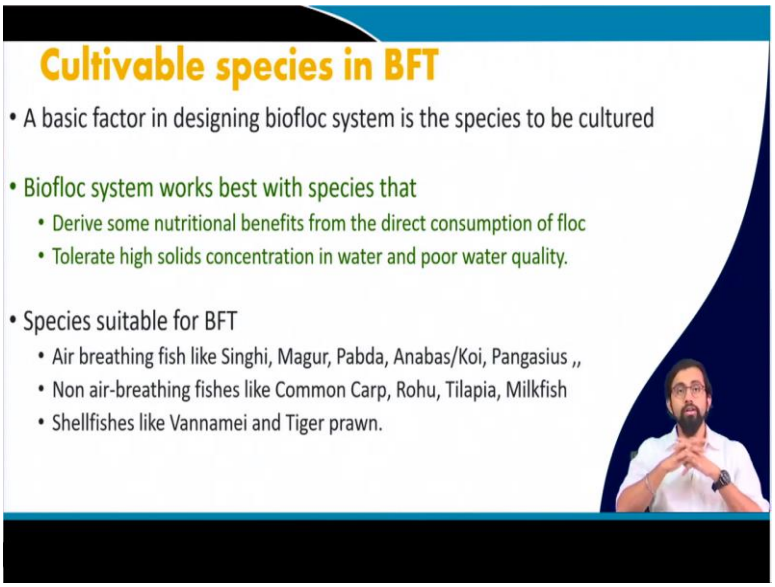

The basic factor in this designing this bio-floc system is the species that is needed to be cultured. Bio-floc systems works best with the species that derive the nutritional benefit from the direct consumption of floc. And also, it should tolerate very high solid concentration in water and poor water quality. Majorly this air breathing fish like Singhi, Magur, Pabda, Anabas or Koi, Pangasius.

So, these are the ones which are normally very famous. So, this air breathing fish are like they can consume or they can sustain a minor environmental changes they do not get stressed much easily even little bit poor water quality also they can sustain, that is why in this kind of bio-floc culture we use them. We also use some non-breathing fishes also like Common Carp, Rohu, Tilapia, Milkfish.

Also, the shellfish like Vabbamei and Tiger prawn can also be cultured using this bio-floc technology. So, for them, the feed will be the bio-floc itself, the microorganism itself. And how this microphone organism is cultured, by consuming the nutrient coming from there excreta only. See, it is like a circle, it is like a proper circle.

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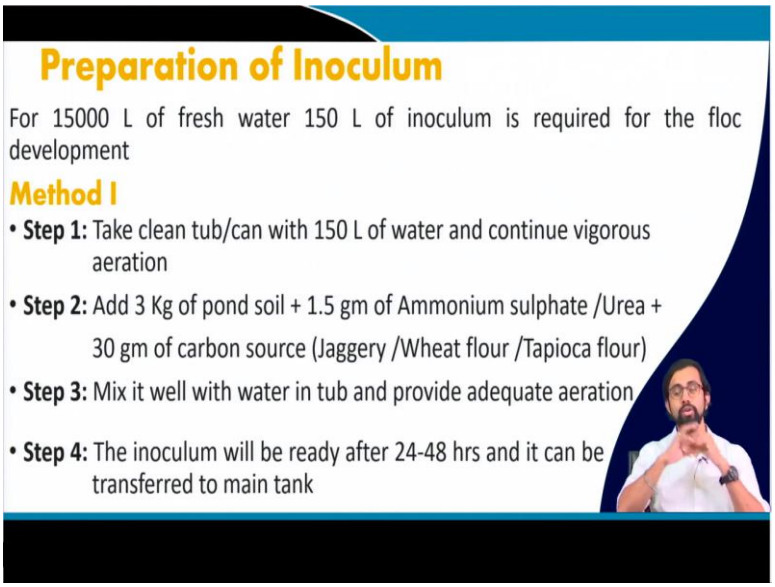

So, in order to give you an idea or the example of how it works, how to design or how to prepare the inoculum, so I am giving you one very specific example like with these two different methods. First one, say you have a 15,000 litre of fresh water which needs to be supplied with 150 litre of inoculum, at least 1 percent of it.

So, once the 1 percent of the freshwater culture that you have you are supplying it with the inoculum for the floc development, how will you supply, how will you go for this preparation. First, this take the clean tub or can with 150 litre of water and this inoculum and continuously and like you continue the vigorous aeration, you provide the aerator, diffused aerator lines in continuously aerated.

Now, add 3 kg of pond soil, 1.5 gram of ammonium sulphate or urea plus 30 gram of carbon source, it can be jaggery, wheat flour, tapioca flora, whatever available with you. Remember this numbers, if you add those things, if you add 3 kg pond soil, 1.5 gram of, pond soil means you have to have a like old pond it in not like very new pond, you have to have an old pond where in the bottom you see they have this slurry like structure, it is like very slurry in nature.

If you take from this bottom, if you dive in and take this pond soil, it is very enriched in different kind of essential microorganisms. This is a very rich source of essential microorganisms specially if it is like properly aerobic in nature, properly you are aerating the environment you can get different kind of aerobic microorganisms, you can get different aerobic nitrifying organisms, like different kinds of heterotrophic bacteria you will get, heterotrophic microorganisms you will get from this pond soil.

This ammonium sulphide is supplied to, so that it will be continuously supplied with the nitrogen source, 30 gram of carbon source is required to maintain the carbon to nitrogen ratio, and mix it well with the water in tub and provide the adequate aeration. The inoculum will be ready to by 24 to 48 hour and it can be transferred to the main tank.

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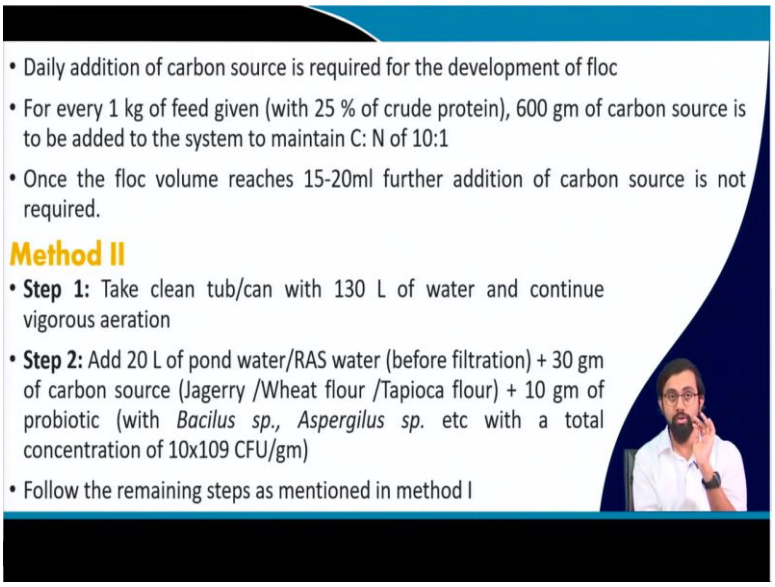

So, once you transfer to the main tank do not forget to provide them with the carbon source every day. For every 1 kg of feed given say like 25 percent of crude protein, 600 grams of carbon source is to be added to the system to maintain the carbon to nitrogen ratio of 10 is to 1. 1 kg of feed that you are supplying with say like 25 percent crude protein just to give you one example.

You have to supply with a 600 grams of carbon source to maintain the carbon to nitrogen ratio of 10 is to 1. Once the floc volume reaches 15 to 20 ml further addition of carbon source is not required remember that. What is another method? Take a clean tub or can with a 130 litre of water and just keep on continuing this aeration. Then you add 20 litre of pond water or ice water before filtration.

So, what happens is pond water if you cannot get access to this pond bottom pond soil you can simply add the pond water also that also has suspended enough microorganisms in suspended condition. Then you add this RAS or Recirculatory Aquaculture System water just before the filtration.

The water is going to the recirculatory aquaculture system just before it reaches the treatment unit before that you take the valve out and take like say like 20-litre of this pond water then

you add it with 30 grams of carbon source same jaggery, wheat flour or tapioca flour. Also, you add it with 10 grams of probiotic.

What are the type of probiotic that you can add? You can add Bacilus species, Aspergilus species, etcetera with a total concentration of 10 into 10 to the power 9, it is wrong, it is not 109, it has to be 10 into 10 to the power 9 CFU colony-forming unit per gram. So, the concentration this colony-forming unit you need to go and google it, it is very important for you to understand what is colony-forming unit and what is the MPN maximum probable number, this is very important biotechnological term that you need to remember.

So, in general just know this unit that 10 into 10 to the power nine CFU per gram of Bacilus or Aspergilus species you have to supply in with like an almost 10 gram in general. So, this process, and then follow up step will be the same as the method 1. So, this way either of these two methods that you can follow to initiate the bio-floc formation.

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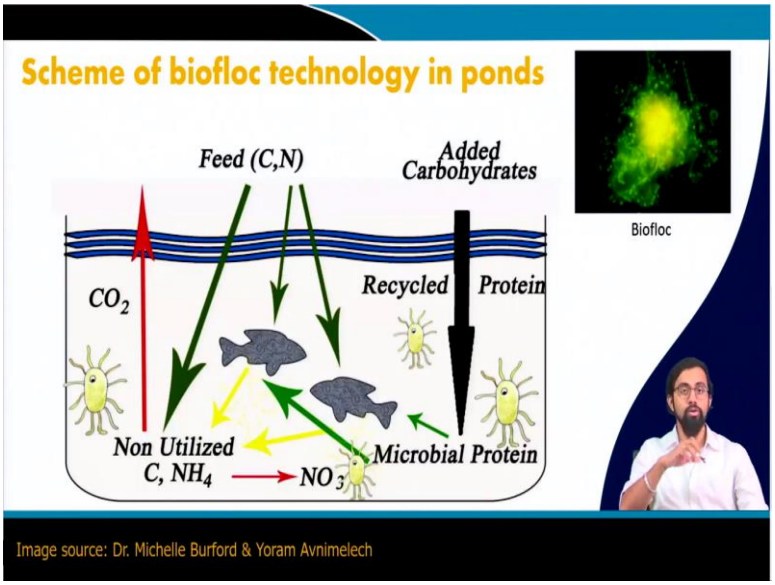

See how it works in general, in this bio-floc technology if you see the scheme the feed which is reached in carbon and nitrogen is fed to the fish or some of them goes on non-utilized. There is non-utilized carbon on some macrobacteria they work on it and they make carbon dioxide out of it and that carbon dioxide goes directly through to the air.

Some of them they convert it to ammonia, this ammonia will be converted into these nitrates by different nitrogen fixing like different nitrifying organisms. And then this, from there then this nitrogen that can be again utilized by the microbial protein and then this microbial protein can be again utilized by the fish.

So, this microbial protein if you add the carbohydrate, because nitrogen is available, but carbon is not always available and also some of the carbon portion is actually we get rid of it because of the formation of carbon dioxide gas. Because the nitrogen production is not available here, nitrogen producing mechanism is not currently available here. Because in general for that you need to provide anoxic condition to have this denitrification process.

That is why the nitrate is there, ammonia is there. And when you add the carbohydrate, this recycle protein and it will be utilized as a microbial protein, this microbial protein is utilized by fish, this microbial protein is nothing but the bio-floc. So, there they have these nutrients, these nutrients are again utilized by the fish and then that is it. So, it is like, this is the very standard practice, standard way of when we discuss about this bio-floc technology.

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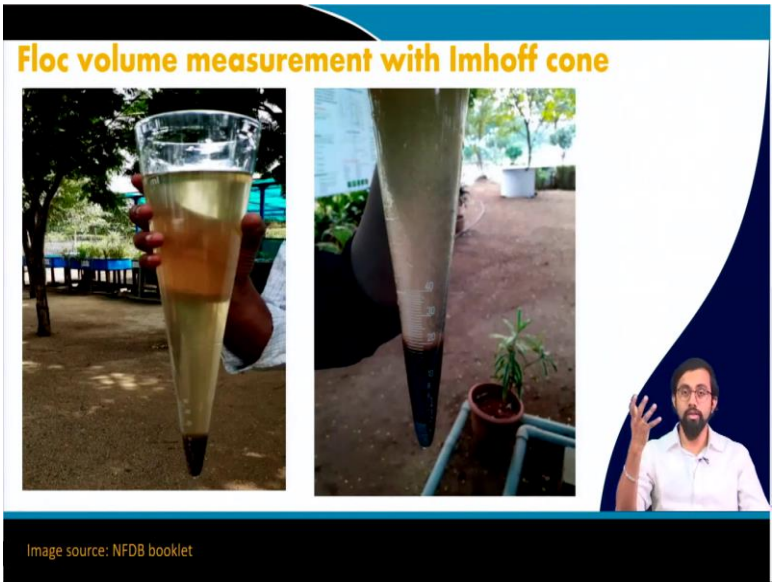

In general, this floc volume we can measure it using this Imhoff cone, this is a very standard practice by which you can measure or you can just simply do it by yourself also, but in general, this is the standard this Imhoff cone that we normally use for the floc volume measurement.

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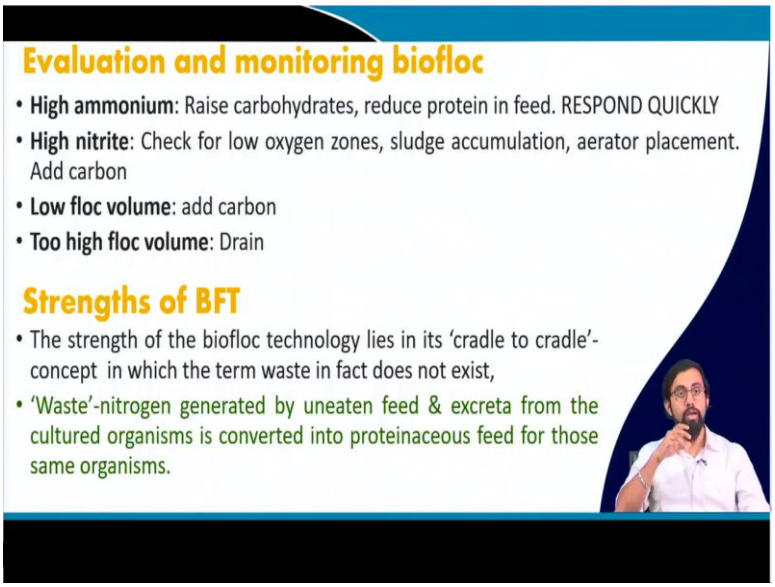

So, in terms of evolution and the monitoring of bio-floc technology, it has a high ammonium concentration like raise the carbohydrate when like suppose it have all of a sudden, your bio-floc has very high ammonium concentration. You always have to treat like every day you have to go and measure all the essential water parameters.

If you go and read the, if you go and check the water parameters on a certain day and you see that there is a high ammonium concentration what you need to do you need to raise the carbohydrate level, you have to simply supply some sugar, simply supply some jaggery or wheat flour. What will happen, it will reduce the protein feed, it will help in reducing the overall ammonium concentration.

This is the troubleshooting manner, just imagine you will not, this is not something bookish knowledge that you are getting, it is like something like you need to remember because this is a real-time scenario that you may face in real life when all of a sudden, your bio-floc technology or if your pond like the ammonium concentration may go high. You simply supplied with the sugar or different like jaggery.

Jaggery is nothing but this Gur, you know it right, in Hindi or Bengali it is called Gur. So, this high nitrate concentration check for low oxygen zones when if its like nitrate concentration definitely there is a chance of denitrification is taking place. If it is taking place somehow what you need to do you have to place the, you have to accumulate the, you have to increase the aerator efficiency somehow you replace the aerator or place it properly.

So, that your addition will be this, how to say that, it will be increased and because of that the presence of this hetero bacteria will be there like not the other sort of microorganisms. And then also you can do what, you can do you can just simply add the sugar. This is like a very standard practice if you have any see any discontinuity of operation you just simply add it with sugar that is the very first thing that you do.

Low floc volume you add carbon, very high-power floc volume you have to drain some of the water. So, strength of BFT, the strength of bio-floc technology lies in the cradle to cradle concept which in terms waste in fact does not exist. What is this meaning waste does not exist? Whatever the waste is there in bio-floc technology is being utilized again and again. Waste nitrogen is generated by the uneaten feed or excreta from the cultured organisms is converted into proteinaceous feed for the same organism. So, that is the beauty of bio-floc technology.

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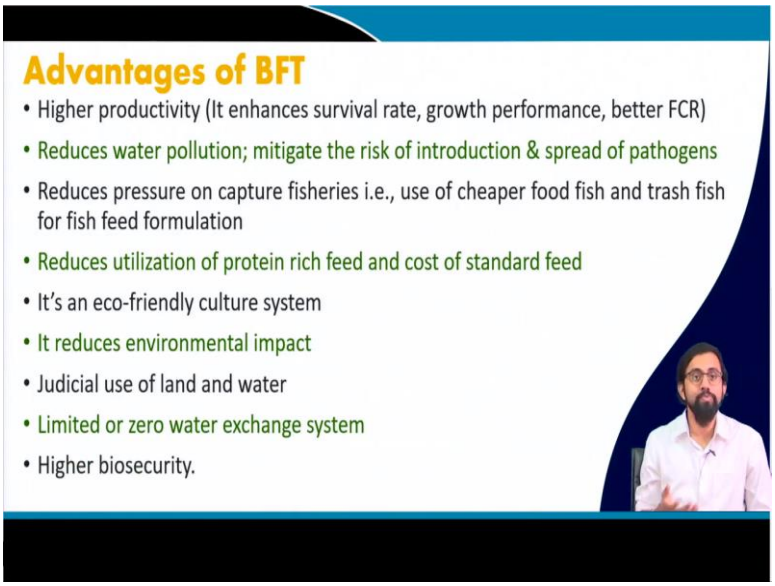

What are the advantages of it? Higher productivity, it enhances the survival rate, growth production, better feed conversion ratio. It reduces the water pollution, mitigate the risk of introduction and spread of pathogens. It reduces the pressure on the capture fisheries that is the use of cheaper food fish or trash fish for fish feed formulation. It reduces the utilization of protein rich feed or the cost of standard feed.

It is eco-friendly sustainable approach. It reduces all kinds of environmental impact, almost all kinds of environmental impact. Judicial use of land and water is possible in this kind of technology. It is almost limited to zero water discharge systems. And also, it provides us like very high biosecurity.

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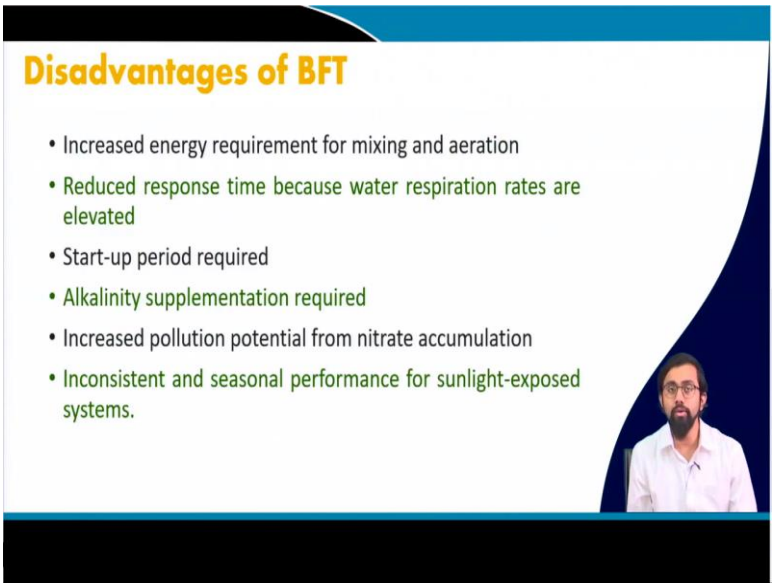

What are the disadvantages of it? There must be some, there is always the other side of the coin. It increased the energy requirement because of the mixing and aeration that it requires. But that can be suppressed that can be somehow that can be troubleshooted by using renewable energy. You just provide a solar system and provide a solar compressor line. Because of that, what will happen, this air compressors or say like, the air flow valve and air flow pump that can be easily powered by the solar panels, that is it.

So, it will reduce your energy requirement or it will become renewable in nature, so it will become, it is not a big issue then. It reduced the response time because water respiration rates are elevated. Start-up period is required because it needs some amount of time. So, in general it does not take more than a week or so, but still that is there.

Alkalinity supplementation is required, sometimes you have to supply it with other sources which will help to reduce the, which will help the increase in the alkalinity of the system in general. Increase the pollution, because in general why, whenever you will be going for some process where ammonia is converted into nitrate or nitrite. So, definitely it is alkalinity (())(26:02) scavenging process in general I can say it that way.

So, we have to supply it with additional amount of, somehow alkalinity supplementation is needed. It can increase the pollution potential from nitrate accumulation, but somehow, we can get rid of it as well. Because you can help to grow some algae because its algae they love to have nitrate because they get their kind of food, they can be reutilized. Inconsistent and seasonal performance of seasonal sunlight-exposed systems.

So, based on the sunlight, also this bio-floc performance varied because of presence of different hydrotropic like different, how to say, these algae that is also there, which is a major part of bio-floc. So, that is why it also sometimes varied, but it is okay, it is not a very big of a issue, big of a disadvantage to think about much rather than the advantages that we have from the BFT.

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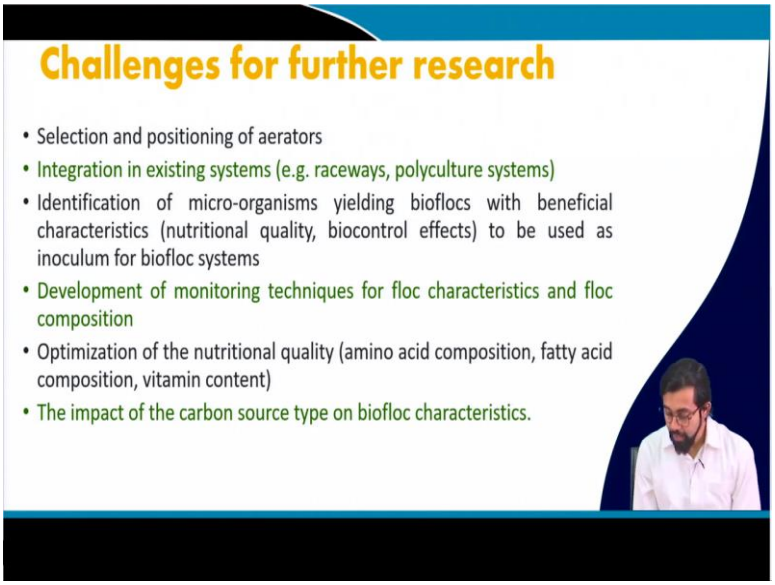

What are the further challenges that needs to be addressed is the selection of proper aerator and positioning them in a proper place. Integration with the existing systems that we call retrofitting, retrofitting is difficult. Because the existing raceways or polyculture systems are there, suppose you want to retrofit it, you want to change the design, and you need to introduce the bio-floc system.

It is difficult, it is little bit difficult. It is not not-doable, it is doable, but it is a little bit difficult. But there are a lot of technologies, a lot of research papers are already available, experts have already been done. So, it is doable. Identification of microorganisms yielding bio-flocs with beneficial characteristics like say, nutritional quality or biocontrol effects to be used as inoculum for bio-floc technology, because it will help the aquatic species to grow much better way.

Development of monitoring techniques for floc characteristics and the floc composition is very important, because at this moment of time, it takes a lot of time. So, we have to develop some real-time monitoring techniques, which can characterize the floc and their composition. Optimization of the nutritional content quality, the amino acid composition, fatty acid

composition, vitamin content has to be optimized because most of the cases because it is a bio-floc technology.

It is actually a little bit hard to control the exact nutritional supplementation to your aquatic species, they can be high someday they can be a little bit low someday, based on different environmental factor based on different operational factors that can go a little bit wrong or that can because of certain environment factor that goes a little bit change.

So, this optimization is very hard in case of bio-floc technology, but it is doable up to a certain limit and that is what being done, that range is being used nowadays. The impact of the carbon source type on the bio-floc technology has to be identified, it is already been done in some of the researches like if you are using jaggery instead of jaggery if you put simply sugar what will happen.

So, there are a lot of literature available on that, like what is the drastic effect of sugar rather than you put the jaggery or you can have different other sugar sources also you can just simply provide and what will be the effect of that it needs to be discussed, it needs to be worked on it like scientists are actually working on it, but there are still some work required.

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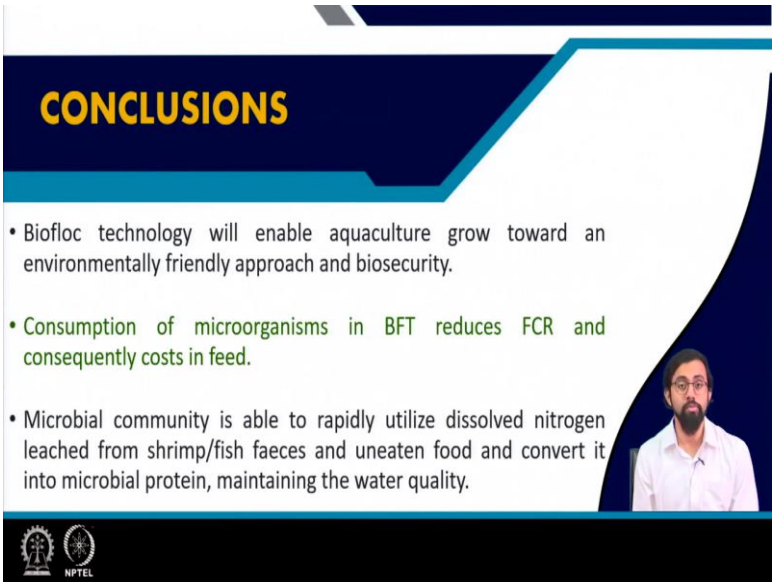

Bio-floc technology it will enable the aquaculture grow towards environmentally friendly approach and it provides as a biosecurity. The consumption of microorganisms in BFT reduces the feed conversion ratio and consequently cost in feed. Microbial community which is growing along with this bio-floc, it can utilize the dissolved nitrogen leached from the

stream for the fishes and uneaten feed and convert it into microbial protein. And by this way, they can maintain the water quality.

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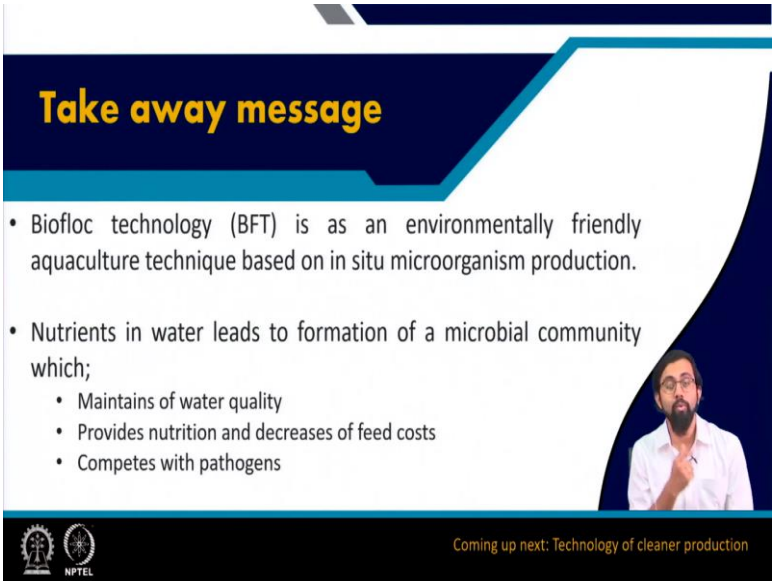

So, in general, the bio-floc technology is an environmentally friendly aquaculture technique based on its in-situ microorganism production. And the nutrient in their water leads to the formation of microbial community which maintains the water quality, provides nutrition and decreases the feed costs, and also, competes with the pathogens. These are the way that bio-floc technology can be useful, can be helpful for us. So, that is it for this module.

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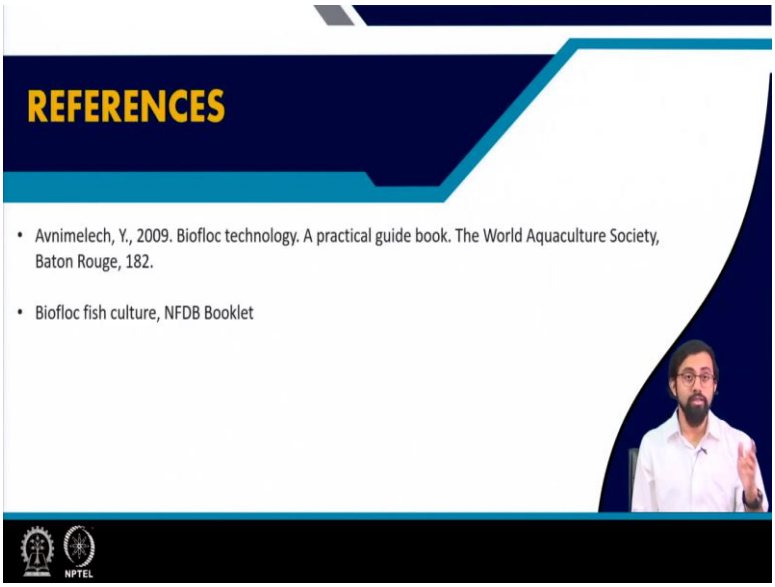

So, these are the references that you can follow for understanding more in details about all these things that we discussed. So, in general, in the coming lecture, I will be discussing more

about some more advanced technology in aquaculture right now and how we can increase the production of aquaculture plus we can have the production of horticulture products also, agriculture product also.

So, that will be called the production of cleaner production in the coming module. So, I hope you got to know a lot of very interesting facts and interesting information from this lecture material. So, see you in the next module. Thank you.