Advanced Aquaculture Technology
Professor Gourav Dhar Bhowmick
Department of Agricultural and Food Engineering
Indian Institute of Technology, Kharagpur
Lecture - 14
Algal Culture

Hello everyone. My name is Professor Gourav Dhar Bhowmick; I am from the agricultural food engineering department of IIT Kharagpur. Welcome to the course advanced aquaculture technology. Today we will be discussing on the aqua algal systems from the for the module-3 of farming system.

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So, the topic that I will be covering are the application of life food organisms, larval nutrition, selection criteria for live food sources, algal culture, parameters affecting the local culture and the microalgae culture methods.

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So, in general live food organisms, from the name itself, we can understand the food which is still in a in living conditions. So, in 1970s, this marine finfish and the shrimp aquaculture, fry were exclusively exclusively captured from the wild. And then this when complete domestication of marine and brackish water started, this hatchery production of fry became a very common practice. This larviculture techniques it is it is in general it various from the conventional nursery and the growout ponds. But, and the techniques that is normally used is the husbandry in husbandry like animal husbandry feed strategies and the microbial controls.

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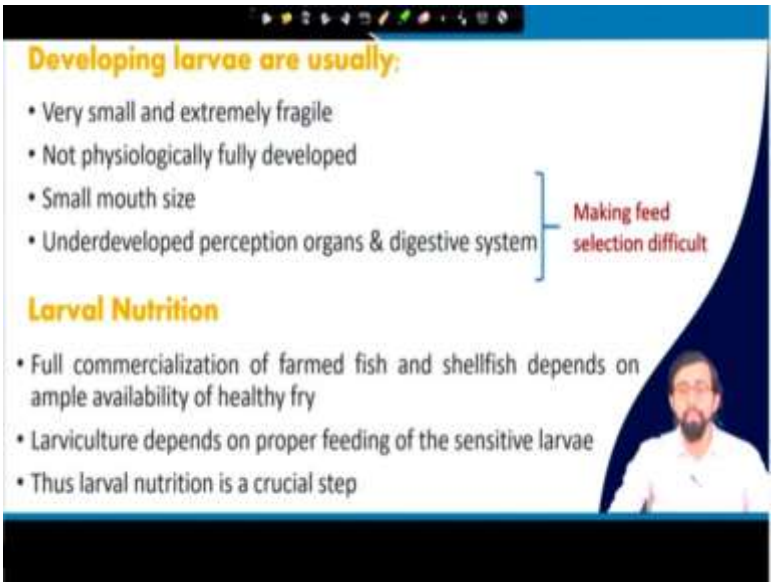

So, in general that the larva that are they have some specific criteria; or I would say like the specifications, it is very small and extremely fragile in nature. They are not physiologically fully developed. They have a very small mouth size and the underdeveloped perception organs and the digest digestive systems.

Therefore, the food that we want to supply to this larva has to be has to have the certain qualities, which will be good enough for them to consume it, and so to grow like make them grow to the for the stage of development. So larval nutrition, if I talk about this full commercialization of the farmed fish and the shellfish, it is depends on the ample availability of the healthy fry. And this larviculture depends on the proper feeding of this sensitive larva's and all. So, thus larval nutrition is very important; it is one of the crucial steps.

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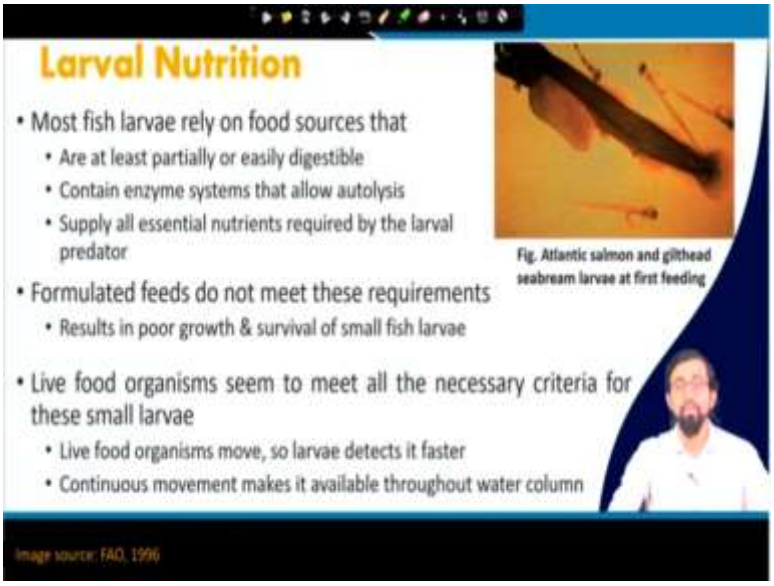

So, what are the, how this fish larva like how this fish larva was this most of the fish larvas that rely; how much they rely on the food source. And what are the criteria based on which they we choose the food source for this larva and all. So definitely, it has to be at least partially or easily digestible, all the food that we are targeting. It should contain the enzymes, it should contain the enzyme systems that allow the autolysis inside the fish digestive systems. It so it should supply the all essential nutrients required by the larval predators.

So, these are the three very essential thing is that is that has to be there for them to consume. And however the formulated feed normally what we do in for other like when adult adult fishes and

adult aquatic species. They are not, they cannot meet the requirements because they cannot meet these requirements in general for the larva species; for the specifically when they are in larval stage, which results in a very poor growth and the survival of small fish larva. That is why people started thinking about the live food organisms.

This live food organisms, they normally they move. So, because of that the larvae can easily detect it; because they have a very poor detection mechanism in their body; because they are in a very early early stage of development. So, this live food organisms this as because they are moving, they are keep on moving. Because of that, they can easily identify this larvae, they can easily identify, they can detect it and they can have it properly. This continuous movement is also available throughout the water column which also, which is which is like. In general, it is the one of the major criteria for the larvae species to have it in their food to have this kind of behavior.

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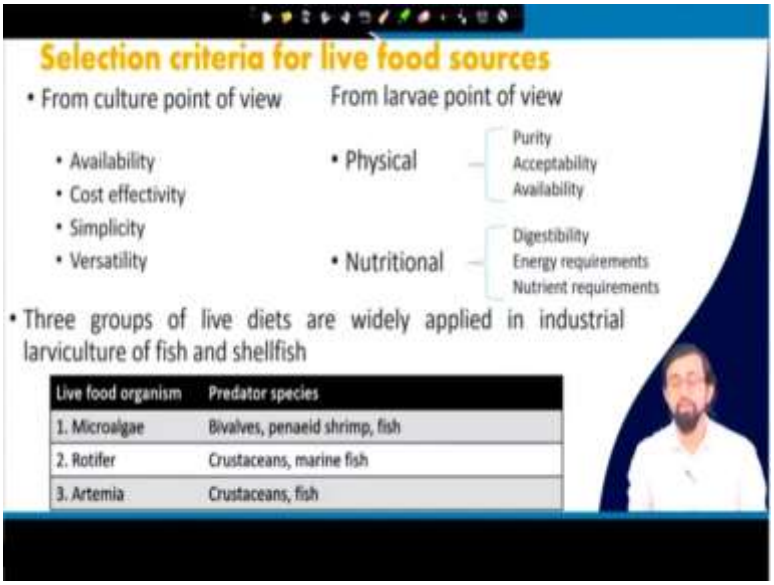

So, selection criteria for the live food sources in general the cultural point of view, definitely it should be available; it should have a cost effective, it should be cost effective in nature. The more simple production, the more easier it is the versatility; the uses of the user using (versus) the uses (versata) versatility of this particular live food organisms for different kinds of fishes, or different other types of; different type of larvas for different type of fishes. So, in larval point of

view, it has to be in physical terms, it has to be pure, it has to be acceptable to the larvae, it has to be available to the larval species.

Nutritional point of view, it has to be easily digestible; it should have a less energy requirement; it should have a less energy requirement for the production of the same. However, it should provide the ample amount of nutrients to the our to our target larval species. So in general, live food organisms based on the predator species it can vary, say microalgae. Microalgae is very famous live food organisms for bivalves, penaeid shrimp, fishes et-cetera et-cetera. So for them, microalgae is a very standard like fishes means like mainly the herbivorous species.

So for them, this microalgae are the major live food sources, which they consume; and they and or their larval source also. For the larva also it is a very major sources of nutrients for major nutrients. Then there comes this rotifer; rotifers are the ones which is a microscopic or semi-microscopic one. And there is another term for rotifer; we call them wheel animal wheel. You know wheel animal also, it is another term for this rotifers. So, rotifers are a very famous live food for the different kinds of crustaceans, marine fishes et-cetera.

Artemia is another type of live food, which also named there is a; there is there we also call them brine shrimps. Artemias is a very small it is actually we call it brine shrimps. Actually it is also kind of crustaceans family, also it is called brine shrimp. So, this brine shrimps are very much famous, it is very much useful for the predator species like for the shrimps, for the other fishes and all. So, for them for those for them, for the when they are in larval stage, it is a very famous; it is a very sort of food for them. And it is being considered in recent days that this kind of live food organisms are very much beneficial for higher growth of your target species and faster growth of your larval species, larval stage as to be specific.

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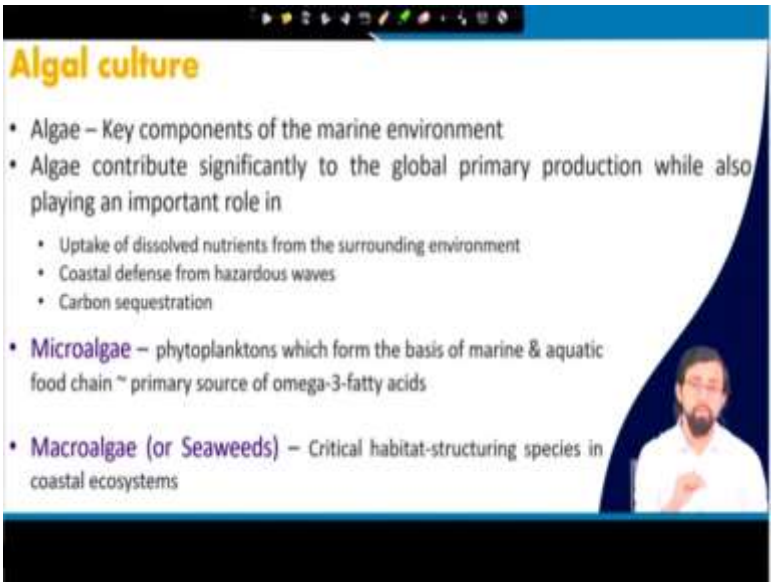

Then there comes the algal culture. In general, it is algae is it is one of the key components for the marine environment. It contributes significantly to the global primary production, while also playing primary production, which is the primary food production that that is what I mean. And while also playing an important role in uptake or up taking of dissolved nutrients from the surrounding environment; and because of that, what will happen? The pollutant load goes down. coastal defense from the hazardous wave, so we can have this sea grasses; and all these sea grasses are how they save the coast coastal regions, coastal mass.

When the sea comes, when the sea wave comes, it will dissipate the energy of the wave. And because of that, it has a lower impact in the landmasses. And so that is why it can it can it acts as a defense system for the coastal regions. Other than that, it causes the carbon sequestration as I already mentioned, that it consumes a huge amount of carbon dioxide and they it also gives back the oxygen. So, it is like a it is acting as a carbon dioxide, carbon sequestration; some major carbon dioxide sequestration technique, which is which we can naturally available and which we can produce artificially also.

We can I mean which can it can kind of utilize this process artificially as well by human intervention, which might providing a huge amount of a lot of seaweed, a lot of sea grass, a lot of mangrove production, so these are it. So, microalgae, microalgae in general, the phytoplanktons which form the basis of marine in aquatic food chain, we call them microalgae. So, they are in

microscopic in nature in general; so, that is why we call the microalgae. Primary source of omega 3 fatty acids and it is considered unlike this microalgae. The difference is like in case of microalgae, they are visible in general.

Obviously, from the name itself we can understand it is it is visible in the naked eye. So, majorly the seaweeds are seaweeds are considered under this category. So, it has a critical habitat structuring species in the coastal ecosystems, which actually does this major, this major job of coastal defense in from the hazardous waves and will dissipate the wave energy.

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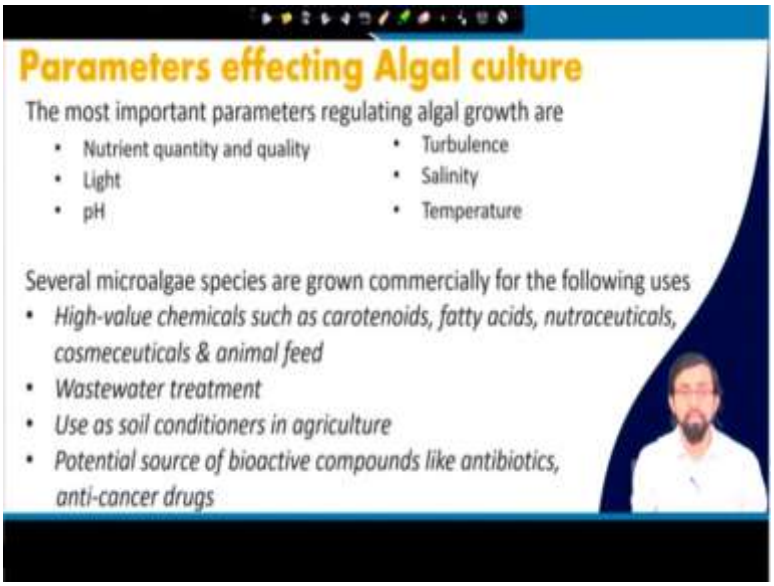

The parameters which can affect the algal culture is the nutrient quantity and the quality, turbulence, the salinity, light, the pH, the temperature. So, these are the ones these are the different regulating parameters which can affects the algal growth; definitely depending upon the culture species, what type of algae it is and where they normally dwell, and what were based on their dwelling nature, based on their choose of habitat. And this this this particular parameters has to be maintained when we try to grow it artificially; we try to grow it by human intervention.

Several microalgae species are grown commercially for the following uses. It can give us a high value chemicals like carotenoids, fatty acid, nutraceuticals Cosmo, cosmeceuticals, animal feed for the personal care products and all like this comes cosmeceuticals and all. This animal feed is for the husbandries and all, we can utilize it. Wastewater treatment definitely as I mentioned, it can consume a huge amount of nutrient from the wastewater; because of that that pollutant load

goes down. It can use as a soil conditioner for aqua agriculture; and believe me, this is one of the major requirement.

This is one of the major how to say, it is it is nowadays people are using all over the world this seaweed extract for agriculture, for a royal for soil replenishment. So, it can we can utilize this seawater extract sea, sorry, the seaweed extracts for agriculture purpose, the potential use of the bioactive compounds like antibiotics, anti cancer, drugs et-cetera et-cetera is also possible from this seaweeds.

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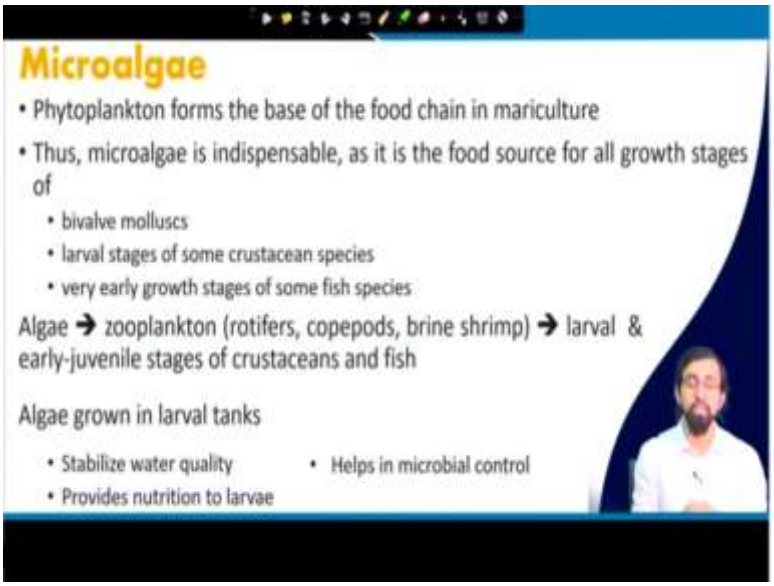

In general, the microalgae they are the phytoplanktons formed from the base of, which is like from the base of the food chain in mariculture. The microalgae, it is actually it is indispensable, and as it is a food source for all the growth stages. So, we have to have this microalgae in the system for the bivalve mollusc, for the larval stages of some crustacean species for very early growth stage of some fish species as well; and obviously, for the herbivorous and fishes as well. In general, how it works? This food chain algae, then zooplankton, like rotifers, this copepods, brine shrimp; or these brain shrimps or this Artemia.

Then, this larval or early juvenile stage of the crustaceans and fish, so that is how it works. In general, the algae which grown in the larval tank, stabilized should have providing the nutrition to the larvae; it helps in microbial control, it stabilizes the water quality as well.

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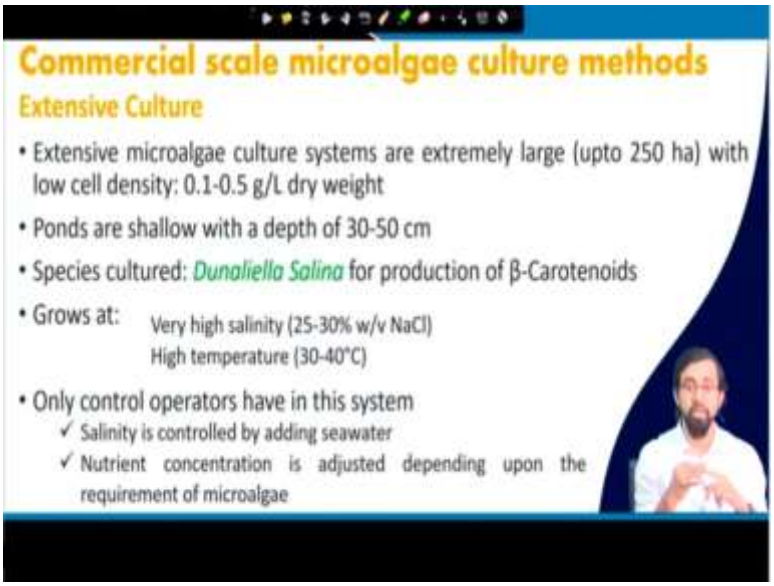

So, the commercial scale microalgae culture methods in general, we have same as like we discussed extensive aquaculture, extensive, intensive and semi-intensive or intensive ones. It is like the same way. In case of commercial stage microalgae culture systems also varies like these three methods; first is extensive. In extensive culture methods, very, we do not actually they have a very very minimal human intervention. In general, they almost no intervention at all in case extensive microalgae culture system.

There can be done in extensive very large area like almost can up to, can go up, can goes up, can go up to 250 hectare. So, like multiply with 10, you can easily identify the amount of size in square meter. So, then you supplied within in a very low cell density of around 0.5 to 0.1 to 0.5 gram per liter of dry weight. Ponds are shallow with a depth of 30 to 50 centimeter and the species cultures mainly, not mainly this is one of the example of this Dunaliella Salina. So, this is one of the example of the species that can be culture; it is actually kind of a microalgae that can survive in the extreme environment as well this D Salina.

So, they can be utilized for the production of beta-Carotenoids; and it can it can grow in a very high salinity 25 to 35 percent 30 percent is weight by volume of sodium chloride and the high temperature up to 30 to 40 degree Celsius it can easily grow; so this can this kind of species. So, only control operator have this system is like the salinity, which can be controlled by adding seawater. If you see that the salinity of this farm is going down; you can simply open the sluice

gate. And whenever the high tides flow condition is maintained, the canal should be designed, canal should be developed.

And through this canal system and through this sluice gate, you can easily control the flow of sea water, influence of the sea water or inflow of seawater in your farm. Nutrient concentration is adjusted by depending on the requirement of the microalgae, you can supply it additionally the nutrients nutrients to the system.

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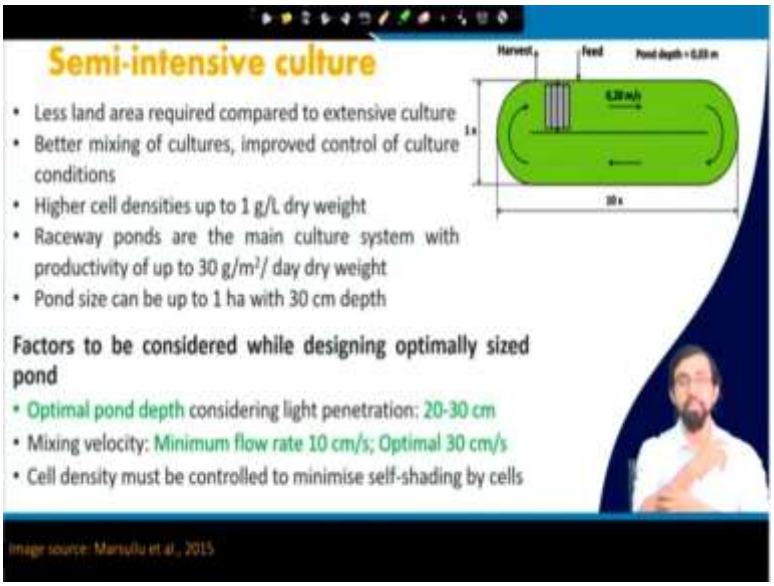

Then, there comes the semi-intensive culture. So, we already know what is the semi-intensive culture; it means there needs some human intervention. So, it has a less, it requires, it require like in general it requires less land area compared to the extensive aquaculture, extensive this algae culture. Better mixing of culture can be done which can improve the control of the cultural condition. See in this particular case, if you see this is a particular raceway what I have designed, where you see this harvest the place where we can provide the feed 0.2 meter per second of flow is maintained.

The pond depth or the time depth is around 0.03 meter with a. You can see the size, the width length ratio is given 1 to 10. Like if it is 1 say 10 meter is the length of the; 10 meter is the width of the tank, so 100 meter should be the length of the tank. So, that is how it is to be designed. Better mixing of cultures it improved the control of culture conditions, higher cell densities up to 1 gram per liter of dry weight can it is it is possible in this kind of case. The raceway ponds are

the main culture systems with the productivity of up to 30 gram per square meter per day of dry weight.

So, in general, so this is the dry weight; this 30 gram is the dry weight that I am talking about. So, pond size can go up to 1 hectare with 30 centimeter of depth. So, that pond depth it should be it is wrong actually; it should not be 0.03, it should be 0.3 meter. So, just remind this and this is now the 0.3. This is 0.3 meter, it is like 30 centimeter, not the 3 centimeter. The factors to be considered while designing the optimally sized ponds; the optimal pond depth around for considering the light penetration, it has to be 20 to 30 centimeter.

The mixing velocity, minimum flow rate has to be 10 centimeter per second and optimal is like better to go ahead with the 30 centimeter per second. The cell density must be controlled to minimize the shelf-shedding shading of by the cell. What does that mean? If you have very high alkyl bloom in your system in your in your culture. What will happen? Because of this algal bloom, so, it will give us shading effect to the species that is dwelling in the bottom or the in the column region.

So, for them they will not be supplied with the enough amount of sunlight. So, proper mixing density has to be mixing velocity has to be mentioned maintained and also cell density has to be controlled based on that manner; it cannot go, we cannot go ahead with the very intensive production.

So, this is how semi-intensive culture look like. And how in general when we go for culturing for a very huge amount in a when we have; we do not have any land issues. We can procure land and or we can lease it, or we can say rent it and land; and we can have our culture of microalgae, so we can go ahead with these kind of systems.

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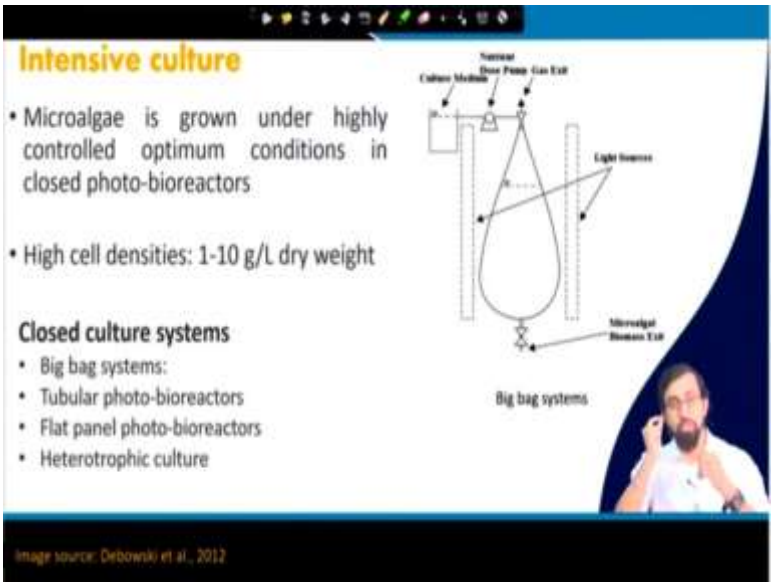

Last but not the least is the intensive culture. From the name itself you understood we are we normally provide in case of intensive culture a very well optimal situations, optimal conditions from each sense, like based on the light, based on the amount of carbon dioxide that you are supplying; I mean based on the nutrient that is available in the system; so everything has to be optimal. And because of that, because of this optimal environmental conditions or the environmental consideration like (situ) the parameters that you are providing to the system, it can grow very intensively.

It can grow the the amount of algae that is present there can grow very at a very high rate and the production rate is. This kind of systems are actually nowadays used for the biofuel production and all. So, we simply extract the lipid and then we use it for the bio fuel production and all. So, that is a very standard methods of the recent days studies based where people are working on this green fuels and all; so they go for this intensive culture of microalgae. It can be grown under a highly controlled optimum conditions that as I already told, and in closed photo-bioreactors.

These kind of systems are called photo-bioreactor, where because of the artificial light that we are providing; that is why we call it photo-bioreactors. Obviously, it is a bioreactor where will be culturing some biological living organisms. It can have a high cell density up to 10 gram per liter of, per 10 gram per liter in on the basis of dry weight it can go, so which is like very high. So, the

culture systems this kind of culture systems can be of different type; big back systems, tubular photo-bioreactors, flat panel, heterotrophic cultures and all.

So, big back system is look like this. You see the culture if you see the picture figure there. So, the culture medium through the nutrient dose permit comes to the these big bags or this particular transparent plastic bags, or it can be made up other materials as well. So, where the light sources because of the light source, it penetrates till inside the system, and you can grow the easily you can grow the algae algae there. At the end if you at the end when it goes, when it starts settled, you can easily take it out from the this bottom ball part for the exit system; the microbial biomass exit system; so that is how it works in case of big back systems.

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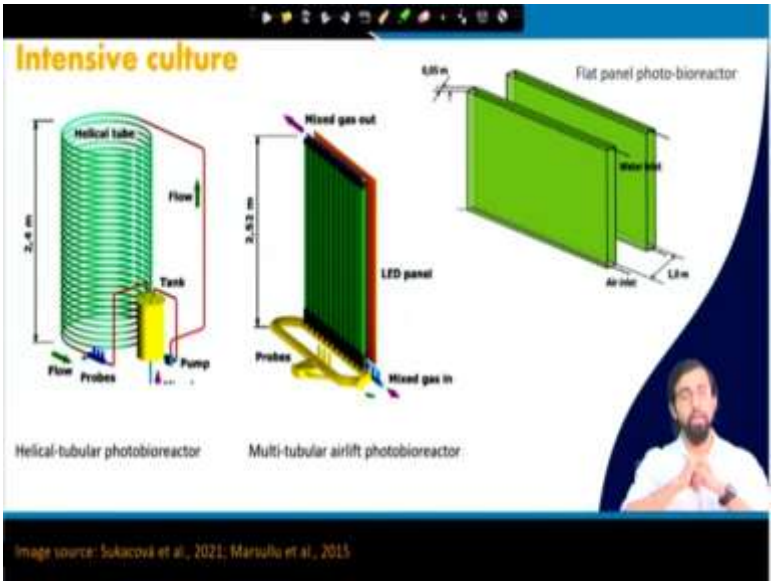

And these are some of the very advanced techniques. So, these are the techniques which nowadays people are using all over the world, like it is not limited to this only these three type of structure; it can be any structure based on a proper scientific design. See the first one. If you see this helical tubes, those tubes are nothing but they are utilized for the culture of algae. There are algaes growing there inside this glass tubes. So, you will see the this is highly optimal situation is provided there. Because of that, there is a huge amount of, there is a the rate of production of algae is very high in this kind of system.

And if you see the tanks through the pump, the flow is provided, flow of nutrient media. Algae is grown in the in this helical tubes and, so this is how it works. So, if the next time this multi

tubular airlift photo-bioreactor if you see. So, the the in the probes and through the mixed gash is come and go inside from the bottom; and the gash which is coming out of the system. So, this actually provides the carbon dioxide or the ample amount to for them to grow. Normally, we mix it with other gaseous also or it is better to go ahead with the flue gases and all.

It can feed the it can fit those flue gases from the industrial region. Nowadays, these are used this kind of photo-bioreactors, and multi tubular; early photo-bioreactors are even used in industries for carbon dioxide sequestration. So, they are having this multiple layer of stacks of photo-bioreactors and there it is fridge like structure. We have this fridge or incubator like structures, where we have this multiple sheets of these photo-bioreactors. And the flue gases industrial flue gases where which carbon dioxide rich or the greenhouse rich gases are actually supplied through it.

So, because of this supply of this carbon dioxide rich gaseous, they consume the carbon dioxide; they even they utilize it. And for the growing of the biomass, they convert it into the biomass. And by this way we can get rid of the global gas greenhouse gases like carbon dioxide and all. So, that is actually a very standard practice; not a standard practice. it is a very cutting edge technology. People are using it. I know a couple of startups all over the world, they are working on it. And they it will be the, it is actually the future; it is actually I am telling you this technologies that I am discussing are the future of human civilizations.

People will be using it a lot in their daily purposes in different places. And not only that this algal biomass that you are actually we are actually harvesting out of these reactors, can be utilized for the production of the this different biofuels and all. This biofuels or the bio diesels are very clean clean energy source. These are actually been used even to run a car nowadays. So, in Germany, people in Germany, this technology are now practiced in different places, especially, in Munich and Berlin; so, they are working on it.

So, where they have utilized this kind of technologies for even running a small, automated small vehicles. So, in future there is a high chances in this there will be in near future will be utilizing this different type of biofuels for the for transportation purposes. So, this other than that, there is another type of flat panel photo-bioreactor; you can see there is like air inlet and the water inlet. And actually there is the medium inlet and I mean like the nutrition this nutrient medium that we normally supply there.

And in this to this two parallel units in between them, maybe we put we can put the light; or in it is like a sandwich like structure. We can put the LED light, we can provide LED panel, we can provide this LED panels have; we can optimize it in such a way there is a chance the exact photo exact luminescence, or exact the wavelength of light that is required for the chlorophyll. For that can be utilized by the chlorophyll of those chlorophylls of those those microalgae; they can utilize it. And because of the exact amount of luminescence that we are providing, exact amount of wavelength of light that we are providing; they can utilize it in optimal way.

And they can they can convert it to the biomass in a very speedy manner. So, that is how the scientists are working on nowadays in different sector, in this kind of sectors, how they are utilizing it. And these are the advanced technologies that I was always discussing you in this lecture series, and maybe I will discuss more in that in later lectures as well, like how these advanced technologies are changing the world and the human, the future of human civilizations.

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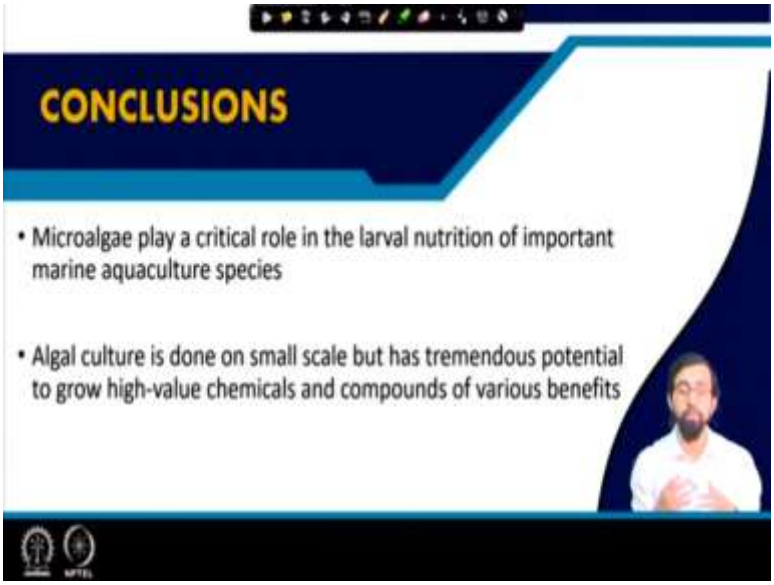

So in conclusion, this microalgae it play actually a major critical role in the larval nutrition of important marine aquaculture species. It is also this algae culture, this algal culture is done in a very small scale; but it has a tremendous potential to grow high value chemicals and compounds for various benefits. And in near future, it can simply be the one of the one of the fastest growing sector in the in the in terms of this aquaculture practice. I am telling you this microalgae, macroalgae is having in this book have a very high impact on the human civilizations.

And people who will be working on this more and more often than now, because these seaweeds I told you they seaweeds and all, this has a huge impact. It has a lot of byproducts that we can recover out of it. But we are not utilizing it at this full stage. Forget about the full fledged, like not even like percentage is a very small fraction of it is utilizing in all over the world. There is enormous possibility of utilizing the seaweeds. Second thing is this microalgae. Microalgae has an enormous amount of benefits. So this microalgae is, it is like a liquid gold. So, if you can use it properly, if you can produce if you can produce it in a very optimum condition.

If you sustainably produce it and scientifically form it, there is a high chance you will get a very high amount of economic return out of it and which you can utilize for your economic benefit; and also for the purpose of the development of your country's GDP.

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So, the takeaway messages from this lecture is the culture of algae is definitely improves the primary production as well as the various benefits of the marine ecosystem. This microalgae forms the basis of the food chain for all the marine aquatic organisms and is this microalgae or macroalgae or the seaweeds are highly beneficial to the habitat and to the system in a general in a in a whole. These are the references that I have taken the information from; so you may consider this references too.

You can pause the video and you can see this refer and look into these references for, in order to have more idea more information about the discussions that we just had. Thank you so much. Let us meet for wait for the next lecture.