Advanced Aquaculture Technology
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Lecture 55
Zero Waste Recycling

Hello everyone, welcome to the advanced aquaculture technology course and this is the fifth lecture, the last lecture of the module 11, Aquaculture Industries. This lecture material is all about the zero-waste recycling. Whatever we have discussed in the last 3-4 lecture, I will be giving one brief and I will also give you some additional information on what is zero waste recycling. So welcome. My name is Professor Gourav Dhar Bhowmick, I am from the Agriculture and Food Engineering Department of IIT Kharagpur.

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The concepts that I will be covering in this particular lecture material and what is first of all to start with, what is zero waste? Like what are the inputs and outputs of aquaculture and how they can somehow be utilized at all the outputs of aquaculture, can further be re-modified in order to adhere to the zero-waste concept? What are the waste of aquaculture? Fish byproducts and zero waste and the systems which use the resources. And we will go ahead with the 1-2 case studies where fish waste can be utilized and it converts into the wealth. So, we call it fish waste wealth.

And the fish silage production and all also we will be discussing details, so just to give you some idea that nothing is waste. Like you can utilize each and everything of your production house, each of your productivity or produce from your farm, and how to do it? I have already

discussed a little bit about the various byproducts. In here also, I will be giving you more overall idea about how to do that, in your farm. In your industry, in your fish processing industry, in your aquaculture farm, how you will utilize each and every stage of your waste and how it can be utilized as a resource for the second stage of it or the other follow up stage of it. Perfect.

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So, to start with, first, I hope I do not have to say these things like to you, like you already know, from the name itself, what is zero waste. Zero Waste is a concept we… like, you know, people started adhering to it like when they started thinking that we are not only you know, by ourselves in this nature, in this world, it is not that we only think about ourselves, we have the production for our benefit and that is it and then we throw away all the rest of it to the nature.

Because earlier the population was less, that time nature can somehow self-sustain or self-proclaim its originality or they can still, it is possible to a certain stage the harm that we were doing for long for this pre-industrialization era. But now we crossed that stage, for the last 100 year we crossed that stage like anything. So, we cannot do the all anthropogenic activity that we are doing right now to the earth without thinking about its environmental impact.

So, to know about… to do something, which does not have any much of environmental impact or even if it is, it does have, actually each and every changes you want to do in the nature is does have an environmental impact, but what you can do? You can minimize it, you can minimize that load in the environment or somehow we try to do it neutral, even negative

impact means you somehow try to even help the environment to grow sustainably so that all the harm that we have done is somehow be neutralized.

So, this zero-waste concept is one of such. This is one of the promising and attractive ways of solving the waste management and the recycling issues. We have the science and technology, we use different scientific and technical knowledge in developing some products and all and once the product is done, all the rest of the material we throw away. What we can do? We make a proper regulatory body to maintain this, to have a proper law, proper regulation who will say yes? No, you cannot do that, you cannot just throw that wastewater which is coming from your industry just like that into the surface water body.

You have to, what you have to do? You have to treat it. You have to treat the water. Try to see that what are the other stuff that you can collect from that waste water and just give me one example. And then at the end, the water which is actually clean enough that you can throw it in the surface water bodies and which will not cause any environmental harm, then only it is possible, then only I will allow you to throw that water to the surface water body.

If the regulatory bodies are strict enough, if they have proper stringent laws about it and the rules are written about it and all the industries or the farms are actually… must have added those laws and all, then what they will do? They will generate the actually environmental awareness.

Because of the environmental awareness this regulatory bodies are doing, all the policymakers are doing, this environmental, because of this environmental awareness this industry is well, first they think like okay, it is an unnecessary rule and all, we have to follow it, it increases our, it reduces our revenue, the net economic return and all. However, for the long run, it is beneficial for all of us,

So, then they will start adhering to these laws and they will start introducing some techniques by which they will reduce their waste imprint or the waste footprint. Because of the lower waste footprint, they started utilizing, because they started utilizing actually they started getting more amount of economic benefit because they are utilizing all the byproducts from that wastewater or silage waste product and then they utilize it for different other purposes.

There was a time you know, I am not giving you the name of the company that they are generating a lot of waste at certain moment of time in one city in India. So, what happened? This industry, they started generating a lot of waste and all, then the regulatory body says no,

you cannot do that. What they do? They put some tree, certain trees there and then you will be surprised. After 15 to 20 years, the tree, the amount of tree that they have shown there and they are giving them additional amount of economic return because of the food that they are getting out of it.

Those are exported from India right now, because of its high quality and all. So, initially what was nuisance for them, what was additional burden to them, it becomes some economic, some way of getting some higher economic return. So, that is how zero waste can be, you know, this concept can be promoted to the industries with examples like this, the zero is not always a burden to you, but it can be further beneficial for you to get some extra benefit because you know, waste is just a misplaced resource. So, zero waste approach is to inspire reshaping the resource supply chain. As a result, the entire product or the byproduct can be reused and recycled.

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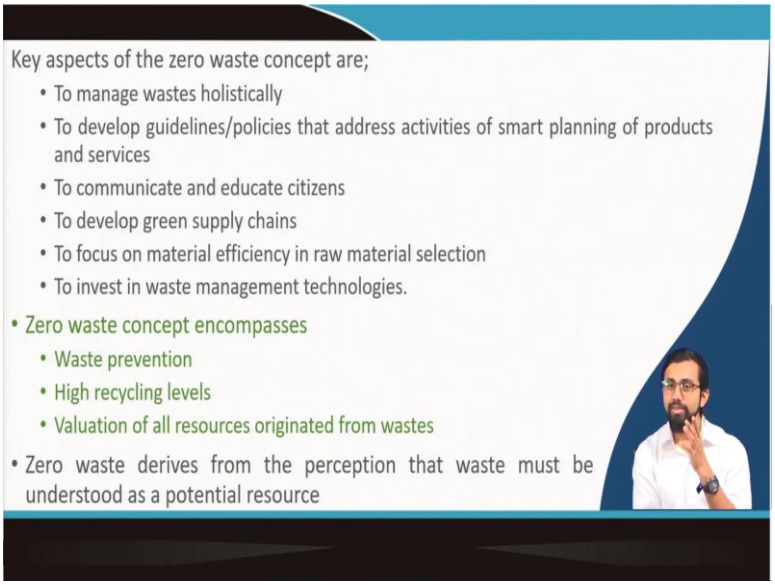

What are the key aspects of zero waste concept is to manage the waste holistically, to develop a guidelines or the policies that address activities of smart planning of products and services, the whole product line actually, to communicate and educate the citizens or the beneficiaries, to develop a green supply chain and also to focus on material efficiency in raw material selection.

What does that mean? Suppose you are utilizing certain raw material, which has a very low efficiency which is like you know, which you can utilize only 50 percent of it and the rest 50 percent goes just like you are not using it. Just to give you one small example you know,

forget about this or that, the industry thing and all, just simple pure aquaculture farm. Suppose when you have a fish, you are giving them food, suppose a flake food or say like pellet food, which that fish is not utilizing at all because of certain factor and all.

Now, you think about it, now you put your brain into it and you started thinking like what can be the reason why the fish is only eating 50 percent of it and 50 percent goes uneaten? Either you have to change the feeding design, either you just simply change the food constituents and make it more lucrative, more available or viable for your fish, they will start eating 70 to 80 to even 90 percent of the fish feed.

Just by changing the texture, wow just by changing the nutrient contents and just by changing the amount of, you know just some additional constituents that you can supply which, fish very much love it and they will start consuming more and they will convert this into their biomass in more amount and because of that, feed conversion ratio will be released and this is how we can, this is one of the example of you know you have to focus on metal efficiency in raw material selection.

Also, to invest in the waste management technology like in case of aquaculture industries, if I talk about, you have to go ahead with the recycle aquaculture system, you can go ahead with the aquaponic systems. So, all these technologies are helpful for helping you to manage the waste in a very holistic way. In general, zero waste concept encompasses the waste prevention, high recycling level and also valuation of all resources all generated from the waste. So, zero waste, it derives from the perception that waste must be understood as a potential resources.

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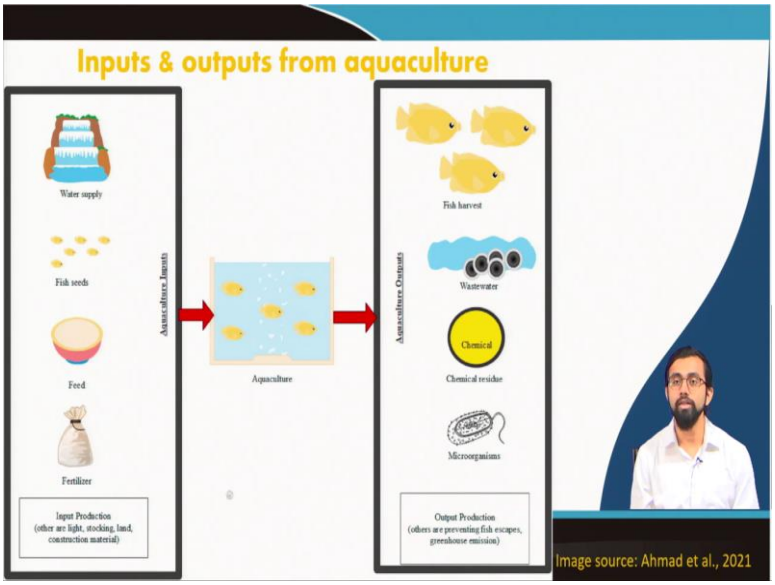

Just see here. What are the inputs and outputs of aquaculture? What are the inputs of the aquaculture? You have the water supply, you have fish seeds, you have feed, you have fertilizers, other than light, stocking, land, construction materials, etc. then there is your aquaculture production. I the end you will get the output. What are the outputs? The harvested fish, the wastewater, the chemical residues, microorganisms, other than the greenhouse emissions and all.

So, out of them, what are the good thing that you can find out? You know, in a very layman's language, the first good thing is the harvested fish. So, you have harvested the fish, that is pretty much good, that you can use, now you do not have your belly full of these fishes and all. So, it can be used for human consumption. First think about it, what about the wastewater that it generates? What about the chemical residues that it generates?

What about the microorganisms still prevailing there and what about the greenhouse emission that it does cause? We have to think about it. In order to go for more sustainability issues and all, when we talk about sustainable production and all, which is very much essential, we have to talk about it. So, when we talk about all these things, we have to think about proper preparation, proper method or process by which you can deal with these problems as well. You can treat the wastewater and to put it back to the aquaculture tank, that is it.

You are utilizing the resource again and again. Chemical residues, you have to treat it, you have to use it, convert it to any biomass and all, then you can perfectly collect it and use it for some manure and fertilizer production. Microorganism, you have to simply kill it, either UV

or ozonation or some, some way you have to kill it before you throw it to any other surface water body. That is the thing that we need to do.

These are the stuff that we need to do. How we can reduce the you know the emission? They just say that if you can, if you reduce the energy that it requires for aquaculture production, that will definitely reduce the energy emission. So, what you can do instead of providing complex, like designing in a very awkward way, suppose you have different in your farm, in your nursery pond to, say like rearing pond or something, so this all the water circulation, it will be better if you can do it all by gravitational method.

You can think about it by which you can use this gravitational water all the time so that you will reduce the utilization of the pump in your system, in your farm. So, in general, so when you design the hatchery, you have to think about how you can reduce the greenhouse emission, how can you reduce the energy application and all. Or if you cannot reduce, go ahead with renewable energy, go and simply use the solar energy.

Solar energy, it reaches a very optimal stage already. So, go ahead and use it and definitely you do not have to worry about you know, not only that solar energy will give you some energy to neutralize the energy demand but sometimes it may also cause some energy surplus which you can even use it for your other than farm activities also.

So that is what we need to think about. That is how we need to think, how we can sustainably go ahead with aquaculture farm production and aquaculture fishing, I mean the fish product and byproduct processing and all. So, all these things has to be put has to be there in our mind.

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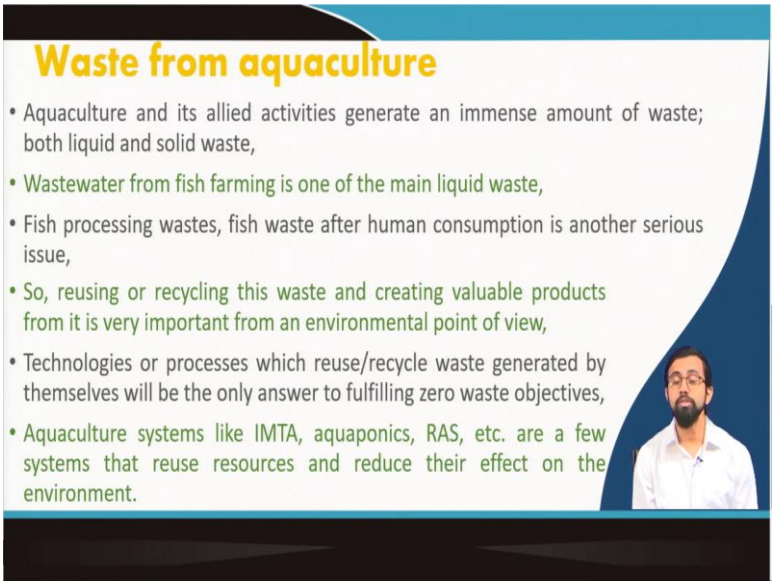

What are the different waste that you can have from aquaculture? In general, it generates huge amount of liquid and solid waste. You know it right? So, in general, one of the major liquid waste is the wastewater coming from the fish farming processes. Other than that, but this fish processing waste and the fish waste after the human consumption is another serious issue but this can also be categorized as liquid waste and the solid waste.

So, the reusing and recycling of this waste and creating valuable products from it is very important from the environmental point of view, is not it? And also, the technologies and the processes, which actually reuse or re-cycle this waste generated by themselves will be the only answer to fulfill the Zero Waste objective of any farm own. Aquaculture systems like IMTA, if you remember this multi trophic aquaculture system, the Aquaponics, recirculatory aquaculture systems, etc are a few examples that can reuse the resources and reduce their effect on the environment.

So, if you remember like, I already discussed like, what can be done, how to reduce and reuse the processes, reuse the waste? You go for some high-end technologies, high end technologies, but which will reduce your environmental impact and which will also give you higher economic benefit, proper waste utilization and all.

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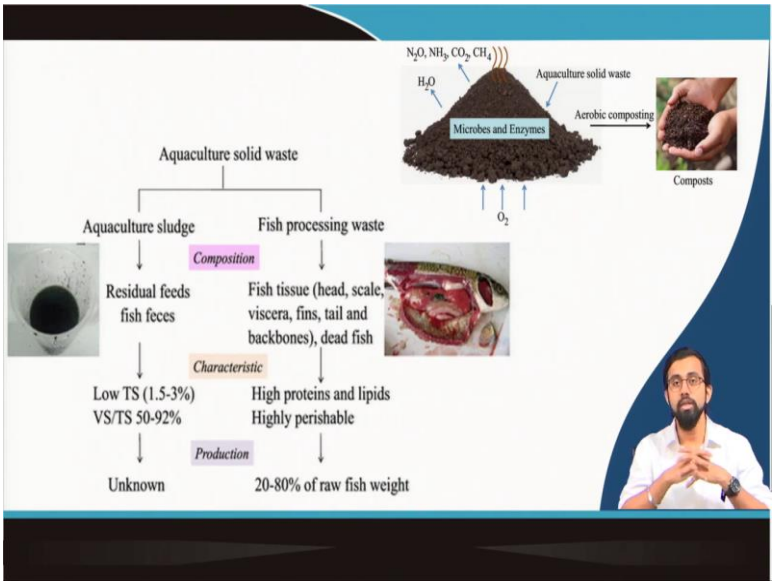

If you see the aquaculture solid waste, how in general it has this aquaculture sludge and the fish processing waste. In aquaculture sludge, they have this residual feed or the fish pieces and all, which is having a very low total solid, like 1.5 to 3 percentage but volatile solid or the total solids around 50 to like, volatile solid to total solids ratio is around 50 to 92 percent and all. So, this volatile solid means it is very high. The higher amount of volatile solid means high amount of, what is there? It has a very huge amount of organic matter or the biomass, organic biomass and all.

It kills that because remember I told you the volatile suspended solid is indicative of the amount of microorganisms present in your system, leaving or like in dead condition, you cannot tell it but in general this volatile suspended solid shows you the amount of suspended… the organic biomass present in your system. Another is like fish processing waste. It normally contains the fish tissue-head, skill, viscera, fins, tails, backbones, dead fish etc. And also, it has a very high protein and lipid and very highly perishable which contains that 20 to 80 percent of the raw fish weight.

What you can do with this solid waste? You can use it for different purposes. Just simply to give you one example, you see the aquaculture solid waste if you go ahead with the aerobic composite, okay if you go for composite waste culture and all, you put it in the aquaculture sludge with time. What happened? Because of the aerobic microorganisms which grows there, they will convert it to different kinds of compost and which can be utilized for manure or fertilization purposes and all.

And it is a very organic organic in nature, it will increase the your crop yield and all because it has a lot of beneficial nutrients which is very much necessary essential for the plants and all and it will also help you get rid of this nitrous oxide, ammonia, carbon dioxide and methane and H2O and at the end you will get a proper composting material and all.

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So, what is the significance of fish byproducts in achieving the zero waste? Remember in the last lecture, we discussed about all the fish byproducts. I am repeating it again, these fish byproducts are a major reason how we can achieve the zero waste from the aquaculture industries or like fish processing industries. In general, the byproducts of this fish actually represents 30 to 70 percent of the whole fish even you can imagine up to 70 percent of the whole fish.

So, you collect a fish, you capture or catch a fish, then suppose you only have a portion that you really like the meat portion, still, you throw away the maximum part of it, it can go up to 70 percent of it, which can be a very good source of macro and micronutrients. But what you do, you just simply throw it unutilized which ends up as a waste. So, to minimize the food loss and the waste from this fish value chain and at the same time to improve the fish waste management strategies, several methods can be used to convert this byproduct into value added products.

We can use it for animal fish ingredients like fish meal or fish oil, if you remember, we can use it for biofuel and the biogas production. We can use it for dietetic products like chitosan and, we can use it for pharmaceutical products like Omega-3 oil and all, fish leather, fish

silage and fish fertilizers and all. So, there are just to give you some examples like you know by which you can have this waste to wealth transformation. All these products I have already discussed in the last two lecture. If you remember there we discussed in detail like what are those different byproducts and what are the use of it.

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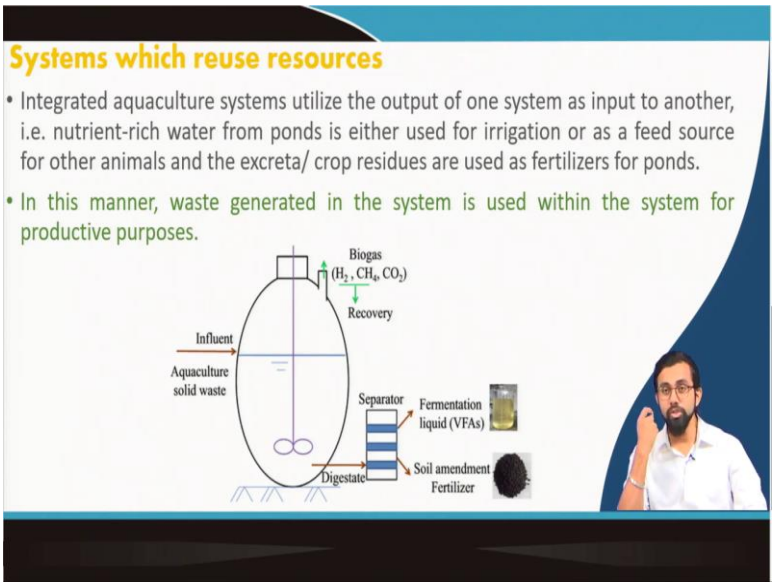

Then other than that, this integrated aquaculture system is also utilized, the output of one system as input of another. Suppose the nutrient rich water from the pond is either it can be used as an irrigation purpose or can be a feed source for other animals and the excreta or the crop residues are used as fertilizer for pond.

So, they can be interconnected and they can be well utilized for different purposes and all. So, in this manner, the waste generated in the system can be used within the systems or for productive purpose or it can be intra-systems or inter-systems as well, like you know from agriculture, aquaculture when you go for this this kind of culture, when you go for this agriculture aquaculture systems in general so, you have this rice field, you have this crop, you have this fishes and all which will help each other to, which will help the symbiotic relation to grow and at the end it will help to reduce the waste matter generation and all.

You go for this, see the effluent in the solid waste how we can do in this, how we can get biogas out of it? You simply put it in the in a digester. In a digester what will happen? There will be a mixture and there will we can even provide it with the oxygen sometimes or if you do not want oxygen, like it will be go for the fermentation process and at the end it will go for separating the strap, you can get the fermentation liquid or vfa, mainly volatile fatty acid and

you can get the soil amendment fertilizers and also the biogas can be generated which will come into contact with the atmosphere, with the hydrogen, methane, carbon dioxide and all.

Now, you say like it is obnoxious these are all the greenhouses and all. So, that is why we can utilize it. We are not just throwing it right away to the atmosphere, you can utilize this biogas. If we have enough amount of digested in your system, you can produce. Definitely, you can use it for continuous production of biogas, which can be useful for your normal household and all. You can create it, you can easily store it and you can utilize it for the reuse and all.

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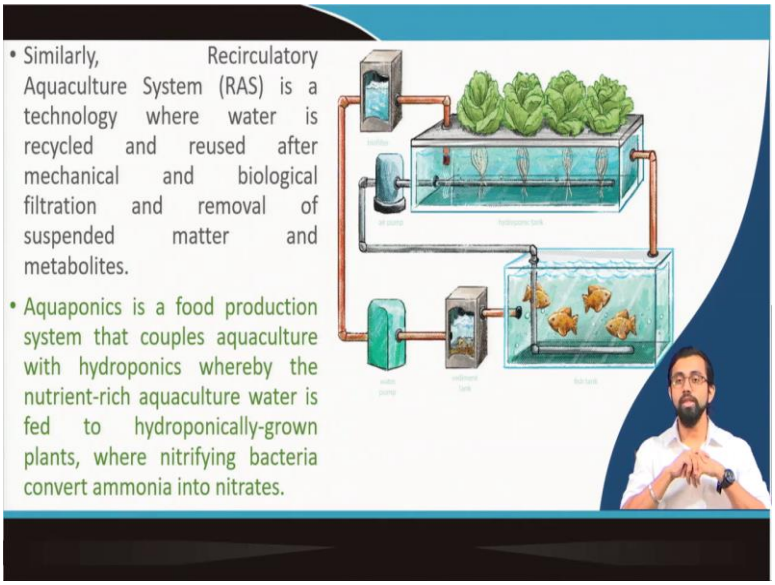

Although these technologies, RAS technology and aquaponics, we have already discussed in earlier modules. In RAS you know, we keep on using the same water which is recycled back to the pond by treating it in the bioreactor and which will and also in the, there will be like in those basic separator, all the solids separators, all the drum filters or something like that we can use to get rid of all the suspended matter and the metabolites.

And at the end the all the organic matter can be consumed and the nitrogenous organic matter and all this into pollutant, load can be reduced by using the organic treatment method, I mean the biological treatment method. So, at the end whatever the product that we will be getting it is very low in pollutant load. Same way the Aquaponics system, you remember we discussed about the aquaponic systems how it was? The fish waste product, you are giving it to the plant, plant is very happy, they are utilizing it.

Before provide it to the plant what you can do? You can little bit change the variant, you can provide it in the biofilter. The biofilter, what they will do? They will convert the ammoniacal

waste coming from the fish tank to a nitrate waste and all. So, this nitrate is actually this, because of the presence of nitrifying bacteria this nitrate is helpful for your plant to grow and then this plant will be very happy to grow there and they will get that, they will consume in this nutrient and they will grow very fast and at the end they will reduce the pollutant load and the water which will be after the treatment, it will be coming to the fish tank again. This way you can generate a whole resource efficient cycle which will give you higher economic return with very low environmental impact, which will give you the idea that we are talking about zero waste.

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So I will give you one or two different case studies. I will discuss in this module, so to give you some brief idea about how it works, like you know fish waste and how it is actually been done. This fish waste in country, densely populated country like India, it is a really something to worry about. And normally what we do? Normally, major of this fish waste is actually dumped in the coastline areas. To tackle this problem our Central Institute of Brackishwater Aquaculture CIBA, we have their head office in Chennai, India.

So, they teamed up with the local people to turn this waste into wealth. They come up with some innovative technology to convert this fish waste into fertilizer products. Like they provided the training, the equipment to convert this fish debris into two value added products- first, the plankton plus that the name which is used for in aquaculture itself to boost the healthy plankton and the second is Hortiplus which is used for organic manure for horticulture. They have shown the 100 percent utilization with nil wastage.

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So, it is doable, it is doable in real life scenario. If you see this, it is done in India, this plankton plus and Hortiplus. What they are doing, actually they are utilizing this all this fish waste that is collected from the market and all this, they have this these silos with this blade and all, they cut it in a small piece which makes this black slurry and then they add some enzymatic, specific enzymatic solution.

This enzymatic solution because of that, after a couple of days of fermentation, it will convert and then they will use the centrifuge and all, at the end they will get the very slurry part of it which is used for growth, which is called as a plankton plus and which is used for healthy growth of the planktons in the aquaculture and by means of that you can reduce the fish feed requirement because if the plankton growth is very high the fish can get enough amount of plankton to have.

So, this way you can use the fish feed requirement and Hortiplus, at the end of whatever the solution is that you are getting and whatever the, I mean like the solid part, the slurry part that you are getting, that you can dry it and at the end you will get the powder which can be used as manure which is a very high nutrient based manual that you can utilize in your horticulture purpose or like agriculture purpose. Just to give you one example, like 50 kg of fish waste can be used for generation of almost 40 kg of plankton plus and almost 1 kg of this Hortiplus and all.

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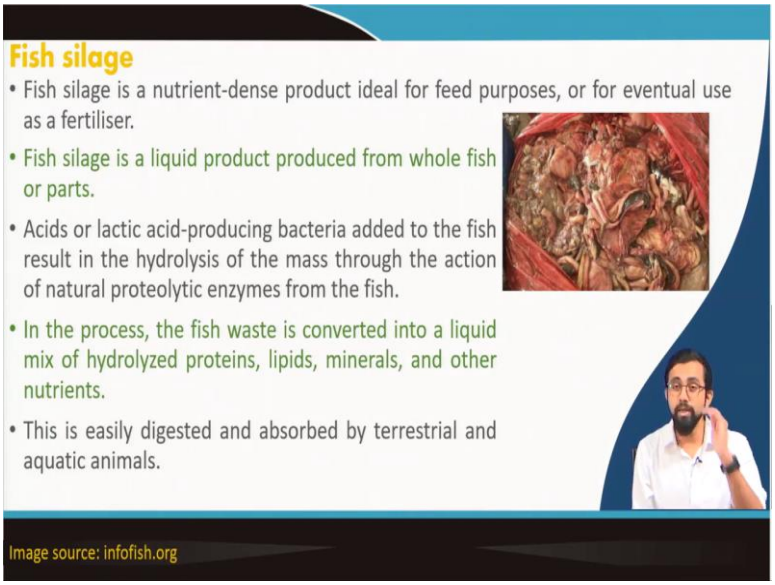

So, this Hortiplus is manure and also this plankton plus, this liquid that it generates and because of its reusable in nature, it can lead to as in very proper even 100 percent waste utilization is possible. So, it is done, it is done by various countries and India also shown it like how it is to be done. And I would really request whoever is working on aquaculture-based industries and all, they try to think about how they can go ahead with this zero-waste concept. Fish silage is a nutrient dense product ideal for feed purposes and all and also for eventual use as a fertilizer.

This fish silage is a liquid product produced from the whole fish or some part of it. In general, we do this, we add it with the lactic acid producing bacteria or the acid producing bacteria for the hydrolysis of the mass through the action of natural proteolytic enzymes from the fish. In this process, the fish waste which is converted into a liquid mix of hydrolyzed protein lipid and minerals is then, it can be easily digestible when absorbed by the terrestrial or the aquatic animals.

So, just slight application, slight additional inoculation can help it to convert it to a very rich nutrient for your aquatics application, aquatic animals, feed for your aquatic animal plus for your terrestrial animal as well. So, just imagine, just this small step can convert any of your the wastage, the fish waste into a very high nutrient rich fish silage and all.

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Because in general, if we do not use it, it simply cause very serious concern to the environment and also it is a useful product, at the end it becomes a useful product which will reduce this kind of waste. So, what we do? We normally process. After the processing is done, we segregate all the waste which is like not possible for us to use it anymore. Grind it, stir it at the acid, store it for a couple of days. That is it, you have your food ready.

Use it as a supplement or as a fertilizer to your pond, you can use it for, mix it with other food to your animal or the livestock's and all. It will definitely have, because of its rich nutrient content, it will give very high growth booster, or it can use as a growth booster for your rearing fishes as well.

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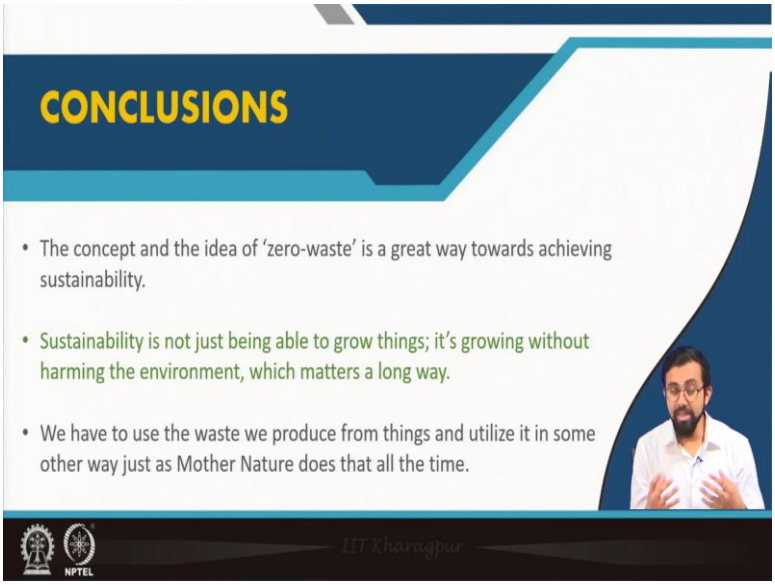

So that is how these are the all different, you know, the places where you can use this kind of aquatic byproducts and all. The concept, the idea of these zero wastes is a great way towards achieving sustainability as we discussed in this lecture. And sustainability is not just being able to grow things, but it is growing without harming the environment, which matters or matters in a very long run. So that is what we understood from this lecture.

We have to use the waste, we produce from things and utilize it in some other way just as Mother Nature does that all the time. We have to mimic the natural system. That is the best way. They are the best architecture. They are the best engineer, I would say, the mother nature. We have to mimic the systems to do stuff sustainably, that is the best way. That is why synthetic biology is growing so much nowadays and people are really working on developing ideas, even engineering developments are happening, mimicking the natural system and all.

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Because those are so precise, so scientifically accurate that we need to follow them in order to grow something really looked at and really sustainable in nature, which should be sustainable in nature. So as a takeaway message, I would say like, you know, the waste to wealth program, it is not only help to benefit the local people, but also it clean up the local environment and boost the aquaculture efforts of your country.

Zero Waste concentrate, it leads to the prevention of waste, recycling of waste and utilization of waste to generate useful products and high economic benefits. Other than that, this old concept also considered the waste as a valuable resource rather than problem which is

something we really need to think about. We simply use the product that we like and all the other things associated with it, which is not okay for you at that particular moment, you just simply throw it and it creates a huge amount of solid waste and the liquid waste.

Especially if you talk about the solid waste you see the landfills in the municipal areas and all, amount of everything it, I am talking about here the aquaculture concept and all the aquaculture at geo waste concept, but think about all the other issues that we are having where we use this, we conceptualized this zero waste and we generate a huge amount of waste rather than and then at the end, it ends up spoiling our own bodies. Because those waste at the end it comes to our bodies itself by bio competition, by various processes.

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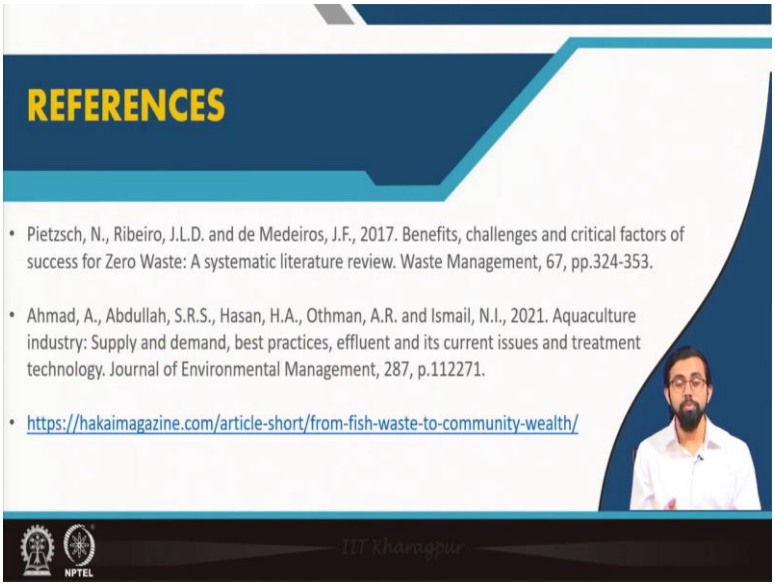

Think about it and I hope like these are the references also you can you can follow to get more idea about it. And I hope you get to know about the Zero Waste concept as a whole, not only for aquaculture purpose, but all the other purposes, all the other industry application and all that whenever you try to find out the solution for one problem do not create other. So, try to find out how the waste that you are generating can further be utilized.

Maybe it is not good for you, but maybe it is good for someone else. Let them come and make a group effort and try to find out the solution and use the waste in a sustainable manner so to generate a proper sustainable society. So, thank you so much. I hope you got to know some important facts from this lecture. I will come back in the coming module. Thank you so much.