Advanced Aquaculture Technology
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Lecture 31
Important Water Quality Parameters and Criteria

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Hello everyone. Welcome to the Module 7 of the subject Adverse Aquaculture Technology. My name is Professor Gaurav Dhar Bhowmick, I am from the Department of Agricultural and Food Engineering of IIT Kharagpur.

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So, in this lecture I will be discussing about the about some important water quality parameters and their criteria and why they are, you have, you have to know this factor you have to know these parameters, and how does it matter in terms of the aquaculture technology and all. Okay!

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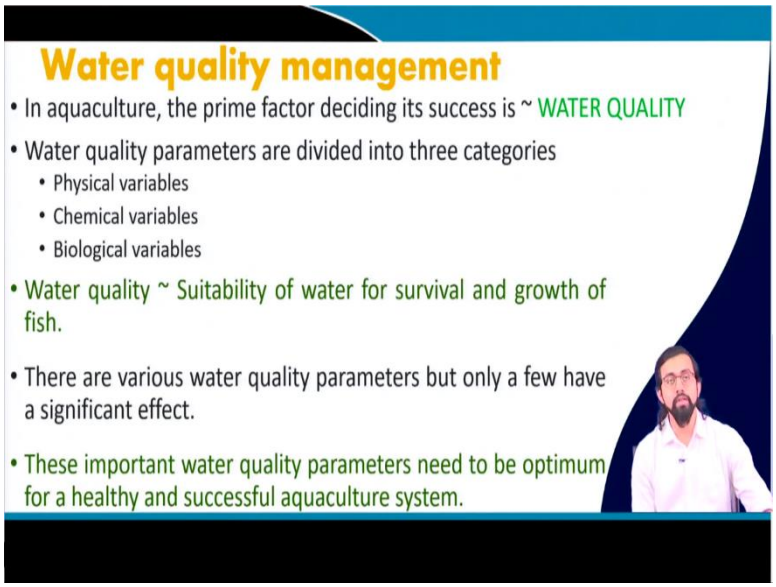

So, water quality management is very important, in aquaculture, it's one of the prime factor that you manage the water precisely you know because that's the, it's like that is all like water is the one what it matters because it's all the aquatic species they are dwelling in the water bodies and all. So, water quality parameters are very important and it can be divided into three major categories, its physical parameters, chemical and the biological ones okay! I will be discussing in details about each parameter soon. Okay!

So, in general, the water quality it should the it should be suitable enough for the survival and the growth of the fish that is what we normally target. And there are different water quality parameters, but a couple of them are very significant in nature and they are very much important to have it in a particular range for your aquatic species to survive. Okay! This important water quality parameters need to be at its optimum level as I discussed at its range for a healthy and successful aquaculture farm and systems. Okay!

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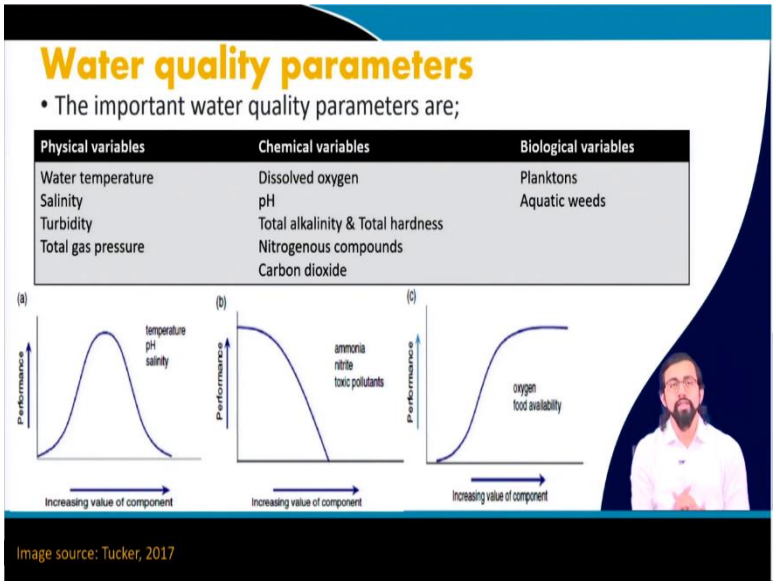

So, what are the different physical variables which are very important to discuss about are water temperature, salinity, turbidity, total gas pressure, chemical variables, dissolved oxygen, pH, alkalinity, or total hardness and nitrogenous compounds and carbon dioxide or the carbonaceous component. Okay! And biological variables are the presence of plankton, it can be phytoplankton, zooplankton, and aquatic weeds. Okay!

So, these are the variables. Those are major and very important. And we need to discuss very precisely at each and every components of each and every variables, we need to have a very basic idea at least on each of these variables so to have a better, be a good water engineer or be a person who can because if you don't know the water quality, if you don't know the water, you cannot understand the behavior of your fish, you cannot understand the behavior of your aquatic species.

You have to know the water quality, you have to know what are the parameters which are very important for your aquatic species, for them to naturally dwell there. Let us discuss about these variables in detail. Okay! Before going that, you will see like a couple of them have you know this with their performance are varied on.

If you see this x-axis, the increasing amount of, increasing value of the components and the y-axis we have the performance it can vary like in case of temperature, pH and salinity, the performance is very low at a certain age, and it goes up to optimum stage and then it again if it increases a certain threshold value, it again drops down the performance.

In case of ammonia, at the very low nitrate and toxic pollutants the zero it is better the best performance thus it is the more the in the value is increased with time or increase in your water body, it will definitely reduce the performance to zero. The more the ammonia the more the nitrite, the more the toxic pollutants these are harmful. So, this is this the graph is showing the harmful pollutants Right?. The zero is better, the higher it is detrimental. Okay!

Third graph is oxygen and the food availability. Zero it is obviously worst. The moment it increase, it means a certain value. After a certain time it doesn't affect the performance at all. If you can increase the oxygen if you can increase the food availability, but it does not affect the performance.

Not much, not much, I am saying here not much, but sometimes the supersaturated oxygen can even be harmful sometimes super, like more amount of uneaten fish, if you are supplying a huge amount of unwanted like, the feed and all, this uneaten feed what will happen it will cause damage passively, it will start increasing the nitrogenous compounds present in the water because they will deteriorate in the bottom or maybe it is a protein, so it will deteriorate the water like anything. Okay!

And supersaturation is also not good sometimes, supersaturation of oxygen is also not good, though the curve is normally given the sigmoid curve, this S-curve, but in general supersaturation is also not good that also you need to think of it, Okay! take care of it. So, these are the different parameters and you see how their performance is varied.

Using these three graphs, you can nicely remember. Okay! So, some of them have this bell curve, some of them has this deteriorating curve, some of them have this sigmoid curve, based on the parameters and their performance and all, their application and all Okay!.

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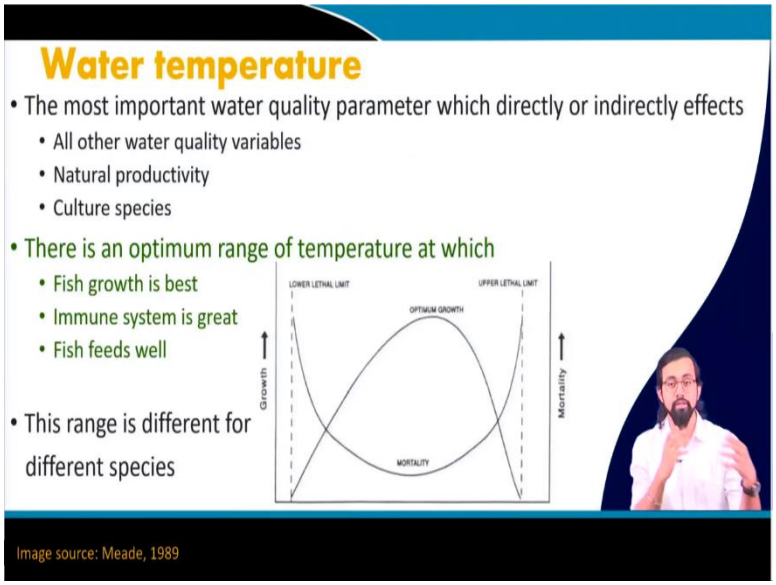

So, let us start with some physical parameters, let us start with temperature. I do not have to say much because you know how temperature can affect with this ectothermic species and all right?. If you see the graph, the temperature of a species at the very low it is very detrimental, at certain moment time it reaches his optimal growth and then it also goes down. The lesser the temperature the mortality rate is very high, see the lower limit, it is a lethal limit.

And the higher temperature is also not good, it is the upper lethal limit. So, mortality is very high in case of upper lethal limit and lower lethal limits. When the optimal growth is reached the mortality is less, mortality rate is very less, definitely.Right? So, that's how most of the cases the species work. So, most of the aquatic species work, all the aquatic species works. Okay!They have their tendency to dwell at its own temperature, own optimal range of temperature. Okay!

You may know about the term cyclophilic, mesophilic, thermophilic, things are known. Okay! This is the different, in case of microorganisms also we can define, in case of aquatic species also we can define, it is like some people are, some animals who are cyclophilic in nature, some are mesophilic in nature, some are thermophilic in nature, cyclo is a lower range of temperature, meso is like medium range of temperature, thermo is like high temperature.

And the water temperature should have to be at a certain stage based on the target species. Right? So, most of the water parameter why it is important, it is one of the major water parameters is this water temperature because it directly or indirectly affects all the other water

quality variable, its natural productivity of your aquatic species or natural productivity of your system and also the cultural species. How it affects the all the water quality parameter?

If the temperature is change, suppose you have another parameters like pH or acidity, alkalinity or say like hardness or any other say like dissolved oxygen and all Okay!. Just to give you one example, you know when we boil the water what will happen, it started bubbling up. What is it all? All the air that is entrapped that is dissolving condition that is getting out of the water body.Right

In general, when we do the we heat the water in a higher temperature, when we boil the water. What does that mean? The more the temperature, the diffused oxygen or diffused air will go out. So, dissolved oxygen level will go down. So, if the temperature is higher that dissolved oxygen will be reduced. So, it will affect your aquatic species, isn't it?

So, in the same way just try to imagine, same way if you reduce the temperature it will increase the overall dissolved oxygen uptake. So, you know these laws, and all how this Henry's law acts this is and there are like different other parameters also which are important in diffusibility of air and all Okay!. So, anyway, so when this diffusibility is actually read directly related to the temperature of your food substance food. Okay!

So, in this case the water temperature it increases, DO level will decrease the temperature decreases, DO level will increase. So, that's how, this is just an example, just to give you an example, how other parameters are also important are also related to the temperature. Okay!

Natural productivity of will definitely be disrupted because the temperature goes increase or like because of thermal pollution, and all because it will kill all the, if not the you know the bigger size or the higher tropic cultures but it will definitely kill all the phytoplankton, zooplankton, and all these things which are actually the feed for all those higher species. And all So, because of the thermal pollution, that is the reason of thermal, that is a detrimental part of the thermal pollution.

So, third is the cultural species, culture species also be in stress. Suppose you are culturing Atlantic sun, which has a very low range of temperature that it can survive. Because if your temperature of your farm is like 35 degrees, 40 degree Celsius, definitely it cannot survive. Right So, that is how it, that is how temperature is, that is why temperature is very important and how it actually affects the overall the water quality parameters, natural productivity and also the culture species.

There is optimum range of temperature at which the fish growth is best, immune system is great and also the fish feeds well. In that sense, the mortality is very low as we already discussed, this range of this range is different for different species though.

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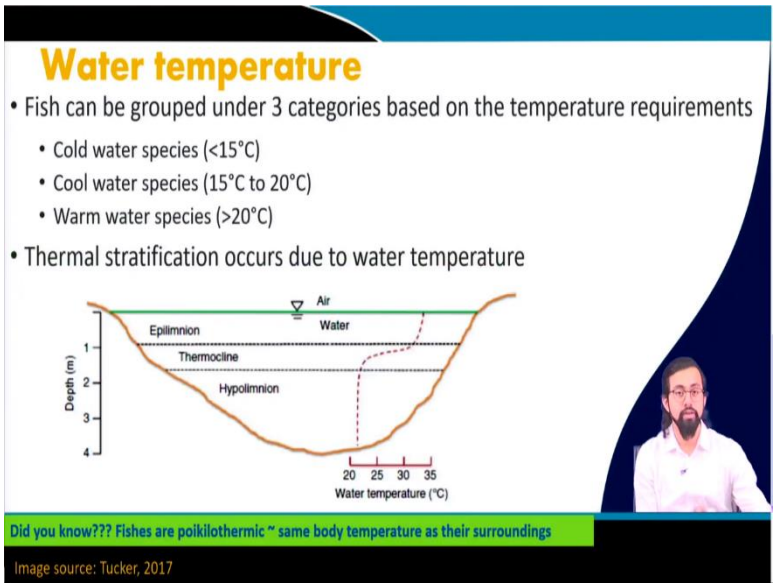

The fish can be grouped under three categories based on their temperature at which they can survive. Cold water species, sometimes we call them you know cyclophilic or sometimes, in general just remember it as a cold-water species. Cool water species and warm water species, it's easy to remember. Cold water species less than 15 degrees Celsius, cool water 15 to 20 sometimes it can go 20, 23, 25, warm water is more than 20.

This range is very important for you to know that which type of species you are culturing and what is it natural temperature optimum temperature for its best growth and best survival that you need to know and based on that you calculate, based on that only you have to prevail that temperature in your farm or wherever you are farming there. Okay!

Thermal stratification, it occurs due to water temperature, you see the water temperature how it varies with the depth, suppose this is a pond as you can see, this red line is showing a pond suppose, the air and water interface you can see. In the water interface up to a certain line is the temperature is almost same, so it is called like in a epilimnion.

From epilimnion, it comes to the thermocline, thermocline, you see the line, this thermocline line, in the thermocline line, it's actually the place where in general the temperature is this dotted line this if you see this, how to say, this thicker line, this thicker dotted line, it is like the thermocline region. Okay! So, the temperature is like say similar all through, anyway.

So, there is like a epilimnion and there is this hypolimnion. In the case of epilimnion or hypolimnion the temperature difference can be almost 10 degrees Celsius can be as high as 10 to 15 degrees Celsius. You see in case of water temperature, in case of epilimnion it is around 33 in this particular example, in case of hypolimnion it can go down to almost 20 degrees Celsius.

So, this huge difference in the water level based on depth can also be witnessed. And based on that also your species will survive. So, if you check your water temperature from the surface that so, your thermometer you say like over 30 degree Celsius. Let us go ahead with all the warm water fishes, then you see in the bottom the temperature and warm water fishes which are normally bottom dwelling one.

Suppose your any benthic species, then you got to know that on the bottom the temperature is almost 15 degrees Celsius. And all. So, they will be in stress, they cannot survive the temperature. So, in that case, either you have to reduce the depth, somehow you have to reduce the depth so that of your tank or if you are doing that you have to increase the surface temperature somehow or you have to provide with the heater or somehow you have to increase the temperature. So, that is just to give you an example like how it will look like. Okay!

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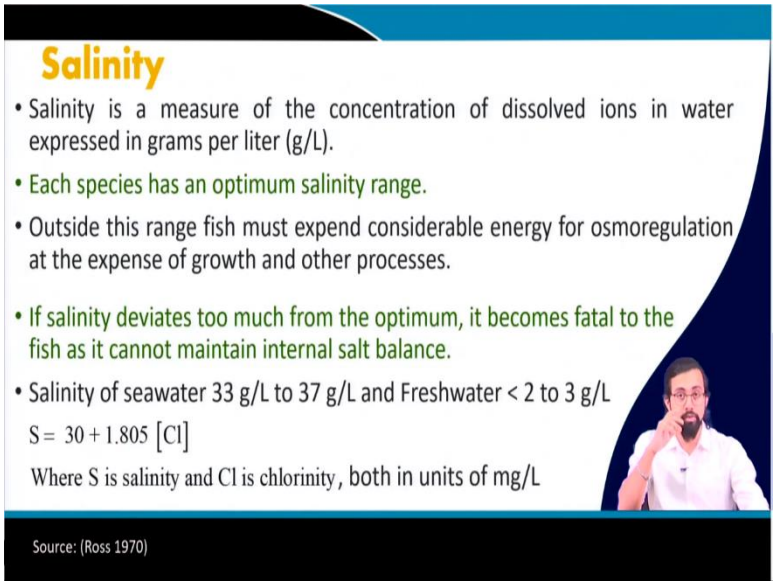

Salinity is another important parameter which actually measures the concentration of the dissolved ions in water, which is normally we expressed in gram per liter. So, each species gram per liter, there is another unit for that also, just for you to remember gram per liter or PPT parts per thousand, not trillion, parts per thousand PPT.

So, in general salinity is expressed in gram per liter or parts per thousand. So, each species has its optimum salinity range at which it can survive because outside this range fish have to expend a huge amount of energy for its osmoregulation process at the expense of growth and other processes. And because of that, it will cause different kinds of health hazard for your aquatic species.

If the salinity deviates too much from this optimum it becomes also fatal for the fish as it cannot maintain the internal soil balance. Salinity of seawater can vary from 33 PPT to 37 PPT, freshwater less than 2 to 3 PPT, brackish water it can be in between, so like 10-20, 10, 15, 20 PPT and all. This salinity, you can easily calculate with this equation 30 plus 1.805 is chlorine, this is the chlorinity.

$S = 30 + 1.805\ [C]$

In general, when we talk about salinity now in see water almost more than 50 to 60 percent because of the chlorine only. So, chlorinity when we talk about it is not only actually chlorine but it actually also count the bromine and iodine also. So, chlorinity actually is submission of chlorine, bromine and iodine.

But however, we normally names it only chlorine, by means of chlorine because it is the major portion of the salt water actually, almost 60, sometimes 65 percent even 70 percent also it can go so that is why we name it chlorinity only. So, chlorinity if you know, if you know the salinity you can easily calculate the chlorinity and the vice versa in both the units or in milligram per liter. When it is calculated in milligram per liter anyway.

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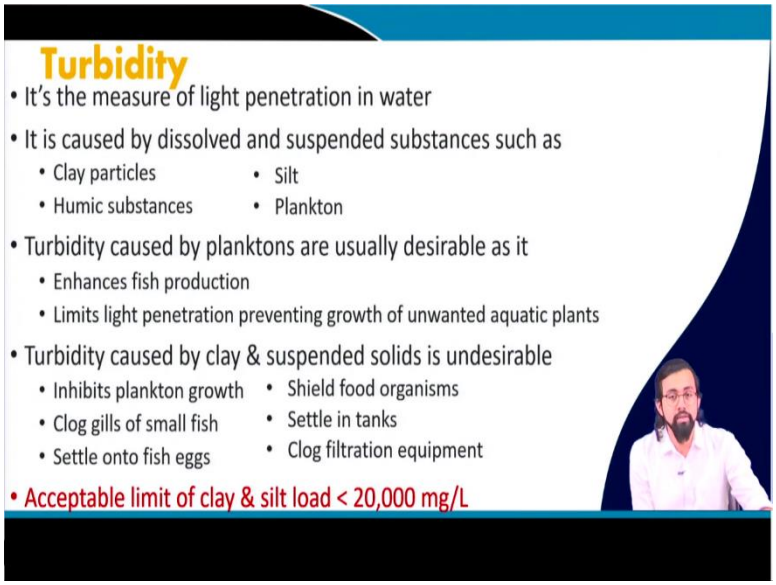

So, the third one that we discuss here is like the turbidity, it is a measure of light penetration in water. I think you know the terms the Brownian motions colloidal particles and all these things. So, I hope you know these things. You know the different suspended particles colloidal particles and all. Anyway, so, these are very important for you to know, you can Google it, you can search for it, it's very important things for you to remember, it is for your own knowledge purpose only.

So, anyway, so let us discuss, let us not deviate much, let us discuss about the turbidity. It is caused by the dissolve and the suspended substances such as clay particle, silt, humic substances and planktons. Okay! Turbidity caused by the planktons are usually desirable as it enhances the fish production, limits the light penetration, preventing the growth of unwanted aquatic species.

So, turbidity after up to a certain level, which is caused by the planktons are usually desirable. However, the turbidity caused by clay and suspended solids is undesirable. Because if there is clay and suspended solids, what will happen, it is just like you know if you have if you go and you have in front of sandstone, what will happen, it will irritate you, you cannot see anything, it will irritate the whole ecosystem between a lot of things, it is like same for them.

For them if there is dwelling area is water where there is a lot of clay, a lot of suspended solids, it will inhibit the planktons growths, it will clog the gills of the small fish, it will settle into the fish egg involved their hatchling activities, shield the food organisms, so that cannot be eaten

by the fish, it settle in the tanks and it will reduce the capacity like volumetric capacity of your tank, it will clog the filtration equipment, its nuisance.

So, the simply acceptable limit for clay and silt load is around 20 gram per liter not more than that. If it is more than that, then that is it, then it is very, then this value is also not fixed, this value is also not fixed for each and every case. It can vary depending upon your stock depending on your funding design.

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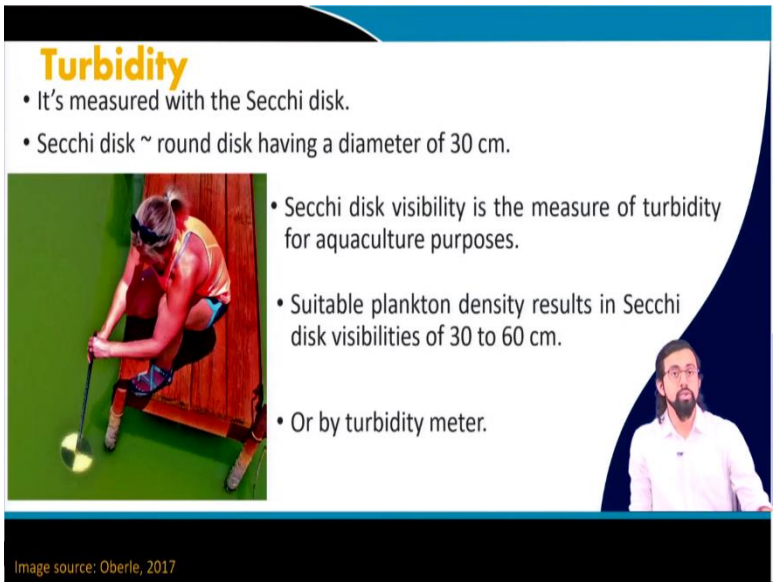

So, in general, it is measured using the Secchi disk. The Secchi disk is around the round disk, you can see this lady is holding a disk, this different colored, this two-colored disk, where it's normally it has a diameter of around 30 centimeter and it actually gives you the visibility as a measure of turbidity for aquaculture purposes.

In case of suitable plankton density results in Secchi disk visibility of around 30 to 60 centimeter. Sometimes we do it, nowadays with all the, instead of Secchi disk we can just collect it and we do it with the turbidity meter as well. This is the increase of turbidity meter mainly we focus not the plankton density, but when what it costs when the turbidity is majorly caused by the clay on the suspended solids.

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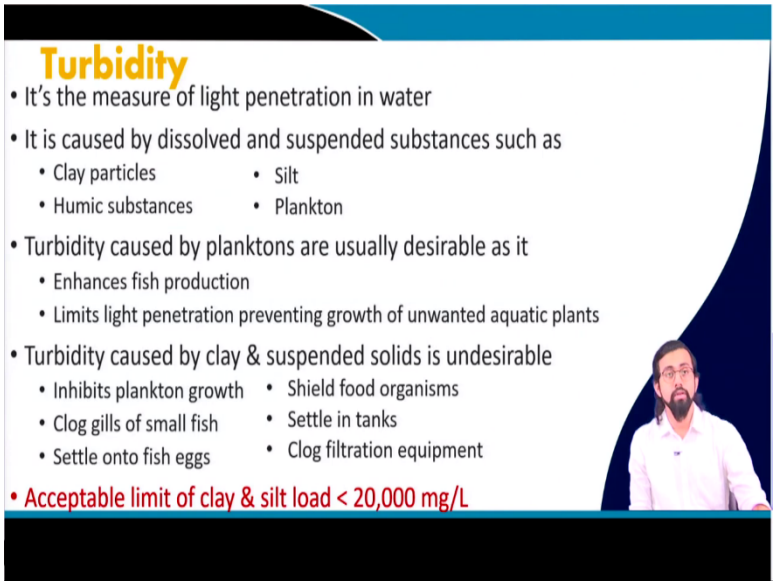

Fourth one is the total gas pressure, this is also another physical parameter which is very important. So, total gas pressure or like TGP in short, we normally do when we discuss we use this word TGP only, is the sum of the partial pressure of all gases dissolved in the water. Okay! The difference between the total gas pressure and the barometric pressure. So, in general, what is the barometric pressure, it is 760 millimeter of mercury right, you know it, Right.!

So, this barometric pressure and the difference between the TGP is the delta P or the delta pressure that we normally discuss. If the delta P is more than 0, that is total gas pressure is more than the barometric pressure that means the water is super saturated with the dissolved gases. What will happen if it is super saturated? In provided the conditions it will dissolve to the atmosphere in general. Okay!

In case of if the del P is less than 0 that means the water is under saturated with that gas, in particular that gaseous component or say like all the gases coming along the gases. Okay! So, this gas saturation how to calculate, in general we use this equation BP plus del P divided by BP multiplied by 100.

$$\%TGP = \frac{\mathrm{BP} + \Delta\mathrm{P}}{BP} * 100$$

So, just give you an example, if the total gas pressure is you are asked to calculate if given the barometric pressure is 760 millimeter of mercury and the pressure differences 38 millimeter, del P is 38 millimeter of mercury.

So, how will you calculate the saturation level? Total gas pressure will be 760 plus 30 divided by 760 multiplied by 100 you will get the value of 105 which is the value which shows us the saturation level that means which is oversaturated. Okay! If the value is 100 that means it is just saturated, if less than 100 it is under saturated, if it is more it is super saturated. Okay! So, that's how the total gas pressure is calculated.

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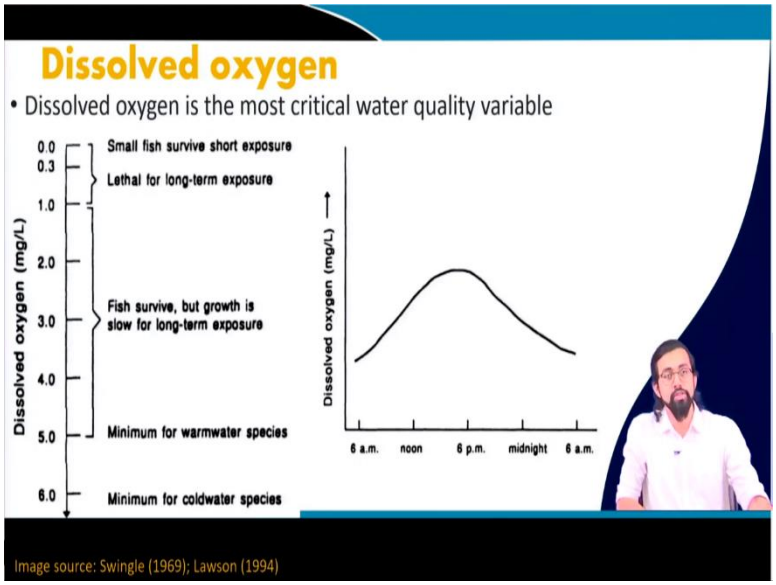

Another important parameters the chemical parameters when if we start discussing about this is like one of them is like dissolved oxygen. Dissolved oxygen, what does that mean? Oxygen is there in the air, oxygen is there in the water also. How oxygen is get into the water? Because of the diffusion phenomena in general. Okay!

So, if you keep on somehow there is action of water action and all, there is a wind activity, because of the wind activities, and all because of the splashing mechanism, because of there are hundreds of phenomenon. You can artificially provide some aerator which will keep on rotating over its surface. So, it will splash the water into the air.

And what will happen in might very small particles, because of that the diffusion rate can be increased, right? So, that's how diffusion rate is increased. And in the dissolved oxygen concentration can be increased in the water body. Why this is important? Dissolved oxygen is the basic means of supply of oxygen for your aquatic species definitely.

So, you then need oxygen as well. If the dissolved oxygen level is very low, definitely it is lethal for them, it's like us, if oxygen concentration instead of like 20.9 it goes to like say even 18, 19, 17, then that is it, it is very, very much toxic for us like we we are start having short

breathing and all, we are having less amount of oxygen in your hemoglobin and all Okay!. So, it will cause different multi organ failures and then different types of disease, like unwanted situations and all.

In general, dissolved oxygen concentration is very important, it has to be at least 5 to say more than 5, better to have it like 6 to 7 this range for any kind of species. Almost any type of aquatic species the dissolved oxygen concentration should be around at least more than 5. If it is less than 5, even for cold water fishes, 5 is lethal, for warm water fishes up to 5 it can sustain because in general you know warm water, low dissolved oxygen and cold water high dissolved oxygen you know it right ?

So, in case of cold water, they normally dwell in a high dissolved oxygen concentration. So, for them 6 is minimum, for warm water they can survive in, they can still survive up to 5 but if it is less than 5, they still can survive but the growth will be slow because of for long term exposure they will be pretty much in irritated, they will very much be irritated.

If it is less than 1 that is completely lethal and they will definitely cannot survive and all. For short time it is okay but long term definitely they will not survive they will die. So, it has to be more than 6 for cold water more than 5 for warm water the better to be around in the range of up to 7, 7.5 something like that.

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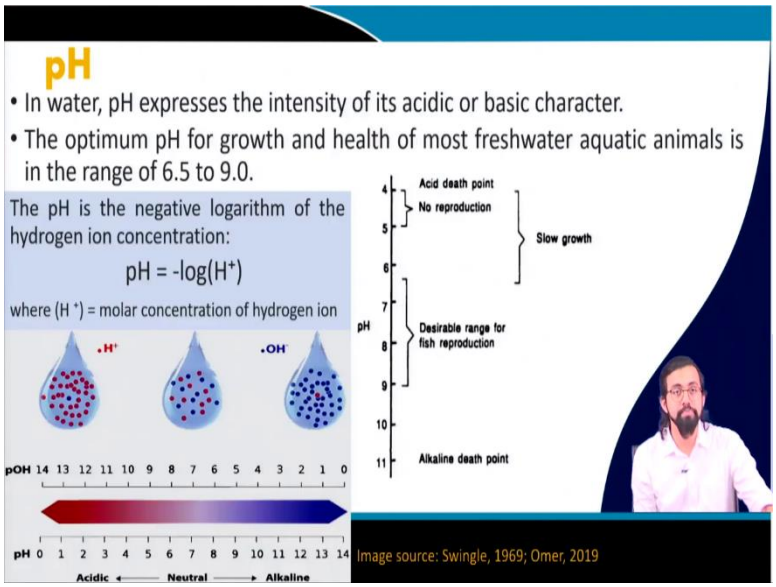

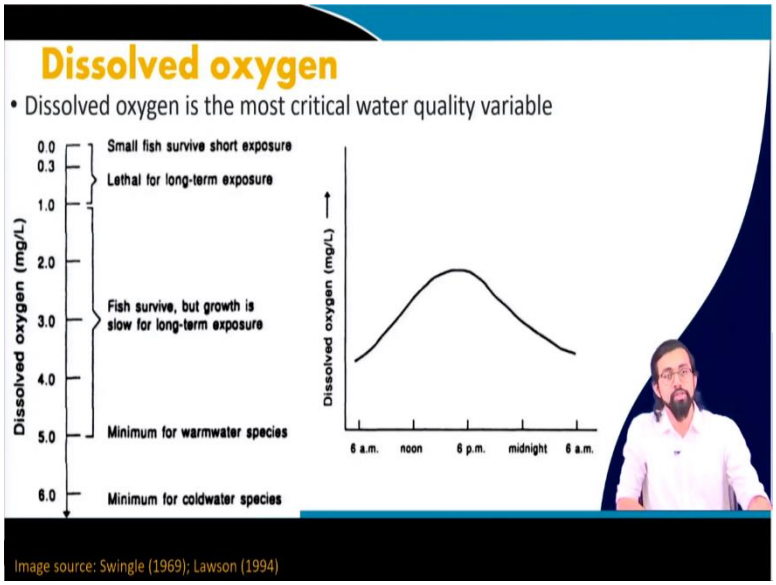

pH, the pH, you know the pH is the negative logarithm of the hydrogen ions concentration and then like you know it, it's there like you know already in chemistry from your chemistry class from I think class 11 or even before that class 7, 8 also we get it nowadays. So, this hydrogen ion concentration is a molar concentration in general of hydrogen ion. If you do the negative logarithm of it, you will get the pH.

It varies from, do you know the range in general, it is normally 1 to 14. In general, we have this less than 1. So, like in general, we have this range of around 1 to around 14, it is in general. The maximum it can reach around 14 and depending there are some solutions for which it can, in most of the cases, it will be like almost in all the cases it could be lies in between that. Okay! Optimal pH range for the healthy fish is like around 6.5 to 9, that's the desirable range.

If it is below than that, that is also harmful, if it is more than that, that is also harmful. One more thing I forgot to tell you when we were discussing about the dissolved oxygen is you have to remember the oversaturation is also not good. So, if the dissolved oxygen concentration, remember this discussion that we are having this 6, 7.5, 8, it cannot go more than that, actually 9.07 milligram per liter, all these units are in milligram per liter or PPM parts per million. Okay! 9.07 milligram per liter is the saturation dissolved oxygen concentration in at 20 degrees Celsius for any water body.

Remember this value, 9.07 milligram per liter at 20 degrees Celsius that is the saturation concentration for dissolved oxygen, saturation of dissolves in concentration in water at 20 degrees Celsius, it will vary with temperature but in general 20 degrees Celsius say like cool water species their pH should be maximum is 9.07, so and minimum is 6.

So, it has to be in between that, that is often should be in between that. pH we already discussed some of the already, I am sorry for going back again. So, in this case if it is like less than 6 or so the fish will start having a slow growth and below than 5 the reproduction rate will be stopped and below 4 it will be called it is called acid dead point, they cannot survive in the water at all, acidic water.

Same way if it goes over 9 that is also detrimental and after 11 they will die that is called alkaline death point. In case of alkaline conditions, the presence of OH radical will be maximum, in case of acidic condition the H plus radical H the presence of hydrogen ion is much more prominent. So, neutral range is the best were around as I discussed 6.5 to 9 is the best range for the growth of aquatic species.

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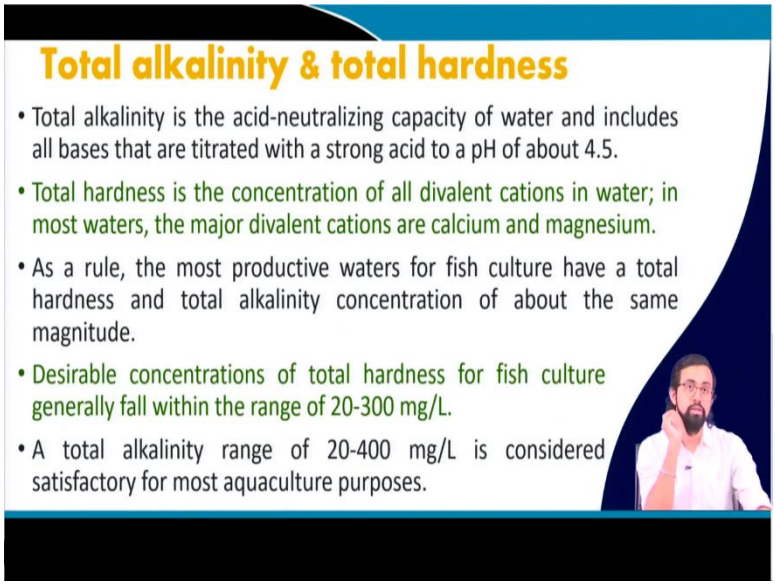

Total alkalinity and total hardness, total alkalinity is the acid neutralizing capacity of water and it includes all the bases that are titrated with a strong acid to a pH of about 4.5. Okay! Total hardness is the concentration of all the divalent ions mostly calcium and magnesium. So, that's how we calculate the total hardness in water.

In general, as a thumb rule, these values are almost same for in the most productive water bodies, like say in case of fish culture generally it falls between total hardness should be 20 to 300 milligram per liter and alkalinity will be also 20 to 400 milligram per liter for satisfactory performance. If you want to know more details, you can Google it, you can search for it and you can go ahead with my other lecture materials as well.

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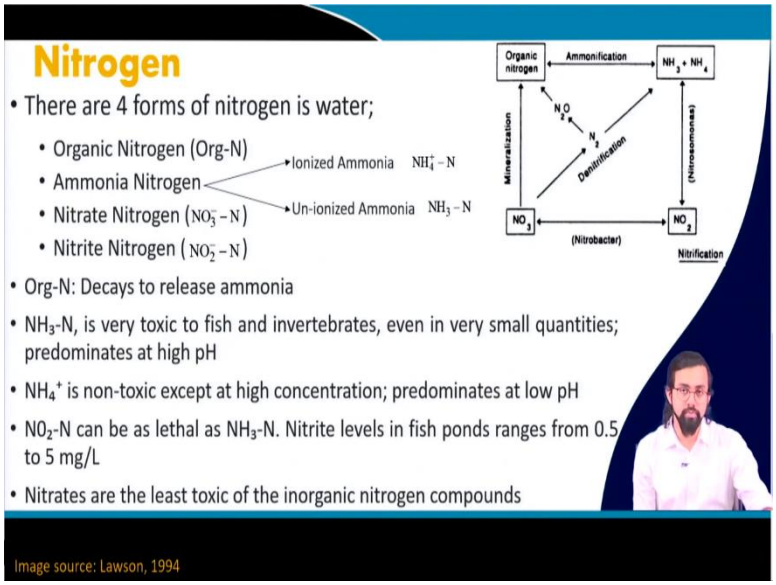

Nitrogen that is also very important thing. Why nitrogen is very important? Because nitrogen, okay nitrogen can be of different species, different nitrogen species can be there in water, it can be organic nitrogen presents inside the body of the cellular organisms, it can be ammoniacal nitrogen, ammoniacal nitrogen can be of two types, ionized ammonia, NH4 positive and also un-ionized ammonia or pre-ammonia what we call, pre-ammonia gas NH3-N. Pre-ammonia is very notorious for very notorious for your aquatic species, it is like in high pH normally this is actually partially reversible equation. So, they are integrated.

The biggest on the pH, the ammonia nitrogen can be in ionized form or in unionized form. If it is low pH, it is ionized from, this high pH is unionized form. High pH unionized form, it is lethal, completely lethal for your microorganisms, for your any aquatic species Okay!, because it is really harmful and then this nitrate, nitrate is still okay but nitrite is another lethal nitrogen species.

We need to get rid of the nitrite nitrogen and unionized ammonia as soon as possible from your system. Just remember this two, unionized ammonia or free ammonia and nitrite nitrogen NO2 negative it is very lethal for your aquatic species. In case of organic nitrogen definitely it decays to release the nitrogen, release ammonia they are presence in the biomass. Ammonia nitrogen is very toxic for fish and invertebrates, even in a very small quantity predominates at high pH.

Ammoniacal, This ionic ammonia which is nontoxic except at high concentration predominates at low pH. Nitrite nitrogen is very lethal I told you, it cannot be more than it should be in the range of 0.5 to 5 milligram per liter, still it is very high 5 milligram per liter. I am saying just

the range based on different species, their acceptability range and all. Nitrates are the least toxic of the inorganic nitrogen compounds.

This is how it looks like, if you see the right-side figure, organic nitrogen and I see the from organic nitrogen you first look into the ammoniacal and ammoniacal nitrogen and which is like either in the both the form. So, this organic nitrogen can, because of the ammonifying microorganisms it can be converted ammonia fixating microorganisms, it can be converted to ammonia then this ammonia because of the presence of Nitrosomonas it is a nitrifying bacteria it can convert it into the nitrite and from nitrate because of the presence of Nitrobacter it can convert into nitrate. Okay!

So, this process is called the nitrification process on we use the nitrifying bacteria like Nitrosomonas and Nitrobacter. Then denitrification process can also happen or the mineralization process sometimes this ammonia denitrification process when happened this nitrate is converted into the nitrogen gas, Okay! this is called denitrification process presence of denitrifying microorganisms which are anaerobes in nature.

They do not need oxygen for that. But in case of nitrifying bacteria, we need oxygen for the survival Okay!. Denitrification process nitrogen gas is there, they just dissolved the air. So, by this process we can get rid of the nitrogen from the wastewater. Another process is the mineralization, this nitrate can be utilized by the plants and all then they will convert it to the organic nitrogen into the biomass.

So, there can be, that is called the mineralization and all okay! And also, that can be used by other microorganisms as well for fixating this organic nitrogen. So, this is how this cycle goes.

Okay!

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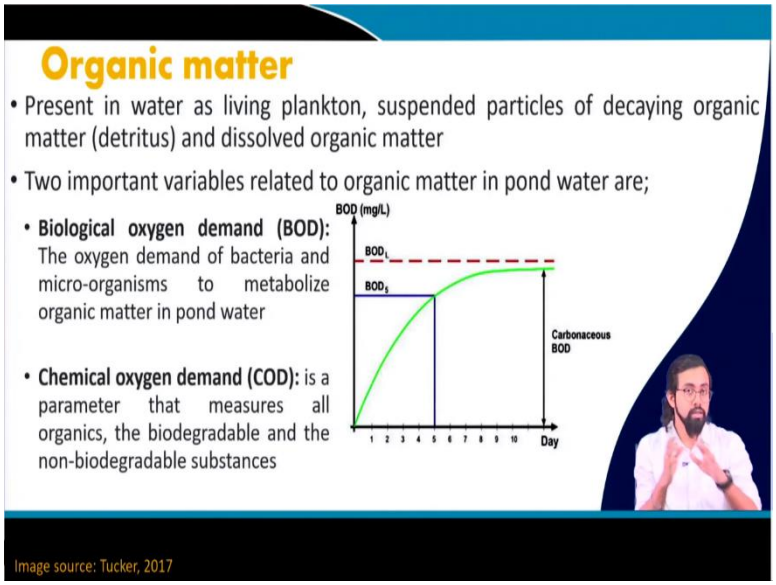

Organic matter, present in water as living plankton, suspended particles of decaying organic matter and the dissolved organic matter. Two very important variables you need to know BOD biological oxygen demand and COD, chemical oxygen demand. I cannot give you elaborated discussion about all these, these two parameters. It is better to go Google it. You can learn a lot of things about it.

It is very important parameters that everyone should know about BOD and COD whenever you are talking about any water related research, what are work. The oxygen demand of bacteria and the microorganisms to metabolize organic matter in pond water is called the BOD, biological oxygen demand. And chemical oxygen demand is the parameter that measures all organic, biodegradable and non-biodegradable substances.

The oxygen demand by this all this matter. What does that mean? BOD means, biological oxygen demand means is the oxygen demand by only the biological materials. COD, they take care of biological materials, all the chemical materials presence like, all the other biodegradable and non-biodegradable substances as well. For them also to degrade how much oxygen is needed. So, they calculate that also.

When we calculate the chemical oxygen demand, that will give us more precise value of oxygen requirement than the BOD. Okay! But BOD also actually kind of a passive way of saying amount of living organisms present in your system or living or nonliving organisms present in your system. I mean like organic matter present in your system. But chemical oxygen demand which will keep the organic plus inorganic oxygen demand as well.

However, not all inorganic Okay!. There are some type of refractory compounds, which still cannot be, we cannot get their oxygen demand value which are very high end engineering they have it. So, we cannot get their oxygen demand by even chemical oxygen demand process also. So, in order to give you a very basic discuss about the BOD and COD, BOD process is done in a biological way.

So, it is in a 300 ml bottle you will see you will Google it, it is better, I cannot give you more details about it in this moment. Because it takes itself a 1-hour lecture, a complete 1 or 2-hour lecture to give you, just to give you a brief about the BOD and COD. And COD is when we use acidic environment and we use diatomic solutions at 150 degrees Celsius for 2 hour, we burn the solution we burn that in and be at the end we calculate spectrophotometrically the amount of COD values.

So, this is the BOD and COD and this is you see BOD, normally 5 days BOD we calculate. So, it can be all the carbonations BOD if we want to really calculate it can take like couple of days, 10 to 15 days but in general we only calculate to make it standardized. We calculate 5-day BOD. In 5 days, how much oxygen is actually being utilized by your organic by the bacteria or the microorganisms present in your water body, metabolize the organic matter in the system. So, that is what called the BOD system, BOD 5. Okay!

And COD is like ultimate one, COD and BOD L is the ultimate BOD and carbonaceous BOD, there are nitrogenous BOD. There are a lot of factors, a lot of parameters that involves with BOD and COD. So, I really request you guys to google it and get to know more details about. And you can go for the NPTEL lecture material on BOD and COD as well to get more details about it. Okay!

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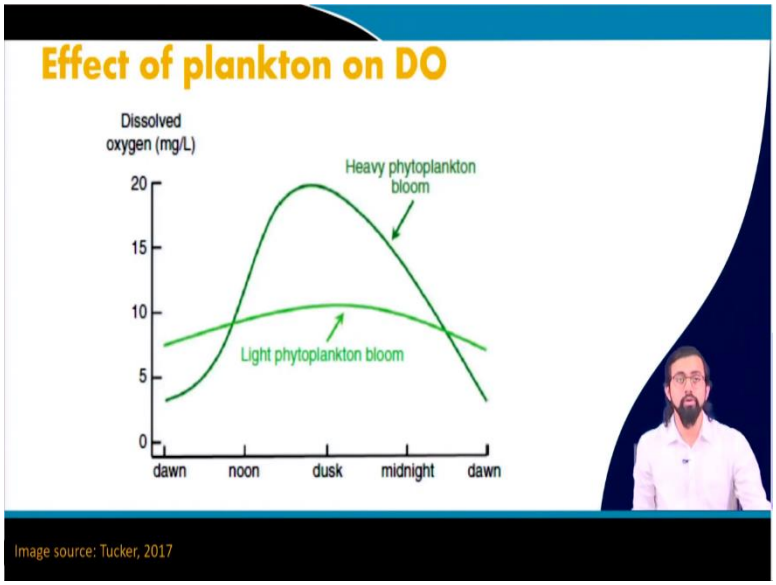

This is the effect of DO on the plank toning activity. If you see the more the DO at certain level and the dusk, in a single day from dawn, noon, dusk, midnight to dawn like this in 24-hour cycle. How the heavy phytoplankton bloom can be expected when there is a high amount of oxygen dissolved oxygen? When there is low oxygen there is light phytoplankton bloom you can expect. Okay!

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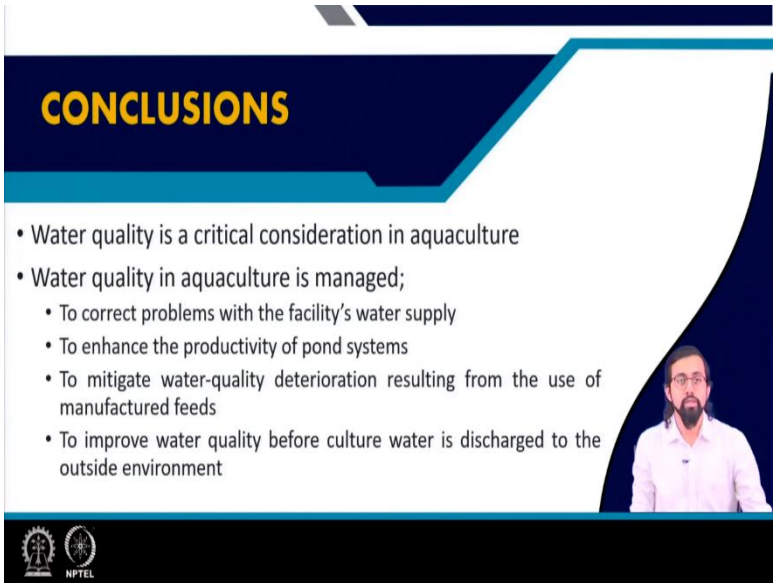

So, in conclusion, water quality is very critical consideration in aquaculture and water quality in aquaculture has managed to correct the facility's water supply to enhance the productivity of the pond system, to mitigate the water quality deterioration resulting from the use of

manufactured feeds, to improve the water quality before cultural water is discharged to the outside environment.

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And the takeaway message we discussed about the aquatic animals they grow best when their environmental conditions are within a certain range that define the good water quality. And water must be managed during the production to ensure good growth and to avoid the stress and death of your farmed species. And water quality therefore the first last and most important consideration for successful aquaculture practices.

And we also discussed about some of the very basic aquaculture water quality parameters that we need to know about and to get well added with the discussion that we will be doing with this based on the any aqua cultural practices. So, I am again emphasizing this point like you guys, everyone should know more in details about this water quality parameters, you can Google it, if you want to know more in details.

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You can go ahead with different research papers, you can go ahead with these references. And some additional details you will get from the Google as well and also you can see from my other lecture measures. So, thank you so much. See you in the next lecture.