Advanced Aquaculture Technology
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Lecture 34
Important Calculations on Aerators

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Hello everyone, welcome to the fourth lecture of the seventh module Water Quality Measurement Management and of this Advanced Aquaculture Technology. I am Professor Gourav Dhar Bhowmick from the Agricultural and Food Engineering Department of IIT Kharagpur.

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So, in this lecture we will mainly be discussing upon different type of aerator calculations and we already discussed the different type of aerators that it involves that involves in our farm design and all and how to measure their different kind of calculations like calculating their aeration efficiency, calculating their oxygen transfer rate in steady state as well as we discussed it for the non-steady state or unsteady state condition.

In case of steady state condition which is like more like field scenario. How to do that? We already discussed all the questions. We have already, we already know. I hope you guys are ready with your calculator because in this lecture I will mainly be focusing on I will give you more real time scenario and I will ask you to we will do the solve the problem with the help of each other. So, here mainly we will be discussing about standard and field oxygen transfer rate, standard and field aeration field efficiency and standard and field oxygen transfer efficiency for different aerators. Okay!

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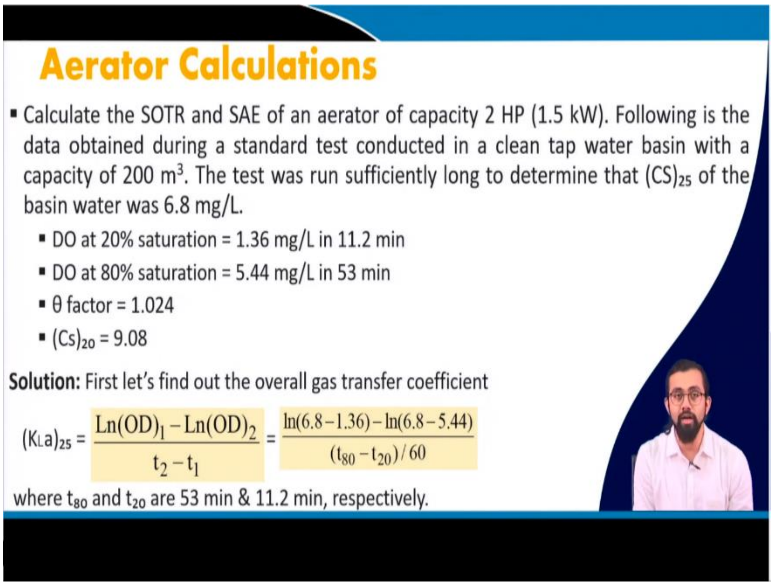

so let us jump out to the first problem. Suppose you are asked you have an aerator, Okay! you just bought an aerator, new aerator. So, from a manufacturing company of say like capacity of 2 HP. 2 HP means almost 746 watts multiplied almost say like to make it easier, 1.5 kilowatt. Okay! So, you have a 1.5 kilowatt of aerator. You are asked to find out the SOTR and SAE of this aerator like standard oxygen transfer rate and standard aeration efficiency.

How are you going to do that? First thing, you are given a clean tap water basin which is having a capacity of 200 meters cube which you just simply multiplied with 1000. So, that much liters. So, you have that this is the volume of basin that you have of clean clear water basin and now you have your aerator. And you know that the test was run sufficiently long to determine that CS 25 of the basin water was 6.8 milligram per liter. That information is also given. So, we have run they have run this test sufficiently long enough to determine the saturation concentration of the CS value of at 25 degree Celsius of 6.8 milligrams per liter. Okay!

Now, the DO at 20 percent of saturation is 1.37 milligrams per liter in 11.2 minutes. What does that mean? It means once you start the reaction, say like from 0 ppm level, DO level was 0. That means 0 saturation level, 0 percentage. From there, after 11.2 minutes you have reached 20 percent saturation level. Just try to understand.

What do I mean by 20 percent saturation level? It is the saturation, total saturation. If suppose like say nine point something, so it'ss like 20 percent of it saturation is like 6.8. 20 percent of it is how much? 1.36 right?. Just simply multiply with 0.2. 6.8 multiplied by 0.2, you will get 1.36 milligram per litre. Same way after 53 minutes they have reached 80 percent Saturation. What do they mean by 80 percent saturation? They simply multiply 6.8 multiplied with 0.8, you will get the saturation concentration, the DO value at the after 53 minutes of test which is 5.44 milligram per liter. Okay!

So, once you do that and also the theta factor which is the temperature correction factor is also given 1.024 and CS at 20 you know, 9.08 milligrams per liter. Okay! The unit is not given, it should be 9.08 milligrams per liter. You know at STP CS is 20 is 9.07 or 9.08 milligram per litre.

Now it will be easier for you to find out the value of KLA at 25 degree Celsius, right? KLA at 25 degree Celsius, that is oxygen transfer rate at 25 is equal to the 1 minus Ln OD 2. So, how to find out this OD 1 and OD 2? OD 1 is the oxygen deficit 1 which is oxygen deficit 1 means the difference in oxygen divisible oxygen value from saturation two, it is 20 percent value. So, which is 6.8 minus 1.36 after 11.2 minutes, that value just logarithm log of E of this value that is Ln of 6.8 minus 1.67 minus Ln of 6.8 minus 5.44 after 53 minutes divided by t2 minus t1. So, here t2 is what? T 80 how much 53 minus 11.2 divided by 60 to make it to the hour. Right?

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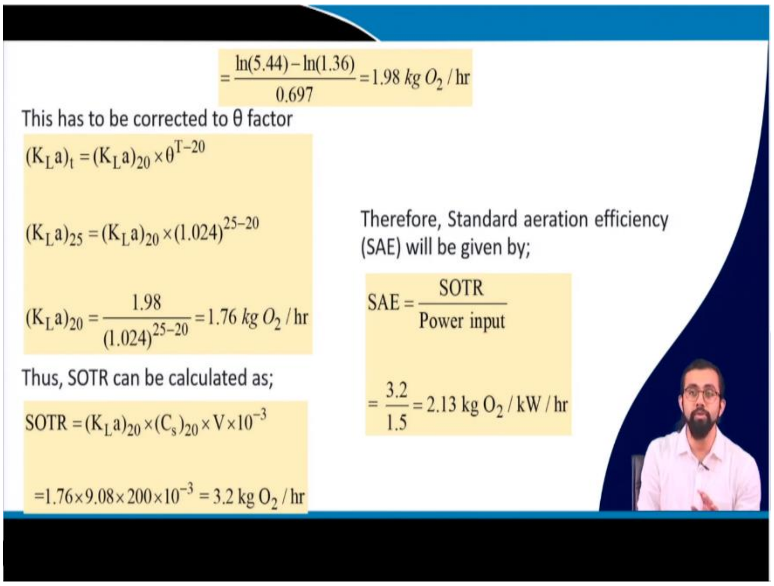

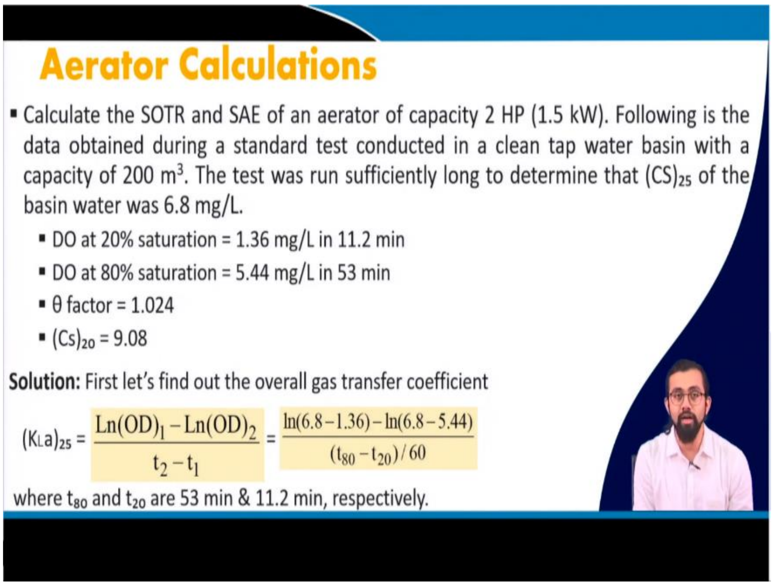

So, now everything is ready. Now if you do the calculation by yourself, you can easily find out the value will be 198 kg of oxygen per hour. I would really request to when you will be learning this, when you will be listening to this lecture, you better be ready with your calculator and paper and notebook. You do it by yourself. It will give you much confidence and like how it is going, how it is to be done. Okay! The calculation has to be done.

Now the value we know that it is 1.98 kg of oxygen per hour. Now it has to be corrected, the oxygen transfer rate that we know, oxygen gas transfer coefficient has to be corrected based on the temperature. At 25 degree Celsius, we have to find out the value at 25 degree Celsius. You know how to what is the equation? KLa 25 equal to KLa 20 multiplied by 1.024 which is the value of theta. The temperature correction factor to the power 25 minus 20. So, what will be the 1.25, 1.024 to the power 5 and in the numerator it will be 1.98. If you do the calculation, it will be 1.76 kg of oxygen per hour.

So, you know now you know the actual overall gas transfer coefficient at 20 degree Celsius also. Now you can easily calculate the standard oxygen transfer rate which is KLa 20 multiplied by CS 20 into V into 10 to the power minus 3, which is 1.76 kg of oxygen per hour multiplied by 9.8 milligram per liter or gram per meter cube.

You remember because it is the same. If you multiply it by milligram per liter with 1000 in numerator and denominator it will become gram per meter cube. So, 1.676 kg of kg per hour, 9.08 gram per meter cube into 200 meters cube, you remember the volume of the basin was 200 meters cube. So, it is 200 multiplied by 10 to the power minus 3 which is used for gram to kg conversion.

So, now the standard oxygen transfer rate is 3.2 kg of oxygen per hour. Tada, so you know the value of transfer rate now, Okay! you know the power input. What was the power input for? What is the capacity of the aerator that you bought? 1.5 kilowatt. Remember, we discussed, we already know from the problem only that it is a 2 HP aerator. So, 1.5 kilowatt. Just simply divided with 1.5, you will get the standard aeration efficiency of 2.13 kg of oxygen per kilowatt per hour.

Isn’t easy? It is really easy. Just you need to know the details of each and every individual components of this equation and how to do that and the calculation that it inverse and you are just ready with the calculator. I am saying once you will do it, once or twice you practice it, it will be as easy as water. It will be very easy for you. Okay!

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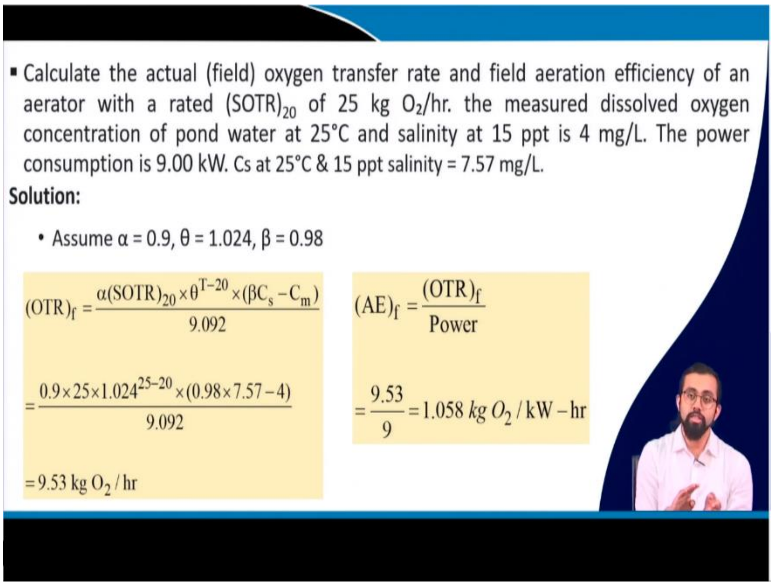

The next problem. In the next problem, let us shift a little bit towards the field situation. What will happen in case of field situation? In case of steady state run procedure? Okay! We are asked in this question to calculate the actual oxygen transfer rate or the field oxygen transfer rate and field aeration efficiency of an aerator with aerated SOTR 20 of 25 kg of oxygen per hour and the measure DO concentration is also given of pond water at 25 degree Celsius and salinity of 15 ppt is 4 milligrams per hour per liter.

So, we know the measured DO concentration is given at 25 degree Celsius, 15 ppt, 4 milligram per litre. The power consumption is given 9 kilowatt, the CS at 25 degree Celsius at 15 ppt salinity is 7.57 milligrams per liter it is also given. So, we also know the SOTR at 20 which is 25 kg of oxygen per hour.

We know a lot of important information from this problem. It is already given. What you need to do? You need to do some assumption when you do the field situation. Remember I discussed about the alpha factor which is what? It's the ratio between the overall gas transfer coefficient for pond and clean water situation. This ratio this value it is more or less, you can take in case of in general condition where it is not given, you can take this value as around 0.9 to 0.95. Okay!

Theta value, if it is not given this temperature correction factor, you can take it as 1.024 and beta value which is if it is not given in a particular problem, then you can assume it at 0.98. Okay! So, these values, you can assume it like this. So, 0.9 and 0.98 and all. Okay! Based on that, let us go ahead with the actual calculation. You remember the equations that we discussed when we discussed about the field oxygen transfer rate which is equal to alpha into

SOTR 20 multiplied by theta to the power t minus 20 multiplied by beta CS minus CM divided by 9.092 and this 9.092 is the concentration of saturation concentration of oxygen at 20 degree Celsius and 760 millimeter of HG.

Now, you replace with the information the data that we already know alpha which is 0.9. SOTR 20 is given 25 kg of oxygen per hour multiplied by theta we know 1.024 to the power p is how much 25 minus 20 multiplied beta we know 90.98, CS we know 7.57 is given as CS at 25 degree Celsius minus Cm. At that moment, what is the measured dissolved oxygen concentration which is 4. We know every other component of this equation. So, we just replace it you will get the value of oxygen transfer rate at field condition 9.53 kg of oxygen per hour.

If you divide it with the power, power is given 9 kilowatt, the power consumption of all the aerators. So, if you divided with the power in kilowatt, you will get the aeration efficiency in field aeration efficiency which is 9.53 divided by 9 equal to 1.058 kg of oxygen per kilowatt per hour. Here, I want to discuss with you one thing. It will It is just for your knowledge purpose. In general, this kilowatt hour, it is the unit of energy that you consume. Right?

In general, when we discuss about what is the overall consumption of your electricity at a particular month from your household, say, like you have a four house with ten amount of tube lights, a couple of bulbs, couple of fans and all. How you calculate this? It is very easy. You know it. This is called vot units as well, these kilowatt hour, this unit per unit charge, I think you know the from electricity office, you know that per unit cost, let us say Rs. 10. Rs. 20 based on the place that you are from,

So, this kilowatt hour, you can easily find the number of bulb or number of say you have four amount of bulbs in your room and each are having capacity of say 50 watt bulb. Okay! Just to give you an example, 50 watt bulb or say 25 watt bulb multiplied by four. So, 100 wattage of bulk that you have in general, in your house multiplied by the amount of time that it runs in a particular day, you will get that much kilowatt hour.

So, like if you are running your bulb for like say say 10 hours, so it will be 100 into 10 which is 1000 watt hour. 1000 watt hour means 1 kilowatt hour that means if you have a four bulb in your house which is running for 10 hours, it will give you it will cost you 1 kilowatt hour or 1 unit of electricity. 1 unit of electricity means in general, when the electricity bill comes to your place, you will see, like you have spent 50 unit, 100 units, 200 units. So, this each unit cost you some amount of rupee. So, here also this kilowatt hour means it is a 1 unit. So, kg of oxygen that it requires, that it provides after consuming one unit of electricity is what we call aeration efficiency.

You understand this point? It’s It’s Just to give you an example of just to give you some additional knowledge about all these things, I am giving you this example. So, aeration efficiency when you calculate, you calculate in this way, Okay!

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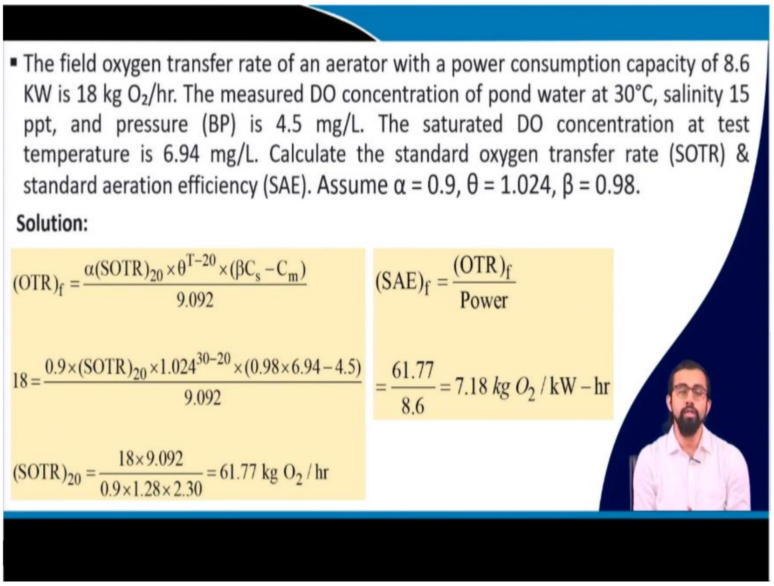

So, let us discuss about another problem. Here also we have the same situation. We are doing the calculation in steady state condition. That means in field condition and the field oxygen transfer rate in earlier questions, earlier problem, the field oxygen transfer rate is what we need to find out. We need to find out, right but in this case, it is given. The field oxygen transferred of an aerator with a power consumption capacity of 8.6 kilowatt is 18 kg of oxygen per hour. So, this value is given provided with you, Okay! So, this field oxygen transfer rate is provided with you. You know It is already suppose some student or some practitioner, they already did it and he found out that he or she finds out the field oxygen transfer rate is 18 kg of oxygen per hour.

Now, the measure DO of concentration of pond water at 30 degree Celsius and salinity of 15 ppt. Here, ppt, parts per thousand remember it. Salinity in general, we provided with the unit of parts per thousand, ppt. Okay! It is 15 ppt means almost blackish water, Okay! And a pressure barometric pressure BP in short, barometric pressure is at barometric pressure, it is like 4.5 milligrams per liter. Here there is nothing given. So, you consider it is a standard barometric pressure and which is you can consider 760 millimeter of Hg each is 4.5 milligrams per liter. So, we know the measure DO concentration. We know the field oxygen transfer rate now. We also know the saturated DO concentration at test temperature which is 30 degree Celsius and the value of saturated DO concentration is 6.94 milligrams per liter. So, we know the saturated concentration also.

We are asked to calculate the standard oxygen transfer rate. It is like you know we have to do some reverse calculation, And also, they are asking us to find out the standardization efficiency which is very easy. Just simply divided with power we will get it. What are the assumptions that we need to do? First, the value of alpha which is 0.9 we can take. Theta as we discussed 1.024. Beta factor is 0.98. Just put it in the equation of this OTR here is equal to alpha into SOTR 20, you know the SOTR 20, we know the value of alpha. We know the value of theta. We know the value of T which is 30 beta 0.98, CS 6.94, CM measured value is given 4.5 divided 9.092. You will get the value if you do the calculation, you will find out the value of SOTR 20 as 61.77 kg of oxygen per hour.

Now, if you simply divide it with the power which is given as like 8.6 kilowatt, you can easily get the value of standard aeration efficiency in field condition which is 7.18 kg of oxygen per kilowatt per hour. Isn’t easy? So, this is how we do the calculation. So, there is a mistake. Just let me be clear with it. In the right-hand side, it should be SA. It is a standard aeration efficiency. It is not f it is a mistake actually, it should be standard aeration efficiency equal to oxygen transfer rate. The standard oxygen transfer rate divided by power. If we do the field condition, that is also doable. In field condition also, if you do this calculation for field condition, that also you can do. You simply divide with 18 divided by 8.6. That will give you the field condition value.

But in case of standard aeration efficiency, the value can be calculated with the standard aeration efficiency will be standard oxygen transfer rate which is 61.77 divided by 8.6. Okay! Remember it, there is a mistake here, it say f, this f is if you use this equation, the value will be different. If you use the only standard aeration efficiency not in field condition but in standard condition, the value is what it is given 7.18 kg of oxygen per kilowatt hour. Okay!

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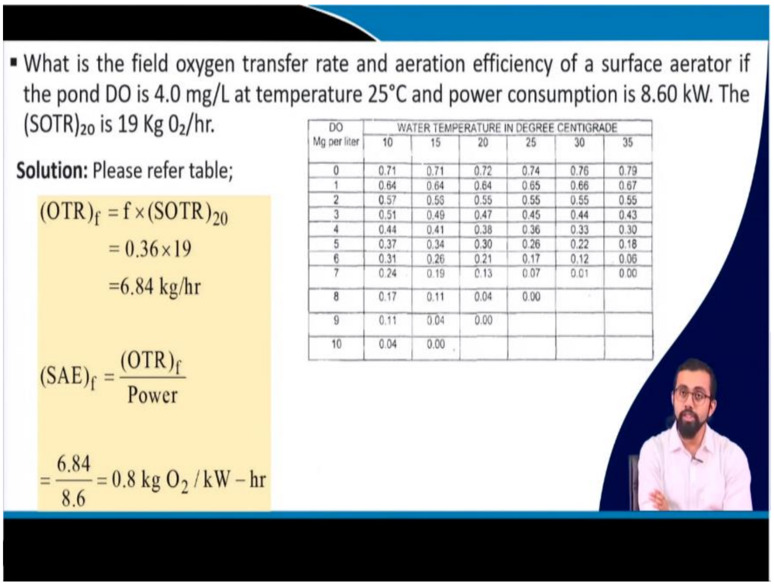

Now lets let us go back to let us go to the next problem. In the next problem, they are asking us to find out the field oxygen transfer rate and aeration efficiency of a surface aerator if the pond DO is 4.0 milligrams per liter at temperature 25 degree Celsius and power consumption is 8.6 kilowatt, the SOTR 20 is also given 19 kg of oxygen per hour. Isn't easy? When you know the value of SOTR 20, you know the pond DO concentration, you know the temperature. You can easily use the table. It is it will also be It is already find out by the experts that this DO at 4 milligram if you calculate it, if you go to the 4, if you go through the DO of milligram per litre, the fifth row, it is like 4 milligrams per liter right?. If you go just point it out and you go towards like 25 degree Celsius, you will find a value of 0.36. This 0.36 is the value of f.

If you put it in the equation oxygen transfer rate equal to f which is 0.36 multiplied by 19 which is the SOTR 20, you will get 6.84 kg per hour. This 6.84 kg per hour divided by 8.6 the power, you will get standard aeration efficiency in field condition which is 0.8 kg of oxygen per kilowatt per hour. Isn't easy? It's very easy. Once you know the fundamentals, once you know the different way of calculating the way what are the measuring parameters and all, you can easily find out the final value.

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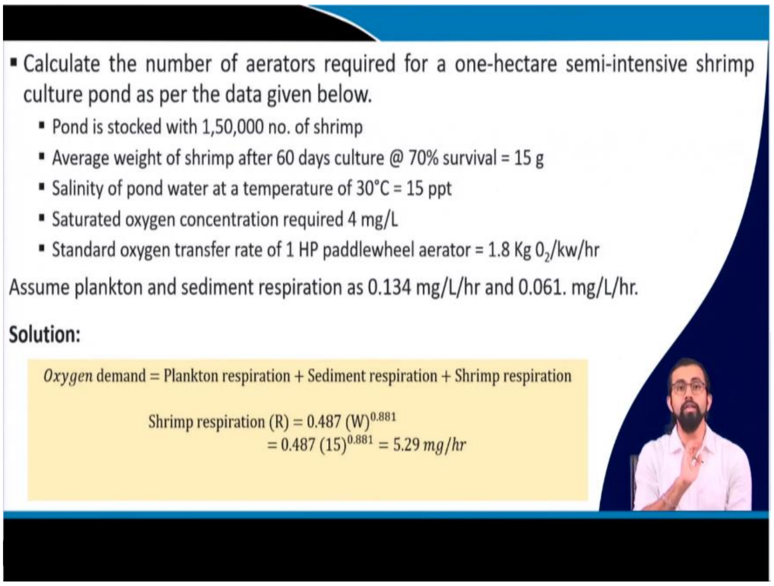

Final one I think. So, this problem what it says is the calculate the number of aerator required for 1 hectare semi intensive stream culture pond as per the data given below. What are the information that we are given? 1 hectare pond. 1 hectare means 10 to the power 4 meter square. Okay! 10,000 meters square first information. Second information, pond is stocked with 1.5 lakh number of shrimps 1 lakh 50,000 number of streams are there. Third information, average weight of shrimp after 60 days of culture at 70 percent survival is 15 grams. Each shrimp has 15 grams of weight after 70 percent survival at 60 days. After 60 days of culture Okay!. So just remember this information Okay!. We need to use it.

Salinity is given 15 ppt at 30 degree Celsius Okay!, saturation oxygen concentration is given 4 milligrams per liter. Saturated oxygen concentration is only 4 milligrams per liter. Standard oxygen transfer rate is 1 HP. For 1 HP, paddlewheel aerator is 1.8 kg of oxygen per kilowatt per hour Okay!. Also, another information is given that the plankton respiration and the sediment respiration rate is also given which is 0.134 milligrams per liter per hour and 0.16 milligrams per liter per hour.

Total oxygen demand, how we can calculate? Planktonic respiration, sediment respiration and shrimp respiration. Now you say how sediment can respire. Right ? Sediment cannot respire but for sediment, you know, it also has some oxygen demand to convert it to the different other molecules. What happens? This is what we call this chemical demand that we normally talk about.right So, this planktonic respiration, sediment respiration or benthic respiration. Sometimes there are maybe some benthic populations that for them. Also, for their respiration purpose also it needs some oxygen shrimp precipitation. Summation of these three will give you the total oxygen demand.

Shrimp precipitation how to calculate? If you remember the equation we discussed 0.487 multiplied by W which is the value of the weight of shrimp each shrimp which is 15 grams to the power 0.881, you will get the value in milligram per hour, 5.29 milligram per hour. Okay! So, we know the shrimp respiration value. Also, we know planktonic respiration. Also, we know sediment respiration value. So, this value total oxygen demand is already with in our hands. Okay!

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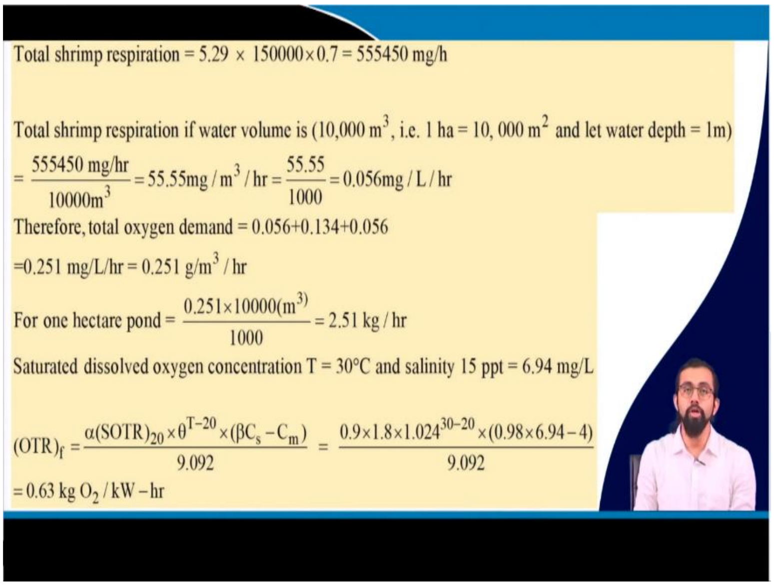

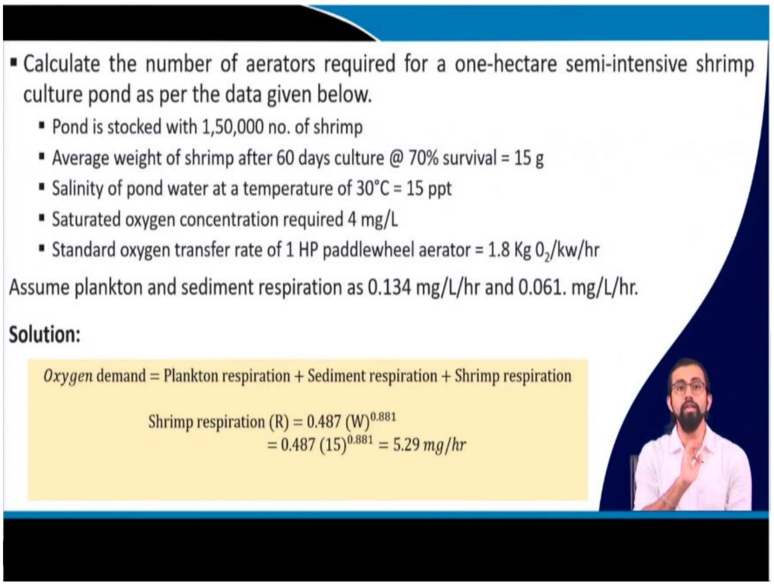

Now, total shrimp respiration will be 5.29 multiplied by 1.5 lakh into 0.7 because you remember 70 percent survival rate. I told you like each and every information is important.

The 70 percent survival rate multiplied by one point lakh into 5.29. That is the respiration value for each shrimp. If you multiply it, you will get 5.5 5.5 okay 555450 milligram per hour or say like 555 gram per hour. Okay! So, just to make it easier.

Now, so the total respiration if the total water volume is say 10,000 meter cube. Here we also take one assumption that the water depth is 1 meter Okay!, In general, it is not more than 1 meter in case of shrimp culture. So, we have 1 hectare area 10,000 meter square. And let us assume that depth is 1 meter. What would the total volume? 10,000 meter cube so now the total shrimp respiration is given 555450 milligrams per liter divided by 10,000. If you do that and you can easily get the value of 55.55 milligrams per meter cube per hour. If you further divide by 1000, you will get 0.56 milligrams per liter per hour.

Here also we are given the value for plankton and sediment milligram per liter per hour. So, now the required units are same. Now we can easily add these three. Now the total oxygen demand 0.056, 0.134, 0.56 total is 0.251. Okay! So, it will be 0.56, 0.134, 0.061. So, it will be 0.251. Okay! 0.251 equal to 0.251 gram per meter cube per hour. Okay! So, this will be 0.061, 0.056 plus 0.134 plus 0.061 Okay! it will be 0.251 milligram per liter per hour Okay!, or milligram per litre you can easily convert it to gram per meter cube per hour.

So, for 1 hectare pond 0.251 gram per meter cube per hour multiplied by total area, total volume 10,000 meters cube, you will get the value in and if you divide it with thousand, you will get the value in kg per hour. So, total oxygen demand is 2.51 kg per hour. Saturation oxygen concentration is given 6.94. It is given 6.94 milligrams per liter at 30 degree Celsius and 15 ppt. Now you can easily calculate the oxygen transfer rate and field field condition. Alpha, you assume 8.9, SOTR is given 1.8, theta is 1.024 to the power 30 minus 20, beta is 0.98 multiplied by 6.94 minus 4 divided by 9.092 which is equal to 0.63 kg of oxygen per kilowatt hour.

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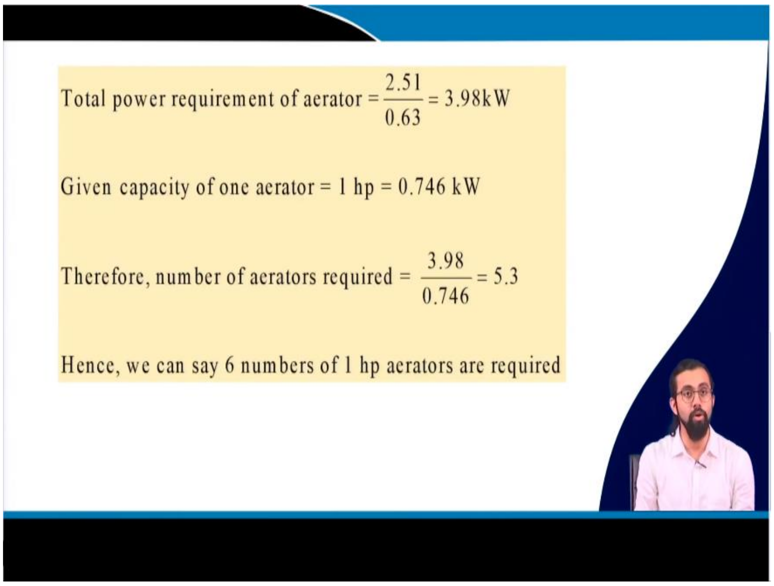

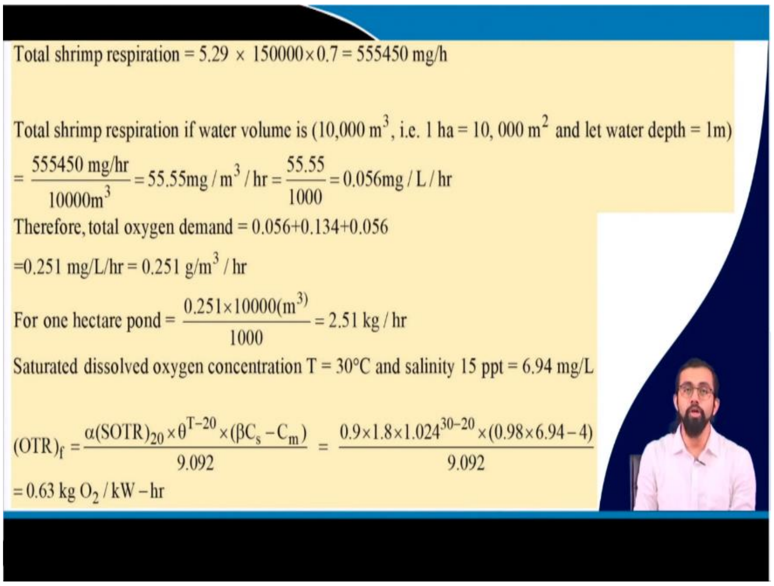

So total power, how you can calculate total power requirement for aerator? 2.51 kg per hour divided by 0.63. So, you will get the value out here and so you will get the total power which is like 3.98 kilowatt. So, this 3.98 kilowatt, if you are given the capacity of one aerator is 0.746. So, if you divide it with 3.98, it will be 5.3. Hence, we can say that to make it to have an option in our hands, we can say almost six number of 1 HP aerators are required. You understand? Isn't easy?

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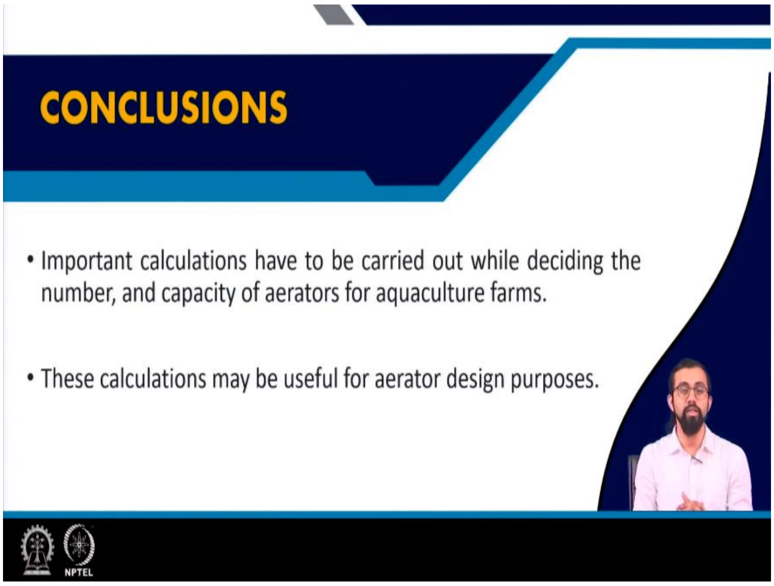

So, in conclusion, important calculations have to be carried out while deciding the number and the capacity of aerators and these calculations are useful in aerator design purposes and we normally do it as we already discussed in this lecture material. I hope it will be helpful for you. There are two or three mistakes are there in the lecture material I already pointed out. Remember this and try not to make the same mistake. Okay!

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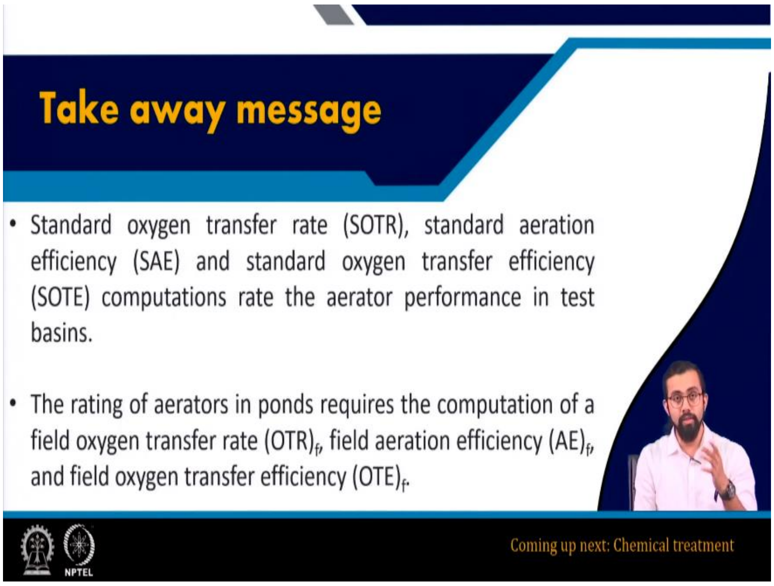

So, thank you so much. This is the Takeaway message.

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The reference that you can check for your further information. So, thank you so much. I hope this module will help you with calculating in general how the aerators are designed, what is the different parameters that we need to follow and how to calculate the aeration efficiency in field condition and in standard condition, how to calculate the standard oxygen transfer rate and oxygen transfer rate at field condition and all.

So, these values are very important and we normally use it very frequently when we design an say any farm. So, it is very important for us to know the value of these different values of these aerators. Unless and until we know the value of this these particular units of your aerators, a procured aerator or say you design it, you cannot utilize it properly. Otherwise, what will happen? You will keep on doing the either over saturating, you will keep on overusing the aeration systems, or like not properly, not optimally using, maybe less using the oxygen option. So, in the both of the cases it is problematic because overusing it is also not good, as we discussed. And also, if you are not providing with enough oxygen that is also not good, it may cause various kind of detrimental effect on your aquatic species.

So, in general, you try to understand these problems. If you have any issues, you definitely google it. There are plenty of options, plenty of examples given and if you have any specific doubt, you can definitely contact me. And so yep That is it. So, maybe we are left with another lecture for this module. See you again. Thank you.

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