Life Cycle Assessment
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Lecture – 39
Tutorial I

Welcome to the life cycle analysis tutorial class. So, in this particular section we will be just looking after various numericals and everything. In any engineering problem and everything it is at most necessary to assess and quantify the values in table if we just take environmental engineering as a small example and everything we have water quality standards, water discharge standards, air quality standards and everything. So, whenever we approach any particular place or a location then we are given a example like it industry analysis or anything we will be looking after that particular problem and will be doing lot of experiments on that particular thing and then we will analyze that particular data and we will arrive to a particular standard.

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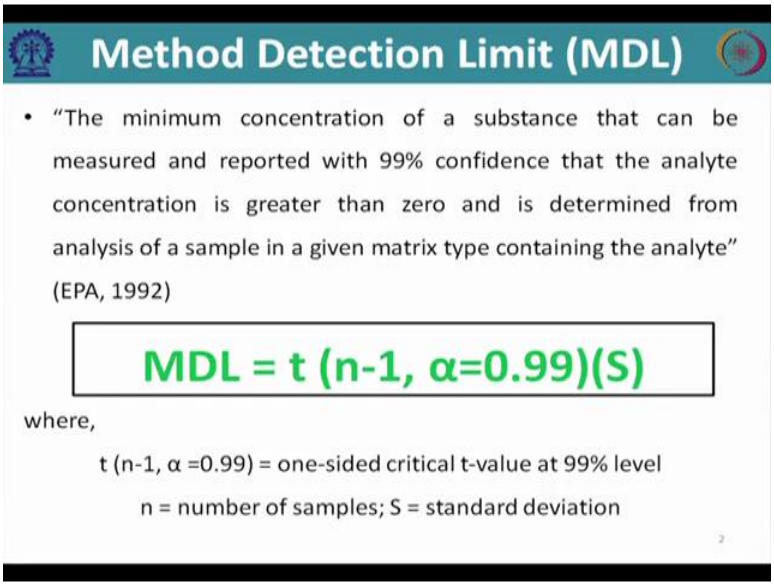

So, that particular standards have to be carefully calculated and done we will use some probability statistics and everything for analyzing all those particular data and then we will correlate that particular data with the quality standard and we will give our results and everything. So, in the life cycle analysis and everything when we are trying to calculate the impact of any particular project or any particular industrial anything we have to follow a different steps in that particular thing which have been already discussed in the previous lectures and everything. So, once we analyze all particular data and everything that data will use for quantifying that particular problem and then we will use some probability statistics and then we will arrive to a final decision which will be useful by any regulatory bodies or stakeholders for doing better decision modeling and everything.

So, in this particular session we will be doing numericals on mass balance models as well as method detection limit and everything. So, now, we will just look in to the method detection limit. So, in the previous lectures we have already said that the method detection limit is the minimum concentration of the substance that can be measured and reported with 99 percent confidence and analyte concentration is greater than 0 and it is determined from the analysis of a sample in a given matrix type containing the analyte. So, in we are seen that the MDL can be determined using that student t test where it is an t is equal to n minus 1 alpha 0.99, this alpha 0.99 is the level of confidence. So, in the numericals we will just see that particular thing.

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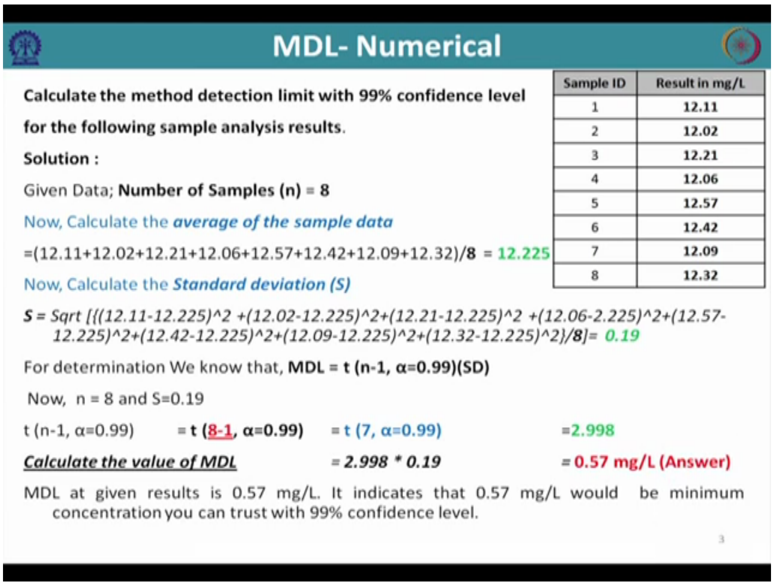

And now we will be using calculate the method detection limit with 99 percent confidence level of the following sample analysis.

So, in this particular thing we will just see there are 8 samples and the results have been given in the milligram per liter now we will try to analyze this particular thing and we will find out the main method detection limit for the analysis. So, the number of samples that are given are 8 and the first step will be calculating the average of the sample data. So, add everything and divided by the number of samples we will get that particular value for this particular numerical it is 12.225 and once we are calculated the average of the sample then will be calculating the standard deviation the standard deviation will be calculated as the square root of the average the sample id minus the average whole square the divided by the number of samples.

So, once we do this particular thing will arrive to the value 0.9 then it is the more next will be determining the method detection limit from the formula we have already seen that it is t will be using that t distribution student t distribution chart where the n minus 1 the more important you have to understand here is we had to take and minus 1 that is the number of samples minus 1 for calculating the value from the t distribution chart that is 8 minus 17 and the alpha where the confidence limit has been shown as 0.99.

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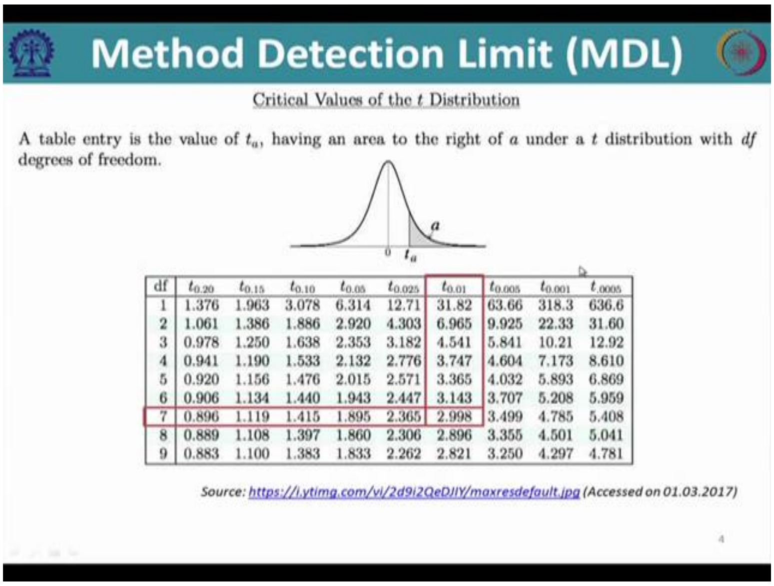

df	$t_{0.20}$	$t_{0.15}$	$t_{0.10}$	$t_{0.05}$	$t_{0.025}$	$t_{0.01}$	$t_{0.005}$	$t_{0.001}$	$t_{.0005}$
1	1.376	1.963	3.078	6.314	12.71	31.82	63.66	318.3	636.6
2	1.061	1.386	1.886	2.920	4.303	6.965	9.925	22.33	31.60
3	0.978	1.250	1.638	2.353	3.182	4.541	5.841	10.21	12.92
4	0.941	1.190	1.533	2.132	2.776	3.747	4.604	7.173	8.610
5	0.920	1.156	1.476	2.015	2.571	3.365	4.032	5.893	6.869
6	0.906	1.134	1.440	1.943	2.447	3.143	3.707	5.208	5.959
7	0.896	1.119	1.415	1.895	2.365	2.998	3.499	4.785	5.408
8	0.889	1.108	1.397	1.860	2.306	2.896	3.355	4.501	5.041
9	0.883	1.100	1.383	1.833	2.262	2.821	3.250	4.297	4.781

So, once if we just understand this particular student t distribution chart which can be easily available from any probability statistics textbook there the 0.99 which is equal into 0.01 that is 100 minus 0.99 will get with this degree of freedom as 7 which is n minus 1 that is number of samples minus 1 will get this value that is 2.998. So, by using this particular value multiplied with the standard deviation we will be getting the method detection limit that is in this particular numerical it is 0.57 milligram, but later. So, on calculating what it represents is the 0.57 milligram would be the minimum concentration you can trust with 99 percent confidence limit.

So, in the exam for the examination everything the values will be given. So, we have to at most take care in determining the average determining the standard deviation and then while we are checking the particular thing that is the degree of freedom when we are checking it should be number of samples minus 1.

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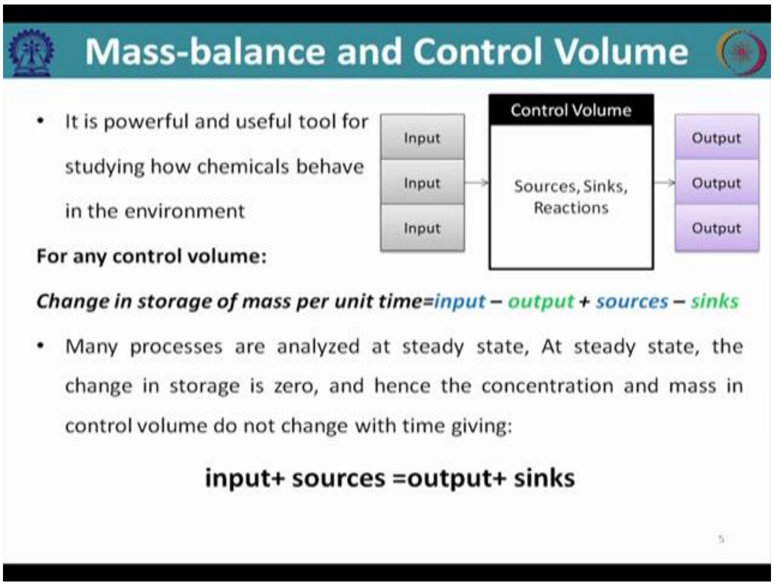

Now, we will just go into the mass balance and control volume numericals this mass balance and control volume numericals have been greatly used in the engineering problems and everything this particular techniques and everything will be useful for analyzing the concentrations and the process mechanisms and everything in across various engineering solutions and everything this is a one of the very powerful tool for studying the chemical behavior in the environment and everything.

So, in this particular thing we will have a control volume. So, in the control volume there will be various amount of reactions taking place there will be a source inside that particular thing which will be generating lot of things and there will be a sink which will be absorbing which will be taken care within that particular volume alone and along with that there will be some inputs from the outside which will be called as input and there will be few output. For example, if we just take a lake there can be an industrial discharge or the outlet which is coming from the industry and that particular thing will be enter into the lake and there will be some reactions going on in that particular thing and fishes or any microorganisms that there they can take that particular pollutant and everything and similarly they release some gases and everything within. So, that can be sources etcetera and the lake will have an outlet which will release the particular thing outside.

So, this whole system we have to understand very carefully. So, any numerical when we just materialize into this particular sort; that means, a control volume in input and then and output and what are the reactions that are occurring that is source sink if we understand this particular thing then we can easily solve the numerical for the confer any control volume the change in the storage of mass per unit time is given by the input minus the output plus sources minus sink. So, this is the general thing what they will be taking and any control volume will be generally solving in a steady state manner.

So, what is this study state manner means the concentration with respect to time will be constant that is a DC by DT is a constant. So, the concentration will rise to a 0, there will be no change in the concentration; variations in the concentration and everything. So, the change in the storage of mass per unit time can be comfortable be placed to 0. So, therefore, the input plus the source will be equal to the output plus sink, with using this particular this particular basic principles and everything.

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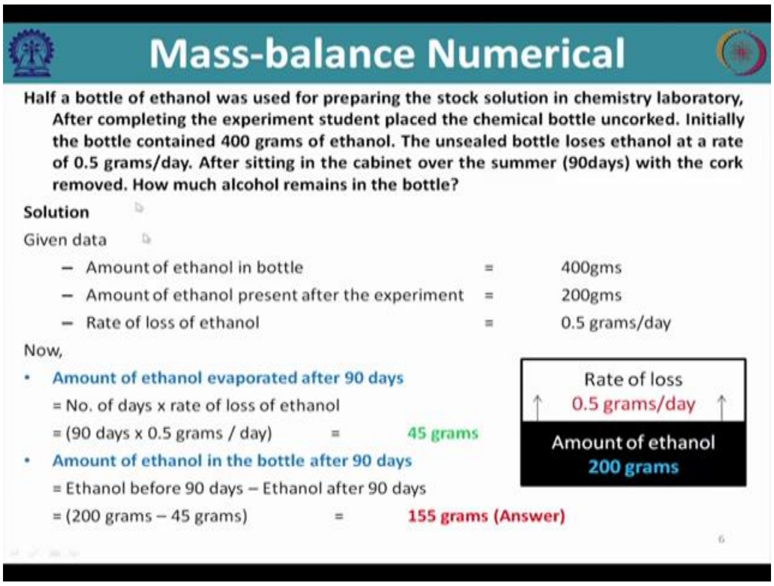

We will be solving the next numericals and everything. So, now, let us solve a simple numerical a half bottle of ethanol was used for preparing the stock solution in chemistry laboratory after completing the experiment student place the chemical bottle uncorked initially the bottle contain 400 grams of ethanol and the unsealed bottle loses ethanol at a rate of 0.5 gram per day.

After sitting in the cabinet that over the summer that is 90 days with the cork removed how much alcohol remains in the bottle. So, ones when we are solving any numerical is the first step what way to take is we will be drawing the control volume diagram the mass balance diagram and everything. So, that will give us a clear idea what is really happening inside that particular system and everything. So, let us see the given data. So, the amount of ethanol in the bottle is 400 grams and amount of ethanol present after the experiment since it has become half. So, it will become 200 grams and the rate of loss of ethanol is 0.5 gram per day.

So, now let us draw the control volume diagram and everything. So, this particular picture is already showing you the control volume diagram. So, the amount of ethanol is 200 grams and the rate of loss is 0.5 gram per day. So, there is no input there is no output.

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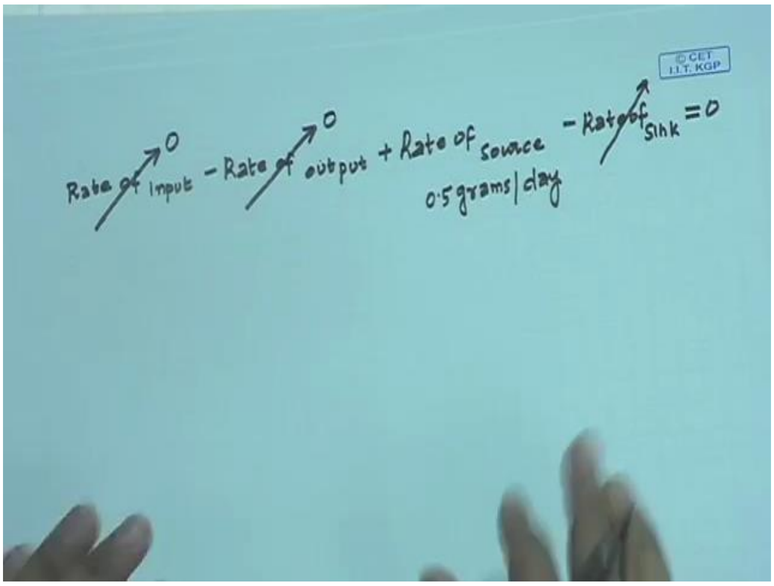

So, now let us just check out this particular thing rate of input rate of input minus rate of output plus rate of source minus rate of sink is equal to 0. So, this is what will be considering here there is no input. So, which can be considered only put to 0, there will be no output which is considered only plus it to 0, we have a source which is being committed at 0.5 grams per day. So, this is thing and there is no sink. So, this is how we have to write the complete equation and understand this thing.

So, here since is asking what is the amount of ethanol that is present we can comfortably see from the units that is ninety days multiplied by 0.5 gram will give us the quantity that has been evaporated. So, which is reaching to 45 grams and the amount of ethanol in the bottle after ninety days is the 200 grams minus 45; 155 grams will be reaching the answer comfortably. So, this is very simple thing numericals and everything we can to first draw this particular mass balance diagram the at most important thing when we are doing the mass balance numericals and everything they are the mass balance diagram indicate what is the input indicate what is the output then indicate what are the sources sayings or any other reactions that have been given to you and then solve the numerical step by step.

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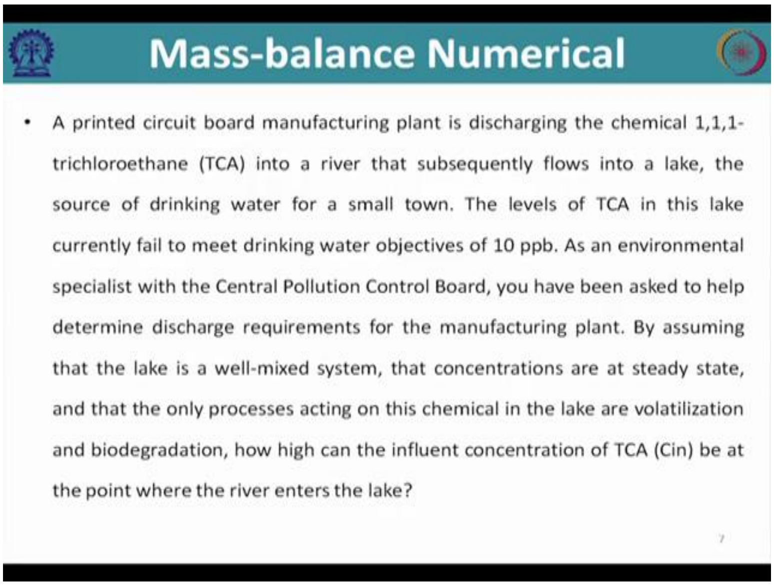

So, now we will just go into in another numerical a printed circuit board manufacturing plant is discharging the chemical 1 trichloroethane; trichloroethane into a river that subsequently flows into the lake the source of drinking water from a small town the levels of TCA in the lake currently fail to meet the drinking water objectives of 10 ppb. So, as an environmental specialist with the central pollution control board you have been asked to help determine discharge requirements for the manufacturing plant. So, by assuming the lake is a well mixed system that concentrations are at steady state and that the only process acting on this chemical the lake are volatilization and biodegradation. So, how can the influent concentration of TCA that is Cin be at the point where the lake and entrance where the river enters the lake?

So, while reading this particular question, there has been lot of data that has been given to us so, but we have to carefully understand that we have to analyze the concentration for the manufacturing plant since it is not meeting the required (Refer Time: 12:48) that is objectives 10 PPB.

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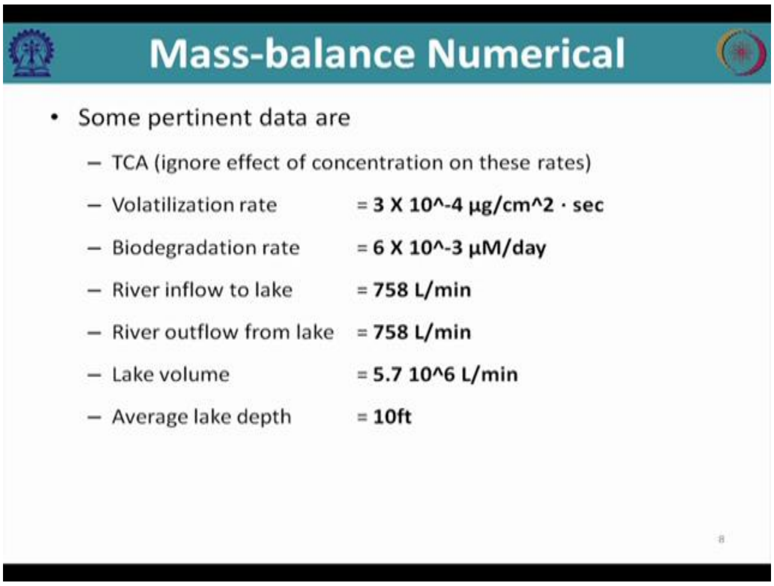

So, we will have a lot of analysis for this particular thing. So, we will we given certain amount of data that has been done by our sampling and then feel testing and everything we will just see the voltage volatilization rate is given that is 3 into 10 to the power of minus 4 microgram centimeters square second then the biodegradation rate has been given that is 6 into 10 to the power of minus 3 micromolar per day and the river inflow into the lake is 758 liter per minute river outflow from lake is 758 liter per minute the lake volume is 5.7 10 to the power of 6 liter per minute and average lake depth is 10 feet.

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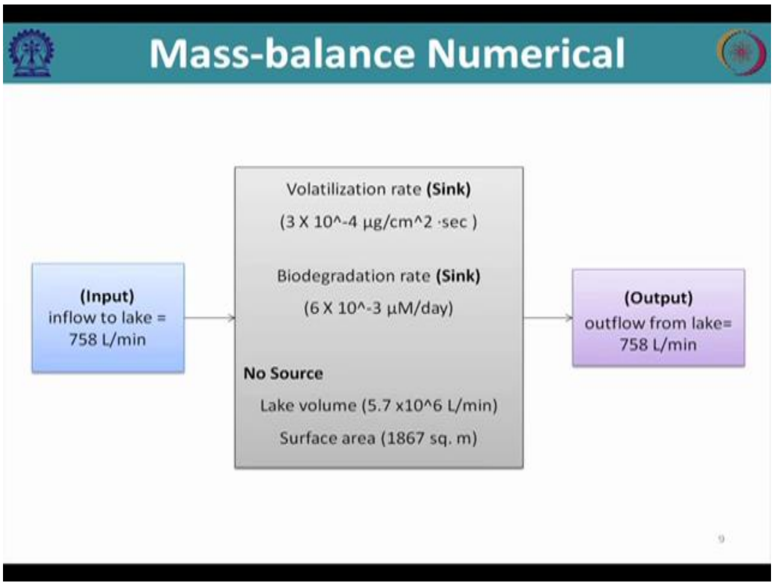

Now, we will draw the mass balance of this particular thing. So, we will take a control volume where it is entering. So, the lake volume is 5.7 into 10 to the power of 6 liter per minutes and we are already doing the surface area as 1867 square meters that is 18,000; 1,867 square meters in the volatilization rate is a sync and the biodegradation rate is a sink and we have an input that is the inflow of the lake at 758 liter per minute and there is an output that is outflow from the lake is 758 per minutes; that means, the input and output are same and we have been already given that this particular system is in study state.

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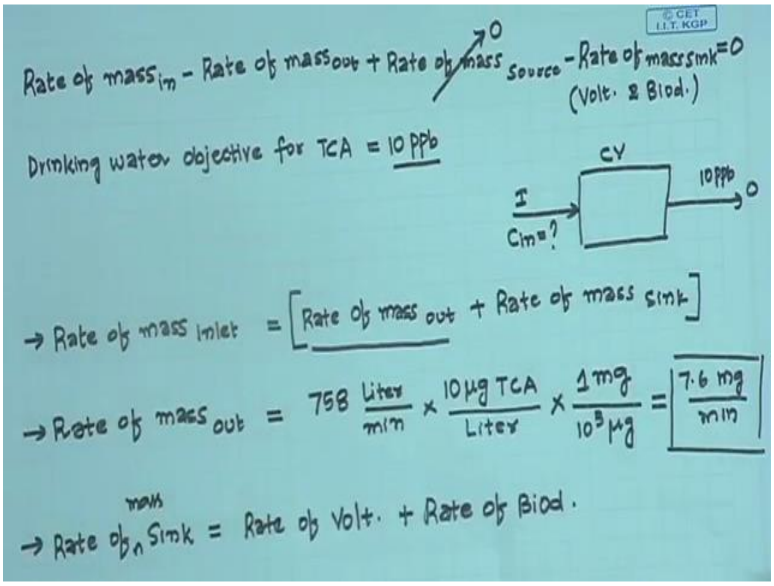

So, now we will just put all these particular things into the equations and everything. So, the rate of mass in minus the rate of mass out plus rate of mass source minus rate of mass sink is equal to 0 since it is an study state. So, now, we have rate of mass in that is the inflow of the river rate of mass out it is outflow of the river and the rate of mass source is not there which is standing 0 and there is a rate of mass sink which is through volatilization and biodegradation done.

So, now, if you just see the given data we have an inflow then the outflow lake volume has been already given and the surface area has been given volatilization rate is given and biodegradation rate is given along with that we have the drinking water objective drinking water objective water objective for TCA, TCA as 10 ppb which is the outlet standard which as the outlet standard we can just draw the diagram for you over here this is the control volume this is the inflow this is the outflow here it should be less than 10 ppb and we have to find out the concentration at the inflow concentration at the inflow.

So, now we will just carefully go step by step we will first calculate the rate of mass rate of mass rate of mass that is at the inlet at the inlet. So, rate of mass at the inlet can be calculated from the rate of mass from the rate of mass outlet plus the rate of mass rate of mass at sink and now to do this we will first calculate the rate of mass rate of mass the outlet. So, which can be taken as 758 liter per minute per minute per minute into 10 microgram of TCA 10 microgram of PCA per liter per liter 10 microgram per TCA per liter this is just because of this particular standard and we have to convert this particular thing into a simpler unit for that we will use the milligram will convert this micrograms into the milligrams. So, 1 milligram is equal to 10 power 3 microgram 10 power 3 micrograms. So, converting whole the things will get 7.6 milligram per minute 7.6 milligram per minute the most important thing what we have to understand in this particular numericals is the unit conversions and everything.

Once if you are doing the unit conversions carefully then the final answers can be achieved now since we have calculated this then we will go to the rate of mass rate of mass rate of mass sink rate of mass sink which is given by the rate of rate of volatilization plus rate of rate of biodegradation.

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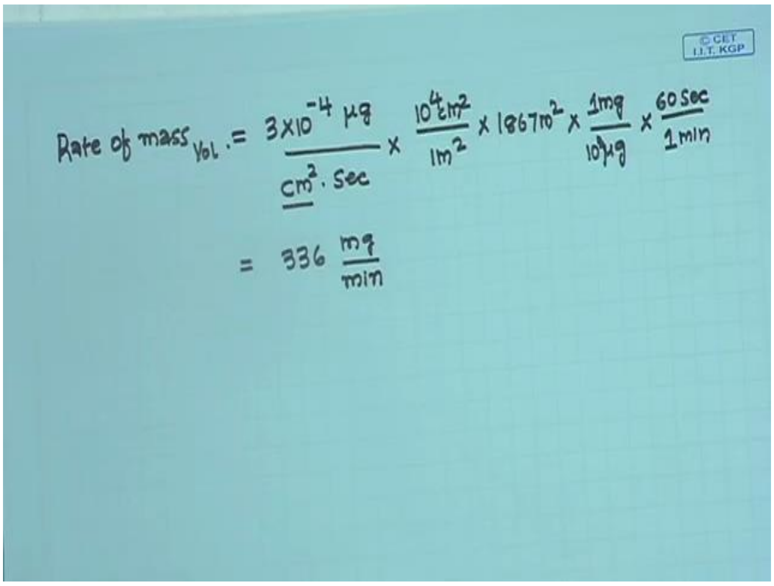

So, now we will calculate the rate of volatilization; rate of mass due to volatilization. So, the value that has been given to us is 3 into 10 to the power of minus 4 minus 4 microgram per centimeter square per second.

Now, we have to convert this into milligram per minute first we will take the square centimeter square. So, one centimeter square when we are taking it is 10 power 4 centimeter square is equal to 1 meter square and it is multiplied by 1867 meter square that is the surface area of the lake surface area of the lake then we will convert this particular microgram into milligram is one milligram is equal into 10 power 3 microgram 10 power 3 microgram and will convert the seconds into minutes that is 60 seconds is equal to 1 minute.

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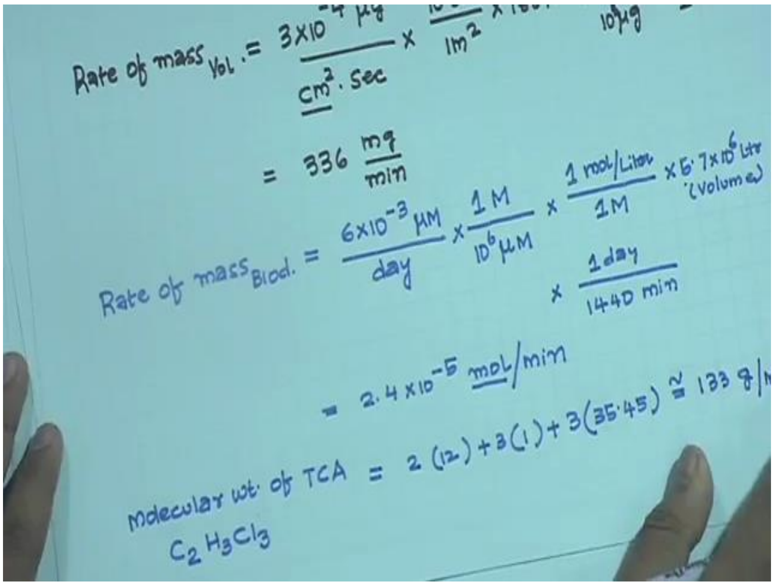

So, the doing this we will get the value as 336 milligram per minute and now we will just calculate the rate of mass; rate of mass due to biodegradation. So, the value that has been given to rate of mass biodegradation is 6 into 10 to the power of minus 3 micromolar per day. So, now, one molar one molar is equivalent to 10 to the power of 6 micromolar and which is equivalent to 1 mole per liter one mole per liter is equal to 1 molar and multiplied by 5.7 into 10 of the power of 6 liters, this is the volume of the lake volume of the lake we are taking and then multiplied by multiplied by one day. So, one day is equivalent to 14; 40 minutes 14; 40 minutes. So, it is 24 into 60 hours into 6.

So, by converting the particular thing we will just get 2.4 into 10 to the power of minus 5 mole per minute; mole per minute, but in our rate of mass per volume is in milligram per liter while the rate of mass for biodegradability is in mole per minute. So, we have to convert this particular mole per minute into milligram per minute. So, how do we convert since this is mole we know we will just determined the molecular weight molecular weight molecular weight of TCA; TCA in the numerical it has been given as one trichloroethane the formula for this particular thing is C2 H3 CL3; CL3. So, we can calculate the molecular weight as 2 into 12 for the carbon plus 3 into 1 molecular weight of hydrogen plus 3 into 35.45 the molecular weight of the chloride. So, it will come approximately to 133 gram per mole 133 gram per mole.

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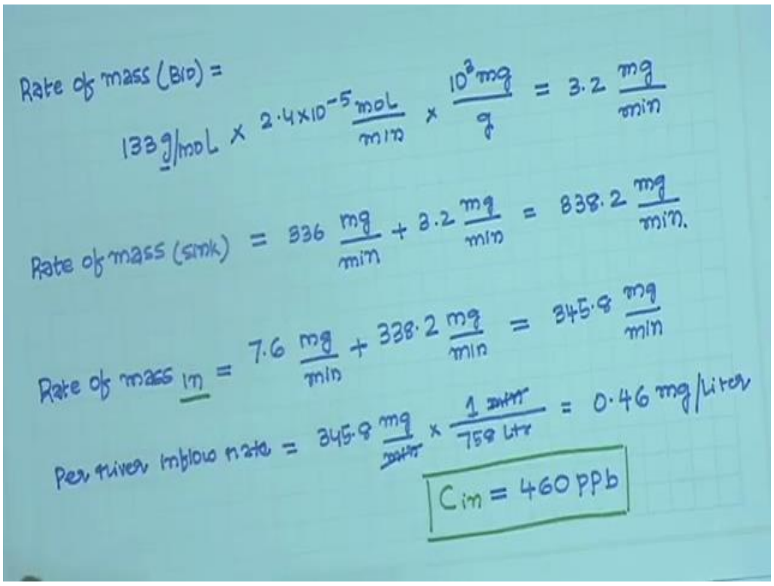

Now, from this particular thing we will be calculating rate of biodegradability rate of rate of mass due to biodegradability due to biodegradability. So, the value that has been obtained is 133 gram per mole is the molecular weight of that particular thing in multiplied by 2.4 into 10 to the power of minus 5 mole per minute is the rate of biodegradability that is obtained in the mole per minute which multiplies a sense it is in gram will be converting into the microgram it is 10 power 3 sorry, milligram is equal to gram which will be equal to 3.2 milligram per minute.

So, in the previous numerical already we have obtained is 336 milligram per minute as the rate of mass per volatilization and the rate of biodegradability mass as been calculated to be 3.2 milligram per minute. So, now, adding this both we will get the rate of mass rate of mass rate of mass sink rate of mass sink. So, which is equal to 336 milligram per minutes minute plus 3.2 milligram per minute which is equivalent to 338.2 milligram per minute.

Now, we have to calculate the concentration at the inlet. So, for this we will just go back and the initial things and we will just see that the rate of mass rate of mass in is equal to the rate of mass that has been coming from the outlet which has being calculated at the initial stages we can just see as 7.6 milligram per minute; 7.6 milligram per minute plus the rate of mass sink which has been calculated as 338.2 milligram per minute per minute. So, totally it reaches to 345.8 milligram per minute.

So, now we have to calculate this particular thing for the complete flow complete flow. So, we have 758 liters of water that is entering into that particular thing. So, we have been calculating for the inflow rate. So, per river inflow rate per river inflow rate per river inflow rate we thing that is 345.8 milligram per minute into for 1 minute; we have 758 liters of water entering 758 liters of water entering. So, which is equivalent to 0.46 milligram per liter; that is the minutes gets cancelled and we know that we know that milligram per 1 milligram per liter is equivalent to 1000 ppb which can be comfortable written as 460 ppb parts per billion parts per billion.

So, this is the Cin. So, we will just again revise this particular numerical from the start from the start. So, what we are being doing in this particular thing. So, if we just see in the mass balance of this particular numerical we are seen the control volume that is what has been given the lake volume surface area volatilization rate biodegradation rate everything and we will have an input and an output that has been taken care and then we are written the mass balance equation since it is a study state equilize it to 0 that is rate of mass in minus rate of mass out plus rate of mass source and sink is equivalent to 0 and we have seen that the mass is not their we can complete kept it to 0 then we have understood what is our standards and everything and what we have to calculate has been taken care from the diagram.

So, with then we will be calculating the rate of mass inlet from left hand side to right hand side we will transferring and we will be checking out what we have to calculate step by step then we have calculated the rate of mass outlet then we are calculated the rate of mass sink the rate of mass sink has been calculated from the rate of mass volatilization and rate of the mass biodegradation. So, in each and every step we have to be very careful in the unit conversions and everything.

So, from then we have moved on to the final calculation of the rate of mass at the inlet. So, once we have got this particular thing we comfortably converting all this particular units into the require discharge standards and everything. So, now, for the TCA manufacturing industry they should have a minimum concentration less than 460 ppb. So, this is what we will finalizing or the bureaucrats or the decision makers or the industrial people they have to take care of this particular thing they have to maintain their standards carefully and finalize for the standards.

So, this is how we will be going on into the numericals and everything. So, we will be taking care of each and every step and in the examinations and everything the necessary datas will be provided. So, once when you are looking into the life cycle analysis portions and everything the in pact as to be translated into the numerical portion and everything which will cater the needs of the bureaucrats or the decision makers or the stakeholders and everything.

Thank you.