Course Name: Industrial Wastewater Treatment

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Lecture 34: Treatment of wastewater produced from Distillery and Dairy Industries

So, welcome you all. Today I am going to deliver my lecture 4 of module 7. which is on treatment of wastewater produced from distillery and dairy industry. So, in the previous lecture we have covered about the distillery industry and then there are brewery sections al So, where the beers are produced and the process of fermentation is carried out for producing the beer. Under this we are going to cover basic introduction on the brewery industry, its growth and then we will be looking about the different unit operations they are involved in brewery, their water demands and then we will be looking upon the production of beer, how the beer is produced using process flow diagram. Then we will be looking about the sources of brewery wastewater where from different sections, where from the waste waters are generated, what type of wastewater are generated and then like you see in the brewery industry there is a major two sections one is like malt house and another is breathing section. So, from these two major sections the best water which are produced they differ significantly in terms of characteristics and as well as in terms of their flow rates. So, we will be looking about the composition and the characteristics of the wastewater which are produced from the malt house and the brewery sections and then finally we will be going through the various treatment process which are used for treatment of this effluents which are generated from the distillery industries.

So, let us first describe about the introduction on the brewery industry if we see that brewery industry produces mainly beer by the way of fermentation of carbohydrates. Wherein the yeast culture is used for fermentation. So, at present if we see we have more than 489 brewery's they are in our country as on January 9, 2024, amongst them if we see the largest brewery's which is like based on Bangalore, the United brewery's which has a production capacity more than 360,000 litres of beer per day. So, they have a production capacity of 3,60,000 thousand litre of beers per day. All of the product from brewery's, wineries and distilleries which are generated one thing is very common that is presence of ethanol and these ethanol depending upon the type of the product like whether we are producing wines whether we are producing beers or different types of whiskeys so, the percentage of this alcohol varies and the growth if we see this industry has got a lot of growth and the growth that can be seen by the rapid urbanization changing, lifestyle exposure to the new and western culture and the overseas education are also, they are contributing to its increasing demand of brewery's in India. So, in near future also it is expected that there will be further increase in the number of brewery's in our country looking into the increasing demand of this distillery, brewery's and wineries product in our country.

So, the wastewater generated from the brewery if we see its composition so it mainly contains the high levels of sugar and alcohol along with the other soluble organic and inorganic substances

which are derived especially from the raw material like the type of grains we are using for brewing and producing the beer.

So, this basically if we see that is the water consumption that are required in different unit operations which are operated in brewery's. So, this pie chart basically represents the various unit operations in a brewery industry and the amount of water used in that brewery having a capacity of one hectolitre beer production. So, these are like brewing section then there are a dilution water that is required then filtration water that is required water for filling, water for cleaning, boiler feed water that is also, like there are different types of sections where the water is required and their values are given like the largest fraction of the water that is used in the brewing section and lot of water that is also, used if we see in filling and CIP that is cleaning in place So, these are different operations that requires the water. So, as water is used in this process this results as a wastewater also. So, that waste water contains lot of these impurities which are involved into the water during these operations during these processes. So, overall if we see what is like the total demand of the water for per litre of beer if we see that is around four to six times that is four to six litre of water that will be required for producing one litre of beer.

So, this is the basically the process diagram which explains which describes how this beers they are produced in the brewery industry. So, first of all if we see that is the raw material we have to procure that is the barley the grains we are using for fermentations which contains lot of starch sugar. So, this basically brewery mostly we use barley as a grain for fermentation of alcohol So, here what happens first of all this raw material is stored into the yards the raw material is stored from the tank that is taken to the next unit operation there that is steeping of this raw material is carried out here basically this raw material is mixed with lot of water and thorough mixing is done cleaning is done so as to whatever the color that is the major ingredient that can be bleached out. So, this process of steeping like the spent grain that is filled with the water and kept for two to three hours so that all the color all the inorganic and organic impurities they are removed out and after steeping is done the next unit operation that is a production of sprouts, they are sprouted under aerobic conditions So, they are kept in a moisture and acid temperature so, as to this sprouts they are grown up onto the grains and then these sprouts what are grown up they have to be dried in the next operation. So, they are dried and then screening is done so as to remove the coarser size of the this is sprouted grains and finally this is sprouted grains that is stored in a malt house. So, this is like the process which are used to convert the raw materials in the form of ready material that has to be used for fermentation whatever this sprouts then they are taken and grinding is done here. So, during grinding this sprouts they are converted into coarser fraction and then the next process that is like preparing the word that is carried out in this section. So, here what happens basically we have to add grounded coarse fractions of sprouts or malt and then we have to mix lot of hot water here and for adding the flavor so we have to add certain plants hops and hubs and then entire this word that has to be boiled so when boiling is done whatever this word that gets which contains lot of starch that gets converted in the form of sugar and after this boiling the entire liquid that is taken to the filtration where this suspended impurities like spent grains and coarser materials they are taken out from rest of the spent liquor and then this basically is having a temperature. So, after filtration this cooling of the fermented liquor that has to be carried out in a cooling tank and then this pulled out liquor that is taken for fermentation. So, there are fermenters which ferment using the yeast culture, this filtered word that will be having

lot of sugar content So, during fermentation all this sugar that gets converted into this beer So, the process of fermentation the biochemical reactions already we have explained in the previous lectures. So, here whatever this sugar that gets converted into the alcohol and this we produce as a beer and after the beers is produced then to aid taste we do carbonization of the beer wherein this carbon dioxide is pushed into the liquor and then finally this carbonated beer that will be sent for sales into the market. So, this is the entire process which are used for producing the beer in a brewery.

So, let us we talk about the wastewater what type of wastewater it produces if we see composition of the breathing effluent, it basically fluctuates significantly depending upon the unit operations, depending upon the type of the raw material we are using, depending upon the process of fermentation so on and average the production of one liter of beer usually needs four to six liters of water. So, if we see the composition in terms of BOD and COD the ratio of BOD and COD that is basically 0.6 to 0.7. So, this indicates that the organics that are present in the wastewater they are biodegradable. So, we can use this biological process for the treatment of this wastewater. So in terms of pH if we see that varies from four to seven which depends upon the amount and the type of chemicals which are used in the CIP operations maybe like depending upon whether we are using caustic soda whether you are using phosphoric acid, nitric acid they all are used in this CIP process. So, this pH of the wastewater mainly depends upon these materials we are using in the process and then also, if we see the nitrogen and phosphorus level they mainly depends upon the handling of the raw material and the amount of yeast that is present in the treated effluent. So, their concentration also, varies high phosphorus levels also, we can be resulted because of the type of whether we are using the phosphoric acid for CIP operations. So, that that are like a lot of variations a lot of fluctuations that can be seen in the brewery wastewater which are generated from different unit operations.

So on an average if we see like the major stream what are generated, as I said there are two sections that is malt house and the brewery sections. So, malt house is whatever the water that is spent water which is generated after the stripping operations So, that is spent water that is generated as a waste water which may contains a lot of starch, a lot of organic and inorganic impurities. So, that one is steam that is generated from the malt house and there are many streams in the breathing sections like there are fermentation wash there is a cooling water also, get inoculated with number of organic and inorganic impurities during CIP process and then busing of containers and equipments floors etc. that also, generates a lot of waste water, so cleaning wastewater. So, this a combined waste water that we say that is generated from brewery sections they are mixed together and taken for the treatment.

And then if we see that is in terms of composition of the waste water which are generated from two major sections like malt house and then brewery sections. So, we will see the major parameters if we see like in terms of acidity, alkalinity or the pH if we see mostly this is in the malt house this is slightly alkaline nature of waste water pH varying from 6.9 to 9.5. Whereas in brewery sections whatever the wastewater if we see that is like entirely different it's it is like slightly acidic waste water which is generated from the brewery waste water and then BOD-COD al So, there is a lot of fluctuations if we see in the malt house it is hardly 200, 300 mg/L these are the ranges for BOD and COD and but in case of brewery sections this BOD and COD level that

varies a lot and that can go starting from 30 to 1225 in case of COD and it's BOD level also, that can vary 70 to 3,000 mg/L. So, that is like lot of variations lot of fluctuations in terms of solids if we see most of the solids they are dissolved in nature because if we see this the total solid variations So, in brewery sections this concentration is significantly higher than the concentration of total solids in the malt house and out of this like if we see in malt house this is mostly suspended solids which are there in the malt house but in case of this brewery sections if we see most of the solids they are in dissolved form. So, they are having variation of 16 to 500 mg/L. So, this is like the major difference the quality of the wastewater which are generated from the two sections. Similar al So, we can see for nitrogen the values varies in case of malt house 14 to 56 whereas in case of brewery section that is 7 to 42. So, these are all like the lot of fluctuations in the wastewater generated from the brewery and the malt house. So, if we see the two streams one is airplane streams and one is acidic streams. So, what we do is we have to neutralize this stream in order to have biological treatment system or any other the secondary treatment system for the wastewater. So, if we mix this wastewater in a equalization-cum-neutralization tank so easily lot of expenditure involved in neutralization and that can be achieved in this type of wastewater.

So, this is basically the diagram showing the conventional treatment system which are used in the brewery industry So, here if we see the brewery wastewater which comes out the combined waste water after equalization and neutralization. So, this is taken and stored in a collection tank and from here basically this goes to the anaerobic treatment system, which is like UASB reactor. So, here because the wastewater if we see it BOD and COD concentrations they are very high. So, here what we have to use first this anaerobic system followed by this aerobic system in order to have final effluent to be treated to the level of its discharge standards. So, here this USB reactor is used where the wastewater is anaerobically treated and after this treatment basically this whatever the effluent is taken out that is taken to the parallel plate separators where this whatever biological sludge they are separated from rest of the treated effluent and then this treated effluent that will be taken for the aerobic treatment process where we can use this activated sludge process we are mostly using activated sludge process but most some of the brewery industry they also, have trickling filter in place for the treatment for aerobic treatment of this brewery effluent. So, after this also, as it is suspended growth system lot of biomass that are generated So, there is the secondary parallel plates are separator units they are also, provided here after the aerobic treatment. So, as to remove out whatever these sludge that are generated from the two process and then whatever this sludge that that will be taken for the sludge treatment and its disposal so, mostly this goes to the sludge drying bed because whatever the sludge that are generated they are good in settleability So, they are taken to the sludge drying bed So, in sludge drying bed this the sludge which contains lot of water that gets filtered through the filter media which are provided in the sludge drying bed and in the sludge drying bed there is a under drainage system which basically collects all the filtered water from rest of the sludge or biomass. So, this water is again generated here. So, this this will be again recycled again back to the collection tank where again it will be mixed along with the rubbish to water coming for the treatment and then in the sludge drying bed whatever water that will be filtered and at the top of the bed there will be like biomass that will undergoes drying through the Sun and this basically sludge drying that takes place like 10 to 15 days. So, this after drying this sludge materials that has to be taken out that's like basically gets anaerobically converted into a good manure. So, that has to be taken for use into

the agricultural activities like for plants, for gardening and for many-many other purposes this sludge can be used because it contains lot of nutrients in the form of nitrogen, phosphorus. So, they can be used as a good fertilizer and here after this if we see after this biomass is separated from the treated effluent this is again taken for the filtration in rapid sand filters, so, here a rapid sand filter is provided because even after settling of this entire treated effluent there are still lot of suspended biomass that will be finer size biomass that can be present they are again filtered here through the sand filters. So, here after filtration of this treated effluent that undergoes to the activated carbon filter. So, activated carbon is basically used for removal of order and taste from the treated wastewater and al So, it helps in removal of the microbial impurities which are present after the treatment into the treated effluent So, this treated effluent again taken for the recycle and reuse within the plant operations for washing and cleaning purposes.

So, then we will having some numerical here which will basically give us some idea about how the distillery effluents they are produced how much wastewater they generates how much oxygen is required for their degradation. So, numerical that will illustrate here some few design parameters So, here if we see this is the brewery effluent which is treated aerobically in a treatment plant we have to assume this data, like the flow rate which is given as 500 m^3/d and the water have lot of acidity having 300 mg/L as a $CaCO_3$ and then average COD concentration that is also, given as 500 mg/L and here the oxygen demand for removal of this BOD that is also, given that is 1.42 gram of oxygen will be required for removal of 1 gram of COD. So, for these given conditions what we have to determine is how much amount of this Sodium hydroxide that will be required for neutralization to bring its pH 7 and then what will be the total oxygen demand that has to be for the treatment of the brewery wastewater.

Let's start with the Solution as we can see the wastewater contains lot of acidity which need to be neutralized So, for this some basic material like NaOH has to be used. So, first of all we have to find out how much total acidity that is generated, that is there in the wastewater need to be neutralized So, total acidity but that will be generated in terms of moles per day that can be find out by using this equation. So, that is like acidity in terms of $CaCO_3$ then multiplied by its flow rate divided by the molar mass of the calcium carbonate. So, to convert the total acidity present in terms of number of moles $\frac{300 \times 500}{100}$. So, what we will get that is the total number of moles that is 1500 moles/day. So, here if we see that concentration that is basically 300 mg/L, so that basically if we convert in terms of gram per meter cube and then this is in meter cube so this meter cube meter cube that will get cancelled and will get how many grams and divided by the molar mass in grams of one moles of this calcium carbonate that will provide us the total number of moles of acidity that is present and if we assume like NaOH is a strong base and it reacts with acid in 2:1 ratio. So, like one mole of this acidity that will require two moles of this NaOH so, accordingly the moles of NaOH that will be required will be equal to two times of this the number of moles we have got here as a acidity So, this basically gives us the total 3000 number of moles of this NaOH that will be required. So, now this we can convert in terms of how much kg/day is required So, for this we have to multiply with the molar mass of NaOH which is 40 g/moles. So, now if we find out total amount of NaOH in grams so that $Amount\ of\ NaOH = 3000\ moles \times 40\ g/mol = 120000\ grams$/day = 120 kg/d. So, this is how we can calculate how much NaOH that will be required for neutralization of this wastewater.

And then let's see how much oxygen will be required for this aerobic oxidation of this organic matter present in the wastewater. So, organic matter that is here represented in the form of COD and that is given as 500 mg/L, this is the influence COD concentration, but entire COD that is removed is around 90% of the COD that is removed. So, here what we see here how much total COD that is removed because theoretically we know how much amount of oxygen is required for per gram of COD removed. So, this basically if we want to calculate how much amount of oxygen is required. So, first of all we have to determine how much total COD that is removed per day from the wastewater treatment plant. So, here that we can say that is equal to Total COD removed per day = $Flow\ Rate\ \times\ COD\ Concentration\ \times\ \%\ COD\ removal$. So, that will give us the total COD that will be removed in the treatment plant per day. So, here $500\ m^3 day \times 500\ g\ /\ m^3) \times 0.9$ and out of this if we calculate we get the value here first in gram and then finally if we convert to the bigger unit, So, it will come around 225 kg/day. So, this is how much COD that is removed and to estimate the how much amount of oxygen that will be required So, we have to multiply with its theoretical oxygen demand. So, this is 1.42 kg/kg and here that is 225 kg of this BOD that is removed. So, if we $225\frac{kg}{day} \times 1.42 kg/kg$ with this we will get how much total oxygen that will be required for treatment of this wastewater. So, this is something 319.5 kg/day that is the total amount of oxygen that will be required for treating this wastewater. So, this is like how these concepts we can use for designing an operation of this treatment systems.

So, for your reference we can refer these books where in all these details they are covered in more specific way.

So, thank you