Basic Environmental Engineering
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Lecture 46
Industrial Pollution Control in GPI 2
(Pollution Control in Distillery)

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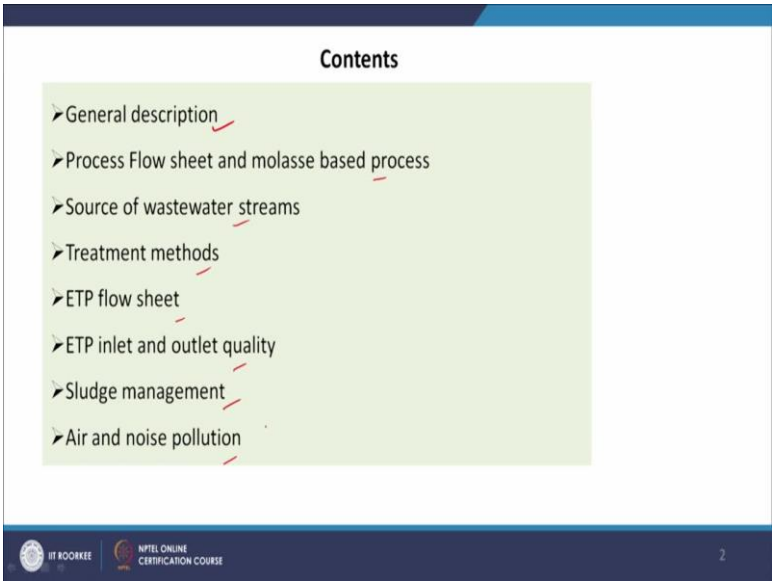

Hello everyone. Now we will discuss on the topic industrial pollution control in grossly polluting industries part II. We will be focusing on the pollution control in distillery unit and the content of this discussion will be general description, process flow sheet and molasses based process for distillery, source of wastewater streams, treatment methods, ETP flows sheet, ETP inlet outlet quality, sludge management, air and noise pollution.

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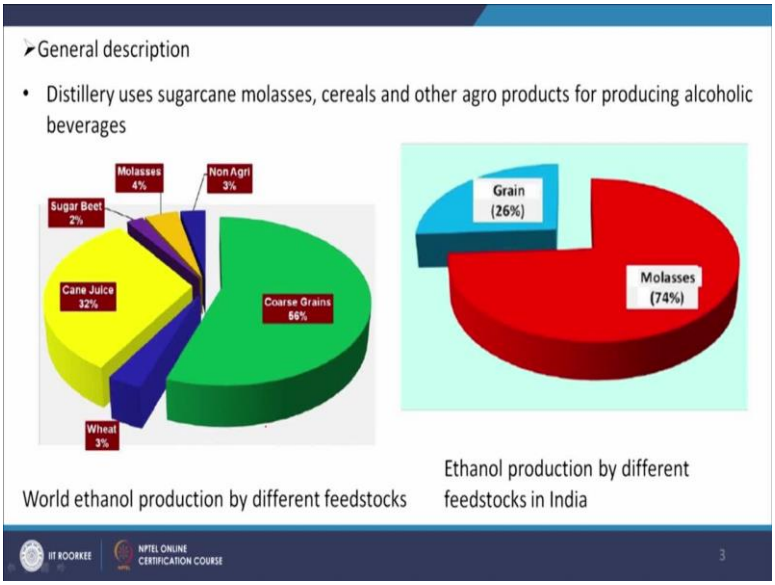

So we will see the general aspect of the distillery unit. Around the globe the distillery produces ethanol or ethyl alcohol and feedstock is used like sugarcane, molasses or grains or it may be maybe beet sugar also. So now, this slide shows us the relative contribution of different grains and molasses for the ethanol production to the distillery unit.

So this is world ethanol production by different feedstock. We see coarse grain 56 % and cane juice 32 %, molasses 4 % and nonagricultural 3 % and sugar beet 2 %, and wheat 3 %. And if we see in Indian case, so molasses is 74 % and grain is 26 %. So suddenly, we will be focusing mostly on molasses-based distillery.

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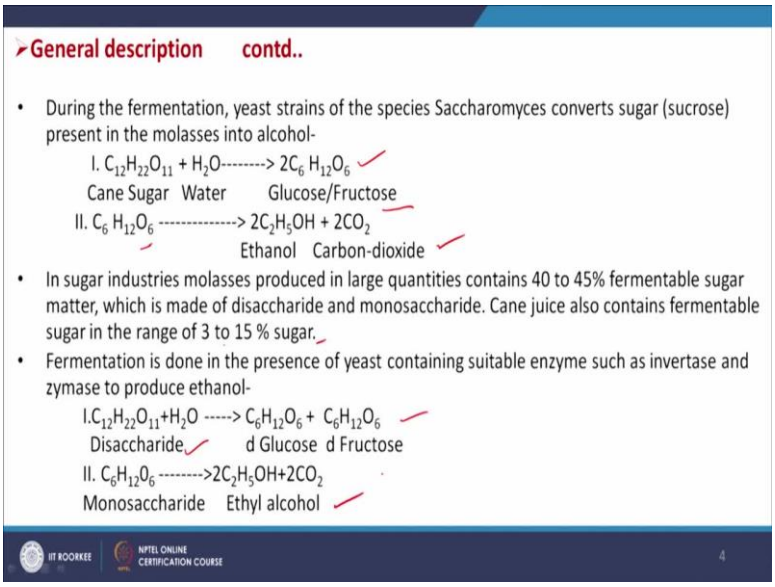

So what happens in case of distillery process, sugar is converted to ethanol in presence of yeast microorganism and monosaccharide and disaccharide present in the sugar molasses are actually responsible for this fermentation. And these are the biochemical reactions which take place.

$C_{12}H_{22}O_{11} + H_2O$--------> $2C_6 H_{12}O_6$

So cane sugar plus water that can give us glucose fructose $C_6H_{12}O_6$ can give us ethanol and carbon dioxide and yeast work on this.

$C_6 H_{12}O_6$ ----------> $2C_2H_5OH + 2CO_2$

The sugar industry molasses produced in large quantities contain 40 to 45 % fermentable sugar matter which is made of disaccharide monosaccharide. Cane juice also contains fermentable sugar in the range of 3 to 15 % sugar. So fermentation is done in the presence of each containing suitable enzyme such as invertase and zymase to produce ethanol. So this is a reaction basically disaccharide to monosaccharide and monosaccharide to ethyl alcohol.

$C_{12}H_{22}O_{11}+H_2O$ -----> $C_6H_{12}O_6 + C_6H_{12}O_6$

Disaccharide d Glucose d Fructose

$C_6H_{12}0_6$ -------->$2C_2H_5OH+2CO_2$

Monosaccharide Ethyl alcohol

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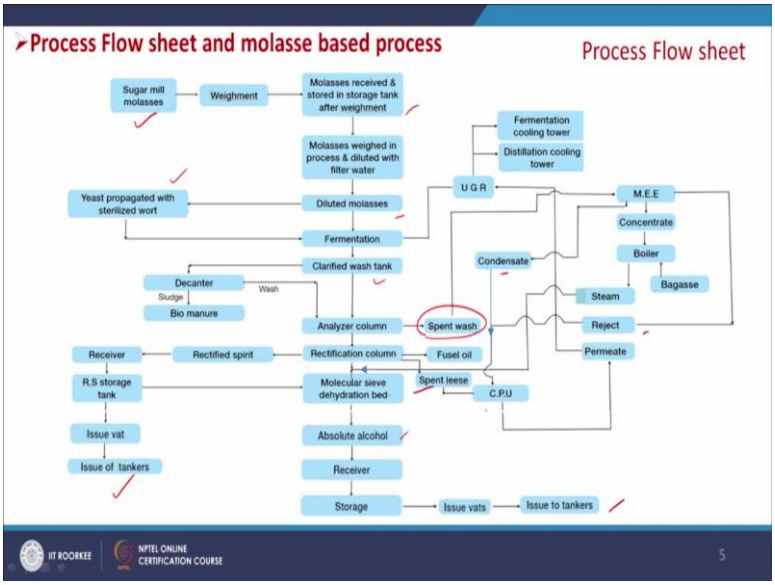

And if we see the flow sheet for the production of distillery with the molasses or sugarcane molasses then sugar mill produces molasses then it is comes to the distillery unit as feedstock

then is after weighing that molasses is received and stored in the storage tank and then molasses weighted in process and diluted with filter water, then diluted molasses which we will get, and we have to add yeast, so these molasses can be used for the yeast propagation with sterilized wort and then fermentation takes place.

So we are adding the yeast broth here in the fermenter and then after fermentation we will be getting the conversion of sugar to ethanol and then clarified wash which we are getting after the fermentation that is going to be decanter and then sludge is going to bio manure and the liquid part which we are having that it wash that contains the ethanol it is coming to analyzer column and from this analyzer column this is heat is applied basically. So we can get the rectified column, we can get the vaporized material, which goes to rectification column and the bottom part of its analyzer column gives us spent wash, which is the waste material that needs to be treated.

And then after rectification column, vapor is going as a rectified spirit and then it is going to receiver and then rectifier spirit to storage tank and then had an issue of tankers that means, we are getting the final product here and that is rectifier spirit. And if we want to get more pure product it can go to molecular sieve dehydration bed and then absolute alcohol and then it is going to the market. And in rectification column we are getting one bottom product that is spent leese and here also we can get some fusel oil.

So fusel oil is used or the oil part is separated from this and then it is sold in the market. And spent leese which is coming into CPU that is condenser polishing unit that spent to us which we have got here this contains very high amount of organic content and this leese managed through different routes here it is sown for thermal route basically to go for operations in a multiple effect evaporator and then condensation the vapor part will be condensed and then it will be sent to condensate and that will be treated in the CPU. So this is a major source of wastewater generation in the distillery unit when thermal power plant is used.

If biological method is also used, then also there will be intermediate another step where biogas production will take place, but thereafter the same operation will also be there. So then this is going to condenser polishing unit that is your water treatment plant. And the concentrate from MEE that is having high organic content and that is used with bagasse for cogeneration in the power plant, in the boiler and then the steam is generated and that steam is used in the process and bagasse and concentrate is burnt in the furnace. And the reject from the MEE that is also coming and treated.

And the UGR, this UGR material basically from CPU, the permit we are sending to UGR, so UGR to this fermentation for dilution etc. this can be used. So this is the overall flow sheet of the production of distillery and we see the wastewater generation is taking place here we have to take it care about and then spent leese, and other reject and your boiler blow down those are the basic wastewater sources in this type of industry.

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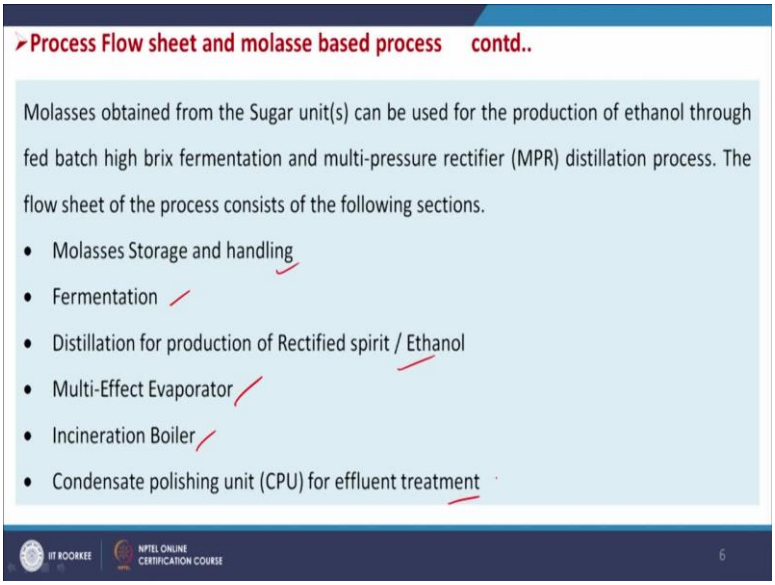

Now if we see the overall process, so it has molasses storage and handling unit, it will be having fermentation unit, distillation for production of rectified spirit ethanol and then multieffect evaporator for the concentration of the spent wash so that one condensate will get as water and concentrated solid that is called spent leese that is called slop will be used with bagasse for cogeneration. And incineration boiler will be used for that purpose and condensate polishing unit basically used for the treatment of the effluent or wastewater generated in the plant.

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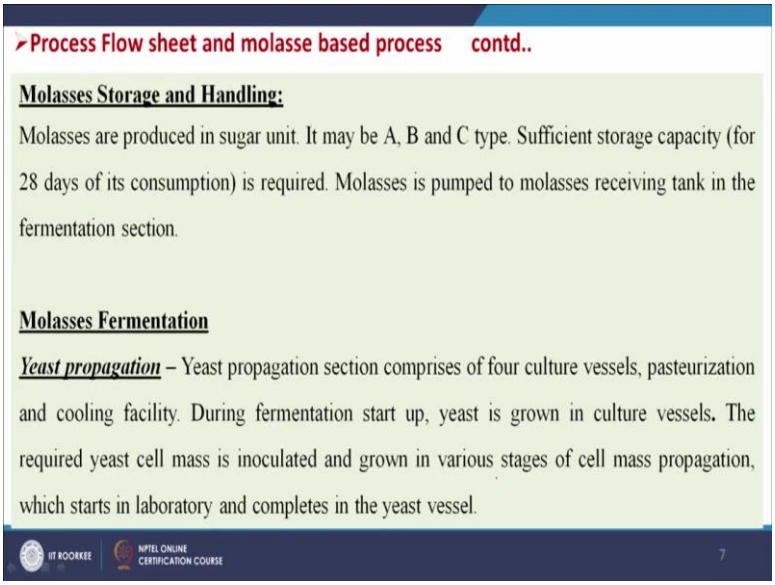

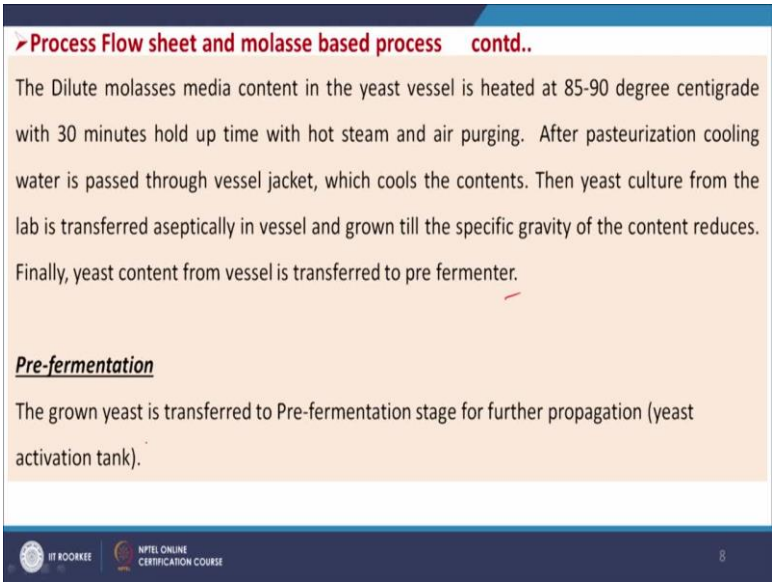

And this is molasses a storage and handling basically, distillery operates throughout the year, but sugar industry operates seasonally. So in offseason to supply the molasses industry needs to store very large amount of mass molasses and the molasses maybe of A, B and C type depending upon the concentration of sugar in it.

And this is a first step and then molasses fermentation, yeast propagation takes place the growth of yeast takes place first and then that is we have to take the dilute molasses media content in the yeast vessel and that is heated to 85 to 90 ^{o}C with 30 minutes hold up time with hot steam and air purging.

After that pasteurization cooling water is passed through vessel jacket, which cools the contents. Then yeast culture from the lab is transferred aseptically in vessel and grown till the

specific gravity of the content reduces. Finally, yeast content from vessel is transferred to pre fermenter. And these pre fermenter the grown yeast is transferred to pre-fermentation stage for further propagation.

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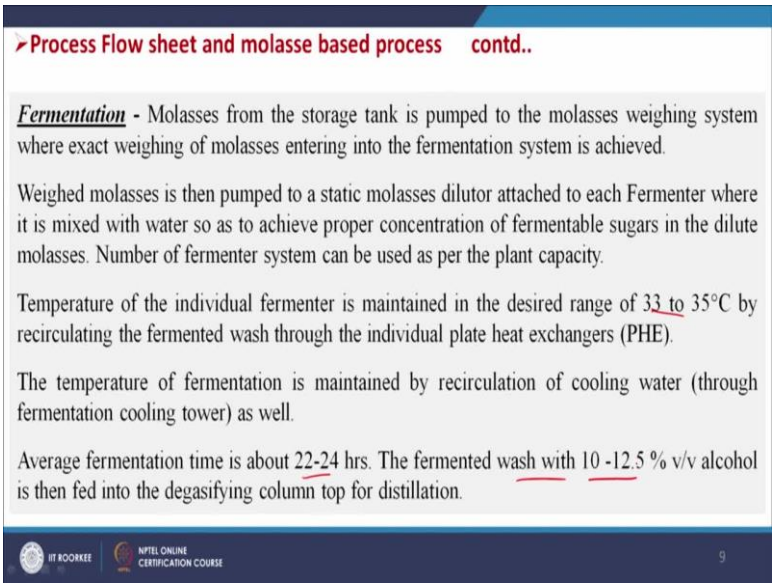

And then it comes to fermentation, where certain condition is maintained so that yeast will be working perfectly on the sugar present in the fermentation media. Temperature is maintained to 33 to 35 ^{o}C and the average fermentation time is 22 to 24 hours. And after this fermentation, the fermented wash that contents 10 to 12.5 % of alcohol, so this is the fermentation unit.

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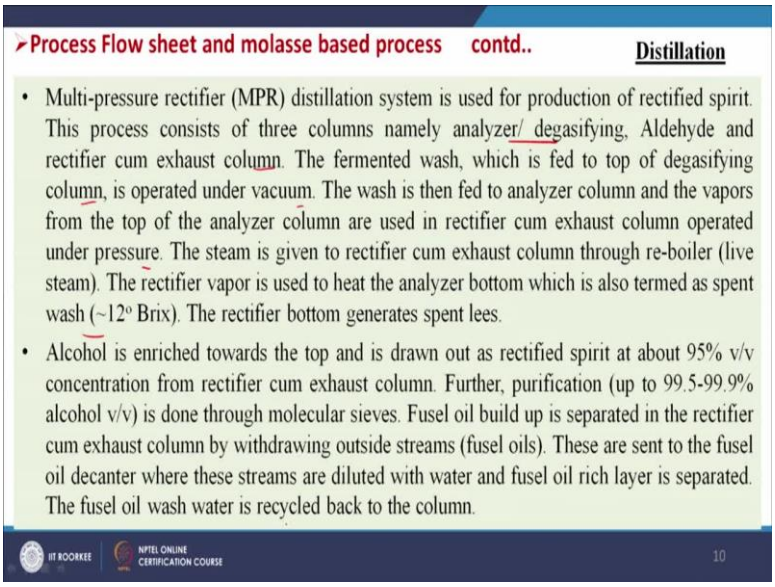

And then distillation unit. So multi pressure rectifier distillation system is used for the production of rectified spirit. Basically, our objective will be to produce say rectified spirit and then in the second step we are interested to produce more pure alcohol, so more than 99 % pure alcohol. So in that case, we need distillation column, so there are 3 columns namely analyzer or degasifying and then aldehyde and rectifier cum exhaust column, so we are present in this distillery unit.

And the fermented wash which is fair to top of the degasifying column is operated under vacuum, the wash is then fed to analyzer column and the vapours from the top of the analyzer column are used in rectifier cum exhaust column operated under pressure. The steam is given to the rectifier cum exhaust column through re-boiler that is live steam and the rectifier vapour is used to heat the analyzer bottom which is also termed as spent wash that concentration it is having 12 ^{o}brix. And rectifier bottom generates spent leese.

So alcohol is enriched towards the top and is drawn out at as rectified spirit at about 95 % concentration from the rectifier cum exhaust column. Further, purification 99.5 to 99.9 % alcohol is done through molecular sieves. Fusel oil build up is separated in the rectifier cum exhaust column by withdrawing outside streams. These are sent to the fusel oil decanter where these streams are diluted with water and fusel oil rich layer is separated. The fusel oil was wash water is recycled back to the column. So this is a process.

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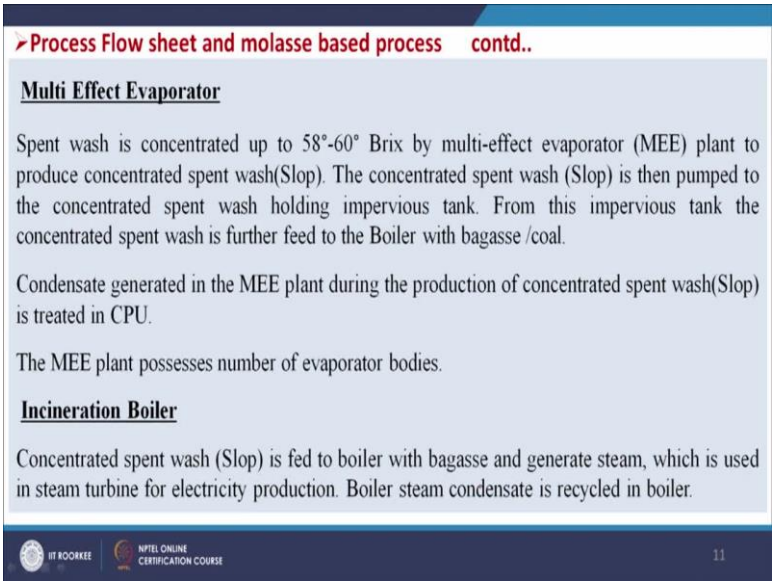

And multi effect evaporator that is the main role is to concentrate the spent wash. So what we have that is 12 ^{o}brix, a 13 ^{o}brix spent wash is concentrated to 58 to 60 ^{o}brix by this multi

effect evaporator. And after this it will give us condensate that will go for CPU for water treatment, and it will give us the concentrated the slop that will be used in the boiler for cogeneration with bagasse. And incineration boiler that is concentrated spent wash is fed to the boiler with bagasse to generate steam.

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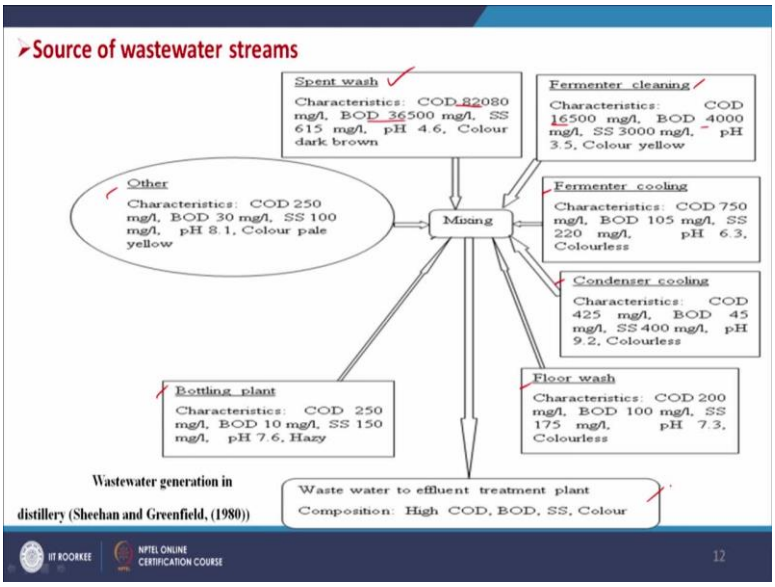

Now we will see the sources of wastewater streams which are generated in a distillery unit, so may need your spent wash, we see very high COD and BOD concentration. Then fermenter cleaning, that is also having BOD and COD relatively higher, fermenter cooling, then condenser cooling, and then floor washing and then your bottling plant and others, that is the characteristic COD 250, BOD 30, SS 100 and, so these are very low organic containing water.

And bottling plant in the fermentation process carbon dioxide is produced and that carbon dioxide is bottled in a bottle and that is called bottling plant. And in this case the wastewater regenerated COD 250 mg/L, BOD 10, SS 150 and pH 7.6, so this also does not require much treatment.

So spent wash leese, spent leese those are required for the treatment. So in a conventional process all these can be mixed and can be sent to the wastewater treatment plant or CPU. Some other wastewater which is generated in the boiler and in a tertiary unit let us say microfiltration, ultrafiltration, reverse osmosis processes. So those residual part can be used for ash management generated in the boiler or can be treated further in the second part of the CPU.

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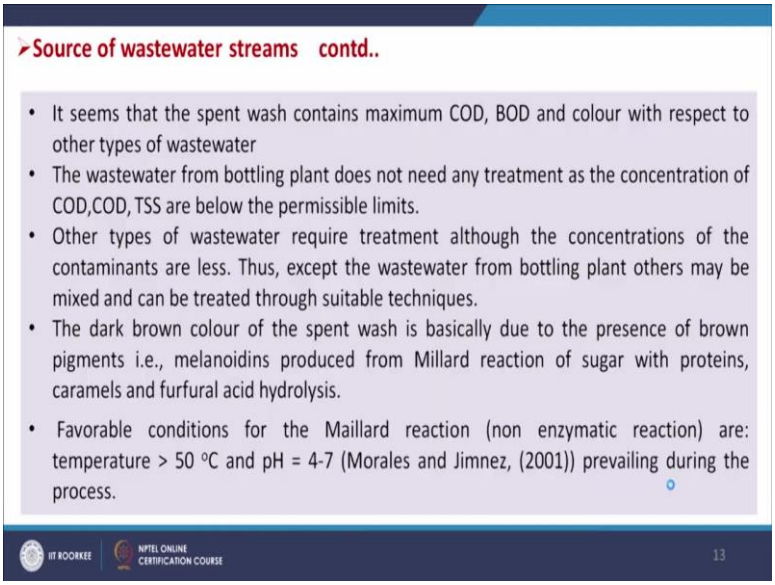

So it seems that the spent wash contains maximum COD, BOD and color with respect to other types of wastewater. And the wastewater from bottling plant does not need any treatment as the concentration of COD, COD, TSS are below the permissible limits. Other types of wastewater require treatment although the concentrations of the contaminants are less thus except the wastewater from bottling plant, others may be mixed and can be treated through suitable techniques.

The dark brown color of the spent wash is basically due to the presence of brown pigments that is melanoidins produced from Millard reaction of sugar with proteins, caramels and furfural acid hydrolysis. So favorable conditions for the Millard reactions non enzymatic reactions are temperature greater than 50 ^{o}C pH 4 to 7 prevailing during the process.

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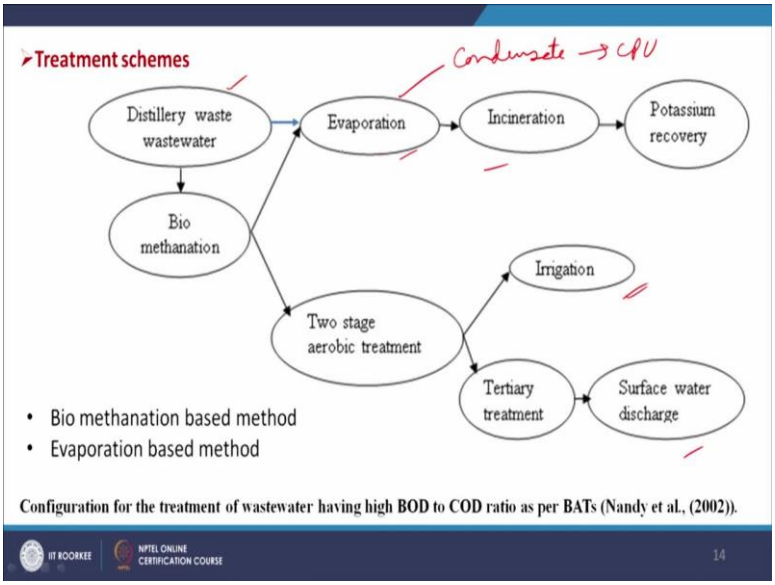

And this is a treatment scheme. So distillery wastewater which we are getting that can be directly evaporated that is spent wash, then it will give one condensate and another will be concentrate. So that concentrate will go for incineration and potassium recovery and it will give us condensate that will go to CPU for further treatment. And another route bio methanation, so biogas will be produced first and then the slurry which you are getting, that can be further evaporated and in the same way it can be processed or it can be going for 2 stage aerobic treatment and then, tertiary treatment, surface water discharge.

After the biogas production, the sludge which will be generated that can be used as the manure production, and can be used also for the composting purpose. So that is the bio methanation waste method and evaporation-based method there are two basic types of methods.

And when we go for bio methanation based method, then the composting is one important process that produces bio fertilizer from the residual part of the bio methanation unit and it requires very large area and in rainy season also there is a good chance of the water runoff and the contamination of the river water.

So in India, the incineration based methods that is the direct evaporation based method is preferred and CPCB has recommended the use of this evaporation base method. And thus more focus is on to use the thermal method or evaporation based method in larger extent.

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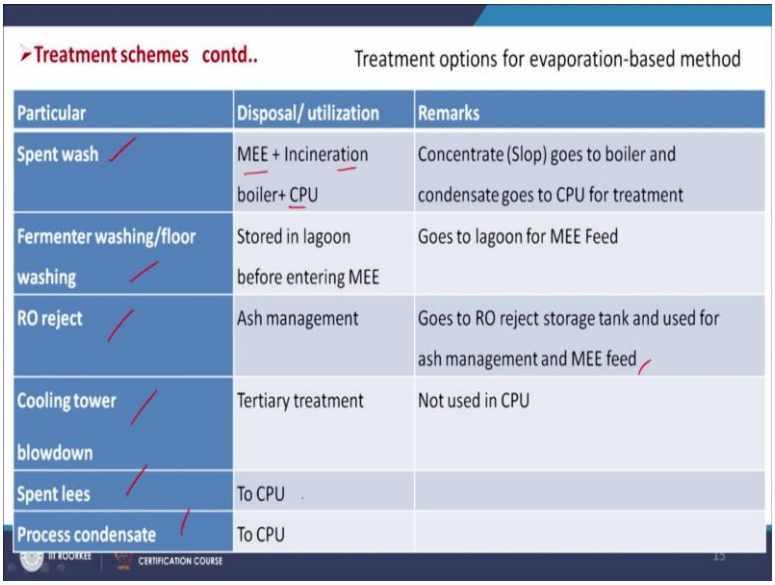

Now we will see in case of this evaporation based methods, so different waste stream we are having spent wash, fermenter washing or floor washing, RO reject, cooling tower blow down, spent lees and process condensate. So these are the disposal or utilization options the spent wash, MEE multi-effect evaporator and then the condensate is going for CPU and solid is going for incineration. The concentrate is going to the incineration boiler. And then fermenter washing, floor washing stored in lagoon before entering MEE and goes to lagoon for MEE feed.

And RO reject can be used for ash management and goes to RO reject storage tank. And MEE feed that from plant to plant it may varies, somewhere this goes to MEE as a feed or in some cases it goes directly to the boiler with the bagasse. And cooling tower blow down tertiary treatment and this entrance into the water treatment plant but not in the primary and secondary step. And then spent lees and process condensate are used in the CPU.

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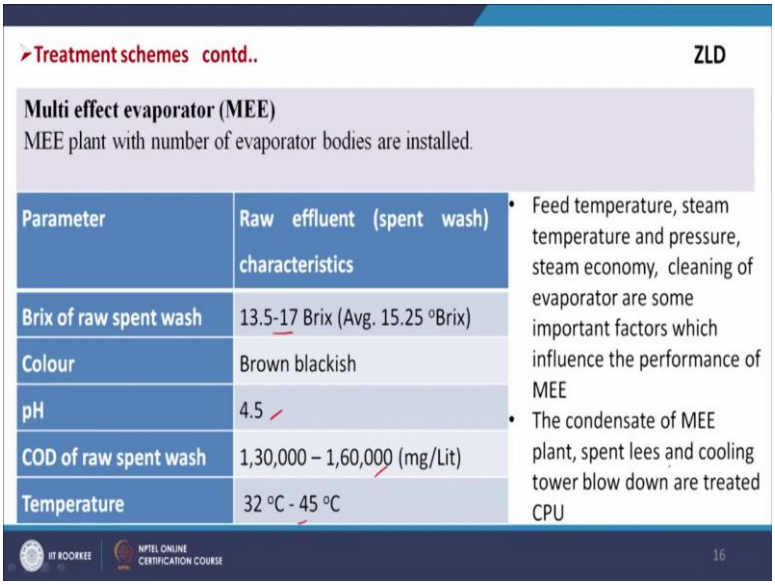

And ZLD is compulsory that is zero liquid discharge is compulsory for distillery unit in India and in this case the use of MEE is must, multi effect evaporator and in case of multi effect evaporator that you have discussed that 13.5 to 17 brix, somewhere 12 to 13 brix that is converted to 50 to 60 ^{o}brix. And the spent wash is having these characteristics COD concentrations and this temperature and pH.

So when it goes through the MEE, so it is concentrated up to 50 to 60 ^{o}brix and the performance of the MEE will depend on many factors that is the feed temperature, steam temperature and pressure, steam economy, cleaning of evaporator are some important factors which influence the performance of MEE. And the condensate of MEE plants spent lees and cooling tower blow down are treated in CPU.

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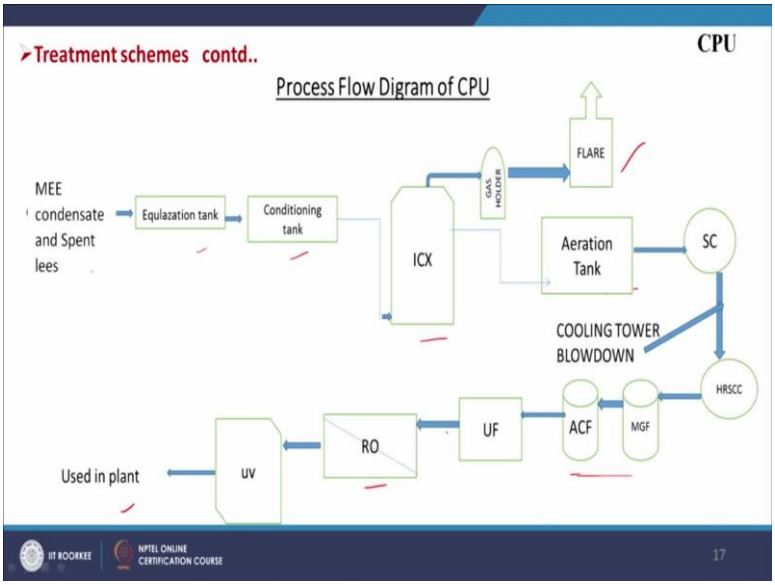

And this is the CPU unit the process flow diagram of wastewater treatment in the distillery unit. So MEE condensate and spent lees is coming, it is equalization tank first step, then conditioning tank, then pH adjustment etc. Then it is going to ICX that is bio tower, biological conversion. So here the biogas is produced it is flare and the supernatant liquid is coming for aeration tank, so here aerobic digestion. So anaerobic degradation then followed by aerobic degradation in this aeration tank, why do you have some aerobic microorganisms.

So organic content will further be reduced then it is going for secondary clarifier. So from secondary clarifier, it is going for HRSCC Hydrate Solid Contact Clarifier. And then it is coming to tertiary unit that is MGF and then ACF, so these are the filters and then activate filters then it is coming to UF and RO and which is ultimately passing through UV for disinfection and used in a plant for your dilution of the molasses and other activities. And as you mentioned that cooling tower blowdown that is entering here that is escaping this primary and secondary step directly it is entering into the HRSCC unit and then it is going for tertiary treatment.

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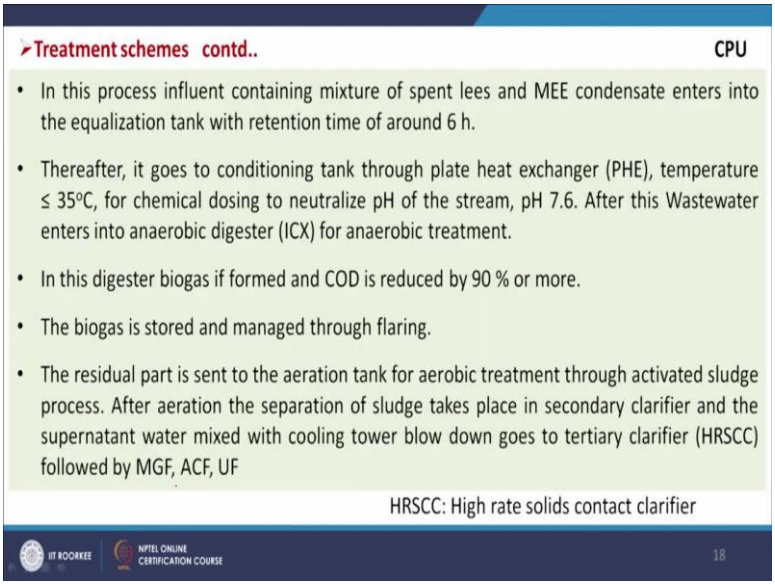

And in CPU in this process influent containing mixer of spent lees and MEE condensate enters into the equalization tank with a retention time of around 6 hour. Therefore it goes to conditioning tank through plate heat exchanger, at temperature less than 35 ^{o}C for chemical dosing to neutralize pH of the stream, pH 7.6.

And after this wastewater enters into anaerobic digester for anaerobic treatment, in this digester biogas is formed, COD is reduced by 90 % or more. The biogas is stored and managed through flaring. The residual part is sent to the aeration tank for aerobic treatment through activated sludge process. After the aeration the separation of sludge takes place in secondary clarifier and the supernatant water mixed with cooling tower blow down goes to tertiary clarifier followed by MGF, ACF and UF.

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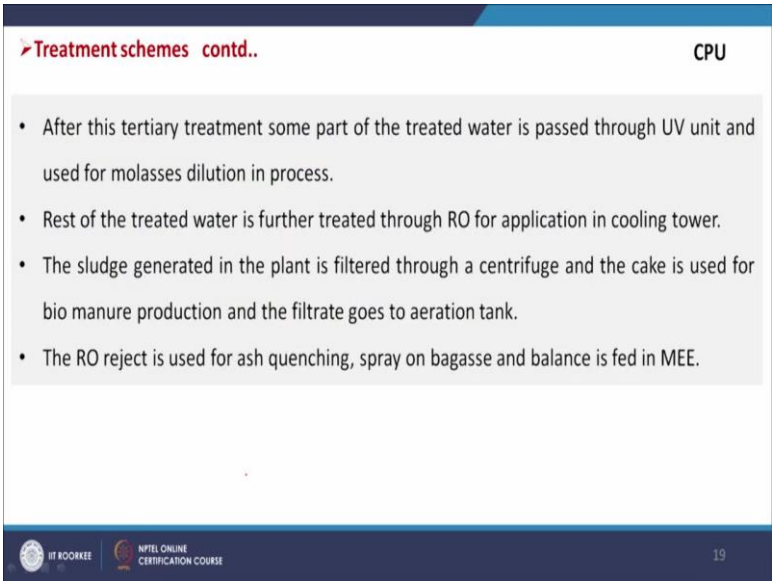

After these tertiary treatment, some part of the treated water is passed through UV unit and used for molasses dilution in process. Rest of the treated water is further treated through RO for application in cooling tower. The sludge generated in the plant is filtered through a centrifuge and cake is used for the bio manure production and the filter goes to aeration tank. The RO reject is used for ash quenching, spray on bagasse and balance is fed in MEE multi effect evaporator.

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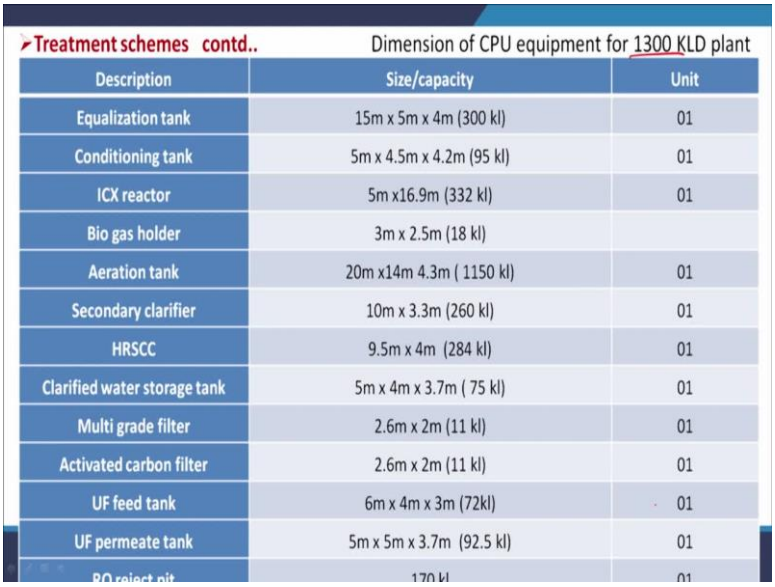

Description	Size/capacity	Unit
Equalization tank	15m x 5m x 4m (300 kl)	01
Conditioning tank	5m x 4.5m x 4.2m (95 kl)	01
ICX reactor	5m x16.9m (332 kl)	01
Bio gas holder	3m x 2.5m (18 kl)	
Aeration tank	20m x14m 4.3m (1150 kl)	01
Secondary clarifier	10m x 3.3m (260 kl)	01
HRSCC	9.5m x 4m (284 kl)	01
Clarified water storage tank	5m x 4m x 3.7m (75 kl)	01
Multi grade filter	2.6m x 2m (11 kl)	01
Activated carbon filter	2.6m x 2m (11 kl)	01
UF feed tank	6m x 4m x 3m (72kl)	01
UF permeate tank	5m x 5m x 3.7m (92.5 kl)	01
RO reject pit	170 kl	01

This slide shows us the requirement of different treatment units for 1300 KLD CPU plant, 1300 KLD treatment capacity different units and their typical size which are required and number of units is provided.

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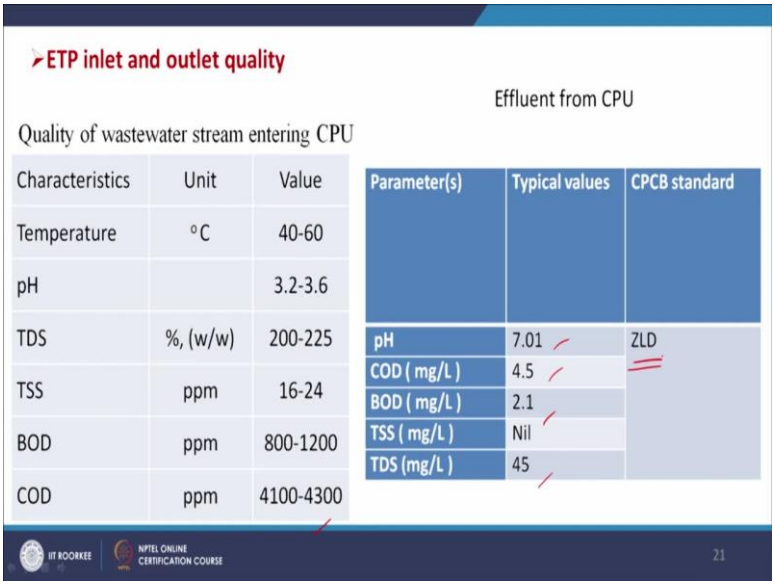

And ETP inlet and outlet quality typically it is given then the CPU inlet is the temperature, pH, TDS, TSS, BOD, COD it is given here and after treatment it produces like this. So all are below permissible limit and moreover CPCB has recommended that there will be zero liquid discharge from this distillery unit and all water which are generated that is recycled and used in the plant itself.

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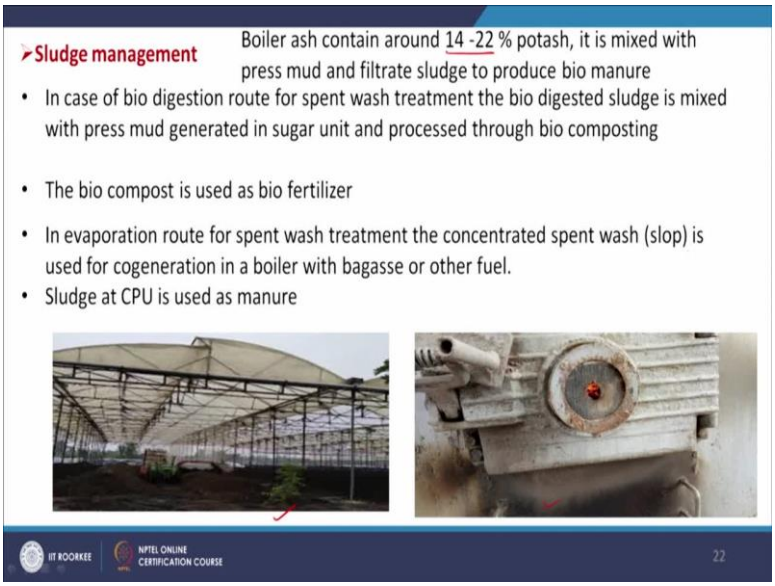

Then we are coming to sludge management. So sludge management which we are seeing that in the CPU unit, we are having some sludge that is used after dewatering it is used for the bio manure production. And in case of bio digestion route for spent wash treatment the bio

digested sludge is mixed with press mud generated in sugar unit and processed through bio composting. And the bio compost is used as fertilizer.

And in evaporation route for spent wash treatment the concentrated spent wash or slop is used for cogeneration in boiler with bagasse or other fuel and sludge at CPU used as manure. So these are the different sludge which are produced in the plant and those are used in different way.

This is showing one bio composting plant and this is your furnace where co-generation takes place. And boiler ash which are generated in this furnace or boiler that contains 14 to 22 % potash and it is mixed with press mud and filtered sludge to produce bio manure or it is also used as fertilizer,

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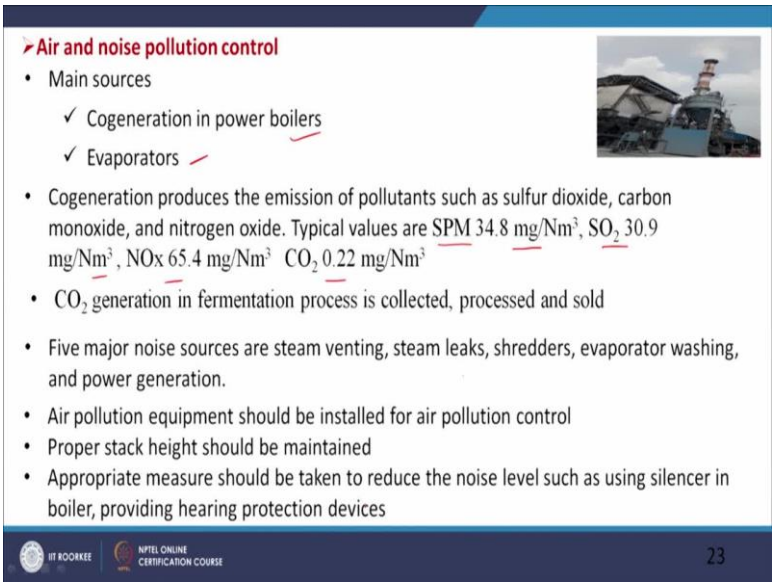

Then air and noise pollution control. So main sources for air pollution are cogeneration in power boilers and evaporators. Cogeneration produces the emission of pollutants such as sulphur dioxide, carbon monoxide, nitrogen oxides, and typical values for SPM 34.8 mg/Nm^3, SO_2 30.9 mg/Nm^3, NOx 65.4 mg/Nm^3, CO_2 0.22 mg/Nm^3.

And CO_2 generation in fermentation process is collected processed and sold as we have mentioned earlier. 5 major noise sources are steam venting, steam leaks, shredders, evaporator washing and power generation. And air pollution equipment should be installed for air pollution control, proper stack height should be maintained as shown here. So it is 80 feet, 100 feet long stack is needed and appropriate measures should be taken to reduce the noise level such as using silencer in boiler, providing hearing protection devices etc. So, these

are the different aspects of the distillery units and the pollution control of distillery unit. We have discussed up to this in this class. Thank you very much for your patience.