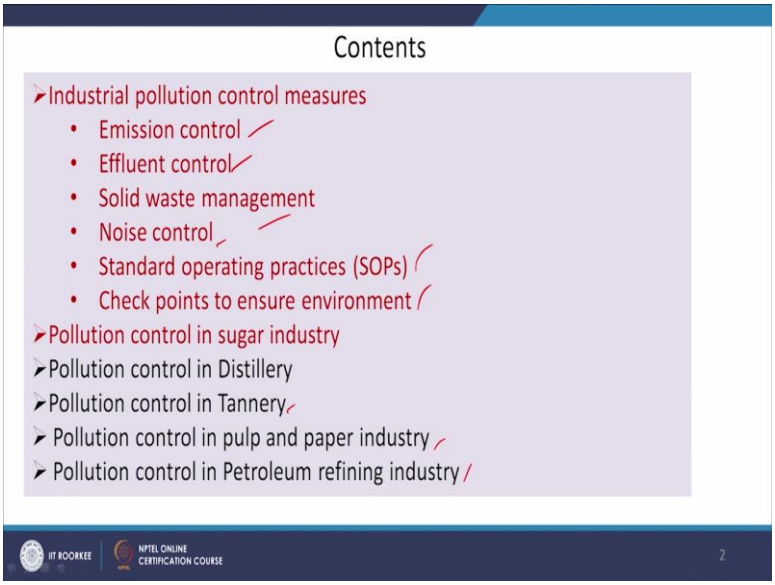
Basic Environment Engineering and Pollution Abatement
Professor Prasenjit Mondal
Department of Chemical Engineering
Indian Institute of Technology, Roorkee
Lecture 44
Industrial Pollution Control in GPI 1
(General Aspect and Pollution Control in Sugar Industry)

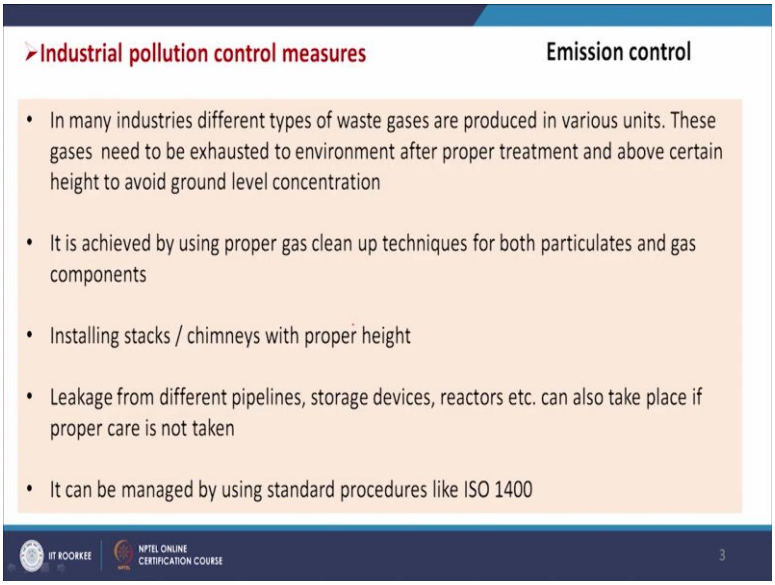
Hello everyone. Now, we will discuss on the topic Industrial Pollution Control in Grossly Polluting Industries Part 1 and in this class, we will be focusing on the General Aspect of the Control of Pollution in Industry and the Pollution Control Practices in Sugar Industry. So, far in this course, we have discussed about the fundamentals of environmental engineering and then how the pollution are generated and can be prevented and can be controlled, like say, how the water treatment can be done, how the sludge management can be done and how the air can be treated. So, we have discussed all those things.

(Refer Slide Time: 01:21)



Here, we will be discussing more on the basis of specific industry type. And before that, we will have short discussion on the overall aspect of the industrial pollution control. So, our content will be industrial pollution control measures, emission control, effluent control, solid waste management, noise control, standard operating practices, checkpoints to ensure environment, these are the overall aspect and then we will be discussing on pollution control in sugar industry, pollution control in distillery, pollution control in Tannery, pollution control in pulp and paper industry and pollution control in Petroleum refining industry in five classes. So, in this class, we will be discussing up to this.

(Refer Slide Time: 02:14)

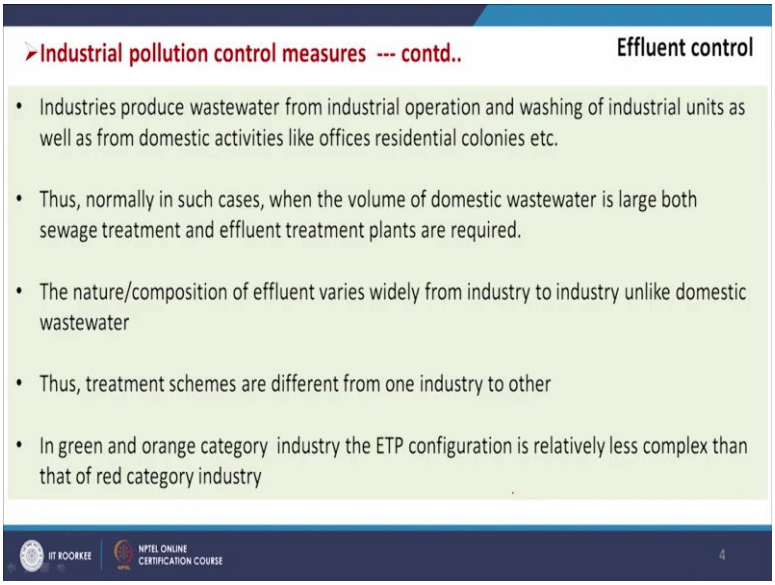


Now, the control measures if we consider then already, we have mentioned in our previous classes also that in industry, gas emission takes place, water effluent comes out and solid waste generated in the industrial premise and noise pollution also takes place. So, all of these are the basic pollution factors in industrial premise. And we know that depending upon the nature of the product of industry, various types of gaseous products comes out and their concentration and volume both varies and in many industries, different types of waste generates, waste gases are produced in various units.

These gases need to be exhausted to environment after proper treatment and above certain height to avoid ground level concentration. We have discussed also that industrial chimney should have certain height, so, that the pollutant cannot reach to the ground level when people are working. And this is achieved by using proper gas cleanup techniques for both particulates and gas components we have discussed in our earlier classes the similar method can be applicable.

Installing stacks, chimneys with proper height, leakage from different pipelines, storage devices, reactors etc. can also be placed if proper care is not taken. So, we should be very careful to prevent any leakage from the pipelines or in the premise that if it is emissions and it can be managed by using standard procedures like ISO 1400. So, these are some standard protocols or procedures if it is followed automatically the environmental conditions in the industry will be maintained.

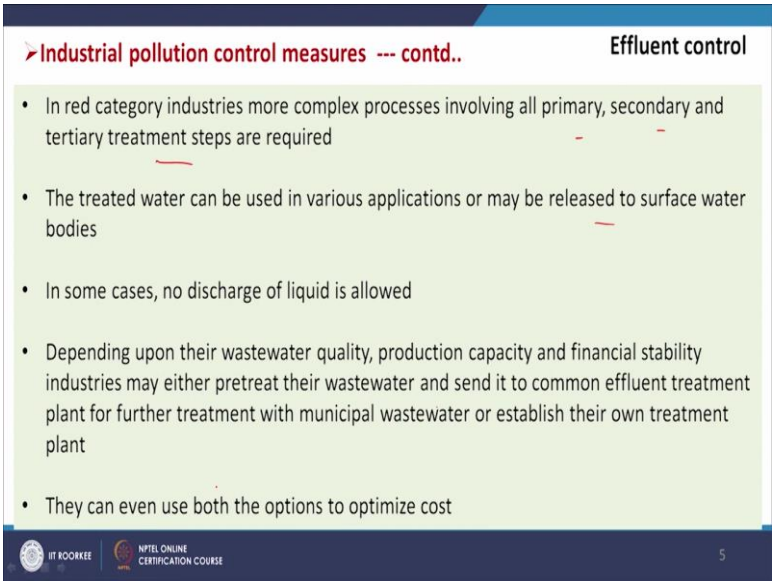
(Refer Slide Time: 04:25)



With respect to effluent control, we see that industries produce wastewater from industrial activities as well as from residential colonies. So, if the residential colony produces large amount of wastewater that has to be treated separately in the sewage treatment plant STP plant and is released to the sewer line. So, big industries are having it, but small industry they are do not having. So, they are releasing these to the sewer line and normally in such cases when the volume of domestic wasted is large both sewage treatment and effluent treatment plants are required.

And nature composition of effluent varies widely from industry to industry unlike domestic wastewater. We know very well that nature of the effluent varies widely from industry to industry unlike domestic effluent and thus the treatment schemes are very different from one industry to other. The green and orange category industry, the effluent configurations is relatively less complex than that for the grossly polluting industries or red category industries.

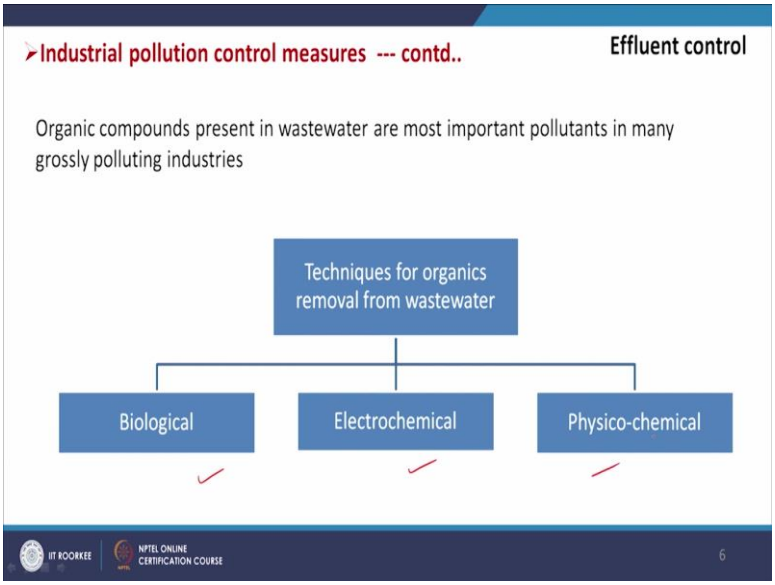
(Refer Slide Time: 05:39)

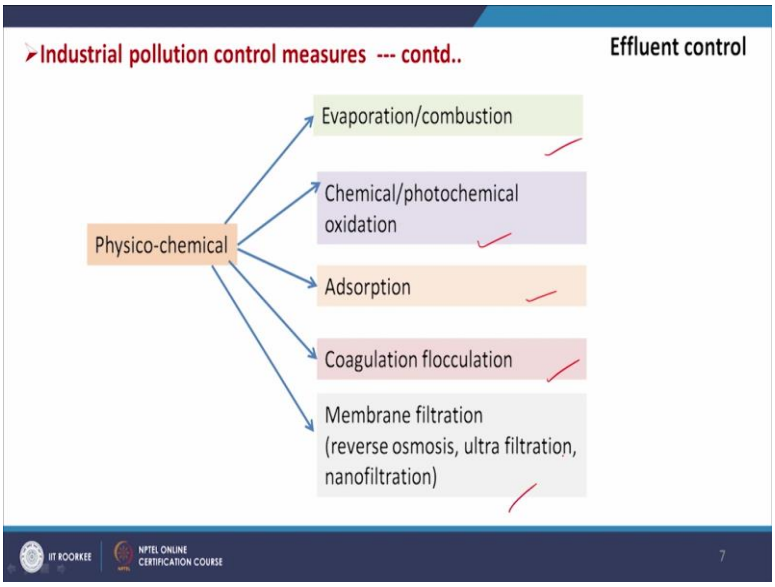


In red category industries, more complex processes involving all primary, secondary and tertiary treatment steps are required. The treated water can be used in various applications or may be released to the surface water bodies, but in some cases generally zero liquid discharge guidelines issued by the CPCB. And depending upon their wastewater quality, production capacity and financial stability industries may either pre-treat their wastewater and send it to the common effluent treatment plant or for further treatment with municipal wastewater or establish their own treatment plant, already we have discussed in our previous classes also.

And not only this industry can also optimize. They can even option for both. So, these are the practices which industry follows.

(Refer Slide Time: 06:37)

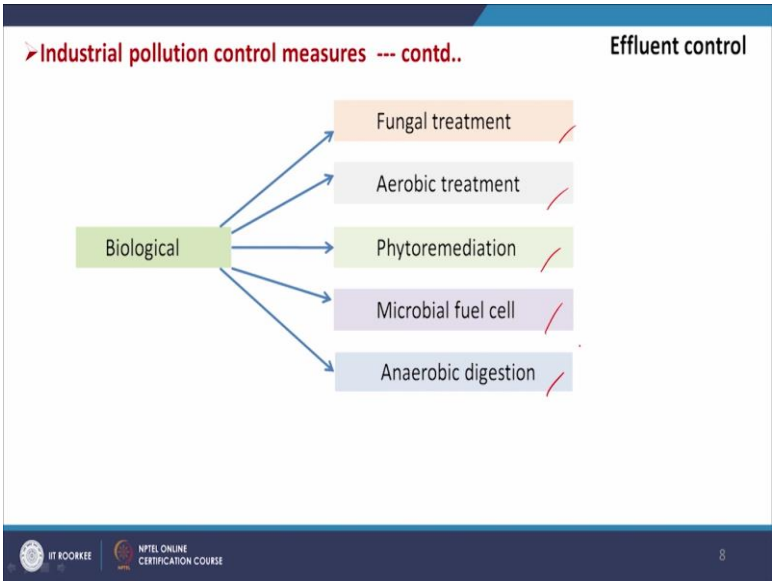




And if we see the type of influence variant in industrial influence, mostly organic compound, which are most important because it reduces the dissolved oxygen content in the river water and makes death to many living organisms like fishes. Heavy metals is also another important pesticides etc. which can come out or sell type of organic compounds which can come out from different types of industry.

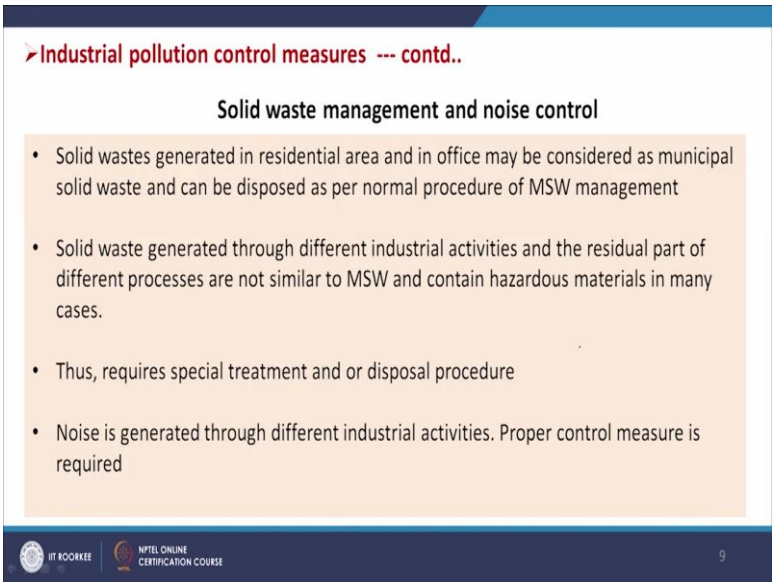
So, here, if we see the techniques for organics removal from wastewater that can be biological, electrochemical and physico-chemical. And these physico-chemicals are evaporation or combustion, it can be chemical or product chemical oxidation, maybe adsorption, maybe coagulation flocculation, membrane filtration, etc.

(Refer Slide Time: 07:36)



So, we have discussed these things also and in case of biological that is fungal treatment, anaerobic treatment, phytoremediation, microbial fuel cells, anaerobic digestion. So, all these methods we have discussed in our previous classes. Now, we have to customize the processes basically as per the need of the specific industry and we have to develop a specific flows sheet for the treatment of the wastewater in the respective ETP.

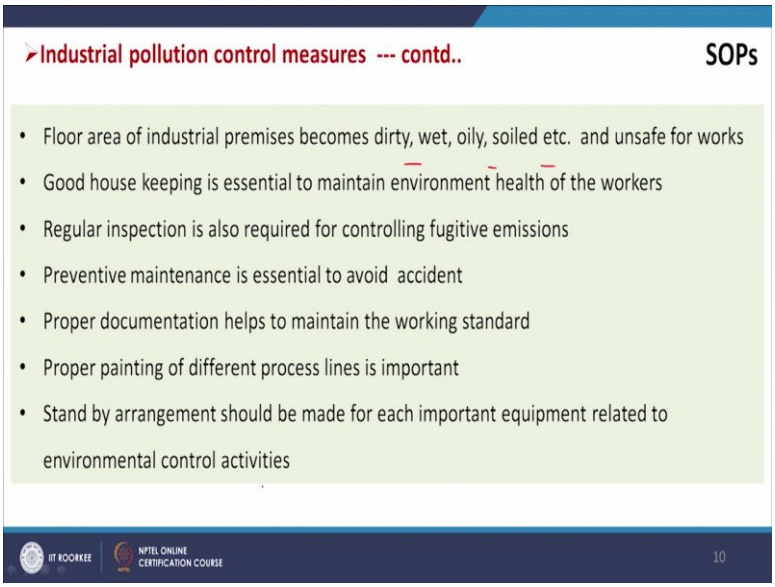
(Refer Slide Time: 08:11)



Similarly, solid waste management and noise control also is important because solid waste generated in a residential area as well as in the industrial area also. So, those nature will be different. So, solid waste generated in the residential area can be managed through the solid waste management what which is generated in industrial activities may contain specific

compounds that will be more toxic or hazardous. So, we have to remove the toxicity or hazardous nature of those solid materials first in the premise and then we can either manage itself or industry can dispose it as per the guidelines for hazardous solid waste management.

(Refer Slide Time: 09:00)

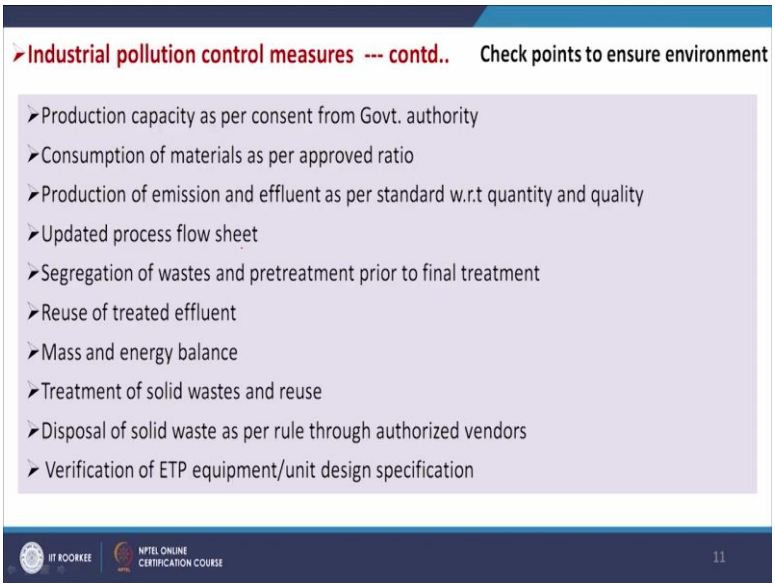


Now, we will discuss about some standard operating practices in industry like say floor area of industrial premises becomes dirty, wet, oily, soiled etc. and unsafe for works. So, good housekeeping is essential to maintain environmental health of the workers. Regular inspection is also required for controlling fugitive emissions. Preventive maintenance is essential to avoid accident and proper documentation helps to maintain the working standard that is why ISO 14,000 if it is implemented in industry, it is expected that the working environment will be more worker friendly and environment friendly.

Proper painting of different process lines is important like say in industry streamline maybe there, maybe some waterline, a gas line so if it is marked with different color as per the industrial practice. Then anybody working in the area will be aware about the nature of fluid being passing through and they will take necessary precaution. So, accident can be avoided and standby arrangements should be made for each important equipment related to the environmental control activities because there may be some need for maintenance for any equipment at any time any equipment can be affected and can be non functional for certain time.

So, at that time, we should have some alternate arrangement. Otherwise, if the time required for the maintenance is more than certain limit then it will be very difficult to maintain the situation or the ETP activities. So, the standby of the equipment is very, very important.

(Refer Slide Time: 10:49)



Now, we will see the checkpoints to ensure environment in the industry. So, production capacity as per consent from government authority. So, government authority gives consent to each and every industry for its operation under certain conditions and it also specifies the production capacity. So, regularly, if the management takes care about it, that we are not producing much more than that, so, certainly environment will be under control and the consumption of materials that were approved the ratio again that some approved ratio is provided in the content these type of materials will be used and maximum amount will be this much the ratio will be this match.

So, all these are maintained means process is followed properly. So, there will be the product will be produced as per the expected situation. So, there will be less pollution chance and production of emission and effluent as per standard with respect to quality. So, each day if we take the reading in each sipped and after a certain interval, the quality of the effluent or the emission since suddenly there will be a good chance to eliminate any sort of environmental pollution.

So, that is done basically. So, now CPCB or state pollution control board are having online camera and they are having some monitoring system to get online data in terms of effluent treatment and detailed water quality and also the gas emission taking place to the stack.

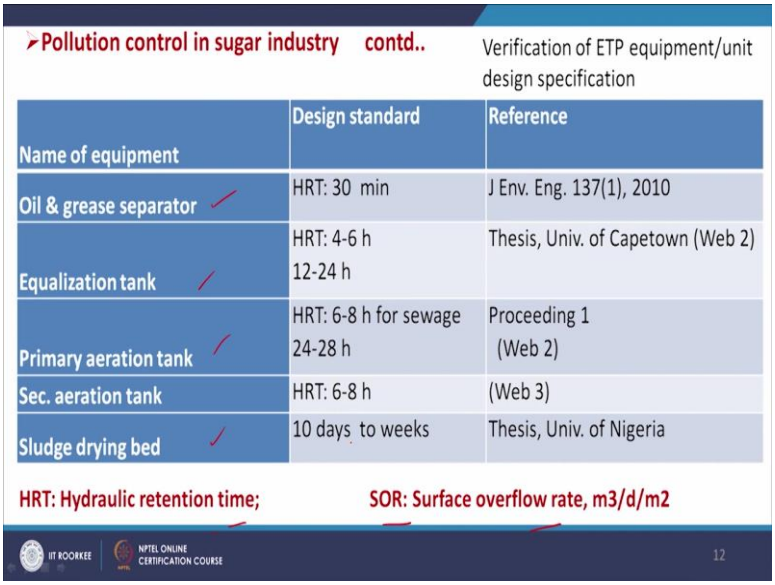
Updated process flow sheet the industry need to update the processes from time to time and to ensure that this is being improved because by the improvement of flow sheet that means the replacement of equipment or some process steps, that there might be possibility to improve the environmental condition.

And then segregation of waste and pretreatment prior to final treatment, so, we will be discussing this part also. We will be seeing that different waste stream is generated in a particular type of industry and those waste streams are having different composition and the if we mix it and treat it centrally. So, that can be difficult for the treatment, but if we remove the specific component from the respective stream, so then the process will be more effective. And reuse of treated effluent again the treated effluent reuse that is a recycling of the treated water that is being implemented, now it is more and more in industries.

And mass and energy balance that is also a check point if we regularly gets the mass and energy balance so there will be certainly the process will be under control and environmental pollution will not take place. Treatment of solid waste and reuse, again solid waste treatment and reuse is also needed and disposal of solid waste as per rule through authorized vendors.

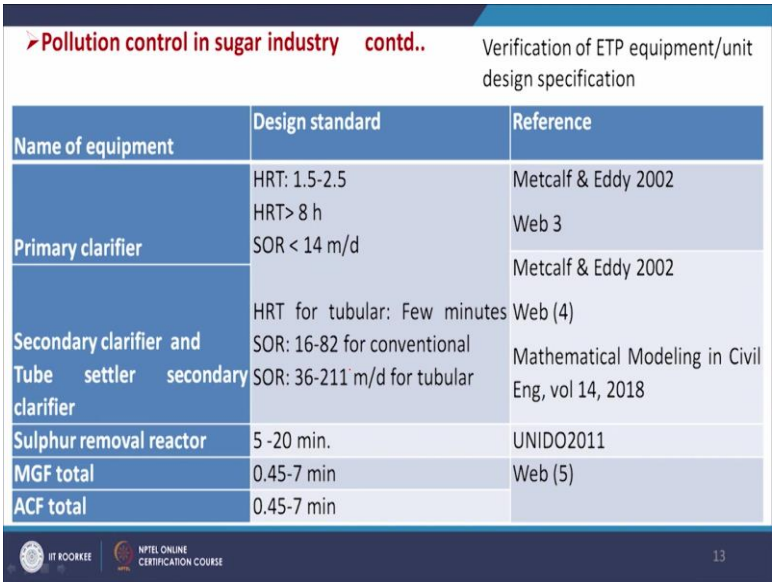
So, certainly, these steps will help us to maintain the environment and verification of ETP equipment you need design specification, we can also check whether the equipment is sufficient for the handling of the effluent generated in the process or not. So, these are the different checkpoints if we take sufficient care to check these so the environment can be automatically under control.

(Refer Slide Time: 14:44)



And these are some verification of ETP equipment guidelines, that is for different types of equipment here mentioned and for that design standard basically, the retention time is considered so we are providing retention time means it is suppose that the sufficient time is provided. So, if other conditions are maintained properly, so the sufficient conversion of organic compounds will take place or the removal of the pollutants will take place. But in case of clarifier or settler along with HRT, SOR surface overflow rate is also determined.

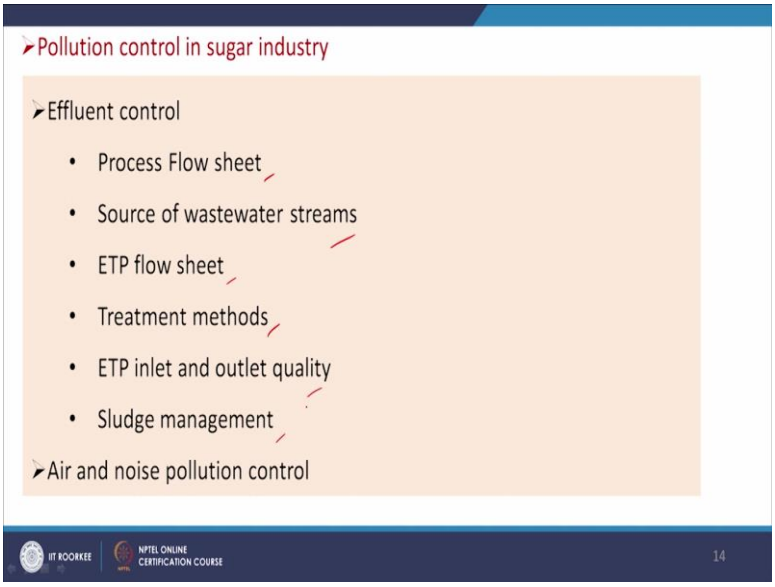
(Refer Slide Time: 15:25)



And these values as mentioned here against different parameters will help us to, to check whether our equipment is sufficient for handling the effluent generated in that in the plant or

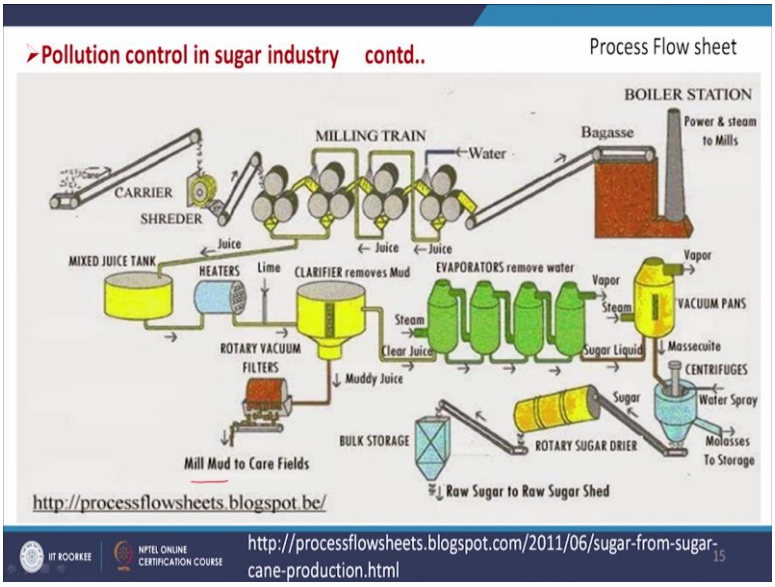
not. So, these are the different standards for different equipment. These are the general consideration now we will focus on the pollution control in sugar industry.

(Refer Slide Time: 15:50)



So, we will be seeing the effluent control, air, and noise pollution control. And effluent control we will see the process flow sheet first, then we will understand what is the sources of wastewater streams, and then ETP flow sheet and the treatment methods, ETP inlet and output quality and sludge management.

(Refer Slide Time: 16:12)



So, this is our process flow sheet for a typical sugar industry. So, here we are taking the sugarcane it is carried here. So, then it is going through the mills. So, this milling train will

give juice and the bagasse. These bagasse will be used in the cogeneration plant for electricity production and the juice which is produced in the mill that is coming here in this mixed juice tank and in this mixed juice tank heat at temperature is increased and here are some lime addition and SO_2 gas addition takes place.

So, after the addition of lime and SO_2 gas addition not shown. So here we will be getting some sludge and some clear liquid. So, clear liquid that will be going through this multi effect evaporator. So, in this evaporator the moisture will be evaporated the water will be evaporated and it will be condensed and collected. And the sludge which you are getting here that will be going to this vacuum rotary vacuum filters and then we will get the cake and the other part which we are having that will be again added here. So liquid part which will be having that is again added here juice tank and again this sulphitor, so then in this tank it will be added.

And after this evaporation that is concentrated material which is available at the bottom of this evaporator that is called syrup. So, this syrup is again further mixed with sulfur dioxide, SO_2 gas and then it is again reacted with it and then some separation takes place some purification takes place. Then it will be going to the crystallization unit and then this is called the centrifuges for the separation of these crystals and the molasses.

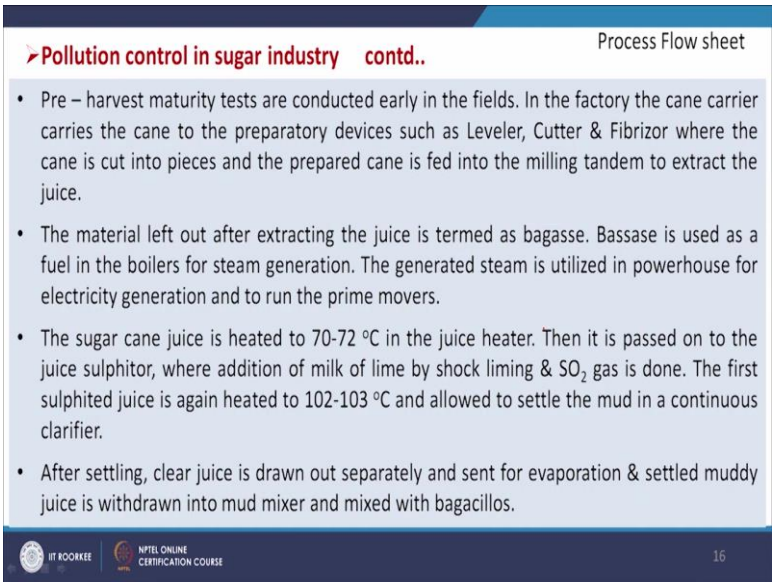
So, the liquor after this vacuum pan that is called massecuite and this massecuite basically contains sugar and the molasses. The liquor is molasses and the super crystal comes out. So then sugar crystal is dried and it is packed and this molasses which comes that molasses will be having different sugar content and A, B, C type is there. And this molasses is the feedstock for the distillery unit.

Now, this is the overall process for the sugar industry. So, we see the wastewater mainly generating here the vaporized water from the juice, which is coming out from this evaporator that is condensed and collected and it is cooled and in this cooling tower that water continuously overflows. So, this is the water one source of wastewater. Other source of wastewater is your in the whole process, the cleaning activities etc. That gives the process water and other type of wastewater can be generated in this evaporator cleaning that you evaporate a tube cleaning will give us other type of wastewater.

So, we see if we consider these three types of wastewater certainly the composition will be different. In case cooling tower overflow that is called this condensed water that will be

containing sulfur because the sulfur dioxide is added so, that will be containing sulfur, but which water is coming from the overall plant that will not containing the sulfur that will containing oil, grease etc. and it is their boiler will be their boiler will be having some blowdown that will be having different quality and when you are doing the cleaning of this evaporator tube, then also wastewater which will be generated that will be having higher pH and that will be more toxic.

(Refer Slide Time: 20:46)

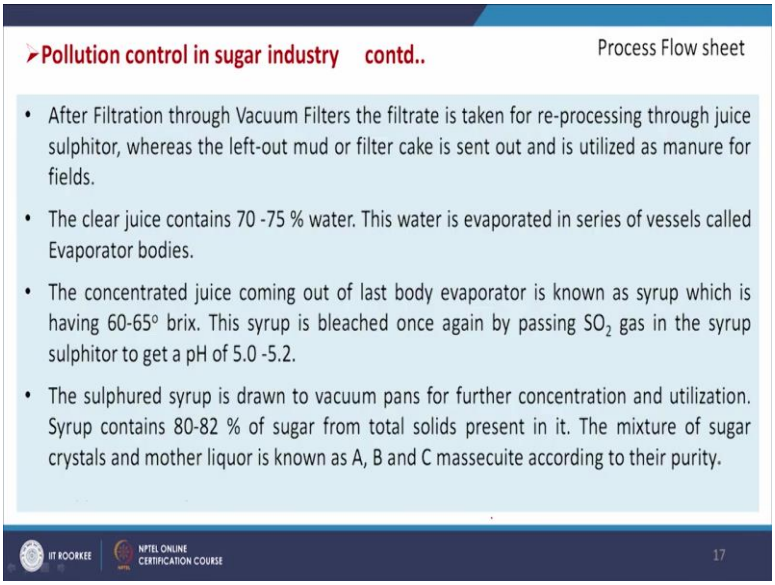


So, these are different types of effluent water we can get. Now, the process flow sheet the description is given we have already described the process. Again pre harvest maturity tests are conducted early in the fields that means before entering into the plant the sugar is tested in field whether it is a suitable time for its use in the plant or not in the sugar industry or not that means it requires more maturity or the concentration of sugar is more in the juice.

So, that is ensured in a field test. And then it comes to that factory and then there are some management for its crashing and then the juice is extracted and juice which is generated as I mentioned that that is heated for 70 to 72 ^{o}C in the juicy heater, then it is passed on the juice sulphitor that was not in the flow sheet where edition of milk of lime by shock liming and SO_2 gas is done and the first sulfated juice is again heated at 102 to 103 ^{o}C and allowed to settle the mud in a continuous clarifier.

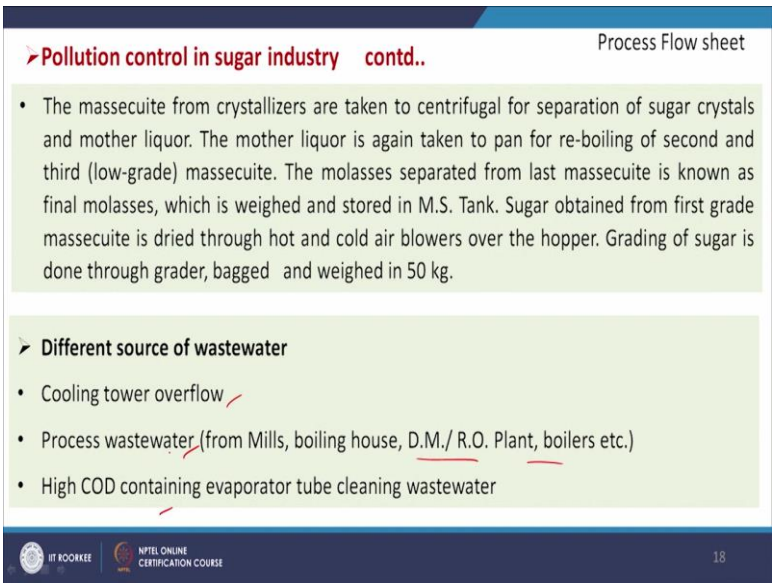
After settling clear juice is drawn out separately and sent for evaporations and settled muddy juices withdrawn into mud mixer and mixed with it bagacillos. Bagacillos are very very small tiny part of the particles of the bagasse.

(Refer Slide Time: 22:19)



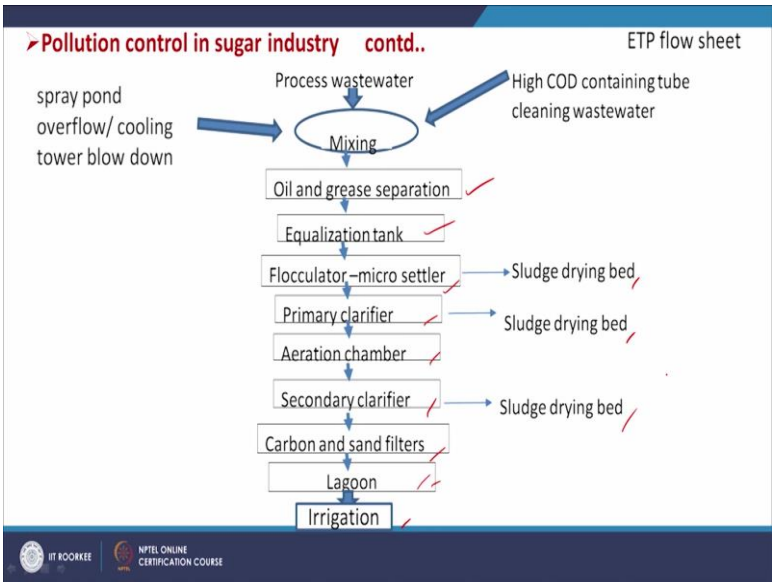
So, after filtration through vacuum filter, the filtrate is taken for re-processing through juice sulpitor whereas the left-out mod or filter cake is sent out and utilized as manure for fields. And the clear juice contains 70 to 75 % water. This water is evaporated in series of vessels called evaporator bodies. And the concentrated juice coming out of the last body evaporator is known as the syrup, which is having 60 to 65 ^{o}brix. This syrup is bleached once again by passing SO_2 gas in the syrup, sulphitor to get pH 5 to 5.2. And the sulphured syrup is drawn to vacuum pans for further concentration and utilization. Syrup contains 80 to 82 % of sugar from total solids present in it. The mixture of sugar crystal and mother liquor is known as A, B, C massecuite according to their purity.

(Refer Slide Time: 23:23)



The massecuite from crystallizers are taken to centrifuges for separation of sugar crystals and mother liquor. The mother liquor is again taken to pan for re-boiling of second and third massecuite. The molasses separated from last massecuite is known as final molasses, which is wetted and stored in M.S. tank. The sugar obtained from the first grade massecuite is dried through hot and cold air blowers over the hopper. So, this is a process flow sheet. And we have also discussed that there are three major three type of wastewater. There is cooling tower overflow, process wastewater and high COD containing evaporator tube cleaning wastewater. D.M. and R.O. Plant or boilers blowdown are also included in the process wastewater.

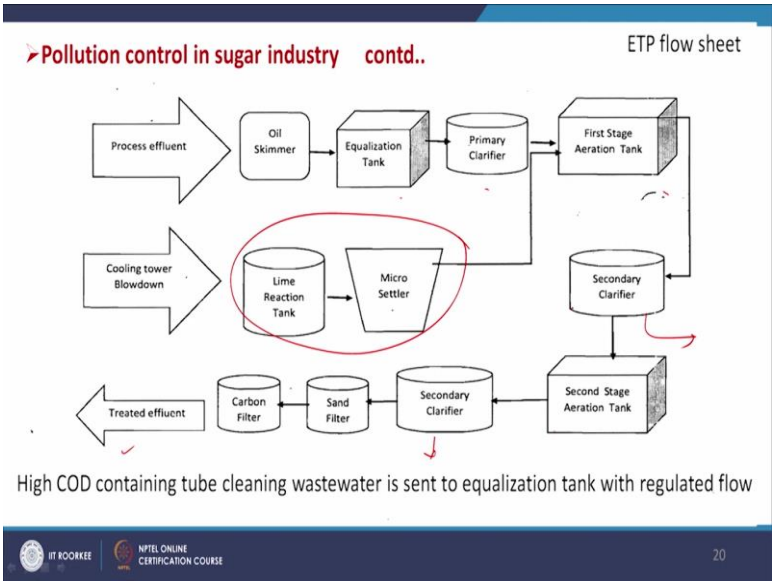
(Refer Slide Time: 24:17)



Now what should be the ETP process? Conventionally there are many plants where these three streams are mixed first. Then it follows the conjugative treatment steps like say oil and grease separation, then equalization tank, then flow coalitions and microcellular, then primary clarifier, aeration chambers, secondary clarifier, carbon and sand filter, then lagoon that is for storage of treated water and then it passes to irrigation. And sludge are collected from different locations and managed through proper process.

Now, if this conventional method is followed, then certainly the performance of the ETP plant may not be that superior.

(Refer Slide Time: 25:02)

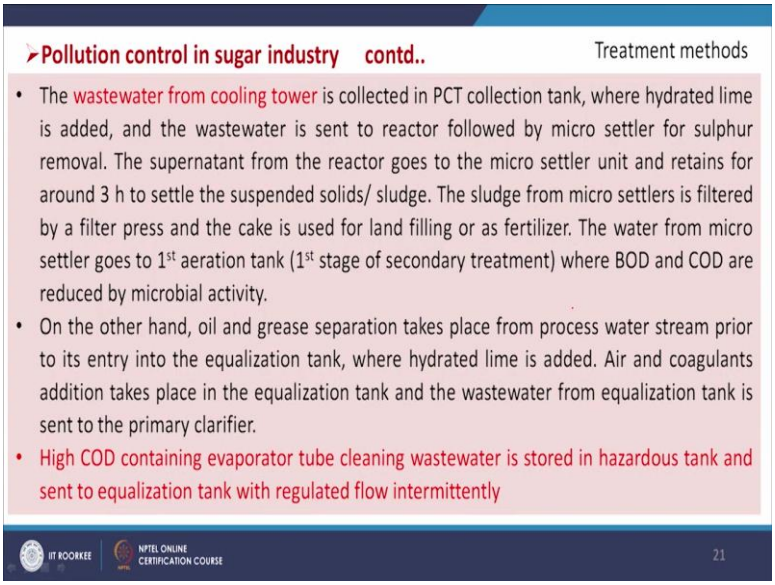


So, there are advisable and now it is implemented in Indian sugar industries to separate three different streams and basically the two stream the three stream which is generated through the tube cleaning of the evaporator that is tolled and intermittently it is mixed with the effluent stream. And other two continuously treated separately like for example, say process effluent which will be having oil, grease, oil separation will take place, oil skimming then equalization tank then primary clarifier then aeration tank. And the cooling tower blowdown. Cooling tower blowdown are overflow we can say cooling tower overflow. So, it is going to through lime addition, lime reaction tank, then micro settler then it is coming to first aeration tank.

So, this process basically is responsible for the removal of sulfur. So, sulfur removal then it is coming to here that means, after that this aeration the microbes which is available here that will be free from the risk of sulfur addition. So, that is the beauty of this process and this is advanced flow sheet we can say and then it is going to secondary clarifier. The secondary clarifier to second stage aeration and here we will be getting the sludge. And then it is going to secondary clarifier. Again we will get sludge and then it is sand filter, tertiary treatment, then carbon filter again tertiary treatment untreated for treated water to go into treated lagoon.

So, high COD-containing, tube cleaning wastewater is sent to equalization tank with regulated flow. So, intermittently it is sent into this equalization tank so that the load is not much on this microbial activity in the aeration tank.

(Refer Slide Time: 27:06)

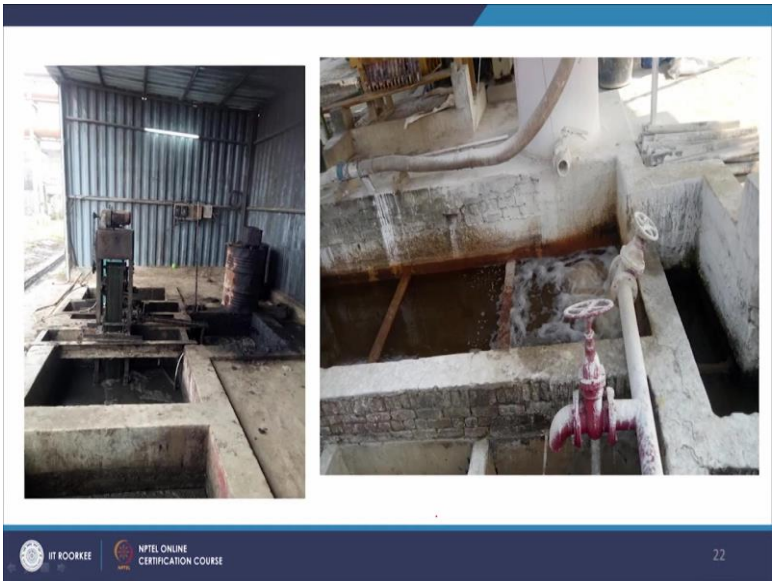


So, these are the treatment methods. So, the wastewater from cooling tower is collected in PCT collection tank where hydrate lime is added and the wastewater is sent to reactor followed by micro settler for sulfur removal. The supernatant from the reactor goes to the micro settler unit and retains for around 3 hour to settle the suspended solids or sludge. The sludge from microcellular is filtered by a filter press and a cake is used for land filling or as fertilizer.

The water from micro settler goes to first aeration tank that is first stage of secondary treatment where BOD and COD are reduced by microbial activity. On the other hand, oil and grease separation takes place from process water stream prior to its entry into the equalization tank where hydrated lime is added. Air and coagulants addition takes place in the equalization tank and the wastewater from equalization tank is sent to the primary clarifier.

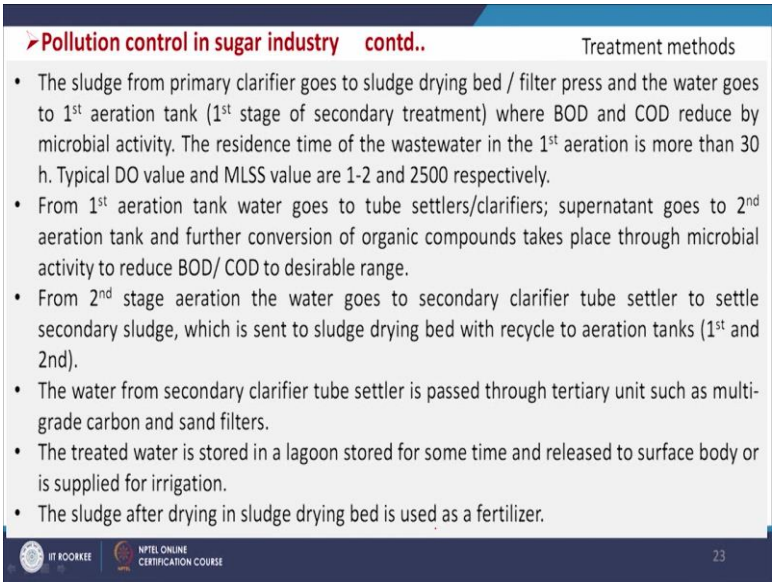
High COD containing evaporator tube cleaning wastewater is stored in hazardous tank and sent to equalization tank with regulated flow intermittently.

(Refer Slide Time: 28:18)



This shows the oil separation unit and this is the lime addition.

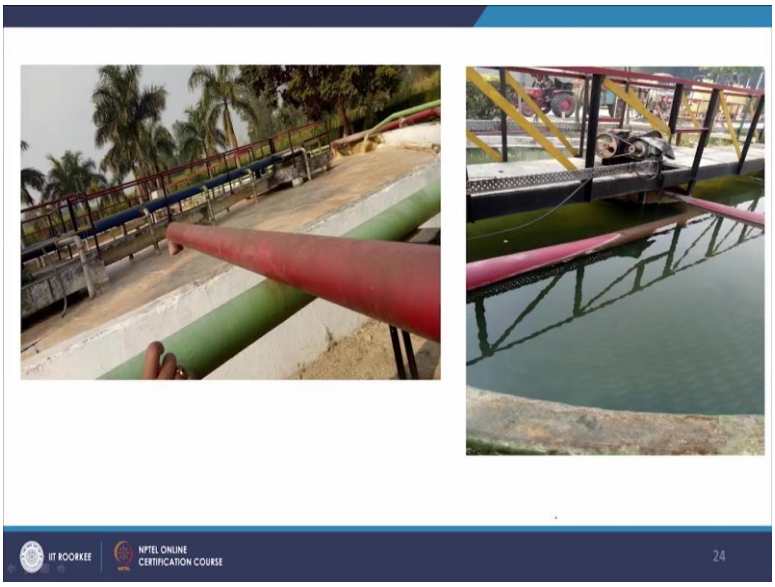
(Refer Slide Time: 28:25)



The sludge from the primary clarifier goes to sludge drying bed and filter press and the water goes to first aeration tank then first stage of secondary treatment where BOD, COD reduced by microbial activity. The residence time of the wastewater in the first aeration tank is more than 30 hour. Typical DO value and MLSS value are 1 to 2 and 2500 mg/l respectively. From first aeration tank water goes to tube settler for clarifiers. Then supernatant goes to second aeration tank and further conversion of organic compounds takes place through microbial activity to reduce BOD and COD to desirable range.

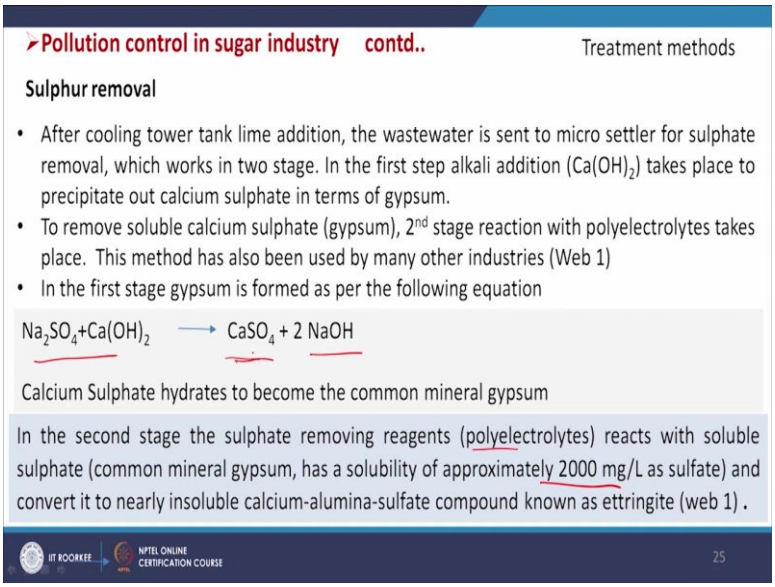
From second stage aeration the water goes to secondary clarifier tube settlers to settle secondary sludge which is sent to sludge drying with recycled to aeration tank first and second. The water from secondary clarifier tube settler it is passed through tertiary units such as multi grade carbon and sand filters. That treated water is stored in lagoon for some time and released to surface body for its is supplied for irrigation. The sludge after drying in sludge drying bed is used as a fertilizer.

(Refer Slide Time: 29:43)



So, this is secondary treatment, you need aeration tank and this secondary clarifier.

(Refer Slide Time: 29:50)

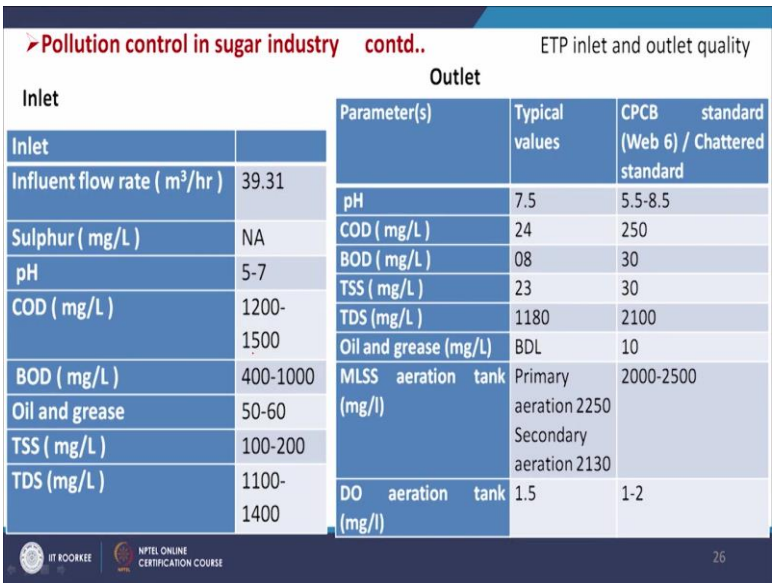


So, sulfur removal is done with the cooling tower stream before entering to the aeration tank. So, after cooling tower tank lime addition, the wastewater is sent to micro settler for sulphate removal, which works in two stage. In the first step, alkali addition takes place to precipitate out calcium sulphate in terms of gypsum. To remove soluble calcium sulphate, the second stage reaction with poly electrolytes takes place this method has also been used by many other industries and in the first stage gypsum is formed that is

$Na_2 SO_4 + Ca(OH)_2 \rightarrow CaSO_4 + NaOH.$

So, $CaSO_4$ is mostly not soluble, so mostly insoluble, but some part is soluble, that solubility is say around 2000 mg/l. So, to separate this sulphate also we need to add the poly electrolytes. So, polyelectrolytes is added in the second step to remove the trace amount of sulfur also. So, this soluble $CaSO_4$ is also removed by that way. So, this is the mechanism for the removal of sulfur.

(Refer Slide Time: 31:07)

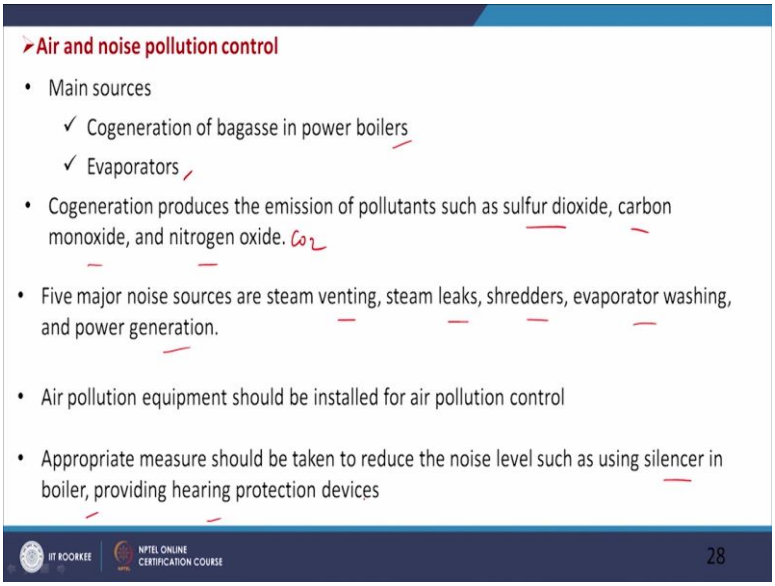


And this slide shows us ETP inlet and outlet quality. You see the inlet quality here, this is not NA means already it has been applicable sulfur has already been removed from the cooling tower stream. So, that is it is NA other values are given here. So COD, BOD, oil, grease, TSS, TDS etc. And after treatment, you see the typical values which is obtain in the sugar plant and this is and for the CPCB guidelines. So, ETP effluent quality must be lower than this. The quality will be higher the values of the pollutants should be lower than this or maximum up to this.

(Refer Slide Time: 31:53)

And sludge management. So, we have seen that the sludge is produced in our primary settler and primary clarifier and secondary clarifier and sludge produced due to COD, TSS and coagulants. And different methods are used for dewatering and drying, like say use of drying bed, use of filter press, use of decanter. So, this is a decanter and this is a drying bed. So, the drying bed requires more land area and dried sludge can be used as manure or dispose through a vendor. So, these are the process which is followed for sludge management.

(Refer Slide Time: 32:32)



Now air and noise pollution control. So, main sources for air pollution or the cogeneration of bagasse in power boiler. So, this is the main source of air pollution and evaporators also. So, cogeneration produces the emission of pollutants such as sulfur dioxide, carbon monoxide

and nitrogen oxide, carbon dioxide also. Five major noise sources are steam venting, steam leaks, shredders, evaporator washing, and power generation. So, these are the source of noise.

So, air pollution equipment should be installed for air pollution control and appropriate measures should be taken to reduce the noise level such as using silencer in boiler, poviding hearing protection devices etc. So, once we are able to identify the sources of the air pollution and noise pollution, then we should need to implement the methods for its control. So, that way, the industries are following nowadays and industry need to take more care in future as well to make environment free from the pollution.

Up to this in this class. Thank you very much for your patience.