Physico-Chemical Processes for Wastewater Treatment

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Lecture 55
Case Study
Wastewater Treatment in Sugar Industry

Good day everyone and welcome to these lectures on Physico-Chemical Processes for Wastewater Treatment. So, we have already studied different physic-chemical processes, which are used for water and wastewater treatment. And we studied regarding aeration, coagulation flocculation, settling, then filtration, adoption and ion exchange, different membrane treatment technologies and then lot of advanced oxidation processes.

So, in any industry depending upon the characteristic of wastewater which is being discharged, few of these units may be used and many of the units may not be used. So, depending upon the characteristic of the water and the quantity of water to be treated, different physico-chemical processes may be used, also their exact location may also vary depending upon the treatment that has to be done.

So, this is the basic understanding of all the physical chemical unit operation that we have studied that is very necessary to properly use these processes with the proper location within the treatment trend, so as to achieve the standards which are desired, as per government of India norms for water treatment in these industries. So, we will be starting taking care few of the case studies with respect to wastewater treatment in different industries. So, today we will be discussing the wastewater treatment in a sugar industry.

So, we will be studying the sugar industry more in detail. And what we will do if that in any of the cases study will first try to learn regarding the product which is formed in that industry, then what is the process that is followed in that industry for production of that particular product, and followed by the sections in which different wastewaters may get generated. So, it is possible that those wastewaters may be treated individually in those units, or they may be combined together and then a treatment strategy is followed for the treatment of water and wastewater of that industry. So, we will be concentrating on the sugar industry today.

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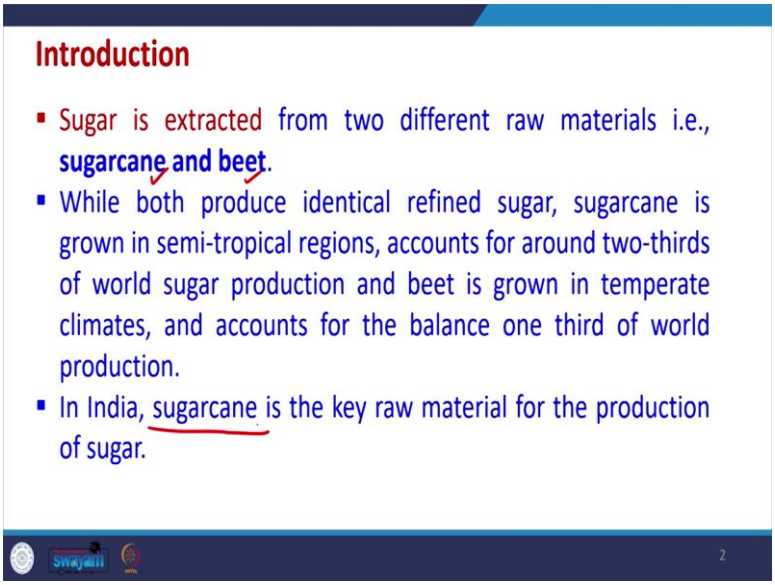

So, sugar is extracted generally over the world from different raw materials, and sugar cane and beet, these are the two common materials from which the sugar is made. While both these raw materials produce identical refined sugar, sugar cane is grown in semi-tropical regions, and accounts for around two-thirds of the word sugar production and beet is grown in temperate climates and accounts for balance one third of the word sugar production. In India sugarcane is the key raw material from which this sugar is produced.

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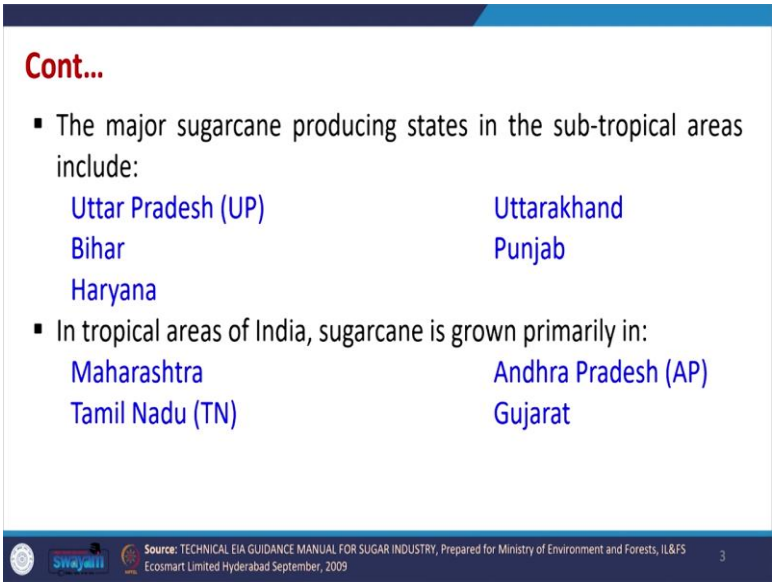

The major sugar producing states in the subtropical areas within the country include Uttar Pradesh, Bihar, Haryana, Uttarakhand, Punjab. Similarly, the topical areas of India where the

sugar cane is produced include, Maharashtra, Andhra Pradesh, Tamil Nadu, Gujarat, etc. So, these are the major states in which the sugar cane is produced.

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Now, sugar industry is one of the most important agro based industry of India and is responsible for creating lot of impact on the rural economy and country's overall economy. India currently produces around 20 percent of the world's total sugar production and the nation is seeing large record level of sugar production due to increased sugar farmland and highly improved yields. So, in last few last decade, we have seen that the yield has increased tremendously and because of that the sugar cane production has increased and since sugar cane production has increased, the sugar production has also increased in the country.

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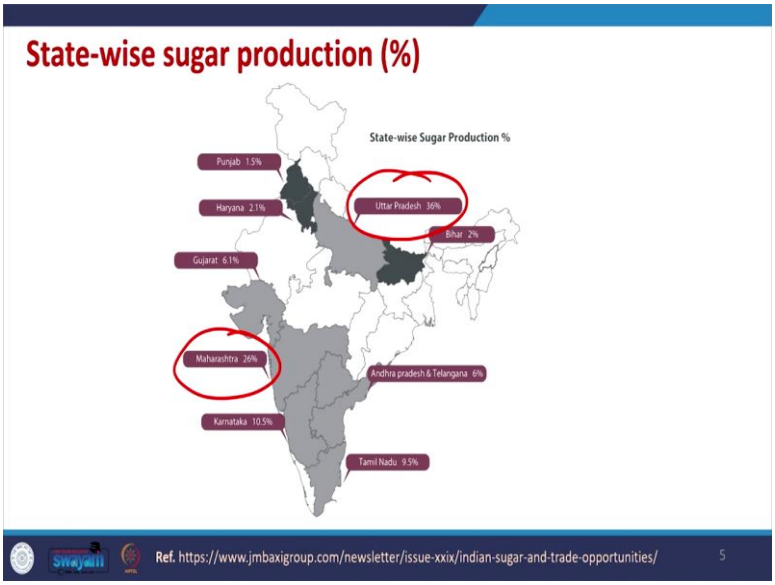

Now, these are the state wise sugar production. So, we can see clearly, Uttar Pradesh produces the largest amount of sugar followed by Maharashtra. So, there are many states which produce sugar we can see here. So, these are the sugar-producing states.

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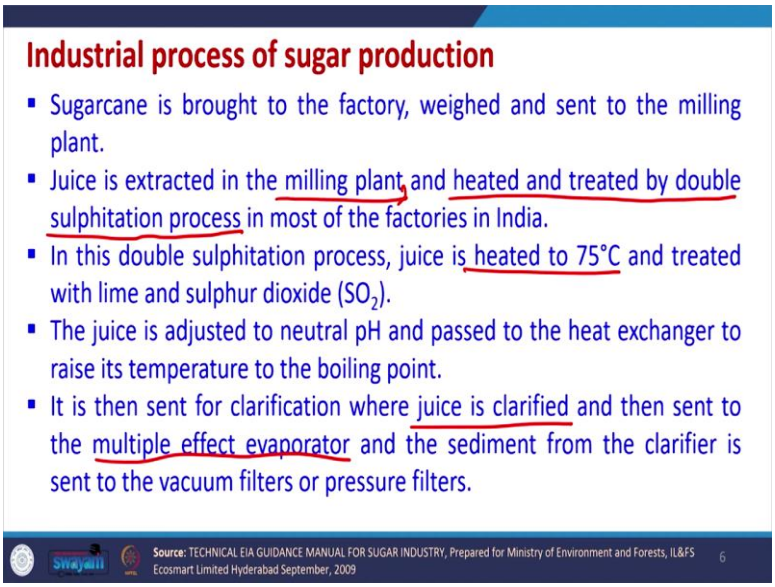

Now, what is the process which is followed for sugar production? So, let us understand that, and from there we will understand that which are the sections in which the wastewater may get produced? So, sugarcane is brought to the factory weighed and sent to the milling plant, after that sugar juice is extracted in the milling plant and it is heated and treated by double sulphitation process in most of the factories in India.

In this process, the juice is heated up to 75 degrees centigrade and is treated with lime and sulphur dioxide, juice is adjusted to neutral pH after that and is passed to a heat exchanger to raise the temperature to the boiling point. And after that it is sent for clarification where juice is clarified and then sent to the multiple effective operator and the sediments from the clarifier is sent to the vacuum filters or pressure filters.

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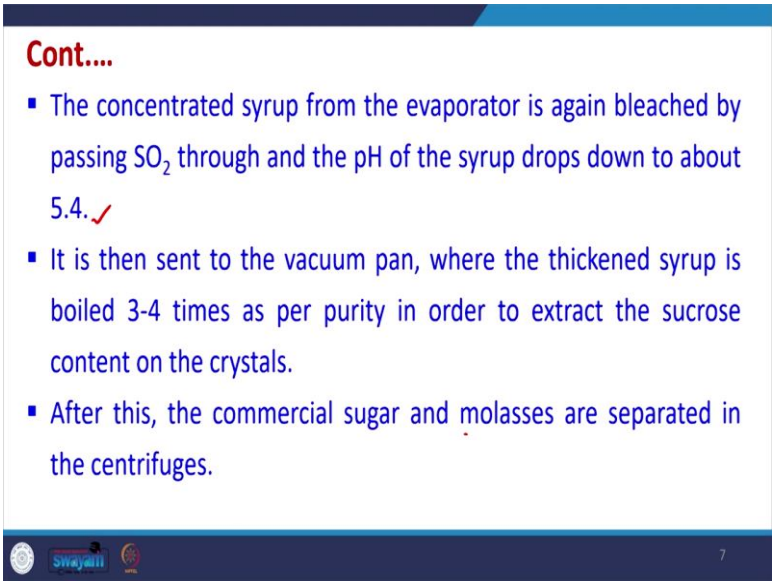

So, these are the steps. The concentrated syrup which is obtained from the evaporator is again bleached by passing sulphur dioxide through it and the pH of the syrup drops to about 5.4. Then it is sent to a vacuum pan, where the thickened syrup is boiled 3 to 4 times as per the purity in order to extract the sucrose content of the crystal in the form of crystals, after this the commercial sugar and molasses are separated in the centrifuges and then used further on.

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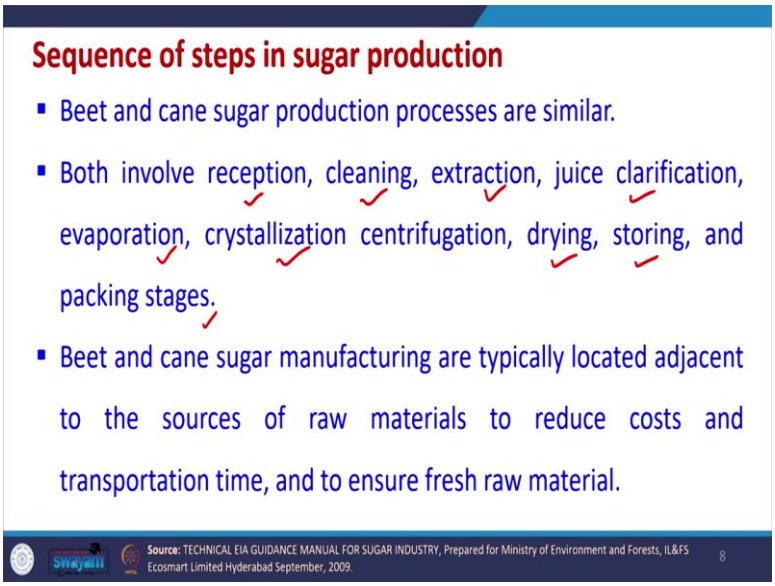

So, these are the different steps which are followed in this sugarcane production. Now, the sequence of steps in the sugar production are given here. So, the beet and cane sugar production processes are in very similar, both involved reception, cleaning, extraction, juice clarification, evaporation, crystallization, centrifugation, drying, storing and packaging.

So, these are the different stages which are there in the sugar production, the beet and cane sugar manufacturing are typically located adjacent to the source of raw materials. So, generally these industries will be in the rural areas where more amount of production is there. So, it also helps in ensuring fresh raw material and lesser transportation time and cost also, so, this is there.

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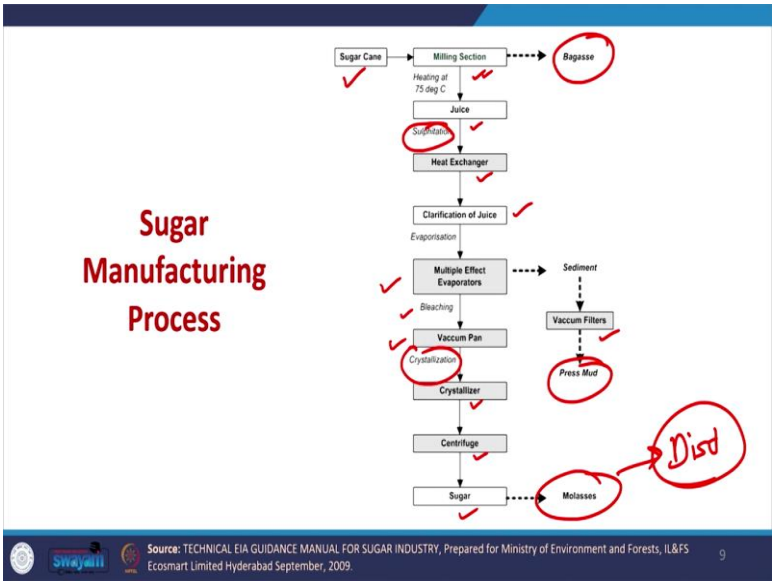

So, this is the flow diagram in a way of sugar productions, so, we have sugarcane milling section where bagasse gets produced and this bagasse is used in pulp and paper industries, other places in the boiler for producing steam. So, heat is extracted out of this bagasse. Then after milling section we have juice which is coming out, this juices sulfite as earlier understood.

Then in the heat exchange, heat exchanger is there, followed by clarification of juice, then we have evaporation in the multiple effective operator from which sediment is coming out and it is vacuum filtered to get the press mud which is like a solid waste from the sugar industry, then bleaching is done in the concentrated slurry. It is goes to the vacuum pump where crystallization happens, we have crystallizer.

Then cryst from the crystallizer centrifugation is there and then the sugar is taken out and we have molasses which is sent to distillery further for alcohol production. So, we will be studying that distillery section in the next lecture. But today we will be concentrating on sugar manufacturing process. So, this is the total sugar manufacturing process which is there.

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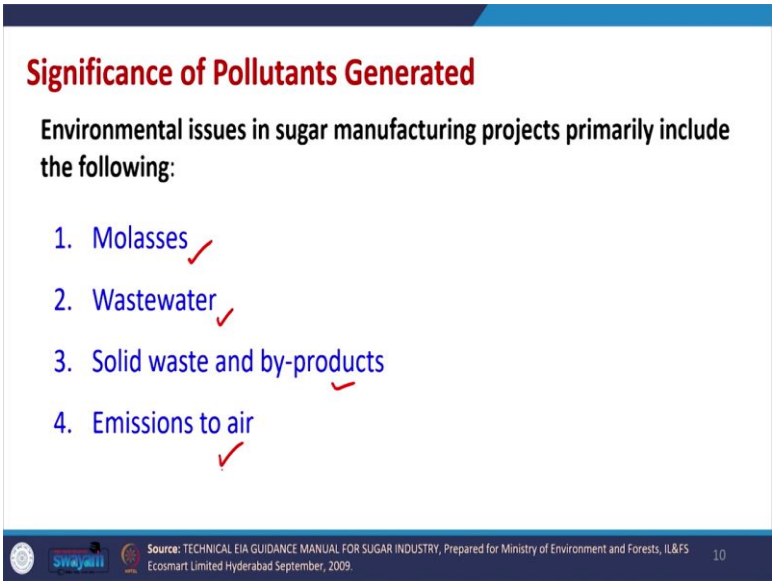

Now, what are the different types of pollutants that are generated in the sugar industry and what are the various environmental issues in the sugar manufacturing project? And these are like the molasses is one of the key parameters because it contains a lot of load. Then we have wastewaters which are generated from different units, that have solid waste and byproducts are generated and then certainly there are emissions to the air, because we are continuously requiring lots of heat. So, far production of heat etc and elevated temperatures we use lot of material, which may be molasses which may be bagasse itself. So, this is because of that emission to the air is also there.

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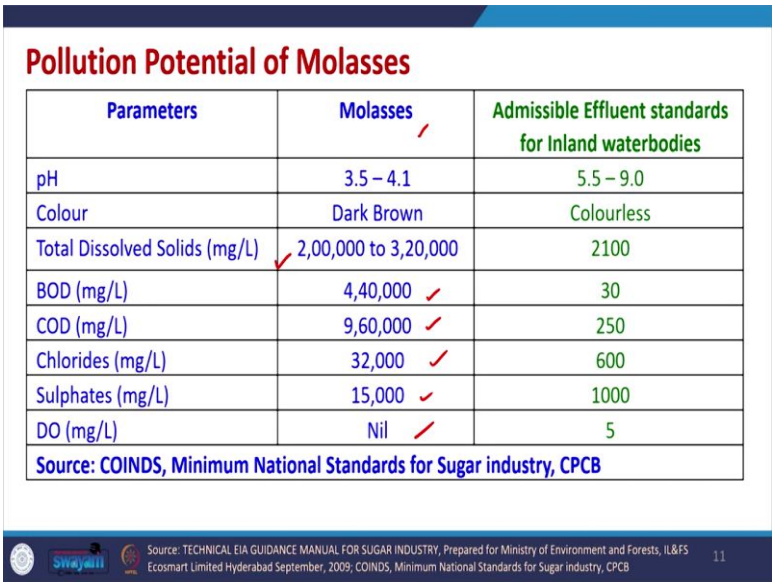

Parameters	Molasses	Admissible Effluent standards for Inland waterbodies
pH	3.5 – 4.1	5.5 – 9.0
Colour	Dark Brown	Colourless
Total Dissolved Solids (mg/L)	2,00,000 to 3,20,000	2100
BOD (mg/L)	4,40,000	30
COD (mg/L)	9,60,000	250
Chlorides (mg/L)	32,000	600
Sulphates (mg/L)	15,000	1000
DO (mg/L)	Nil	5

Now, we will be only concentrating on the water pollution. So, with respect to molasses, molasses has these properties, certainly it is neither, it goes into the distillery. So, it is already taken care of. So, but the content of the characteristics of molasses are given here. So, total dissolved solids maybe from 2,00,000 to 3,20,000, then we considere BOD, COD, chlorides. All are very high value. And so, that is why this is taken care of because the alcohol production takes place from molasses.

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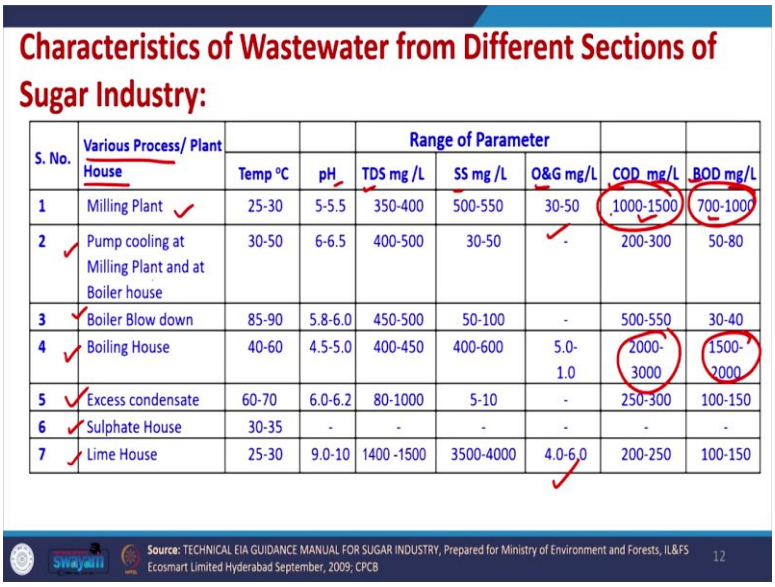

S. No.	Various Process/ Plant House	Range of Parameter						
		Temp °C	pH	TDS mg /L	SS mg /L	O&G mg/L	COD mg/L	BOD mg/L
1	Milling Plant	25-30	5-5.5	350-400	500-550	30-50	1000-1500	700-1000
2	Pump cooling at Milling Plant and at Boiler house	30-50	6-6.5	400-500	30-50	-	200-300	50-80
3	Boiler Blow down	85-90	5.8-6.0	450-500	50-100	-	500-550	30-40
4	Boiling House	40-60	4.5-5.0	400-450	400-600	5.0-1.0	2000-3000	1500-2000
5	Excess condensate	60-70	6.0-6.2	80-1000	5-10	-	250-300	100-150
6	Sulphate House	30-35	-	-	-	-	-	-
7	Lime House	25-30	9.0-10	1400 -1500	3500-4000	4.0-6.0	200-250	100-150

Now, characteristics of different wastewaters which are generated in different sections of the sugar industry. So, there are various processes or plant within the sugar industry, where different types of wastewater are coming out and their pH, TDS, SS, oil and grease, COD, BOD values are shown. And we can see here from many plants, the wastewater will be coming out, so it will be having BOD of 1000 to 1500, COD of 1000 to 1500, BOD of 700 to 1,000 milligram per liter.

Similarly, from pump to cooling at the milling plant and the boiler house, then boiler blow down, within the boiling house, there is water which is discharged, then condensate which is discharged then sulphate house from that and lime house we have some amount of water which is coming out from lime house. So, the characteristics of these wastewaters are here shown and it is seen that some of them may contain oil and grease, some of them may contain high amount of COD like here and here, other places it is lower, similarly, some may contain very high amount of BOD also beyond the limit, so, this is there.

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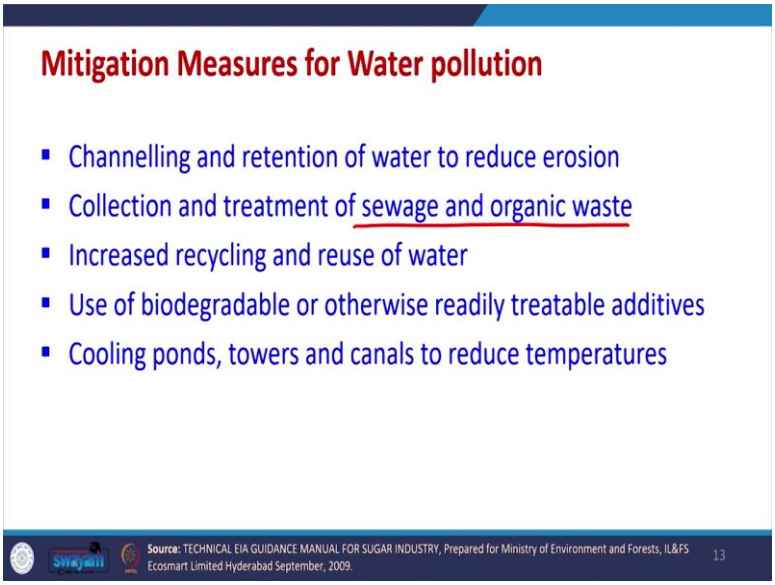

So, these are the characteristics of water which are discharged from different section. So, what are the mitigations measures that are generally taken in a sugar industry. So, channeling and retention of water to reduce the erosion, so, this is their. Collection and treatment of sewage and organic waste. So, this is also done because a number of people are working in the industry.

So, we have lots of sewage generation also taking place. Increased recycling and reuse of water in different section, use a biodegradable or otherwise readily treat well additives if they have to be used. Cooling ponds, towers, canals, etc to reduce the temperature of the water because the temperature of the water is sometimes high beyond the if you can see here the temperature is more than the ambient temperature, so certainly it is there. Also, neutralization and sedimentation of the wastewater dewatering of the sludge and appropriate disposal of the solid. So, this is has to be taken care.

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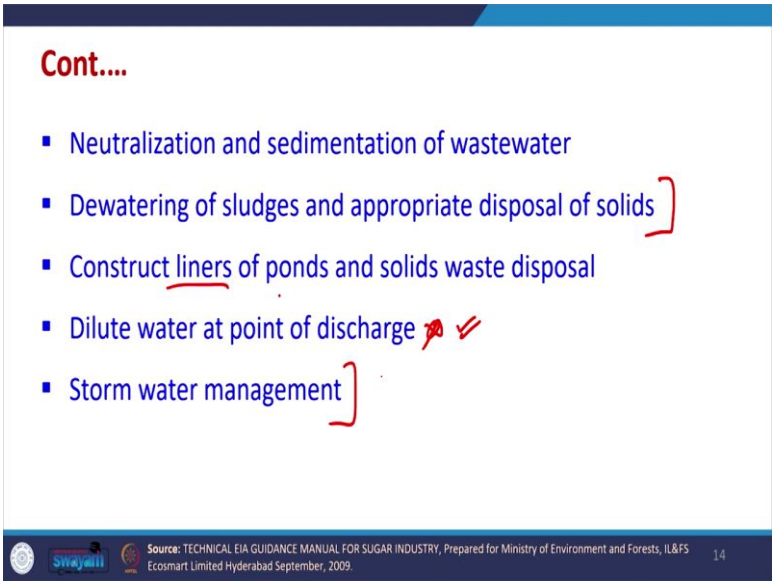

Construct liners of ponds and solid waste disposal units all in these units we have to construct liners also, dilute water at point of discharge if it is there, this is dilute with the already some other water which may be there which has to be treated. So, this then storm water management, this is not what is preferred. So, this is always the water has to be recycled, if it is beyond a certain value and it has to be treated further.

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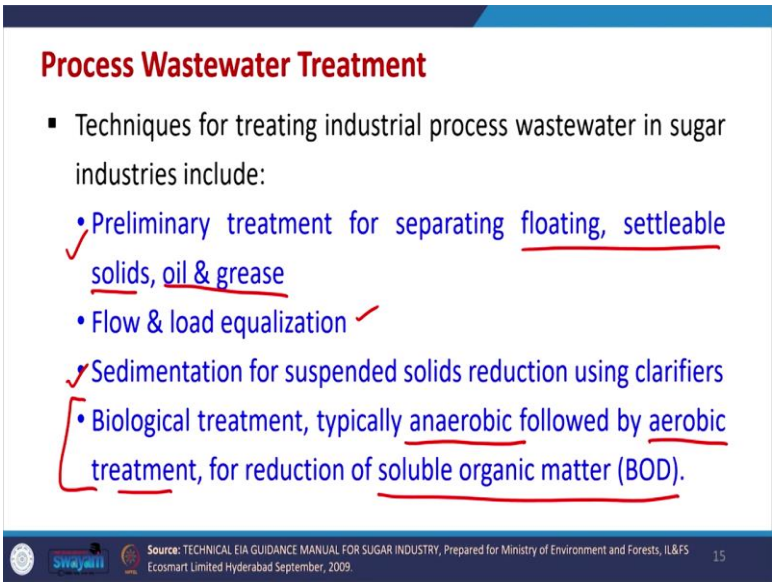

Now, process water management. So, we have two sections in this, one is process water management and another section is with respect to the storm water etc. So, techniques for treating industrial process wastewater in the sugar industry include, preliminary treatment for separating floating, settleable solids and oil and grease. So, we have preliminary a

pretreatment. After that there may be flow and load equalization basin for different because the water is produced in the different section, so, we have to equalize the overall load, so that is there.

Then sedimentation for suspended solids reduction. So, this settling and sedimentation basin will be there. After the biological treatment will be there, because sugar industry has more amount of biological organic load. So, that may be well taken care of by biological treatment methods including anaerobic followed by aerobic treatment for reduction of soluble organic matter that is BOD. So, biological treatment is practiced more in the sugar industry.

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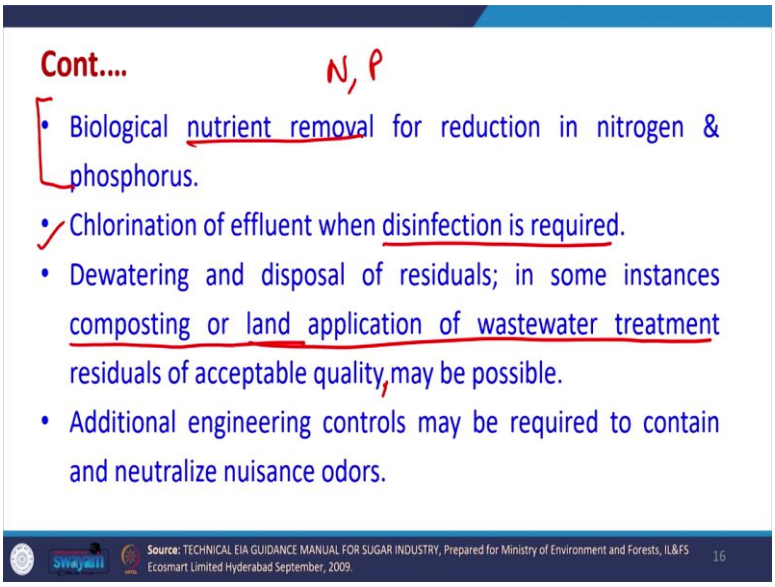

Then also because lot of nutrients are present in the sugar industry water, so, nitrogen phosphorus, etc., may be present. So, we have to see the biological nutrient removal for reduction in nitrogen and phosphorus is done, and in India the sugar industry wastewater is allowed to be used in the field also for irrigation after treatment up to a certain value. So, there also we can be and this is because the sugar industry wastewater contains large amount of nutrients.

So, as such it should not be discharged into the aquatic body otherwise eutrophication and other problems will happen. Similarly, chlorination of effluent when disinfection is required or we can follow any other disinfection method also, we have to perform the dewatering and disposal of residuals and in some instances like composting or for land application of wastewater treatments are already told, land application of wastewater after its treatment is allowed in India. So, after getting water up to acceptable quality, so, this is possible within

India and this is allowed. Additional engineering controls may be required to contain and neutralize the odor, sometimes which is coming from the wastewater, so this is there.

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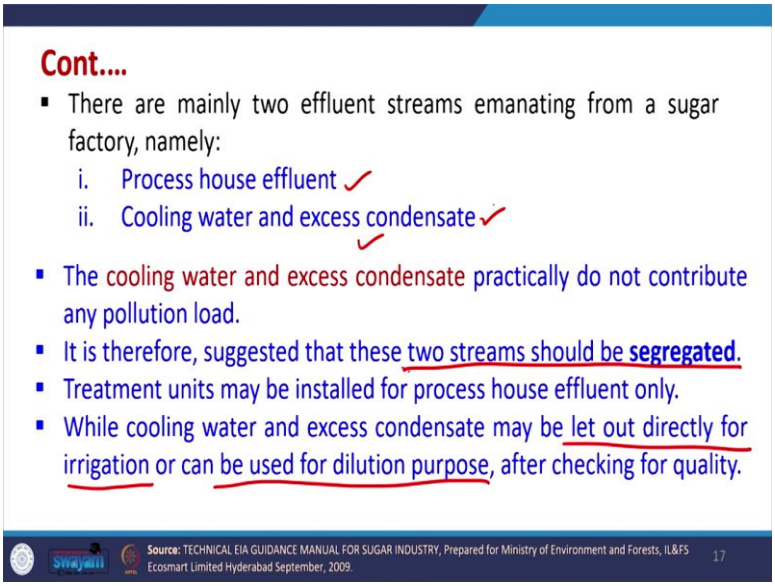

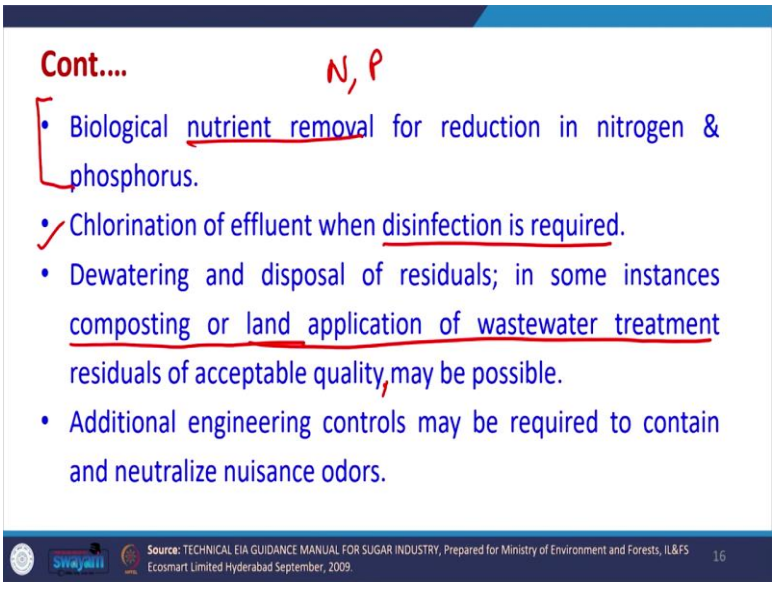

There are mainly two effluent streams emanating from the sugar industry. So, we have process house effluent and cooling water and excess condensate. So, the process water treatment already we have discussed the cooling water and excess condensate which is there that they do not have any pollution load.

So, it is always suggested that these two streams should be segregated and they should not be mixed and treatment units may be installed for process heights effluent differently as compared to for cooling water and excess condensate, and for cooling water and excess

condensate they may be laid out directly for irrigation and can be used for dilution purpose sometimes, so, this is how this particular stream can be used.

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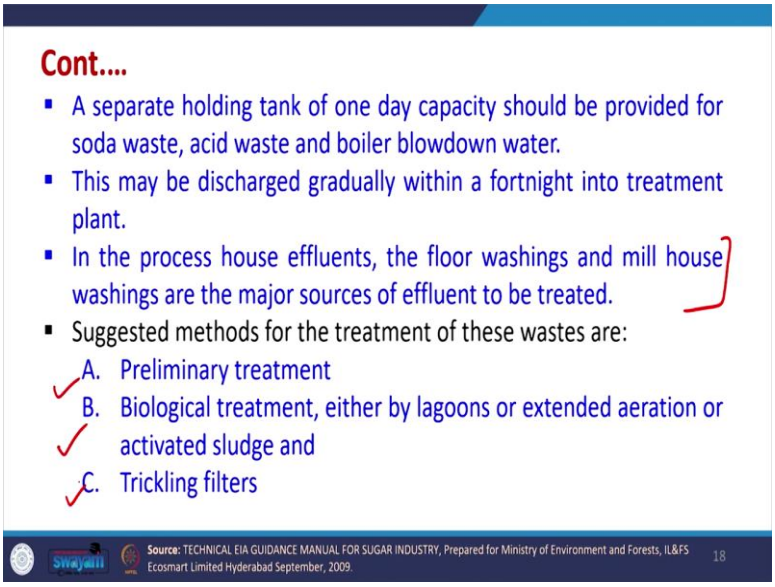

A separate holding tank of one day capacities will be provided for a soda waste, acid waste and boiler blowdown water, etc. And this may be discharged gradually within a fortnight into treatment plant because they have different loads so this is the idea. In the process house effluent, the floor washings and mill house washings are the major sources of effluent to be treated. So, suggestion methods are preliminary treatment, biological treatment and tickling filter, we have already discussed a little bit.

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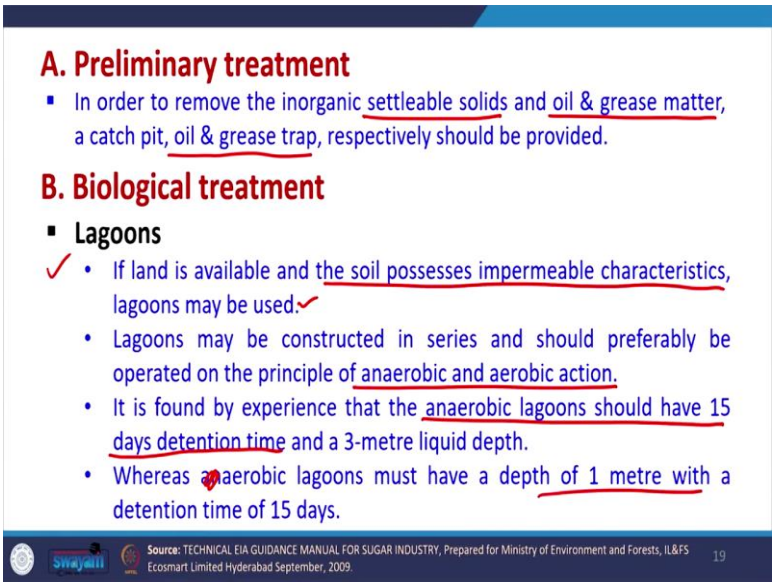

So, this is, the preliminary treatment will include oil and grease removals, settleable solid removal and these will be using a catch pit or is oil and gas trap, etc. Then biological treatment has to be done of these wastewater because they contain more of the nutrients or easily degradable materials. So, Lagoons may be used for wastewater treatment, if land is available, the soil processes impermeable characteristics so lagoon may be used. So, we have to cross-check whether these conditions are being met or not.

So, lagoons may be constructed in series, should be preferably be operated on the principles of anaerobic and aerobic action. So, depending upon that and it is found by experience that anaerobic lagoon should have 15 days detention time and 3-meter liquid depth. So, this is the usual condition for sugar industry wastewater, whereas anaerobic lagoons, aerobic lagoons must have a depth of 1-meter with a detention time of 15 days, so, this is there.

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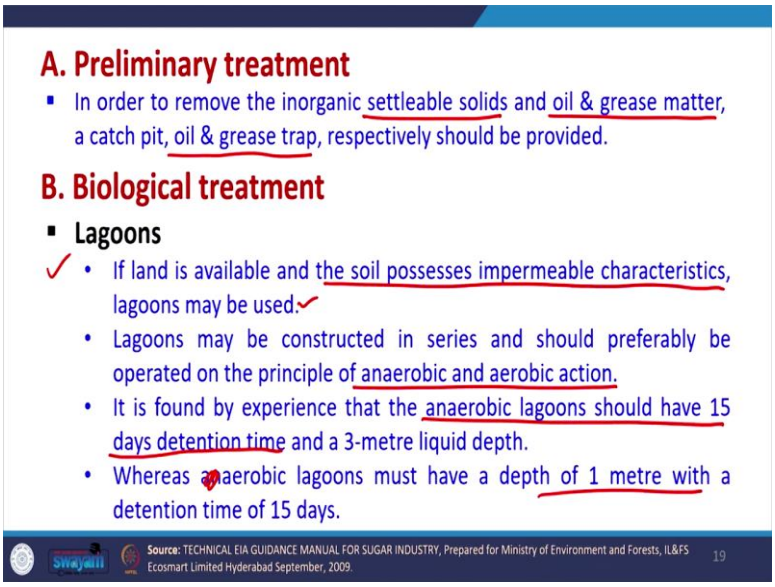

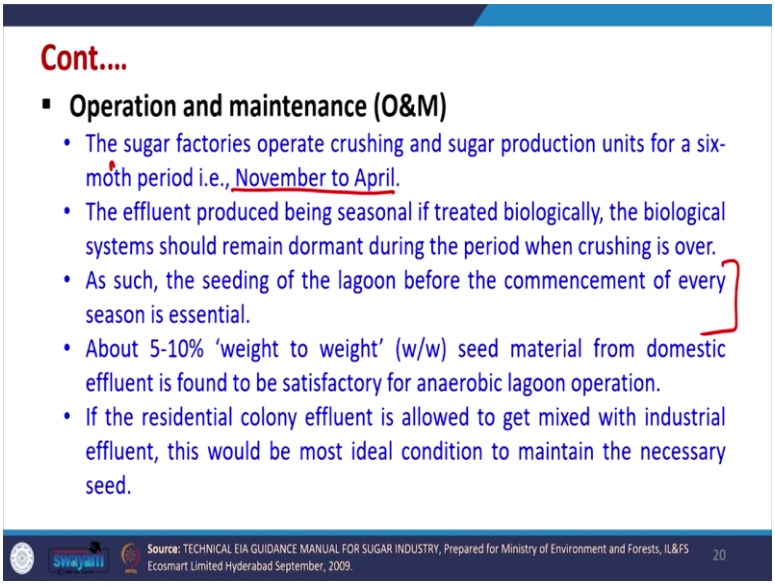

And these are the some of the strategies for operation and maintenance in the sugar industry for the lagoons which are there. The sugar industries operate the crushing and sugar production unit for 6 months period. So, there may be from November to April or beyond that also, nowadays 9 months many times they are operating. So, effluent produce is seasonal and if treated biologically the biological system should remain dormant during the period when the crushing is over.

So, this problem may happen in the sugar industry. As such the seeding of the lagoon before the commencement of every season is highly essential. So, this is one of the challenges which is there in the sugar industry, about five to 10 percent weight by weight seed material from domestic effluent is found to be satisfactory for anaerobic lagoon operation. And if the residential colony effluent is allowed to getting mixed with the industrial effluent this would be most ideal to maintain the necessary seed in the biological treatment.

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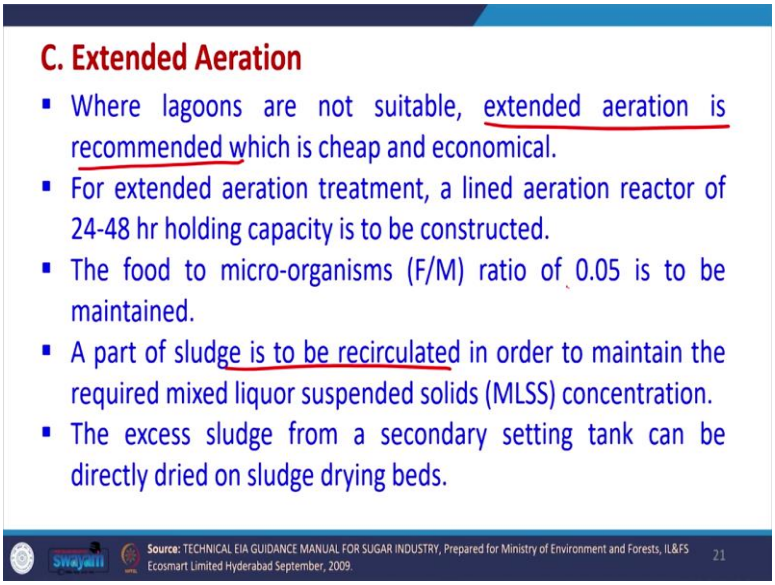

Then, we can have a extended aeration in the sugar industry, where when lagoons are not suitable extended aeration unit is recommended, which is cheap and economical, for extended aeration unit a lined aerator, aeration reactor of 24 to 48 hour holding capacity has to be constructed. The food to micro-organisms ratio has to be maintained beyond a certain value, a part of sludge has to be recirculated in order to maintain the MLSS concentration, the excess sludge from secondary settling can be directly dried on dried sludge drying beds. So, this is common.

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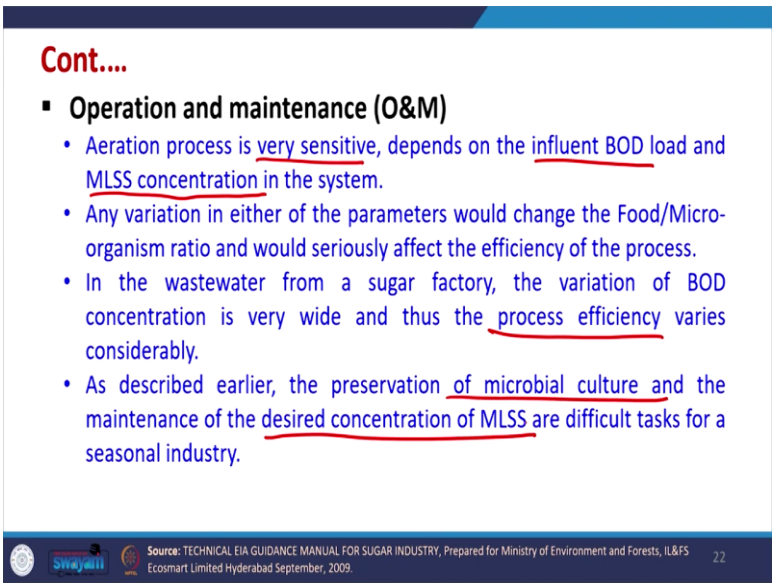

And here also because it is a biological process and the sugar industry operates on a seasonal basis again the temperature becomes very important. So, aeration process is very sensitive to,

it depends upon the influent BOD load and the MLSS concentration. So, any variation in either of these parameters will change the FM ratio and because of that the treatment efficiency it may change. So, in the wastewater from a sugar industry, the variation is BOD is very high. So, thus the process efficiency may vary of these aeration units, extended aeration units. So, the preservation of microbial culture and the maintenance of desired concentration of MLSS are the difficulties which are faced by sugar industry in particular.

Then we may have activated sludge and trickling filter again the biological operation and here they can treat very high amount of water, but activated sludge process they control the controls involved in activated sludge process are many and as such in this process, we have to be highly careful with respect to using this process. The factors which are mentioned in extended aeration units also apply for activated sludge process.

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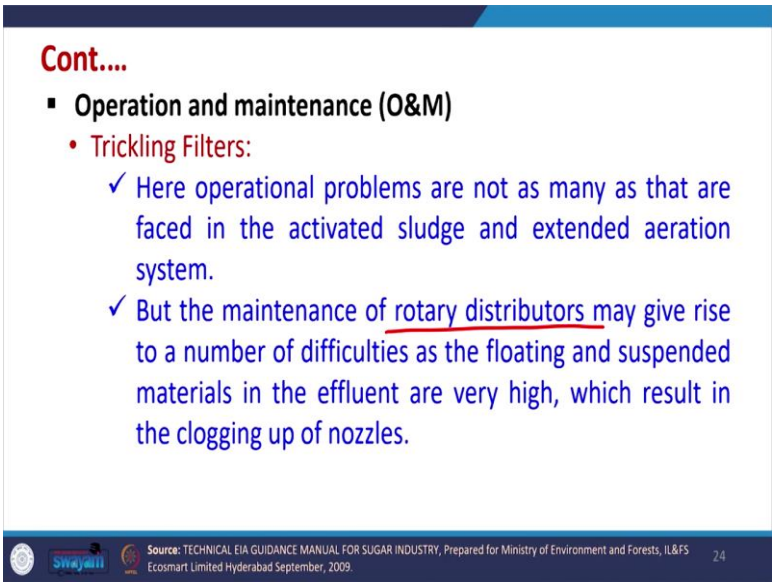

Similarly, for trickling filter also, all the operational problems are similar, but are not as many as that are there in the activated sludge process or that aeration unit. The maintenance of rotary distributors which are there on the top of trickling filter that is one of the problematic areas. So, we have to take care of that.

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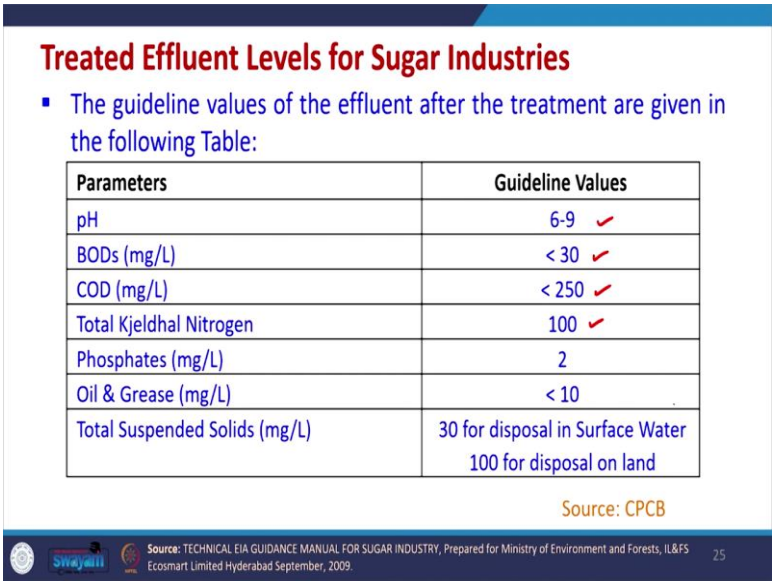

Now, treated effluent levels for sugar industries are given here, the guidelines of the effluent after the treatment are that the pH should be between 6 to 9 the BOD should be less than 30 the COD should be less than 250, the kjeldhal nitrogen because a lot of nitrogen is coming should be less than 100, then phosphate oil and grease and total suspended materials, for all these the there are some minimal standard values which have been there.

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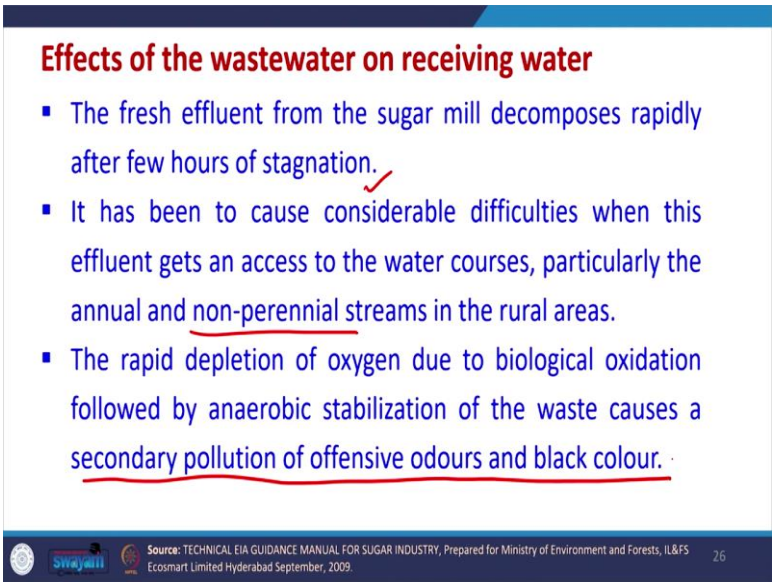

Now, for sugar industry, it is allowed the water after treatment is allowed to be used in the adjoining irrigation, adjoining field for irrigation. The fresh effluent from the sugar mill decomposes rapidly after few hours of stagnation, and it has been to cause considerable difficulties when this effluent gets an access to the water courses, particularly annual or non-

perennial streams in the rural areas. So, we have to see that the proper treatment is done. The rapid depletion of oxygen due to biological oxygen, followed by anaerobic stabilization of the waste causes a secondary pollution of offensive odor and black color so, this is the challenge which is there with respect to sugar industry.

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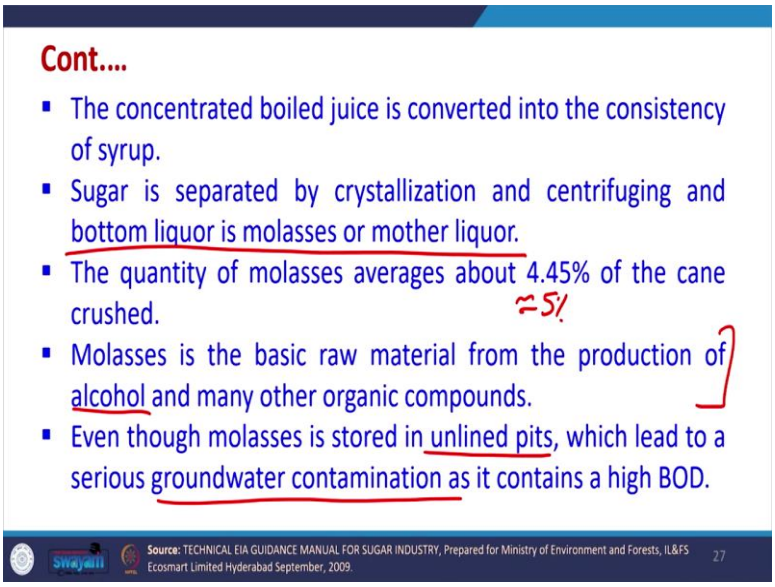

The concentrated boiled juice is converted into consistency of syrup and sugar is separated by crystallization and centrifugation. And bottom liquor is called molasses or mother liquor, the quantity of molasses may vary about 4.45 percent we can say about 5 percent of the cane crust. So, molasses is the basic raw material, which is used in the production of alcohol. So, it is used there. Even though molasses is stored in unlined pits, which may lead to serious groundwater contamination, if it is kept in unlined pits, but now, generally we have all the line storage units. So, that problem has been taken care of.

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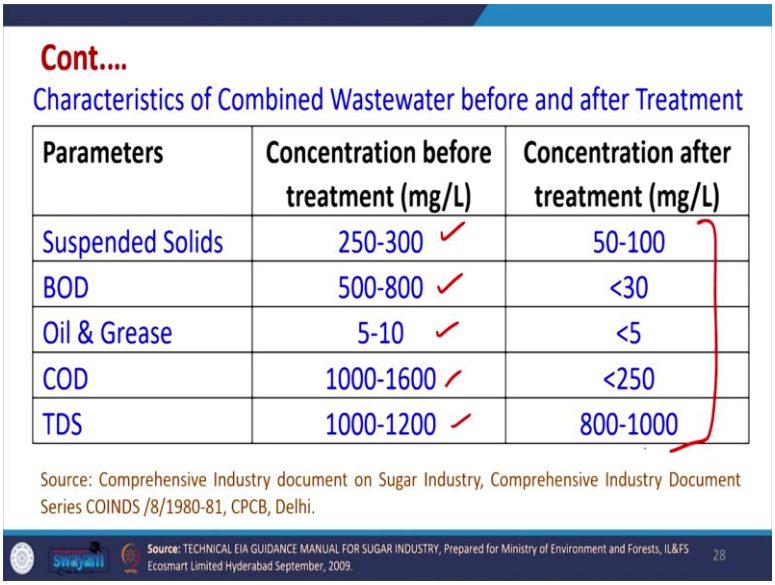

Characteristics of combined wastewater before and after treatment in the sugar industry, so, this is there. This is before so, it is generally it has to be reduced to up to these values which are shown here. So, this is how the treatment of water in the sugar industry done.

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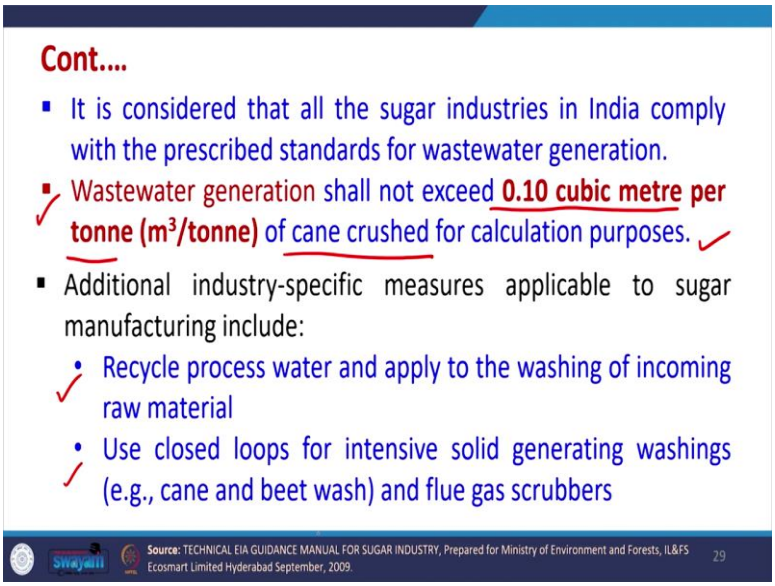

It is considered that all the sugar industries in India comply with the prescribed standards for wastewater generation because many times the treatment efficiencies are not being met. So, it is possible that some of the industries may take out water from the ground and then they may dilute the wastewater. So, that is why there is a curve has been kept that the wastewater generated shall not exceed 0.10 cubic meter per tonne of cane crust.

So, whatever is there cane crushing capacity or how much amount of cane they are crushing, depending upon that, there is a limit of how much water wastewater they can generate. So, this helps in curbing the tendency of the industries to take out water from ground and diluting the wastewater. So, that is why this particular type of norm has been kept. Additional industry specific measures applicable to the sugar manufacturing include recycled process water and apply for the washing of incoming raw material, use closed loop for intensive solid generation washings and flue gas scrubbers.

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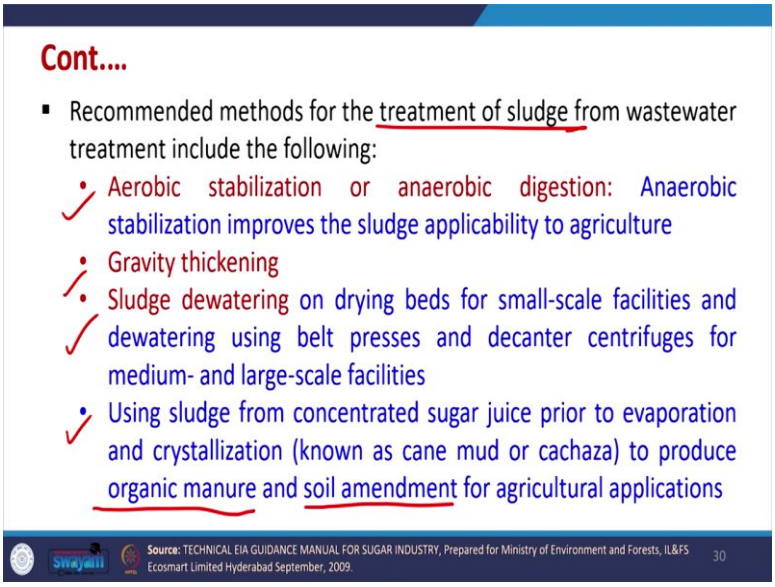

Recommended method for treatment of sludge from wastewater treatment include aerobic stabilization, gravity thickening, sludge dewatering and using sludge from concentrated sugar juice prior to evaporation and crystallization to produce organic manure and soil amendment for agriculture applications. So, this is how the, we have to take care of the sludge which is generated in the wastewater treatment plants, so this is there.

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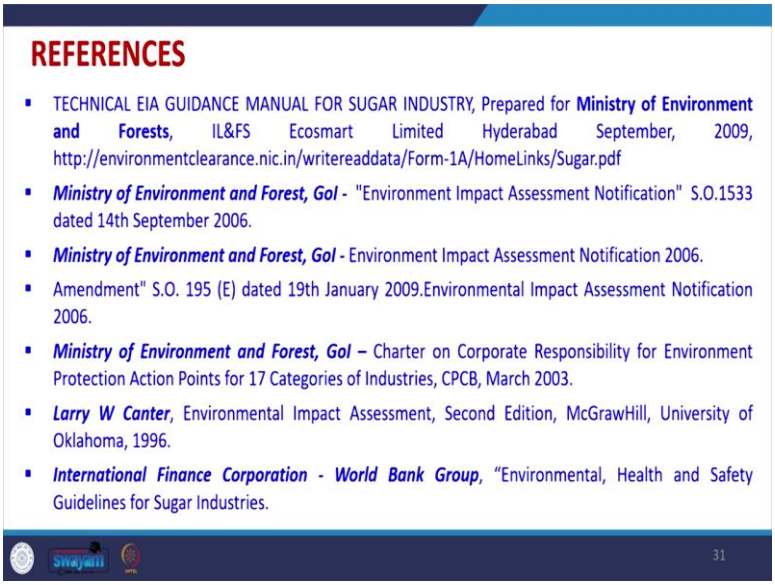

These are the references which have been followed for making these presentation and today's lecture. So, you can always refer to these manuals, many of these are technical guidelines issued by government of India, so you can always refer to them for better understanding. Thank you very much.