Lecture 35: Treatment of wastewater produced from Distillery and Dairy Industries

Welcome you all. Today I am going to deliver lecture 5 of module 7, which is on the treatment of wastewater produced from distillery and dairy industries. So previously we have seen number of processes involved in distilleries, wineries and today we will be dealing about with the dairy industries, a basic introduction of the dairy industry, the various types of products, they are manufacturing and then what are the different production activities involved into dairy industries. Then how this dairy product they are produced, they are processed and because of this processing lot of water is used and which gets converted into the dairy flint, the wastewater. So we will be looking into the characteristics of the dairy flint which will be generated and then qualitative and quantitative analysis of the dairy wastewater, the method of the treatment of the wastewater generated from dairy industry along with the flow diagram and the various treatment techniques that can be used and then we will be looking about the final quality of the treated flint that is generated from the treatment process, what are input characteristics, output characteristics, so that we are going to deal one by one.

So let us first get a basic introduction about the dairy industries. So, we all know that dairy industries they are having rapid growth in our country because of increasing rate of population in our country. So, there is a lot of demand for various types of dairy products. So, if we see that the India is the largest milk producer country and it ranks first position in the world which contributes around 24.64% of the total global milk production in the world. This is as per the data published in the year 2021-22. So, milk production basically in India that also registered a rapid growth that is around 58% increase during the last 9 years and with the total production capacity of around 230.58 billion ton in a year. So, among the different states these are the states which are contributing to around more than 50% of the total milk production. So, they constitute to 53.11% of the total milk production in our country. So, first rank is Rajasthan where this of the total 15.05% contribution from the state of Rajasthan, Uttar Pradesh also produces 40.93% of the total milk produced in the country and the third place that is in MP followed by Gujarat and Andhra Pradesh. So, these are the quantitative data that basically entails like the production pattern, the contribution of different states in the total milk production and in terms of exports also India is exporting lot of dairy products to the tune of around 67,572.99 million ton to the world for a total worth of 284.65 million dollar and this as per the data of 2022-23. So, this is like the basic introduction about the dairy products, the industries, its growth and the contribution of different states in the total production of dairy products.

So, if we see the raw material what in this industry the raw material that is used water and the milk. So, milk let us see its properties, its characteristics like how much percentage of different

ingredients they are found in the milk. So, if we see the major fraction of the milk constitute as a water so it varies from 85 to 88.7% and of rest the 3.9% that contains basically the milk fat which may vary to a range of 2.4 to 5.5% and rest 8.8% that is basically the solids which constitute non-fat materials which may range from 7.9 to 10%. So, that includes basically the protein, lactose, minerals, acid, enzymes then various types of gases present like oxygen, nitrogen, various vitamins they are present. So, their contribution like it entails like what are the ingredients that is found in the milk.

And this is like the flow chart of the total production process that are adopted in a dairy industry for producing various dairy products. So, here if we see this is first the inputs what are the raw materials that they are used. So here in the form of raw material this raw milk is used and some minor ingredients that are needed for adding taste and order to the dairy products then the second major raw material that we use that is the water then lot of energy in the form of electricity is used for generation of steam and then number of detergent and sanitizers they are used for cleaning and maintenance operations then refrigerators, various types of refrigerants that are used for cooling operations along with various types of packaging materials which are required for final packing of the various types of dairy products. So, first if we see and this basically portion tells the production process and this is like the outputs like what are the final products they are generated so various types of dairy products and along with this dairy products lot of water is used so lot of wastewater that will be generated. So, from cleaning, washing and milk there are lot of spills of milks and cheese so there is these materials they are mixed with the water and they generate lot of wastewater. So, this is the effluent which is mostly generated from dairy industry which require its proper treatment and then it may also generate lot of air pollutions from combustion of gases, milk powder dust and refrigerant gases orders it also generates lot of solid waste, damaged products and the products which are out of order so they are generated as a solid waste from these plants. And if we see the total production process so this entails like first of all the milk is received and after seaming it, it is stored in a tanker and then separation and standardization of milk will be done in the next process where from this butter will be produced and then after this the part of milk that will go for production of milk powder and after that if we see the rest of the portion that goes to the pasteurization. So, total milk is get pasteurized at a higher temperature so that the milk is disinfected against the microbial populations, virus, bacteria and then after pasteurization the milk is sent for producing the whole and skimmed milk products and then after producing these products they are stored in the cold storage where from they are taken for packaging and distribution and then these are basically the cheese production there is a parallel process going, so it produces cheeses so all these products which are generated into the production process like butter, milk powder, cheese and then whole and skimmed milk so this all material that goes and to the cold storage wherein it is stored and finally goes for packing and distribution.

So, this is slides basically explains the various processes they are involved, the various unit operations, how this different dairy products they are produced and then let us see the how this dairy products they are processed. So these are the major four process that takes place into the dairy like first clarification and cream separation. So, the first process if we see this clarification and skimming is basically done that is in a rotating container so when this is rotated at a high speed so whatever the butter and cream that is contained into the milk that gets separated from

rest of the milk so they are taken out and because this process is carried out in rotating containers and during rotation because of the centrifugal forces the solid impurities they get separated from the bottom and this cream and the butter materials they are taken up at that from the top of the container. So, this is processed for separation of the cream and butter from the rest of the milk and to remove whatever the solid impurities they are present along with the milk. So this process is the first process that has to be carried out and then after this basically this pasteurization is done this process basically that is Louis Pasteur has discovered this process for pasteurization of the milk so whatever the bacteria, whatever the microbial impurities present into the milk they get disinfected at a high temperature but this operation is carried out for a short duration so this process basically maintains the HTST pasteurization process wherein milk is disinfected from rest of the biological impurities and then heat treatment is accomplished using in this process the heating is basically done by the use of plate heat exchanger or circulating heat coils. So these are the two methods that can be used because this process is carried out at high temperatures so this heating is required which can be done either of the way either through plate heat exchanger or we can have this circulating heating coils that can transfer the heat to the tank for pasteurization purpose. And then there is also called UHT treatment, UHT means that is ultra-high temperature treatment that is carried out for final sterilization of dairy products before the packaging is done. So, this packaging is also done in already sterilized containers. So, this process basically ensures the complete sterilization of microbial impurities presented to the products so for this a temperature range more than 135 °C is maintained so as to kill and disinfect all types of biological impurities present in the form of bacteria or virus. So, this is another process and then a process called homogenization of the milk and milk products that basically means that the mechanical treatment of the fat globules of the milk they are converted into the finer size and the milk gets homogenized. So this is carried out at a high pressure which results in a decrease in the average diameter and the increase in the number and the surface area of the fat granules so this is a process to make uniform concentration homogenize the products all the milk products of similar diameter similar concentration, so this is the process what called homogenization and milk production.

 And then let us see the wastewater because this process number of process we use so that may generate number of n types of wastewater from different operations. So, if we see that is the first and the major stream which gets generated from dairy industry that is processing water which basically includes the water which is used in the cooling and heating process. So this effluents are normally free from the pollutants so it can be recycled with the minimum treatment for recycle and reuse within the plant so sometimes it can be discharged if there is a no storage required so it can also be discharged without any major treatment. Then there is another type of wastewater which is called the cleaning wastewater this basically emanates from the cleaning of the equipment that has been in contact with the milk and milk products is plays of milks and the milk products way pressing and the brines. So, these are the process wherein a lot of cleaning and of the equipment machinery the vessels containers has to be carried out wherein we use a lot of acids and disinfect sterilizers so these are generated wastewater streams and then there is also like residential area offices. So that also generate another type of wastewater called sanitary wastewater which is directed for its treatment in a sewage treatment plant.

Then this if we see the overall analysis qualitative and quantitative analysis of the dairy wastewater. So, if we see how much water is used and how much wastewater is generated. So we can see the amount of wastewater that is approximately 2.5 times higher than that of the processed milk in terms of volume like if one liter of the milk is generated so this will generate 2.5 liters of wastewater from the dairy industry but nowadays with advanced technology for production and carrying out different process of cleaning and adopting best management practices into the plants so this wastewater volume that has been reduced to 1 meter cube per meter cube of the wastewater or we can say pattern of the milk products so this is now using the good management practices, cleaning in place the amount of wastewater that can be reduced in the ratio of 1:1 from 2.5:1 which was earlier there and this 1:1 this only can be achieved when we have a good management practices and cleaning in place operations which basically are the major factors involved in generation of the quantity and characteristic of wastewater. So here we have also seen that introduction of GMP can reduce and what's wastewater mean volume which is generated can be reduced from 0.5-37 to 0.5-2 m^3 of the effluent per meter cube of processed milk so this is like a quantitative analysis of the dairy wastewater so on an average if the industry is old they are not adopting the CIP and GMP process, so they may generate 2.5 times of the wastewater compared to 1:1 that can be achieved by using this CIP and GMP practices within the plants.

So, this if we see the overall characteristics of the wastewater that is generated so from different types of milk products over here in the first column if we see there are mixed dairy there are milk reception there is a fluid milk, yogurt, butter, ice cream then cheese cottage. So, there are number of types of milk processing is carried out for producing different types of dairy products so from each operation the wastewater generated having a lot of variation in the pH but mostly we see except this butter and this milk reception all the wastewater that is mostly acidic in nature other than these units and it hardly contains alkalinity so that is very-very less. So, this is basically the characteristics of wastewater in terms of BOD and COD if we see, all the values if we see that is given in gram per liter so here also if we see that BOD and COD ratio that is around 0.5-0.6. So, this is really biodegradable wastewater generated from different sections similarly we can see this fat oil and grease concentration that is basically high in this type of wastewater. So, if we see in terms of solids, total solids and the total suspended solids so we will see it has also a lot of variation in different types of products but all over and all if we see the highest solid concentration that is generated from cheese operations and it contains around 10-20% is suspended fraction. So this is like a lot of variation in different chemical parameters then there is a lot of nitrogen and phosphorus so you can see these are the concentration in different types of milk products. So, it contains a lot of nitrogen and phosphorus as well. So this is basically the overall characteristics of the wastewater which are produced from this industry so if these are the wastewater we see it basically generates a lot of acidic effluents and having a lot of BOD and COD suspended solids total solids and also contains ample amount of nitrogen and phosphorus so this wastewater needs to be treated biologically as a major treatment unit operation.

So, let us talk about different methods different techniques which are used for the treatment of the wastewater so here if we see there are different methods for the treatment of this wastewater so that there are mechanical methods, there are chemical methods then there are biological methods also so in mechanical methods if we see there are screening is done basically so screens

are used to remove out the larger size of floating impurities present into the milk so the filtration process that is carried out for removal of the very fine suspended impurities present into the wastewater and then this is basically the sedimentation tanks they are also used for removal of inorganic impurities of settleable nature which uses basically the gravity separation process so then flotation is also is used as a mechanical methods for removal of fat oil and grease which are there in the form of floating impurities into the wastewater so they are aided by gas bubbles to which the particles of impurities become attached and they get floated onto the surface and finally removed so this type of process they are also used as a mechanical methods for removal of various types of impurities then reverse osmosis operation would also remove dissolved contaminant but this is very costly and huge amount of wastewater is generated so it is not mainly suitable for a large scale so this and if we talk about the chemical methods so there is a precipitation process chemical precipitation process, coagulation population process that can be adopted for removal of very fine collides which are present in the wastewater colloidal solids and for this we have to select proper coagulants like iron sulphates, iron chlorides aluminum they are mostly preferred coagulants they are used in coagulation and flocculation process for removal of these very fine and colloidal impurities which are present in the wastewater.

And then if we see in biological methods also there are aerobic treatment system there are anaerobic treatment system so as a secondary treatment we use this biological method which are mostly suitable for this type of wastewater which contains a lot of suspended and dissolved organic compounds in the wastewater so here again this aerobic treatment system is suggested because it contains a lot of organic matter which are easily biodegradable by activated sludge process by aerobic bacteria so here mostly activated sludge process and this trickling fin tufts they are used wherein in low-cost treatment process aerated lagoon stabilization ponds oxidation ditch they are the major preferred treatment process in the industries this basically describes the wastewater treatment system.

So, let us see how this wastewater is treated in actual industry so there is a case study of Sanandaj dairy, wherein this process this is the flow diagram of the treatment process what they end up for the treatment of their wastewater so first of all if we see their wastewater that comes out it undergoes preliminary treatment. So, preliminary treatment basically that is screening is done then removal of fat oil and grease material that has to be done by skimming process skimming tank so this includes all this treatment system which are required for removal of fat oil and grease apart from the coarser and other unwanted floating impurities present into the wastewater so they are removed in the preliminary treatment and then the water after this preliminary treatment goes to the primary clarifier where all the inorganic set level suspended solids which are introduced into the water during cleaning and washing operations they contains a lot of inorganic impurities so here this grape tea separation process that is used in a primary clarifier so all this set level suspended solids they are collected here at the bottom and the overflow from this tank that goes for the next treatments so whatever this sludge that is generated it is generated as a primary sludge and then finally it is taken for its further treatment process and whatever the overflow that comes out from this primary clarifier that goes to the activator sludge process so this basically complete setup that shows the activator sludge process so here if we see this setup basically that constitute to the activator sludge process so here what we do whatever the settle wastewater that comes to the aeration tank aeration chamber where it is aerated through

various mechanisms so diffused air is provided into the wastewater so it gets a lot of oxygen which is required by the aerobic bacteria which are inoculated into this tank. So, this aerobic biodegradation of the carbohydrate starch and alcohols which are present into the wastewater so that is carried out in this activator sludge process so air is basically required for providing the oxygen which is required for its aerobic decomposition so here the wastewater is kept for four to six hours ten hours depending upon HRT and wastewater after getting aerated after its aerobic decomposition that goes to the next unit operation that we call that is the secondary clarifier so this waste effluent which generates from the aeration tank because this is a suspended growth process so here it will generate a lot of suspended biomass so this biomass gets out along with the treated effluent and is basically clarified in the secondary clarifier separated from rest of the treated wastewater so this secondary clarifier removes all this biomass here at the bottom which is again taken out as a sludge so this sludge which is generated from primary clarifier and secondary clarifier both they are taken to the further sludge treatment process which constitute of sludge thickeners, sludge digestion, sludge dying beds so number of treatment process they are carried out for this sludge treatment and its disposal and then after this secondary clarifier the treated effluent if we see which goes for the disinfection purpose so next unit that is to disinfect all type of bacterial impurities which are present in the treated wastewater. So, after disinfection this treated water is taken out which can be discharged or it can be recycled depending upon the requirement.

So, this is basically the plant data which has been collected from the dairy plant which having this activated sludge process in the treatment system so this data is basically for different months for different process parameters like BOD, COD, TSS. So, we can see there is a lot of removal of BOD. So, this BOD in the inflow if we see that is 237, so outflow it is having 11.90. So, this more than 90% that is 95% of the BOD which is present that is getting removed similar is the case for COD so COD removal that is around 70 to 80% here in this type of system and similarly suspended solids if we see that is basically this is more than 95% suspended solids they are removed from the system so this is like the performance data for different months so we can analyze that from this process performance data that this activated sludge process is very efficient in removal of BOD, COD and suspended solids which are present in the wastewater. So overall after this treatment the wastewater is basically nowadays because of the stringent standards this wastewater is further treated to high quality water and then it is recycled within the plant and this zero-discharge policy that is basically adopted in the industry.

So, this is the references we can use for more description more details on the topic.

Thank you.