Course Name: Industrial Wastewater Treatment

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Lecture 3: Treatment of wastewater produced from Textile and Dye and Fertilizers

So, welcome back. We are in module 9, lecture 3 and we are discussing the treatment of the wastewater produced from the textile and dye industries as well as the fertilizer industries. So, in this lecture, we will cover the topics like the synthetic textile mill wastewater characteristics and the treatment. So, we have already discussed the manufacturing of the synthetic textile fibers in the previous lectures. So, here we will be discussing about the treatment of the wastewater, its characteristics etcetera in this lecture and we will also talk about a viscose rayon plant operations that is how the viscose rayon fibers, so they are produced and similarly, we will talk about that what is the composition of the wastewater in a viscose rayon plant and we will talk about that what is the effect of the viscose rayon wastewater on the receiving water and sewers. We will talk about the treatment of the viscose rayon wastewater and then we will also talk about the zinc recovery which happens during the treatment of the viscose rayon wastewater plant.

So, we have already discussed about the synthetic textile fiber manufacture in the previous lecture. So, where we discussed that how nylon 6 can be produced from the carpalectum. So, here also the waste which is generated from the manufacture of the synthetic fibers only. So, this may lead to a wastewater which may have the colloidal particles into it.

So, these colloidal particles may lead to lot of turbidity in the wastewater, and it may also lead to a typical color which color is generally gray yellowish in color and this color is imparted because of the manufacturing process because the chemicals that we are using during the manufacturing process. So, it imparts a color to the wastewater and this wastewater is having a low alkalinity. So, the pH is nearly 7.5 in this case, and it may contain very high amount of total solids which are mainly organic in nature because we are using the manufacturing process because we are using the raw material which is organic in nature and this concentration of these solids may be as high as 2500 milligrams per liter and it may contain small amount of suspended solids also. So, the wastewater may also contain a high amount of nitrogen which is mainly of the organic origin and the wastewater may also be characterized by a high COD value.

So, the COD values may be as high as 500 milligrams per liter and the BOD values are low. So, BOD values are nearly 50 milligrams per liter. So, this means that the biodegradability of the water is quite low because here the BOD by COD ratio is coming

out to be nearly 0.1. So, the major pollutants of the wastewater which originates from the synthetic fiber manufacture.

So, it may result from the scouring and the dying chemicals into the wastewater and the characteristics will also depend upon the type of fibers that is being processed and we generally find that the wastewater that is being generated from the synthesis of the synthetic fibers is generally having a lower discharge in comparison to the wastewater that is being generated from the cotton or woolen textile mills. So, we may go for the treatment of the synthetic textile mills by using the biological method, but the treatment by using the biological method may not be easy in the sense that the wastewater is having high COD by BOD ratio. So, that is why it will be very difficult for us to treat it biologically. However, we can dilute it by using the domestic wastewater and then we can treat it along with the domestic wastewater and we generally keep a ratio of nearly one part of the synthetic fiber wastewater and the three parts of the domestic wastewater. So, they are mixed and then it is taken for the treatment by using the biological methods as we do in case of the domestic wastewater treatment.

However, if we go for aeration which is preceded by the dilution process and the utilization process and later on if we add phosphoric acid to it, so it is capable of removal of nearly 85 percent of COD reduction. And similarly, we also see that the waste that is being generated from the preparation of the fabric, so they are more or less similar to those obtained from the scouring and dyeing operation that we see in other textile mills also. So, that is why the wastewater that is being generated is of similar nature of that of the wastewater generated in other textile mills and the treatment methods will also be similar as that of the treatment methods adopted in the cotton and woolen textile mills which we have already discussed in our previous lectures. So, now we come to the manufacture of a fiber which is semi-synthetic in nature. So, this is known as the rayon fiber or viscose rayon fiber and this viscose rayon fiber is generally produced by using the regenerated cellulose. So, these rayons may dye easily with most of the dye stuffs which are used in the cotton textiles, but it is not resistant to the chemicals as we see in case of the cotton textiles. And it is also highly adsorbent, and it can take up the chemical reagents, oils etc. easily. So, it can react with the chemicals very easily and the resistance to the acids and the oxidizing bleaches, so it decreases with the higher temperature. So, we perform the process of the dyeing and bleaching at higher temperatures, so it is possible that the efficiency of the process may be enhanced.

So, the raw material used for the manufacture of the viscose rayon is the wood pulp and this wood pulp is taken to the plant and this wood pulp is first of all shredded after the shedding process, we take it to 18 percent of the caustic soda solution and so this solilose which is there, so this solilose may be converted into the alkali cellulose, so some part may be soluble and some part may be undissolved and this undissolved cellulose is known as the alkali cellulose. And later on, this alkali cellulose may be taken and the water which is

there or the wastewater rather or the spent liquor rather is basically separated out from the alkali cellulose by using the hydraulic press. And this spent liquor, which is generated from this process, so this may be taken to the dialyzer, so that we can regenerate the sodium hydroxide that we have used during the process. So, after this process the alkali cellulose which we obtain, so it is shredded and then it is later on aged for a certain period of time, and it is done at generally under the controlled temperature. After the aging process is over, then this alkali cellulose is treated by using carbon disulphide again at controlled temperature, so it yields an orange colored mass and this orange colored mass basically is of the cellulose xanthate that has been formed by the reaction of the cellulose with the carbon disulfide.

So, now this cellulose xanthate that is obtained, so this is dissolved in 6 to 7 percent of the caustic soda solution and this dissolution leads to the formation of a fluid which is a highly viscous fluid, so this is known as the viscose and this viscose is used for the manufacture of viscose rayon fibers. So, this viscose may be filtered through a filter press and after which it may be ripened and after which it may be deaerated under the controlled conditions. And then later on this viscose solution, so it may be extruded under pressure and it is passed through a number of spin rates and into the continuously flowing acidic spinning bath and this acidic spinning bath may contain around 8 to 10 percent of sulfuric acid, it may contain 13, 20 percent of sodium sulfate and it may contain 1 to 2 percent of the zinc sulfate, so that we can draw out the fibers out of this viscose solution. So, the viscose is coagulated and regenerated by this process and it results in the formation of the filaments and these filaments basically are generated from the spinning bath, they are collected on a spinning bucket and they are bound on the spinning bucket which is spinning at a very high speed and this these filaments then together can make rayon yarn and this rayon yarn may be used for the making of the viscose rayon fabric. The washings from the rayon yarn that is that is generated, so this may be done so that the zinc, which is used in the process, so that can be recovered from these washings.

And similarly, the intermittent wash waters they are sent for the chemical recovery along with the spent spin bath solution that we have used during the process. So, now the rayon yarn is further treated with alkaline sodium sulfide solution, so that we can remove the sulfur from it, so that we can desulfurize it, and which is deposited on the rayon fibers during the spinning operations. And then the yarn is washed, it is bleached then again washed with dilute acid and the detergent and then again it is washed with the rainwater successively. So, then this yarn, which is generated, so it is finally, dried to up to a proper moisture content and then it is sent to the weaving mill for the preparation of the viscose rayon fabric. Now, this spent spinning bath, so it may be sent to the evaporator, so that we can recover sodium sulfate out of it. And then the sodium sulfate basically may be used for the spinning bath solution. So, here we may add required amount of sulfuric acid to it, or we may also add zinc sulfate to it, so that the requisite spinning bath solution may be made

by the recycling of the sodium sulfate. Then the further processing of the yarn for the finished cloths, it requires much less pre-treatment because it dies very easily because it is highly adsorbent in nature, it is also not resistant to the chemicals. So, that is why it is also possible that the pre-treatment that is done for the other fibers as you have seen in case of the cotton fibers as well as the in case of the woolen fibers, so that may not be required in the viscose rayon fibers. So, now this is a flow diagram which shows us that how the viscose rayon manufacturing process proceeds.

So, we can see here that the pulp of the wood is taken to a mixer first of all and where we add a high amount of NaOH to it and after this alkaline cellulose is formed, so this is taken to the press where basically the spent the liquid basically is sent to the dialyzers, so for the recovery of the NaOH, the NaOH which is recovered, so this is taken to the tank where basically we are recycling the NaOH from here, we may require to make up the NaOH by adding certain NaOH from outside also and then basically in this form the NaOH can be recovered by this process and after this the alkali cellulose is taken to a shredder and then it is taken to an aging tank where it is aged for some time and later on it is taken to the Xanthate where Xanthate we try to react the alkali cellulose by the carbon disulfide and this carbon disulfide reaction leads to the formation of the cellulose Zen-theater and later on the cellulose Zen-theater may be added with sodium hydroxide and then it is taken to a ripening tank, then it is passed through a filter, then it may be deaerated and later on after the deaeration process it is taken to the spinneret where basically the spinning bath solution is there in which the fibers are drawn from here and which are basically bounded on the spin bucket which is rotating very fast in this case and later on the rayon yarn which is produced so it is washed and it is desulfurized so that the sulfur compounds which are there on the rayon yarn they can be removed and then it is again washed, it is bleached then the anti-chlorination may be done and later on it is again washed and softened, dried and later on the coning is done and later on this the fibers that are generated the yarn that is generated so that may be taken for the manufacture of the fabrics. So, here the spent spinning bath solution so it may be taken to a evaporator and after the operation the cooling is done so this cooling may lead to the generation of the acidic waste and from the evaporator the sodium sulfate may be recovered and this sodium sulfate may be added in the makeup tank and here we add zinc sulfate to it, sulfuric acid to it so that the spinning bath solution may be made and this spilling bath solution may be again taken to the spinning bath. So, when we talk about the wastewater generation in a viscous rayon manufacturing plant so we can have two types of wastes that are being generated so one is acidic waste and other is the alkaline waste. For example, if we talk of the acidic waste so it mainly comprises of the spin bucket washing and the first rayon yarn wash water that is generated so it may be acidic in nature. Similarly, the cooling and the condenser water, which is discharged from the spin bath evaporators, so this also joins the acidic waste flow.

So, acidic waste may also be generated from the spin bath makeup tanks where we are regenerating the spin bath solution by addition of the sodium sulfate to it. So, we can see here that during the process the two types of waste streams will be generated. For example, if we talk about the dialyzer so dialyzer may be producing a highly alkaline water so this basically may form the alkaline wastewater. From the Xanthate also we get the wastewater which is alkaline in nature. Similarly, from the ripening tank the wastewater that is generated it joins the alkaline stream.

Similarly, from the filters from the deaeration tanks so the wastewater that is generated it is alkaline in nature. After the desulfurizing process and when we are washing the rayon yarn so this may also lead to the formation of the alkaline wastewater which is which joins the alkaline wastewater stream. Similarly, here we see the wastewater that is being generated from the cooling of the evaporator from the cooling of the spinning bath evaporation. So, this may lead to the formation of the acidic waste. Similarly, the acidic waste may also be generated from the makeup tank from the spills which are taking place from the makeup tank and the wastewater may also be found to be acidic when we are having this spin bucket.

Whereas, from other ways for example when we are going for bleaching, anti-chlorination, washing, softening so they also basically may form they may also join the acidic wastewater stream. So, the alkali wastewater generates from the caustic soda dialyzers, it may be generated from the viscose ripening, it may be generated from the deaeration tanks, it may be generated from the zenithating operations, it may be generated from the desulphurization process also. And the strong alkaline waste is also obtained when we are going for the washing of the filter clothes. So, the large quantity of the wastewater may be originated during the fiber spinning and its subsequent washing process. So, these wastewaters may contain a high amount of zinc for example nearly 85 percent of the total zinc which is used in this process.

So, this may come into the acidic waste. And the volume and the concentration of the wastewater depends upon the washing which are given to the yarn in the bucket if the washing frequency is higher then it will lead to the higher generation of the wastewater from the spinning bucket. So, the zinc recovery from the segregated spinning bucket washings is highly preferable so that we can recover the zinc and reuse it for our processes. Otherwise, the acidic wastewater they mainly comprise of the sulfuric acid, sodium sulfate, zinc sulfate, waste fibers, hydrogen sulfite etc. and whereas the alkaline waste may contain sodium hydroxide, soluble hemicellulose of the raw pulp, residual viscose, it may contain sodium polysulfide and sodium thiosulfate.

So, we can see that the composition of the two main streams of the wastewater which are coming out from the viscose rayon plant. So, we can have the acidic waste where the pH of the acidic waste may be between 1 to 2 and it may have a higher acidity in comparison

to the alkaline waste. So, we see that nearly 4200 to 7700 milligrams per liter as calcium carbonate may be the acidity generated in the acidic waste. Similarly, the total solids may be very high so it is nearly 26800 to nearly 32300 milligrams per liter and similarly the dissolved solids concentration is also very high whereas the fraction of the suspended solids may be low in case of the acidic waste. Similarly, we find that the COD values are also between 390 to 790 milligrams per liter and the chlorides concentration may vary from 20 to 800 milligrams per liter here and the sulfate concentrations are very very high because we are using a number of sulfate salts here or acids basically are being used so the sulfates which are generated in the acidic waste is really very very high whereas zinc also finds its way in the acidic waste because of the zinc that is being generated from the spent spin bath solution.

So, alkaline waste may contain a pH of nearly 9.2 to 10.7 and it may not have acidity, but it may have alkalinity of nearly 310 to 790 milligrams per liter. It may also have very high total solids, but the solids are not as high as in comparison to the acidic waste whereas the dissolved solids may also be higher in this case and a smaller fraction will be of suspended solids. The COD values may vary from 154 to 1160 milligrams per liter which are very high, and the chloride levels may also vary from 140 to 242 milligrams per liter.

The sulfate concentrations may also be here because of the use of certain sulfate compounds in the alkaline waste and when we talk of the composite wastewater so then the composite wastewater may have an acidic pH which may range from 2.8 to 4.1 and the acidity is reduced in this case because of dilution with the alkaline waste. Similarly, the total solids may also be reduced in comparison to the acidic waste, and it may be 1630 to 2780 milligrams per liter and again the fraction of the dissolved solids is again high here whereas the fraction of the suspended solids is small. And COD values may vary from 35 to 210 milligrams per liter.

It may contain chlorides up to a maximum of 184 milligrams per liter. The sulfate concentrations are high because the sulfate concentrations were high in the acidic waste. So, in the composite waste also we are having a concentration of the sulfate as high as 669 milligrams per liter and the zinc basically comes into the composite waste because the zinc concentration was high in the acidic waste and when we combine it with the alkaline waste so the concentration may be reduced, or it will be diluted in case of the composite wastewater. So, the impacts of the wastewater which is being generated from the viscose rayon plant so if it is directly dumped into the environment so it may have lot of adverse impact on the environment for example the sodium thiosulfate which is being produced from the desulfurization process so this may be highly toxic to the aquatic life. Similarly, we find the zinc and the hydrogen sulfide that are being generated in the wastewater so they may be highly toxic to the fishes.

The sulfuric acid and carbon dioxide sulfide so they can also adversely impact the aquatic life if it is not adequately treated by the receiving water or if it is not treated. Similarly, the precipitation of different compounds so which are there in the wastewater it may happen because of the very slow chemical reaction that happens between the acidic and the alkaline waste. So, it is possible that this precipitation may happen for a long period of time and it these types of compounds basically may settle down at the bed of the river and it may go up to a long stretch of the river and slowly and slowly they will decompose, and they will start depleting the dissolved oxygen of the river. And the slow decomposition of the hemicellulose may also cause serious problem in the sense that it may lead to the depletion of the oxygen present in the river bodies. And similarly, we also see that the excessive sulfate which is present in the wastewater so it may lead to the erosion of the riverbanks as well as it can also lead to the corrosion of the hydraulic structures.

So when we talk of the treatment of the viscosity on wastewater so the segregation of different waste and recovery of the chemicals it is a very important process and which is a inbuilt process here for example when we talk of the recovery of soda so we have seen that the recovery of soda is already done from the spent solution during the manufacturing process only so it is a integrated part of the plant operations. Similarly, the spent spinning bath is also treated so that we can recover the sodium sulfate out of it so we pass it through the evaporator so that the sodium sulfate recovery is done and later on we can use this for the spinning bath solution. The recovery of zinc is also done that may not be economically profitable but it may be justified for example if the concentration of the zinc is high for example if the concentration of zinc is more than 3800 milligrams per liter so in that case the recovery of zinc may be economically profitable by using the different methods that already discussed for example the chemical precipitation method or by using the ion exchange method. So, there are two methods which are used for zinc recovery so we can have chemical precipitation we can have ion exchange method and further this rayon waste after the recovery process so it may be taken to the different processes like the physical process the chemical processes and the biological processes. So, in the physical process we can take it to the equalization tank first of all we can screen the wastewater and later on we can go for the sedimentation process.

So, here the polysulfide decomposition to the hydrogen sulfite so it can be removed by following aeration process so if we aerate the wastewater which contains a lot of polysulfide so this hydrogen sulfite is generated from there this hydrogen sulfite may be removed when we are going for the aeration of the wastewater so this hydrogen sulfite may be expelled from the wastewater. Similarly, the hemicellulose and sulfur it can settle very well in the alkaline conditions so these can be removed by the settling processes however the necessary adjustment may be required by using lime when we are treating the acidic wastewater. The residual carbon disulfite and the polysulfite which is coming out from the desulfurization process so it can be removed by segregating the waste and treating them by

using a trickling filter. So, these pollutants may be precipitated in the secondary settling tank however the BOD removal in the trickling filter may be low it may be nearly 70% only and the disposal of the sludge that is generated from this process so it may be a problem in the sense that the calcium sulfate sludge which is produced so which may be produced from the zinc recovery as well as during the neutralization process by using lime so it may pose a problem that is it dries it takes a long time for drying and it dries with very great difficulty so that may pose a problem so large land area may be required so that this type of sludge may be dried and further dispose it of property. So, we can see here that this diagram is showing the zinc recovery so the yarn watch water or the spin bucket watch water so this is taken first of all to a mixing tank where the lime is added and later on after the mixing with the lime we can take the waste water to a clarifier where the sludge that is generated it may be wasted it may be taken to the sludge drying beds and later on the this effluent will be taken and the sodium hydroxide will be added here which is again taken to another clarifier and the effluent basically may be taken for the further treatment and from this clarifier the water the sludge is generated so this sludge may be treated by using sulfuric acid and then basically the zinc sulfate may be recovered from here and which is taken to the spin bath makeup tank.

So, after the treatment process it is very necessary that we follow certain standards for the discharge of the effluent which are getting generated from the textile industries so here we can see that these are the standards which have been prescribed by the AMOF and CC in 2016 for the treated effluents which are coming out from the integrated textile units of cotton woolen carpets polyester printing dyeing bleaching process or the manufacturing of the garment units also so here we see that the pH that should be there should be maintained between 6.5 to 8.5 for the discharge of the effluents which are coming from the treatment of the textile industry wastewater suspended solid should not exceed 100 milligrams per liter similarly the color in the platinum cobalt unit it should not exceed 150 the biochemical oxygen demand for three days at 27 degrees centigrade so it should not be greater than 30 milligrams per liter the oil and grease should not exceed 10 milligrams per liter the chemical oxygen demand should not be more than 250 milligrams per liter and the total chromium that may be there in the wastewater after the treatment it should not exceed 2 milligrams per liter similarly the sulfites also should not exceed 2 milligrams per liter in the base water effluents the phenolic compounds may also be generated during the manufacturing process so these phenolic compounds should not exceed 1 milligram per liter in the treated effluents the total dissolved solids should not be more than 2100 milligrams per liter and the sodium absorption ratio should not exceed 26 similarly the ammoniacal nitrogen as nitrogen should not exceed 50 milligrams per liter so these standards may be applicable for the all modes of the disposal however in case of the discharge of the into a river or the stream so the central pollution control board or the state pollution control board may prescribe more stringent standards based on the condition of the receiving water body if the receiving water body is already polluted so these conditions

may be made stringent by the central pollution control board or the state pollution control board and similarly the standards for the TDS and the sodium absorption ratio so they may not be applicable in case of the marine disposal through the proper marine outfall so this completes our textile industries and we have already discussed that how we can manufacture a different type of fabrics whether it is made from cotton or it is made from the wool or it is made from the synthetic fibers or it is made from the semi-synthetic fibers and how the wastewater generation takes place what are the various wastewater contaminants that are generated from such processes and how we can treat such type of wastewater so we stop here and in the next class in the next lecture we will discuss about the about the fertilizer industries the wastewater generation and their treatment so these are the references that we have used for the preparation of this lecture.

Thank you