Course Name: Industrial Wastewater Treatment

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Lecture 1: Treatment of wastewater produced from Textile and Dye and Fertilizers

Welcome back. So, we are in module 9 and lecture 1 and in this lecture, we will talk about the treatment of the wastewater produced from textile and dye and fertilizer industries. So, the topics that we will be covering in this lecture will be on the textile industries and we will cover in this lecture the cotton textile mills about its manufacturing process, how the cotton textiles are produced and what are the wastewater characteristics and composition that is generated during this manufacturing process. What are the points where we get the wastewater generation? So, we will talk about all these things. So, the word textile has come from a Latin word that is textiles which means to weave. That is textiles can be woven by hand or by machines.

So, in the small textile industries we generally find that the hand process is adopted whereas in the large textile mills we find that the machines are used for production of a large-scale textiles. So, textile industry is also one of the largest waters consuming industries and the wastewater generated from this industry may contain number of pollutants. First and the foremost pollutant that is the dyes and then it may contain lot of organics which may be degradable in nature. There may be detergents, soaps and stabilizing agents, desizers, inorganic salts and heavy metals.

So, these are the pollutants that may be released into the environment if we are not treating the wastewater by different means. So, it can pose a lot of serious threat to the health as well as the socio-economic life of the people. That is why it is very important that the wastewater may be treated before we discharge the textile wastewater into the environment. So, the textile industries are generally classified based on the textile fiber they use. For example, the fibers that the textile industries are using, so it may be natural, or it can be synthetic.

That is natural means that it is generated from the natural sources whereas synthetic means that the fibers they are man-made fibers, and these categories basically may be for example we can have cellulose fibers, we can have protein fibers, and we can have synthetic fibers. The examples of the cellulose fibers are cotton or rayon. The examples for the protein fibers are silk and wool. The synthetic fibers are like polyester, nylon and acrylic. So, the cellulose fibers they are obtained from plant sources such as cotton, flax, ramie, hemp and jute etc.

Whereas protein fibers are generally obtained from the animals for example we can have wool, angora, mohair, Kashmir and silk and similarly we can have the artificial synthesized fibers which includes polyester, nylon, spandex, acetate, acrylic and polypropylene. The production process of the textile industries can be divided into two major components that is spinning process which is the dry process. So, the spinning process or the dry process means that is the production of a certain fabric that is there. So, this is generally a dry process, and this process does not use water and so this process may not lead to the generation of any wastewater. And similarly, we can have the wet process where we go for the processes like scouring, dyeing etc.

So, which uses a lot of water and in this case when we are going for the dyeing process so in that case lot of dyes can also be used in the process. So, these dyes may come into the effluent. So, this means that the production of the cotton textile it may involve the separation of the cotton fibers that is from the cotton seeds from the raw material. So, from where we separate out these cotton fibers and we spin it into cotton yarn. So cotton yarns basically are prepared from the raw material that is the cotton seeds which are available and then we draw out the fibers from there and these fibers are used for the production of the yarns and when we produce the yarns so they are then weaved successfully so that we can make a fabric we can make a cloth out of it and so the cloths then undergo a different type of wetting process.

For example, we can have the processes like scouring, we can have processes like de-sizing, bleaching and dyeing process and these processes require a huge amount of water and because of which we get a generation of very high amount of wastewater from the textile and dyeing industries. So, we can see here that in 2022 it was reported that the China is the biggest exporter of all the textiles followed by the European Union, followed by India, Turkey and USA. So, we can see that the China is the largest producer of the or exporter of the textiles followed by the European Union and followed by India. So, this is one of the biggest industries in India and the wastewater generation from here may also pose a lot of problems so that is why it is very very important that we go for the treatment of such type of wastewater so that it can be disposed of safely and the environment may not be harmed because of the improper disposal of the wastewater. So, if we talk about the integrated cotton textile mill so it produces its own yarn and from that yarn generally the cloths are produced in the same mill so that is why it is known as integrated that is the production of the yarn as well as the production of the cloth basically takes place in the similar industry so that is why it is called integrated industry.

So, yarn may be produced from the raw cotton so we can have number of steps which are generally physical and mechanical steps for example, we can have the opening and cleaning of the raw material that is the cotton seeds here similarly we go for the picking, we go for carding, we go for drawing of the fibers from here, we go for the spinning process then winding and warping. So, all these processes they are mechanical processes, and these

are all dry processes which are used, and they are generally used for manufacture of the yarn from raw cotton that is available, and these are the dry operations and that's why they do not require much water in this case and that's why there is no contribution of the waste water from this mill. So, after the yarn is produced then the slashing of the yarn is done so that the strength can be gained by the yarn so this slashing may be done by number of materials for example, you can use here starch or other sizing substances so this provides a strength to these fibers to the yarn that is produced and this yarn may later on be used for the weaving purposes. So, the wastewater generated here from this section may be very very small and it may occur because of the spilling process that is there, and it may also result from the floor washings because of the spills which has gone on to the floors. So, the floor washing may result in the generation of the wastewater and again this section may not contribute very high to the wastewater generation.

So, after the slashing process the yarn is taken for the weaving process where basically the fabric is made where the weaving is done, and this weaving results in the formation of a cloth. After the cloth is prepared so that is possible that the surface of the cloth may contain hairy substances on it or basically the protruding fibers are there on the surface of the cloth, so it needs surface so for obtaining that we go for a process which is known as the singing. So, singing means that is the fabrics or the yarn which are prepared now so they are exposed to the direct flames, or they may be heated on the plates so that the protruding fibers the hairy substances which are there on the yarn so they may be burnt, or they basically may be removed from the cloth and this process is also known as the gassing. So once the cloth is prepared so it may require the process which is known as scouring and de-sizing so that we can remove the natural impurities which are there on the cloth as well as we can remove the slashing compounds that we have used in the previous process of slashing where we have used starch so that we can provide strength to the yarn. So, these substances we want to remove then we have to take it to a scouring process and in the scouring process we use a number of chemicals like we use caustic soda, soda ash or detergents and it is generally done in the boilers which are known as the tear boilers.

So, if we replace the soap that we are using in the scouring process by using low BOD detergents so we may reduce the load of the BOD up to 35 percent. So, the scouring and desizing contributes to about 50 percent of the pollution load whatever the wastewater is generated so in that 50 percent contribution of the pollutants comes from the scouring and desizing process. After this we go for the bleaching operations where we use oxidizing chemicals like peroxides or hypochlorite so that we can remove the natural color which is there on the fabric. So after this process we may take the cloth to the moisturizing process so this may be optional we can either take it directly to the dyeing process also or we can use the moisturizing process and if we want to enhance the quality of the cloth so in that case we pass the cloth to a 20 percent caustic soda solution and this process provides the strength, elasticity, luster and the dye affinity towards the cloth so this enhances the quality

of the cloth in this sense. So, here the chemicals that we use we can also recover that chemical for example the sodium hydroxide recovery can be done and then the waste from here generated from this section so it may be recycled also and so the whatever the waste is generated from in this section so it may contributes little to the BOD whereas, it may contribute higher amount of calculating in the waste water because of the sodium hydroxide that we are using in this process.

So after the process of bleaching we can take the cloth to the dyeing process for example, here we can use a number of dyes for example there can be the cationic dyes, anionic dyes or non-ionic dyes and we use a number of dyes like for example we can have anthraquinone dyes, we can have azo dyes, we can have xanthine dyes, indigo dyes, thylocyanin dyes, diphenylmethane or triphenylmethane dyes, nitroacetate or nitrated dyes, polymethine dyes, cationic or basic dyes, reactive dyes, metalliferous dyes and the direct dyes, Sulphur dyes, dispersible dyes, wet dyes and we can use a number of pigments also for the dyeing and printing process. So, dyeing use a number of chemicals so not only dyes, but they also require certain auxiliary chemicals also so that these dyes can be adhered to the surface of the fabric. So, as we have stated that dyes may be of cationic or anionic or non-ionic types and when we talk of the anionic or non-ionic dyes so it may mostly contain the azo group or the anthraquinone group in the chromophores of the dye. So, the wet dyes they require caustic soda and sodium hydrosulphide so that the dye can be reduced and it can come into the soluble form and then later on when we are going to put it to the cloth so when the fabric is impregnated with it so then we use certain oxidizing agents for example, peroxide or chromate is used for the dyes to get adhered to get adsorbed by the yarn material. So, these are some of the dyes for example, we can see that we can have the azo dyes.

So, azo dyes can have azo bond that is the n double n bond, and this bond is highly resistant to the degradation and that's why you may have mono azo dyes where we have single azo bond, we can have di-azo bond, we can have tri-azo dyes. So, these dyes as the number of bonds azo bonds increases their degradability, their biodegradability also decreases. So, we can have a number of azo dyes which are available, and these are we can say highly toxic into the environment in the sense that they are not biodegradable, they may be toxic to the aquatic life also. Similarly, we can have anthraquinone based dyes. So, these are the examples of the anthraquinone based dyes and we can also have the tri-aryl methane dyes, and these are some of the examples of the dyes that we generally used during the textile process.

So, indigo dyes are also similar to the wet dyes, but here we do not require the chrome for the oxidation, here we require only air oxidation is required so that the dyes can get impregnated onto the surface of the cloth. Whereas, in the naphthol dyeing we generally the naphthol is applied to the fabric first of all and then it is derived and then basically it is taken to a developer so that the chemical coupling takes place so that the dyes basically

may be developed onto the surface of the cloth. And the developing dyes may require acid as well as sodium nitride. So, the color is developed when we are treating it with the developer. So, the problem of the color is that it is not only aesthetically objectionable as it imparts the color to the drinking water supply.

For example, if you put this colored wastewater even after treatment also if the color is not gone so then basically it is aesthetically objectionable as it goes to the receiving water bodies. So, it may become useless for a number of purposes. For example, it will not be suitable for the domestic as well as the industrial purposes also. Similarly, the color that is there so it may be toxic also to the aquatic life. So, though it may not impart for example, if we are having the dyes which are non-biodegradable in nature so it may not impart BOD to that, but it may be toxic to the environment.

And this color may also lead to less penetration of the sunlight because of which the aquatic ecosystem may be adversely affected. It also because we have seen that the dyes when we are using dyes so the chromium salts are also used and if these dyes are containing the chromium salts so then basically it will it can be quite toxic to the environment and that is why it is necessary that we treat the waste water which contains chromium separately so that after the treatment of chromium we can go take it for the treatment of the other waste water parameters. The thickened dyes as well as the printing gums are also used for the printing process and when you are washing these printed cloths so it is possible that the unfixed dyes they may come into the wash waters. So, after the dyeing process we take the cloth to the finishing section where various type of processes is used so that the fabric can be finished. For example, we can use a number of chemicals here, we can use starch, we can use dextrin, we can use natural and synthetic waxes, we can use synthetic resins etc. so that the luster, the strength, the quality of the cloth basically may be improved. So, when we talk about the composite waste which is coming out from an integrated cotton textile mill so it may contain a variety of organic as well as the inorganic substances. For example, as you have seen that we are using starch, the cellulose will come into the wastewater, sodium hydroxides may come into the water, the detergents may also come into the water, the dyes and pigments which we are using for the dyeing process. So, dextrins may also come into the wastewater, wax, soap, sulphate and sulfites so these basically form the part of the wastewater. So, we can see here the flow diagram which represent that how basically an integrated cotton textile mill having its operation.

For example, the raw cotton is taken so it is gone for the opening and cleaning first of all and then we go for the picking process and later on we go for the carding process so that we can draw the fibers out of it. So, here we also go for the combing process also so that whatever the materials which are entangled in the fibers so that may be removed and after the drawing process the fibers basically that are drawn so they may be sloped and then they go for the spinning process and after the spinning we go for the winding and warping of the yarn that is produced out of this material. And after winding and warping process is

over so we go for the slashing process where we add starch to it so that the strength is gained by the yarn and after the slashing is done we go for the weaving process so that we can weave the cloth out of it, weave the fabric out of it and after the weaving process we generally go for the process which is called singeing or the gassing where basically whatever the protruding elements are there on the surface of the fabric so they are generally burnt off and after the singeing process we go for the de-sizing and scouring so basically we remove the chemicals which we have used during the sizing process or the slashing process and we go for the scouring process after this. After the scouring we prepare the cloth for the bleaching process and bleaching is done after this process so that we can prepare the cloth for the dyeing processes and after the bleaching it is optional that we go for the moisturizing process where we improve the quality of the cloth and after the moisturizing process we can take it to the drying and the printing process and later on we can go for the finishing of the cloth. So that's how the integrated cotton textile mill is having the process.

So, when we talk about the characterization and composition of the textile wastewater so it may contain lot of dyes, it may contain organic acids and salts, it may contain bleaching agents, it may contain trace metals in variable concentrations. So because of lot of pollutants are present in the textile and dyeing waste water so it is possible that if we are putting this untreated waste water into the environment so it may deteriorate the surface water quality, it may deteriorate the groundwater quality as well and it may also affect the soil and the vegetation and it may also cause certain diseases to the people who are coming in contact with this waste water for example hemorrhage, ulceration of the skin, nausea, severe irradiation of the skin and dermatitis may take place if the person is coming in contact with the waste water which basically contains these harmful elements into it. So, the washing operation after drying so it may lead to the nearly 50 percent of the dye released into the effluents. So, when we are going for washing of the finished cloth that is the dyed cloth so there it is possible that this dye which is there on the cloth so that may come into the wastewater and nearly 50 percent of the dye is released into the effluents. So that is why the effluent which is produced so it may be highly colored in nature and that is why it is very very important that we treat this wastewater for the color removal first of all and then later on we can take it for the further treatment. And if we are using azo dyes so in that case the azo linkage which is there if it is broken so in that case it may lead to the formation of the toxic amines in the effluent so which may be carcinogenic in nature. Anthraculine based dyes are more resistant and they basically remain in the environment for a long time in the waste water so that is why it is very important that such type of dyes basically may be first of all treated and that is why it is very important that we have to see that what type of dyes we are using so that a specific treatment method can be adopted for the treatment of such type of dyes and then basically we can dispose of the water safely by after getting rid of these dyes in the waste water. And these colors which are there so they are visible to the human eyes and at a very low concentration also. So that is why it is

very important that we remove the color from the wastewater before putting it into the environment. And it is also there that most of the dyes that we use here so they are highly stable, and they have no effect of the light or the oxidizing agents and generally what we do that we use reduction process so that we can first of all break these dyes into the biodegradable compounds and later on we can treat it by using biological methods. So, that is why the oxidation of these dyes may not help in the treatment process and we have to adopt other processes for example, we have to go for adsorption or we have to go for the process of reduction by using certain metals for example, zero valent iron can be used for reduction of the azo dyes so that we can get rid of the color, we can get rid of the azo bond which is providing the stability to these azo dyes and later on when it gets decolorized then we can use other processes like biological processes for the treatment of such type of dyes. And wastewater may also contain lot of metals into it for example, we can have two sources of metals here. First is the metals which are coming from the impurity within the chemicals so certain chemicals that we use for example, we use caustic soda, the sodium carbonate and the other salts so they may also be impure and they may also contain a number of metals into it and secondly the source of metals can be for example, dyes stuff itself for example, the dyes stuff contains the metallized mordant dyes so for example, when we are using metal complex dyes so they are generally based on chromium so these metals may come into the waste water and similarly other metals like for example, cadmium, copper, iron, lead, mercury, nickel and zinc so they may also be coming into the waste water because of the different chemicals that we are using during the process. So, textile dyeing it uses large amount of sodium sulphate and other Sulphur compounds so when these compounds or they basically come into the anaerobic conditions so in that case these sulphates may become converted to sulfides, and we may find sulfides in the wastewater. Oil and grease may also be found in the wastewater because of the number of oils, fats, kerosene and lubricating oils that we are using during the finishing processes, and the chlorine compounds may also come into the textile wastewater because of the leaching process and that is why we generally find that there is residual chlorine present in the wastewater coming out from the textile industries.

So, there can be a number of chemicals that may be used so that we can get a type of textile finishes for example, there can be a number of chemicals that may be used so that we can get antimicrobial finish, wire resistant finish, grease resistant finish, anti-static finish, easy care finish, hydrophilic finish and non-slip finish. So, these are the number of you can say the modifications that have been done to the cloth so that it can suit to different type of purposes, it can suit to the present-day requirement of different type of finishes that we generally require. For example, we have seen during the COVID time that we basically are demanding a cloth which are antimicrobial in nature. Similarly, there can be the fire-resistant finish means that is the people who are working in industries where basically they are more prone towards the fire so they can have the that fire resistant finish. The crease-

resistant finish may also be applied for the people basically who do not care much, or they do not go for ironing of the cloth very frequently.

Similarly, we can have other type of finishes that may be coming as per the requirements. So, these finishes may be achieved by using different chemicals for example, formaldehyde, silicon, phenols, organo-silver, quaternary ammonium compounds, oxy-ethylated polyamides, silica gel, chlorinated flame retardants, ruminated flame retardants, phosphorous containing flame retardants or poly ammonium quaternary salts. So, these all chemicals that we use so they find their way in the wastewater, and this may impart the hazardousness or the toxicity in the wastewater. So, here we use starch so because starch is used for the removal of the wrinkles during the preparation of the cloth it also adds gloss to the fabrics right. So, these starches basically they can release a high strength organic into the wastewater and these starches may come from the sources like potato, corn, sago, cassava, rice and wheat.

So, these types of starches basically may come into the wastewater, and they may increase the BOD load in the wastewater. So, textile production also uses a number of harmful acids for example, the HCL, sulfuric acid, phthalic acid, citric acid, formic acid, acetic acid, nitric acid, ammonia and the oxalic acid. So, these are the acids that are generally used for so that we can basically enhance the process of the dyeing they also find their way into the wastewater discharge. So, if we talk of the different type of processes which are generating the wastewater during the preparation of the cotton textiles. So, here for example, the desizing it may impart BOD which may come from water soluble sizes and synthetic sizes, it may impart lubricants, it may impart biocides, anti-static compounds etc.

The scouring process imparts disinfectants and insecticides residues into it, the sodium hydroxide, the detergents, fats, oils, pectin, wax, lubricants, spin finishes, spent solvents they may find their way into the wastewater. Similarly, the bleaching may contain hydrogen peroxide, sodium silicate or organic stabilizer and this may contain high pH values. Similarly, the moisturizing waste may also impart high pH to the wastewater, and it may contain sodium hydroxide. So, dyeing process may impart metals, salts, surfactants, toxics and then basically cationic materials, color, BOD, sulfite, acidity and alkalinity and the spent solvents into the wastewater. Similarly, the printing may impart suspended solids, urea, solvents, colors, metals, heat, BOD and foam to the wastewater and the finishing process may impart lot of BOD, COD, suspended solids, toxics and the spent solvents.

So, that is why the textile industry waste, so it may contain lot of chemicals, dyes, acids, starches etc. So, it may produce a water which may be having a hazardous characteristic. For example, the toxicity is there where the chemical which we are using in the textile processes, they are highly hazardous to the environment as well as the human health. So, the wastewater, which is coming out from the textile industries, so this may be toxic in

nature. Similarly, it may be corrosive in nature because we are using a number of sulfites here.

Similarly, we are using dyes and bleaches, so that basically can lead to the corrosiveness to the environment. Similarly, the oil we are using, so this basically may be there in the wastewater which are resulting from the lubrication processes that we adopt during the textile processes and this wastewater may be highly reactive because it contains a number of compounds or substances that can chemically react when they combine the wastewater also or otherwise also. And similarly, there can be number of compounds that may be highly favorable in nature. So, that is why we say that the textile wastewater that is coming out, so that may be hazardous in nature. So, when we talk of the wastewater characteristics of the composite cotton textile mills, so we can see here that the pH is generally alkaline in nature.

So, we are having a pH between 9.8 to 11.8. We are having a total alkalinity ranging from 17 to 22 milligrams per liter as calcium carbonate. We may have BOD values very high nearly 60 to 900 milligrams per liter. The COD values are also high that is from 1400 to 1700 milligrams per liter. The total solids are nearly 6000 to 7000 milligrams per liter, and it may also contain chromium and total chromium in the wastewater is generally 10 to 13 milligrams per liter. So, we stop here, and we will continue our discussion regarding the wastewater treatment in our next lecture. So, these are the references that we have used for the preparation of this lecture.

Thank you.