Biological Process Design for Wastewater Treatment
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Lecture: 01
Introduction to Biological Process Design for Wastewater Treatment

Welcome everyone. Today we are going to start a new NPTEL online certification course on Biological Process Designed for Wastewater Treatment. So, in today's lecture, we are going to study the importance of this subject as well as the importance of water treatment as well as wastewater treatment in today's scenario. We are going to understand the course structure as well as the books and the reference book that will be given later. So, let us start the introduction related lecture today itself.

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Now, we understand the need of water and wastewater treatment has increased in today's society. The reason is that we require water for various uses and these uses include in the domestic as well as in the industrial sector. Now, if we require the water that water has to be supplied from some source, the source of water which is generally used includes river, lake and ponds, groundwater et cetera. And now, these sources when their characteristics are getting altered, we need to treat these water before their probable use in the domestic as well as in the industrial sector along with the agricultural uses as well.

Now, depending upon the uses, that we do in our domestic or industrial sector, lot of pollutants get added to these water when the uses is being done of the water. And the generation of these water after their uses has lot of characteristics which get altered before

their uses. So, that means we generate lot of municipal and industrial wastewater which have entirely different characteristics as compared to before they enter into the respective domestic place or industrial place. So, that means the altered characteristics have some problem and we need to treat the wastewater also before further uses or discharge into aquatic bodies. So, we have entirely different strategies for water and wastewater treatment and that depends upon the uses of the water, source of the water et cetera.

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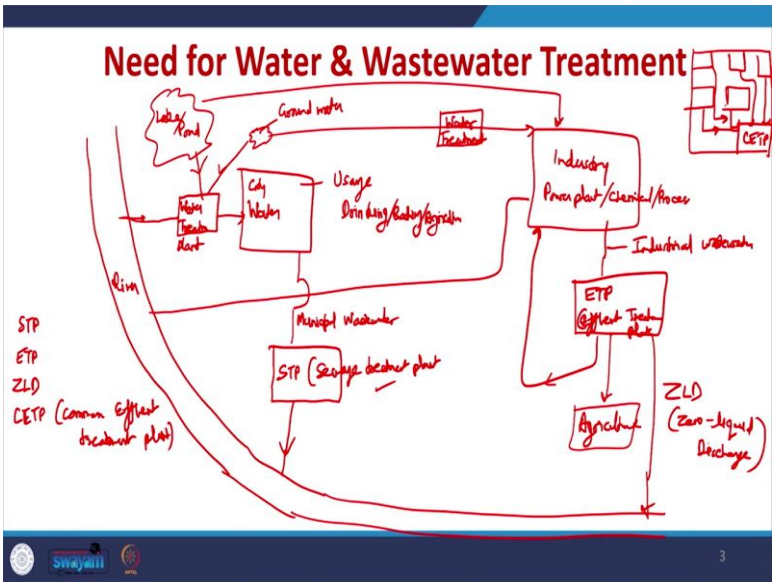

Now, let us understand this with a pictorial diagram and study understand the difference between water treatment and wastewater treatment. Suppose we have a river which is flowing near to vicinity of a city and this river is flowing and we have some colony or a city which is there near to this river. Now, this city or colony will require water for its uses. Now, what are the sources? One of the source is this river which is there. Now this river can be one of the source, there could be other sources like a lake or reservoir is there and that could be another source of water for this city or this community. So, this may be a lake, a pond or any other reservoir. There could be other sources also that a groundwater is there and groundwater can be used as a source of water.

Now, if the water in these sources is not good enough for direct use in the city and the city uses maybe for domestic purpose, for drinking et cetera and the water quality if it is not there, it may be for drinking, bathing, for agriculture, some of the uses may be there. Now, if the water quality is not good enough from any of these sources, what we will have to do is that we have to use a water we have to do the water treatment before using this water in this city. So, the river water will come in this water treatment plant and it will be further going into this

city or similarly for lake also we have to treat and similarly for groundwater also we have to do the treatment, the water treatment done here may be of different size like if we are taking groundwater and groundwater is being stored in the water tanks in the community.

So, the water treatment done there will be of lower level. Similarly, if groundwater is directly going into a home, so, they may be having a small treatment unit, which will be of the size of maybe 1 meter cube et cetera or much lower than that, and then the water is being used in that particular home. So, the water treatment done before uses in the domestic may vary depending upon the size of the community, from where it is taken, and within the water treatment plant or water treatment unit, the different units that will be there in the treatment will also depend upon the characteristic of the water from where it is being taken and how much water is being taken.

Now, similarly, from all these sources, there is a possibility that we have a industrial cluster or an industry is there. So, this industry will also require water for its uses, it may be like a power plant, this is a possible that this industry is a power plant or any other chemical and process industries. So, any of these industries will require lot of water and for them the source of water, maybe this river itself, or this groundwater or this lake or reservoir. So, any of these sources may be there.

Now, depending upon the uses for the case, like suppose power plant is there, and we have to make electricity in the power plant. So, under that condition, the hardness level in the water should be minimum possible. So, under that condition, there will be again water treatment will be done for any of these water and then only it will be going into the industry. So, under that condition hardness has to be removed and that hardness removal can be done by a simple ion exchange unit et cetera. So, again for industry, if the industry is sugar industry or any other industry, the treatment unit will be different, it will depend upon the industry and what type of water they require for their uses within the plant.

Now, once the water has been used, either in the city or for agriculture or in the industry after that uses lot of compounds and pollutants get dissolved into the water and water gets released. So, this water is called it is being it is coming out of from the city. So, it will be called as municipal water. So, this under that conditions will be generating a municipal wastewater and then we have to treat this wastewater in a wastewater treatment plant that may be STP generally called as STP or sewage treatment plant. So, this sewage treatment

plant will be there and we will have to treat this water. So, this and then it will be discharged maybe into the river itself after treatment. So, this is possible.

Similarly, from the industry, we will be having some water which is getting generated and that water will be treated this is industrial wastewater, which is getting generated and that water has to be treated in a effluent treatment plant. So, this is commonly called as ETP or effluent treatment plant. So, this water has to be treated here and then it will be discharged or maybe recycled back into the industry. If the unit is ZLD, ZLD means the zero liquid discharge unit. So, all the water after its treatment has to be recycled back. So, this is called zero liquid discharge.

If that industry is allowed to give water for agriculture uses like sugar industry, then that water will go into the fields where the it may be used for agriculture. And similarly, if it is possible for discharge of the water from this, so, it will ultimately go into the river and ultimately it will be discharged. So, depending upon the final uses of the water after treatment in the industry, recycling may be done it may be discharged to the agriculture, it may be discharged to any other aquatic body . So, this type of treatment so, there is a difference that I wanted to highlight is that the water treatment and wastewater treatment is different.

In the water treatment when the word is water treatment we try to treat the raw water which is obtained from either river, lake or pond or groundwater for its probable use in the domestic or in the industrial sector. Then there is another term which is called as wastewater treatment. In the wastewater treatment this is used for treatment of the municipal wastewater which is discharged from a city or for treatment of industrial wastewater which is discharged from any industrial premises. So, these are the different terms.

Now, within this now, we can learn few terms which are very important and before going further ahead, and these terms are like already I have told regarding STP, so, STP is sewage treatment plant which is for municipal wastewater treatment. Similarly, we have ETP, ETP is for effluent treatment plant generally that term is related to industrial wastewater treatment, then there is another already learned one term is called ZLD, ZLD is generally term for water treatment in those industries which are not allowed to discharge any water outside the premises. So, that means, after treatment they will have to recycle back and use the water either in the process or for irrigation or for any other uses maybe steam generation et cetera.

So, ZLD units are those which actually have to recycle back all water after treatment. Then there is another term which is called as CETP. So, CETP means, common effluent treatment plant. So, common effluent treatment plant, now for common effluent treatment plant are used in those places where we have special economic zones or an industrial cluster is there. So, that means, suppose any industrial cluster is there and we have lot of small units which are there. So, what these units are expected to treat water up to a certain level and after that all industries will discharge water into a common effluent treatment plant which is called CETP and which will ultimately treat the water discharged from each of the industrial premises.

So, all these small industries will treat water only up to a certain level after that, that will go into the CETP where the final treatment will then be for the discharge of water into aquatic bodies. So, this is there. So, this is a very common term CETP. So, we learn regarding water and wastewater treatment and their difference.

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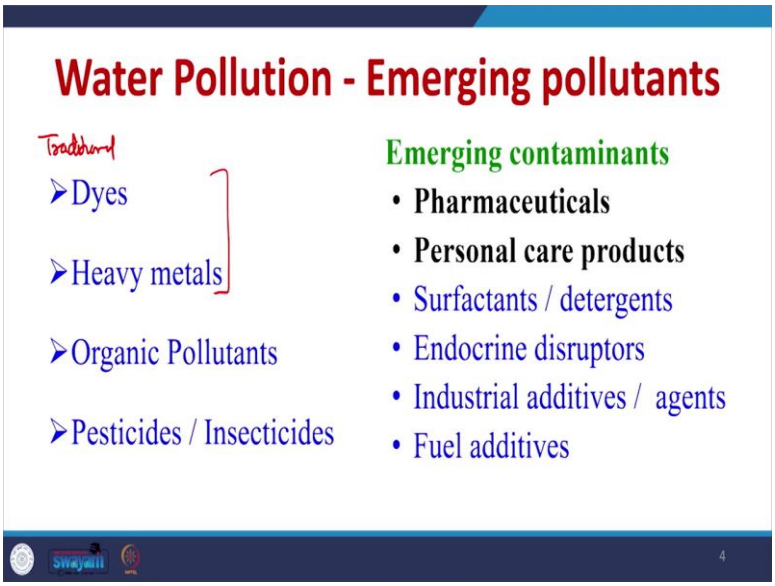

Now, further going ahead, when the water is being used in any of the domestic cases as well as in the industry, many pollutants are coming and new new types of pollutants are coming into picture. The traditional pollutants which were present in the water, they included like heavy metals, dyes, organic pollutants, pesticides insecticides et cetera and we can understand that these are coming from maybe industrial sources or from maybe uses in the homes et cetera. So, we have municipal wastewater where lot of organic pollutant may be there up to a certain level and then agriculture from agriculture we have pesticide, insecticide

which is getting dissolved into the water and which is ultimately going into the pond or reservoir et cetera. So, this is there. So, all these are traditional pollutants.

Now new type of emerging pollutants are coming into picture and these contaminants and emerging pollutants, they are basically being discharged because of the uses are certain types of compounds in our daily life. Now pharmaceuticals, nowadays, we are using lot of pharmaceutics in our homes, and in fact there is overconsumption of pharmaceuticals in our daily life. And once they are used and they are over consumed, so certainly they will go into the water also and in the sewage, so they are ultimately going into the river.

Similarly, we are using lot of personal care products in our day to day life and once they are clean from our faces et cetera and when we are bathing, so, they are ultimately going into the water and these personal care products are causing lot of problem. Similarly, surfactant and detergents are being used for cleaning clothes, floors and household things and in the industries also they are being used. So, these things are also going into water. Many of these compounds are endocrine disruptors and they cause lot of changes in our body.

And similarly, in the industry, lot of industrial additives when agents are going into the water bodies when these industrial units are being cleaned, their floors are being cleaned or their condensates are coming et cetera. Similarly, in fuels, we are using lot of fuels and fuel additives are being used also in our day to day life and they are also going into the water bodies. So, these emerging pollutants need to be removed from the water bodies if we have to take care of our environment and if we have to use the water for various uses. So, there is lot of challenges with respect to emerging contaminants.

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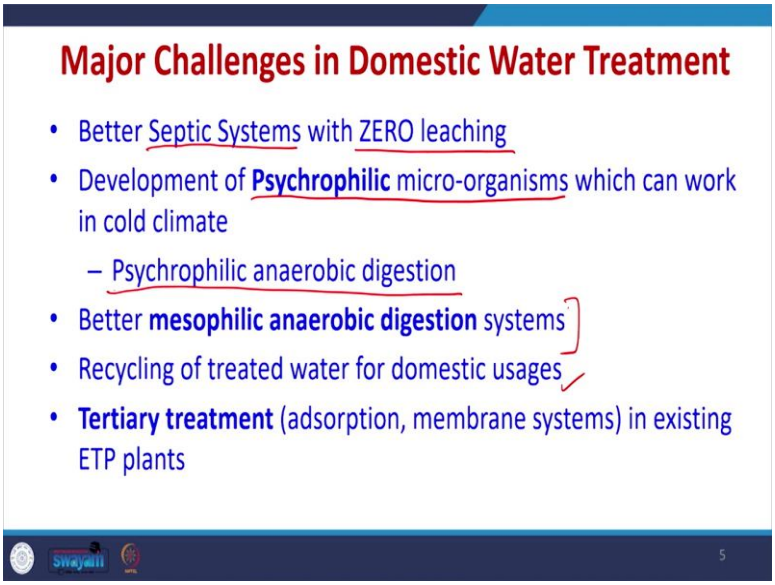

Now, going further, there are many challenges which exist presently in our country and other countries as well. And these challenges I have discussed in two slides, and before going for understanding what is the designed in our course. So, we have lot of major challenges with respect to domestic wastewater treatment, domestic water treatment, as well as the wastewater treatment in the next slide.

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So, in all those colonies, which get developed with time, and there is no plant planning for development of those colonies. So, this happens in our country a lot, we purchase a plot, then somebody else will purchase a plot, we will make a home there, but we do not have any water discharge system, or sewage discharge system and collection and treatment system. So, under

those conditions, what we do is that we have a septic tank in our homes, and we have a condition where many home small homes are built together, where the water is being taken from the ground and in the same home may be of 1500 square feet, the septic system is also there where water is going again back into the ground maybe leach.

So, we require systems where ZERO leaching should be there that means there should be no leaching and a proper treatment may happen within the short residence time. So, this is very very important for our country, in particularly for unorganized developed colonies and if this is not happening, then the lot of water problem may happen and the groundwater may get polluted.

Similarly, we have lot of terrain where the temperature is always very less and this is a true for many countries where the temperatures are down. And in the higher terrain also, above 3000 meter height, we have the microorganisms or the temperatures which are less and the microorganisms are not able to degrade the waste. So, under those conditions, we require psychrophilic microorganisms to be developed, which can work in cold climate conditions and still work very well. So, this is the need of the hour. And this is more correct for all those soldiers and army people who are actually living in those cold climate regions and they have colonies et cetera.

Similarly, anaerobic digestion, psychrophilic anaerobic digestion is important issue. And this is so because many of the industries which are actually in the plane terrain, and during the most of the time, the temperature is good for mesophilic digestion to happen. And under those conditions, we are getting methane et cetera. But for few months, 3 to 4 months, the temperature goes down and all these anaerobic digestion unit which are based upon the anaerobic bacteria or microorganisms, they do not perform well, and their efficiency goes down and the treatment does not happen. We do not get any methane and other type of fuel gases. So, overall efficiency goes down.

So, for these digesters, we require anaerobic, psychrophilic anaerobic microorganisms which can work well. So, this is very important for development of such things. Similarly, recycling of treated water in the domestic uses. In India we do not have any concept as such right now, generally the individual colonies also do not recycle the treated water again back into the system. So, we should develop a strategy for recycling this water and also the people should accept that we need to use the recycling water, recycled water maybe for flushing, maybe for irrigation in the lawns et cetera. Ultimately, we will have to go for recycling the water so, that

the ultimate water which is discharged as municipal wastewater gets reduced. This has to be better managed.

Similarly, tertiary treatment has to be added in many of the municipal wastewater treatment plant and in maybe adsorption system, membrane systems will have to be added so that the water discharged from such STP then ATP into the water bodies is much better and the water bodies are not getting affected because of this water.

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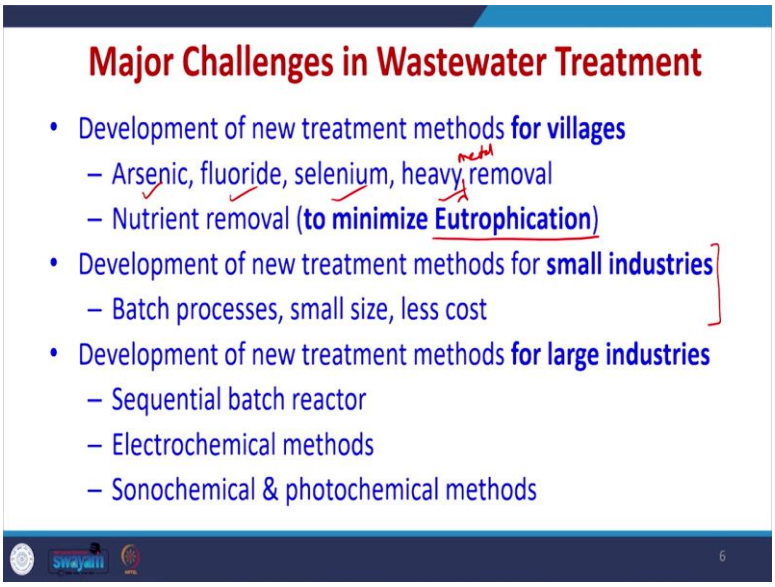

Similarly, there are some challenges major challenges with respect to wastewater treatment, in particular for industries as well as for villages et cetera. In villages, we have lot of problems which is happening with respect to drinking water, like arsenic, fluoride, selenium, heavy metals, all these are coming into the drinking water and we need to remove these heavy metals, arsenic, fluoride, selenium, et cetera, because they are causing lots of chronic problems to the villagers. So, we should device some technologies which can be install in the villages and they should be low cost and easily operable by the villagers themselves. So, that these things can be removed.

Similarly, lot of nutrients get generated, nutrients get generated and they go into the water and ultimately eutrophication of the lakes and reservoirs is happening, and because of which these lakes are dying out, and ultimately the water carrying capacity within the village gets reduced. So, we will have to devise strategies for nutrient removal from the villages as well.

Similarly, we have lot of small industries, and now these small industries generally they do not want to incur much money under treatment. So, we need to develop batch treatment

processes, which are small in size, which should be economical in nature, and that can be installed by this small industry, so that the water treatment happen. So, this and remember, these industries have very small space. So, they have to be small in size, then only they will be used by these industries.

Similarly, for large industries, a new type of treatment methods such as sequential batch reactor, electrochemical methods, et cetera have to be developed, and they have to be merged together with the traditional biological treatment method, so that the overall efficiency of biological treatment method improves along with these new treatment measures. So, this is the need of the hour.

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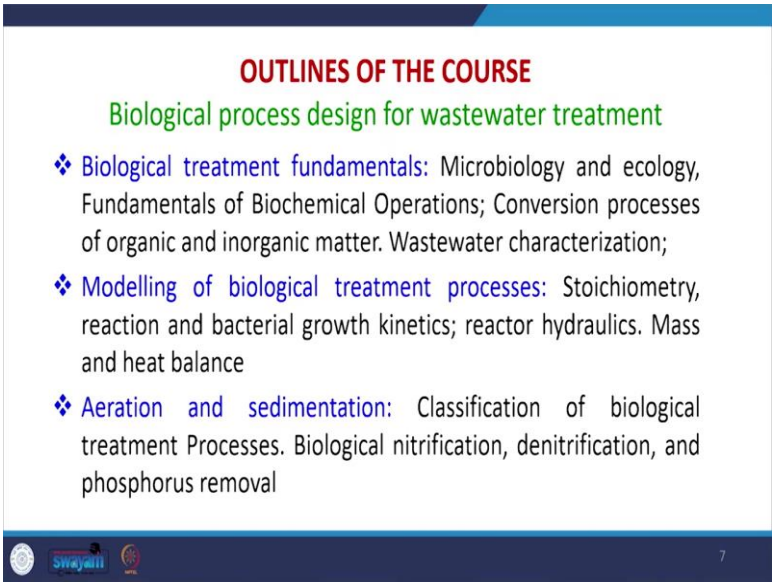

Now, going lastly, we will try to understand what is the outline of the course and what we are going to study in this course. So, the course you know very well that this is biological process designed for wastewater treatment. Already myself I have delivered a course on physico-chemical treatment of wastewater. So, overall treatment includes physico-chemical as well as biological treatment. So, this course will only focus on biological process design for wastewater treatment or biological treatment of wastewater, it will not focus much on the physico-chemical treatment of wastewater. If you want to study that you will have to the study the other course on physico-chemical treatment of water.

Now, this course has been divided into various section. One of the first sections is biological treatment fundamentals will study regarding little bit of microbiology, ecology, fundamentals of biochemical operations, convergent processes et cetera. Similarly, the second unit is

related to modeling of biological treatment processes, including stoichiometry, reaction, bacterial growth kinetics reaction, reactor hydraulics, some mass and heat balance things. And then the third unit the third week will be focused on aeration and sedimentation because they have some biological aspects involved. So, classification of biological treatment processes including nitrification, denitrification, and phosphorus removal using biological microorganism.

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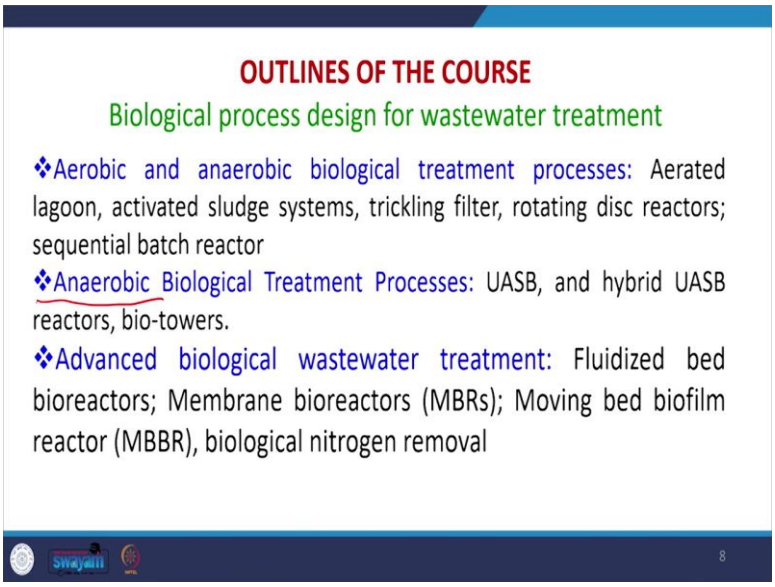

And then we will go further and study the aerobic and anaerobic biological treatment processes, including aerated lagoon, activated sludge system, trickling filter rotating disk reactors, et cetera. Then we will further study anaerobic biological treatment processes including UASB reactor, hybrid UASB reactors, bio-towers et cetera.

Lastly, we will study the advanced biological wastewater treatment methods including of fluidized bed bioreactors membrane, bioreactors, moving bed biofilm reactor and biological nitrogen removal.

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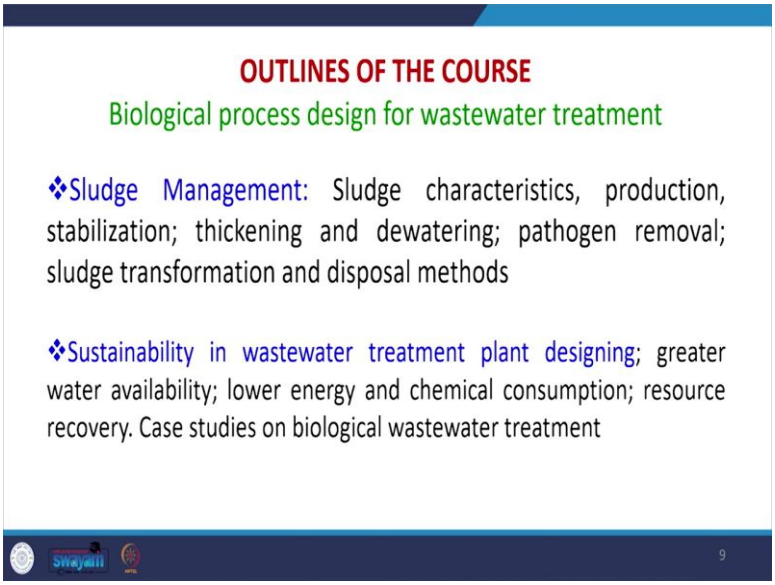

After that, because all these processes biological processes generate lot of sludge, so sludge management essentially becomes part of biological process design. So, we will study regarding the sludge characteristics its production, and stabilization, thickening, dewatering, pathogen removal from sludge, and ultimately sludge transformation and disposal. And lastly, we will do some studies or understanding of sustainability in wastewater treatment plant design.

So, in this aspect, we will try to focus on how to design a wastewater treatment plant, which is having sustainability aspects. Those include lower energy and chemical consumption. And minimum gas generation. So, this is there, and will lastly study some cases of treatment of industrial wastewater in those industries where biological treatment is more dominant. So, will end with this last section.

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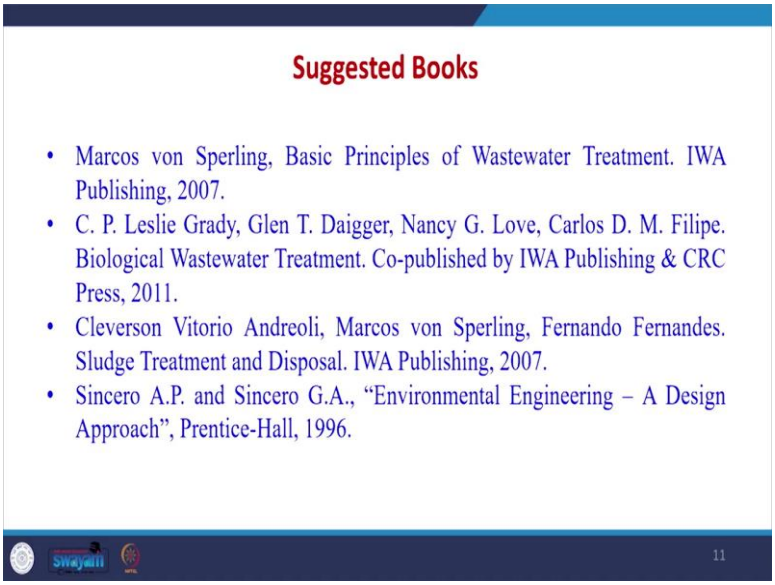

There are some books which are listed here. And which I will be using in this course, you can study any of these books, and you can always refer to these books. And I think thank you very much.