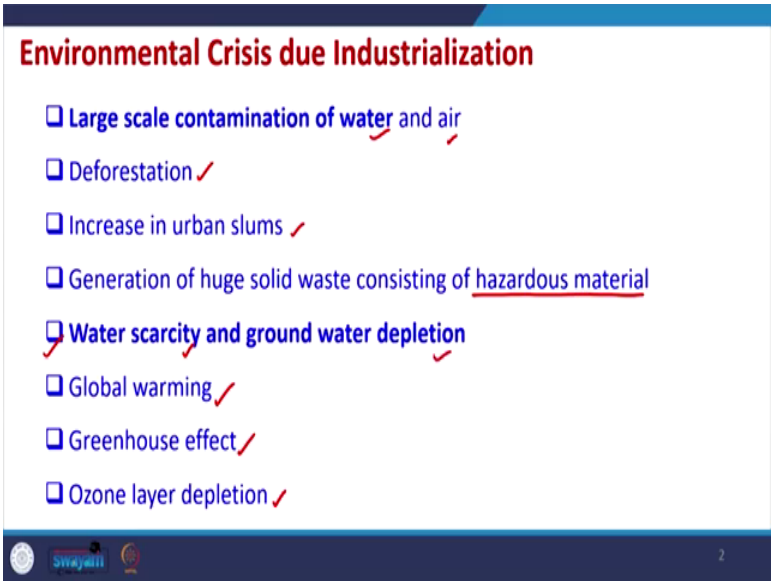
Physico-Chemical Processes for Wastewater Treatment
Professor V. C. Srivastava
Department of Chemical Engineering
Indian Institute of Technology, Roorkee
Lecture 01
Introduction to Water Pollution and Control

Good day everyone, and welcome to these lectures on physico-chemical processes for wastewater treatment. So, today we are going to start our lectures on the treatment of water and wastewater by a various physico-chemical processes. So, we will start with that, why we need these type of processes for water and wastewater treatment, what are their importance, and what we will be covering in this course.

So, today, we are going to discuss all these aspects. So, let us start and understand what are the various environmental crisis that is there in the present decade or thereafter, and why this has a reason, and what we should do so as to tackle these aspects. So, environmental crisis has started after the industrialization has fastened all throughout the country as well as globally.

(Refer Slide Time: 1:29)



So, large scale contamination of water and air has happened because of this industrialization. So, the society is requiring new and new type of facilities along with that, they require a lot of energy as well as other types of chemicals and products, which can be converted are used in our day to daily life and because of this industrialization, and also because of the growth of infrastructure, etc.

So, large scale contamination of water and air both has happened, and for industrialization, we require a lot of land, lot of water, as well as other utilities. In addition, we require a lot of wood and metals and others. So, for taking out like wood, we have to do deforestation.

Similarly, if we require metals, so, that means the mines have to be dig and from their allies etc, or different types of materials have to be taken out and for which that deforestation has to be done. So, that we can take out the resources from mother earth. And because of this deforestation, the characteristic of land as well as the air has changed.

So, also because of industrialization and rapid growth in the population, the increase in urban sloughs has increased because of the movement of the people from the villages and suburban areas to urban areas. So, these urban slums have increased day by day, and all these issues are highly challenging for our society. Generation of huge solid waste consisting of hazardous materials as well as simple municipal solid waste has also increased because of uses of lot of material in our day to day life.

Now, industries used lot of metals, nonmetallic material, organic materials and other things, and convert them into various products. During this conversion, lot of waste is discarded as well; because of their various characteristics, these waste may be hazardous in nature, and they cannot be reused or recycled. So, they have to be either kept aside and just use for landfilling, secure, landfilling, etc. So, latter lot of solid waste is getting generated, which has these hazardous characteristics.

Similarly, from residences, because of use of lot of package materials, the amount of municipal solid waste, which is getting generated from residential colonies etc, is increasing very quickly. And we have to see that how we can manage these waste.

Similarly, because of the uses of lot of energy sources, and because of the combustion that is happening, not only inside the residences, but also in various furnaces, engines, etc, which are running all the society. The CO_2 vision is taking place and the global warming is happening.

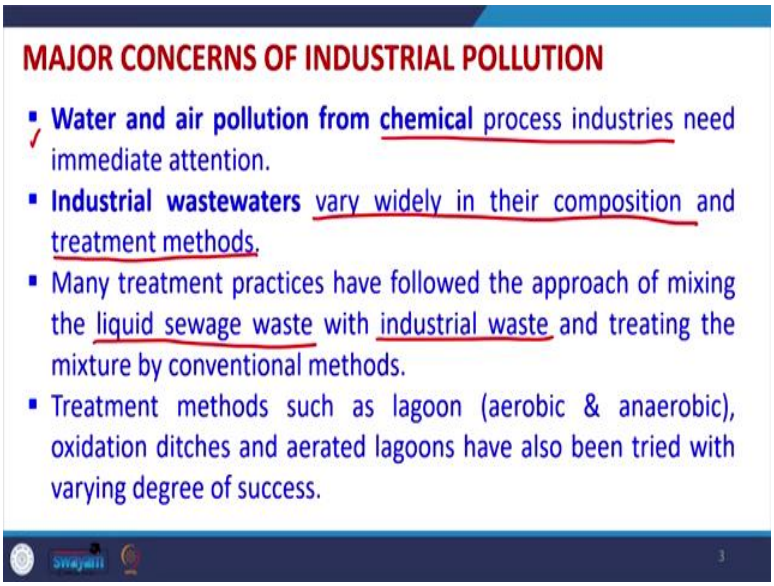
Similarly, this because of the CO_2 and other greenhouse effects are also increasing. Because, of the uses of lots of CFCs and other types of material for refrigerant, the ozone layer depletion is well-known. But, in this present course, we will be discussing more regarding the water scarcity, or in particular, how to tackle the water issues in particular the water pollution.

So, how to take care of the needs of the society with respect to drinking water, irrigation water, industrial water. And after their uses in various residential and colonies as well as in the industries, how to take care that these contaminated water is not discharged back into the aquatic bodies. So, that these aquatic bodies still remain as such.

So, all these aspects we will be covering in the present course. Water scarcity is highly alarming. All those places were 20, 30 years back, water scarcity was never thought of, now there is the water drinking water is also not available. If it is available, it is contaminated with lot of materials, which because of which the water cannot be used for drinking.

Similarly, because of overexploitation of water for irrigation and for various other purposes, the groundwater depletion has occurred in most of the places in the country. And because of which the availability of groundwater has also gone down. And we have to see that how we can tackle these problems, which are increasing day by day.

(Refer Slide Time: 6:55)



Going further, because of industrialization, the industrial pollution has increased, and this industrial pollution has caused a lot of issues. So, what are the major concerns that are associated with industrial pollution? Water and air pollution from chemical process industries need highly immediate attention.

Now, the Chemical and Process industries, they make lots of chemicals and products, which the society needs. And these came these products cater our day to day needs, starting from morning

till in the night. Now, all the products that we see, generally day to day life is starting from maybe clothes, all the material that we use, all the plastics, these everything is made from petrochemicals, or some other chemicals.

So, the uses of chemicals, petroleum products, petrochemical products has increased day to day life. And because of that, these chemical and process industries are increasing. And the water and air pollution from these industries is different as compared to that from municipal wastewater.

So, the treatment strategies or the control strategies with respect to water endure also need to be different as compared to from common sources, where the pollution is occurring. So, these the water and air pollution from these industries require immediate attention.

Similarly, industrial wastewater, which is generated from these industries as well as various other industries, they vary widely in their composition and their characteristics may be entirely different. So, some wastewater may be highly acidic, some wastewater may be highly basic.

Similarly, the pollution load in some of the industries may be entirely different as compared to other industry. Similarly, the some key type of elements may be present in one industrial wastewater, which may not be present in another wastewater.

So, depending upon the industry, where this manufacturing is occurring, and from where this wastewater is getting discharged, so, their composition is likely to be highly heterogeneous. So, under that condition, the treatment methods also need to be well understood.

So, that we can apply different treatment methods. And their strategy of application has to be different and that will vary depending upon the composition, or the type of wastewater being discharged from that particular industry.

Many treatment practices, that we are following in our country, many times they require what they do is that mix the liquid sewage waste, which is like municipal wastewater, along with the industrial waste and then they treat the water by conventional method.

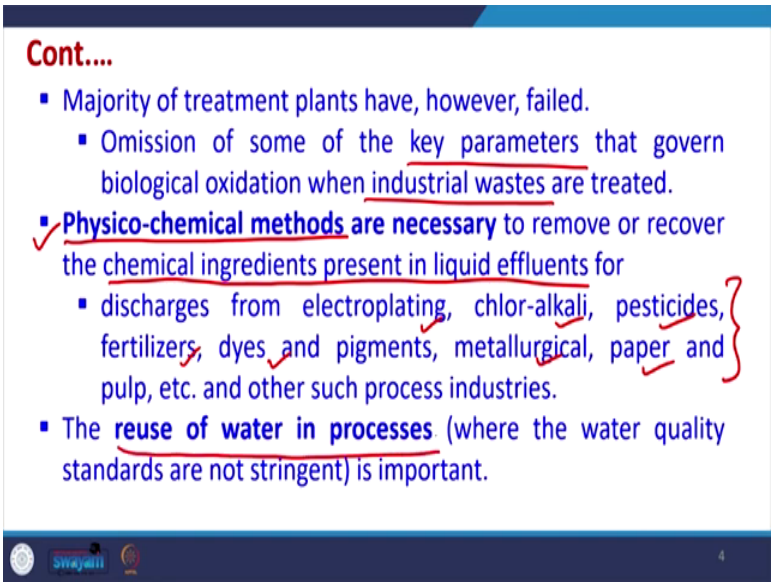
This may not be accurate and we have to see that the treatment of industrial wastewater has to be done up to a certain level, before mixing the municipals sewage. Because, their characteristics are entirely different and the conventional treatment methods, which are used for treatment of municipal wastewater may not be correct for treatment of industrial wastewater, because they

may contain different types of pollutant, which are entirely not present in the municipal wastewater.

So, we have to understood, the characteristics of the wastewater as well as understand the various treatment methods and their basic, knowhow that how they work out what are their possible efficiencies and which type of water quality parameter they are able to remove as compared to other methods.

So, if we have that understanding, we can develop a treatment train for some particular wastewater, which may not be applicable for another industrial wastewater, or municipal wastewater. Treatment methods such as lagoons, aerobic or anaerobic, oxidation ditches, aerated lagoons have also been tried, but they may not be good enough for treatment of industrial wastewater in particular.

(Refer Slide Time: 11:55)



Majority of traditional treatment methods, if they have been applied for industrial wastewater, they have failed. And because these conventional treatment methods, they are not able to remove various other pollutants, which are present in these industrial wastewater and they are not able to remove. So, these pollutants remain in the water after treatment also.

So, omission of these key parameters, we have to see that these key parameters still have to be taken care of while the treatment of industrial waste is being done along with the biological treatment as well as other treatment methods. So, we have to see that, that how we can take care

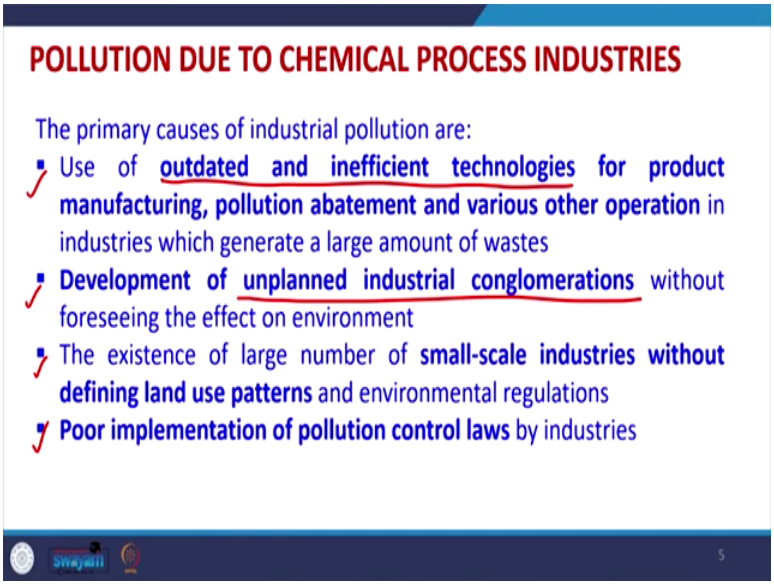
of these key parameters, which are may not be present in the municipal wastewater, but they are present in the industrial wastewater.

So, for treatment of such wastewaters, which have some different parameters, we require physico-chemical methods for treatment of such wastewater. And these methods are necessary to remove, or recover the chemical ingredients, which may be present in their liquid effluents for many industries, like electroplating, Chlor-alkali, pesticides, fertilizers, dyes and pigments, metallurgical, paper and pulp, etc.

So, all these industries which are there, their composition may varied entirely. These wastewater may contain some key parameters, which will be entirely different than other industries. And certainly these parameters are different as compared to municipal wastewater. In addition to treatment of wastewater, the reuse of water in the processes, which are being practiced in these industries is very, very important.

So, we should try to recover most of the water and reuse in the processes industrial processes, so that the actual water demand decreases and the actual wastewater, which is has to be discharged is also lower in quantity.

(Refer Slide Time: 14:27)



Now, the pollution due to chemical process industries, the primary causes of industrial pollution in the chemical process industries is because of the use of outdated and inefficient technologies. So, many of these industries are very small, and they practice inefficient technologies, they are

using such technologies, which are outdated, and they are not able to remove these key parametric water quality parameters, which may be there in that industry.

So, we have to see that these outdated and inefficient technologies, which are there for product manufacturing, pollution abatement, and various other operations, which are being practiced in these industries. They have to be omitted, and new technologies had to be used in these industries. Also, in our country, the development of unplanned industrial clusters without forcing the effect on environment has been done.

Now, in last few decades, the government is taking lot of care with respect to these aspect, that we have industrial clusters, where maximum care of environment is taken. But still there are many places where these unplanned industrial clusters are there, and we have to see that how the environment is still taken care of in these old clusters are any new industrial cluster, if it is getting develop.

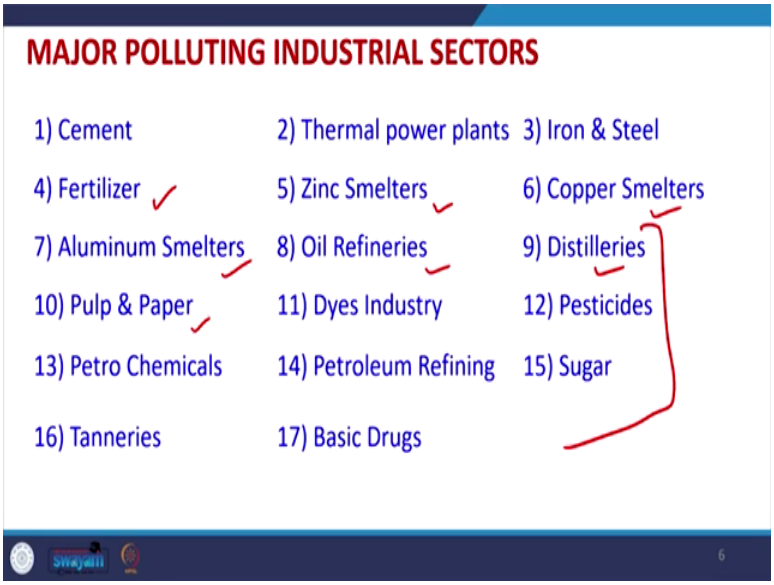
The existence of a small number of, large number of small scale industries. So, in our country, there are many industrial units are there, so that may be textile, dyeing, tannery that will be pulp and paper industry. So, we have a lot of small-scale industries also.

Now, these industries do not want to incur money on the wastewater treatment, or other environmental pollution things, because these control strategies require a lot of land. In addition, they require a lot of capital cost as well as operational costs.

So, the existence of these large number of small scale industries, which actually resist using money on these pollution control norms, is a challenge and we had to see that how they can be, we can develop technologies which can be used by these small scale industries.

Now, the poor implementation of the pollution control laws by the industry is one of the basic problem, which is there with respect to pollution which is occurring from these chemical process industries. And certainly this implementation aspects have to be improved for checking the pollution, which is happening because of these industries.

(Refer Slide Time: 17:43)



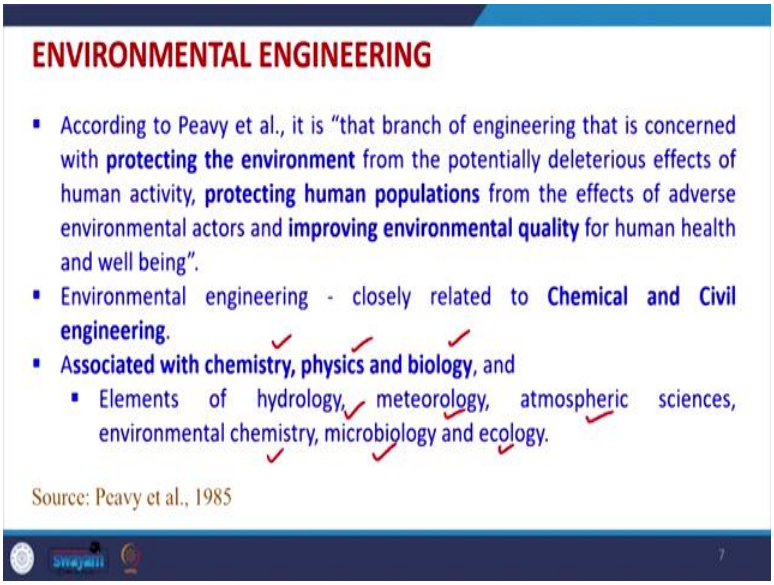
There are many major polluting industrial sectors in the country, and these are listed here and many of the other new type of industries are evolving in our country. So, there may be industrial sectors beyond these sectors, where which are considered to be highly polluting.

So, these include, so and this pollute this polluting nature is here referred to with respect to both air, water, soil, but some of the industries may be having more air pollution, some of the industries may be having more water pollution. So, we had to see, but the common industries are listed here. So these include cement, thermal power plants, iron and steel industries, fertilizers, where different types of water may be getting discharged having different characteristics.

Then Zinc smelters, Copper smelters, Aluminum smelters. Then, oil refineries, distilleries, Pulp and Paper, dye, all these industries are major chemical and process industries, which generate lot of pollution. And they are these chemical and process industries, they also not only generate what wastewater in high quantities, their characteristics are entirely different and pollution load is also high as compared to municipal solid, municipal wastewater etc.

So, we require basic understanding of various physico-chemical processes for using them properly in these industrial sectors so that the water wastewater after treatment is good enough to be discharged as per the government of India norms.

(Refer Slide Time: 19:58)



Now, environmental engineering as a subject is evolving very quickly. And in the last few decades, it has become very, very important. Traditionally, environmental engineering was considered to be a part of civil engineering, but many other disciplines of engineering in particular chemical engineering is now playing a major role, along with that many science disciplines are coming into picture.

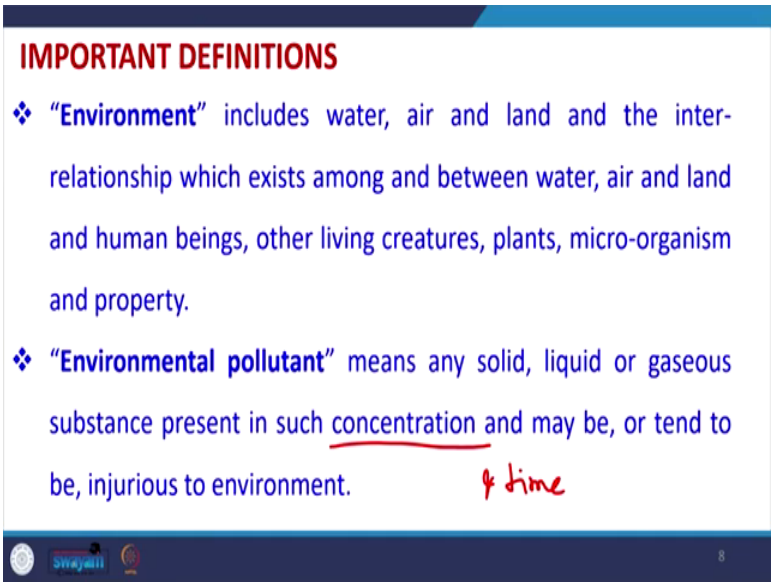
Now, environmental engineering as per definition, as per the book Peavy et al., It is that branch of engineering that is concerned with protecting the environment from potentially deleterious effects of human activity, protecting human populations from the effects of adverse environmental factors and improving the environmental quality for human health and wellbeing.

In general, the environmental engineering, environmental engineers need to protect the environment protect the human population from the effects of the environmental changes. And also improve the environmental quality. So, that the human health are the life any other life health and wellbeing is maintained.

So, this particular branch is more closely related to chemical and civil engineering as compared to other, but it is associated with other disciplines as well which includes chemistry, physics, and biology. And also it has lots of elements of hydrology, metrology, atmospheric science, environmental chemistry, microbiology, and ecology. So, these things are there.

So, it is a more of interdisciplinary branch with major content from chemical and civil engineering. So, this is there and this particular aspect is evolving a lot and its importance in the society is increasing day by day.

(Refer Slide Time: 21:48)

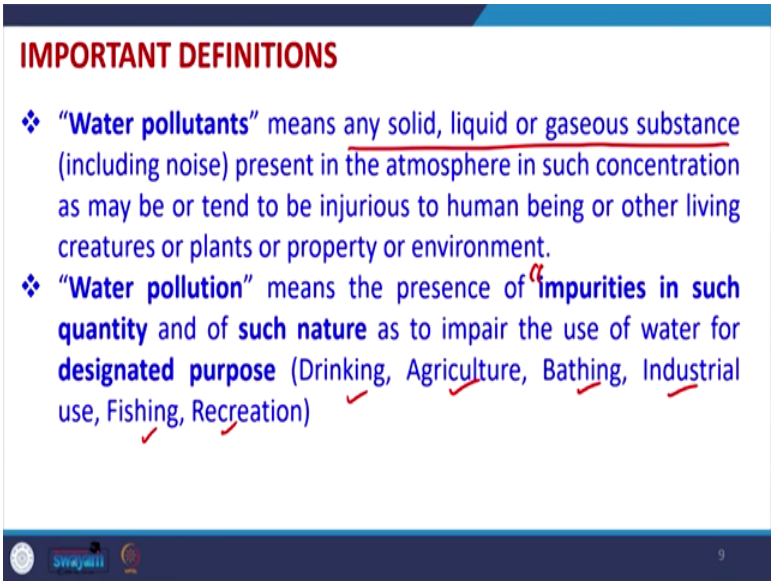


Now, some of the important definitions, which are there with respect to environment, or environment pollutants are given here. So, environment in general is water, air and land and the internal relationship which exists among and between water, air and land and human beings and other living creatures, plants, micro-organism and property. So, this is how the environment is defined.

So, similarly environmental pollutant means any solid, liquid, or gaseous substances, which is present in such concentration and maybe, or tend to be injurious to environment. So, any substance, if it is present in quantity beyond a certain concentration, after which it starts affecting the environment, it is considered as environmental pollutant. Many of these pollutants will not be considered as pollutant if they are present in below certain concentration limit.

So, concentration is the key parameter with respect to defining whether anything is environmental pollutant or not. And also sometimes, or many times, how much time that pollutant is present at that concentration that also affects the its definition, that whether it is a pollutant or not. So, concentration and time, these are two important parameters based upon which the pollution term or pollute environmental pollutants are defined.

(Refer Slide Time: 23:16)



Water pollutants means any solid, liquid, and gaseous substance, including noise, if present in the atmosphere in such concentration as may be or tend to be injurious to human being, or other living creatures, or plants, or property, or environment.

So, any of these solid, liquid, gaseous substances, if they are present in the atmosphere, beyond a certain concentration. And if they are affecting human beings, or other living creatures, plants, property, or environment they are considered as water pollutant.

Now, water pollution means the presence of impurities in such quantities. So, the quantity is very important and of such nature so as to impair the use of water. So, if any water is there and it has certain impurity present in such quantity that we cannot use it the water whatever designated purpose may be drinking, maybe irrigation, maybe bathing, maybe industrial use, maybe fishing, maybe recreational, then that will be called as water pollution.

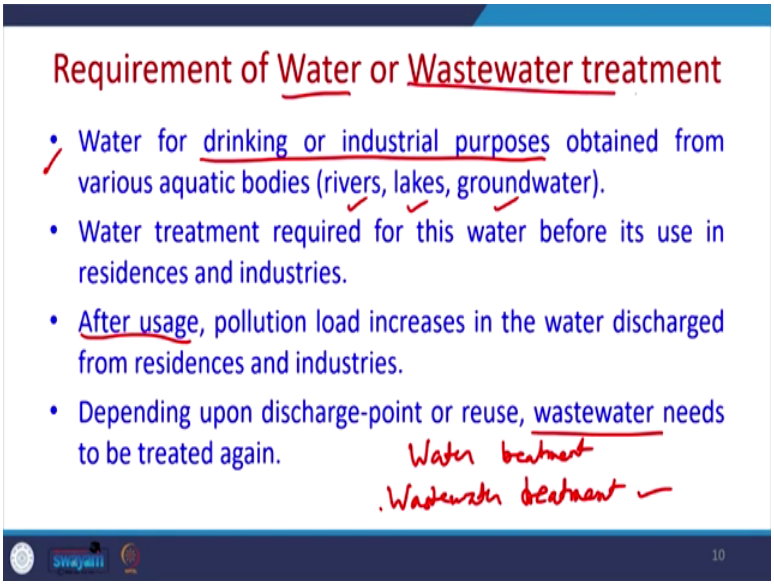
So, remember, suppose we have to use a water for drinking, and it contains some pollutant, so certainly that pollutants should be present in mineral water quantity because that can affect us if we drink that water.

Now, suppose the same water has to be used for agriculture. Now, we can go on beyond that concentration and maybe use some more concentration can be avoided in agriculture. Similarly, for bathing also we can avoid a little higher concentration. So, concentration is very important parameter with respect to the designated purpose for which water is to be used.

Now, similarly, some of the impurities that may be there for some designated use, they will not be considered for other designated use. Suppose we have to use a water for steam formation in industry. So, under that condition we have to avoid all the TDS etc., because that will form a scale if it is present in the water and if it is used for steam generation.

Now, the same drinking water it is possible that we can use it for drinking or bathing. So, one key parameter it is possible that it has to be totally avoided for one designated use, but it may be used for other purpose. So, any of these, both concentration, time and then the designated purpose for which the water has to be used that becomes very, very important.

(Refer Slide Time: 26:19)



Why are we required treatment of such water or wastewater? Now, water for drinking or industrial purposes obtained from various aquatic bodies. So, we take water from rivers, lakes, groundwater, etc., and we use it for drinking or any other industrial purpose. Now, if the water is not good enough for drinking, then we have to treat that water.

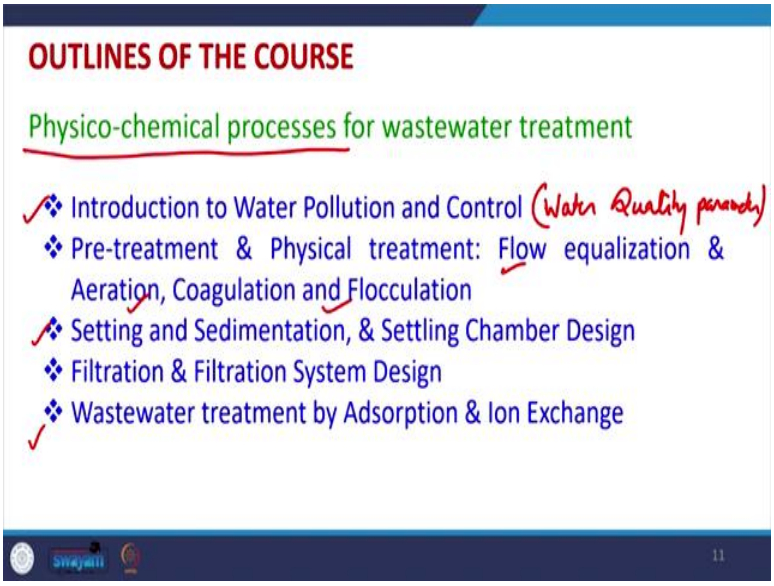
So, water treatment is required for this water before it is used in the residences or industry. Now, once they are used, after uses, the pollution load will increase in the water discharge from these residences and industries. So, depending upon the final discharge point or reuse of this water the wastewater, which is discharged needs to be treated again. So, this has to be done for uses.

So, we have two terminologies one is called water treatment, and another is wastewater treatment. So, water treatment means that the water, whichever water we are getting from river,

lakes, and reservoirs, that has to be treated before it is used. Wastewater treatment means that after the uses of the water, whichever water is discharged, that has to be treated further before discharging the water into any endpoint or discharge point. So, that is wastewater treatment.

So, this wastewater is the water which is already used. And water treatment means the water we are getting from natural sources like reverse, Lake, groundwater that has to be treated if it is containing any pollutant, or any undesirable thing before it is used. So, these are the, that is why there are two terms water treatment, and there is another term which is called as wastewater treatment. So, remember this.

(Refer Slide Time: 28:25)



Now, what we will be studying in this course? So, this is given here. So, this particular course will be discussing physico-chemical processes for wastewater treatment. So, in the wastewater treatment or water treatment, both physico-chemical and biological treatment are done.

So, some industries do not require biological treatment because they generate the water which is having as such that characteristic that the usual conventional biological treatment cannot be good enough for treatment. So, many times only physico-chemical processes may be required.

Similarly for water treatment in our residences. So, you must all of us have seen that a small, very small units are installed in each and every residence, where the groundwater, or the water which is obtained from municipal that is treated further.

So, we have a lot of these small-scale water treatment units. So, they do not use any biological treatment. Generally, they will be using only physico-chemical processes for wastewater treatment. So, this particular course will be only concentrated on physico-chemical processes for wastewater treatment.

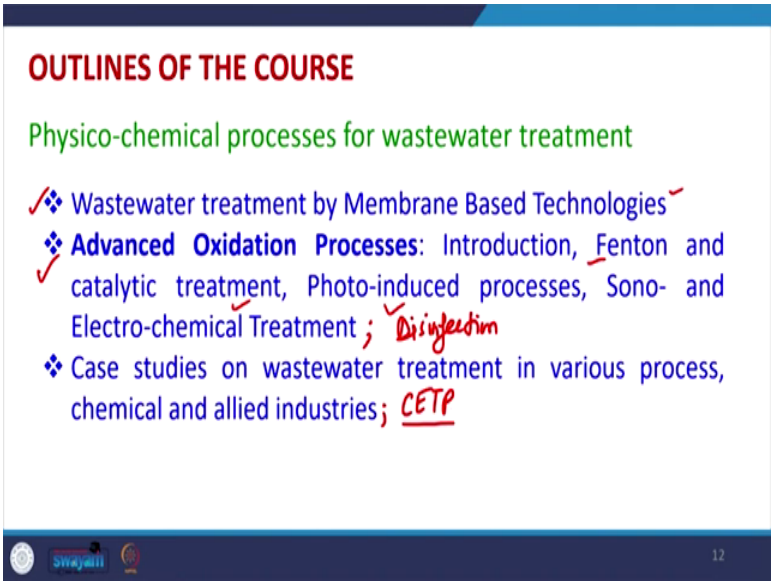
So, we will be starting with the introduction of water pollution and control. And within this section we will be studying in detail the water quality parameters. So we will be devoting lot of time with respect to water quality parameters. What are different physico-chemical water quality parameters? And how they are analyzed? What are the basic understanding of these water quality parameters? So, what are their effects on the environment on human health, or other uses?

So, we will be covering all these aspects in the introduction of water pollution and control. Within this we will be discussing regarding the pollution control norms, etc., also and also what are the different standards which have been prescribed by government of India. So, we will be covering everything of this in the introduction.

So, they will be this will be the first section. After that, there will be a pre-treatment and physical treatment section. So, wastewater treatment strategy actually involves three, four stages. So, that these include pre-treatment, physical treatment, biological treatment, then tertiary treatment, so, we will be avoiding will not be discussing biological treatment, but we will be discussing pre-treatment, physical treatment, tertiary treatment, etc., in this particular course.

So, we will be discussing flow equalization, aeration, coagulation, and flocculation. After that, we will be discussing settling and sedimentation, the settling chamber design, certainly. Then filtration and filtration system design. Thereafter, we will be going further and studying the water and wastewater treatment by adsorption and ion exchange.

(Refer Slide Time: 31:48)



Further, we will be discussing the wastewater treatment via membrane-based technologies. So, that will include microfiltration, ultrafiltration, nanofiltration, and reverse osmosis. So, these are being practiced a lot nowadays. So, we will understand all the basics and little bit more detail of these technologies. Further on, we will be discussing the advanced oxidation processes.

Now, it is a large number of chemicals, and newer types of chemicals emerging pollutants are there and these are getting produced from pharmaceuticals, insecticides, various other types of chemicals, including surfactants, etc. So, these chemicals are coming slowly and slowly into the water. And many traditional chemicals, which are produced by industries, they also cannot be treated by conventional means.

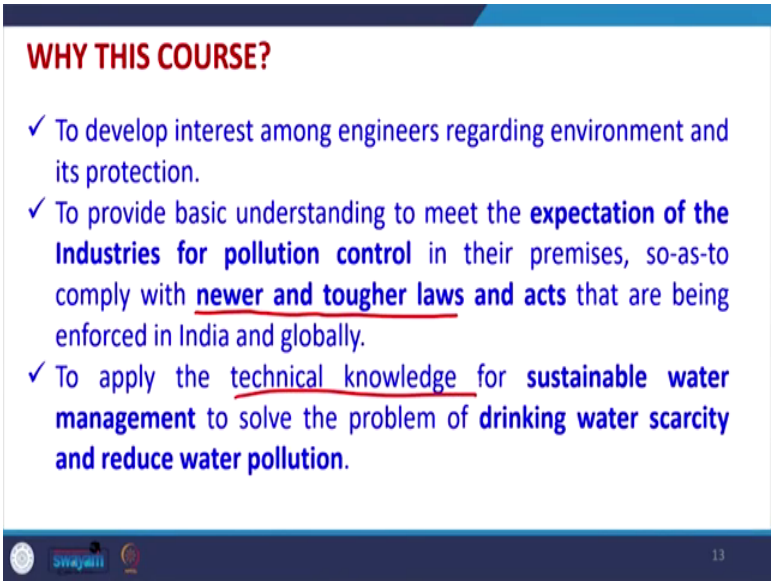
So, these pollutants need to be mineralized. So, for this we have, we have to use advanced oxidation processes. So, we will be discussing regarding the advanced oxidation processes in detail, including Fenton processes, catalytic treatment, Photo-catalysis, Sono and electro chemical treatment methods, and their hybrid combinations as well.

And these processes can also be used as disinfection process, because new types of bacteria, virus and pathogens are coming into the water. So, many of these advanced oxidation processes, they can be used for disinfection. So, we will be discussing that disinfection, also within the advanced oxidation processes.

Going further in the last we will be discussing wastewater treatment in some of the chemical and allied industries, as well as in the common effluent treatment plant. There is a term, which is called as CETP. So, we will be discussing the how the treatment of water, wastewater can be done in these industries.

Some examples we will be taking, so that we can understand that what is the how the treatment strategy depends upon the wastewater characteristics, which are discharged from different industries. So, in the last, we will be doing that. Similarly, in industrial clusters, the utilization are uses of CETP is increasing. So, we will be discussing common effluent treatment plant in the last. So, this will be the course content of this particular course.

(Refer Slide Time: 34:42)

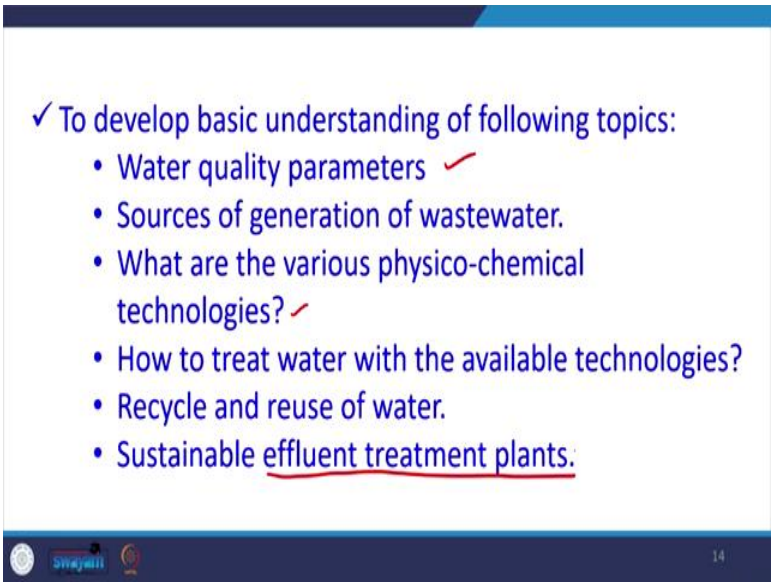


Why attend this course? It will help you understand the various environmental challenges and its protection in particular the water issues. Also, it will provide the basic understanding with respect to what should be the expectation of the industries with respect to pollution control within their premises.

And what are the new and tougher laws and acts that are being enforced in India and globally. So, these are going to be enforced anyhow. So, we should have the basic understanding that how different types of physico-chemical operations, or unit operations can be used for wastewater treatment. So, this knowledge will be provided in this course.

So, we will be getting a lot of technical knowledge for sustainable water management, and also we will be getting to know that how we can use these strategies for getting drinking water as such. So, all these aspects we will be covering within this course.

(Refer Slide Time: 35:51)



So, this particular course will be providing the basic understanding of water quality parameters. Sources of generation of wastewater in various industries. What are the various physico chemical process technologies? And how they can be applied in the industries? How to treat water with the available technologies depending upon the composition of the water? Some recycle reuse aspect of the water will be covered.

And also we will be understanding the how the effluent treatment plants can be better designed via using these physico chemical processes. So, all these aspects we will be covering in this course, you are welcome to understand all these physico-chemical aspects and the all these will be covered within this course.

(Refer Slide Time: 36:43)

So, these are the references that I have used in the present slide. Thank you very much.