Basic Environmental Engineering and Pollution Abatement

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Lecture 01
Introduction

Hello everyone, I welcome you all to this course, Basic Environmental Engineering and Pollution Abatement. This is the first module of this course and I will give you some introduction on this subject in this class. As you know, in 21st century, energy security and clean environment are two major concerns. Due to ever increasing population urbanization and industrial growth, pollution generation is increasing day by day around the globe resulting many disadvantages or health impacts on human as well as different living organisms and it is changing the climate across the globe.

In short, we can say that in 21st century our sustainability is under threat, so to ensure the sustainable development of the society it is very essential to reduce and control the environmental pollution and this can be done if we can create more awareness among the common people and we know the basics of environmental engineering along with other engineering and science subject.

We also have to be more responsible when we are taking some new initiatives, so that we will be taking sufficient measures to protect the environment. We also need some guidelines, some regulatory framework so that the system works nicely.

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So, in this module, we will discuss on this topic that is environment and its components, natural interactions and cyclic processes for clean environment, society and environmental pollution, environmental pollution and sustainability, environmental pollution prevention and control, environmental ethics global imperatives and environmental laws, and environmental sciences, environmental engineering and environmental studies, so we will have some overall discussion on these topics.

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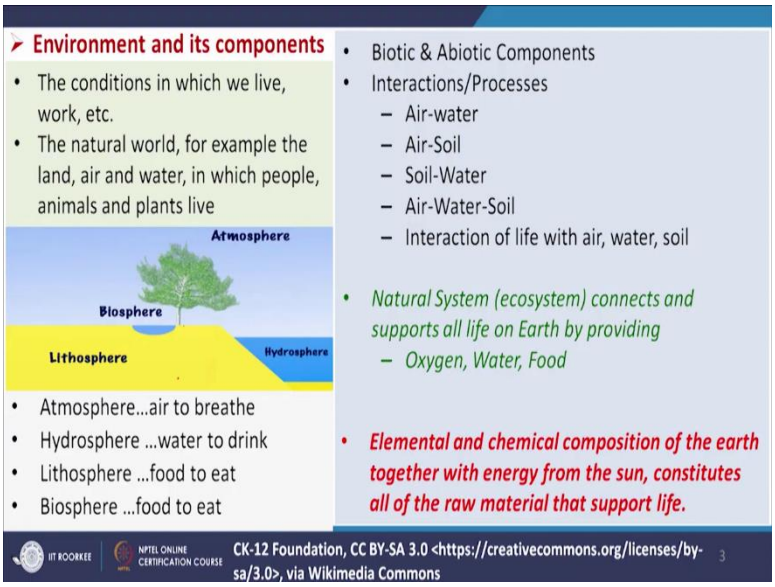

So, you see what is environment? So the condition in which we live work etc., that is our environment or you can say the natural world. For example, the land, air, and water in which people, animals, and plants live, so that is our environment. And if we see the components of environment, then it has both biotic and abiotic components. Biotic components are all living organisms and abiotic components are soil, water, air, and energy is also an integral part of this environment or the ecosystem.

These abiotic and biotic components of environment they have some interrelation like say Air-Water, Air-Soil, Soil-Water, Air-Water-Soil or Interactions with the biotic and abiotic components also. And we know that this natural system or ecosystem that connects and supports all life on earth by providing oxygen, water, food, and services. If we see the environment has four parts, that is Atmosphere, Hydrosphere, Lithosphere, and Biosphere. So, atmosphere gives us air, lithosphere that is related to soil and gives us food, and hydrosphere gives us water, and biosphere is that part where living organisms coexist with the non-living elements. And elemental and chemical composition of the earth together with

energy from the sun constitutes all of the raw material that support life. And in nature, the natural interaction and cyclic processes are available for clean environment.

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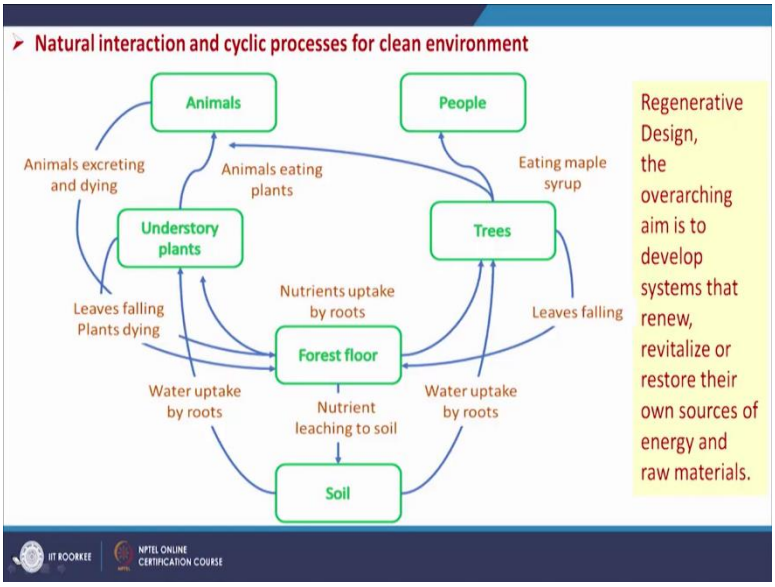

For example, in this figure if we see, we know that the trees and plants produce food from the sunlight using water and carbon dioxide, and that is taken up by the other animals including the human being, and after the growth of this human being and the other animals, the dead biomass comes into the environment from where again the nutrients enters into the soil as shown in this figure. So here, this is trees, and then plants, and we are the, people is taking from it **animals** are taking from it the food and they are growing and after that again it is coming to the forest floor, so these are the nutrients.

So, what we see here that in environment has some regenerative design, if there is some disturbance so it can accommodate it and it can revitalize or restore their own sources of energy and raw materials, this is the beauty of the natural environment. But, what is happening, due to excessive population growth many activities are taken up which are affecting the natural cycle process of the environment.

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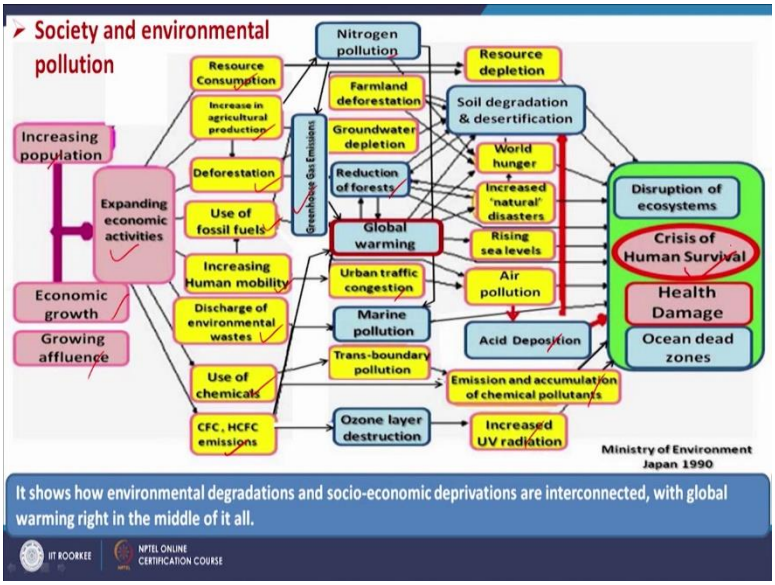

So, this slide gives up some idea about it you see when we are going for increasing population, so economic growth and growing affluences that means you know the prosperity of the human society, so those are compelling to expanding economic impacts and which are giving us some activities like say resource consumption, increase in agricultural production, deforestation, use of fossil fuels, and increasing human mobility, discharge of environmental wastes, and then use of chemicals, CFC, HCFC emissions. So, these are the inevitable consequences of the expanding economic activities and because of these activities we are getting some secondary and tertiary impacts which are interrelated in many cases to each other, for example say greenhouse gas emission we are getting, so that is nitrogen pollution we are getting, okay.

So, we are getting farmland deforestation, ground water depletion, reductions of forests, global warming, and then urban traffic congestions, marine pollutions, trans-boundary pollutions, ozone layer destructions, all those things are some impacts of these activities. And another impacts are also you see resource depletion, soil degradations, and desertification, world hunger, increased natural disasters, rising sea levels, air pollution, acid depositions, and emissions and accumulations of chemical pollutants, and increased UV radiations.

As a whole, the human survival is under threat, but this is the crisis of human survival. So, the human activities are responsible for the destruction of the cyclic process which is available in the nature. As a result, the ecosystem is being degraded and our environment is being polluted. Now, we will see how the wastes and pollutions are generated, what types of

wastes are there. So, if we classify the waste, we can classify it in based on hazardous and non-hazardous nature and they are based on phase also.

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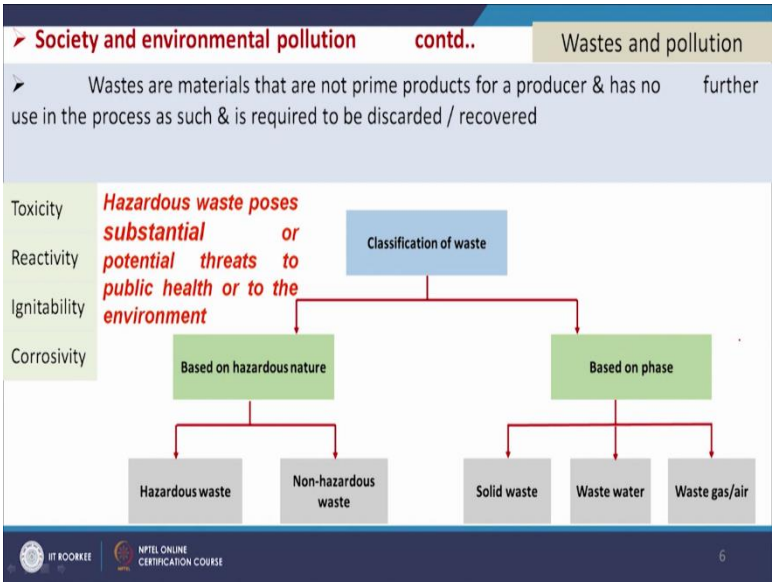

So, hazardous and non-hazardous, we know that the wastes are pollutants which are having certain properties like say toxicity, reactivity, ignitability, corrosivity or any one of these or any combination or all are having the hazardous characters and those are those wastes are those pollutants are hazardous pollutants or hazardous wastes and non-hazardous those are not having those characteristics and based on the phase the waste or pollutants can be in solid waste water or in gas phase also. And we see, the economic development influences the waste generation.

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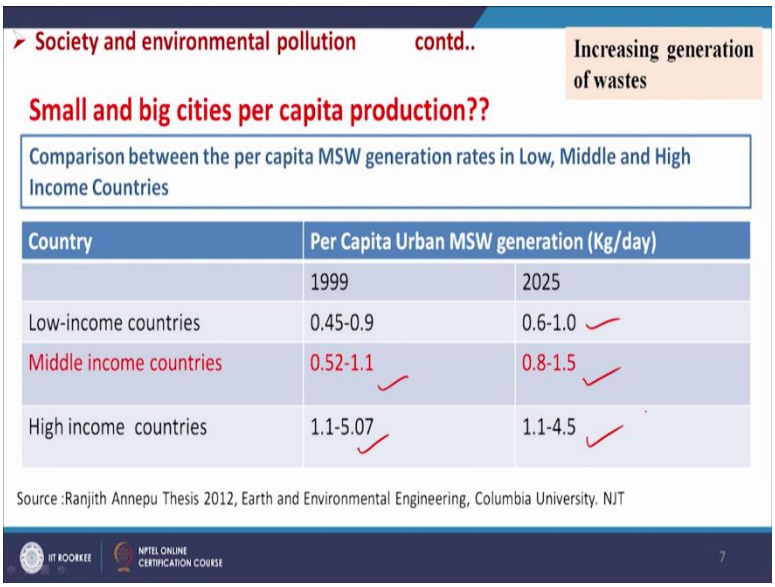

This table shows us some information that is low-income countries, middle income countries, high income countries, higher the per capita urban MSW generation is increased during past few years 1999 and it is predicted in 2025. So, you see that low-income countries 0.45-0.9 to it is coming to 0.6-1.0 but for middle income 0.52-1.1 to 0.8-1.5 and for high income countries 1.1-5.07 to 1.1-4.5. So, what we see that with economic development, the waste generation is increasing gradually.

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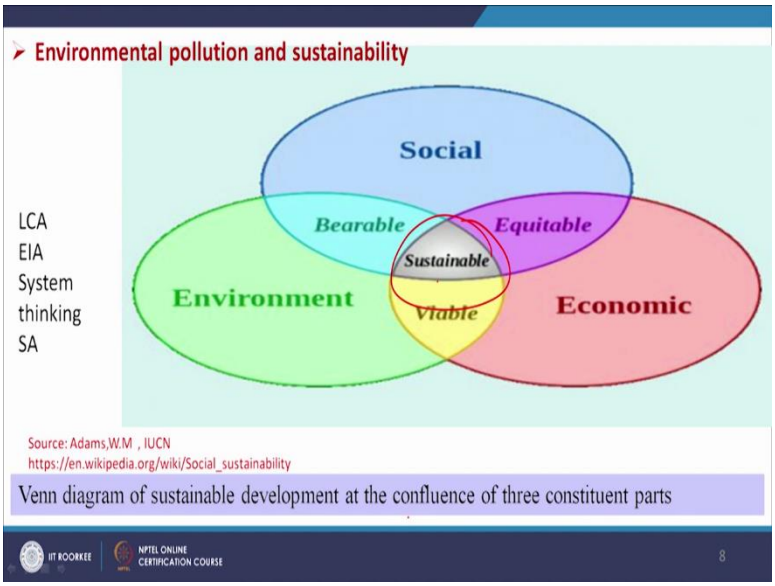

And due to this, our existence, the sustainability is under threat. We know to make a system sustainable or to make a process sustainable, it has to be economically viable, it has to be environmentally bearable, and it has to be socially equitable, so this is our sustainable, so this zone, okay.

So, since the environment is disturbed due to the pollution so we cannot attain the sustainable society although we can achieve the economic target and social equity but still the system cannot be sustainable, to make the sustainable environmental sustainability is essential and for that we have to do something. What are those? we can do the LCA analysis, Life Cycle Analysis of any processes or any system and we can take a decision for its modifications for a changes etc.

And then environmental impact analysis that is also practiced and system thinking can be implemented for any new initiatives, so that we will think about the every stakeholders not a linear thinking and the cause and effect relationship. And sustainability analysis will also be tool that has to be implemented for any process to analyze or new initiatives the what will be the impact to the environment, so that the environment can be saved.

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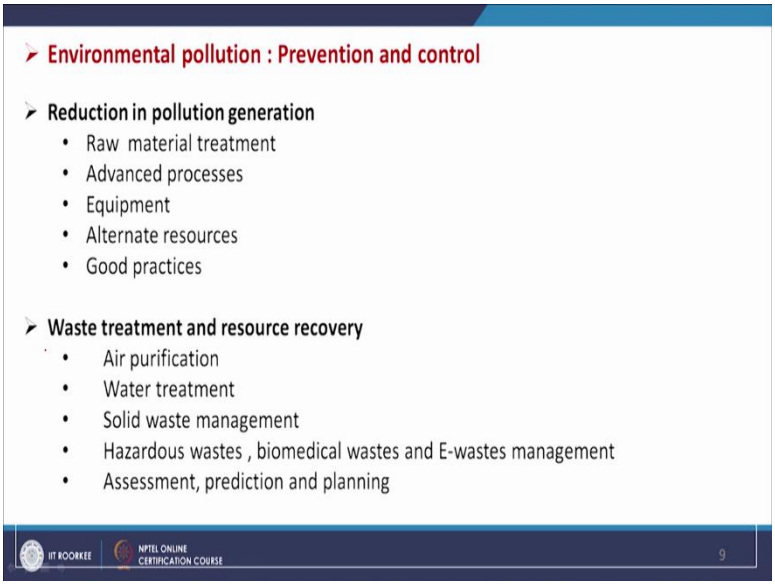

Now, we will be talking about the prevention and control of pollution. You know, we know very well that for any problem prevention is better than cure, so our first approach will be to prevent the environmental pollution, so that the more pollution is not generated. And in the second step, if some pollution is generated then we can develop some control strategies and methodologies to control the pollution, so that way prevention and control can help to improve the environmental quality. So, how it is so the prevention that is reduction of pollution generation that we can do by raw material treatment.

So, when we are using a process, for example, say coal combustion we are using flue gas and then it is used in a thermal power plant for electricity production. In that case, if we remove the sulphur from the coal prior to its application, then shocks emission will be reduced, so environment will be saved. So, raw material treatment is an step which can help us to reduce the pollution generation.

And Advanced processes, we can use some developed processes so that it will be able to generate less pollution to achieve or to give the same amount of work, to perform the same job. Like say example, say one is your conventional combustion and another is your oxy fuel combustion, so in oxy fuel combustions we will be using oxygen in place of air, so the carbonaceous material will be producing flue gas which will be rich in carbon dioxide, so separation of carbon dioxide and its sequestrations will be very easy, so it will not come into the environment.

And equipment, we can improve the equipment like say fixed bed reactor combustor to flow is with combustion reactor or combustor in by the modifications in the equipment, we are

able to reduce the pollution load to the environment. And, alternate resources like say coal petroleum and natural gas, we use for the production of electricity which are creating large number of pollutions into the environment, we can reduce its use, we can use the renewable energy resources like solar energy, hydro energy, etc. so that our energy production will be achieved but environmental pollution will be less, so that way also it can be possible and good practices.

You know by applying good practice also we can save good amount of energy losses, so when we are able to save energy losses, at the same time we are able to maintain or reduce the pollution generation during the production of that amount of energy in a thermal power plant. Ultimately, we are able to reduce the pollution load to the environment.

Now, waste treatment and resource recovery this is another aspect, you know when we are not able to prevent then pollution is being generated we have to treat it and we have to recover valuables from that stream.

So, this is the latest research area, the many people are working the waste to wealth, okay, this concept. So here, we can work on the air purification, we can work on water treatment, we can work on solid waste management, we can work on hazardous waste, biomedical waste, e-waste management, and we can work on assessment prediction and planning. So, these we will be discussing in subsequent chapters regarding this all control aspect or treatment and management aspect. Apart from this, we need assessment of the pollution, we can be in a position to predict what will be the pollution after 10 years, after 20 years, after 5 years, long term and short term and accordingly, I have to take a planning or decision, so those things are very very important, so for that we need to understand the principles of environmental engineering and sciences.

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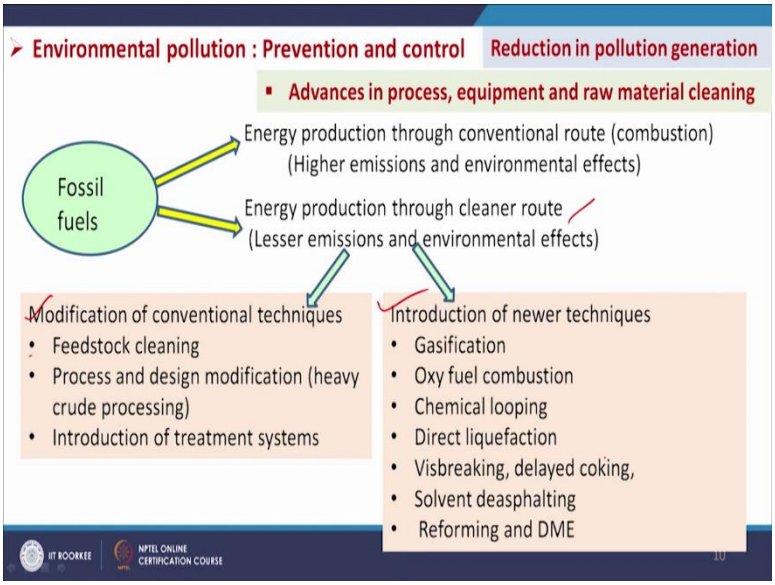

Now, I will give you some example here, this slide that is reduction in pollution generation, already we have discussed also that energy production through conventional route that is combustion route, it gives up higher emissions and environmental effects but if we go for energy production through cleaner route that is lesser emissions and environmental effects and cleaner roads can be you know, modification of conventional techniques or introduction of newer techniques.

I have given you some few examples, here we are having some more examples, for say modification of feedstock, modification of conventional techniques like say feedstock cleaning, I have already discussed process and design modification, heavy crude processing, that is one example.

Another example, so crude, petroleum crude which is taken out from the interior of the well, so then dilution is made and then it is transported, so another approach is that that if the crude is heavier, then transportation is becoming difficult. We have to use more energy for its transport, we have to more diluent for it and ultimately more pollution. But if we process to some extent this heavier crude at the production site and transport it, then it may be possible to reduce the environmental load and that way the research is going on and technologies are being developed, so that is one.

An introduction of treatment systems, so if it is there that means some gas is say flue gas desulphurization techniques so for the separation of shocks or separation of NOx from the flue gas so different your introduction of treatment systems is possible to reduce the pollution.

Another introduction of newer techniques like say gasification, oxy fuel combustion, I have given one example and then chemical looping system, direct liquefication of coal, and then visbreaking, delayed coking, solvent deasphalting, these three visbreaking, delayed coking and soluble deasphalting are the residual upgradation of any petroleum refinery, and then, we can go for reforming a DME synthesis, Dimethyl Ether Synthesis.

So, natural gas can be reformed without going to your combustion route, we can, it can be reformed and then dimethyl ether can be produced, once dimethyl ether can be produced, the hydrogen can be produced, so the carbon dioxide emission to the environment will be reduced. And, this is another alternate sources of energy production, we can use other sources of energy productions in place of fossil fuel based energy.

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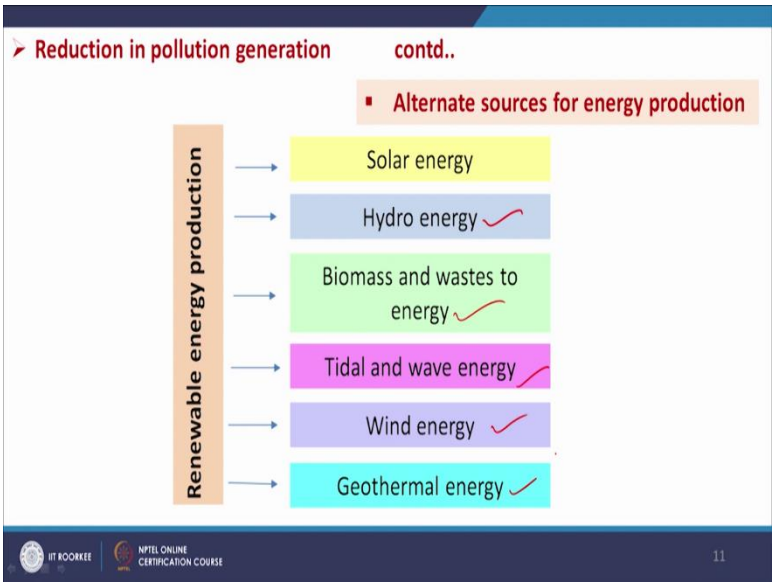

Like say, solar energy, we can use hydro energy, we can use biomass and waste to energy, and then tidal and wave energy, and wind energy, and geothermal energy, so these are some examples of renewable energy.

So, if we can produce energy through this routes and reduce the use of fossil fuels, as a result we will be able to save some environmental pollution, so pollution will be reduced. So, that good practice we have also talked about a good practice, one example here you see that energy conservation.

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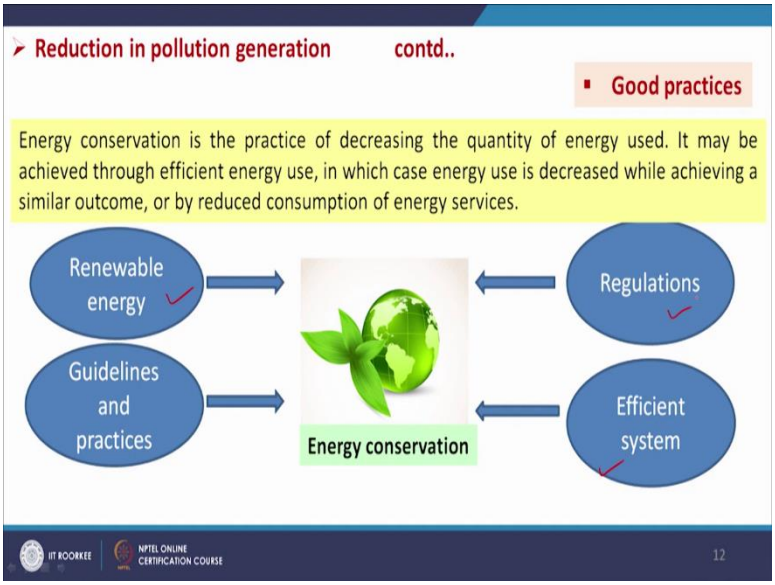

So, what is this energy conservation is the practice of decreasing the quantity of energy used, it may be achieved through efficient energy use in which case energy use is decreased while achieving a similar outcome or by reduced consumption of energy services. So, this energy conservation is a technique or a practice, this can be achieved by different ways one is efficient system, we can use efficient system, so that the energy loss will be reduced.

We can use renewable energy then also our emission will be reduced, we can frame some regulations so that there will be stricter control of the process, so that the permissible limits will be reduced, so ultimately environmental pollution load will be reduced.

And guidelines and practices, some guidelines are there, some practices may be there, like say for any individual event can develop some practice, all of us we can develop our practice, and when we are not in the room or not working anything will not put our fan switched on or tube switched on, so that can be a practice. We may prefer to use staircase in place of lift, when possible, so that way also that will be good habit and energy saving and as a result, the environmental pollution will also be reduced.

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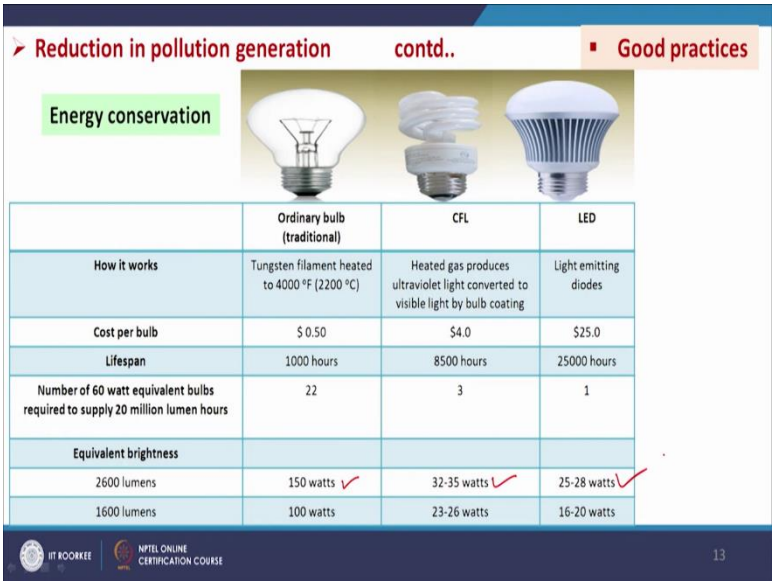

Another, you see with respect to energy conservation here, I am giving you some example, say we know that today we use the LED, prior to it we used CFL, prior to it we used ordinary bulb, so by the use of this technology and making it a practice, you see initially we need to invest more, but ultimately we get the gain from all aspect, economically and environmentally. You see here, what is the power requirement 2600 lumens same energy intensity, so 150 watts here for your ordinary bulb and here we need to 32 to 35 watts and for led we need 25 to 28 here watts.

So, as a result we are using very less amount of energy to get the same impact. So, initial investment is higher but we are able to save the environment by reducing environmental pollution and consuming lesser energy. So, that way this practice can help to improve the environmental quality. Similarly, the fans there may be on off operation or maybe continuous operation.

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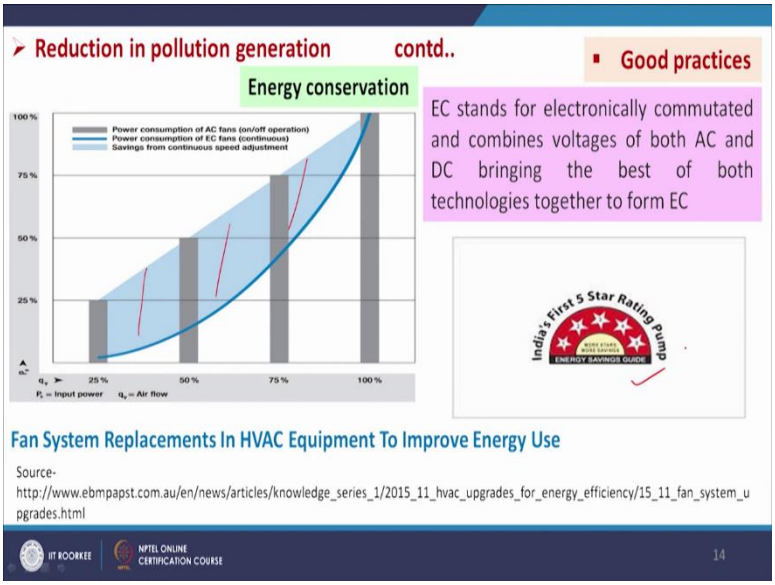

If we go for continuous operation, so then we will see that we can save this amount of energy, okay, this is for continuous operation this is for run of operation, so that is also practice we can purchase only 5-star rating elliptical appliance so the energy consumption will be less then the other one.

So, these practices will help us to get the environmental quality. And then, we are coming to the treatment, so wastewater treatment, we can do the waste water treatment that there are primary, secondary, tertiary treatment methods are there and through which we can reduce different types of pollutants present in the wastewater.

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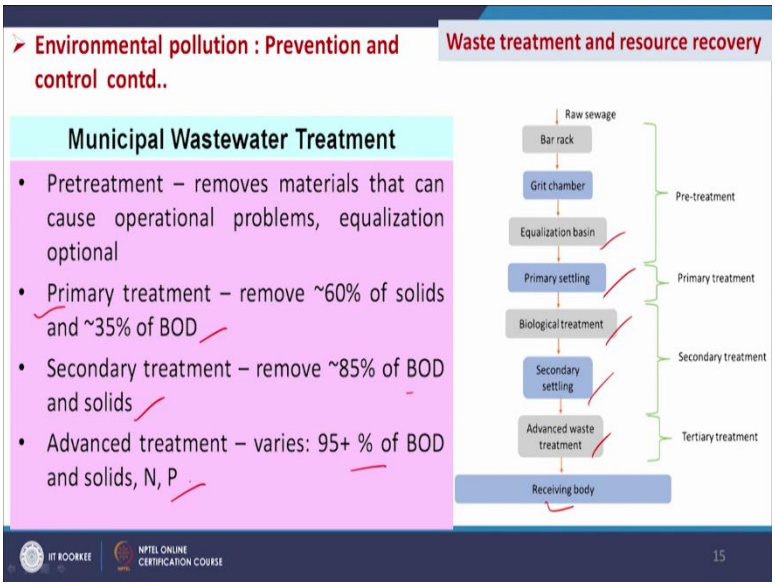

As example say, here bar rack, then grit chamber, equalization tank, primary settling, biological treatment, secondary settling, advanced treatment, and ultimately receiving body water, the treated water we can use for other application.

And we see the primary treatment remove 60% of solids and 35% of BOD and secondary treatment remove 85% of **BOD** body and solids and advanced treatment varies 95± of BOD and solids nitrogen phosphorous all those things are removed by this treatment methods, so we can develop techniques for the municipal solid waste management.

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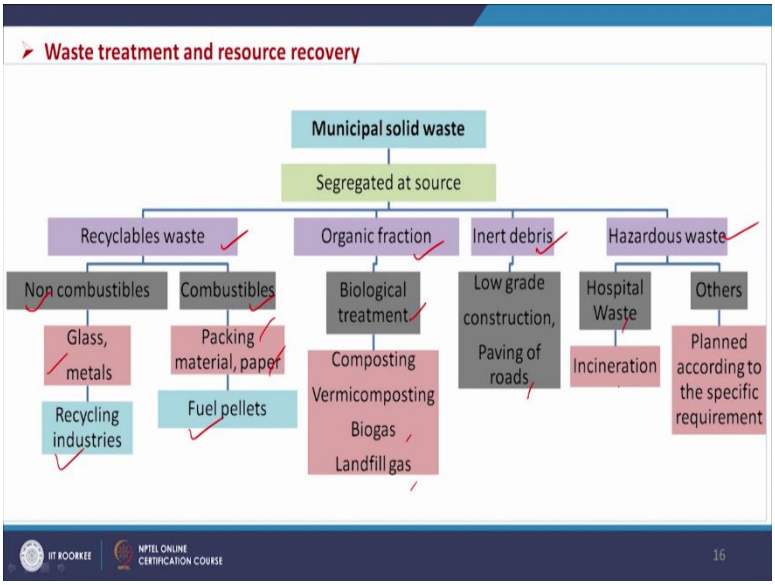

That is, you know, segregation of the waste at the source, that can be into segregated into different fractions, that is recyclable waste, may be organic fractions, may be inner debris, may be hazardous waste, and all those fractions will be managed in a different way likes a non-combustibles and combustibles out of the recyclable waste, if we have, then those will be managed in different way.

For non-combustibles glass, metals like that, that will go through the recycling and this packaging materials, papers, these combustible materials can be converted into fuel pellets and it can be converted into energy and organic fractions treatment it can be processed through and composting, vermicomposting, biogas, landfill gas, these are some methods which can be used. Inner debris can be used for low grade constructions and paving of roads and then hazardous waste that is hospital waste and others may be processed in as per the quality and the quantity of these wastes. So, we will be discussing in detail about all those things and as I told you that waste to wealth and waste treatment and wealth recovery is becoming a new concept and people are putting more effort to recover wealth from the waste.

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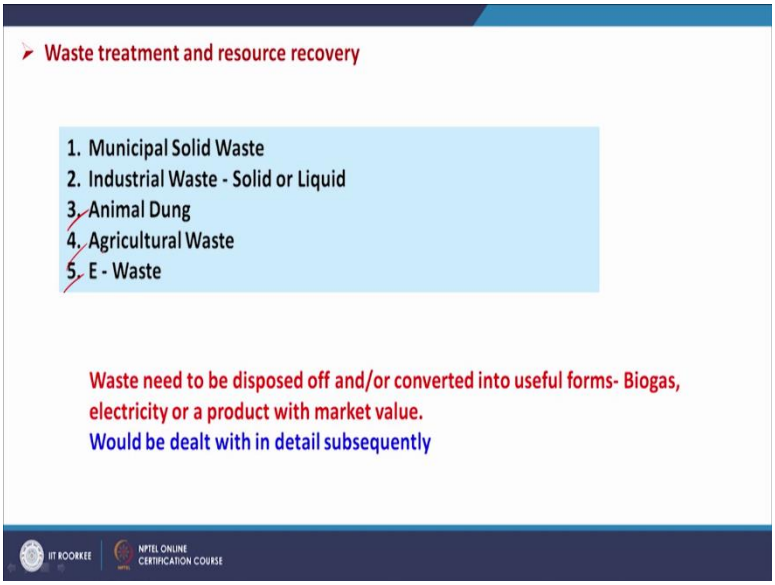

So, municipal solid waste, industrial solid waste, animal dung, agricultural waste, e-waste all are being investigated to produce valuables from it and for a better management of the system so that environmental pollution will also be reduced.

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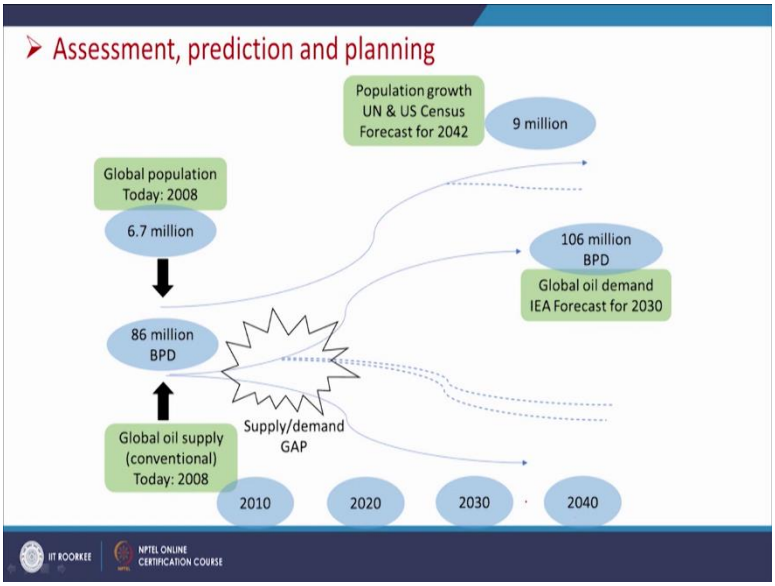

And as you talking about that I need to do some assessment or due to we need to do some predictions and we need to do some proper planning, so that is why this slide gives us some examples, the how the populations will increase in up to 2040 and how the energy demand will increase all those information's we need to study and take a decision. Then, you know we also need to take decision and planning for our future environment, clean environment.

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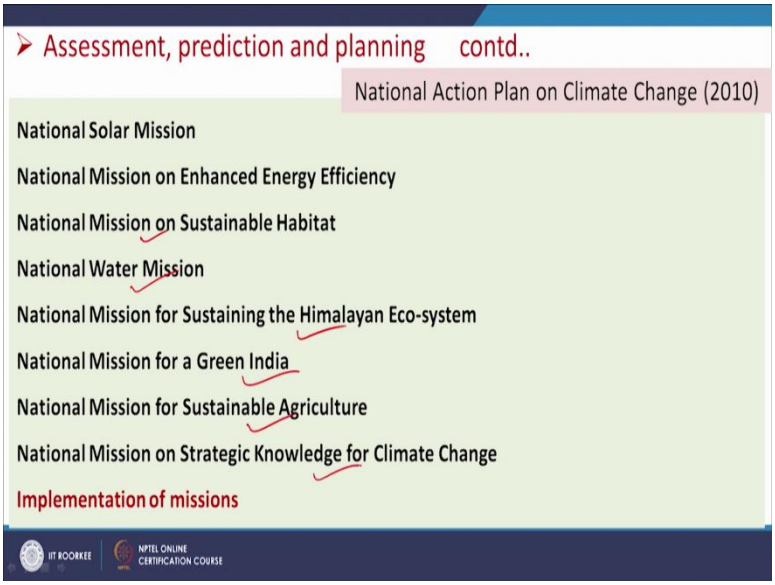

For example, you see National Solar Mission, National Mission on Enhanced Energy Efficiency, National Mission on Sustainable Habitat, National Water Mission, National Mission for Sustaining The Himalayan Eco-System, National Mission for a Green India, National Mission for Sustainable Agriculture, National Mission on Strategic Knowledge for Climate Change, and another is Implementation of these missions. Missions, we can mix, we can develop some missions but the implementation is most important, so that is also we have to do to ensure the clean environment.

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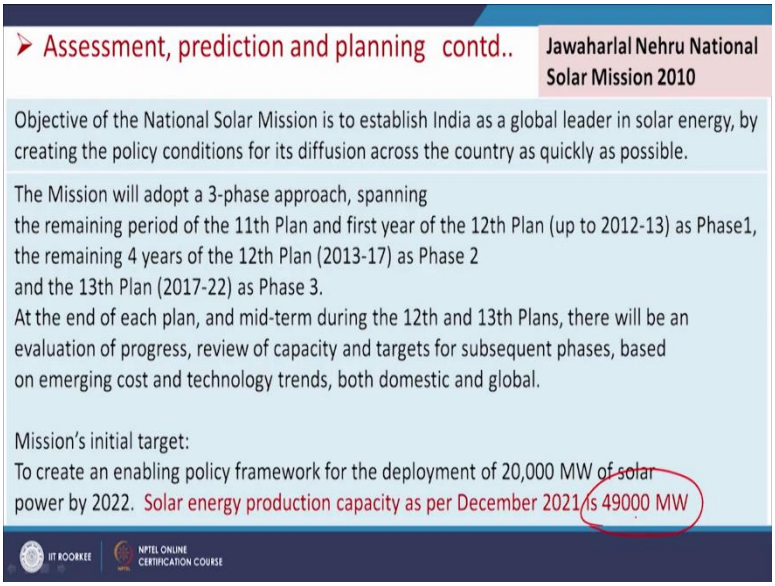

Now, just I will give you some glimpse of the Jawaharlal Nehru National Solar Mission in 2010 it was established and then the target was to make 20,000 megawatt of solar power by

2020 and there are some interim assessment options were also there, but you know we are very happy to know that this mission got success and before 2022, in December 2021, 49,000 thousand megawatt solar energy is produced in the country, so this is install capacity in December 2021. So similarly, you know many international accords or treaties are also done to maintain the climate change, okay, to protect the climate change across the globe.

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Like say, some examples are Montreal Protocol, Kyoto Protocol, United Nations Climate Change Conference and then Nagoya Protocol, Cancun Agreement, Durban Climate Change Conference, Rio plus 20 Earth Summit, Paris Agreement, Kigali Amendment. So, these are some accords which are related to the climate change. And, then we need one framework and we should have good ethics on the environment. Each individual should be responsible to maintain the environmental quality through their different activities, that is very essential, we have to make the people aware about it.

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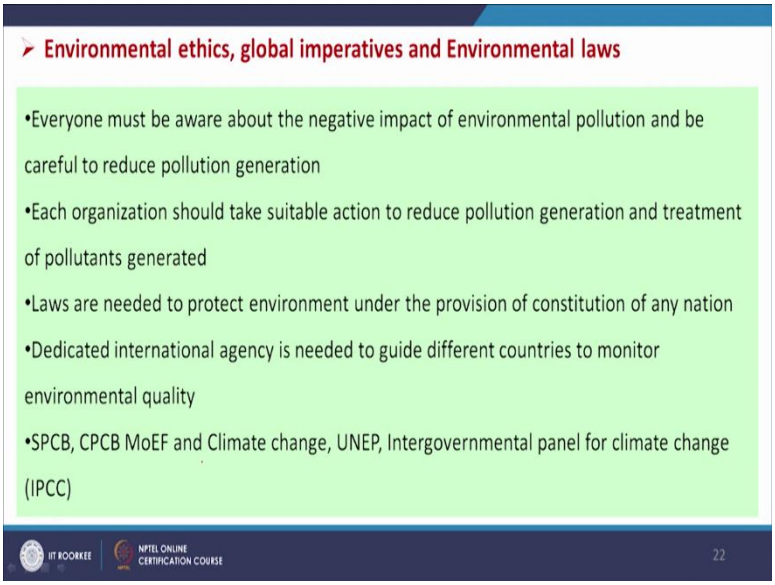

And each organization should take suitable action to reduce pollution generations and treatment of pollutants generated and laws are needed to protect environment under the position of constitution of any nation and Dedicated International Agency is needed to guide different countries to monitor environmental quality and all these are in existence.

Like say example, in our country we have State Pollution Control Board, Central Pollution Control Board, CPCB a Central Pollution Control Board is working under the Ministry Of Environment and Forest and Climate Change. UNEP United Nations Environmental Program and Intergovernmental Panel for Climate Change IPCC, these are also organizations which are working international level to maintain the environmental quality. Now, at the last we will see, the what the environmental science, environmental engineering, and environmental studies are.

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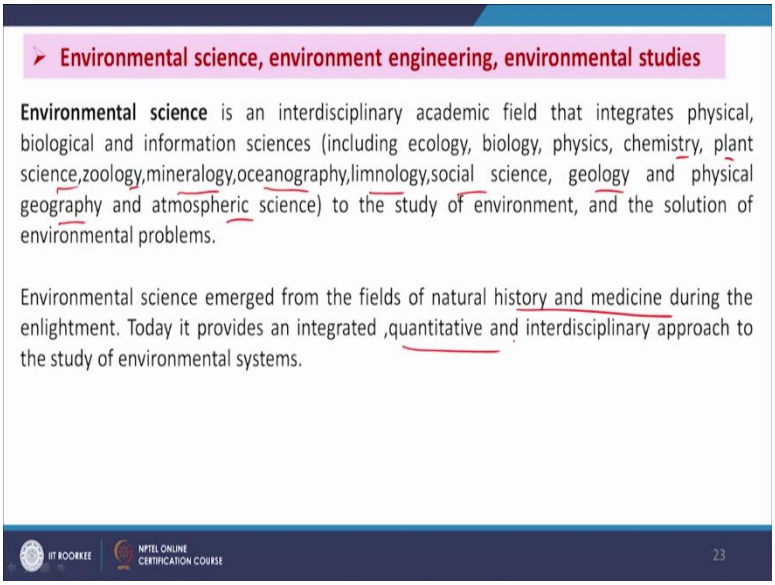

So, environmental science is an interdisciplinary academic field that integrates physical, biological, and information sciences to the study of environment and the solution of environmental problems. So, it includes ecology, biology, physics, chemistry, plant science, zoology, mineralogy, oceanography, limnology, social science, geology, and physical geography, and atmospheric science, okay. So, environmental science emerged from the fields of natural history and medicine during the enlightenment. Today it provides an integrated, quantitative, and interdisciplinary approach to the study of environmental system.

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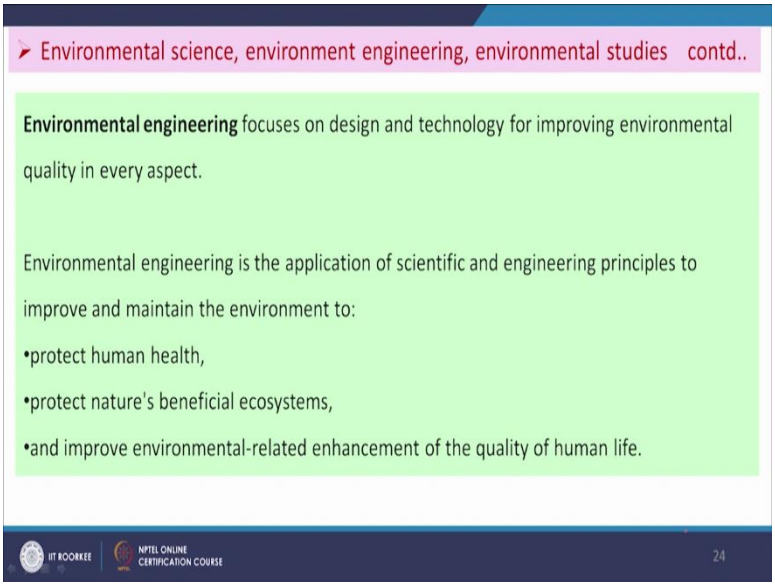

And environmental engineering focuses on design and technology for improving environmental quality in every aspect. Environmental engineering is the application of

scientific and engineering principles to improve and maintain the environment to protect human health, protect natures beneficial ecosystem, and improve environmental related enhancement of the quality of human life. And environmental study is a multi-disciplinary academic field which systematically studies human interactions with the environment.

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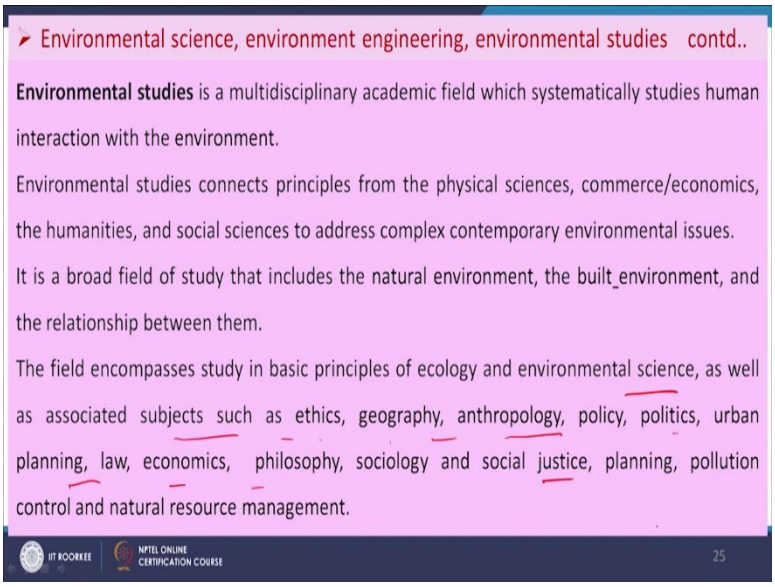

Environmental studies connects principles from the physical sciences, commerce, economics, the humanities, the social sciences, to address complex contemporary environmental issues. It is a broad field of study that includes the natural environment, the built environment, and the relationship between them. The field encompasses study in basic principles of ecology and environmental sciences as well as associated subjects such as ethics, geography, anthropology, policy, politics, urban planning, law, economics, philosophy, sociology, and social justice, planning, and pollution control, and the natural resource management. So, these are the different subjects which we should know so that we can take proper action to prevent and control the pollution. Thank you very much for your patience.