Sustainable Materials and Green Buildings
Professor B. Bhattacharjee
Department of Civil Engineering
Indian Institute of Technology, Delhi
Lecture 3- Factors Affecting Carbon Cycle

So last class, if you remember we discussed something related to planet equivalent, ecological footprint; we defined global hectares and we are talking about carbon, carbon cycle, right. And if it is, if the carbon cycle goes out of balance, this class we will look into some of those issues further, later on we look into materials.

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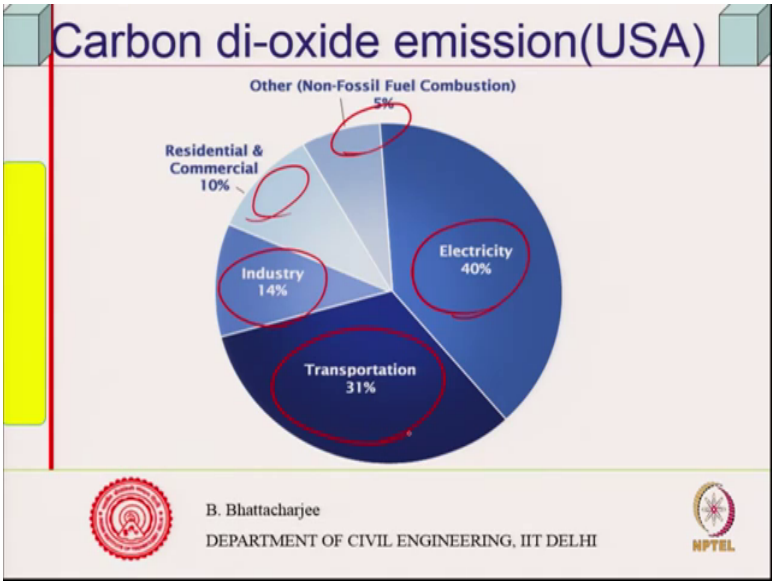

So if you look at carbon dioxide emission globally this is, I mean this is for United States of America, because they have data available, you know, United States they have all data available, so it is easier to get their information rather than many other places. And what one could see is that carbon di-oxide emission comes 40 percent from the electricity. You know it comes 40 percent from the electricity, right.

So this is 40 percent coming from electricity, industry 14 percent, non-fossil fuel combustion 5 percent because you can have timber burning for example, it is not fossil fuel as yet. Then residential and commercial cooking etc, everything put together, transportation 31 percent. So it is these two, but this may not be same in all the countries because in India, if one looks at India let us say we have large amount of thermal power plants. So significant contribution might come from this place itself.

Transportation also but if you see again Europe, you might find there are some countries where they rely largely on hydel powers, some on nuclear powers and transportation may have also less because they might be using less fossil direct fossil fuel based transportation. So this will differ but that is the carbon dioxide production and we said that carbon dioxide production if it is imbalance it can create problem, we will see what it is.

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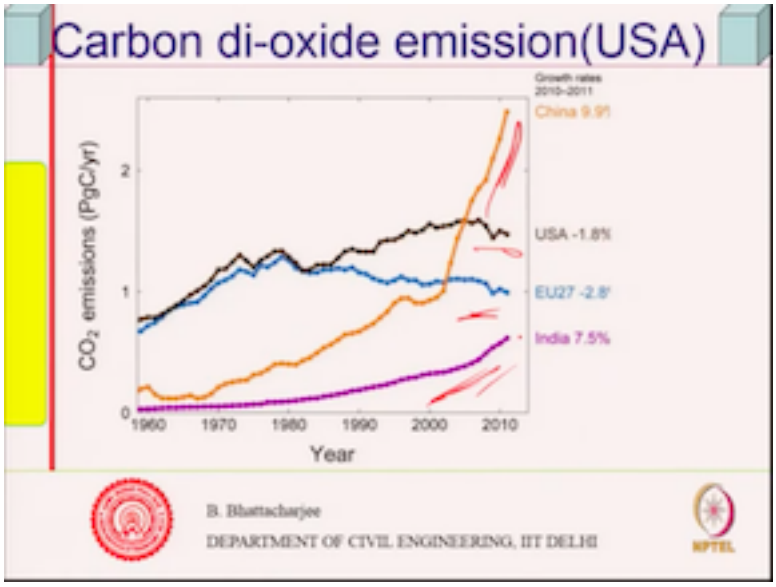

So some of those rates of increase if you see these countries have relatively stabilized, they have relatively stabilized with time but then these are the countries or many other African countries, Latin America is also by and large stabilized, they have a lot population density, so that growth rate is higher for most of these countries.

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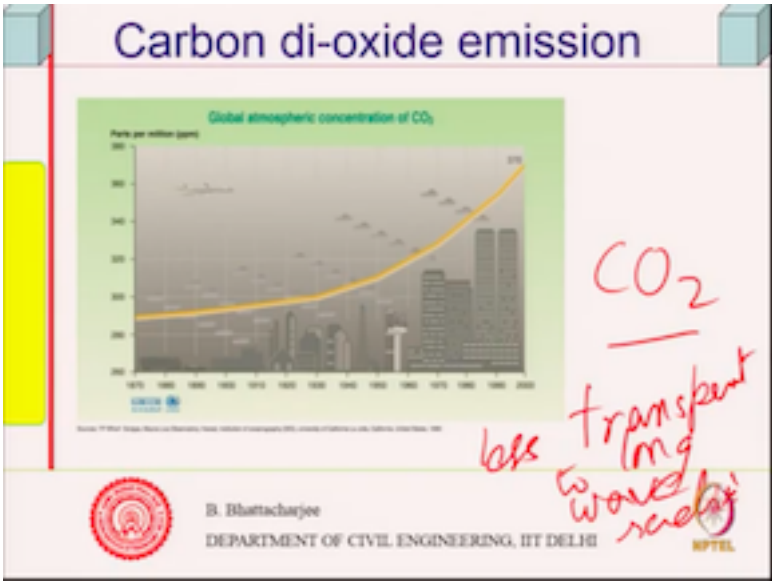

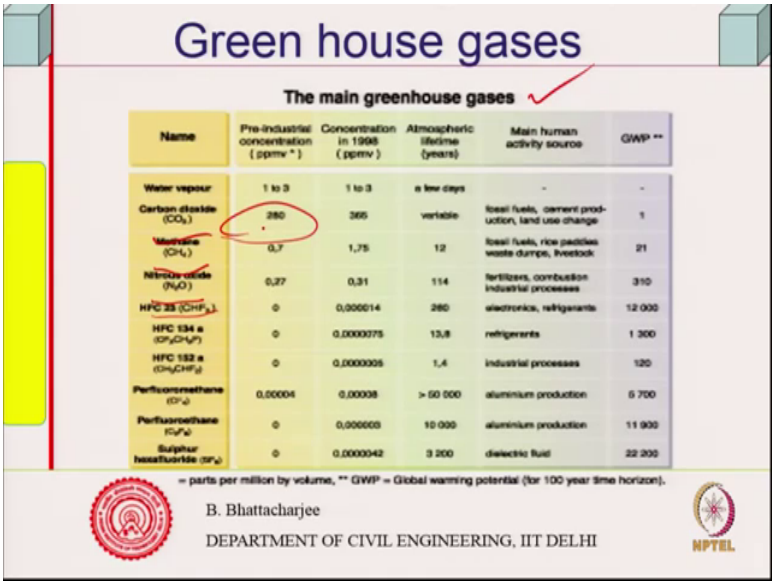

So global atmospheric concentration of carbon dioxide is increasing as you can see exponentially over the period of time and last class I was mentioning something called greenhouse effect, because global concentration of carbon dioxide, property of carbon dioxide is, it is almost behaves like it is you know less transparent to long wave radiation but like the glass. Glass allow solar radiation to come in but does not allow long wave radiation to pass through. So it is something similar and its imbalance can result in too much of carbon dioxide you are generating, can result in layer of carbon dioxide formation on the top of the atmosphere.

So the greenhouse gases if these are for example carbon dioxide is one of them, methane is another of them, N2O nitrous oxide, Fluoro Carbon, Hydrofluorocarbon, HFC, CHF2 etc, so even moisture there. Out of this major contribution comes from actually carbon dioxide. It is a green gas, so a greenhouse gas what does it do? Does not allow longer radiation to get dissipated from the earth.

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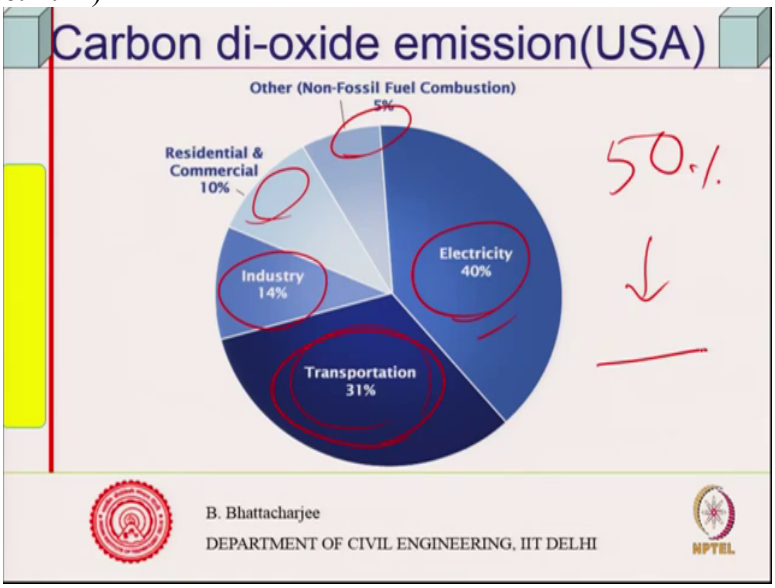

50 percent of the, 50 percent of the sun's radiation is received onto the Earth surface, about 25 percent goes away from the atmosphere itself, reflected back by the atmosphere, right, 5 percent or something by the sea or land straight away reflected back, 20 percent is what is stored in the atmosphere and then goes back, I mean it is, so around 50 percent reaches the earth. And this 50 percent also yearly if you see finally they are dissipated back, some by evaporation from the sea, conduction current it will go and then radiate, some directly by long wave radiation in the night et cetera, so there is a balance. Now if carbon dioxide is present it will not allow this dissipation to occur easily especially the long wave, so that is the idea.

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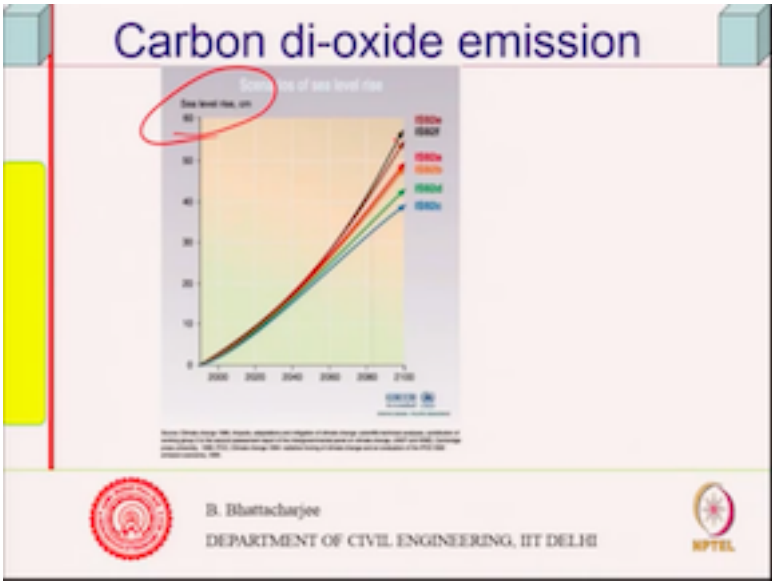

So that is why this we have bothered about it and these are of course some sort of projection that if I increase my carbon dioxide level there can be sea level rise, different scenarios, projection actually at certain rates, the higher the rates, sea level rise could be higher.

So these are projections, there are oppositions to this either also, there are some people who do not think that much of concern is there but nevertheless system must be efficient, all our infrastructure that we are having must be efficient so that we do not really generate too much of carbon dioxide or anything of that kind. So these are the projections actually because if the energy is not dissipated the temperature of the earth will go on increasing, it will go on increasing because the energy that you are receiving you are not able to dissipate out, in a year there has to be a total budget, so that is what it is.

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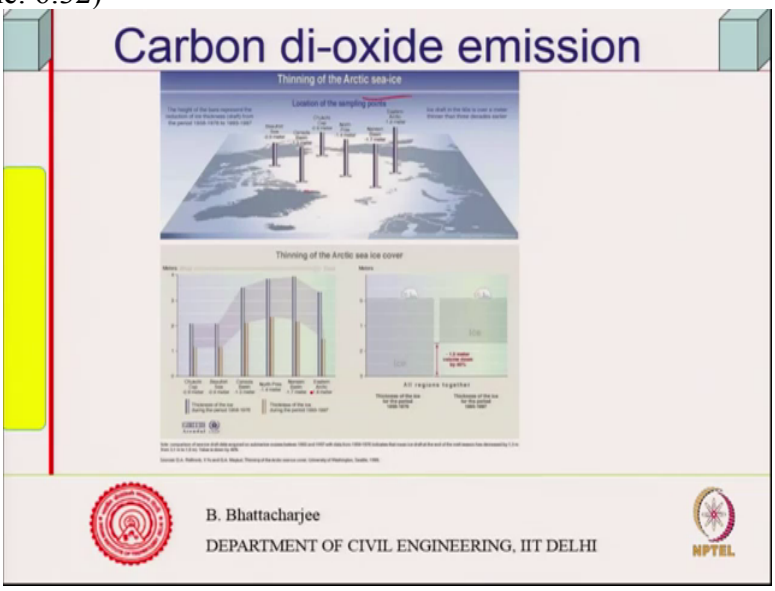

So you see the results some of them they predict that there is a thinning of Arctic sea, Arctic sea, right. In Arctic ice, so there is thinning, there are some results available and these are the kind of issues related to sustainability.

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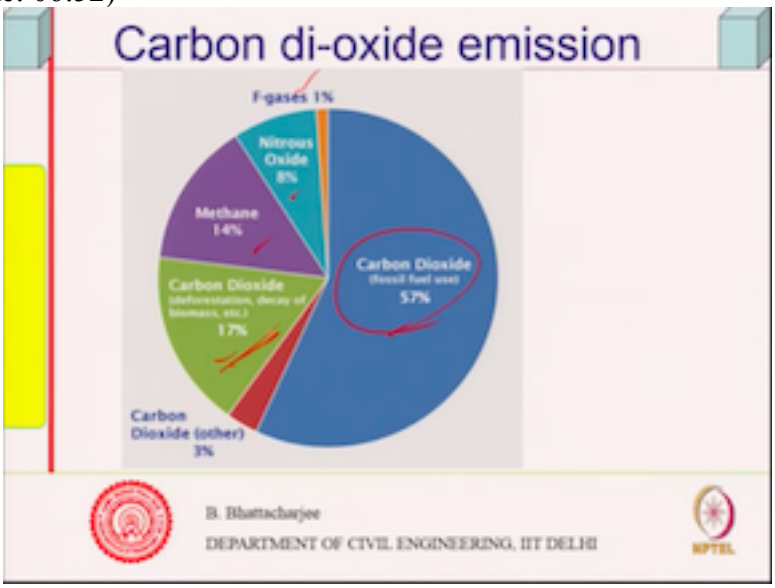

So globally this is carbon dioxide comes out to be 57 percent or so. Nitrous oxide around 8 percent, methane 14, and deforestation et cetera and decay of biomass they can generate 57 percent. So if you see the greenhouse gas distribution this is again the major one, carbon dioxide is a major one; carbon dioxide from different sources, they are the major one. Nitrous oxide also we do produce, some methane gas also are produced but they are much less and Fluoro gases are 1 percent. So the greenhouse gases if you see major culprit is again carbon dioxide. Other greenhouse gases also we do emit somewhat but the low ones, right.

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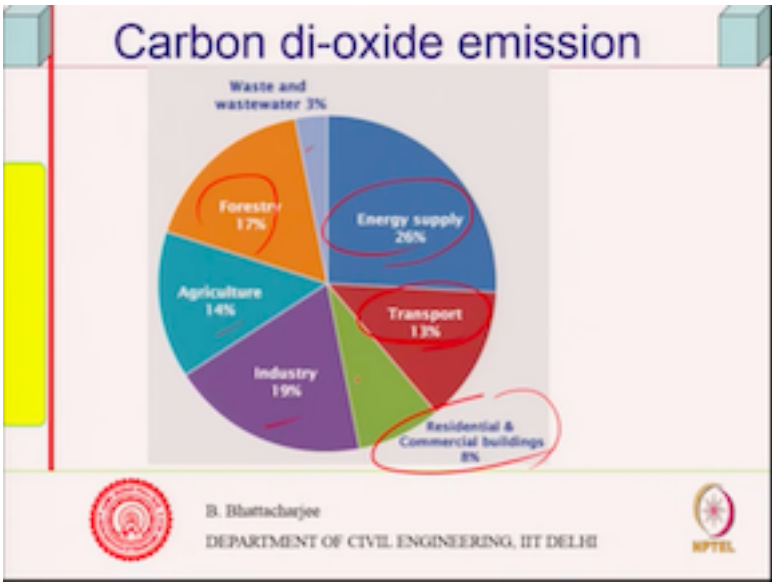

Residential and commercial building, 8 percent; transportation 13 percent contributor, energy supply 26 percent and 17 percent waste water, waste and waste water is this. Agriculture, 14, so carbon dioxide contribution from different ones are something of this kind, right.

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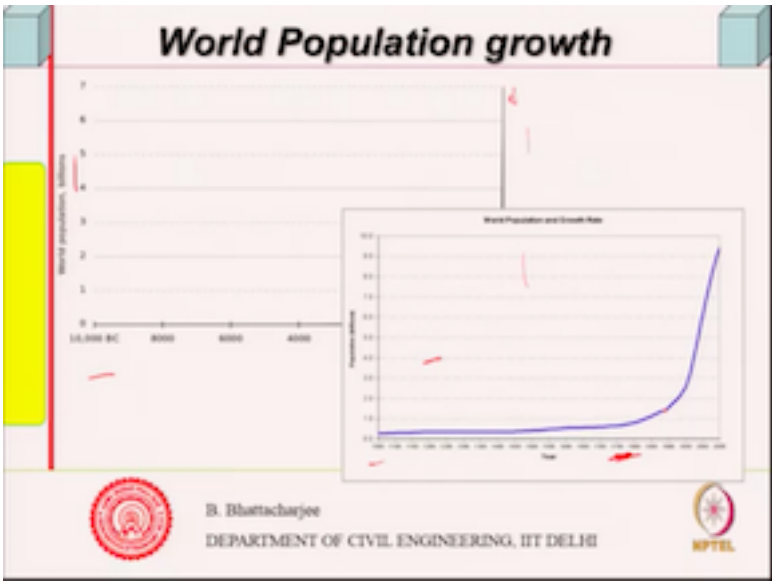

So the other day I was mentioning about the population growth, so carbon dioxide is a greenhouse gas and it is the major contributor of compared to other greenhouse gases, that is what we understand from all this discussion so far. Now carbon dioxide is increasing, rate of carbon dioxide increasing, now this is also linked to world population growth and last class some time I said the projection, this is the real data. You see, if you look at it 10,000 BC practically there is nothing even AD1 there was nothing world population in billions and then

2000 it has gone to somewhere around 7 billions or something of this order. The rise is very steep here; it is something like this.

So if you see in 1050, exponential rise started from around 1800 or so or it is linked to industrial revolution, simple as that. Industrial revolution you know and development in medicine, mass medicine over the period of time that resulted in a high population growth, child mortality rate that is reduced. Also epidemic, death due to epidemic, death you know famous London Plague or smallpox that used to kill a lot of people. Of course, cholera and such things that used to kill a lot of people, so those deaths have actually reduced, child mortality rate has reduced and average life has increased.

So therefore that is what because modern medicine has brought that. For example, before antibiotics came into being tuberculosis was one of the diseases for which lot of people would die. Before vaccination came into picture smallpox, genre, smallpox vaccine, right, so it vaccine you inject, they inject a little bit of whatever it is the bacteria or system you know, it is a far more complex system into the body itself which is will generate the resistance, resistive cells and so on so forth.

Also things like polio vaccine, solve vaccine this kind of things have actually changed the whole scenario and that is why the growth and that results in carbon dioxide.

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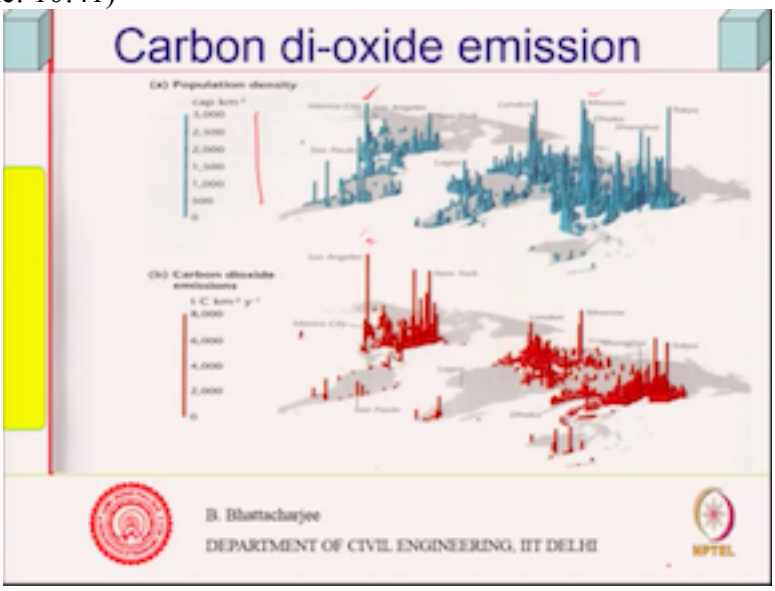

Issue is all are related together and if you see this is interesting to see that different cities in the world, population density is given here right, so Mexico city, you know city-wise, urban city-wise, Moscow, Dhaka, et cetera, London, population density is given and here the carbon dioxide emissions tons per kilometer square per year et cetera per capita, this is what is given.

So you can see that there is some sort of link. The towers are somewhere there. Los Angeles, very high carbon dioxide, Mexico city is somewhere there. So this kind of data, information is available and urban centers are the one which are the major contributor to carbon dioxide.

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Interesting data is there on, so this is basically the urban centers are the one which generally are the contributors. Now what is an urban area? Little bit because maybe one or two you would have come across if an architect but generally there are may features which some of those features would definitely be there in an urban area. First thing is, it is bounded by a geographical boundary, is bounded by a geographical boundary, right? Bounded by geographical boundary. Usually it is non-extractive population, what is non-extractive population? The population which do not generate resources from the mother earth, I mean for example, no agriculture, no mining. So mining means they are extracting something from the mother earth, agriculture means you are using the area and so on.

They must have a mechanical infrastructure facility like transportation, water supply system, electricity supply, power supply system and all that and usually characterized by high population density, might have a political status like corporation, municipal body and so on.

And sometimes it is a symbol of wealth and lifestyle as well, urban lifestyle, then we say rural. So that are the concepts of urban.

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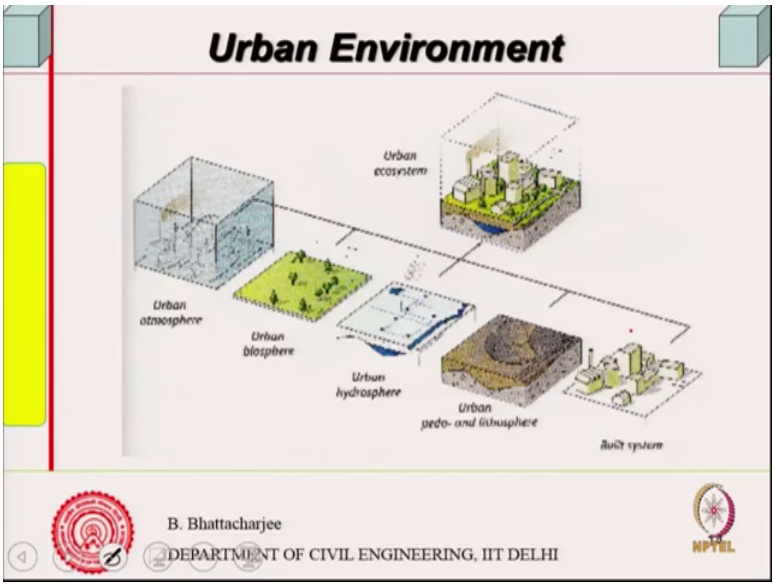

And if you look at it, urban system has got different parts which we will come to, for example if you look at this diagram there is something like hydrosphere, ground water, biosphere, right, then biosphere is a greeneries and so on. Lithosphere, built an environment and then atmosphere. So in urban system we will have this kind of component and generally this is the ecosystem around that city environment, right.

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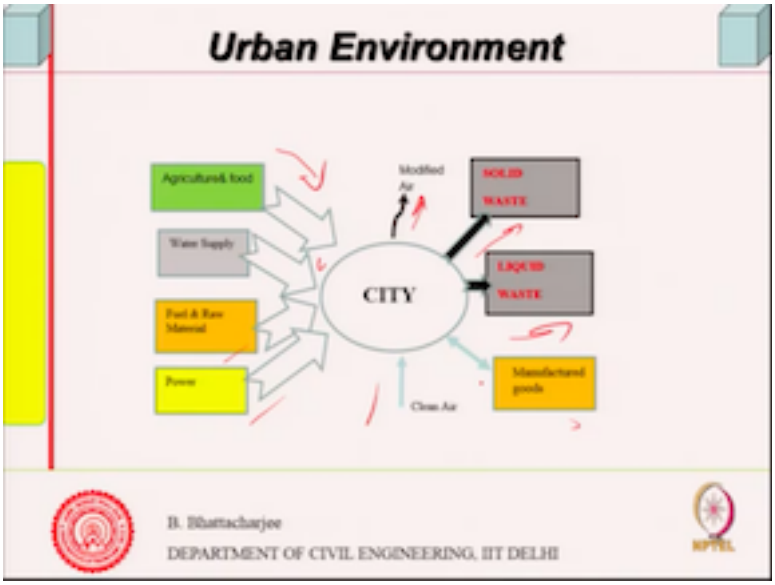

Ok, so this city or urban area, it is non-extracting so it depends for agricultural food from outside; water supply, fuel, raw material, power all comes from outside and that generates solid waste, might generate some liquid waste and of course modifies the atmosphere, gets the clean air, modifies the atmosphere around. Manufactured good may come in as well as go out, so that is a typical urban area and contributes also towards the, it is one of the major contributor to carbon dioxide for various reasons.

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So if you see Mexico in 1975 there are hills, lakes one can see, there is a lake, hill and currently it looks something like this, you know all could build up, anyway this looks so nice.

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But Delhi you can see 1807 there were hardly anything around, right, 50 years after, nearly 50 years after you know the British took over the reign of Delhi after the mutiny and this is how 1930 when capital was shifted and it started building.

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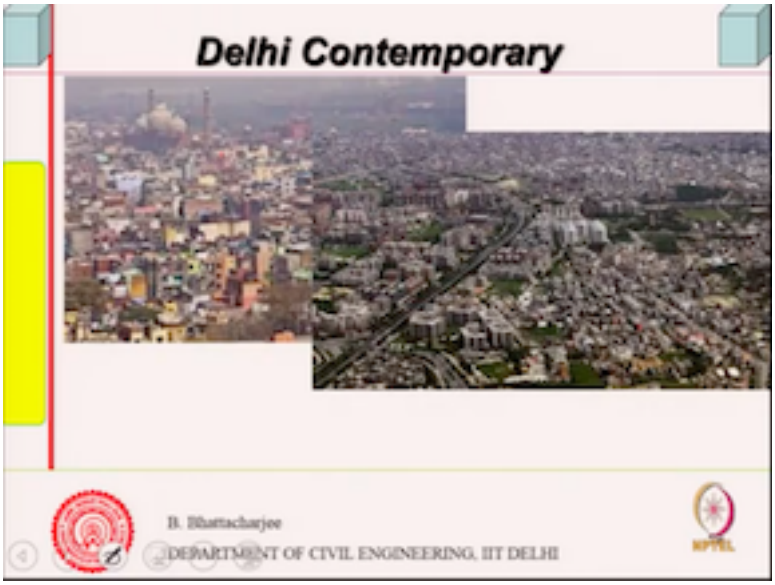

And if you look at contemporary Delhi, this is what it looks like, like you can see the Red Fort area and this is how some other area of Delhi, so it is all built up areas now.

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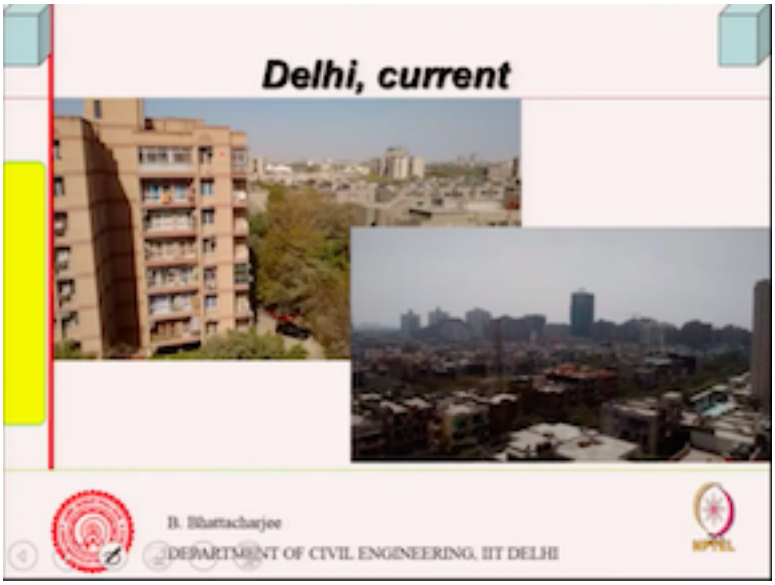

And some look like, NCR looks like this, so there is a changing pattern and link to that population increase that you would have seen. So globally this has happened and carbon dioxide so, carbon dioxide or you know related resource consumption or anything that are linked to all this.

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Current Delhi NCR here, some more diagram, something like this. So current NCR Delhi is something of this kind, so it is lot of construction.

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Master plan of Delhi in 2021 which is available in Net in fact it will show you this kind of green areas, it is a planned city by the way, relatively more planned than most of the cities in India, relatively more planned. New Delhi area is by and large planned. So they have controls.

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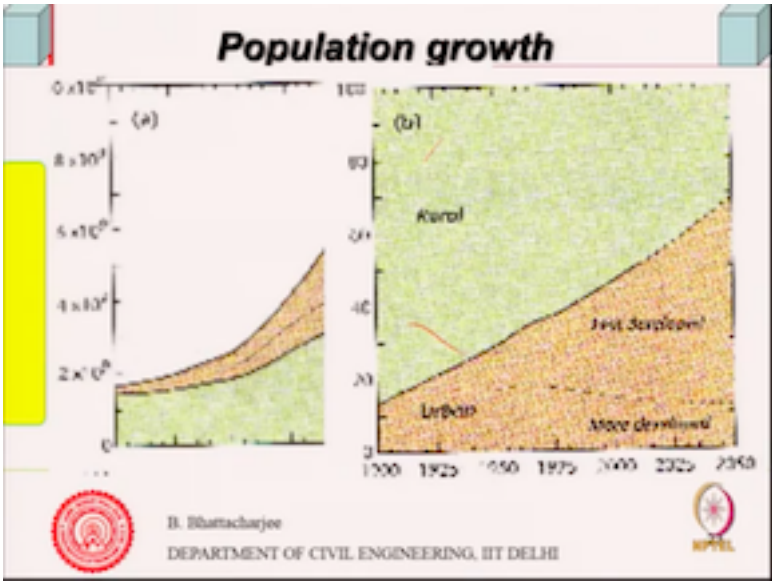

So rural population is reducing, urban population is increasing, that is what is happening, right. Rural population is reducing, urban population is increasing, that is what it is.

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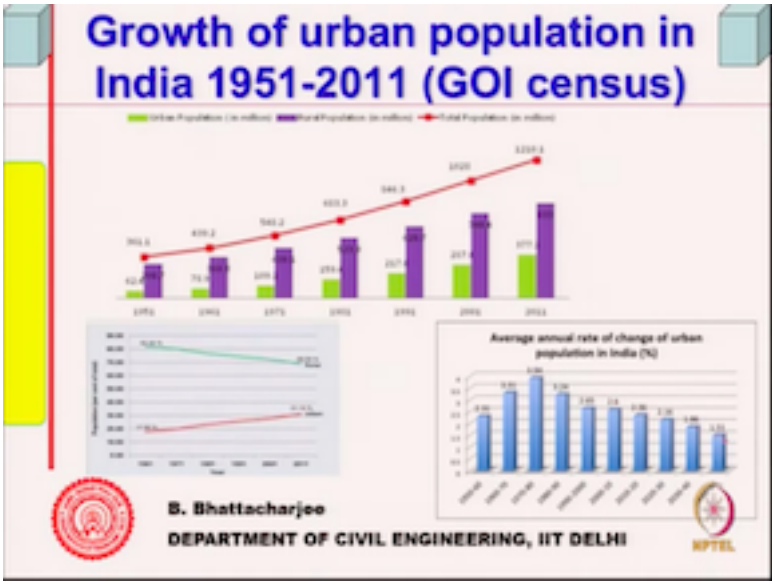

And India wise if you see growth of population is going something like this, government of India Sensex data of 2011, rural population is decreasing, urban population is increasing, this is urban, this is rural and average annual rate of change of urban population is something like this, right. So that is some kind of data is available.

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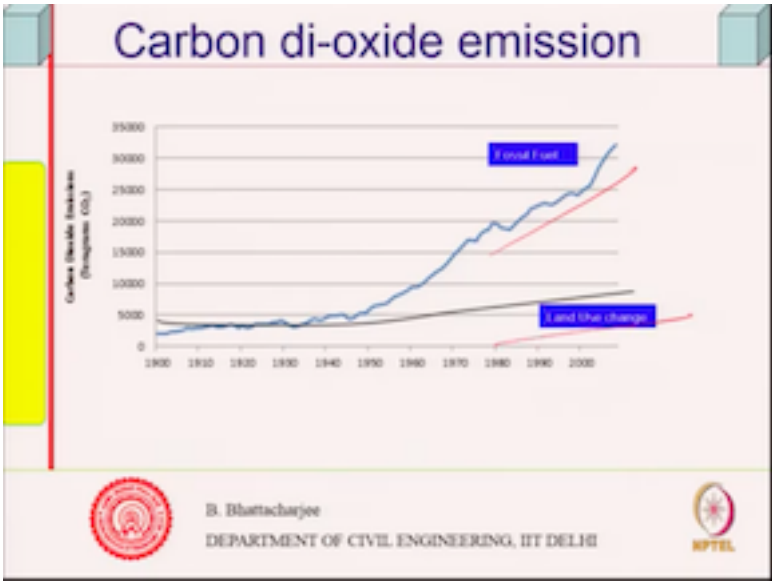

So these are all linked, carbon dioxide emission is linked to this, you see these carbon dioxide towers that we have shown is all related to urban area and more urbanization you do more carbon dioxide. So you have to take care of this, it is not that you do not do it because that is how you can sustain your population as well economical issues we shall look into. So land

use changes, carbon di-oxide emission comes from fossil fuel, land use change and obviously in this one cement also comes into picture.

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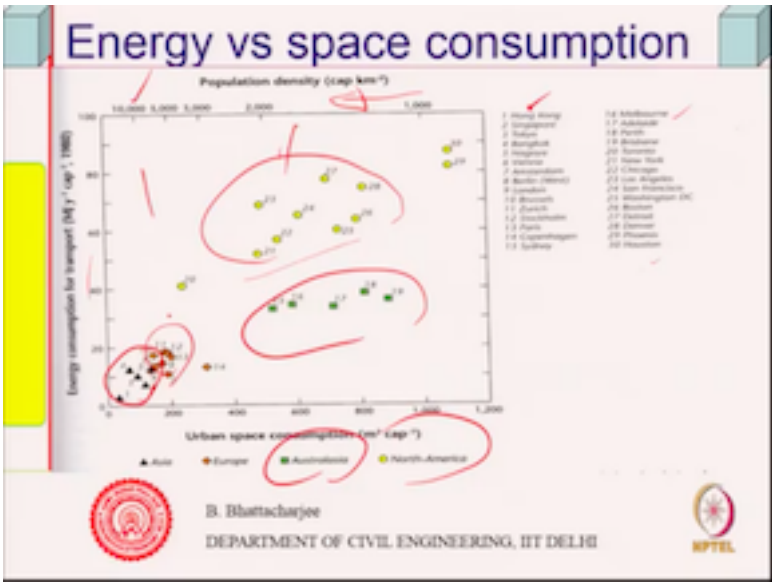

There are some kind of data available, population density versus energy consumption in transport. This is urban space consumption meter square per capita or population density goes person per kilometer square. So different cities are given Hong Kong, Melbourne to Houston, and all those are given, largely Asian countries are somewhere here. Population densities are very high, Europe is somewhere there, there also seems to be population is high, North America population density is relatively somewhere there but their energy consumption in transport is high.

So higher the population density apparently transportation energy consumption is relatively less, these are information. How you use them that is a different issue but city planners have to look into those issues altogether in when if you are looking at you know issues like sustainability and so on. So these green ones are from Australasia where there population density is relatively less but then their transportation energy is also less.

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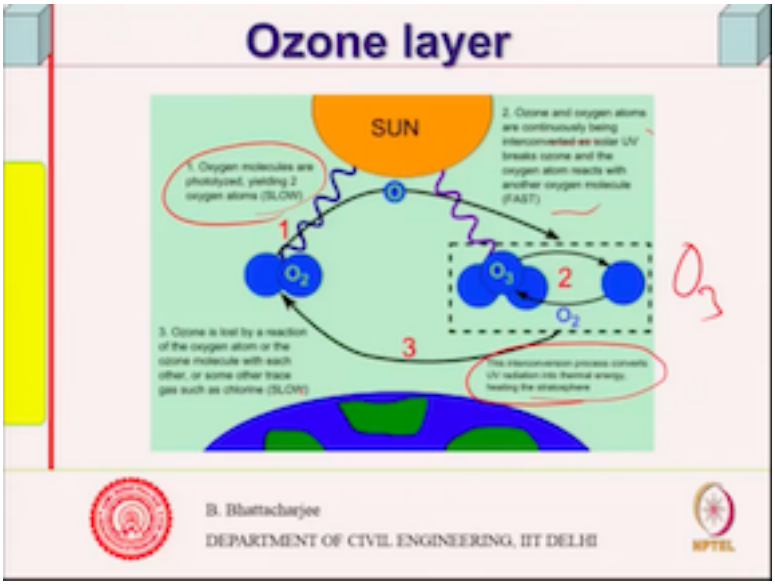

Other issue is ozone layer depletion. So what we have seen? You are consuming too much of resources, planet equivalent, the other, the next thing is you are generating greenhouse gas, right. Greenhouse gas and all are linked to population growth and urbanization, right. So when we look at you know urbanization we should look in such a manner that we are able to handle the situation properly and not going to a disastrous situation. Control possibly the greenhouse gas emissions so that there is no global warming, the Syria's potential that we looked into projected; similar thing does not happen.

Whether this is very skeptical because somebody might say this is extremely skeptical because we do not have too much of proof on those because we look at the data of temperature changes of the globe, there are perturbations and some people do oppose but some people say they show that ok there is some changes in last so may years and things like that. But however we should be conscious about it, so that is what it is.

The other factor that is there is the depletion of ozone layer. Now these oxygen molecules, you know molecules in the presence of sunlight photolyzed and they form basically they form ozone. Ozone is allotrope of oxygen O3 right, so ozone is basically you know interconverted as solar because the UV radiation can break them, ultraviolet radiation can break the ozone, convert into oxygen back actually. So ozone and oxygen atoms are continuously being interconverted as solar UV breaks ozone, ultraviolet radiation breaks ozone and the oxygen atoms reacts with another oxygen molecule to form again O2. So the cycle is something like

this O3, O2 photolized to O3 and ultraviolet radiation is absorbed by O3 to come back to O2 and you know there is a kind of cycle, so this interconversion process converts UV radiation into thermal energy.

Which means that ozone layer would actually block the UV radiation coming into the earth which is also human health hazard, right. So ozone lost by reaction with oxygen atom and the ozone molecule of each other come right. Ok, so if you have, if there is a ozone layer depletion because of concentration of other gases increasing and so on it can result in ultraviolet radiation reaching to the earth.

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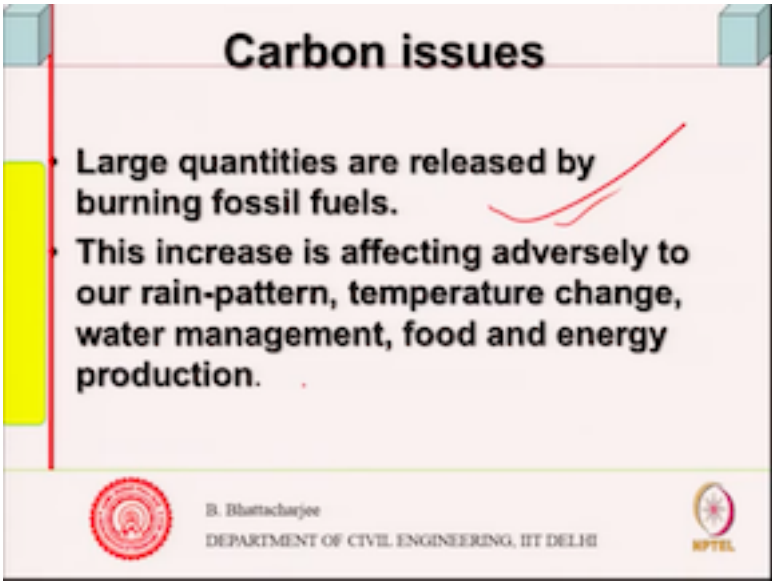

So these are the issues actually related to global sustainability. You know global or rather I am using the word I have not defined as yet, the sustainability, you know global continuation of civilization and in a stable manner and so on. So large quantities of carbon we have seen now repeating this from fossil fuel, it can adversely affect the rain pattern because if there is trapping of the solar radiation, temperature change, water management, food and energy production.

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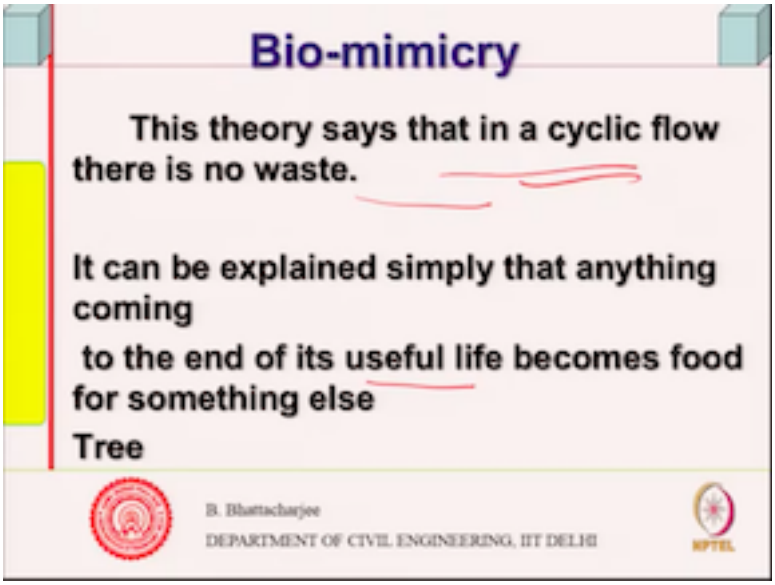

So that is what it is, now we should try to do a bio-mimicry, mimicry of the whole nature as it is, there should be cyclic flow and no waste. Carbon dioxide is actually a waste, waste you are producing by burning the fossil fuel because you know in gaseous form waste there can be liquid and solid waste as well. So biological system, a living being is born, plant, animal whatever it is and I mean plant you can easily understand the process is a dynamic process, the growth et cetera and eventually there is a death and then the body decays.

So plant grows from the seed, grows up and balances many things, there is a need for everybody actually, the planet or everything all that kind and then when it dies it decays simply and serves purpose for certain other living beings. So there is no waste left, it is a complete cycle, that is what there is no waste in the natural system, there is no waste generated in the natural system, it is all balanced.

So anything coming to the end of its useful life becomes food for something else. You know trees, I mean even before their death trees of course are killed sometime by termite or some sort of animals who survive on living organisms or living beings which survive on them. Once it is dead then termite will simply eat it away. So therefore nothing is left, right, so that is bio-mimicry.

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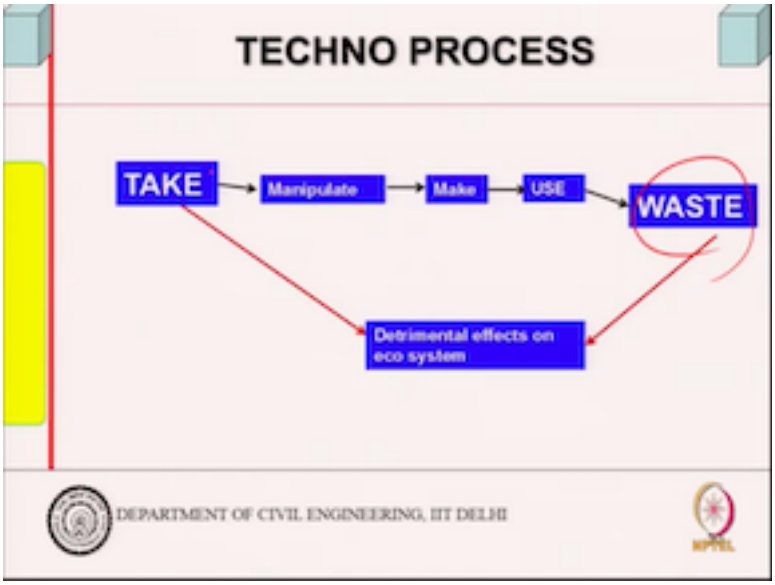

But our technological processes, we take form the mother earth, handle it, manipulate it in some manner and then make something out of it and then use it and then generate, throw it away waste. Both these cases are taking itself is detrimental to ecosystem and if I generate waste, residue waste is left at the end of its useful life, that is also detrimental to ecosystem.

So technological process you know we have to make it as efficient as possible, leave nothing here, neither at this stage but that is not possible, that is almost not possible, that not possible, right.

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So the impact is two ways; first we use resources, second we dump waste. So we use material from the mother earth and some of them are not infinite, some of them are not infinite, so we are consuming them right, stored ones and finishing them also, might finish perpetually I mean might finish eventually after some 100-200 years, some of those materials and in all cases we are generating waste also, right.

So by this techno processes we take everything from earth that we can take, after that we use it, consume it, process it, dump it as a waste in the liquid, solid or gas form. All these things are harmful to the environment because they create disbalance. They create disbalance of some form or the other.

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And material plays a very important role here, right, everything taken from the mother earth is material. So many of the techno processes or most of the techno processes are so inefficient that 80 percent of the material taken from earth goes into waste and which could be harmful to environment, right.

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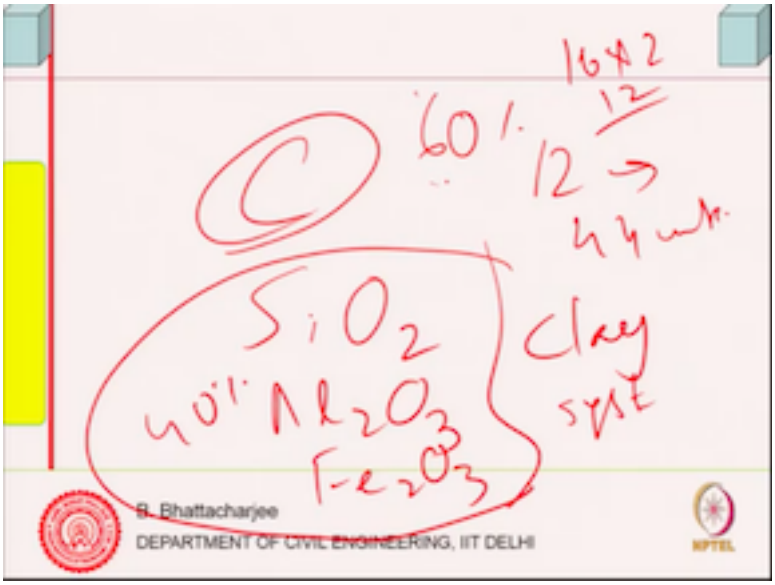

Now we shall see this later on, ok, just quickly let me quickly have a look, into just a minute may be I will come back to this. Yeah, for example simply you take, you take coal, right so it will have compositions of carbon and SiO2, Al2O3 et cetera which are basically I have Fe2O3 right, the part of the clay system and let us say this is 60 percent and this is about 40 percent.

So when you are burning them, two things you are doing you are getting energy alright but 12 proportionally if you will see 12 unit mass units of carbon would generate 44, you know 16 into 2 plus 12, 44 units of carbon dioxide, right and this is the solid waste, this is the solid waste which you leave it.

So how much, if you calculate out how much you are producing the waste that you are producing, even on mass basis that will be significant, that will be significant, that is what we are saying that most of our techno processes are, most of our techno processes are quite inefficient at some point, not all but you are trying to improve it of course and you have to improve this. So many of the material goes into waste in some form or other.

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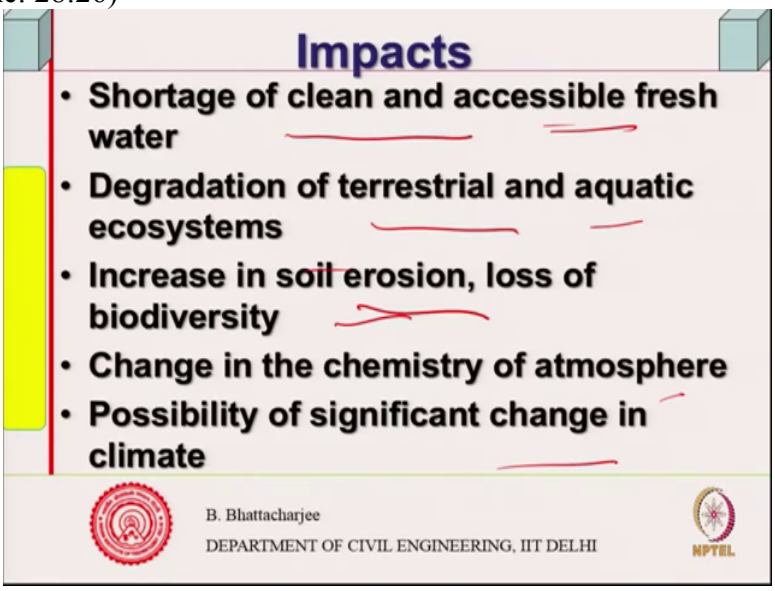

This leads to some cases shortage of clean and accessible fresh water. Terrestrial and aquatic system can be, aquatic ecosystem can be disturbed. For example, if you are dumping something in sea or lake, in fact many many lakes in Bengaluru suppose to be all polluted, there are so much of news coming. So soil erosion, loss of biodiversity and change in chemistry of atmosphere and possibility of change in significant climate.

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So if you look at it in past actually we are only concerned about storage of resource you know, our concern was storage of resource for future only one or, we are trying to economize, use the material, minimal material. We are trying to use the material minimally because the cost is involved, cost of extraction of the material, right.

So that is why the cost is and that is what we are concerned about and we know that other resources only is not the only problem, consumption is not the only resource is taking, resources is not the only problem, but environment around is also an important issue. So these concerns have come over the period of time, right.

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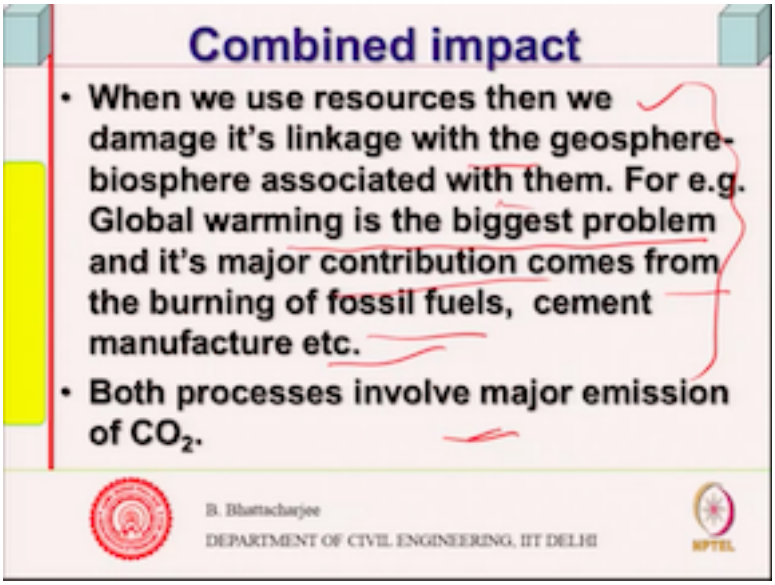

Ok so we can, you know when we use these resources we can damage the linkage with the geosphere, biosphere, as I shown in the urban area associated with them. For example, global warming is the biggest problem and its major contribution comes from the burning of fossil fuels, cement manufacture etc, because these processes both involves carbon dioxide emission.