Non-ferrous Extractive Metallurgy

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Module No. # 01

Lecture No. # 33

Energy and Environment Related Issues in Nonferrous Metals Production (Contd.)

Friends, we are continuing our discussion on issues related to energy and environment in relation to non-ferrous metals production as well as a general subject. I have mentioned that, I intend to define certain terms very clearly and in that context, I have defined two words, waste and industrial waste. Perhaps, I will give some other definitions of these terms and other terms little later.

Then, I gave some examples of industrial waste in non-ferrous metal industry and the biggest waste in non-ferrous metals industry is the redmud, this you must remember. Two tons of redmud being produced for every ton of aluminium produced and till today, we have not found, nobody has really found the right kind of use for that redmud.

One of the main problems is that the redmud would have some alkali. That alkali is retained from the leaching process and once there is an alkali, many other things that you may think of for use of redmud will no longer work. For example, the composition of redmud is such, that if we forget about recovery of aluminium or titanium or whatever else valuable, may be there if just to get rid of it. If we think of a bulk use, it can certainly go for the building industry. One can make bridge, provided you can remove that alkali first, because if some alkali is retained in a brick and a house is made using bricks that have alkali, then the bricks will dissolve away very soon. They would not be stable. Now, if one wants to remove the alkali by some process, then it becomes a very costly affair.

So, why was redmud not been used? Because a proper technology for abatement of the environmental problem was not available. Under pressure technologies come. Today for

example, the biggest aluminium company, one of the biggest aluminium company of the world, Alcoa they have announced a process which would kill two birds with one stone.

See on one hand, we have a problem of CO2 being coming out of thermal power plants. Many of these thermal power plants are there for aluminium industry because they generate power for the electrolytic cells. The CO2 is being coming out. We do not know what to do with it and here is redmud which is alkali and because of the alkali, we do not know what to do with the redmud. Alcoa have patented a process where that CO2 from the thermal power plants is injected into the redmud to neutralize the alkali.

So, the CO2 has now been made use of. Alkali has been neutralized and you will produce there some carbonates. These carbonates may be tolerable, not only in the building industry, it can be tolerable elsewhere. In fact, there is talk of using that material to making artificial corals. I mean that may be dumped in the sea shores to create blocks which will be just right for sustenance of marine life, artificial corals or other things. In that case, we have taken care of CO2, which we call CA2; sequestration has been taken care of. Alkali has been neutralized.

If we can do that, then we can find a bulk use of redmud, but still this process has not become widely applied as yet. There is another problem. Very often the thermal power plants are situated near places where there is coal available and the leaching Bayer's process is established where bauxite is available. They may not be close by. For example, in NALCO, Damanjodi where leaching is taking place and some several 100 kilometers away in Angul is the electrolytic process set up, where the thermal power plant is operated.

In such a situation, how would you take CO2 from this place to that place? Had they been side by side, things will be simpler. These are impediments in application of the process, but to start with a technology was not being developed without enough pressure for development of technology. So, that is why I mentioned and ended the lecture by saying that there has always been a gap between technologies of production and those of pollution abatement.

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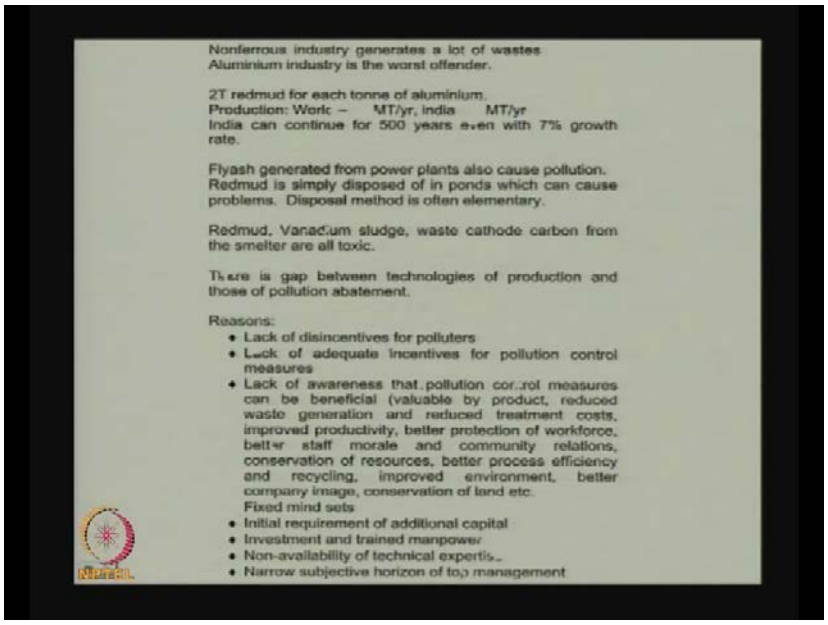

Let us go through all the reasons one by one.

The first was lack of disincentives for polluters. Some 20 years ago, one could pollute and get away. Nothing would happen to polluters, but now the policy is that polluters must pay. Polluters must be punished. There must be a disincentive for pollution. Now, this is more easily said, than done because to do that, you have to go through some legal process and it is very often that the guilty who wins because he has better lawyers. That continues even now.

So, it is very difficult to implement environmental rules and regulations, unless the government is very strict. The government is now becoming more and more strict, but unless the industry becomes more and more aware of the importance of pollution abatement that they should do, they will always resist it. Traditionally, the resistance was there, this is gradually disappearing.

The second point would be first, there was no disincentive. Second is lack of adequate incentives for pollution control measures. Those who do employ pollution control measures, they should be rewarded. Now, there are rewards coming in many ways. For example, there are now international protocols that if you can improve your process and show that you have cut down on carbon consumption, then you get what is called carbon credit and it can be traded. Somebody who is not able to bring down that carbon

consumption, they can get away by paying a fine. That fine will come to those who have done that.

So, there is a trading of carbon credit that one industry says ok, I will pay fine because I am not able to cut down carbon consumption that money comes to those who have actually been able to implement a method of reduction in carbon consumption. Unfortunately, this is not an ideal solution. This could mean that somebody who is rich simply gets away by paying a fine. He is really not being punished accepting in terms of some financial loss, but half the thing is gained. One who is able to cut down carbon consumption, gets carbon credit which he can trade internationally, benefit financially.

I will give you an example of how some companies are benefited, but ideally there should be a stronger punishment, not only financial but something else for one who pollutes. The motto should be polluters pay; those who bring down pollution must be rewarded. So, there has to be disincentive and there has to be adequate incentives.

Now, the third point is very important. There had been in the past lack of awareness that pollution control measures can be beneficial. Many industries, at least the traditional industries thought that if they have to bring in equipment for control of pollution, say removal of dust, cleaning of the water that you have to throw out in the river etcetera, then it is going to cost you extra money. So, the benefit will come down, but now many companies have actually shown if you take control measures, eventually you gain.

I remember going to Jamshedpur 25 years ago. The place used to be so dirty. In the evening when the Bessemer converter would blow, all the fumes would come and actually you could see things falling in nearby areas. There was dust everywhere. Inside the plant, it was so dirty, but today the entire city is like a garden. Even inside the plant when you walk, it looks as though you are walking through several buildings with gardens and flowers and everything.

The company did that consciously in a planned manner, improved the environment and spent a lot of money to do that. Not only for aesthetics, but they brought in advance equipment for control measures and eventually, all that paid off. It did cost them money, but the benefits were much more because they had a longer subjective horizon and they had a commitment.

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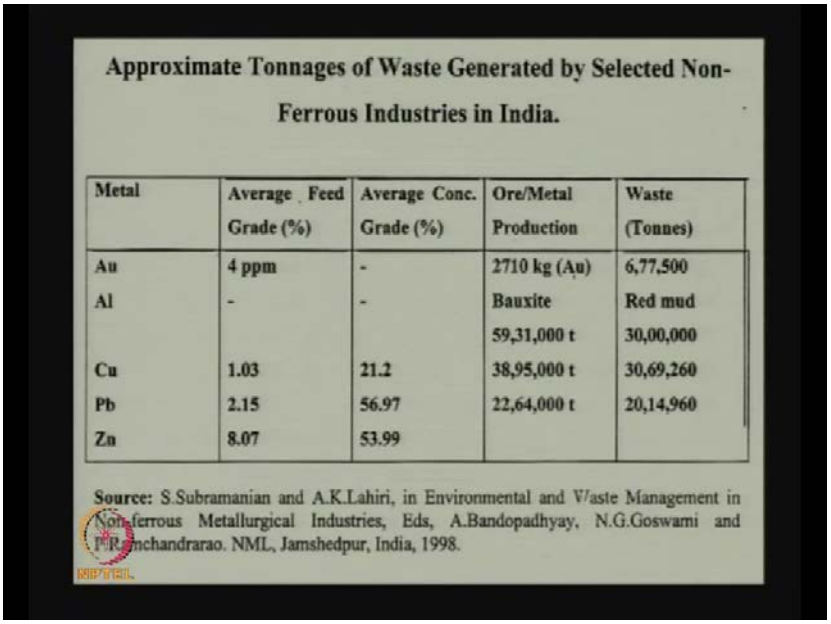

Now, let us see what kind of advantages will come if you take pollution control measures? Pollution control measures often give rise to valuable byproducts, which initially through your ignorance you are simply rejecting. If you are careful, they will be reduced waste generation. You will have a improved industrial metabolism and if you are reducing waste generation, then the treatment costs will also come down, productivity will improve, the work force will be better protected, better staff morale and community relations will be better. As a matter of fact, even the factory owners may benefit because many of them had doubt due to pollution related disorders.

So, if they implement them, not only the labor and the work force are better protected, the management would also be better protected because after all they cannot live in air condition rooms all the time. If we cut down wastes, then there is conservation of resources, process efficiency would be improved and we may be able to think of recycling for our benefit, environment will improve, aesthetics will improve, breathing will be easier, living will be more comfortable, the company image will be better and land will be conserved. If you could find a technology to take care of that redmud, that will conserve land.

See everywhere there are so many benefits of pollution control measures which made some company's do not see straight away. So, they have to be made aware. Some

companies had been reluctant or may be still reluctant because there is an initial requirement of additional capital. Nobody can deny it. There would be investment and there would be requirement of trained manpower. There will be cost of having awareness programs. All these are investments.

Somebody may say that technical expertise is not available. They may have to bring in consultants for discussions in plant training and many other things. All this will cost, but then in the long run, it pays. Why our technologies of production and those of pollution abatement had a gap is because of many of the reasons and also a narrow subjective horizon of the top management. They were not trained to think. They could not visualize a scenario for the future. They were always thinking in terms of tomorrow. Things are fortunately changing everywhere.

Now, let us see the kind of waste we are generating or we had been at least, until recently generating in non-ferrous industries in India. This data, the data are about 10 years old, but I do not think they have changed far too much. They are more or less the same. Gold average feed grade is 4 parts per million. You have elemental goal, but in rocks, 4 parts per million. If we produce ore metal, if you produce 2710 kilogram of gold, it generate 6,77,500 tons of waste.

This is rock soil, all kinds of gangue things that we have thrown out. We have taken out the tiniest fraction of the metallic value less than 300 kg and we have produced from a beautiful rock surface, so much of muck and that too in a fine form because you have crushed them, ground them, so we had a solid hill rock. We have broken them out, created this crushed and ground thing, taken out a tiny fraction of gold, thrown the rest. What do you do with that waste? It will occupy lot more volume first of all than when it was in the form of a rock.

I saw a cartoon of Dennis the menace the other day. He and his little friend, they were digging the earth and when they got the soil out, when they tried to fill it up, they found there was something else left. So, they said we have to dig another hole to put that thing. So, obviously when you loosen what was a compact mass, you end up with lot more volume. The same thing happened here. So, you have cut out some rock surfaces and then you wind it up with huge amounts of fine crushed and ground gangue material, this much.

For aluminium, ores are fairly high grade, very high percentage of alumina in the ore. If only we could, if we had a pyrometallurgical process like we had in the case of iron, things would not be so bad. We will have aluminium and we will have some slag and the slag would find some use also. Like today in the iron steel industry, all slag that comes from blast furnace, goes for cement making straight away. No more blast furnace slag dumps. This is not true for steel making. Steel making slags cannot find a ready use. Fortunately, steel making slags are less involved, but bauxite unfortunately does not go through pyrometallurgy. It goes through electrometallurgy preceded by that leaching process which generates redmud and I have told you, 1 ton of aluminium will give you 2 tons of redmud.

Here, it is even worse. It says for ore metal production 59,31,000, now it is showing slightly less. I exactly do not know what it means. For copper, 1 percent grade, average concentrate would be 21 percent. There you see for this much production of copper, 38 million tons, no it is 3 million tons. Almost the same amount, slightly less amount of waste is generated.

For lead, we have so much production and we have slightly less amount as waste matter. So, everywhere the same story is repeated that you are producing certain amount of metal, but you are also producing a lot of waste.

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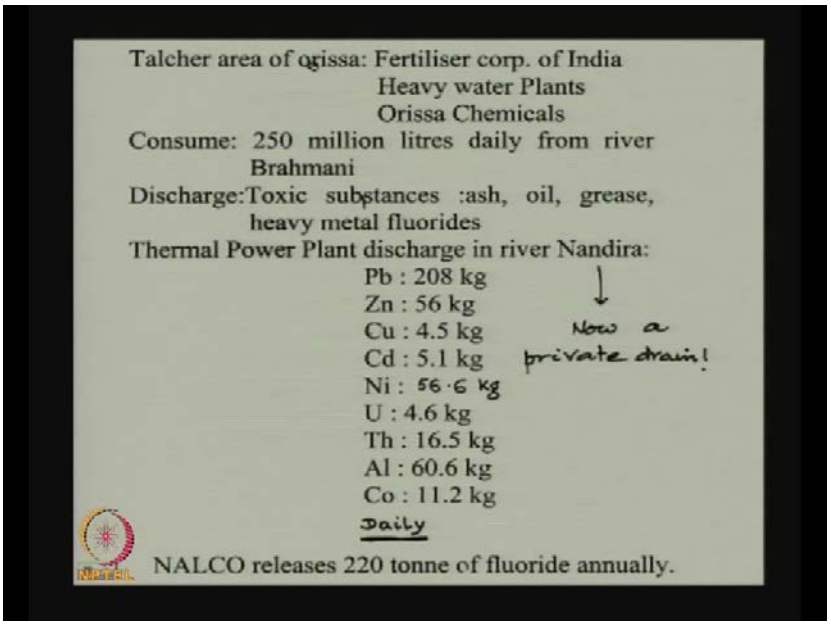

Since, we mentioned NALCO which is you know spread near Bhubaneswar, there is the smelter and elsewhere in Damanjodi, there is the alumina production. We are talking only about redmud, but see what happens in the atmosphere. NALCO releases 220 tones of fluoride and volume (()) releasing fluoride. There is a thermal power plant, which discharges in the nearby river called Nandira. Many people now call it a private drain of the thermal power plant. It is discharging daily 208 kg of lead, 56 kg of zinc, 4.5 kg of copper, 5.1 kg of cadmium, there is nickel, some uranium, some thorium, some aluminium and some cobalt. All these are simply discharged in river Nandira. No wonder there is no fish life now. Not only that even the surrounding areas beyond the river will no longer be fertile. Things do not grow. Same is the problem. This is only which is going into river. Now, the thermal power plant is also discharging flyers, which is flying, going all over, falling in fields creating havoc.

Actually, the Talcher area of Orissa, where we have Fertilizer Corporation of India, every water plants, Orissa chemicals, very highly industrialized area; it consumes 250 million liters daily from river Brahmani. So much of water it consumes and all of them are discharging into the air, land and sea, all kinds of wastes, toxic substances, ash, oil, grease, heavy metal, fluorides all that. Now, something has to be done about it.

There are metallic values in many of the discharge, like here you see there are metallic values of zirconium, copper, cadmium even uranium, thorium, aluminium, cobalt. Now, it may not be possible to take out all these, but at least we have to stop them from going into the water body.

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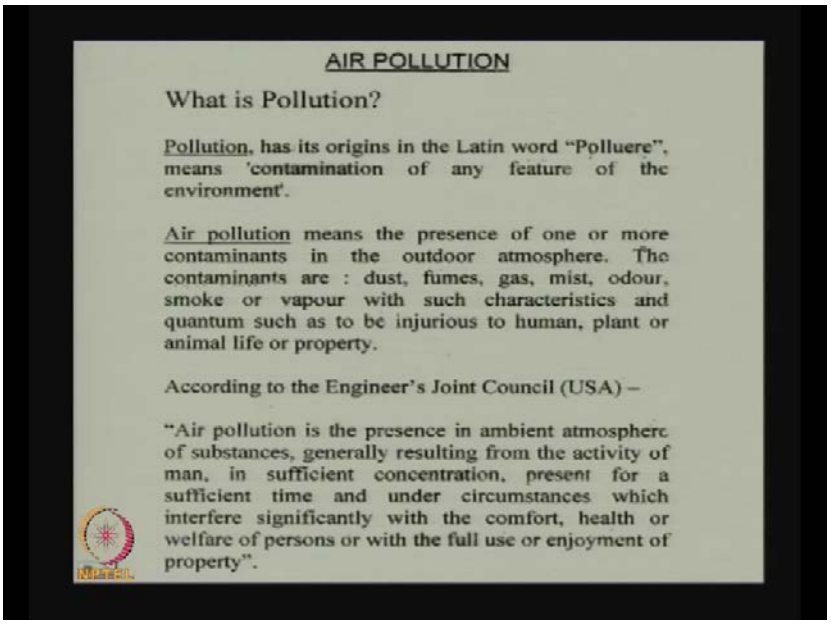

Let me start with one area which we normally do not talk about because we are always talking about solid wastes, discharges into the river. Let us start with air pollution. After all, air is what people breathe whether you are in the plant or outside the plant in the city. We may get used to what we are breathing, but you know if you go to the hills, you know the difference between breathing air there than breathing air in metropolitan cities, like Bombay and Calcutta.

Those of us, who live in Calcutta or in Bombay or in Delhi, see the difference when you go to hill station. Why a hill station, even to a city, like say Bhubaneswar or outskirts of Nagpur or Bhopal or Udaipur where the air is cleaner, you can see the stars at night. You can breathe easy and you can take a long breath and not cough. You do not feel choked. We cannot see what is in the air, but there are all kinds of things in the air that are not desirable.

Fortunately, the human system tries to adjust in the short run. Nothing happens, but long term effects are enormous. You know we do not have that long subjective horizon. If somebody says, take a job here and breathe, nothing will happen to you next week. I will accept even if it is a polluted atmosphere. I would not worry what happens to you next year. May be next year I would not survive.

Much of this comes from water, air pollution because we have all kinds of water purifiers. We drink water. We can at least try to purify, boil it or you can have some equipment, but we cannot go around using an air purifier. We do not even go around putting something to cover our nose and mouth, so that we take out from the air the undesired things. We are not habituated to that. So, air pollution is a very important. Even in the industries, you will find visibly there are all kinds of particles floating around. The labourers may be working without covering their mouth and nose. The management may not even insist on that. They have got used to the pollution. So, let us talk about air pollution.

What is pollution? We have defined wastes and industrial waste. One definition of pollution will see now. The word pollution has its origins in the Latin word polluere, which means contamination of any feature of the environment. So, if any feature of the environment is contaminated, by the word contamination means addition of something undesirable, then we have pollution. So, it encompasses a very wide area, anything undesirable in the environment is pollution and the word contamination has an implication that what is there has an adverse effect. That is why you say contaminated.

So, if you put dry fruits in milk, we would not call it contamination because it is adding to the value, it is adding to its nutritive value, makes it tastier. Contamination means when you have added something that has an adverse impact. Now, from that we can mean by the word air pollution, the presence of one or more contaminants in the outdoor atmosphere. We make a distinction between an air conditioned office and the outdoor atmosphere, where everybody is exposed.

What can be the contaminants? Dust, fumes, gas, mist, odour, smoke or vapour with such characteristics and quantum such as to be injurious to human plant or animal life or property. See how well this is defined. It takes into account affect on human, plant, animal life as well as property, immovable property. If something is injurious to the buildings, it is a contaminant. It may not do something to you, but the buildings are destroyed in the long run. It is a contaminant and it has characteristics and quantum such as which are injurious. It is possible that it has undesirable characteristics, but the quantum is so small that it is not injurious. Then it is ok. It would not be called a contaminant.

Similarly, the quantum may be large, but the characteristics may not be negative. Then, it will not be a contaminant. So, the contamination has to be in terms of both adverse characteristics and also quantum. I will read it again because it is a very nice definition and you should try to remember the basis of that.

Air pollution means a presence of one or more contaminants in the outdoor atmosphere. The contaminants are dust, fumes, gas, mist, odour, smoke, vapour with such characteristics and quantum such as to be injurious to human plant animal life or property.

Now, the Engineers Council of USA has given a definition which perhaps is little more precise. I will give that definition also. Air pollution is the presence in ambient atmosphere. Ambient atmosphere again means atmosphere that is all around you for the general population. The presence in ambient atmosphere of substances, generally resulting from the activity of man in sufficient concentration, present for a sufficient time under circumstances which interfere significantly with comfort, health or welfare of persons or with the full use or enjoyment of property.

Now, this is much wider in scope. It even brings in certain soft subjects such as comfort, enjoyment. It will bring in anything that gives you discomfort. It may not do something to your health, but it makes you uncomfortable in mind. It comes in the way of your enjoyment of the property, so that will improve lot many things.

Now, unless you come up with definitions like that, then the law cannot be strong also because law has to be defined in terms of specific things like that. Somebody can go to court and sue a company, saying that this is the ground on which I am suing the company or the government can attack the company, saying you have to be punished on such and such ground, retaining such and such clauses. That is why the engineer council had to give a definition like this. What kind of definition we are adopting, I might discuss later.

Let me repeat the definition. Air pollution is the presence in the ambient atmosphere of substances, generally resulting from the activity of man in sufficient concentration, present for a sufficient time and under circumstances which interfere significantly with the comfort, health or welfare of persons or with the full use of enjoyment of property.

Now, here there is a very significant thing has been put in generally resulting from the activity of man. Now, there can be natural processes, where suddenly something happens. We may not call it pollution. For example, you know when there is some vegetation, you know the vegetation undergoes some spontaneous processes and may begin to generate methane. That is what happens in bogs where some vegetable matter is in contact with submerse, little pools of water. It may create methane and sometimes this methane catches fire also spontaneously.

Now, here is a phenomenon which is creating a gas, which would put people in discomfort. It can cause fire which is hazardous. It will last for a while. It does not happen all the time, but we will not perhaps call it pollution in the sense. When an industry creates pollution because of manmade activities, man has created that industrial damage. So, there is a very stronger feeling against a man made contaminant than a natural contaminant. So, that is polluting the atmosphere no doubt but, that air pollution is different from the air pollution in an industry setup by man. Man is far more guilty. That is what we would like to understand.

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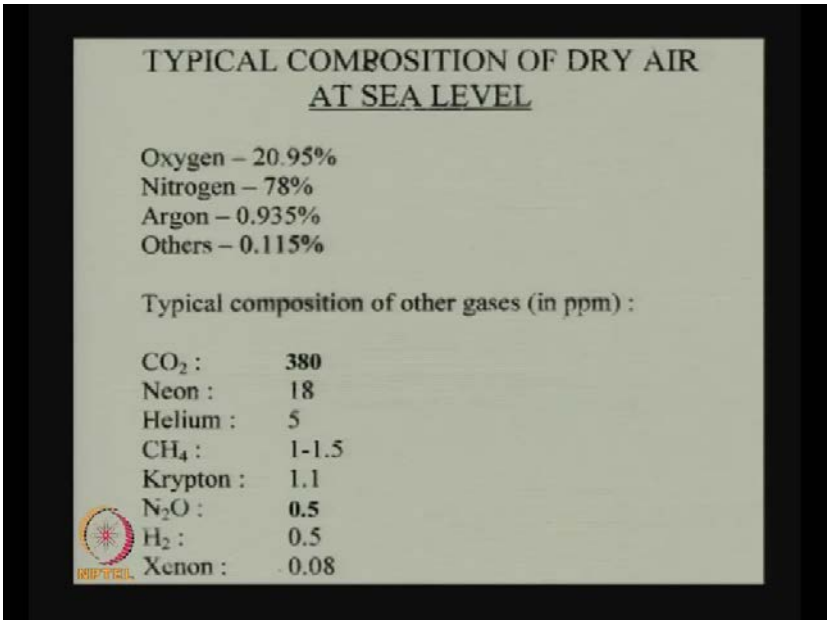

Now, typically at sea level, this is the composition of dry air, 21 percent nearly oxygen, nitrogen, argon and others. What are the others? Today, CO2-380 parts per million, there is some neon, helium, methane, some krypton, some N2O, xenon, hydrogen. These are

also there. Now, with time, this CO2 is gradually increasing, say 400 years ago when Shahjahan built the Taj Mahal, he was breathing in Agra, an air, which had around 280 parts per million of CO2. 280 per million parts of CO2 were there in Agra, say 400 years from now. Over the years, it has gone up to 380. Of course, in Agra it will be much more than 380. There are industries, there are foundries and there are human activities. It will be much more, like if you stand in the street corner in busy street of Calcutta or Delhi or Bombay, air will be much more than 380 CO2 parts per million, even much more but this is typical today.

That is the reason that the water, the rain water today, I do not know how many of you know the pH of rain water which is supposed to be very pure, almost like distilled water is not 7. The pH of rain water is around 5.6 or 5.7. It is acidic. Why it is acidic? It was acidic perhaps always slightly acidic because there is CO2 in air, so when the rain drops fall through the air, it absorbs the CO2. Now, there are areas where there is more CO2, rain water becomes more acidity. If there are industries where there is SO2 as was at one time, say in Ghatshila, where we had a copper plant, that SO2 that came out of the roasters and smelters turned all the plants everywhere yellow. I had been there 40 years ago. The trees did not have green leaves, they had yellow leaves. That SO2 and sulphur had turned everything yellow. Even if you entered houses, somehow you felt there was sulphur everywhere.

Fortunately, they have now changed the processes. You have the green has come back again, but if there are still SO2 in the atmosphere, but not to the extent we used to have. If there is SO2, again water will dissolve that SO2 and the water will be acidic. That is how we get acid rain in many industrial areas, that rain that falls is actually an acid. It can burn your skin. You think acid is coming from the sky. If it falls on vegetation, it is acid falling in vegetation. If it is falling on clothes, it is falling on clothes. We call that acid rain. Today’s industry is causing even rains to become acidic. It is a dangerous situation.

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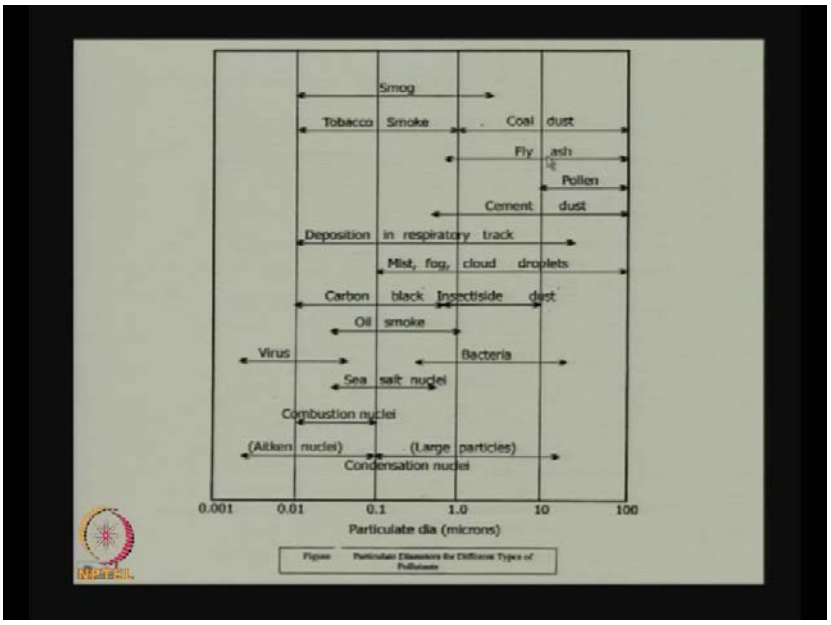

Now, what happens if we talk about air pollution? Now, in air if we have gaseous species like SO2, CO2 that is in the gas, it is pollution mind you, but they are gaseous pollutants, but very often what you feel more immediately are solid particle pollutants that particles of solid in air that is sensed more readily.

There are particles coming out of smog which is combination of smoke and fog. Tobacco smoke, coal dust, fly ash, pollens from flowers, cement dust, mist, fog, cloud droplets, carbon, black insecticides, oil, smoke, combustion processes give something. Now, here also, we have indicated particle sizes why we have indicated particular diameter. You see if you have solids in the air that you are inhaling; if there are very coarse solids, then the hair we have inside our nostrils, capture it. That is why god has given us a filtration device that our nostrils are full of hair, coarse particles are caught up there. So, you can clean your nose. They have not gone into the system.

If particles are very fine and I will tell you can guess from here, what they are. You will inhale them. They will go into your lungs and they will come out doing no harm. So, particles which are very coarse do not harm your system. Particles which are very fine solid particles, also does not cause any harm to your system. They will go in and then will go out. It is the intermediate range particles which can go in but which cannot come

out. They get deposited in our respiratory track. It is like that Abhimanyu's chakravyuh. He knew how to get in but he did not know how to come back.

So, once that we are here, like if you stand in a plant where coal is being processed and coal dust is coming, it will get into your nose and if you clean your nose, you will see all kinds of black things coming out, that is coal dust. Some pollen are also or cement dust, they are very coarse. They will not go into your system.

Small viruses can go in there and there are some small very fine particles will go in and come out, but a whole lot of things in between, including smog, tobacco smoke, carbon black, oil smoke etcetera enter our respiratory tract cannot come out. These are the ones which are very harmful.

So, we have contaminants in terms of the solid particles in air, contaminants in terms of gaseous species in air. They both are bad not only for human life, they are bad for vegetation, they are for animal life, they are also bad for property, buildings, equipments, plant matter. They are also bad from the point of view of aesthetics, comfort and enjoyment of life. All these are causing environmental pollution. Incidentally, you will find in many plants, many industries, the plants have been corroded. You will find they are rusting off. If there is acid in the environment, we may not feel it but the plant and equipment, they know because they get corroded.

So, the definition we get was a very apt definition. It is in terms of aesthetics, comfort, enjoyment, injury to property, man, plant, animal life everything. So, you see that it is a very serious matter, air pollution.

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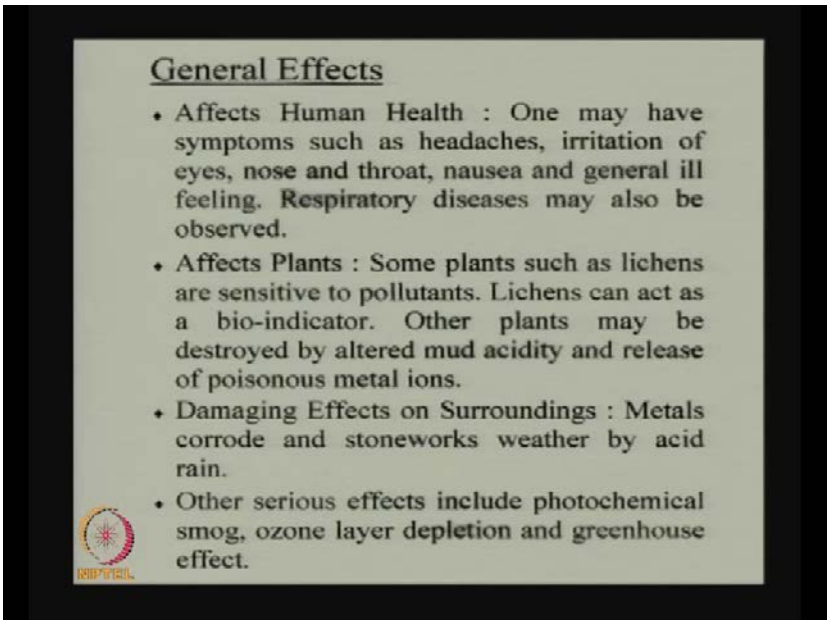

To summarize the general effects of air pollution, what we will have. It will affect human health of course. We can have to start with very minor things like symptoms such as headache, irritation of eye, nose, throat, nausea, and general ill feeling. Then, the long term you can have respiratory diseases and Calcutta, where I belong is now full of respiratory diseases. Unfortunately, the attack is more severe on children, which systems are more delicate and once they catch those diseases, it will become progressively worse. Those of us who have enjoyed a better atmosphere when we were younger are better off today because we did not catch the diseases in younger days. It does not matter so much if I catches it now, but think of the poor delicate children. If they get affected now, what happens to the rest of their life?

Why we are not doing anything to protect them because we do not have a long subjective horizon and we have also all kinds of reasons you are given. There is no disincentive, there is no incentive. When we come to a democratic process of voting who is worried about environmental issues. Does a party, any political party says, we are going to improve the environment and even if they say, are they going to get more votes. We do not care which means the public is also not aware. They do not have a long term prospective, their thinking of tomorrow. You cannot blame them also.

When we are in the lower stages of development where we are worried of day to day life, just bringing in something to eat for today and survive for today, they cannot have this wider outlooks of that. So, with development, these things go hand in hand.

Second is, they will affect plants. Some plants such as lichens are sensitive to pollutant. Lichens can act as a bio-indicator. We can have some plants, which will tell you by changing their color or shape or form that yes, the air is not polluted. I remember I was working in a place where we were working with producer gas and you know from producer gas, we generate CO. It is a dangerous thing because CO does not have a smell. In a room if you close the door and if you leave a coal stove [F1], you will not wake up alive in the morning because the CO that comes out of that would make you unconscious and kill you. I have seen such a thing.

I saw in a hostel in Kanpur. It was very cold. A small boy was feeling cold. The canteen closed at night, nobody told him that even if it is cold, keep the door open. He closed the door for more warmth. Next morning he was found dead because CO does not have a smell, it kills.

Now, there is a very simple way of knowing whether the CO concentration has exceeded the dangerous limits. Of course, there are CO meters are available, but simple thing is to have some small birds. It is not very kind, being very kind towards the birds, but then it is a practical thing. You know Munia, small birds if they are kept in cage; they are far more sensitive to humans because it has a delicate system. As I talked about the children, the bird will die.

So, when we are working in the plant and with the producer gas plant were CO, I told my colleagues to hang some cages with Munia birds in them. If they are chirping, running up and down, you know you are, but if you say they are becoming drowsy, then you know the CO concentration has gone up. You are not finding discomfort now, but what happens to the bird will happen to you little later. So, a bird can be an indicator. Similarly, these lichens can be used as bio-indicators. Other plants may be destroyed by altered mud acidity and release of poisonous metal ions. If there is pollution in the discharges, they will also be affected. Not only air, but liquid will also be affected. Then, there is general damage in effect of surroundings, metals corrode, stone works wither by

acid rain as I mentioned. Other serious effects include photochemical, smog, ozone layer depletion and green house effect. All this is coming out of air pollution.

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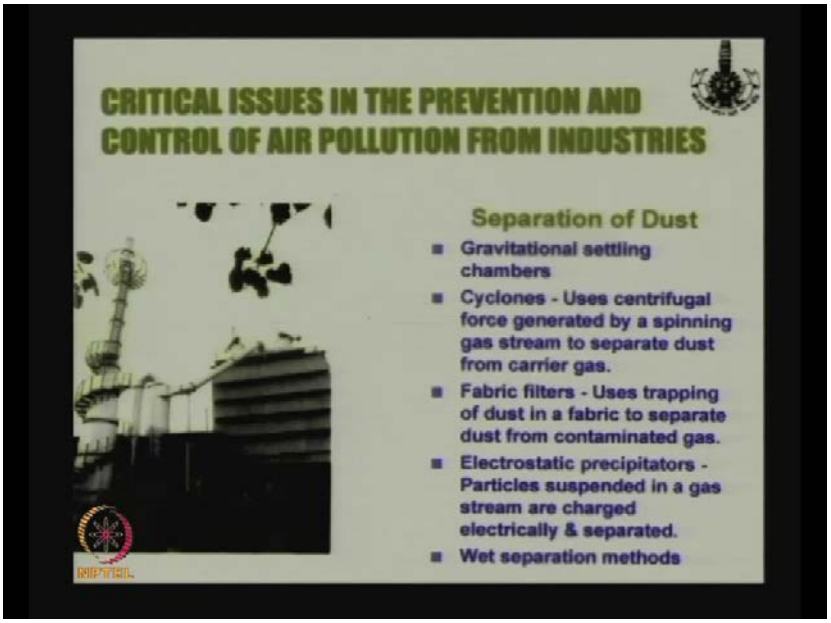

Now, about dust. Many industries have now standard processes for combating dust pollution, like whenever a pyrometallurgical process is taking place; all kinds of dust are likely to flow out. Especially, when hot gases are coming out, fine particles flow out with the hot gases. So, there are gravitational settling chambers, means suppose there is a gas coming out, you take it out and go through a process where there is outlet and then there is a chamber and so the whole thing hits the bottom of the chamber. The gas has to go out again and gravitational, the solid matter that was in the thing will drop to the bottom. It is a gravitational settling.

There are some devices called cyclones, which use centrifugal force generated by a spinning gas stream to separate dust from carrier gas. The gas chamber is coming out is made to spin that will separate out the solid particles. There are fabric filters, like I had mentioned that in the lead blast furnace, we have dust bags, silk bags that the gases go through, but the dust gets caught in them. They are plain filters made of different kinds of fabrics. They are used for trapping of dusts in a fabric to separate dust from contaminated gas.

There are electrostatic precipitators. If there is a gas stream and there are dust particles under an electrostatic potential, they can be charged and they can be drawn towards an electrode and the particles will go and stick to that electrode, gas will flow. There are some weight separation techniques, means if the gas containing solids are passed through a liquid, the gas will go through the liquid and the solids will get trapped.

So, in the industry, there are many kinds of matters today to handle dust, air pollution, dust pollution, but provided you are talking about a definite stream where there is dust pollution. If there is an industry where dust is coming out everywhere, through all kinds of cracks and holes, how to gather all that? That is not possible. It has to be a well defined process. The dust coming out with a stream of gas, we can certainly handle. So, design of the process is very important.

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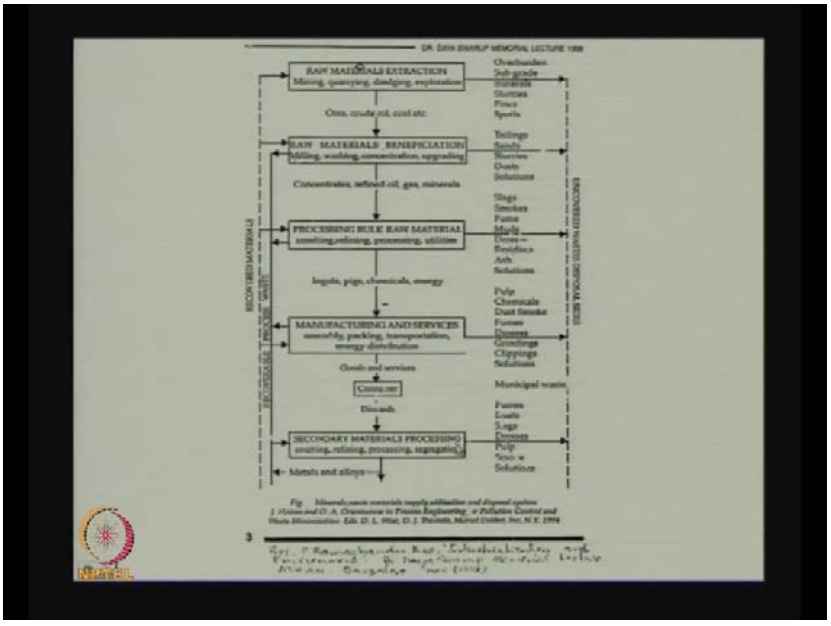

Now, I will go little more into the detail to tell you, in an extraction processes what all kinds of wastes that we generally generate, but this is going to take bit longer. Like we will start from raw materials extraction, then beneficiation processing of raw materials manufacturing and services, secondary metal processing, from the entire gamut or trying to take out raw materials from the earth's crust goes to the consumer. Then, after consumer, you have secondary metals and they will come back again. We will consider the whole cycle and try to see, at which step we generate what waste.

I will not discuss that any further as to what quantity or how much of what, where to which metal, but a general idea you should have because after all, the whole idea of my talking to you is to give you a general idea of the environmental issues. Also, you should connect it with energy. The solutions will come once you become more aware. This is what is happening in the industries. Industries are subjected to constant, not only constant pressure, but constant awareness program, so that once they become aware, they find the solutions themselves many times. Sometimes, they have to take the advice from consultants. I will come to discussing this table in my next lecture. Thank you very much.