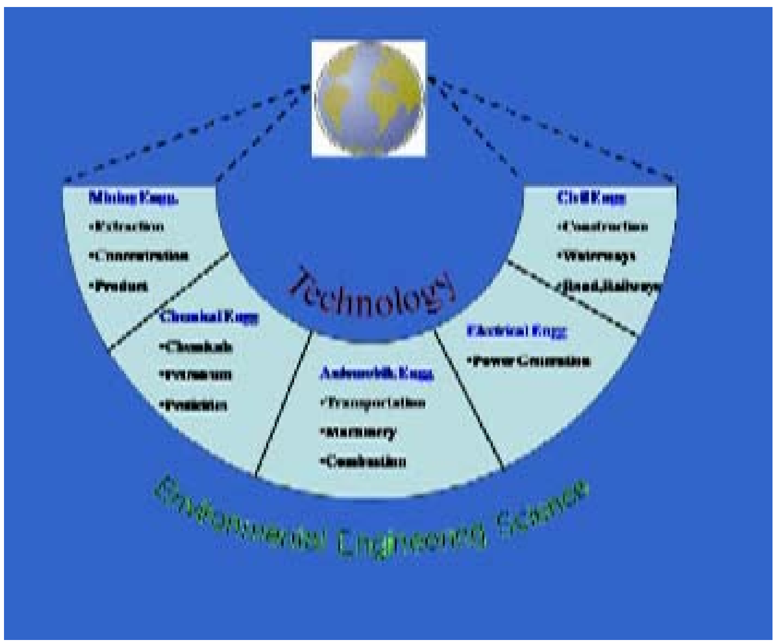
Enivronmental Air Pollution

Prof. Mukesh Kumar
Dept of Civil Engineering
Indian Institute of Technology, Kanpur

Introduction to Atmosphere
Lecture 1

We will try to define what environmental engineering is before we go on to air pollution.

(Refer Slide Time: 00:00:26 min)



What you see here is a great deal of technological development that has happened since the industrial revolution. First, we had civil engineering and now you have all kinds of engineering. There has been so much development and advancements that you have all kinds of engineering breakups, branches and sub-branches; think of: mining engineering, chemical engineering, automobile engineering, electrical engineering and civil engineering.

All these technologies, all these developments, have happened with just one simple objective in mind: to make life comfortable. Human society, you know, has become more and more comfortable to use a technology; you can do things faster, you can do things to make life comfortable and as a result a lot of good things happen: people live longer and health facilitates are better. This has given rise to globalization, communications have become good, the transportation has been good and material comforts are plenty.

But having said all that, if you go over each one, one by one in a line, eventually this leads to some kind of problems. We then probably can go into details that mining people will do harmful things; they will go down underneath the earth for 3 kilometers, 4 kilometers…. If you can say that God has made everything under the ground so it is not disturbed; man has been able to bring it up and we have all kinds of problems that come up…. Well some for good things, but then again there will be some associative problems; we all can talk about new chemicals being added and the problem of pesticides. We can talk about the transportation and all… very nice; you can drive through the cities quickly, but then again the issues and the problems that come from the transportation and automobile engineering. So also in power generation, and all kinds of problems; not only the SO_2, NO_2 particulate matter, but let us not forget carbon dioxide. In civil engineering, also there are many things that lead to problems as well.

What was happening is, when these things were developing, people were very happy; then you started seeing the after effects or the backlashes of the technology. Everything has a good side as well as a bad side. So, there were also the backlashes that started coming in, then the people from science, people from the medical sciences and [personal and] environmental health, they came up and said there are certain problems: things are not so perfect, these things the way we are talking, the way we are developing, the way we are progressing, cannot be sustained; it is impossible. I mean, you just cannot go on expanding, you cannot go on increasing the mining area, making extractions and have product after the product.

Just imagine the iron and steel demand - is it sustainable? Suddenly the Chinese are growing at 12%, India is growing at 10% and the first requirements for building anything are iron and steel.

You see all kinds of international politics. The international companies are taking over other smaller ones and as a result, issues have come up. Similarly, with the number of automobiles sold every day.

Is there any guess as to how many vehicles we might have in Delhi?

More than forty lakhs, I mean, forty-five lakhs. Almost like one thousand new vehicles are registered in Delhi. Apart from that, Delhi being the centre, there are many vehicles which come in and go out of Delhi. Vehicles come from adjoining areas: you can talk about Faridabad, you can talk about Noida, you can talk about Gurgaon; this is impossible to sustain. Not only in terms of the infrastructure limitation, but from the backlashes; this kind of unbridled uncontrolled growth simply cannot go on. This is one example which is very apparent but that is true with everything that is happening.

You have all these problems. These things, with technologies of engineering, which came for the good of human society has started creating problems. This development cannot be sustained unless, the people, this science that we do - EM or air pollution or the water pollution, this came into being and then that encompasses the whole thing. It just not here or here; we can add on the many things, there could be tens of branches here. So, this came into being and then they said, well all right, if we want this kind of growth, there has to be something more you have to pay. The interesting point is, you have products everywhere, but this is not an engineering that gives you a physical product to see. All engineering gives you a product, a comfortable product; to make you comfortable. However, this science or engineering does not give you any product, but it sustains all other products.

This bubble of being healthy, being wealthy, will burst; it is impossible, it cannot be sustained. So, this is how this came into being; and then you see here, what we are talking about. It cannot be the job of civil engineers alone, or mechanical engineers alone, or the person of hydraulics background. So, the very subject of environmental engineering science becomes interdisciplinary. So, that is why there is more and more emphasis on the interdisciplinary solutions.

The best person to clean your house is you - yourself. I cannot come and clean your house because I do not know what is in your house, how the things are stored and what the best way is. Your systems should also work and you should be able to clean it also.

So what is happening is within this thing a kind of environmental engineering is developing. A person knows best about his own product because he wants to continue to use of the product. Therefore, he has put in a lot of development to sustain his product, within development of clean technologies, but this is our job – to sustain all these things.

So we, in fact, are the engineering which is helping or making every other engineering survive: this is my interpretation of environmental engineering. The focus for this course will be, as you know, air pollution. You see the fundamentals are very important but in this first lecture, we will talk more about of the atmosphere. Stop me at any point, whenever you have a question.

(Refer Slide Time: 00:08:27 min)

We will talk about the origin of the atmosphere, is very interesting. How the atmosphere was created, what it was before and how it happened. Let us quickly go through this because we should have the idea. The person who has lost the history and has lost his roots is an unsuccessful man. When we are talking about atmosphere, we should know the history of atmosphere, leave aside the history of air pollution; now, let us see how the atmosphere was formed.

The origin of the atmosphere, to start with probably was all hydrogen and helium; nothing else. Why do I say Hydrogen and Helium? When the universe was created, it is believed, that largely the gases around the planet were hydrogen and helium; the most light kind of thing and people still believe it or this is what science that tells…

If you go to Jupiter, for example, still the Jupiter is least effected because anything far away sitting in its corner still full of hydrogen and helium, but change in the style of life things got changed.

But then the air was like… air is sitting on a such a middle place on the universe that you are not so hot like the planets which are close nor we are so cold like we are far away from the sun that where nothing will happen. So beautiful temperature settings we have on the earth; many things happened on the earth.

The original atmosphere was then slowly stripped of the hydrogen and helium because of the solar wind. It became devoid of hydrogen and helium with time. That is why it says the hydrogen and helium have the smallest item by mass; we all know that, and then it was very easy to drive them out. The early earth was not protected by a magnetic field, so the removal was very [ ]. The current atmosphere is a secondary atmosphere. We started with this one and this is why in Jupiter you can find the hydrogen and helium.

(Refer Slide Time: 00:11:13 min)

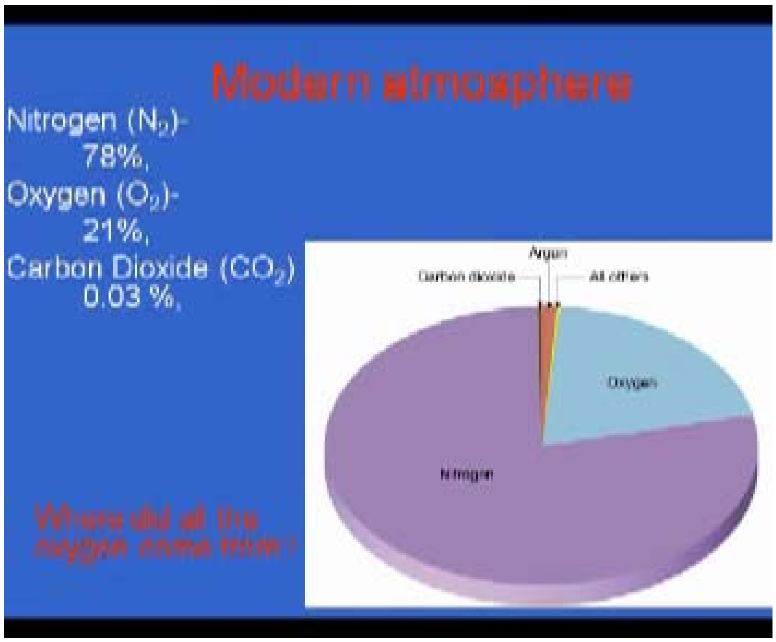
So things got changed. We are not talking about the primary atmosphere; it got changed to something else. We are talking about the secondary atmosphere and then what is largely believed is that it is the kind of atmosphere we have and the responsibility for the kind of atmosphere is from the degassing or venting of the volcanoes. Many things came from there and that is the basic thing in the atmosphere that has essentially come from there.

Any idea what comes out from the volcanoes? SO_2, yes. Not so much of Hydrogen. Huge amounts of CO_2 and huge amounts of SO_2. This is a typical picture of a volcanic eruption. What you will find is that apart from the gases emitted, initially, after hydrogen and helium were gone, the gases in the atmosphere were similar to the volcanic activities that we see. There is a huge amount of water, ash that comes out, CO_2 and SO_2. Apart from that, there are other things also: a little bit of sulphur, chlorine, nitrogen, hydrogen, ammonia and methane.

What we can quickly tell is that this is not the atmosphere what we see today. Many things would have happened even after this. What do you think that could possibly have happened after this? Cooling is constantly going on. What would happen once we have the cooling - what will happen to H_2O? It will start condensing and that might have created the kind of waters in the oceans. Something should happen to CO_2. What is the kind of percentage of CO_2 are we talking about today in the atmosphere?

.03%, right. In terms of ppm tell me. So this was the scenario. Let us quickly see what happened.

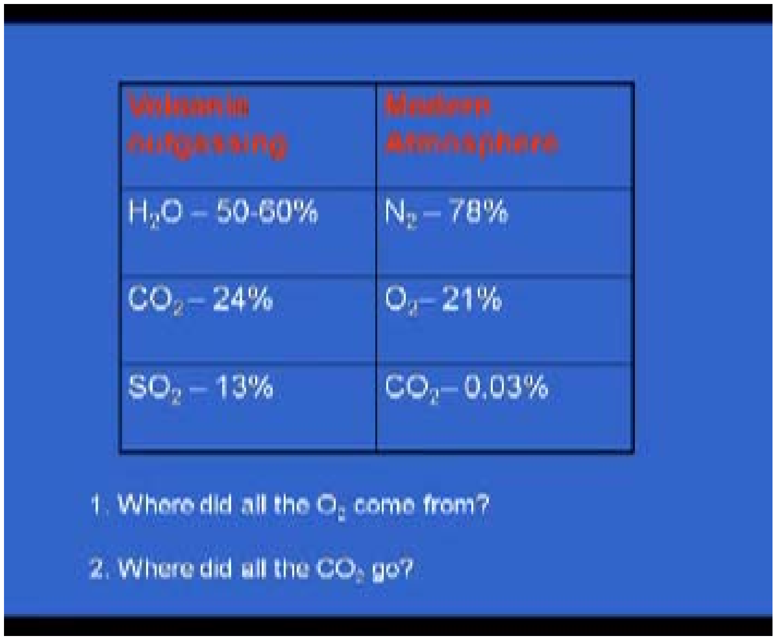
(Refer Slide Time: 13:58 min)



The title you can see - modern atmosphere. We know about this and we will not spend much time on it. The nice picture you see here and that is fundamental to our survival. The water should disappear, nitrogen should come, the oxygen should come and of course, carbon dioxide is a byproduct. But the main thing is the oxygen. Is the oxygen a product coming out from the volcanoes? No.

The atmosphere has undergone very serious and very interesting changes. Now, let us see what those changes were. Now, we can question ourselves: where did oxygen come from? Today oxygen we are breathing every moment.

(Refer Slide Time: 00:14:58 min)



This is the comparison you see. This side is what you see from volcanic eruptions; these are the levels in the modern atmosphere (Refer Slide Time: 00:15:05). You see things have dramatically changed and are very different now. Do you know how this happened? We should always at least know the basics in history: how things happened and all of that. Of course, these are all theories, largely believed to be true; we do not know, but this is what science tells us that probably this might have happened.

Now, I will try to answer where all the oxygen came from and then, let us not forget where all the CO_2 went. Let us talk about water.

(Refer Slide Time: 00:15:46 min)

We are talking about the formation of oceans. We saw the earth cooled enough that it has condensed to form the oceans. But the kind of calculations that you can do, the water was probably or H_2O in the vapor phase that probably came out. It was not so much as that it could create two-thirds of the land mass and the kind of depth the oceans have; so that theory does not quite hold.

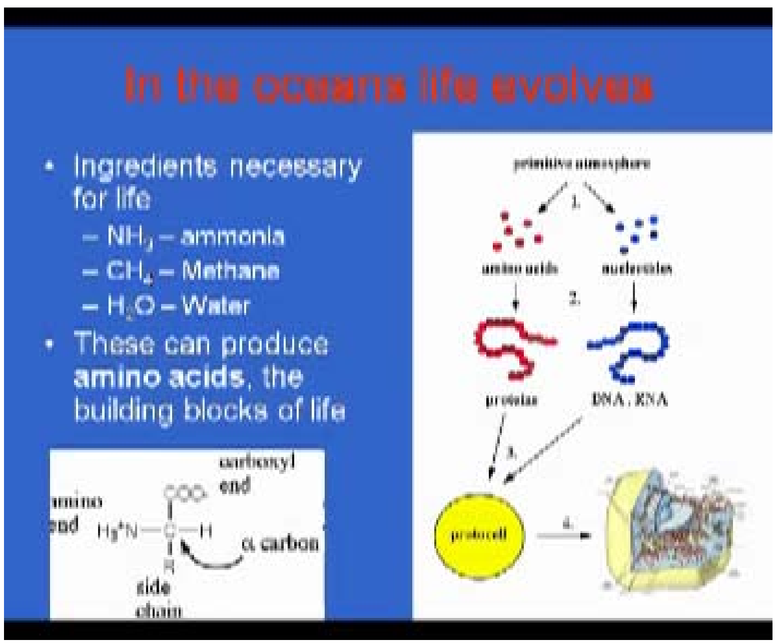
So what is the other thing that people are talking about? Estimates of the amounts of the H_2O out gassed is not enough to fill the oceans, but it was largely believed that a large volume of the water was added by the impact of icy meteors. Many of the meteors were very icy and contained lot of water. Some of the planets also contained water, and that that came and hit the atmosphere of earth and in the process also got condensed; the meteors will lose their temperature. This largely could explain the amount of water that we have.

Once you have the water, CO_2 will dissolve. What is the law which governs the dissolution of gases? Henry's law. That was one thing, but again you can see that if I have 20% of CO_2 or whatever the CO_2 that was there… but the amount of CO_2 that disappeared would not have disappeared - because there was a huge amount of CO_2.

What would happen if I dissolve more and more? What should I do? I should consume it. Then I can dissolve more and more and more as long as I can drive out the CO_2 from a system and somehow use it. Again, these are theories; again, that is the kind of knowledge we have; we are all trying to answer how the CO_2 levels we have were achieved.

We will quickly have look at the things that led to life on earth. The kind of atmosphere which you see was possible because somehow, we do not know how, life came to earth. The spark we talk about the life that somehow happened; how it happened we do not know.

(Refer Slide Time: 00:18:00 min)



If you look, essentially if you look: what are basic ingredients or building blocks for life? Amino acids and the cells; to make amino acids what you really need are ammonia, methane and water. We had plenty of methane from the volcanic eruptions. A certain amount of ammonia was also scattered there; water in the form of water, not in the form of vapor. So you had basically all this things necessary that dissolved into the water. We are talking about the oceans; we are not talking about life on land - these things were there. Somehow, we still do not know how it happened… we cannot have ammonia, CH_4

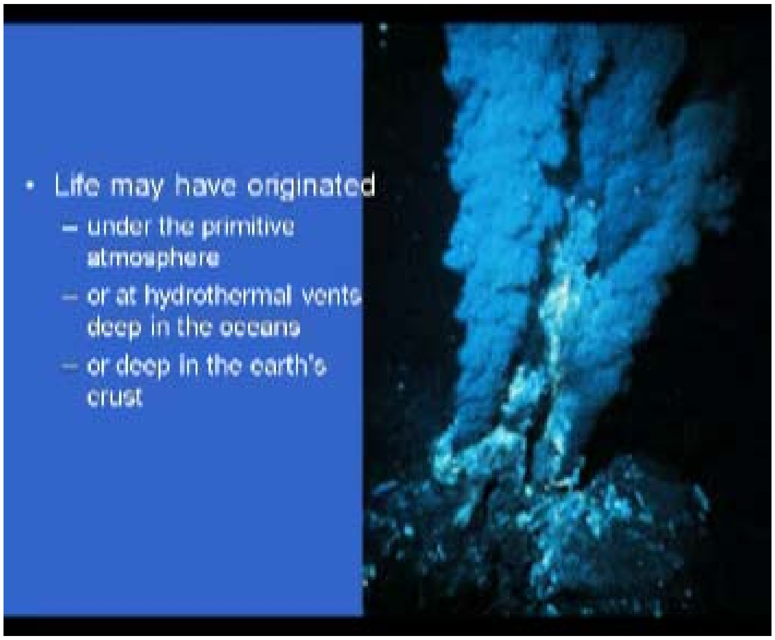
and water and try to make life – it is not possible. But this process we just looked at can produce ammonia acids - the basic building blocks; most of you know the structure of the amino acids. When you have ammonia and there this (Refer Slide Time: 00:19:28 min) is the side chain which can have something here; this is the alpha carbon; this is carboxyl and this is the hydrogen. The complex sequencing of amino acids gives us proteins and that is a basic building block. So, that is probably what happened.

What you see here you possibly know. Amino acid, nucleotides were formed, DNA, RNA, protein and some kind of proto cells, which we all now know are inside this one and we thoroughly understand.

Which scientist talked about the basic living structure cell? Robert Hooke. When and how did he come up with this name? He was slicing through cork; he saw hexagonal structures and said that is a cell. That is how the cell came about. We should not forget we are talking about the atmosphere. We all now know what possibly happened and this little tiny thing, the smallest thing you can think of, this came up and this could then multiply.

The basic definition of the living thing is that it is able to reproduce itself; that is the fundamental definition of any living thing.

(Refer Slide Time: 00:21:09 min)



So if it could reproduce and multiply very quickly, that might have occurred, we do not know, under the primitive atmosphere or at the hydrothermal vents or deep in the oceans, or in the earth's crust but largely it is believed that it happened in the ocean.

(Refer Slide Time: 00:21:33 min)

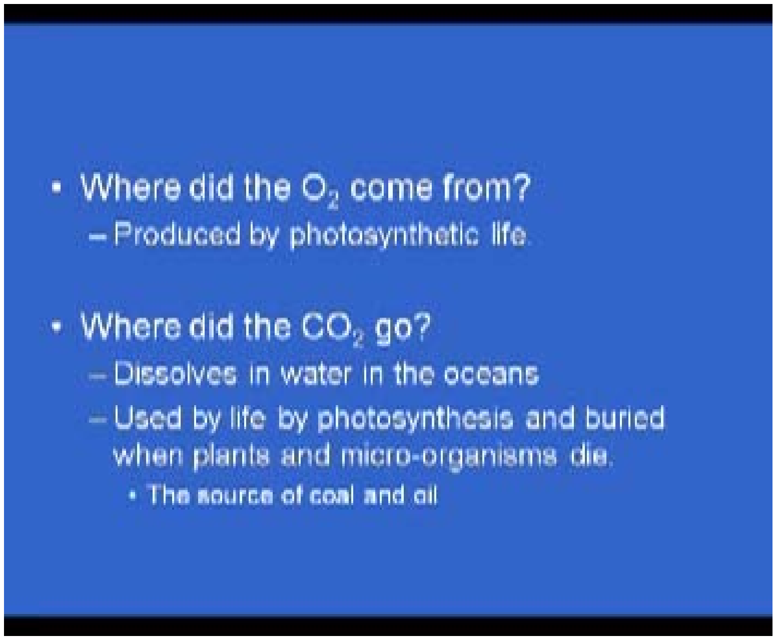
You have the conditions to produce a life but sometimes the life changes the very condition from where they were born. There are different kinds of atmosphere and it created life; now, life has become responsible for the change in the atmosphere and creates another kind of life. How it happened we will see in a moment.

It is largely believed that all the unicellular organisms or algae occurred in the ocean or wherever there was place where they could sit and grow. You see here what would happen: largely they would consume CO_2 and methane. So CO_2 will come and getting fixed. So, as a result more and more CO_2 will dissolve in the oceans of water. As a result of these activities, they will give out the byproduct: oxygen. There is no oxygen in the atmosphere at this stage, but the CO2 is getting fixed, the respiration is going on and the oxygen is the end product here. Oxygen will be excess in the ocean, slowly, with time; the time scale we are talking is billions of years. This oxygen that will evolve and that will try to come out of the ocean and slowly started building up in the atmosphere. In a way, we have said: how CO_2 got into earth, how CO_2 was consumed, more CO_2 was dissolved and then the oxygen started coming out. It is largely believed that even on the land, plant life had started growing on land slowly and so in the process all the carbon got fixed in the plants.

We all know that the earth was very stormy, very dynamic and that many of the forests that were created or many of the biomass got subsized into the land. Everything got fixed and as a result CO_2 is one which constantly went down and the kind of levels of the CO_2 that we have were eventually achieved.

When we say the evolution of the life, the first cellular organism was cyanobacteria; you all know that because you have done the basic courses; it began to use the gases in the early atmosphere: ammonia, methane, water for energy; and what I have said is the photosynthetic activities - these organisms breathes in CO_2 and produce oxygen as the waste product. In fact, oxygen started as a waste product. We try to reason it out as to where the things are and how it happened. Let us move to the next slide.

(Refer Slide Time: 00:24:38 min)

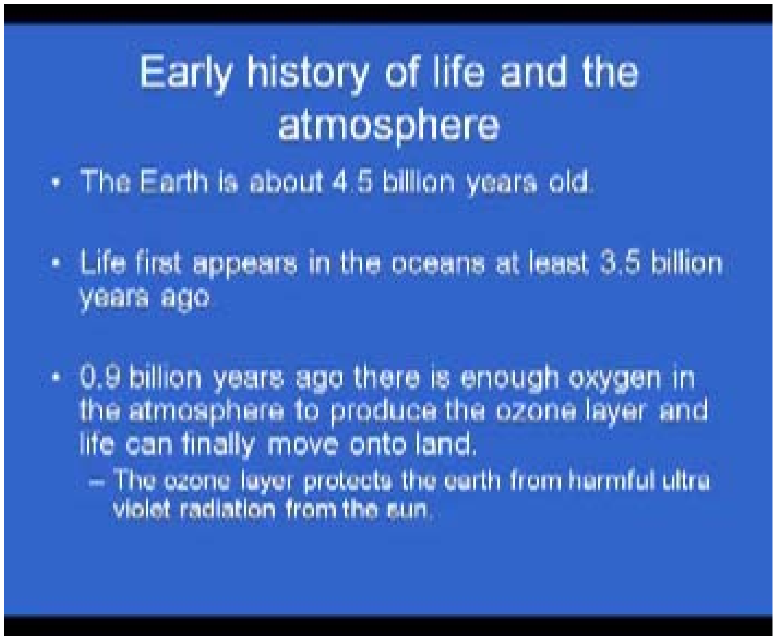


We try to explain as to what happened and how it happened. That is: where did the oxygen come from? And where did the CO_2 go? – We are trying to answer that: it dissolved in water in the oceans, used by the life by photosynthesis and buried when the plant and micro-organisms died. The source of coal and oil also comes you know because of that kind of waste.

We are using so much of fossil fuel that we are trying to build more and more CO_2 again. The CO_2 levels probably will not go to the kind of levels which were there in the beginning.

The other issue you are familiar with is the green house gases and the earth temperature going up but we will not talk about that.

(Refer Slide Time: 00:25:27 min)



Look at the time line. The earth is about 4.5 billion years old. Life first appeared in the ocean at least 3.5 billion years ago. It is about 0.9 or one billion years ago that there was enough oxygen in the atmosphere. So, in fact, it is largely believed that many of the species that were there on the land, the oxygen was very toxic to them; because before the oxygen came, some of the life that was there - life in terms of the plants or whatever kind of bacteria, largely anaerobic bacteria - might have grown and they could not sustain the kind of oxygen that started coming out. The adaption to the condition, survival of the fittest, was how they survived. That we all understand by Darwin's survival of the fittest theory.

There was change in the life style also. The kind of the man and the life you see is largely because they could adapt and change itself to the changing atmosphere. There was enough oxygen in the atmosphere to produce the ozone layer and life can finally move onto the land. When we started having lot of oxygen what would happen? We all know there is a lot of ozone in the stratosphere – how did this happen? Though, we have lot of oxygen and uncontrolled UV radiation that will reach on the surface of the earth.

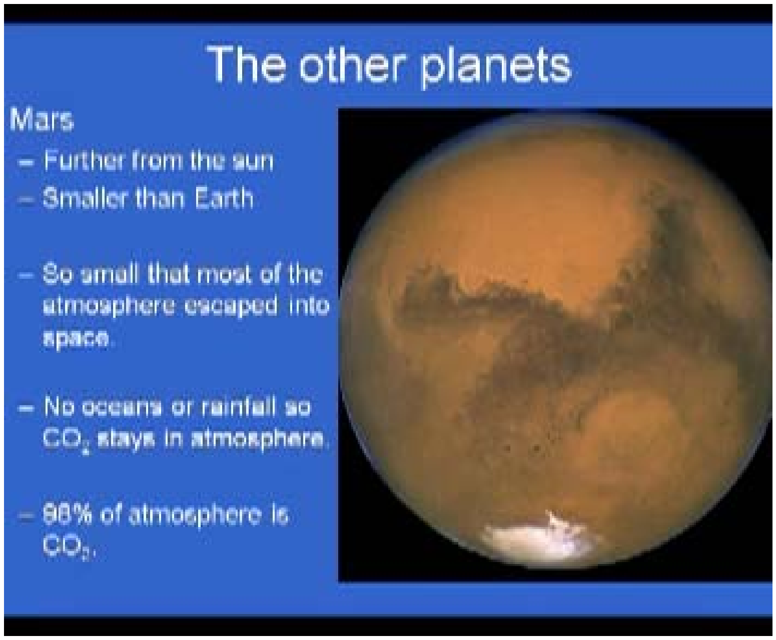
In the stratosphere how was the ozone layer formed? Ozone is formed when oxygen is broken down, because of the kind of radiation that was coming in the stratosphere, to the nascent oxygen. O_2 is broken down to O plus O. This O will combine with oxygen to make ozone. Right now this is happening in the stratosphere but in the beginning that was happening right down the stratosphere, as a result slowly the ozone level went up and we have the kind of a layer that envelops the whole earth. So the UV radiations were stopped from reaching the earth. The kind of life here somehow cannot survive UV radiation. So you see how with the period of billions of years things changed and then we have the kind of atmosphere; ozone is sitting up there. These are the basic stories people largely believe how life started on land.

(Refer Slide Time: 00:28:21 min)

See the other planets, Venus, it is very close to the sun and the surface is very hot. So water vapor in the atmosphere does not condense. We do not know if there is life on Venus but the possibility of life is very low. There is the greenhouse effect; there are no oceans or rainfall; no CO_2 or whatever is there, and it does not dissolve. So it more or less stays the way it is.

Earth is very uniquely placed in the universe and there is life here. And so here we are talking and discussing and trying to sort our problems out.

(Refer Slide Time: 00:28:42 min)

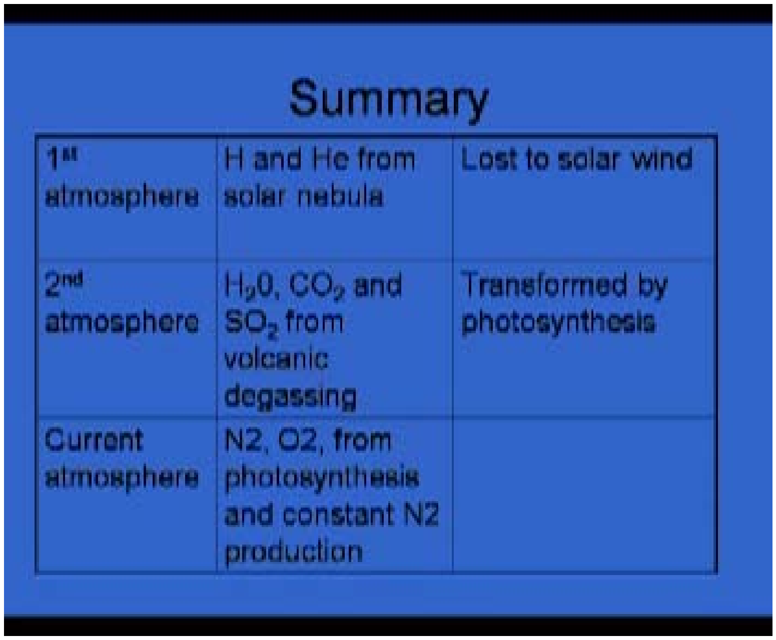


Mars is a little cooler than Venus is, but smaller than Earth; so small that the most of the atmosphere escapes into space. There are no oceans or rainfall, so CO_2 stays in the atmosphere; 98% of the atmosphere is CO_2 there. Now Mars we know much better than what it was before. So there is no hope of life there.

(Refer Slide Time: 00:29:02 min)

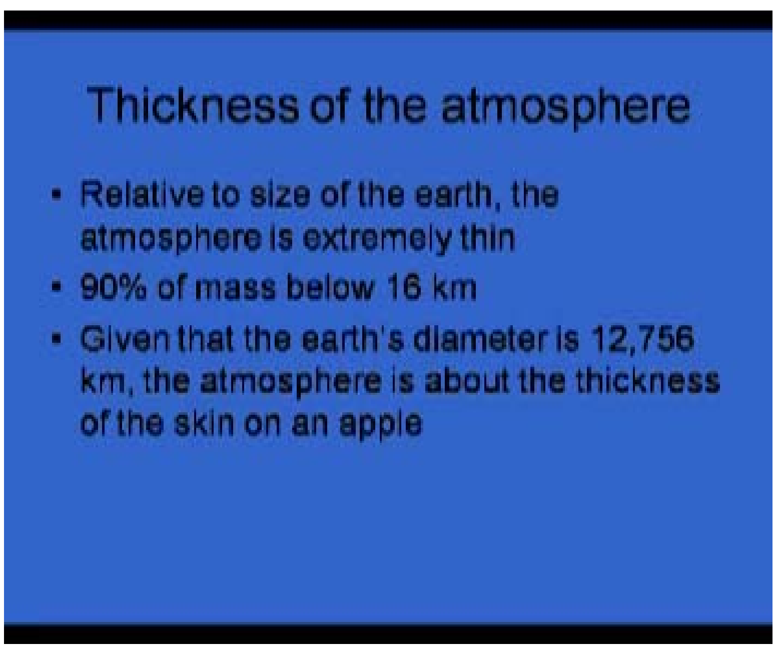
Jupiter is unchanged. And that is why it is largely believed that the kind of universe which we see, or our solar system, or our galaxy was being formed, it was with Hydrogen and Helium. But things got changed on to Earth because of our unique situation that we have: moderation in temperature made things possible.

(Refer Slide Time: 00:29:27 min)



You can all quickly see this slide. Let us quickly see the summary of what we have talked about. Let us move on to something else. Let us now talk about few things in the atmosphere.

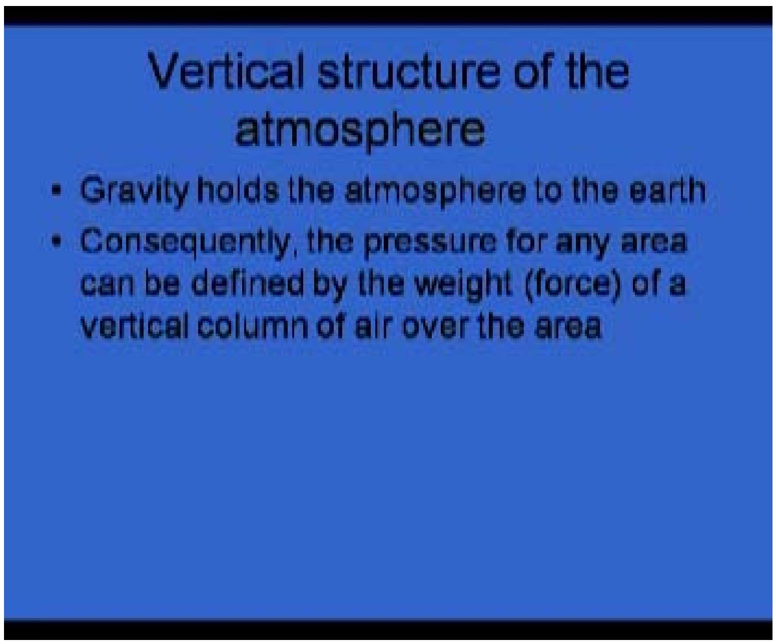
(Refer Slide Time: 00:29:49 min)



What do you see? You see is that the atmosphere is very small; it is just a very little field. Relative to size of Earth, the atmosphere is extremely thin; 90% of the mass is below 16 kilometers; given that the Earth's diameter is so much, the atmosphere is about the thickness of the skin of an apple.

Now, let us talk a little bit about the vertical structure of the atmosphere in terms of the pressure, maybe little bit about the temperature.

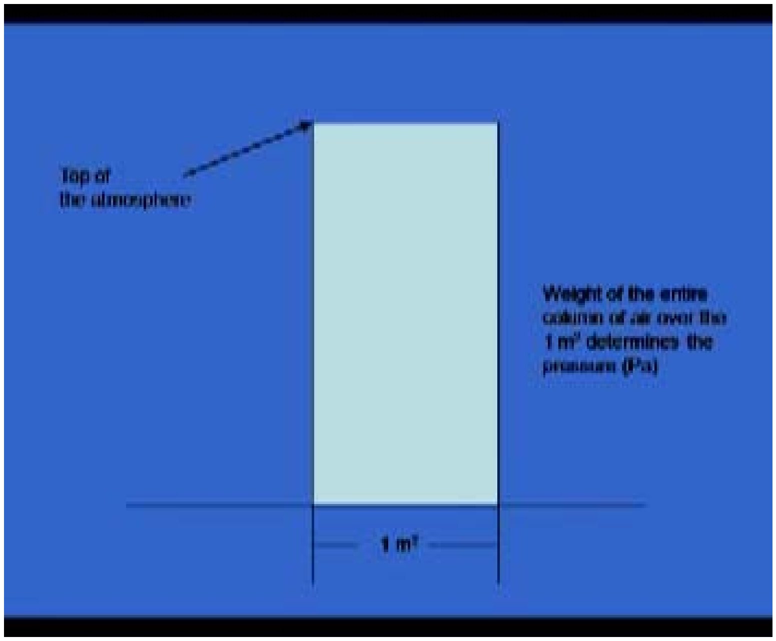
(Refer Slide Time: 00:30:21 min)



Gravity holds the atmosphere, no doubt about that. Consequently, the pressure for any area can be defined by the weight that is force divided by unit volume of the area. We can define the pressure, these are basic things all have done. We can define the atmospheric pressure; top of the atmosphere takes the kind of force it exerts or just take area of one meter square and that is what pressure is.

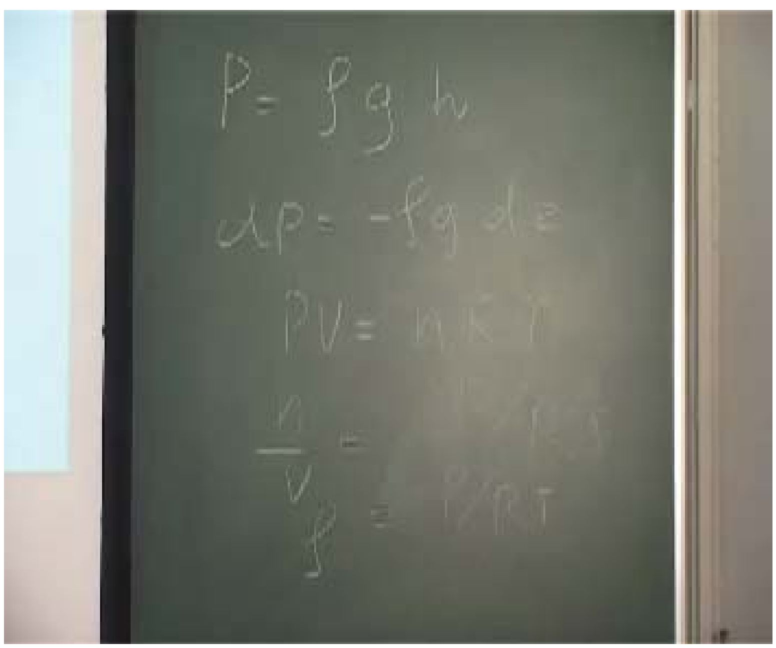
What is interesting is that it is not the integrated pressure that we are talking about but what is of interest for us is the effect of air pollution on the atmospheric pressure. How the pressure changes with time with height.

(Refer Slide Time: 00:31:14 min)



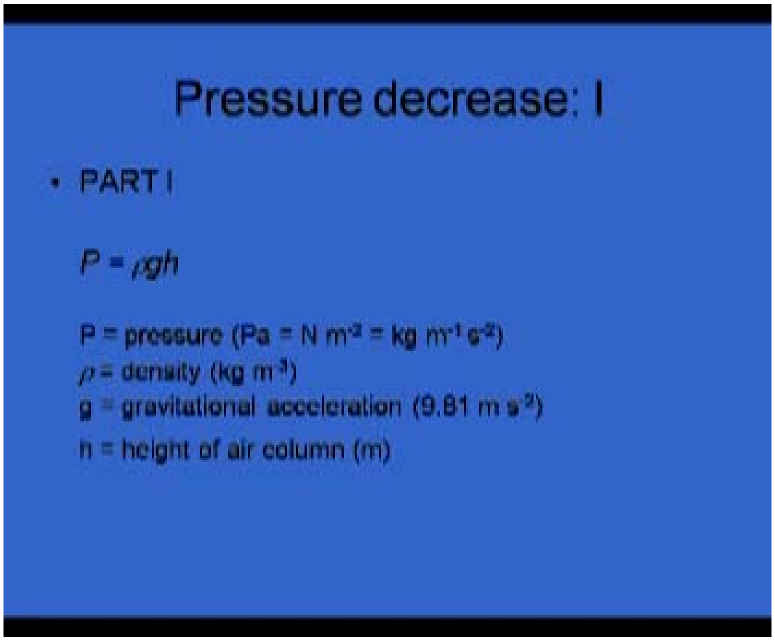
We all know how the pressure changes.

(Refer Slide Time: 00:31:22 min)



I am talking about z or h and all the definitions and the numbers that you see. If you take the rho as kg per meter cube; g meter per second squared; h as meter; does is it come to the force by area? It comes to height that comes then it is it is fine. So unit wise you can see here. Now what I want to do is to define the pressure with respect to height. I can make this as a differential equation using h or z; we use z and do what? We put a negative sign because the pressure is decreasing.

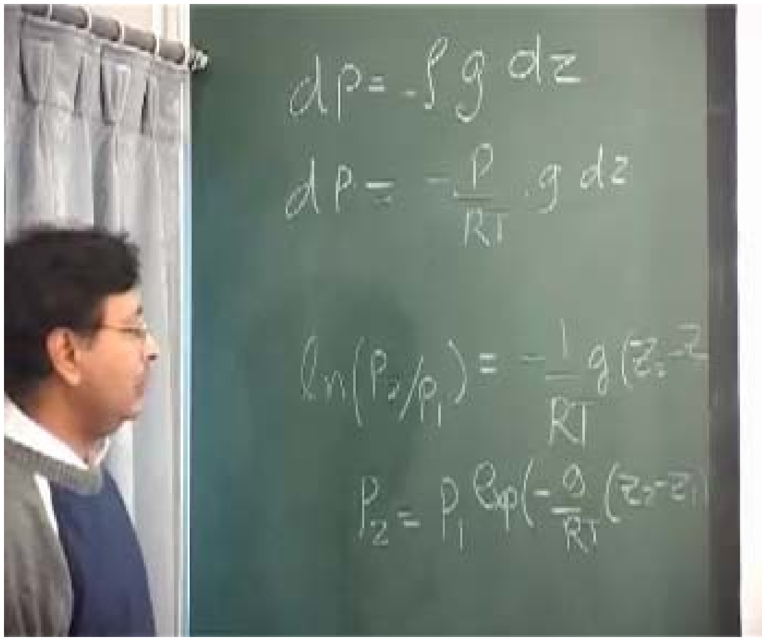
(Refer Slide Time: 00:32:09 min)



This is called hydrostatic law. You all know it; it is nothing new. That is also applicable where the water is a fluid. We are just extending this to the air or change in pressure is equal to the density times acceleration times the change in the height. The [ ] of air is balanced by the upward and downward forces acting upon it. We are talking about the stability of the atmosphere, what are the forces acting on to the particle in the fluid? Gravitational, buoyancy and drag. Let us get to the how the things are in a complete sense, how it will change with z.

This kind can also change, the density part; so we will try to then remove the density out of air. This may be we will use maybe hundreds of times - universal gas law, PV equals to nRT. What is the n? A mole fraction over the light. Can I find out the rho from here and try to replace the rho? P by RT. What does this become? P by RT, I can replace here.

(Refer Slide Time: 00:34:30 min)

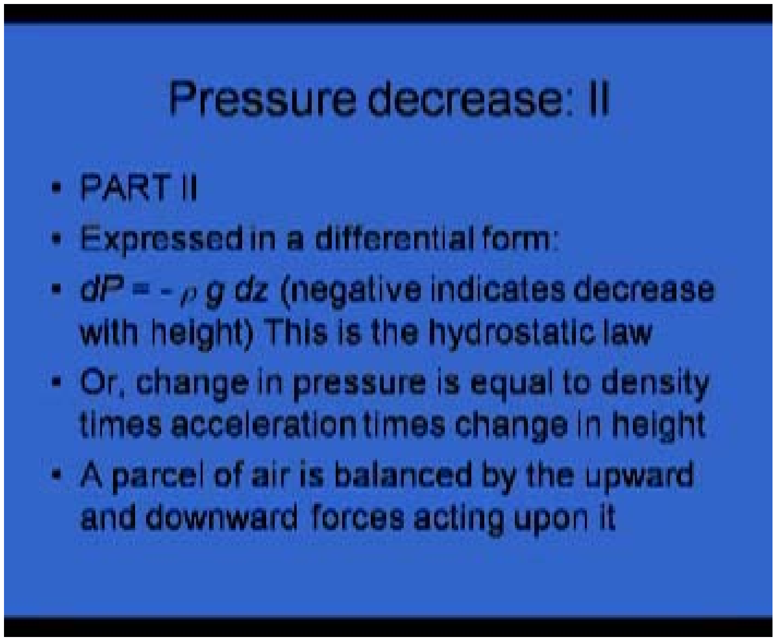


What was this about? dp was rho g dz. What is at rho we found? P by RT g dz and dp; I can find out the pressure. Find out what will be the pressure that will change as the height changes. Take any height initial condition as z_1, z_2; initial pressures P_1, P_2 and tell me what expression you are getting.

We will take ln p two by p one minus one by RT exponential e g; z_2 minus z_1; make it more simplified. P_2 equals P_1 exponential minus g upon RT.

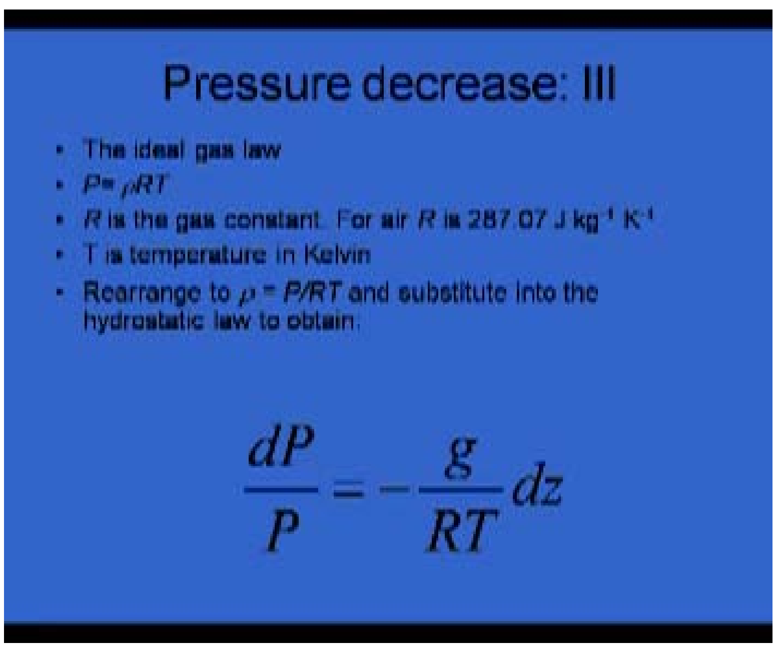
The idea of getting this equation down is just to explain how exponentially the pressure will decrease with height. That is with high school basic physics we can write this one. And that is what probably the next slide should be.

(Refer Slide Time: 00:36:30 min)



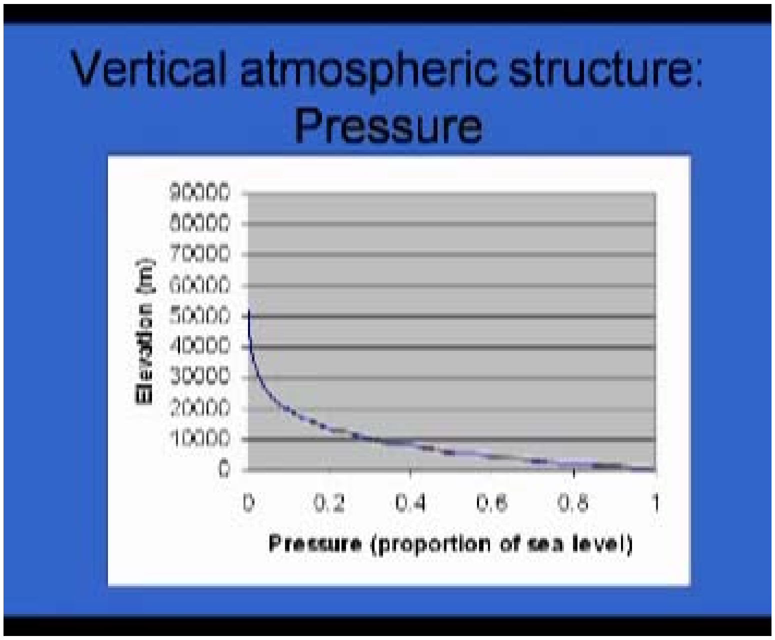
You can find out the pressure and then always what you should do is not only derive it, you should always show it graphically.

(Refer Slide Time: 00:36:45 min)



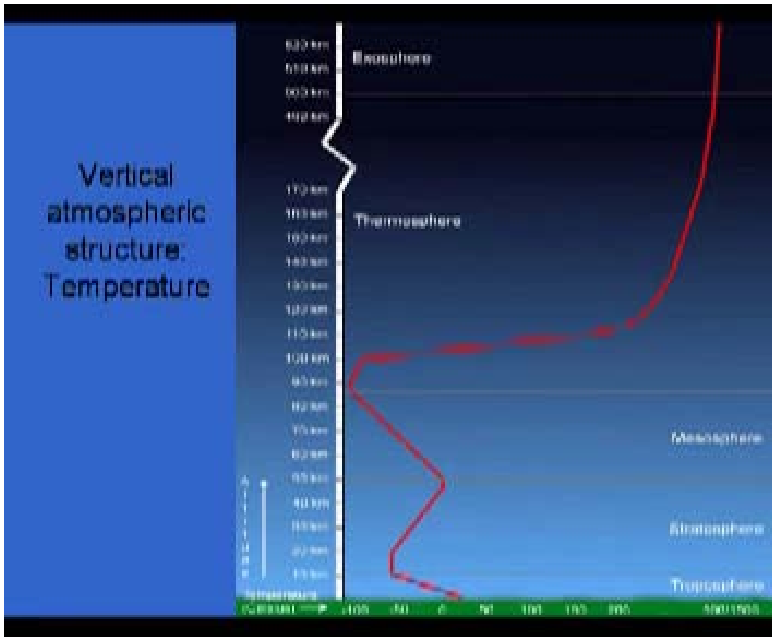
It is important to get the feel because more than the equation the picture gives a much larger, much better feel and understanding.

(Refer Slide Time: 00:36:57 min)



So you see this little the picture coming up here, as to how the pressure will change as you go up almost insignificant pressure.

(Refer Slide Time: 00:37:27 min)



Let us talk about the temperature. You all know what happens to the temperature when we go up? It increases. Katmandu is cooler than Kanpur, Shimla is cooler than Kanpur. It would be cooler at the top of the Himalayas. How tall is Everest? 8824 meters. So what kind of temperature can you expect there? Around minus forty or so, because somewhere here, here, here, and then you bring it here down (Refer Slide Time: 00:38:03). So this is what up to 16 to 18 kilometers, we consider this as a troposphere, you all know about that. This is called tropopause, the temperature is not changing here. Then you see there is a rise in temperature in the stratosphere. All our airplanes will be within. Is that right? Any more that this? (Refer Slide Time: 00:37:33 min) Probably not. Most of the flights will fly at 30,000 to 40,000 feet at the most, which is around 10 kilometers. Spacecraft will go even further. But the planes, they sometime they travel back and forth here.

It will be interesting to know that the ozone depletion we all talk about, things go from here and some of the ozone is also contributed from stratosphere to the troposphere. There is the background of the ozone levels that we will have and we do not know; we will talk about this.

As we go up the temperature increases and again decreases and again increases; it goes on infinitely. We are talking about very high temperatures here. We should know the reason; in this course I am sure not so much as to here (Refer Slide Time: 00:39:38 min) because we are dealing with the air pollution. We are dealing largely within the 10 kilometer and we will derive an expression for this.

You will see with the height, all this temperature will change that we will see later on. The mathematical part for this it is much easier, so I have done that. This will require some background at some point (Refer Slide Time: 00:39:54 min). We will try to derive an expression for this temperature changes to see how much it changes.

Now the question is: why should the temperature be higher or temperature should decrease with height in troposphere?

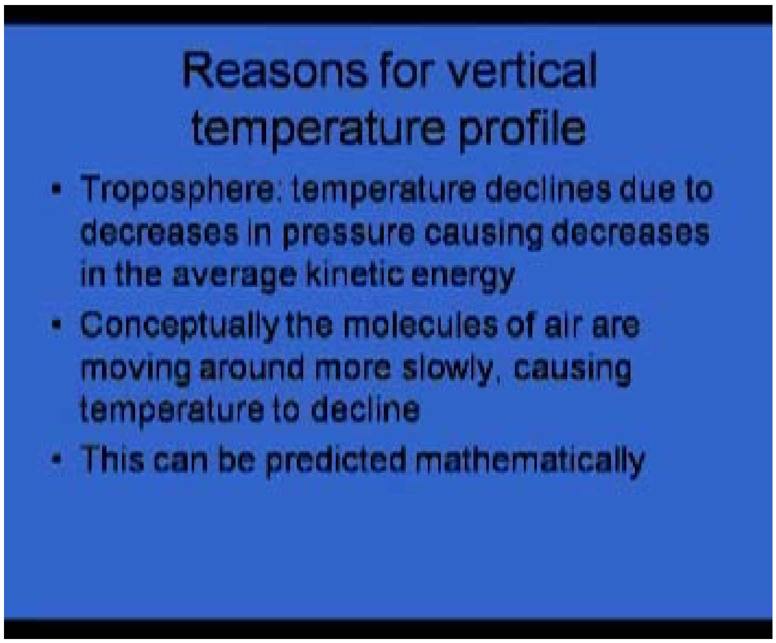
Why as the temperature… forget about earth I am talking about some other region... why should the temperature decrease?

We all know it decreases and there has to be physics behind it. Why? What is the relationship between pressure and the temperature? So what happens when the pressure is more? Temperature also increases; that is the point number one. The other way you can look at it is you need something to absorb the energy and once we are absorbing energy temperature must go up. Suppose in this room you are 15 and there is a certain temperature. Now, I make a hundred people sit here, the temperature will be more. Maybe you absorb more, so there are more molecules here.

In fact, these things are not heated by the air that is coming up, but it is the radiation that goes back from the earth that is heating the atmosphere. You see here, there are lot many molecules here of the earth, so they will absorb more. Suppose I put a steel plate in my hand and then I have a source of heat, there is no rise in temperature. Suppose the steel plate is put in front of the fire. So many molecules, closely associated, they have more numbers so they will absorb more heat and then as a result the temperature will be higher. You know the number of the atoms and molecules of the air that will reduce, as a result the temperature decreases and also the pressure is very high. If that is the argument, so why would this increase.

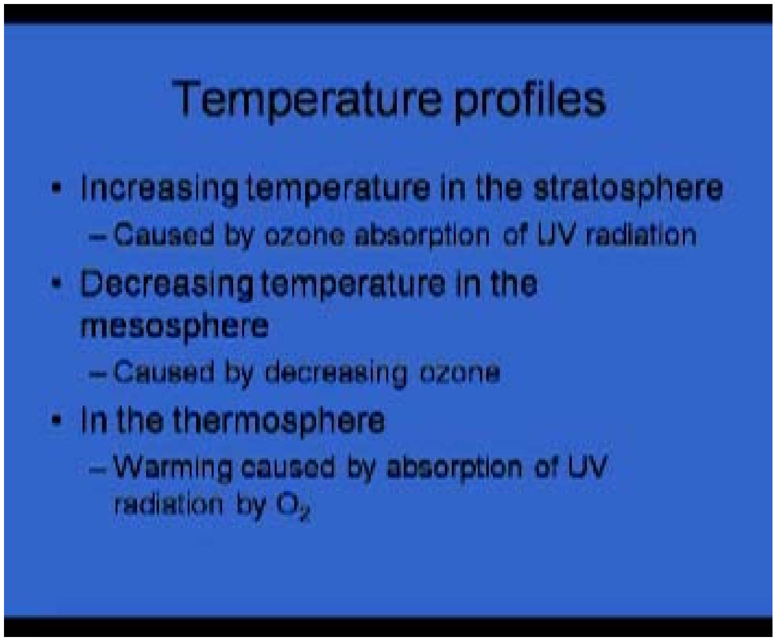
Precisely. The ozone absorbs, then as a result, why should it decrease? As you go up, after this one, there is nothing that will absorb the heat. But then again the question is: why is it going up again? We will see the reasons very quickly.

(Refer Slide Time: 00:42:53 min)



The temperature declines in the troposphere due to the decreases in pressure causing decreases in the average kinetic energy. Conceptually the molecules of air are moving around more slowly causing temperature to decline. This can be predicted mathematically. That we will see later on in this course but not now.

(Refer Slide Time: 00:43:14 min)

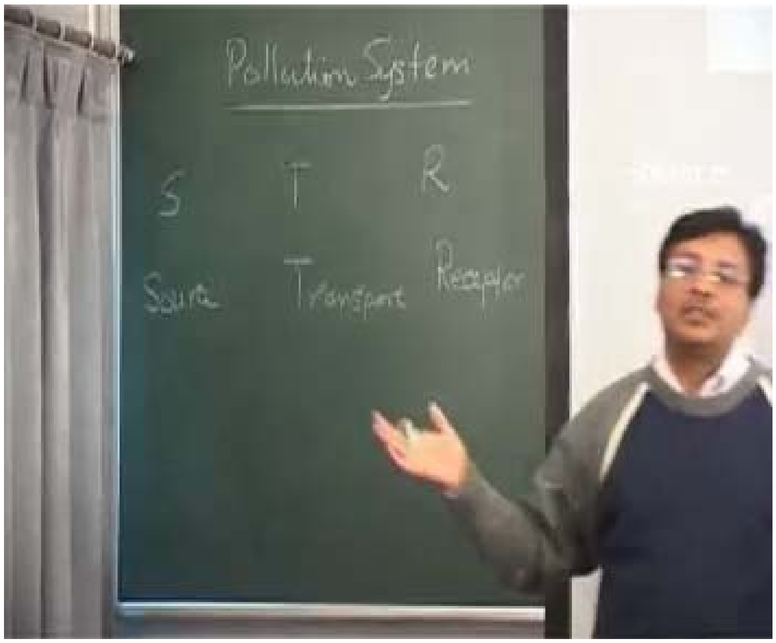


The increasing temperature in the stratosphere, as been mentioned, it absorbs the UV radiation. When it absorbs the UV radiation, the temperature should be higher and decreasing temperature in the mesosphere, that we saw there, is caused by decreasing ozone. That means the ozone has disappeared because the ozone layer is a layer and beyond that there is no ozone. So there is no one to absorb the heat and the temperature should decline. In the thermosphere that is the temperature goes up.

The warming caused by the absorption of the UV radiating by oxygen, oxygen which has left on top of this and that it is able to get more oxygen in terms of the fraction. It is largely the oxygen which is able to absorb even more UV radiations in certain range. So that as a result in thermosphere you get the higher temperature. So this is the structure. You can write in the mathematics also for this answer, again it will involve something but that we will not do right now. If you have to remember something today or learn something by heart today then it is these two equations. Because in the atmosphere, pressure, volume, temperature are so interdependent and we can really make terrible mistakes if we do not use them properly and correctly. These two equations, we do not need to give and define these two equations, but you should very clearly understand this. Let us do an example so that you will get more used to it.

I want to move to something, we might repeat a little bit. We are slightly moving away from that atmosphere and we are coming to the air pollution. What I will talk to you about is pollution system. Let us talk about the pollution system first.

(Refer Slide Time: 00:45:08 min)



What do I mean by pollution system? A system has the certain components and their interactions. That is what a system is. We have a teaching system, I am one component, you are one component, the visual aids are another component. We are all interacting; I am interacting with that and I am interacting with you; this is the system. So we have the system. In the air pollution system, there are three things. The entire environmental engineering is about just three things. There is not a fourth thing in the system. The system components are: source of pollution, whatever that we are talking about; there must be a mechanism to transport, if there is no transport, well let it happen, I will run away from here, but unfortunately from the source the pollution is transported; and then it impacts someone so vital to us and that vitality we call it as the receptor. So we have three components: source, transport and its impact on the receptor.

You can talk about water pollution, you can talk about air pollution, you can talk about soil pollution and you can talk about noise pollution. Three components; very important things: source, transport and receptor. We study these all the time. The sources are industrial sources, combustion sources, you know like wastewater generated, transport through the rivers, and some of this are affecting the receptor. Who is the receptor we can see it later. Air pollution is the source; atmosphere the receptor. Soil pollution soil is source; transport of the soil, that may be through the underground and there are some receptor which we consider. Source, transport, receptor; that is all you are trying to do in any course in environmental engineering.

Some people become an expert in handling this; some people become an expert in handling this; some people are just on to this one; some people are experts in integrating these things (Refer Slide Time: 00:47:52 min). Those who are expert on integrating these things – who are those people? Those who are able to integrate this they are the modelers. They can model the system and that is what we have called system modeling. Those who are able to integrate this versus this versus this, maybe they integrate entire system and then they become the system modelers (Refer Slide Time: 00:48:18 min). Those who are dealing with the air become air modelers, water modeler, soil modeler and so on.

We will stop here.

Thank you very much.