Environmental Air Pollution

Prof. Mukesh Sharma

Department of Civil Engineering

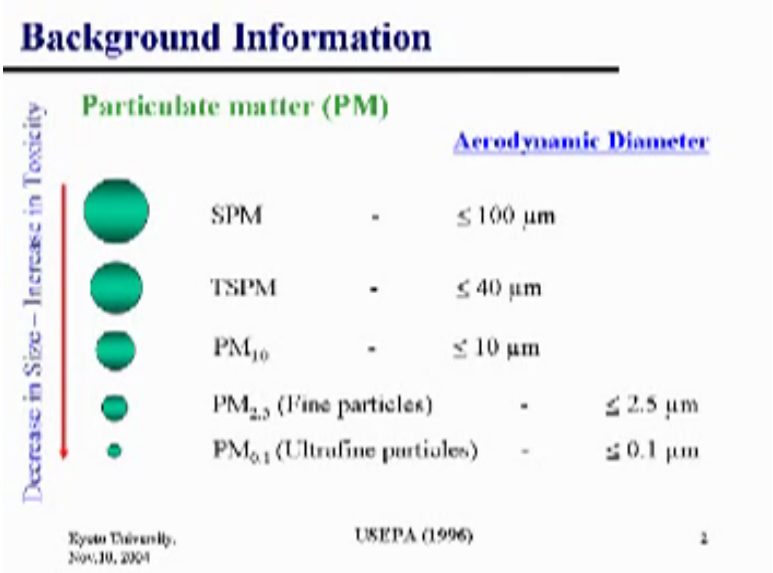
Indian Institute of Technology, Kanpur

Lecture No. 13

Air Pollution and Health – 1

We will be starting a new topic and that topic is more related to health effects on the air pollutants. If you recall, we began with three components: STR – source, transport and receptor. Then, we said the basic objective was to safeguard the receptor and then decide what source emissions could be allowed, how the transport mechanism should be and so on. We have been so far studying the transport or not transport but the transformation largely the atmospheric chemistry. We now want to quickly and briefly capture the important points of health effects. Neither are we medical people nor do we want to be medical experts but we should understand what the doctor says and what health effects really mean to us. If you recall, this is something that we had we had talked about several times.

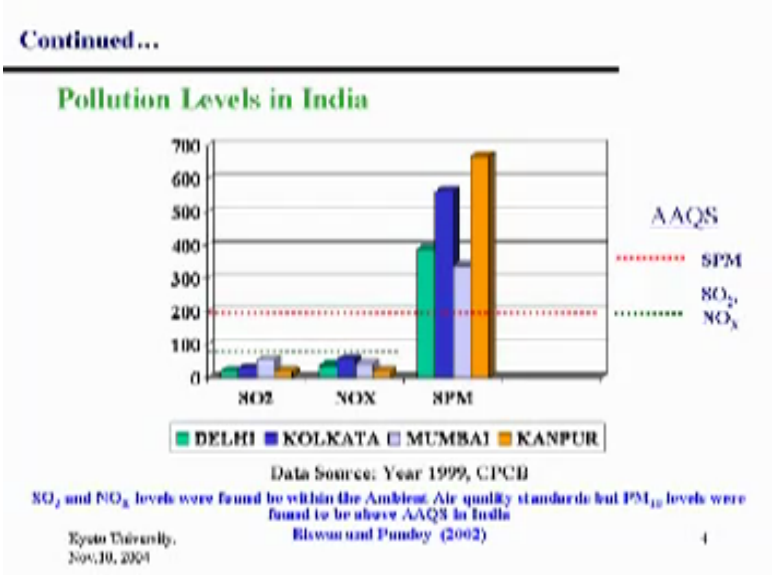
(Refer Slide Time: 01:32)



Large particles, small particles, PM_{10}, $PM_{2.5}$ and ultrafine particles. You will also see that as the particle size decreases, the impact or the implication in terms of health effects goes up for two reasons – both physical reason as well as the chemical reason. When the particle becomes small, its surface area becomes very large and surface [02:01] large is going to absorb or adsorb a lot of toxic compounds, which may be organic compounds or metals. As a result, as the particle size goes smaller, then you have the problem. You will also see small particles will penetrate deeper in the lungs.

The bigger particles will be stopped at the nasal entry or at the upper part of your respiratory system and then you sneeze – the body has n number of mechanisms. The lung is such a vital organ. Unfortunately, the particles go very deep and the particles are not able to come out and it can cause serious problem. We will see how it happens but you can see again from the health point of view…. We looked at the formation point of view if you recall in the class, but here we say that even from the health point of view, smaller particles are of a greater significance.

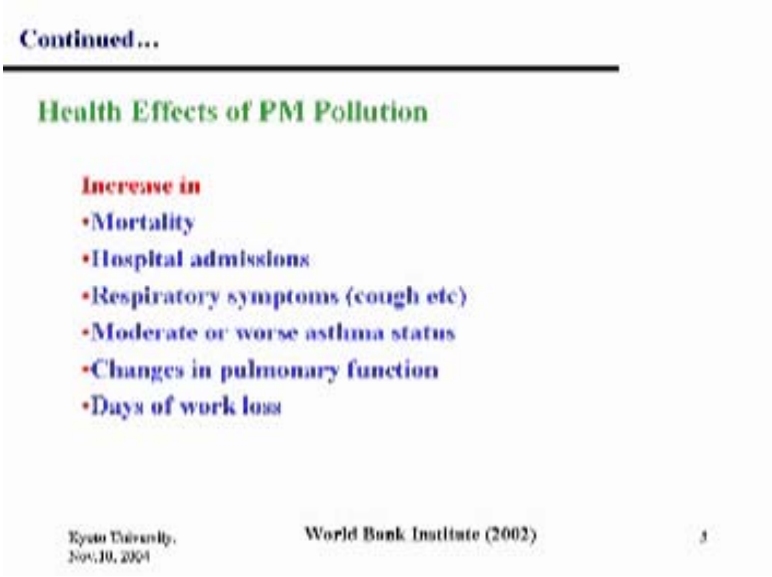
(Refer Slide Time: 02:58)



Let us look at the Indian condition for example. We will focus a little bit on particulate matter more than the gaseous. This is an old picture that we have of 1999, but things have not changed so much. When we were talking about the SPM, if SPM is high, it means by

and large, the PM_{10} will be high, $PM_{2.5}$ will be high. [03:19] different cities and this is the annual standard – 160 or so. The pollution levels are way high, the gaseous are still manageable but we will discuss the associated problems a little later but the particulates are important to us. We will devote this lecture to more about the particle health effects.

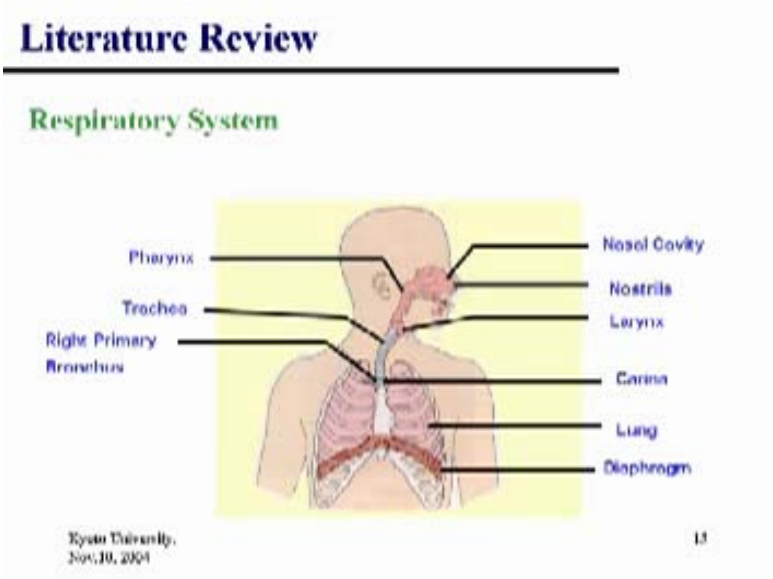
(Refer Slide Time: 03:41)



Before I explain more, all this is established in the literature but that we do not have to cover in this course. Changes are not only changes but increase in particulate pollution, increase in mortality. It has been documented, researched, published and established that more people died in an area that is polluted. Both in terms of the annual as well as a daily variability in the particulate pollution, people have shown an increase in mortality.

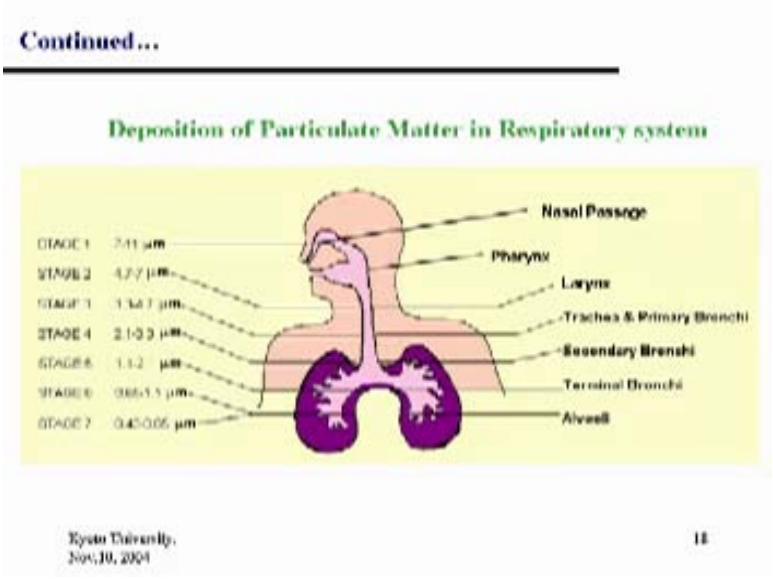
So it is in hospital admission, respiratory symptoms, moderate or worse asthma status. [04:26] asthmatic can trigger asthma, asthmatic attack. Change in the pulmonary function. You can take pulmonary function as the lung function. The days of work loss – efficiency goes down. These are the broader issues but we need to get a little bit more specific.

(Refer Slide Time: 04:49)



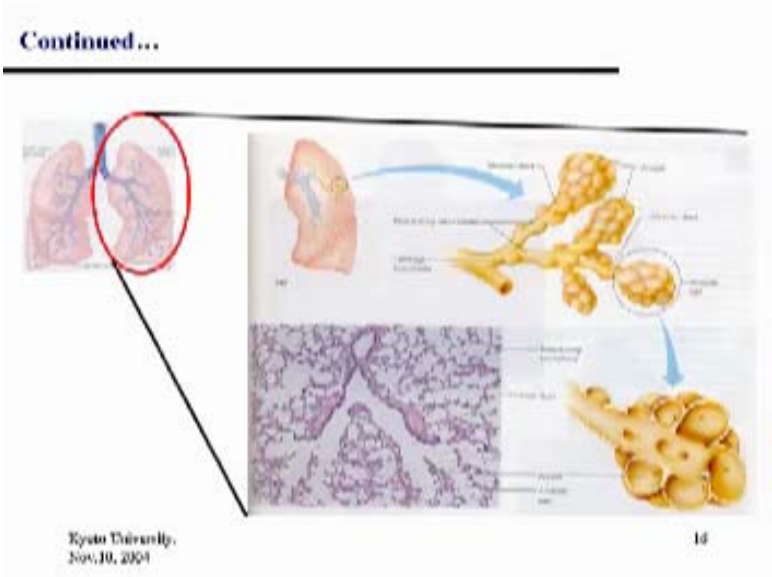
The main target organ for air pollutants is lungs. Other things also happen but largely, it is the lungs, which are very very important. This is the nasal cavity, this is the larynx, you have the carina, these are the lungs, this is the diaphragm which is like a pump and pushes back and forth your [05:14] this thing. Then, this is the trachea and then it is not being shown but on the left-hand side, there will be bronchi – left bronchi and the right bronchi. The further breakdown and further classification as to what happens will become clear in the next picture.

(Refer Slide Time: 05:33)



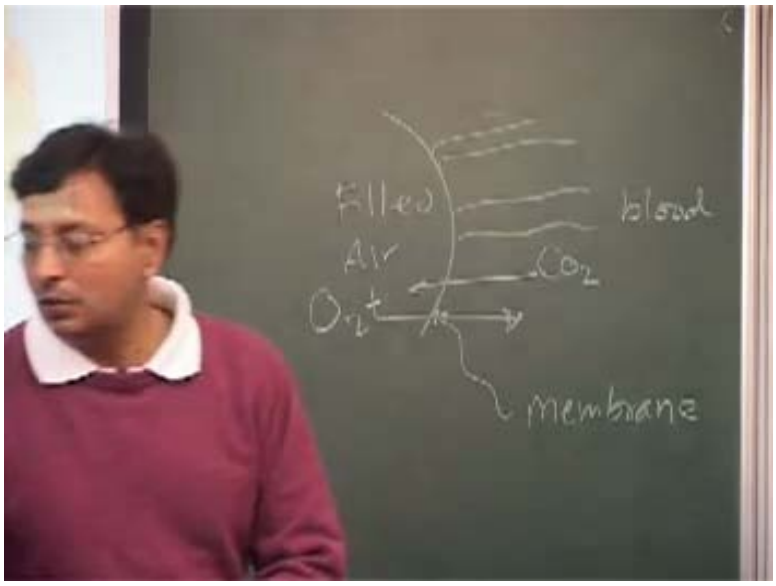
But before that, you can also see how the particles, what kind of particles would be stopped at what place. The larger particles 7 to 11 microgram would be stopped somewhere here but once you come to stage 2, it is particles of less than 10 and they are likely to stay at the trachea level. Stage 3 is upper trachea and primary bronchi. This is primary bronchi and then you have the secondary bronchi, which could be left bronchi or the right bronchi. Then you see the particle range coming to about 2.1 to 3.3. The ultrafine particles you see are going very very deep – almost at the place where the actual oxygen transfer takes place. We will show you a little picture of this as to what it looks like.

(Refer Slide Time: 06:32)



Bear with the light system that we have here. If you see here, if you take the lung portion [06:30], then this you can take as the bronchi. This will be the left bronchi and then finally something that terminates into the smaller. This structure is called the terminal bronchi. You cannot read it in the back but this is the terminal bronchi because after that, there will be no more bronchi. This is called the terminal bronchi. Then, what you see at the end is called sacs. They are like a bunch of grapes and it provides a lot of surface area. If you try to look from inside, you see these are really filled by the air as you breathe. These things have a lot of elasticity. So the lungs are filled with air as you can see and this is a membrane. The other side has all your blood streams that will carry the blood.

(Refer Slide Time: 07:47)



What happens if you have something like this? This is filled with air. On this side are the blood-carrying not arteries but blood vessels. Here, you have the oxygen plus pollutant. See the partial pressure of oxygen is way high on this side and the partial pressure of CO_2 is very high on this side. The CO_2 will exchange because I have…. This is the membrane – do not forget. This is the membrane. Your CO_2 will transfer from the blood into the lungs and the oxygen from the lungs will go this side. This goes on and this exchange takes place. We are talking about these things.

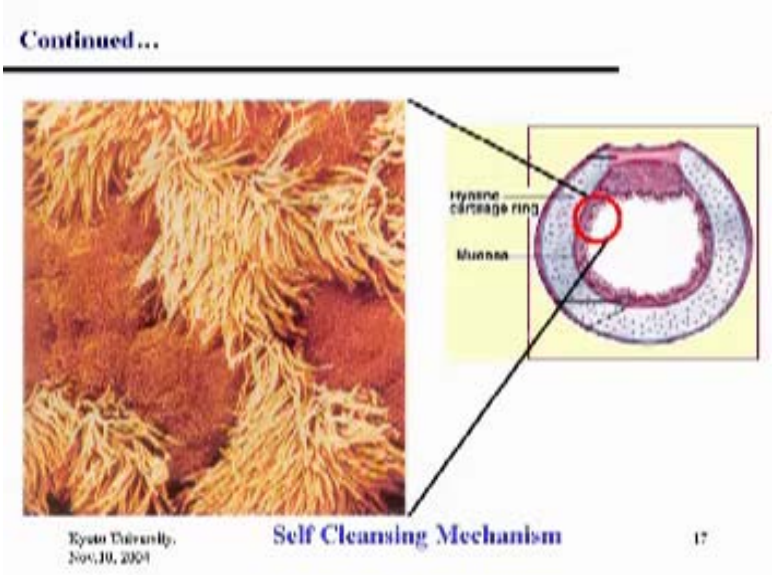
You can see the fine particles that can come here. In fact, they do come. The kind of path that they go through is a treacherous path. It is very unlikely that once they get deposited.… There is no mechanism through which they can be taken out – they will stay there for quite some time. In fact, they stay there permanently because the upper part you sneeze and all the dirt from here will come out.

The body also has a mechanism to clean things even from this region. We will see it how it does but then if things go deeper and get deposited, they will be damaging the tissues here. Once the tissues are damaged, there is almost no possibility of recovering. People suffer because of the ageing process. What really happens when tissues are dead, they

lose their elasticity. Once they lose the elasticity, they cannot maintain the partial pressure, so the exchange of both oxygen as well as the CO_2 is affected.

Both happen – it is because of the pollution as well as the ageing process. If the person is old and he is in a polluted area…. As it is because of his ageing process, he has difficulty and then he is exposed to the higher pollution level. You can see how it ends up causing problems. Older people will have the problems and there is no way these can be regenerated. Fortunately, in the body, there are millions of sacs (sacs are like pockets). Millions and billions of sacs are there but they get damaged. If the particle is not deposited, there is also the possibility that the particle can go back because we are talking about very fine particles with almost insignificant inertia. We are not doctors, we are not going into detail things but still we should know about this. Let us look at the upper respiratory part of the lung – not at the end but the upper part.

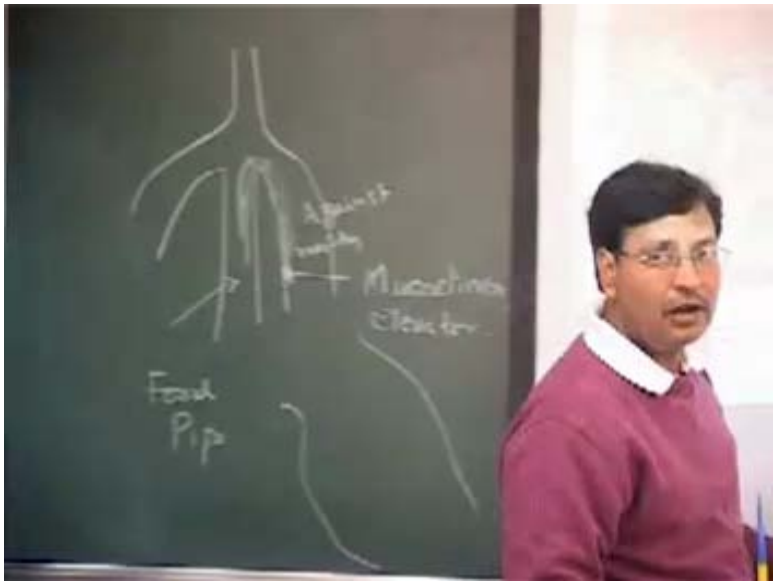
(Refer Slide Time: 11:06)



The air flows through this. It has a hairy structure. If we take the blow-up picture of this, it looks like this. This hairy thing is called cilia and in addition to cilia, there is a mucous layer there. Sometimes when we sneeze, it is mucous that is coming out. That is also secreted. The particles are on the upper part because of the wet surface. At this point if you have the wet surface, I think the person will die. That is why we just want the gases

there but in the upper part, we have the mucous and mucous layer. In the body , the moment particles are there, more mucous is released. The cilia are constantly waving in the lungs. Once they are waving, the particles come and then it pushes them up.

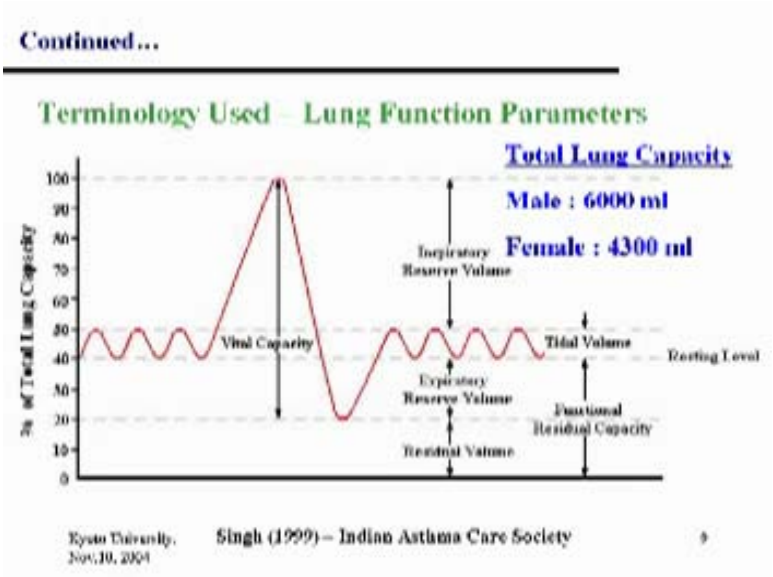
(Refer Slide Time: 12:15)



Once they push them up…. You have little cilia here. This is the upper part and the lower part is somewhere here. In fact, this is the mucous layer where the particles will be trapped. This travels against gravity. The cilia is cleaning things and the particles that are trapped (little larger particles – 3 micrograms or so) will be traveling along with the mucous. It is the same on the right side. This is your food pipe. Almost all the dirt will reach here and then you swallow.

All the dirt that was affecting the lungs goes back into your food pipe. In fact, this mechanism is called mucociliary elevator. You have to check the spelling. Mucociliary elevator is like a lift that is lifting things against gravity (see the body mechanism) and all the particles that are there. The particles in the upper part of the lungs can be taken care of but we go deeper. These mechanisms are not so good. The small particles are of great significance. There is a need to understand some terminologies. I will pass on these things to you and you can have a look.

(Refer Slide Time: 14:20)



Suppose on this side I am plotting the percentage of the total lung capacity from 0 to 100. As you normally breathe, normally at rest, this is how you are breathing – in, out, in, out, in, out. Suppose I ask you to take endless breaths as much as you can. This person is asked to take a deep breath and he fills his lungs with the entire air that he can. Then I ask him to exhale as much as he can. This capacity is called the vital capacity. No matter how much he tries, this amount of air or this volume of air he cannot exhale. That is called the residual [15:20]. That kind of volume is always present in the lungs.

The total capacity minus the residual capacity is called the vital capacity. Why vital? It is vital from the operational point of view. We cannot use so much. This is what we called as the vital capacity. I can transfer this into volume units. This is what is measured in the volume. I do not think I have the numbers here but [15:58] do we write here. This is a little higher. This was pointed out by the doctors to me. Generally, males will have about 5,000. This is really really high –5,000 ml. Females will be have about 3,500 or so. You can see that your total lung capacity. This is also taken as the vital capacity. The normal capacity, the volume that you are taking in and out is called the tidal volume. Why? It is because it is like the tidal process – goes up and down.

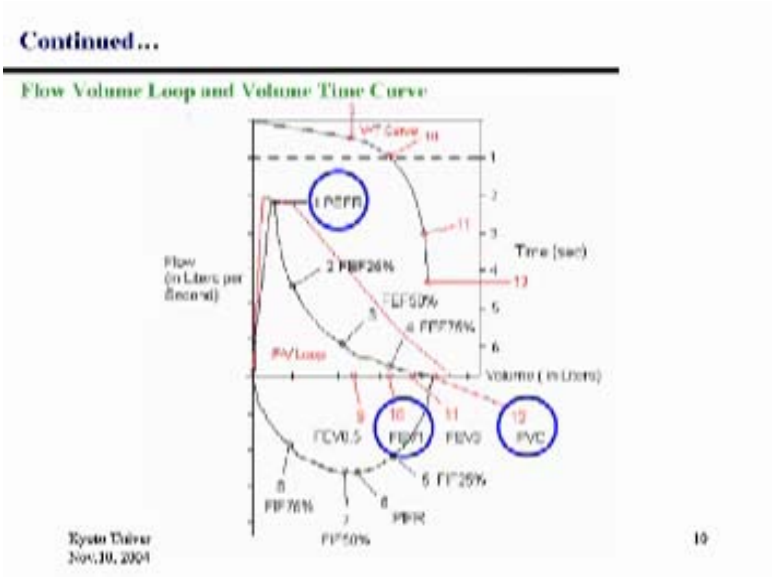
Now you see here. From this point, you have to be a little bit careful here. From this point, if I ask a person to exhale out as much air as possible…. From here, this point is the same as this one. I ask him to exhale the maximum that he can. We are here. At normal operation, the maximum that he can exhale is this volume [17:28]. That is called expiratory because you are expiring – expiratory reserve volume.

What it really indicates is suppose you are feeling very suffocated and polluted air has gone in, how quickly and how much you can exhale out is called the expiratory [17:47]. From a normal level that you have expired. This is the level. Inspired one, inspiratory…. Normally, I have taken and then again, I want to take. This is normal. See this [18:04] and then go beyond that. That is called the inspiratory reserve volume. This volume is also very very important. That again, lung capacity….

Suppose you want to go into a smoky area and still want to do something. You see the smoke and want to go and put off the stops somewhere. What you will do if you have good inspiratory volume, then go there. Do not inhale or exhale but store. Reserve it because this is the reserve volume and then quickly do what you want to do and come back. This is what we call as inspiratory reserve volume. This is what is the functional residual capacity. This is normal this kind of residual capacity but do not think that this is a dead space. There is always an exchange but this is what you will have always in storage. A water pitcher is there and you are constantly maintaining some [18:59] water, but that water is being exchanged. If it is a dead volume, then you will have a lot of problems. It can become dead volume if you lose the elasticity of your lungs. They are not functioning, that volume is sitting there and the person can be in trouble.

We need to know these things. This figure was taken from the Indian Asthma Care Society. We will try to understand these terminologies. Let us do one more thing. This is something very important. I will give you the copy of this. This is the test that doctors or physicians or chest specialists will do – something called spirometry.

(Refer Slide Time: 20:04)

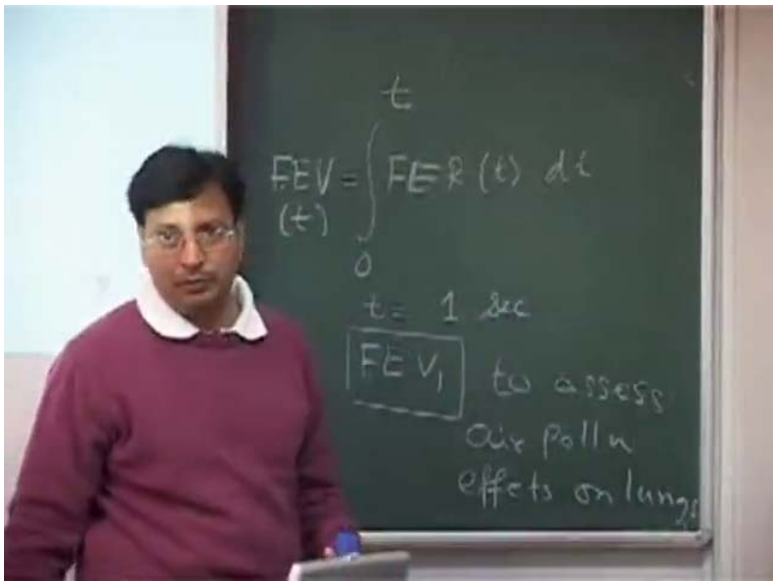


In spirometry, what they are plotting here is…. You can say this is the time and here, they are expiring the air. For the time being just forget I take a deep breath and then I am asked to expire as quickly as I can. This is the normal…. Just for the moment, let us forget about this. Imagine that we are talking about this curve starting from this point. I will take a deep breath and now I will start. What will happen? I will have the peak expiratory flow rate at some point and then the amount of air that I am able to exhale out with regard to time will reduce and there will be one peak and afterwards, it reduces. Then again, I will take…. This is the cycle of inspiration. This is deep inspiration and you are trying to exhale as much as you can. This is called flow volume loop.

This flow rate at different times is of great significance to doctors and also to see the effect of the air pollutants. What you see here…. Do not forget this is the flow rate in liters per second. We are calling the first number as PEFR – peak expiratory flow rate. This is a very good indicator of the person who is having asthma. The moment you go into a polluted area, your PEFR will reduce. That is again established. When this is reduced, you need to exhale and inhale quickly and you feel very uncomfortable. The point number 2 is the flow rate when 25 percent of the total vital capacity of the air has been exhaled out at that point. FEF 25 percent is the point number 2.

I again repeat that this is the flow rate (do not forget we are just talking about the flow rate) at the point when 25 percent of the volume of the vital capacity has been exhaled out. This is the point where 50 percent is exhaled out, this is the point where 75 percent of the vital capacity is exhaled out and we are giving this the number 12, but it does not matter. Finally, when you have exhaled out everything, that is your vital capacity – you recall that everything was exhaled out. That is called the vital capacity. This is very very important.

(Refer Slide Time: 23:16)



What I have plotted here is FEVR with time. You see here that the amount of FEVR is changing with time. Suppose I integrate FER (forced expiratory rate), which is a function of time as [23:30]. This is a function of time. What will this give me? At different times, it will give me the volume of the air that has been exhaled out – flow rate times dt. I can put this as…. This will give me the volume or I can call it as FEV, not r. It is a function of time. This is the volume. Simple integration. This is also a very very important parameter. [24:12] expirated volume.

When t equals 1 second, this number FEV we call this as FEV_1. FEV_1 is the amount of air or the volume of air if not amount expired in 1 second in the spirometry operation – not during the tidal thing but when I am running through spirometry. This kind of graph

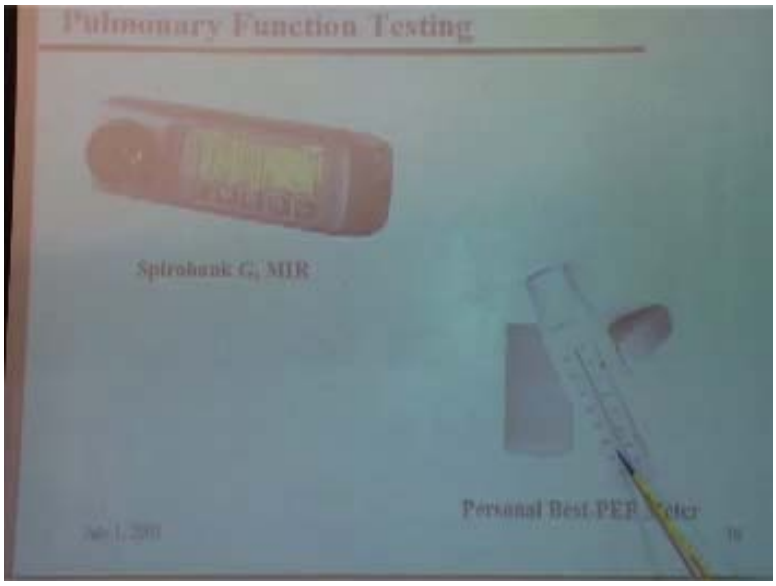
that we are trying to show here has essentially been plotted here. That is called volume time curve. That is what we call as a volume time curve. The same thing what I am telling you is also the machine or the equipment that you are using will produce this kind of graph. Now, I am having the units as time and the volume. You are measuring the volume on this side and the time.

What you are really doing is you have this function that you are integrating. If I have to find out what is my FEV_1, I should go at 1 second, plot this and look at this. Clear? No problem with that? I can also find out the other parameters like FEV_1, FEV_2 and $FV_{0.75}$ but this is an important parameter.

I will show you how to assess air pollution effects on lungs – one of the important things. There are many other things that people do. You can see that here. This is 11, that is FEV_3 if you see here – 11 and then if you go here, this is also FEV_3. [26:32] 3 second, how much was the volume? Finally, the last thing. The whole operation is over in about 5 seconds or so. This is the last total volume that you will expire – that will be forced vital capacity but from the air pollution point of view, the doctors have a lot of meaning of this one.

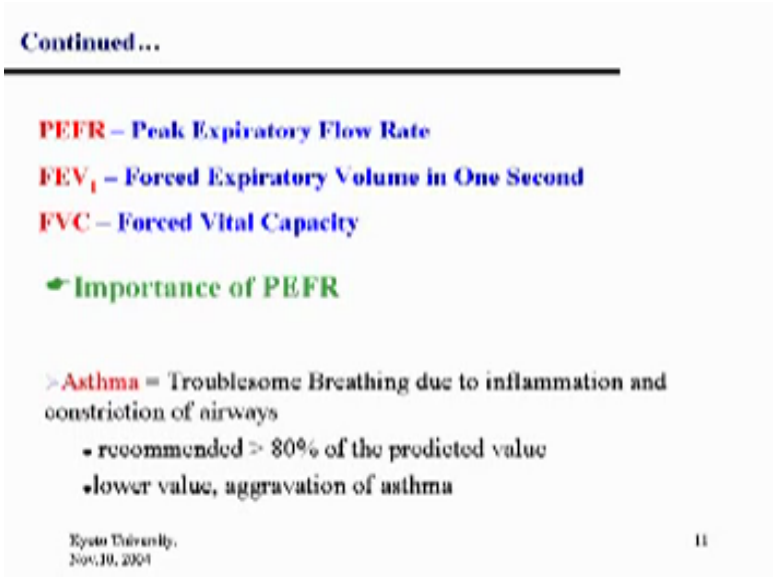
You have two parameters that are important: FEV_1 is the amount of volume that is expired in 1 second and the forced vital capacity. That decides as to what the conditions of the lungs are generally from the air pollution point of view – you should understand that. Do not worry. I will pass on everything. The third thing of course is the PEFR. These three things are…. Other things are from the medical point of view. A lot of analysis is done with this. In children, things are a little different but from the air pollution point of view, these three things are good indicators of air pollution.

(Refer Slide Time: 27:36)



This is the machine generally used for the peak expiratory flow rate. It is a very simple ordinary machine – no moving parts, no motor, nothing is required, but spirometry is a little complicated. This will require that you attach a computer. What you might do right now is… or maybe I should go one step further before we go to this. What is their significance when it comes to air pollution?

(Refer Slide Time: 28:07)

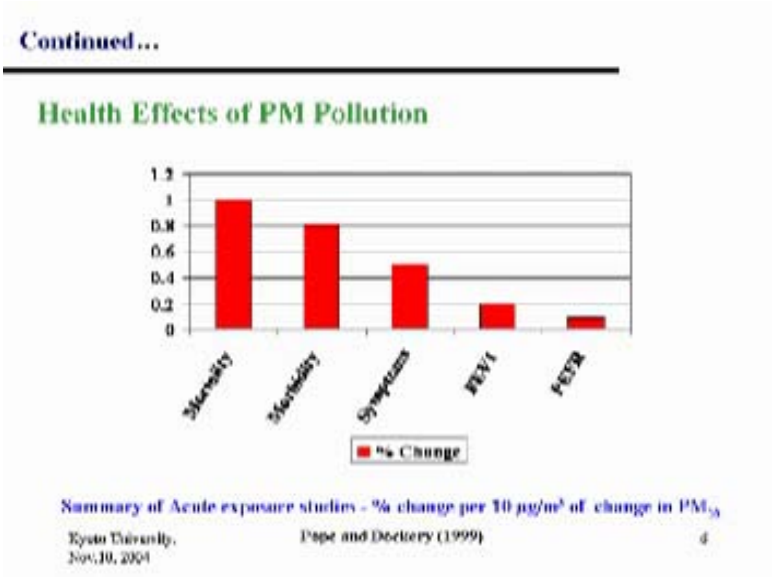


We have defined peak expiratory flow rate. FEV_1 is forced expiratory volume in 1 second. Forced vital capacity. What is the importance of PEFR? PEFR is also an indicator to some extent about asthma – troublesome breathing due to inflammation and constriction of airways. Your airways are constricted. If I take the section of the airways here, which looks like this, somehow they are constricted (Refer Slide Time: 28:36). That shows this thing.

The PEFR value depends on whether a person is male or female, body weight, height and the ethnic origin, for example. For those people from north India, the PEFR values will be different and for those from south India, it could be different. Then for healthy people, it is defined – all software tells you what should be the value for the kind of person you ask. When we do spirometry, you also need to find out the weight and height. They will ask you the age of course and the sex. They will also ask you which part of the country you come from or which part of the world you come from. For that, they will have a standard value. If the value what you [29:26] suppose it is less than 80 percent of the value that you should have, it means you are likely to be having asthma or the problem is about to begin; a lower value suggests the aggravation of asthma.

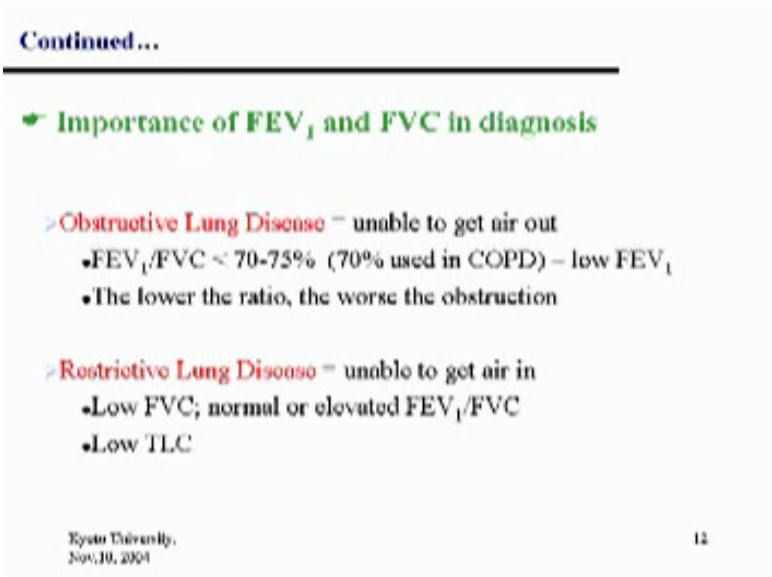
Asthma is not quite an air pollution problem but once you suffer from asthma, it can trigger if you are exposed suddenly to a large air pollution area. There are some data that we did not want to show in the beginning – percent [29:58] change in the mortality. This is normally 0 is the normal death rate at which people die but what is the change because of the particulate matter pollution?

(Refer Slide Time: 30:10)



This is a summary of acute exposure studies – percentage change of 10 microgram per meter cube of PM_{10}. This is some study by Pope and Dockery that says that the mortality change could be so much, morbidity change could be so much, so could be symptoms that you can say, this will be the reduction percentage change, the reduction in FEV_1 could be so much and reduction in PEFR could be so much. You see the differences. These are indicators of air pollution. You should have some idea but not to the extent that doctors need to have. I want to define two things to you: restrictive lung disease and obstructive lung disease.

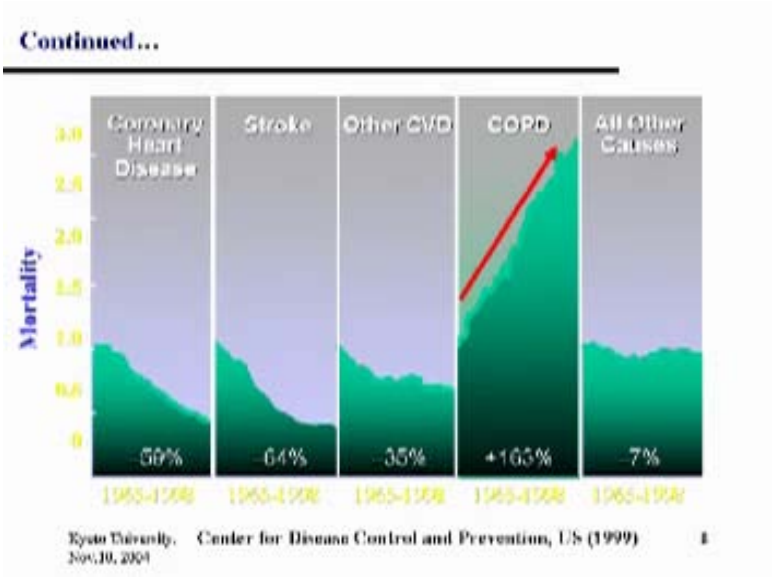
(Refer Slide Time: 30:58)



When you are unable to get air out, that is called obstruction. Most of the air pollution diseases are in the category of COPD. What does COPD stand for? Chronic obstructive pulmonary diseases. The indicator for them is that if the ratio of FEV_1 to FVC.… Both are in what units? Volume, liter, all the units are volume, so the ratio will be unit-less. If this is less than 70 percent, then which will be higher – FEV_1 or FVC? FVC will be higher. It is the total forced vital capacity and this is the amount of air exhaled in 1 second. That is much smaller than the total volume that is there. So this becomes much smaller than 70 percent and the person is suffering from COPD. COPDs, the obstructive diseases are generally more attributed to air pollution. Immediately, the person who is smoking will immediately show this. So you either smoke cigarettes or [32:13] be in the polluted area and COPD will quickly be seen. Lower the ratio, worse is the obstruction.

The restrictive diseases are the problem to get the air in. Lower the FVC, then normal or elevated you get the ratio FEV_1 to FVC but then what your finding here is FVC is lower [32:37] and the low total lung capacity is there. What I would like to do before I go into something else is that we have this instrument called spirometer. It is a very expensive instrument – the little thing is about Rs. 1.4 lakhs. We need to attach it to the computer. Let me also show you this graph – that is very important. It is again taken from the Centers for Disease Control and Prevention.

(Refer Slide Time: 33:13)



These are adjusted values. For coronary heart diseases, this is dated from 1999. This is the period from 1965 to 1919, the way the studies have been done for this period. Many people die. I am not saying that people do not die because of the coronary heart diseases. Generally, the death rate or mortality is decreasing because of better health facilities and better education to the people. There is a decrease in the coronary heart disease and so it is with stroke. Then, other vascular diseases are stable but look at COPD.

It is not that people have suddenly started smoking more cigarettes – more people start smoking cigarettes and people are smoking more and more. No, that is not the issue. Generally, that is what [34:12]. You see how important the…. I am not talking about the number of deaths – do not misunderstand that I am talking about number of deaths. The cause of deaths is this. We are saying that COPD has increased compared from 1965 to 1980. This can largely be attributed to either smoking or to air pollution issues. So this is on the rise.

What we want to do is hopefully, we should be able to demonstrate to you the spirometry test so that you can really get a feel of this. Either you volunteer. All this is disinfected and it is a brand-new thing. Before we try, someone just try. But do not try if you are a smoker, then you will be a little disappointed. Does somebody want to try? It is a normal

thing. Do you want to try? Come. We cannot do it for children because children do not cooperate so much. What you have to do is normal operation – take a breath as much as you can and forcefully as much as you can, force it out.

Naresh, we should have the software for this, is it not? This is not my computer, so I am going to have a little difficulty. We have to open this. You gave all the inputs in terms of the various things. You give the name of the person, then you put that he is from north India and then of course the date and time, year, height, weight and then you can also give smoker or non-smoker. All set? Normal operation and then forcefully go to the last moment that you can exhale out everything because you want to go to the last level of the residual volume that you have.

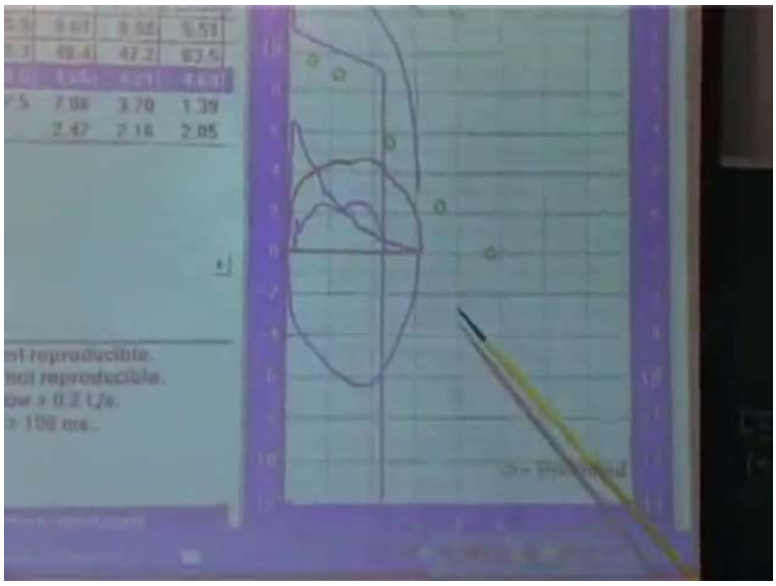
Try. First, normal. I will do it. What doctors do is that they put the drug – before the drug and after the drug and see the improvement but now, you try. Maybe you need to hold it like this. You have to put it inside. OK Sir. It has to be all the way like this and you cannot put your finger here.

[Conversation between student and professor - Not Audible (37:25 min)]

[37:29]

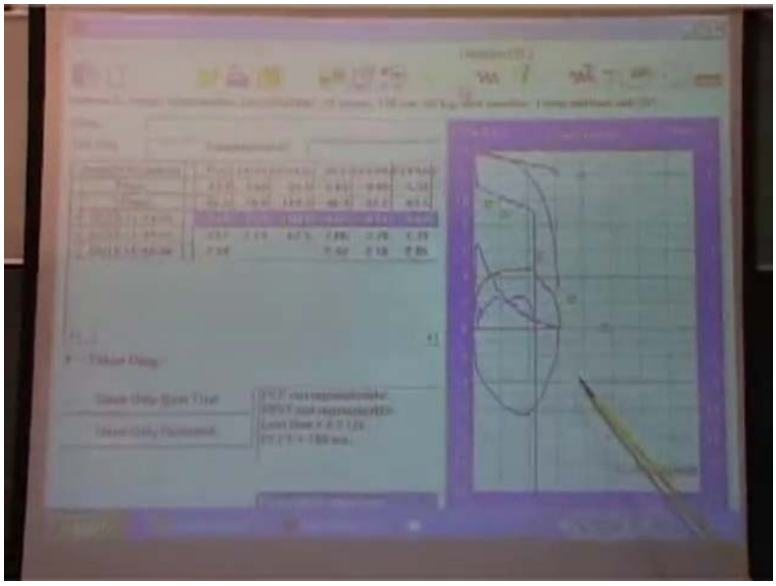
I think you need to [37:41]. Naresh, why do not you do it? This is much better. Let Naresh do one time and then we can repeat. This is how it is really done. Hey, wait, wait, wait. We normally put the little this thing here. Naresh, show there. Normal ordinary thing. Then….

(Refer Slide Time: 38:26)



See here. As he exhaled out, this is your flow rate in meters per second. The flow volume curve is coming here. Then, you see here, this is what you say is PEFR and at different times. Then, you get the total capacity. These are the predicted values for him – this, this, this, this and this. Obviously, he has not performed so well because he said that he is suffering from something. Normally, it should be like this for his condition.

(Refer Slide Time: 39:07)

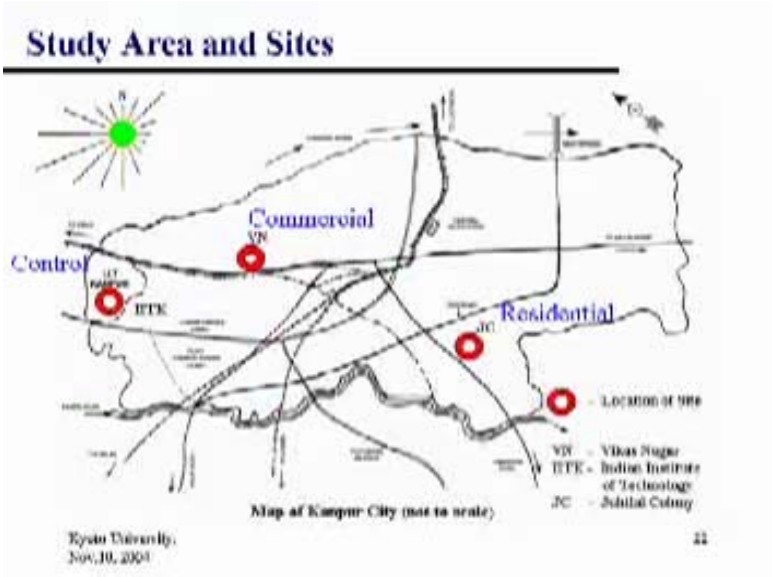


You can find out the forced vital capacity, FE_1, FEV_1 percentage and then PEFR is 9.61. These are the predicted values. It means for a person of his age and his height, which I have mentioned here, the forced vital capacity should be 4.7, FE_1 should be 3.96, FEV_1 percentage or the total capacity should be like this and PEFR should be this. These are the 25…. After 25 percent of the volume is exhaled out and 50 percent is exhaled out. Then, you see here that he could only perform 66 percent of what he should be – that is this percentage. This is only 79 percent of this. This is FEV_1, this is 19.3 percentage. This is how you can find out.

This is done… We have to get the best results. For the same person, it is done twice or thrice and then the best results out of three times are taken. You can record and you can see how people are performing in terms of what we as air pollution people normally want to see – this and this and PEFR; three things. Especially for PEFR (peak expiratory flow), the performance was not very good.

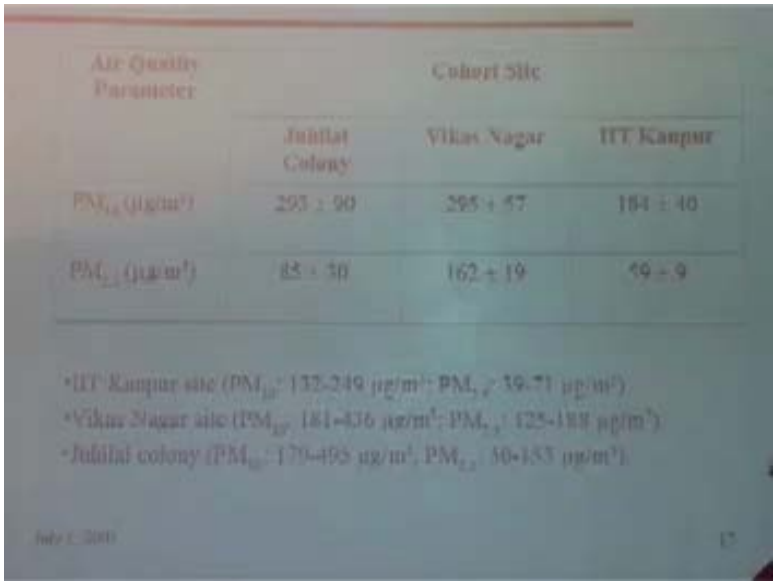
You see here whatever was expected was at some point somewhere here (Refer Slide Time: 40:46) and he performed here. This is only about 48 or 50 percent. Suppose this is 6, it should be about here. That is how you can really measure and you can really see things. Of course, this is done by doctors normally, but most of the time, the data are used and analyzed by air pollution people. We will leave this part there because that is all I wanted to demonstrate to you. We do this thing three times and the best results are taken. I will show you some of the work that was done so that you can get a real feel and real numbers.

(Refer Slide Time: 41:49)



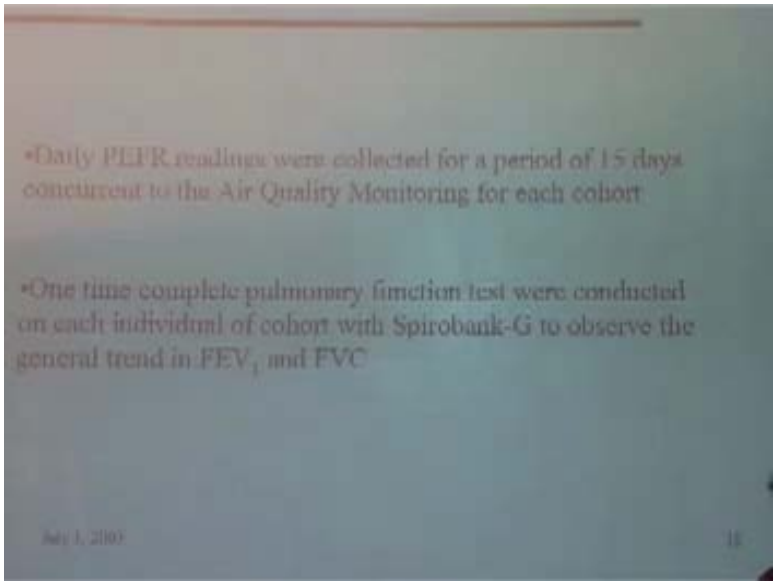
A Masters student went on to do the measurement of the pollution levels at three different locations and he involved some people for the measurements of spirometry at these three locations and analyzed the data. The three locations were Vikas Nagar (this is Vikas Nagar at Kanpur) and Juhilal Colony here. What he did was….

(Refer Slide Time: 42:13)



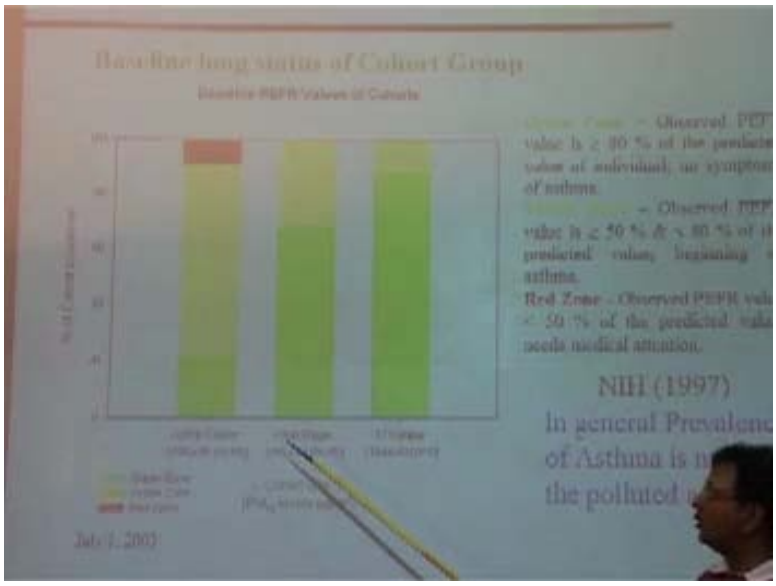
I have cut down many slides. He got some measurement for PM_{10} at different places and also for $PM_{2.5}$ – that is important. IIT Kanpur was on the cleaner side. These were at comparatively higher pollution levels as you can see here. A lot of people were involved.

(Refer Slide Time: 42:35)



Then the PEFR measurements was done on a daily basis [42:40] it was very simple. [42:42] blow this thing but spirometry is a little complicated as you can see. It takes a while. Spirometry was done in various seasons. They were conducted on each individual of cohort with Spirometry-g. This is the same equipment to observe the general trend in FEV_1 and FVC and this was done daily.

(Refer Slide Time: 43:05)



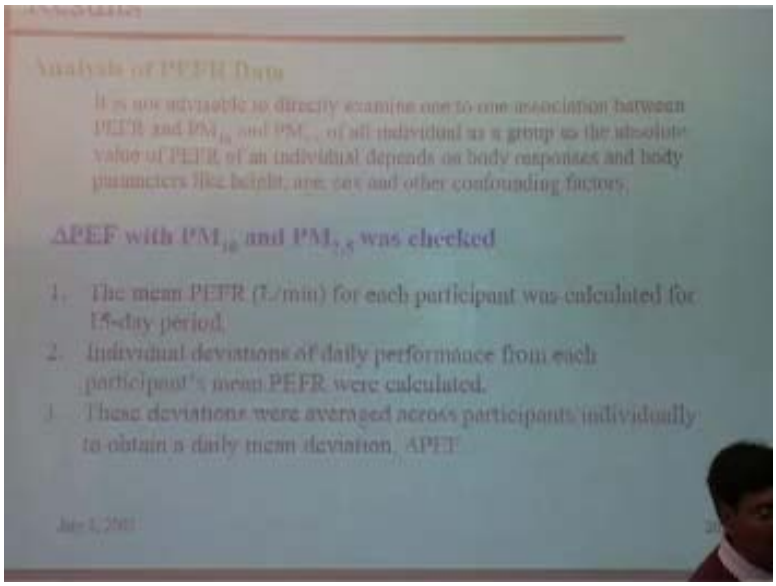
Based on PEFR, the people in Juhilal Colony…. This is the percentage of the population. It means 90 percent or let us say that the performance of about 20 percent of the people was as good as it should be. What you see here is a green zone. It is the observed PEFR and it was above 80 percent of the predicted value. Predicted value in this concept is the normal value – the normal performance based on age, height and sex.

For example in IIT Kanpur, almost up to 90 percent of the people, 90 percent of the cohort or group performed very well. The performance of only about 15 percent was a little poor – 50 to 80 percent of their actual value what it should be. As they come to the polluted area in Juhilal Colony and Vikas Nagar, you see that the performance of the people is only about 65 percent or 70 percent as per what they should really be performing.

But if you go to a more polluted area in the city, only about 20 percent of the people could perform as per their expected value. Many of the people were in the range 50 to 80 percent. Some percentage of people, close to 10 percent, were in the red zone. It means they are performing even below 50 percent. Certainly, that is taken to mean that the person is already suffering from asthma. The likelihood of these people will… pollution

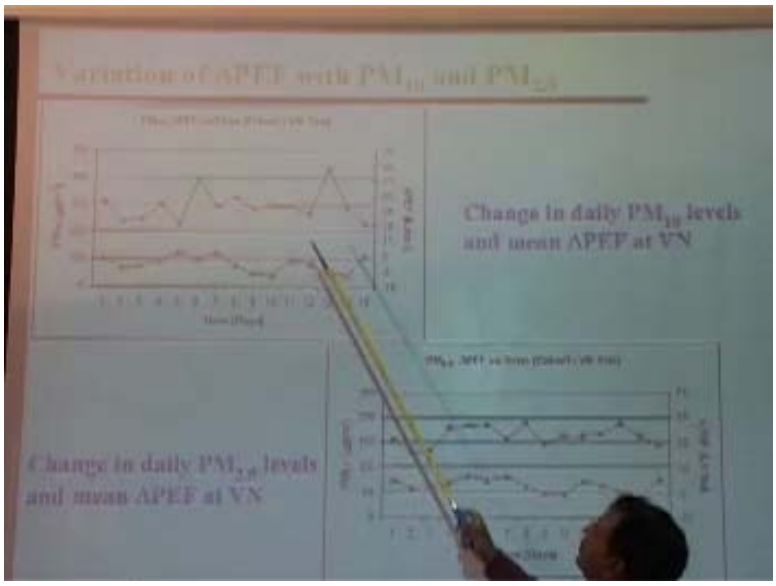
or whatever the reason, they could be pushed to the red zone or the problematic zone. You can clearly see how the pollution… and they have the effect on PEFR.

(Refer Slide Time: 44:58)



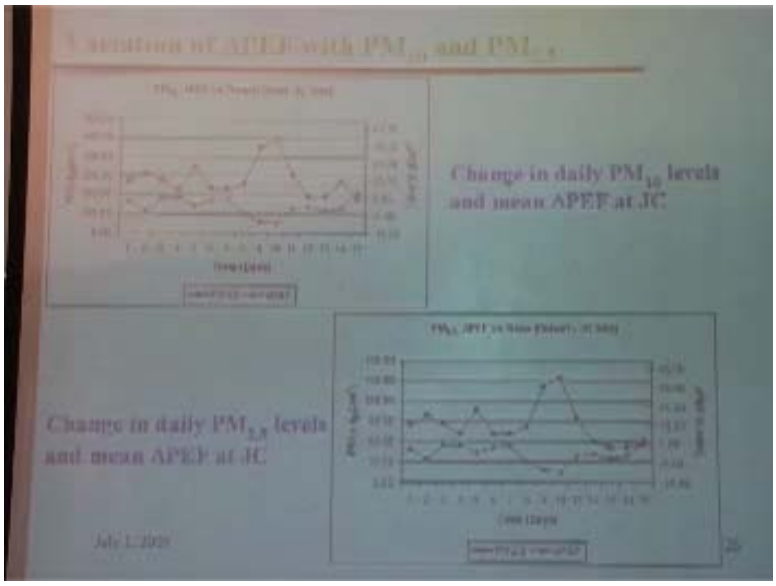
But more than that was…. The analysis was done for the changes in the delta PEF with respect to PM_{10} and $PM_{2.5}$, How it was done was what was the average change in the performance of the people as there was a change in PM_{10}. We will not go into so much detail but I will show you the results if I can.

(Refer Slide Time: 45:25)



See here on 15 days at various sites, they went. This was the cohort site Vikas Nagar for example. What you are seeing here is the…. These are your pollution levels – they are measuring every day. I show the pollution level on this side PM_{10}. Sometimes, it is 300, 200, 250, 300, 400, 450 or so. Then, every change in PEFR of the people is plotted on this side. Then as you see here, as the pollution level goes up, there is a drop in PEFR. Delta PEFR negative [46:11]. There was a drop here. Again… and the pollution level again goes up and then you can see constantly there is a drop in there. This was the $PM_{2.5}$. It was not so apparent for $PM_{2.5}$, but you will see the other areas.

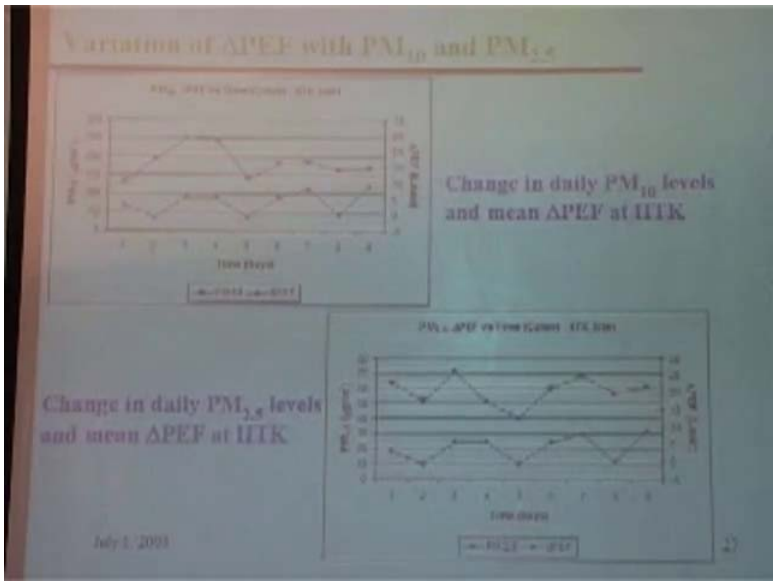
(Refer Slide Time: 46:37)



This is at the Juhilal Colony site. The pollution level increased, decreased, very high, then decreased and again high. The performance [46:50] in terms of change in PEFR and this is average for all the people – it is not just one individual. One individual can perform anything. Here, you can clearly see that as the pollution level is going up, the performance is dropping from the people; as the pollution level goes up, the performance is dropping.

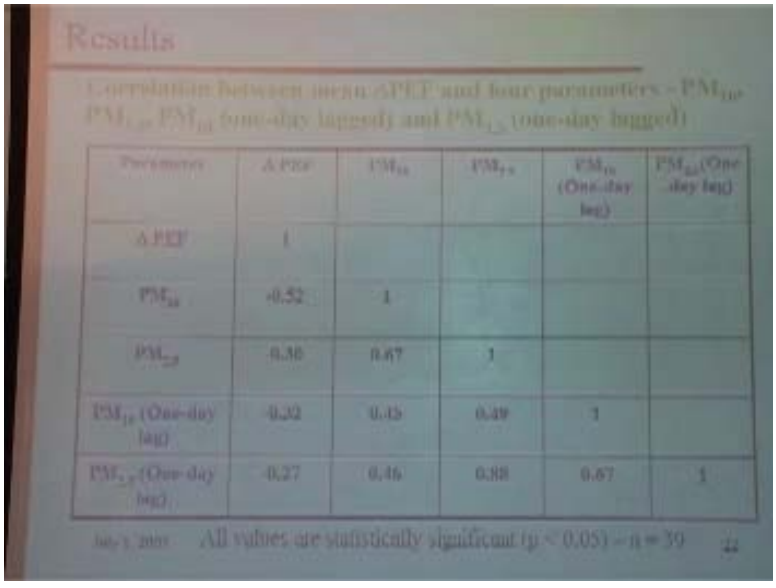
Similarly for $PM_{2.5}$ at Juhilal Colony, that also is clearly seen as the pollution $PM_{2.5}$ goes up to 150 or so because the pollution level is high and so the performance decreases here. In fact, it becomes negative from the normal performance and then as the pollution level drops, which is close to about 60, their performance improves. PEFR is related even with the daily activities. You can improve and it can go down. This is what was clearly seen but it was more related with PM_{10} than $PM_{2.5}$. This was a little surprising.

(Refer Slide Time: 47:56)



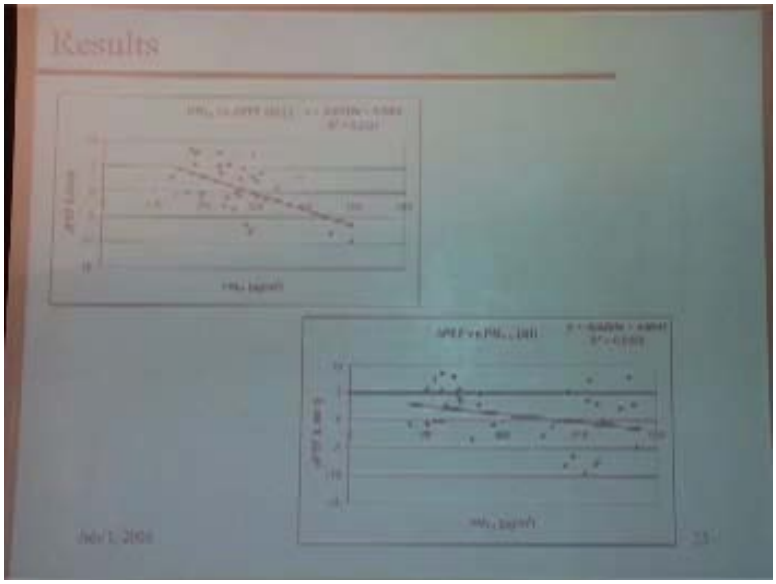
I should also show you the results from IIT if we have. IIT performance. Since the levels were so low, the variation were also not so much. We did not see as clear a trend as we did for the other two locations. In IT Kanpur, we could not see so much of the correlation – one is going up and the other is going down.

(Refer Slide Time: 48:18)



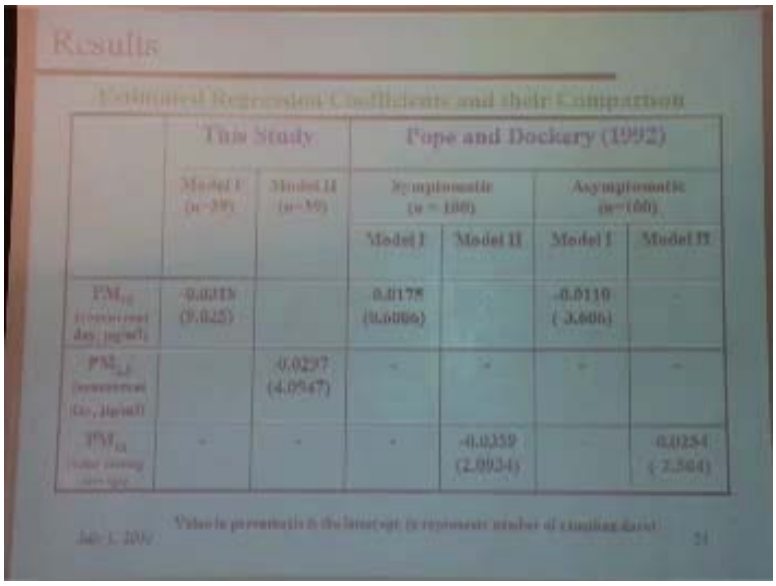
What the student did was that this delta PEF, he correlated with respect to PM_{10}, $PM_{2.5}$ and with PM_{10} one-day lag. He took the PEF value for the next day, the PM_{10} value one day before and then $PM_{2.5}$. They could see there was a correlation between delta PEF and PM_{10}. So there is a negative correlation. It means as the pollution level went up, the performance – delta PEF decreased or PEF decreased. That was [48:52] but more related with PM_{10} and you will see that PM_{10} and $PM_{2.5}$ are related; PM_{10} the previous day and current day would be related; so will be $PM_{2.5}$ and $PM_{2.5}$ was highly related. $PM_{2.5}$ does not change as quickly as does the PM_{10}. So the correlation between $PM_{2.5}$ of today and yesterday was very high; PM_{10} and $PM_{2.5}$ also correlated. These were all significant statistically. You can see clearly the effect of air pollution on PEFR.

(Refer Slide Time: 49:33)



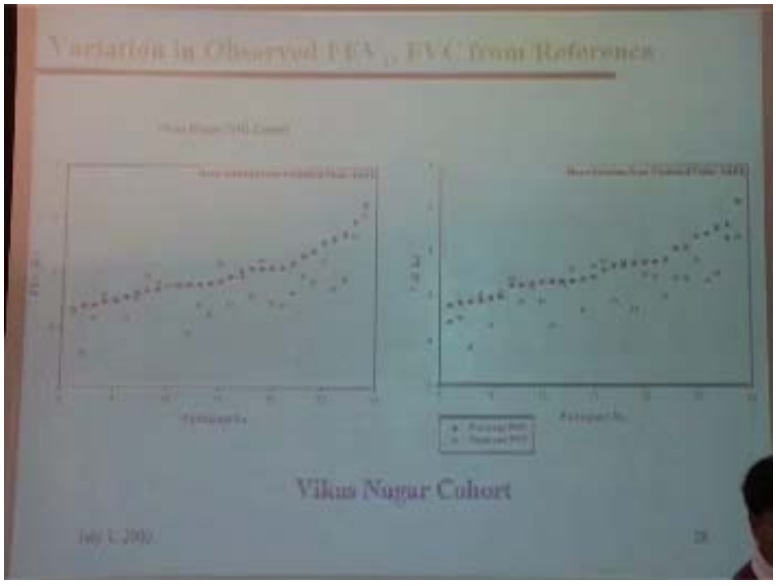
This is a graphical presentation of how the PM_{10} was changing. As it was increasing, the performance in terms of this thing was decreasing. It was not so significant about $PM_{2.5}$.

(Refer Slide Time: 49:57)



You can fit a model to this and then you can say how things will change. About 39 people were involved and you can see how PM_{10} concentration and the…. It is basically the coefficient that you can compare with.

(Refer Slide Time: 50:13)

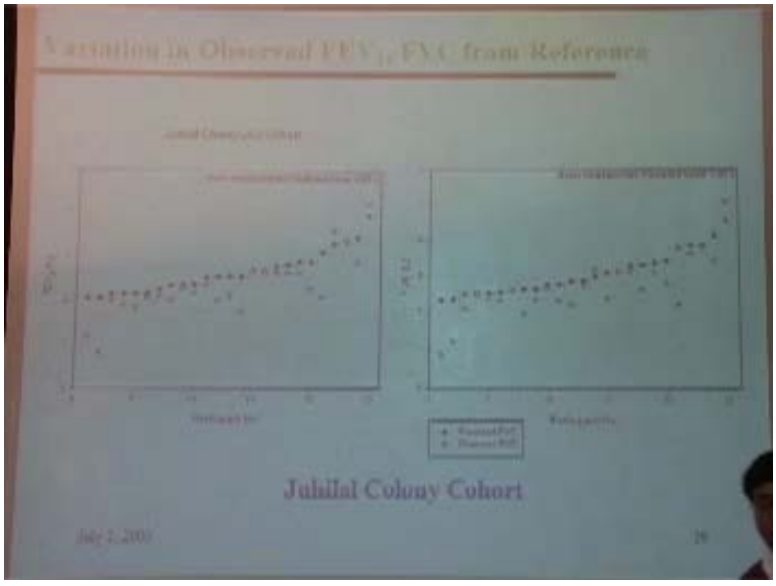


The other thing that I must show you is this one about how people performed in terms of FEV_1. About 30 people were there. What this student did was he plotted the solid spots.

The solid spots indicate what they should actually perform based on their body weight, based on their height, based on sex and based on which part of country they come from. This is what it should be for the person. You see immediately below this is what people performed. So there is a one-to-one correspondence for everything. Some people did perform better than what they should but there is a likelihood because this area was polluted and in general, people performed much below than what their actual performance in terms of FEV_1 should be.

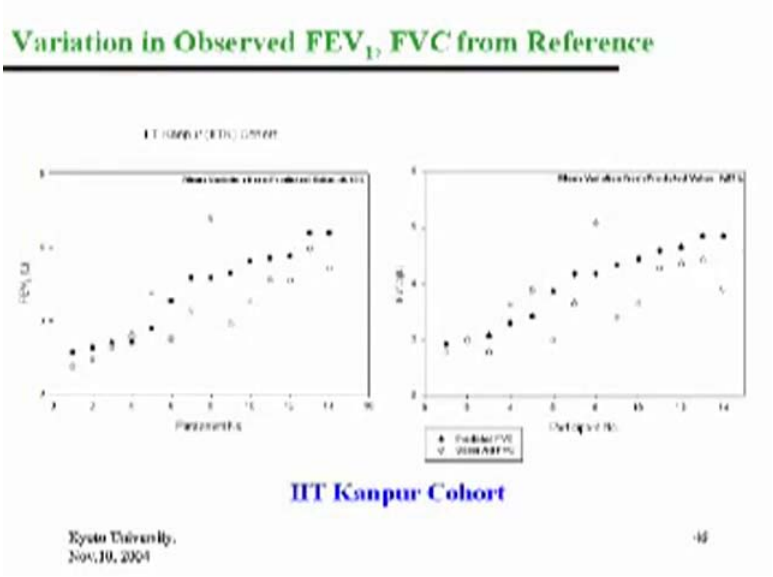
This average deviation was about 0.3 liters, which is quite high. The same thing was in the area of…. This is forced vital capacity of the lungs – you can see that also. The solid things show that is what they should be – they have put them on purpose in the increasing order so that the graph is seen very clearly. You can see here the people performing below their…. For example, he should perform at this level but he was performing at this level. For example, this person number 20, let us say, should perform at this level but maybe he was performing at this level. Again, we can find out the mean variation from the predicted values. It is again 0.42. It means that most of the people are performing below what it should be and the average decrease in their vital capacity is about 0.42 liters.

(Refer Slide Time: 52:06)



The same thing was in Juhilal Colony. That was again a polluted area. You can see people performing below this thing and 0.31 here and again close to 0.4.

(Refer Slide Time: 52:19)



I also have the IIT data here. In terms of FEV_1 and FVC, in IIT also, people performed a little below but that performance was not as bad as it was in the city. You can see here the mean deviation of 0.13 – that was the deviation. The graph is a little exploded, so you see the difference is more, but the difference is not that much because it is starting from 2 liters here. So was the FVC, this was about 0.27 liters or so. You can clearly establish how the pollution will affect people, their lung performance and then associated lung diseases. There are many more things that people do in this kind of study but we need to cover particulate matter and health effects just in one lecture so that you can …. We will stop there and for some of the gases, we will talk in the next class.

We need not be experts of health effects but we should know. Obviously, now, we have this information. Where do we use this information? To set the ambient air quality standards right? That is what you want to say. We want to at least reduce this 0.13 to let us say to 0.05. Then what should be the improvement in the air quality? We can do with our studies and then decide to set this standard at this level.

The problem was that people were insisting that we should do some studies of our own because we are all the time trying to borrow the data from somewhere else. Indian conditions are very different; the pollution levels are different. There are two arguments somebody says that the nutrition level is so bad, so low for people in India and so the likelihood of you poor lung performance will be high. The other argument is that we are acclimatized to poor conditions and so the body response will be better and body has acclimatized itself to perform better even under the worst conditions.

There were a lot of arguments. Sometimes, we need to create and develop our own medical tests and medical studies. Obviously in this work, many medical people were involved. This was one of the Masters' theses. The student did a very good job. This is what a thesis is – 30 pages of thesis, but now, we see the M. Tech. thesis to be very long but the work done was very good. This was published in some good international journal. We will stop there.