Soil Fertility and Fertilizers
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Lecture: 33
Soil Health and Quality, Problem Soil, Land Capability Classification (Contd.)

Welcome friends to this lecture number 33 of NPTEL online certification course of soil fertility and fertilizers. And in this week we are discussing about soil health and quality problems soil and land capability classification.

So, in our previous 2 lectures we have discussed about soil degradation and soil health card, we have discussed what is the necessity of soil health card scheme, what are the benefits of soil health card scheme, what are the different aspects of soil health card scheme that means, how many parameters and how they are made, how these measurements are being done.

And also we have discussed we have seen the soil health card and the fertilizer recommendations and how we can get the fertilizer recommendation in the soil health card. So, all these things we have discussed, we have also briefly started discussing about soil quality and soil quality index. So, we will start from there in this lecture and discuss how to calculate the soil quality index.

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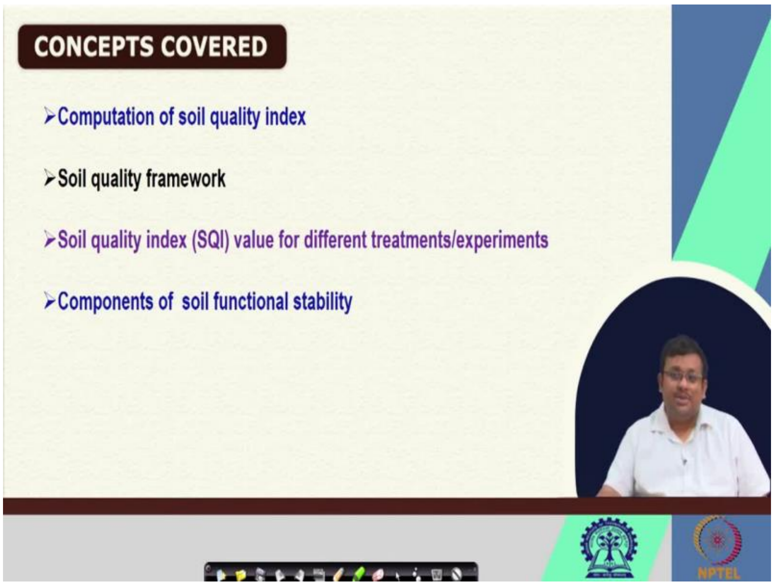

So, these are the concepts which we are going to cover in this lecture, computation of soil quality index, then soil quality framework, then soil quality index value for different treatments and experiments and then components of soil functional stability. So, these are the some of the concepts which we are going to discuss in this lecture.

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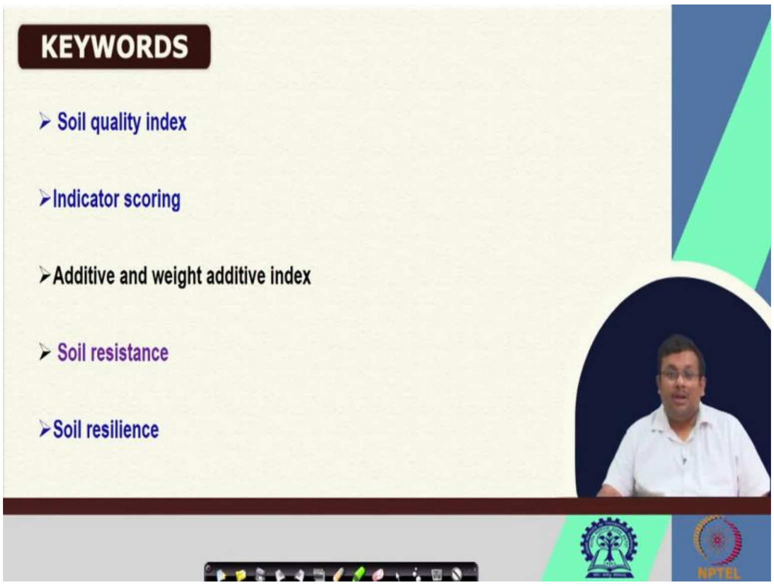

These are the key words of this lecture, we are going to learn about soil quality index and then indicators scoring, then additive and weight additive index and then soil resistance and soil resilience. So, these are some of the keywords.

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So, if you recall the soil quality and soil quality index, which we have briefly discussed in our last lecture, soil quality is the capacity of the soil to function. So, and soil quality index basically is an indicator, numerical indicator which helps to assess the soil quality of a given site or ecosystem. And also it enables comparison between conditions at plot, field or watershed level under different land uses and management practices.

So, for different management practices for different crops, we can calculate the soil quality index and there are different methods to calculate the soil quality index which we are going to discuss, but before that, please try to remember that soil quality is a broader concept, which shows the ability of his soil to function and second soil quality index is an indicator of soil quality numerical indicator I must say.

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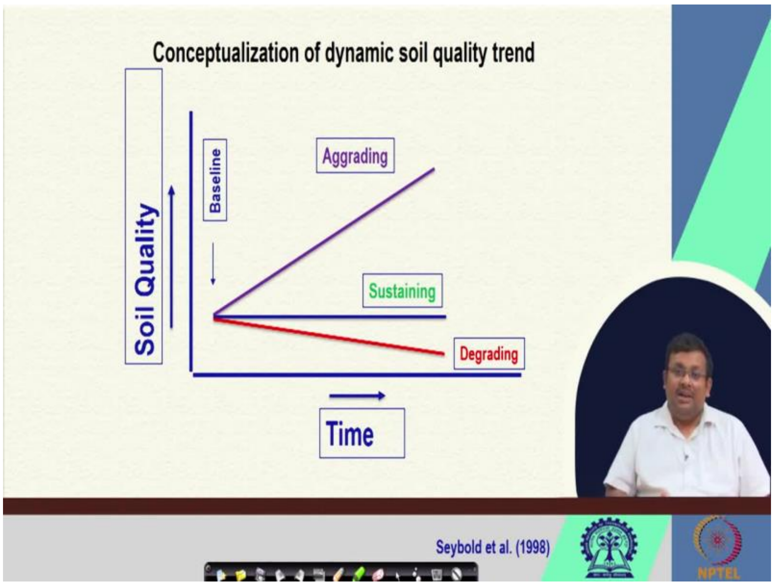

Now, if we see the conceptualization of dynamic soil quality trends, we will see that the soil quality generally degrades either it can either degrade either it can show some aggravating trend or they can be maintained at a sustainable level. So, soil quality can have 3 different trend. First of all, it can degraded, it can degrade over time, it can improve over time or it can maintain its level over time. So, in these 3 conditions, we can get 3 different types of trend.

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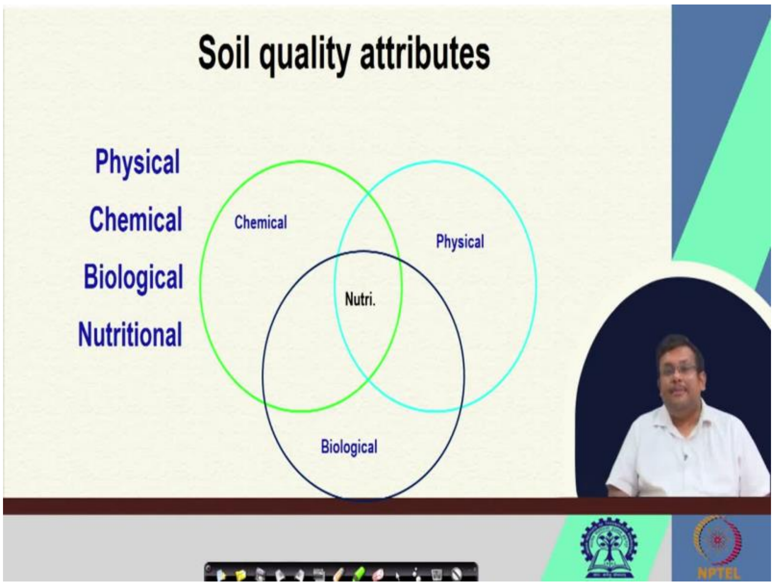

So, also we know that soil quality attributes are basically an interplay between chemical, physical, and biological and when they intersect with each other of course, that also encompasses the nutritional aspects or nutritional features also. So, not only the physical, chemical, biological, but also nutritional features are also important for the soil quality attributes.

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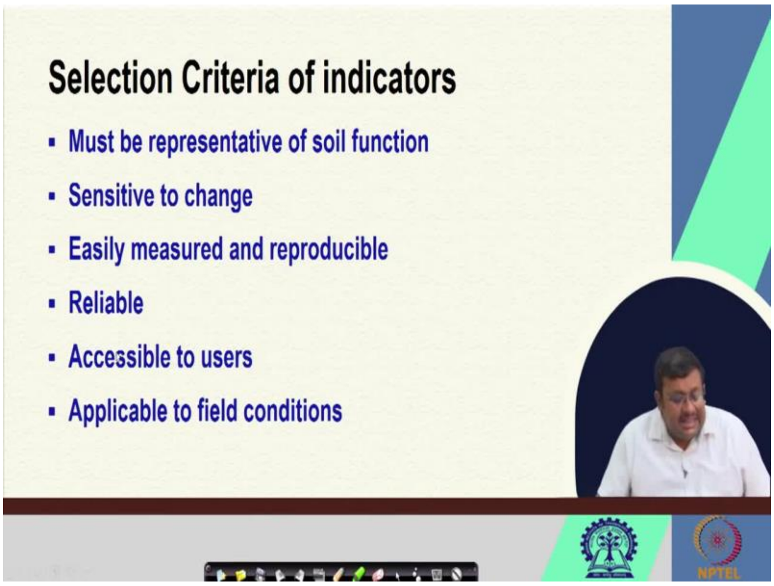

Now, selection criteria of the indicators now, for calculating the soil quality index, we have to first select the indicators. Now, how to select those indicators what should be our considerations? First of all, these indicators must be representative of soil function, it should be sensitive to change, it can should be easily measured and reproduce, it should be reliable, it should be accessible to users, and it should be applicable to field conditions. So, these are the selection criteria of the soil quality indicators.

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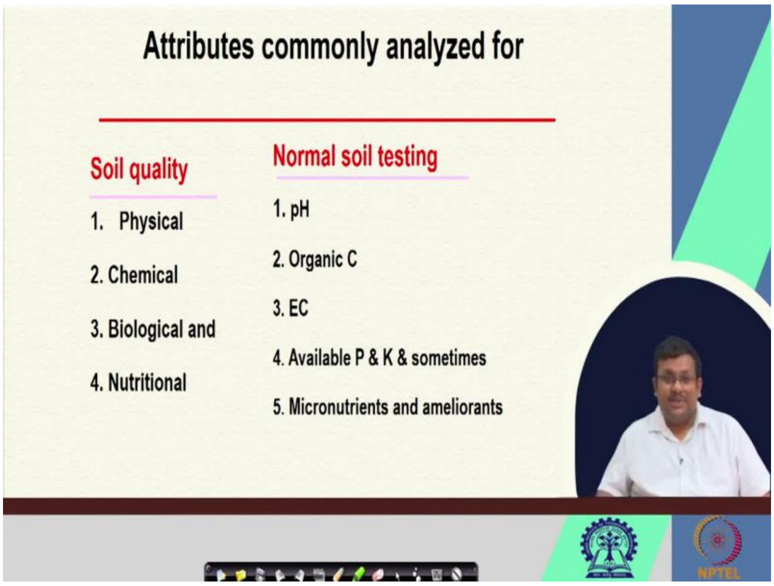

Now, in the normal soil testing generally we take care of pH, organic carbon, electrical conductivity and available phosphorus, potassium and sometime micronutrients and ameliorants like, lime or gypsum. However, for soil quality we take care of, we will consider both physical, chemical and biological and also nutritional factors or nutritional indicators.

So, this is very important that or it is a comprehensive characterization of soils ability to function.

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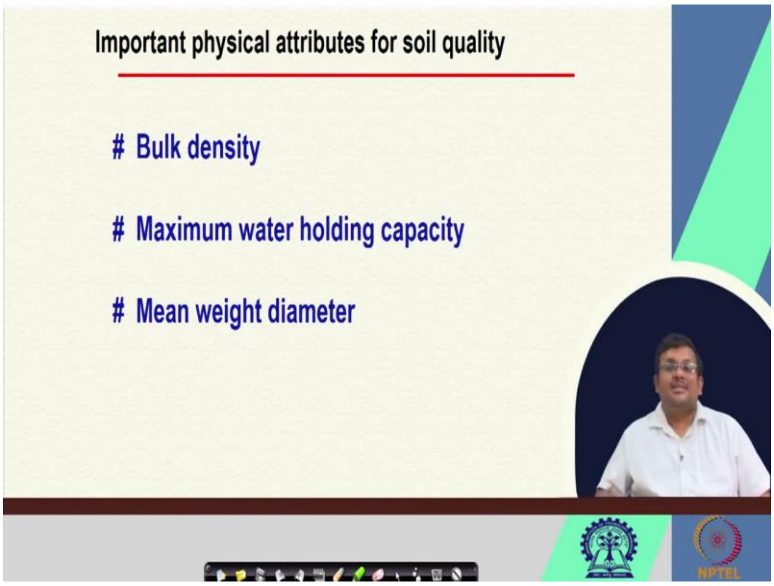

So, what are the some examples some important physical attributes which are generally considered for soil quality are bulk density, maximum water holding capacity and mean weight diameter, I hope you all know about the mean weight diameter and maximum water holding capacity and bulk density I am not going to discuss those in details, but based on these factors or several soil fertility and also soil quality indicators can be I mean, these are the soil quality indicators and based on these quality indicators, we can grade a soil as a good bad or medium quality.

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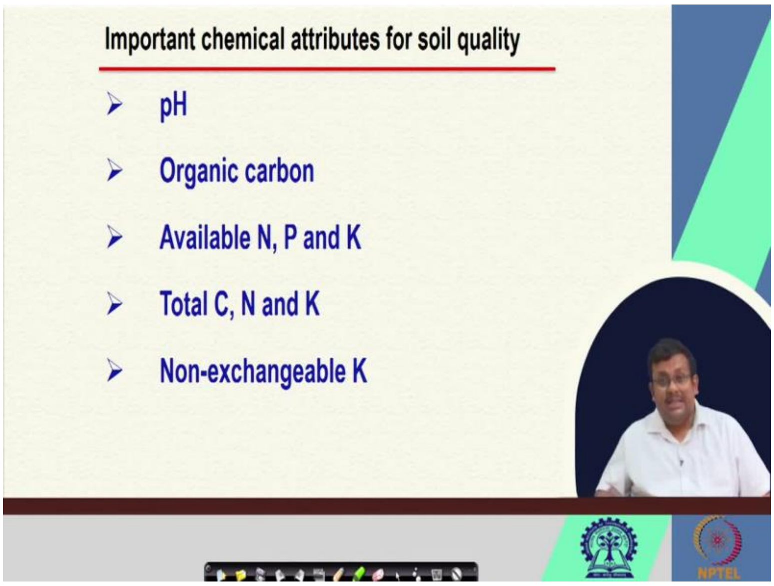

So, some important chemical properties or indicators for soil quality are pH, organic carbon, available nitrogen, phosphorus, potassium, total carbon, nitrogen and potassium non exchangeable potassium. So, pH is a very important indicator of soil quality, because most of the nutrients are generally available in the mean range that is in the normal in the neutral range and they become unavailable in extreme pH conditions.

Organic carbon is a very important indicator of soil quality and then total available nitrogen phosphorus potassium are also very important indicators of soil fertility and soil quality. Total carbon, total nitrogen and also potassium, total potassium is also very important indicators of soil quality and also non exchangeable potassium. So, these are important chemical attributes of soil quality.

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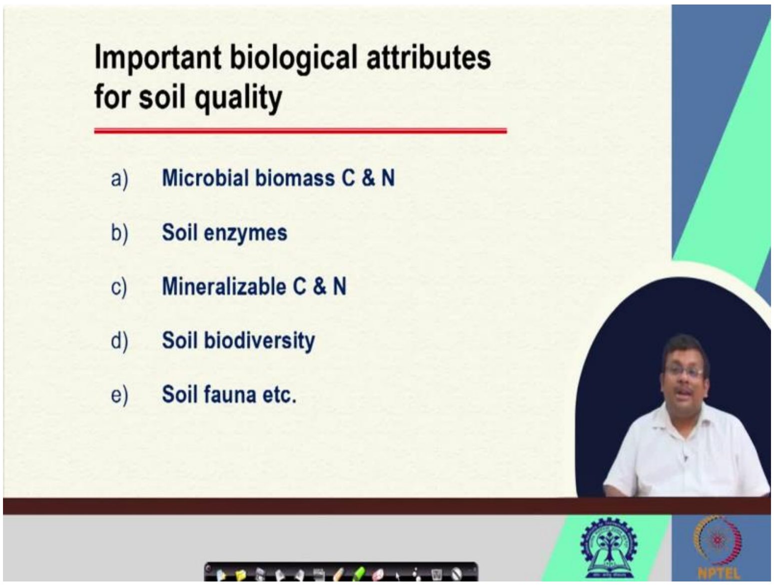

Now, what are the important biological attributes of soil quality? Like microbial biomass carbon and nitrogen, soil enzymes, mineralizable carbon and nitrogen, soil biodiversity, soil fauna et cetera. So, more biodiversity more, higher quality soil, more soil fauna beneficial soil fauna that means more higher quality of the soil microbial more microbial biomass carbon and nitrogen that means higher quality, higher quality.

So, these are the indicators now, remember that these are very general indicators. Scientists across the world are trying to establish novel physical, chemical and biological indicators and it is a continuous process you can see that several scientific groups are working for developing new indicators for calculating the soil quality. So, these list is ever changing. So, these are some of the well-known biological attributes.

However, the list is continuously updated by the different research groups. And you can see that they are also they are proposing other biological properties, other chemical properties and also other physical properties as indicators of soil quality.

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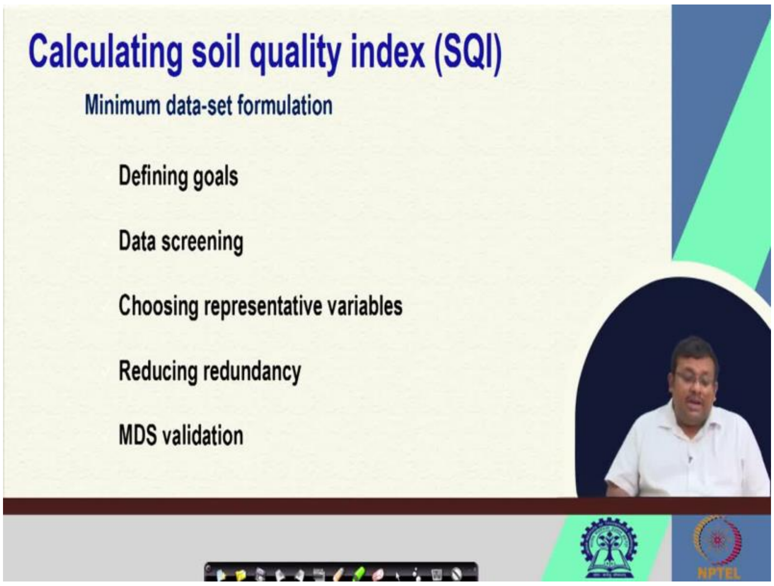

Now, how to calculate the soil quality index? So, soil quality index basically also depends on these minimum dataset formulation. The minimum data set sometimes we call it MDS, so, this MDS formulation basically depends on several steps first of all you have to define your goals and then you have to screen the data.

Once you screen that data, the next step is to choose the representative variables and then reducing the redundancy you should not include those variables which are interrelated to each other. So, that will basically incorporate the redundancy in the soil quality index model. And finally, these minimum data set validation is another important step for calculating the soil quality index.

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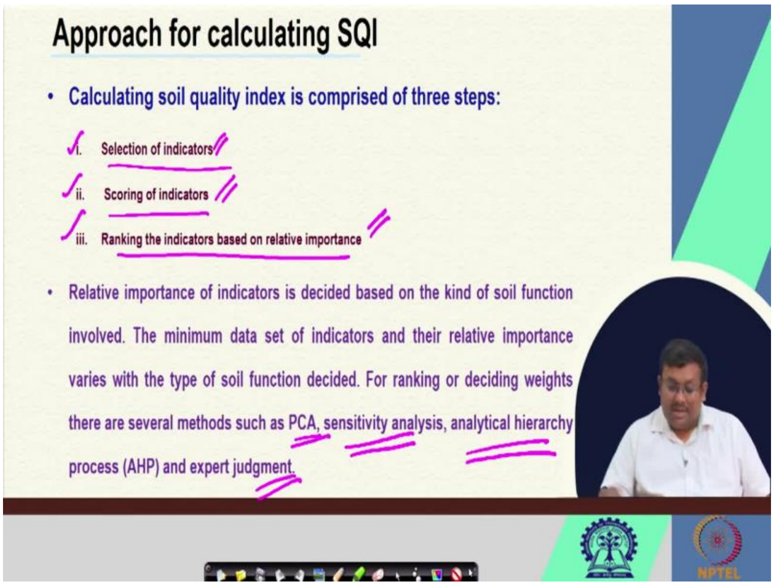

Now, what are the approach, what is the approach for calculating the soil quality index? Now, calculating the soil quality index is comprised of generally 3 steps, the first step is selection of the indicators. So, this is the first step this is the selection of the indicators. And then second step is scoring of the indicators. And third step is ranking the indicators based on relative importance.

So, first of all, we have to select the correct indicators, and then we have to score them, I am going to show you, how to how we score them and based on their score, we can rank the indicator based on their relative importance. So, the relative importance of indicators, so, how to calculate the relative importance of indicators. So, this relative importance of indicators is decided based on the kind of soil function involved.

Now, the minimum data set of indicators and their relative importance varies with the type of soil function decided. So, the based on the type of the soil function, the minimum data set of indicators and their relative importance varies for ranking or deciding weights, there are several methods like principal component analyses, then sensitivity analyses, then analytical hierarchy process and expert judgment.

So, these are the different processes through which we can decide the weights of those individual, parameters and there... So, I am going to show you how to how we calculate that in using the principal component analysis. But remember that these are the 3 general steps.

First of all, selection of the indicators, then scoring of the indicators, we have to know how we score the indicators and finally, we should rank the indicator based on their relative importance.

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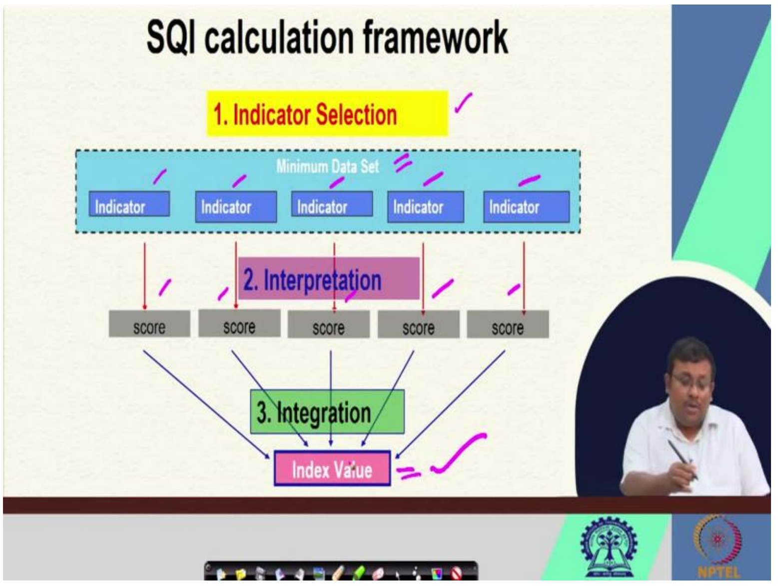

Now, if we go ahead and see the framework of this SQI calculation, we can see that first of all, we have to select the indicators and then the minimum data set we have to select because we cannot produce redundancy information. So, they are maybe different indicators and based on these different indicators, we have to score these different indicators based on whether they are good or bad, and then we can integrate their score to get a final index value that is called the soil quality index.

Now, these scores should be normal addition or it could be weighted summation also. Now, to judge these weighted summations or to execute these weighted summation, you have to first measure their, we determine their weights and these weights of individual indicator can be determined by using principal component analysis.

Now, remember that guys, there are different methods for soil quality index calculation, you can see that it is also a continuous process like identifying the soil quality indicators. So, soil quality index calculation is also being suggested by different scientific groups. So, we are going to discuss here only the most common methods. However, you should remember that there are also other methods for calculating the soil quality index.

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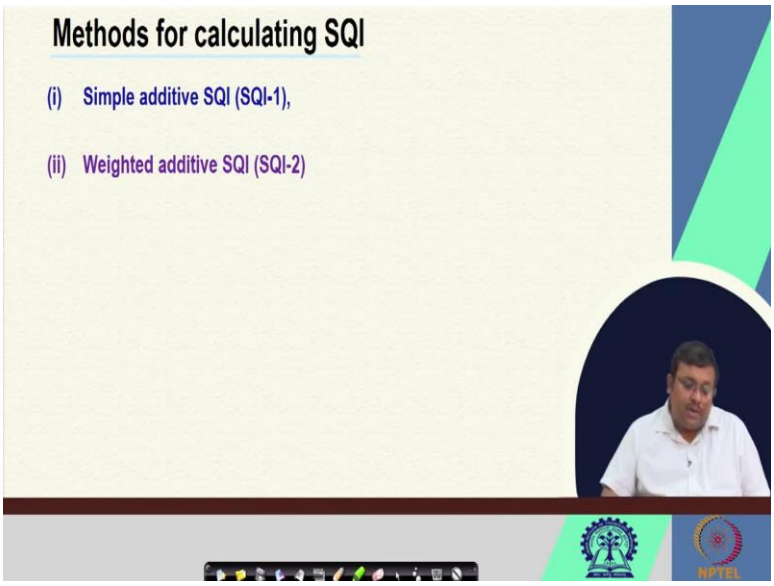

So in general there are 2 methods one is simple additive soil quality index and other one is weighted additive soil quality index. So, these are the 2 generally accepted method and people are also nowadays using different other ways to calculate the soil quality index however, in this lecture we are going to discuss only these 2 that is simple additive soil quality index and weighted additive soil quality index.

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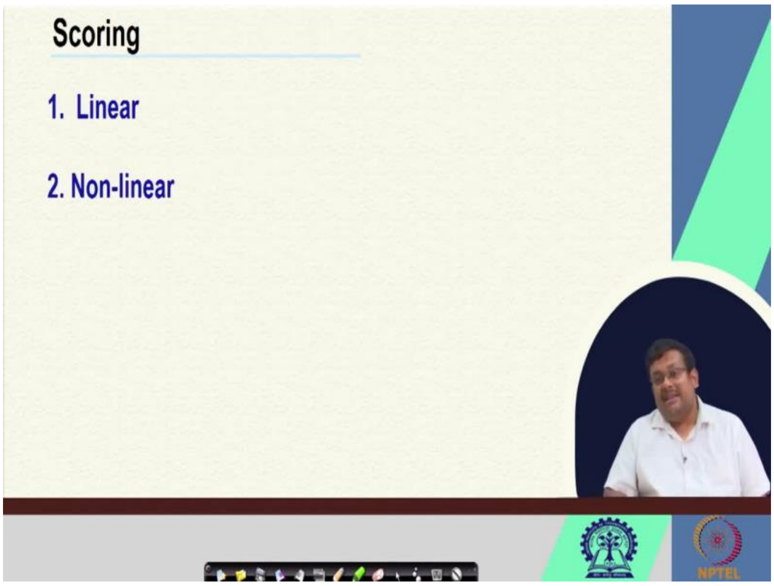

So, but before we discuss about the simple additive and weighted additive, let us first see what is scoring and how we do the scoring? Now, the scoring of the indicator can be of 2 types one is called linear scoring and other is nonlinear scoring. So, let us see what is linear scoring and what is nonlinear scoring.

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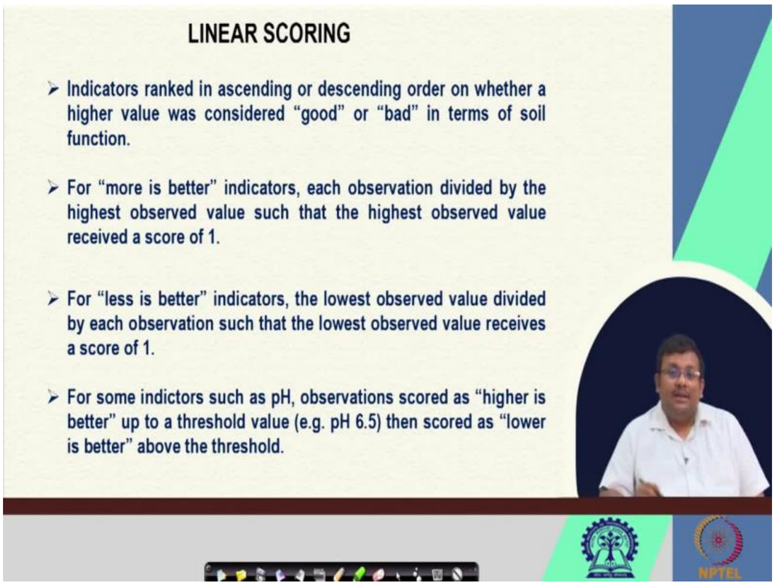

Now, in case of linear scoring indicators ranked in ascending or descending order on whether a higher value was considered good or bad in terms of soil function. So, basically these indicators we generally ranked in ascending or descending order on based on whether a higher value was considered good or bad in terms of soil function for example, if I considering soil organic matter, soil organic matter higher the value it is considered good.

So, in this way we should rank either in the ascending order or descending order for more is better indicated each observation divided by the highest observed value such as the highest observed value received a score of 1. Suppose for organic matter more is better it is a more is better indicator.

So, for each observation, so, it should be divided by the highest observed value such that the highest observed value received a score of 1 and the other values are getting the score of less than 1. In opposite the less is better indicators, the lowest observed values divided by each observation that the lowest observed value received a score of 1.

So, in both approaches basically we divide the value by the highest observed value or lowest observed value. So, in the more is better approach, each observation is divided by the highest observed value and for less is better the lowest observed value divided by each observation. So, that the lowest observed value receives a score of 1.

However, there are some indicators which are in between. There are either not more is better or less is better. So, some indicators like pH the observations scored as higher is better up to a threshold value that is pH 6.5 then scored as lower is better above the threshold. So, here we have they have considered these pH 6.5 as the threshold of pH and the higher is better, up to a threshold value that is up to 6.5 and above the threshold that is lower is better.

So, in this way, if we can score you will see that when the values are converging towards the neutral pH then the will get the higher scores, which basically makes sense because the soil should have neutral pH to maintain the optimum supplier of the nutrients. Now, so, this is about the linear scoring.

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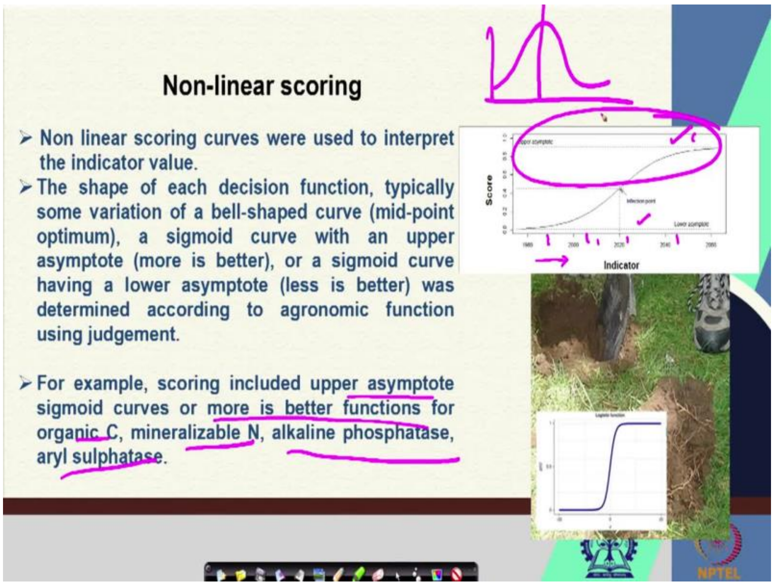

Now, let us talk about the nonlinear scoring also. So, nonlinear scoring curves were used to interpret that indicator value. So, here you can see this is a nonlinear scoring curves, which are generally used to interpret the indicator value. Now, the shape of the each decision function typically some variation of a bell shaped curve. So, it could be a bell shaped curve, just it like a normal curve where the midpoint optimum is there.

Otherwise, there will be a sigmoid curve with an upper asymptote. So these are sigmoid curve, this is a sigmoid curve. So you can see this upper asymptote and a sigmoid curve with or a sigmoid curve having a lower asymptote. So this is a lower asymptote where less is better. So upper asymptote basically shows the more is better and lower asymptote shows the less is better.

So we determined this according to the agronomic function using our judgment. We basically identify, we give the score. So suppose in the x axis we are putting any indicator these are some hypothetical values so we can get any this is a hypothetical indicator, but you can take a particular indicator like available nitrogen maybe then you can put their values and then you can get their scores and then from there you can get there those scores should be used for the subsequent calculation.

For example, scoring included upper asymptote sigmoid curve or more is better function for organic carbon mineralizable nitrogen, alkaline phosphatase and aryl sulphatase, these are generally belongs to this zone that is sigmoid function with upper asymptote were more of these contents are considered as better for soil quality. So, they are giving more weight for these indicators, when they are going to the higher when we are getting higher quantity of these indicators, we are generally giving them higher scores.

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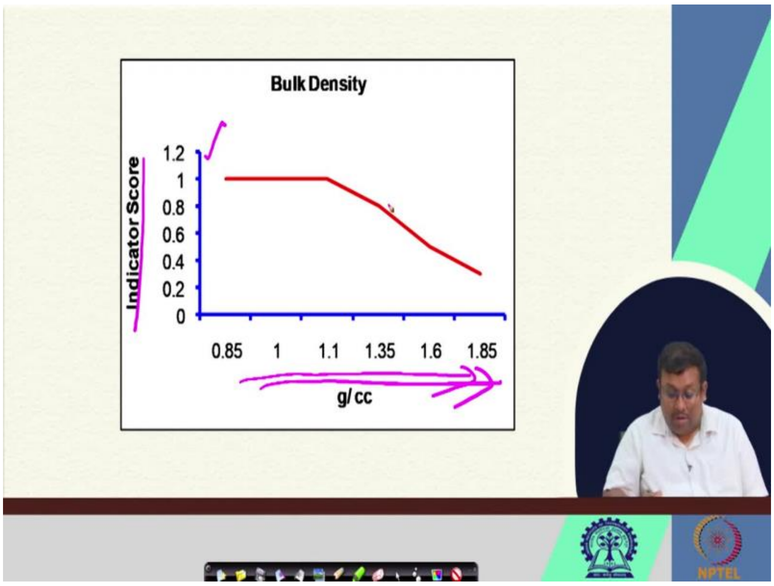

Now, for example, here is an example. So, here you can see bulk density, we know that as we increase the bulk density there hardness or compactness of the soil increases and when the hardness or compactness of the soil increases, that is not useful for maintaining the soil quality because that negatively impacts the water and air movement and also that creates mechanical resistance for the root growth and plant growth.

So, of course, you can see the indicator scores are higher at the lower bulk density. However, as we increase the bulk density the indicator score goes down. So, this is an example using a physical indicator of soil.

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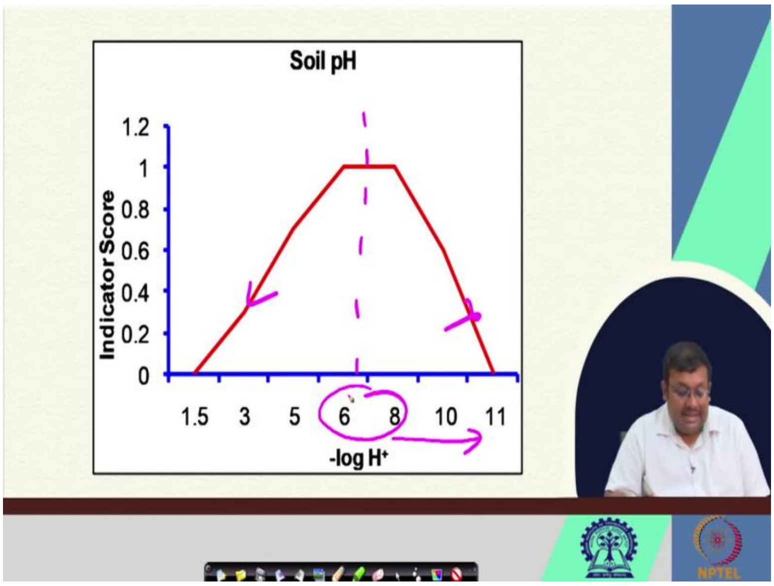

Now, if we see one chemical indicator just like I told you that as the pH is approaching the neutral, we are getting higher indicator score and as it is exceeding the neutral pH again this indicator score is decreasing. So, we have to find a threshold and based on that we have to assign these indicators score.

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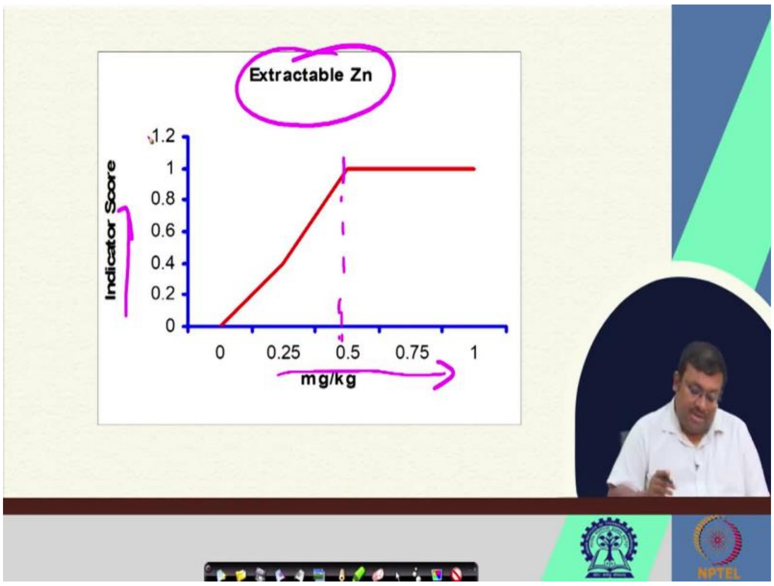

Also here you can see these chemical indicators scoring of a chemical indicator. So, here you can see as the extractable zinc is increasing in the soil of course, their indicator score will be increased after a particular after threshold, you see that indicators scores are relatively stable because we have got the enough amount of extractable zinc for sustaining the soil quality. So, this is another example of chemical indicators.

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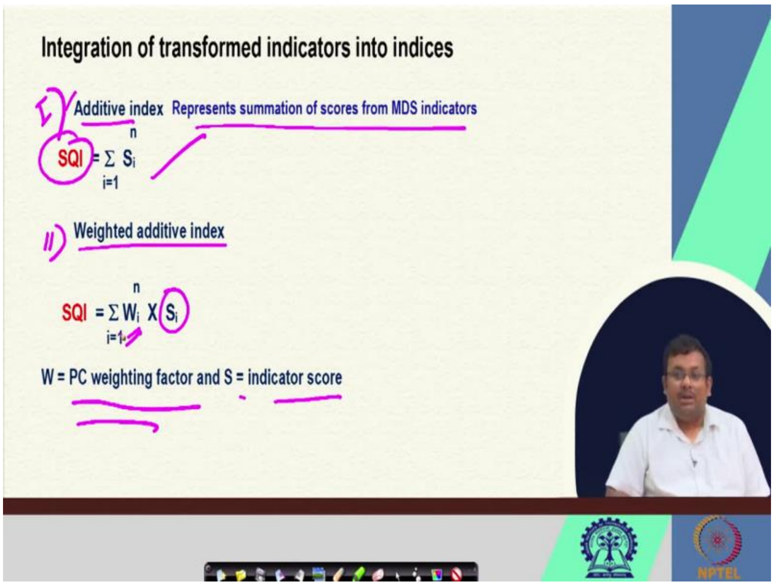

Now, once we calculate all these once we assign these scores to these physical, chemical and biological indicators, next step is to integrate them into a single index. So, here you can see first type is called the additive index, which represents the summation of scores from these minimum data set indicators.

So, here it is very simple, it is a simple summation. The second approach is, this the first approach and this the second approach that is called weighted additive index. Now, the weighted additive index basically, there is a weight assignment and these weight assignments is basically nothing but this PC weighting factor and S is the indicator score.

So, here, we are basically multiplying the indicator score with the principal component weighting factor, which we generally get from the principal component analysis. How we do that, let me show you.

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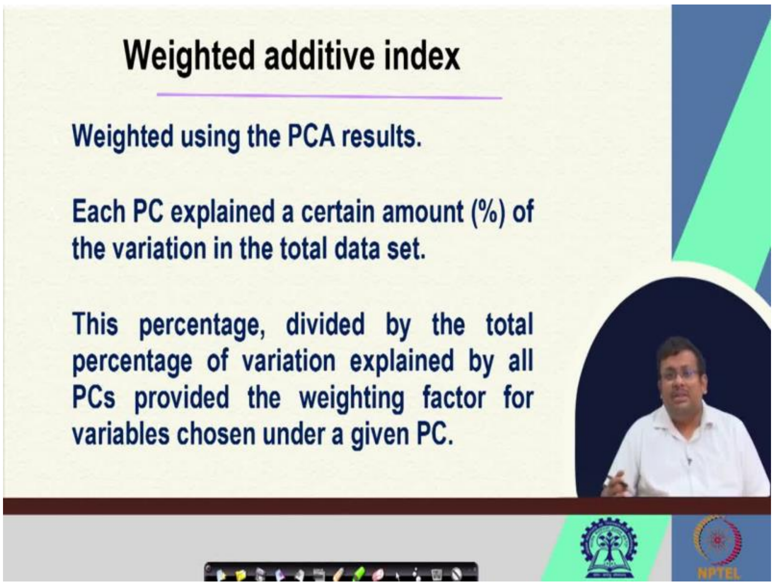

Now, these weighted additive index basically used weights basically use the PCA results or principal component analysis result. Now, you know that in case of principal component analysis, each PC generally explains a certain amount of the variation in that total data set. Now, this percentage is divided by the total percentage of variation explained by all principal components provided the weighting factor for variable choosing under a given PC.

So, here basically, we take the variation, total percentage of variation explained by all the PC and we also get the percentage of a particular PC and then we divide the amount of variation explained by a particular PC to the by the total percentage of variation then we can get their weighted, I mean we can get their weight. And from that weight we will assign that weight to that particular indicator.

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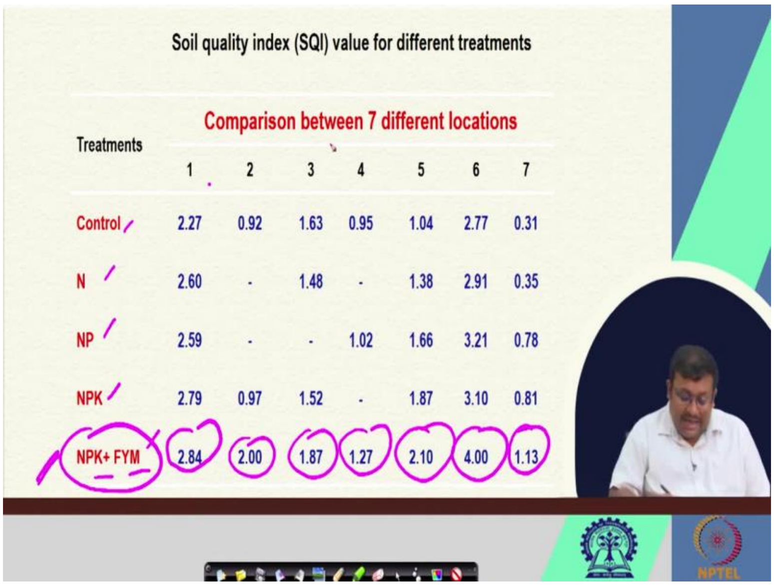

So, here are some examples are given, you can see here guys it is a comparison between 7 different locations for 5 different treatments like control, nitrogen, nitrogen phosphorus, nitrogen phosphorus potassium, and nitrogen phosphorus potassium plus farmyard anure.

So, you can see here in the first location we can get highest soil quality index of course, it is a judicious application both chemical and organic manure and you can see also for location 2 and then location 3, location 4, location 5, locations 6, and location 7 for all these location this combination of synthetic as well as the organic manure, synthetic fertilizer plus organic manure gives the best comparatively highest soil quality index score. Now, also these are varying from one location to another location. So, this is how we can calculate the soil quality index for different treatments.

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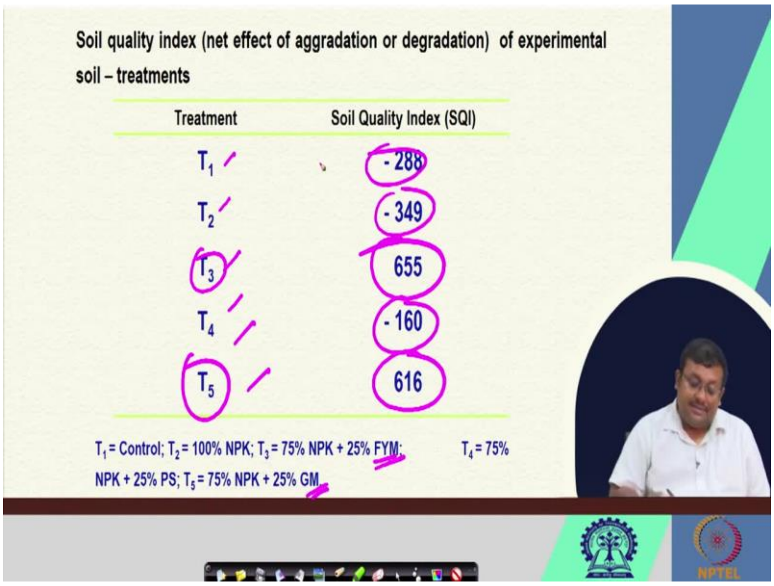

Also, we can also calculate the soil quality index as net effect of aggradation that is improvement of soil quality or degradation of the soil quality of experimental soil treatments. So, you can see here there are 5 different treatments. First treatment is control, second treatment is 100 percent nitrogen phosphorus potassium and third treatment is 75 percent of NPK and a plus 25 percent of FYM and fourth treatment is 75 percent NPK and 25 percent of PS and then T5 is basically 75 percent of NPK and 25 percent of GM are remaining.

So, basically when we add when we compare then we can see that in this T3 and T5 where we are applying the manure with the synthetic NPK we are getting the positive or improved soil quality index. For the rest of the cases where we are only using the fertilizer, chemical synthetic fertilizer then we are getting negative soil quality index. So, that shows the importance of judicious and integrated nutrient management for maintaining the soil quality.

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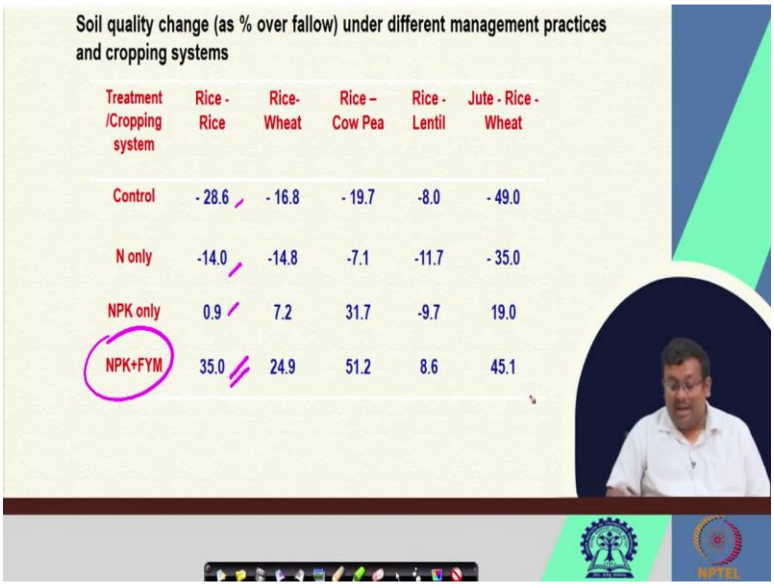

Now soil quality change over the fallow condition under different management practices and cropping system is also being given here. You can see for control system you can see for rice-rice, we are getting negative changes in the rice-rice system soil quality, for if we use the nitrogen only we are also getting negative changes, for NPK we are getting slightly positive change.

However, again NPK plus FYM we are getting positive changes. So, you can see for different cropping systems we are getting different results and from there we can have an idea about which one is best combination for maintaining or improving the soil quality.

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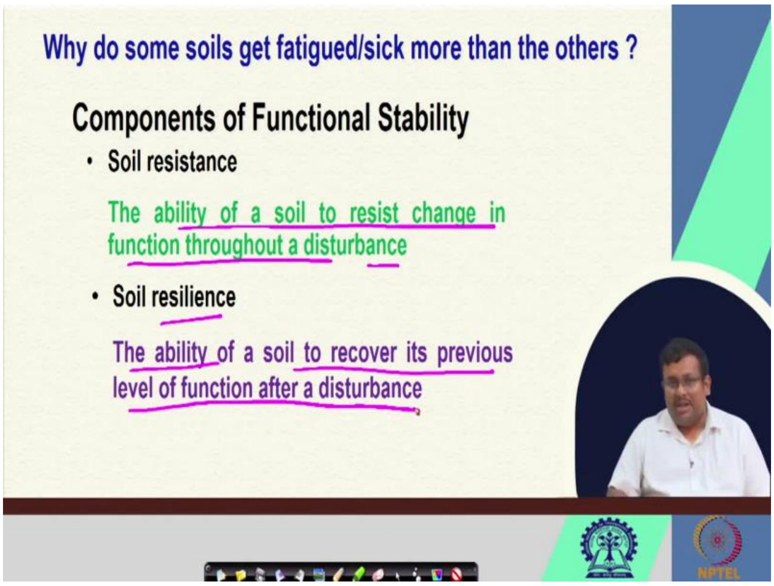

Now, why some soils get fatigued or sick more than others. Now, there are 2 important terms which we have to understand one is called soil resistance and soil another is soil resilience. So, these are the 2 important terms which defines the functional stability of the soil.

Now what is soil resistance, soil resistance is basically the ability of a soil to resist change in function throughout a disturbance and what is soil resilience? Soil resilience is the ability of a soil to recover its previous level of function after a disturbance. So there is a slight difference between these 2 terms.

The first one is the soil resist, ability of the soil to resist change in function throughout a disturbance and second is soil resilience is the ability of the soil to recover its previous level of function after the disturbance.

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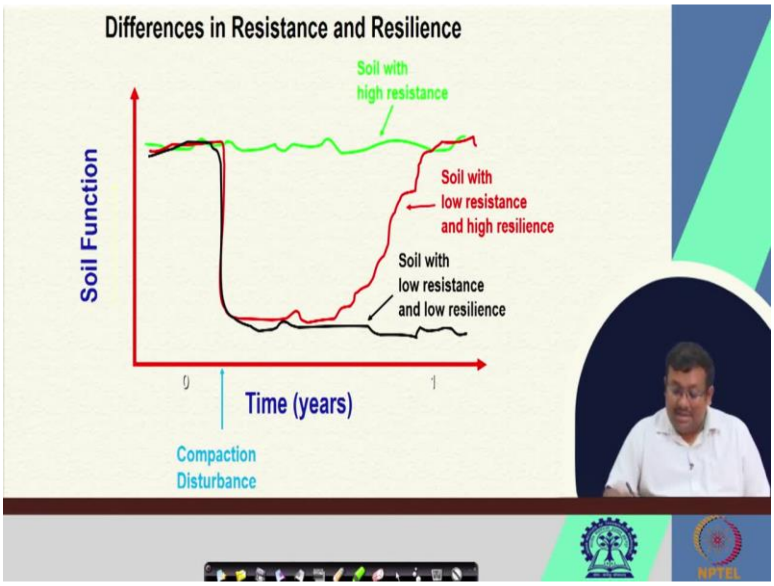

So, let us see. So, here you can see in the x axis we are putting the time in years and suppose there are compaction disturbances and as a region in the y axis we are getting the soil function. So, you can see a soil with high resistance will resist any changes due to soil disturbances.

So, this is a soil with high resistance, but this is a soil with a low resistance and high resilience although the soil has low resistance, so, that is why you can see the soil function is declining in this zone, but since the soil has high resilience, it can recover to the previous level after a certain period of time. So, this is the difference between the soil resistance and soil resilience and different level of soil resistance and resilience of a soil.

And here in the third you can see it is a soil with low resistance and low resilience. So, in this condition, not only the declining the soil function, but it cannot recover to its previous position because it has low resilience. So, these are the 3 conditions which we see as a response 2 different types of disturbances in the soil.

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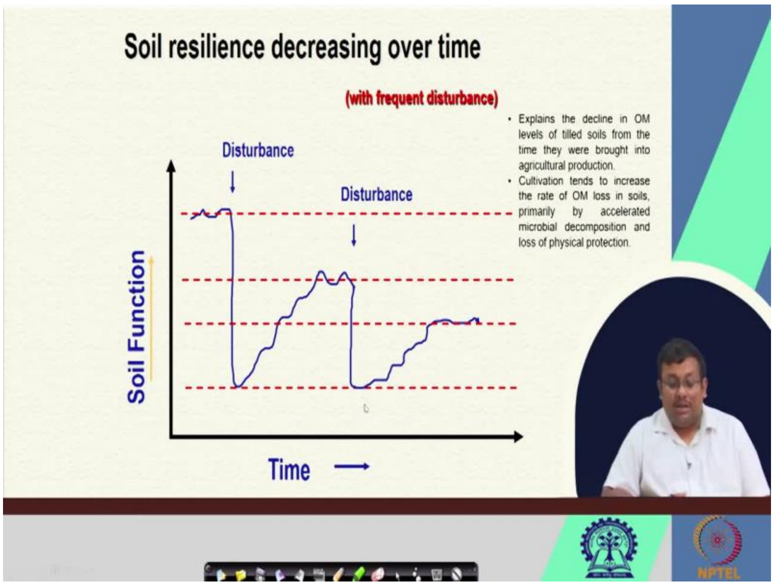

So, with frequent disturbances the soil resilience generally decreases over time. And so, in frequent disturbances, yearly disturbances we can see that soil resilience can go down over time and it basically explains the decline in organic matter levels of tilled soils from the time they were brought into the agricultural production and also cultivation tends to increase the rate of organic matter loss in soil primarily by accelerated microbial decomposition and loss of physical protection. So, this is why there is a continuous decrease of soil resilience over time.

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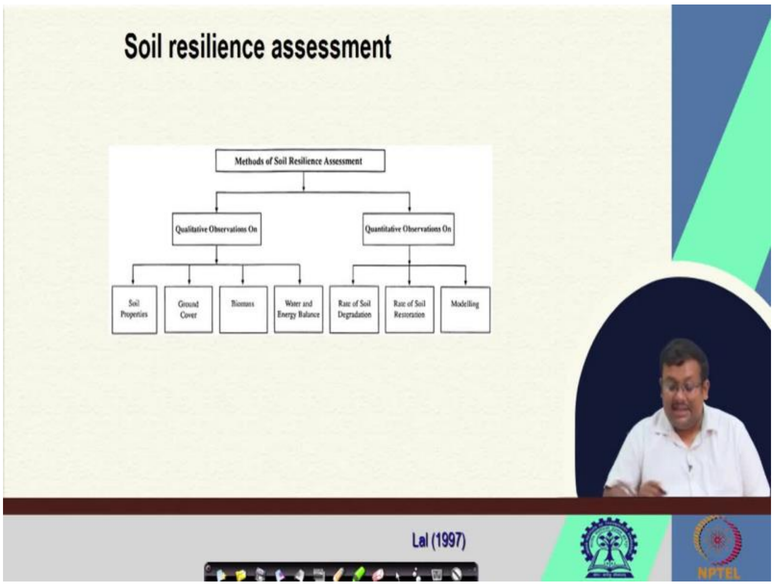

Now, Lal in 9097, he has proposed a different methods of soil resilient assessment. So, you can see here we can measure it, we can assess the soil resilience by some qualitative observation and also with some quantitative observation. Now, with some quality observation, what are the quality observation? Like soil properties, ground cover, then biomass, water and energy balance. So, these are quality observations.

And under the quantitative observation rate of soil degradation, rate of soil restoration, modeling. So, these comes under the quantitative observation for assessing the soil resilience.

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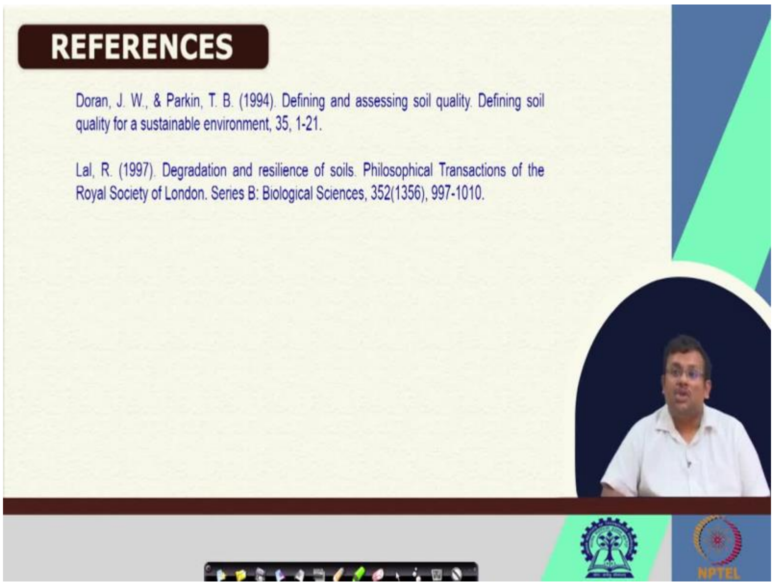

So, guys, these are the references I hope that you have now and comprehensive idea about the soil quality and soil quality index, how to calculate the soil quality index, how to what are the minimum data set for the indicators and then how to score those physical, chemical and biological indicators. After the scoring how we can add that by simple addition or weighted addition how to do these weighted additions by PCA we have discussed.

So, these are very much used by the soil scientists nowadays for defining the soil quality and new, new methods are also evolving for determination of soil quality index, please go through the available literature in and also you can you can discuss, you can see these 2 papers and you can have a comprehensive idea about soil quality and soil quality index.

So, thank you guys. Let us wrap up this lecture and let us meet in our next lecture and continue from there. Thank you very much.