Soil Fertility and Fertilizers
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Lecture: 57
Agriculture Productivity and Environmental Quality (Contd.)

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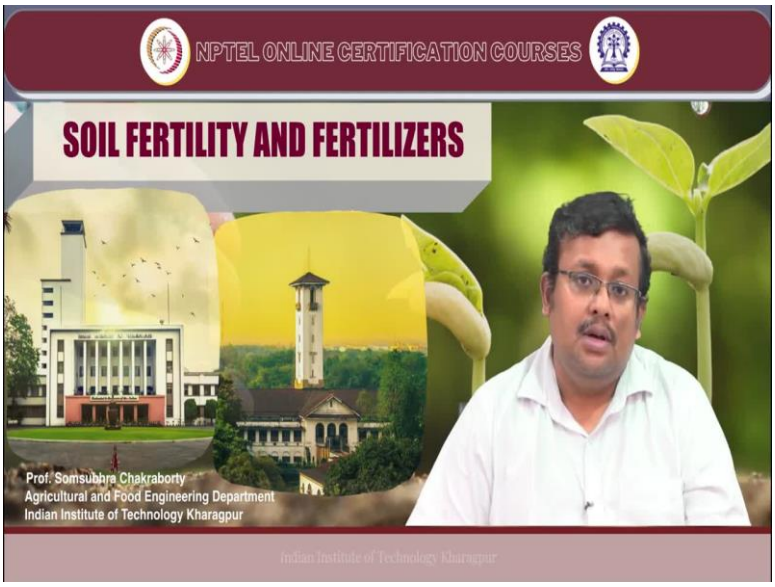

Welcome friends to this second lecture of week 12 of NPTEL online certification course of Soil Fertility and Fertilizers. And in this lecture, lecture number 57, we are going to cover another aspect of environmental quality which is related to agricultural productivity and plant nutrition.

In our previous lecture, we have discussed in details about soil carbon sequestration, however, in this lecture we are going to discuss the pollution which environmental pollution which are resulting from the synthetic chemical fertilizer application.

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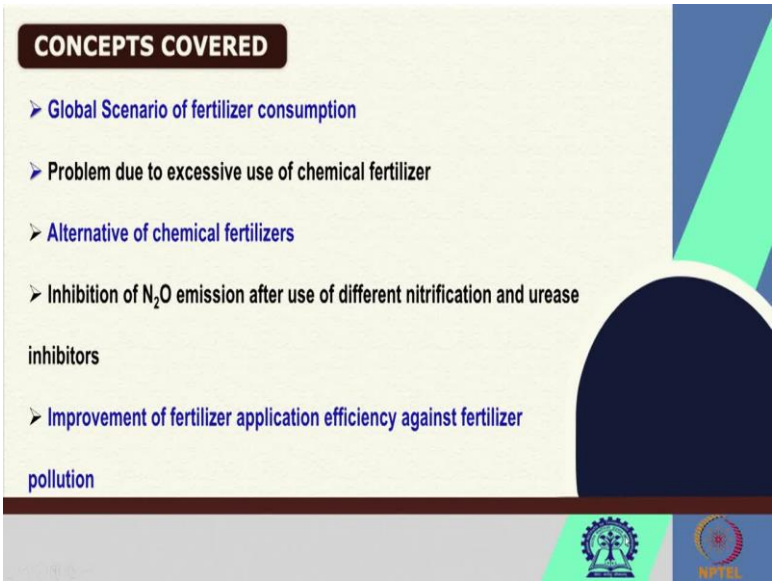

So, these are the concepts which we are going to cover in this lecture. So global scenario of fertilizer consumption and then problem due to excessive use of chemical fertilizer, then alternative of chemical fertilizer, then inhibition of nitrous oxide emission after use of different nitrification and urease inhibitors and improvement of fertilizer application efficiency against fertilizer pollution. So these are the concepts which we are going to discuss in this lecture.

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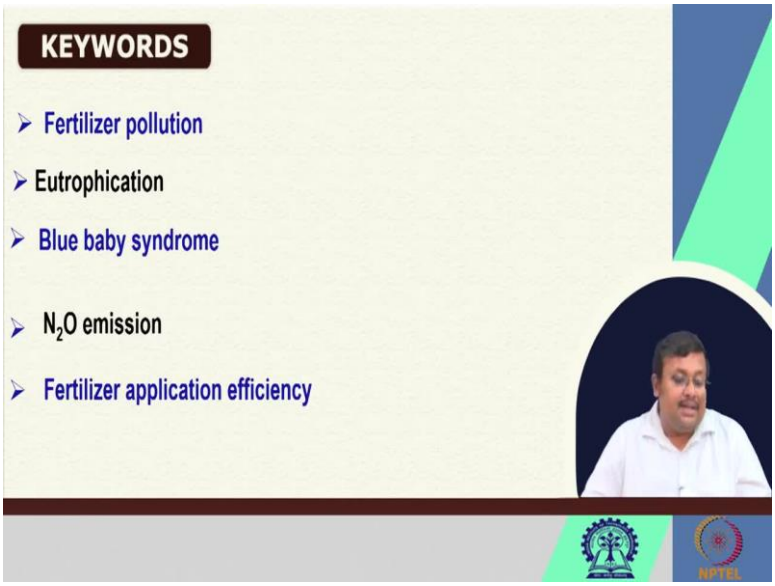

And these are the five keywords for this lecture, fertilizer pollution, eutrophication, Blue baby syndrome, nitrous oxide emission, and fertilizer application efficiency.

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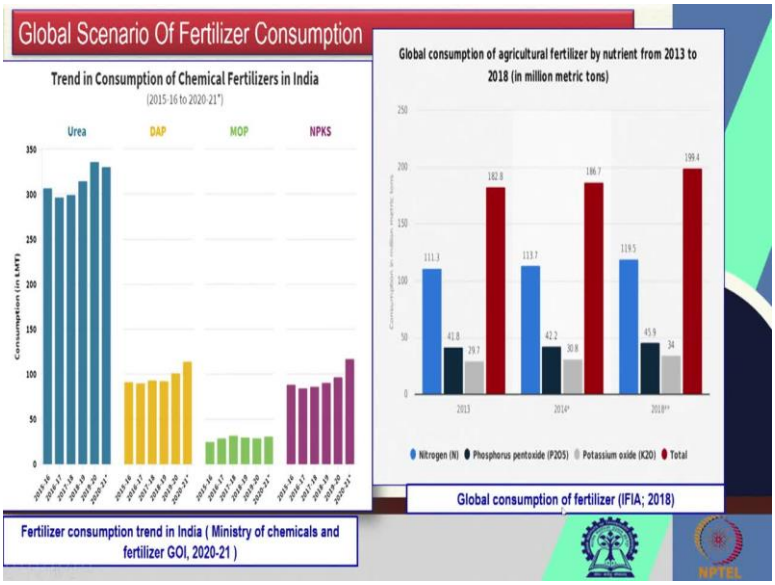

Now, if I see the global scenario of fertilizer consumption these gives us the trend in consumption of chemical fertilizer in India. So this first graph gives us the fertilizer consumption trend in India and this shows the global consumption of fertilizer. So if you see from 2015 to 2021 the consumption of fertilizer urea in lakh metric ton has increased. Similarly, consumption of DAP, MOP and DAP is also increased, MOP has increased and also but increase of MOP is not that prominent however, the NPKS of fertilizer have also increased.

And if we see that global consumption of agriculture fertilizer by nutrient from 2013 to 2018 we can also see that nitrogen has increase and also the consumption in million metric tons, so we can see that the nitrogen was used in 2013, so this is 2014 and this is 2018. So from 2013 to 2018 we can see the nitrogen consumption in million metric tons changed from 111.3 million metric tons to 119.5 million metric tons.

So also you can see there has been an increase in phosphorus pentoxide consumption from 41.8 million metric ton to 45.9 million metric ton. Similarly, for potash also we can see from 29.7 million metric tons to 34 million metric tons increase in from 2013 to 2018. And if you see the total increase global consumption of fertilizer you can see 182.8 million metric tons to 199.4 million metric tons. So there has been a continuous increase in all the fertilizers globally as well as in India.

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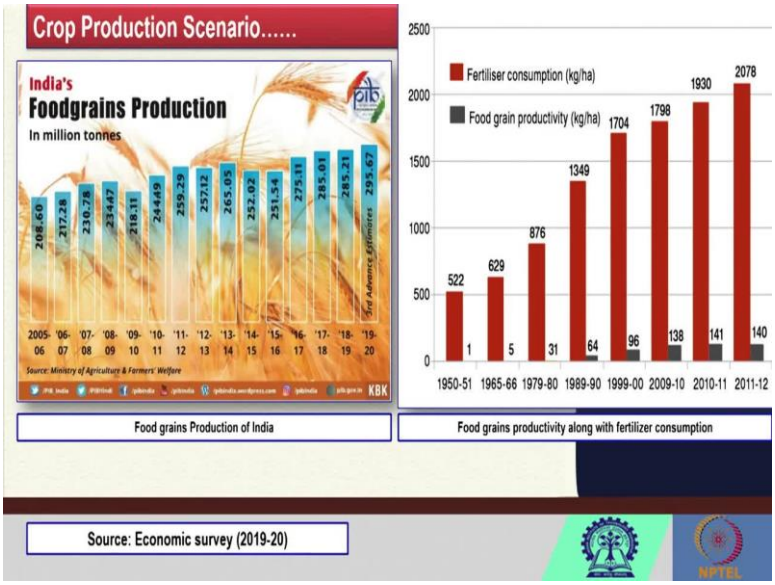

Now, if we see the simultaneously the crop production scenario in million tons. So the crop production, the Foodgrain production in India in 2005-06 was around 208.6 million tons whereas, in 1920 according to the third advance measurement it gives 295.67 million tons. So if we see the fertilizer consumption trade and food grain productivity, if we plot them side by side one thing is clear that there has been a disproportionate increase in fertilizer consumption and there has not been any drastic change in the productivity, foodgrain productivity with the fertilizer consumption, increase in fertilizer consumption.

So that shows that increase in fertilizer consumption somehow is not affecting the increase in foodgrain productivity. So that means it can have a negative impact on foodgrain productivity.

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Now, what is the problem due to excessive use of chemical fertilizer? Now, intensive fertilizer application causes serious environmental problems like eutrophication of water, loss of biodiversity, global warming and stratospheric ozone depletion, soil and plant health problems. So these are the problems which are related to excessive use of chemical fertilizer and fertilizer also contains heavy metals which enter into the food chain via soil. So thus, fertilization leads to water, soil and air pollution.

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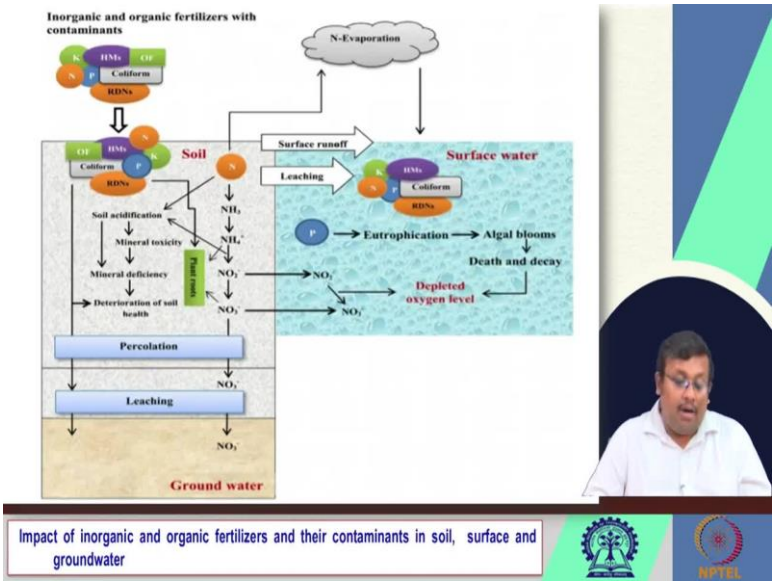

Now, this shows the impact of inorganic and organic fertilizers and their contaminants in soil surface and groundwater you can see that different contaminants can not only infiltrate into soil but also they can go to the water body and then they can they can create the

environmental pollution. So these pollution can occur from different fertilizer elements like NPK it can occur to, these pollutions can also occur from heavy metals, coliforms and so on.

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Now, if you see the fertilizer consumption in India, on average India consumed about 500 lakh metric ton of fertilizer per year in the last 10 years. Now as per the data shared by the government in Rajya Sabha, urea is the most consumed fertilizer with around 300 lakh metric ton being consumed each year according, accounting for 55 to 60 percent of the chemical fertilizer consumption in the country.

So urea accounts for the majority of the fertilizers consumed in India. Between 2016 to 17 and 2019 to 20, there has been a steady increase in the consumption of urea, DAP and NPK's as we have seen and the data for 2020-21 is provisional is and is available up to February 2021.

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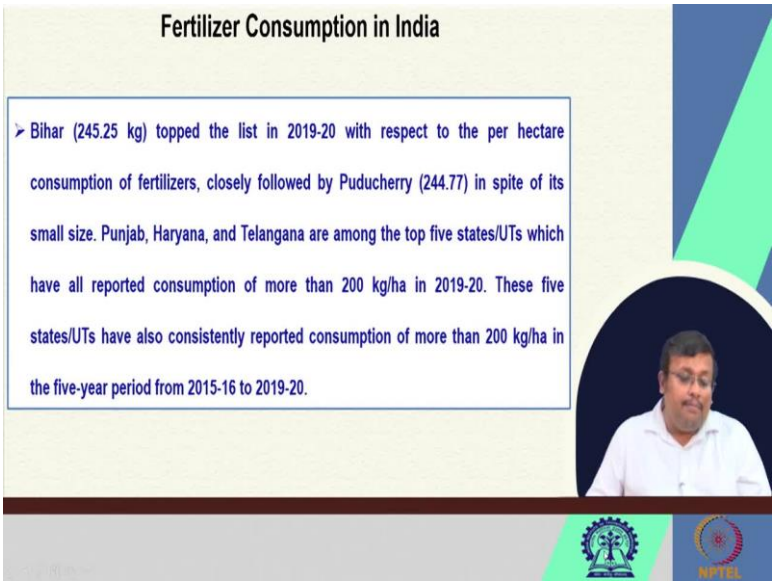

Now Bihar, which is a state of India topped the list in 2019-20 with respect to the per hectare consumption of fertilizer, closely followed by Puducherry in spite of its small size, and also Punjab, Haryana and Telangana are among the top five states or union territories, which have all reported consumption of more than 200 kg per hectare in 2019-20. So these five states or union territories have also consistently reported consumption of more than 200 kg per hectare in the five year period from 2015-16 to 2019-20.

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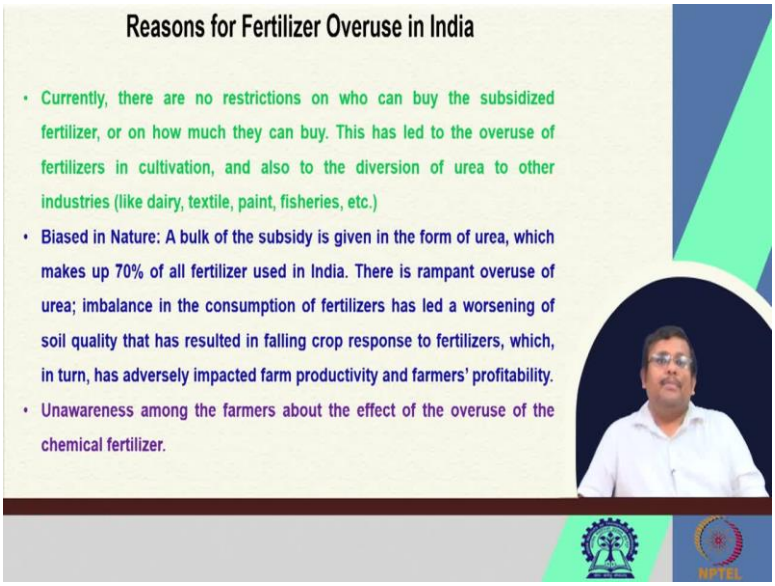

Now let us see what are the reasons for fertilizer overuse in India, there are couple of reasons. First of all, there are no restrictions currently on who can buy the subsidized fertilizer or on how much they can buy. So there is no restriction. So this has led to the overuse of fertilizers

in cultivation and also to the diversion of urea to other industries. So the people buy these subsidies urea and they use it in other industries like dairy, textile, paint, fisheries, etc.

Secondly, a bulk of the subsidy is given in the form of urea, which makes up 70 percent of the fertilizers used in India. So there is a rampant overuse of urea and which creates the imbalance in the consumption of fertilizer and ultimately this imbalance in the consumption of fertilizer has led a worse had led a worsening of soil quality that has resulted in falling crop response to fertilizer which in turn has adversely impacted farm productivity and farmers profitability, we have discussed what is the bad impact of imbalance fertilizations.

So basically, due to the overuse of urea, there is an imbalance fertilizations and ultimately, that creates the negative impact on the farm productivity as well as the profitability. Thirdly, the unawareness among the farmers about the effect of overuse of the chemical fertilizer is another reason for fertilizer overuse.

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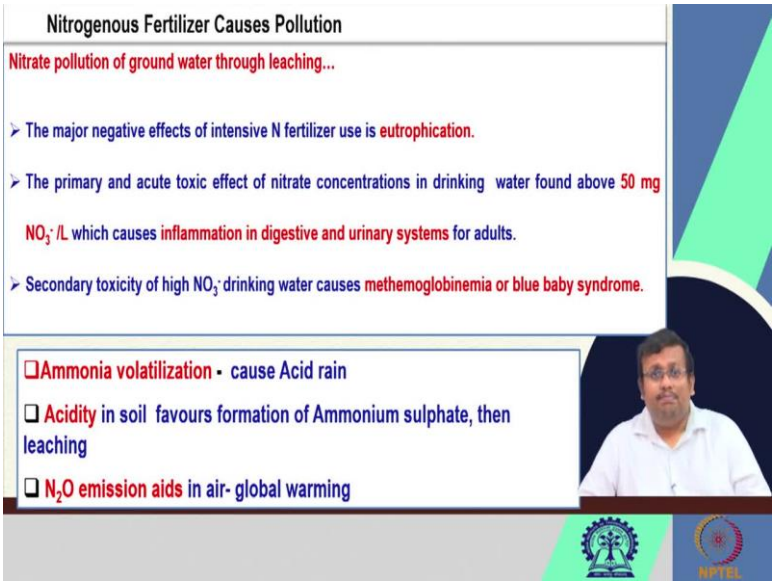

Now, we know that nitrogenous fertilizer causes pollution because nitrate pollution of groundwater occurs through leaching and the major negative effects of intensive nitrogen fertilizer uses eutrophication. And the primary and the acute toxic effect of nitrate concentrations in drinking water found to above 50 milligram nitrate per liter, which causes inflammation in digestive and urinary system for adults.

And secondary toxicity of high nitrate drinking water causes methamoglobinemia or blue baby syndrome. So ammonia volatilization also creates acid rain and acidity in soil favours

formation of ammonium sulphate then leaching and then nitrous emission aids in global air global warming.

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So we can see here blue baby syndrome then eutrophication and also the nitrous oxide emission from different anthropogenic activities in the industrial areas as well as from the fertilizer overuse. So these nitrogenous fertilizer is another reason for your nitrous oxide emission.

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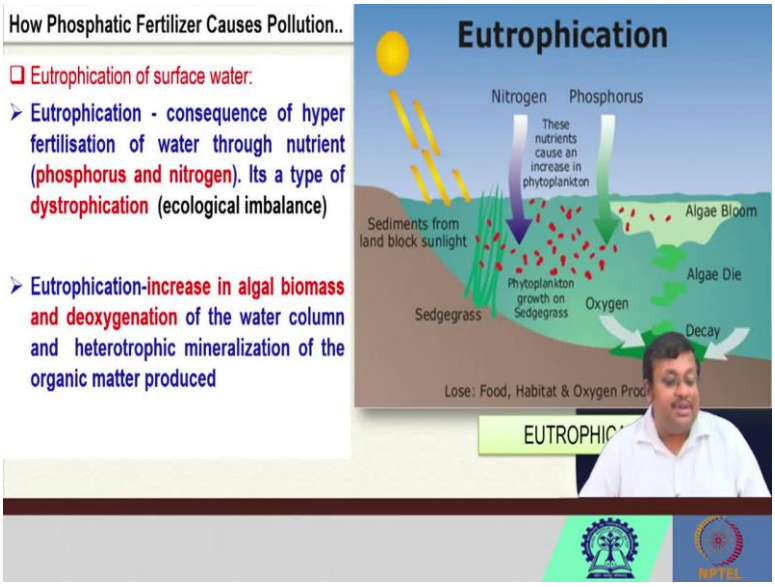

Now, another important thing is eutrophication, what is eutrophication? Eutrophication is the consequence of hyper fertilizations of water through nutrient which are basically nitrogen and

phosphorus and it is a type of dystrophication or ecological imbalance. So what happens when there is huge amount of nitrogen and phosphorus goes to the water that will create the algal bloom.

So these algal bloom when this algae will die, they will their body will be decayed using the dissolved oxygen and this dissolved oxygen will be depleted, thereby negatively impacting the health of the all the water organisms. So water borne organisms, so ultimately they will die.

So the fish and other animals or organisms which are there in the water will die eventually. So this is called eutrophication. So these eutrophication creates increase in algal biomass and deoxygenation of the water column and heterotrophic mineralization of the organic matter produced.

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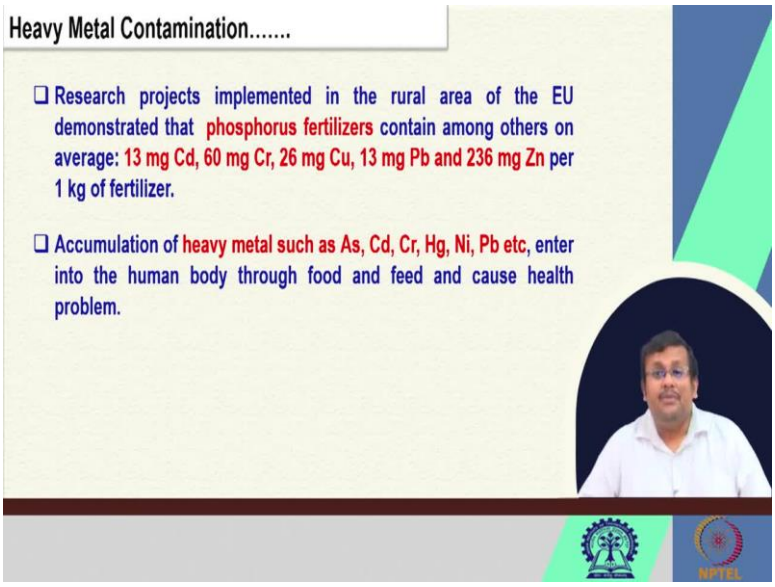

Another one problem is heavy metal contamination. So research projects implemented in the rural area of European Union demonstrated that phosphorus fertilizer contain on average, 13 milligram of cadmium, 60 milligram of chromium, and then 26 milligram of copper, 30 milligram of lead and 236 milligrams zinc per one kg of fertilizer. And this accumulation of heavy metals such as arsenic, cadmium, chromium, mercury, nickel, lead, enter into the human body through food and feed and cause a health problem.

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So we can see some examples are given due to the arsenic pollution Black Foot disease you can see. In case of cadmium pollution, Itai Itai disease is there. In case of lead pollution, we can see Dislexia in among children and then using an in case of a mercury pollution we can see the Minamata disease can occur.

So these are different types of human health hazards which occurred due to these heavy metal pollution but these heavy metals also can come through fertilizer overuse. So synthetic fertilizer, chemical fertilizer overuse can also create these different heavy metal pollution.

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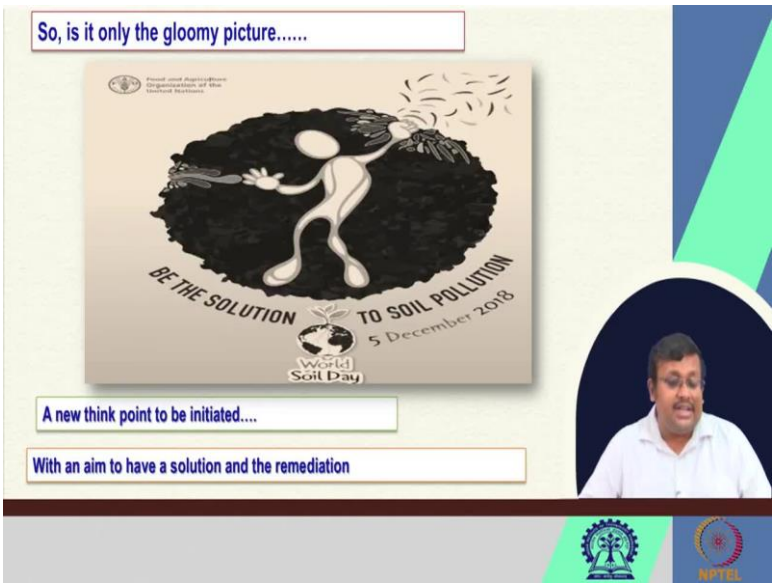

So it is only the gloomy picture. So we need to think about in solution and remediation for these negative impacts from synthetic fertilizer application.

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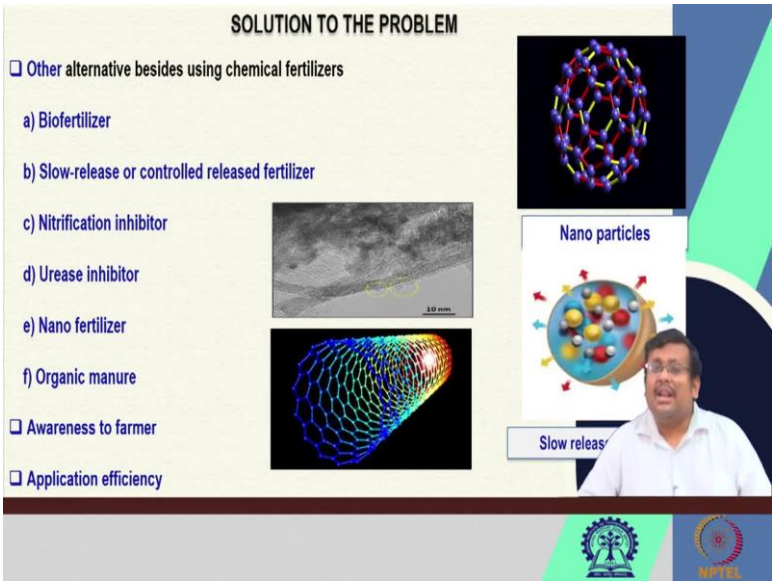

So what are the solution? There are several solutions and those solution we have already discussed in details in our previous lectures. So biofertilizer instead of only using the chemical fertilizer, we can use a conjoint use of other chemicals along with the chemical fertilizer or organic matter.

So we can add biofertilizer, we can add slow release or controlled release fertilizer, we can use nitrification inhibitor, we can use urease inhibitor, we can use nano fertilizer, we can use organic manure and also we need to increase the awareness among the farmer and also we need to increase the application efficiency of the fertilizers.

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So biofertilizer we have already discussed. So we know that biofertilizer differ from chemical and organic fertilizer in the sense that they do not directly supply any nutrients to crops and they are basically cultures of special bacteria and fungi. So these bio fertilizers are environmental friendly ecofriendly and they can be very efficient as far as the plant nutrition is concerned. So we can apply this biofertilizer to enhance the nutrient mobility as well as the nutrition I mean the nutrition status of the soil, thereby increasing or augmenting the plant health.

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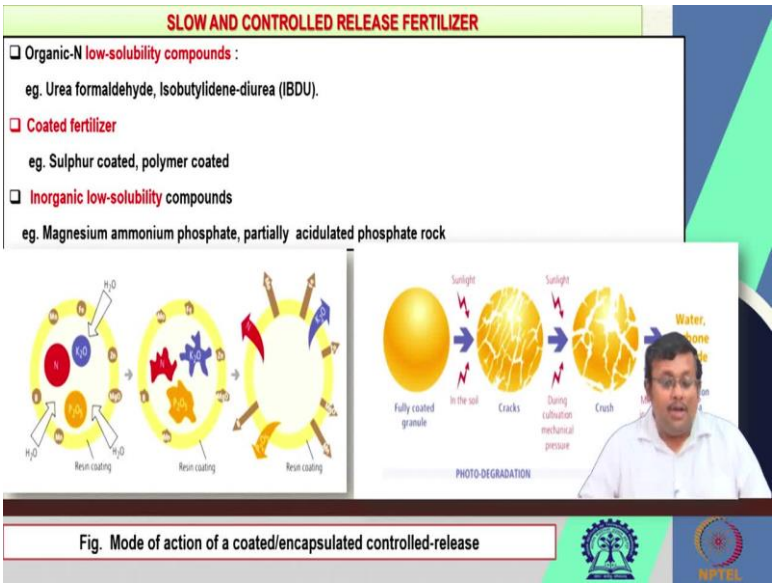

Also we can apply the slow and controlled release fertilizer, we have discussed these in details, so I am not going to discuss them again. However, let me just go through very

quickly. So organic nitrogen, organic nitrogen is low or low solubility compounds we can see urea formaldehyde and then IBDU or isobutylene diurea we can use.

We can use coated fertilizer like sulphur coated fertilizer, polymer coated fertilizer, we can use different types of inorganic low solubility compounds like magnesium, ammonium, phosphate or partially acidulated phosphate rock. So these can be used for work as a nutrient source, so that they can manage the nutrient release and thereby reduce the negative impact of rampant synthetic chemical fertilizer and use.

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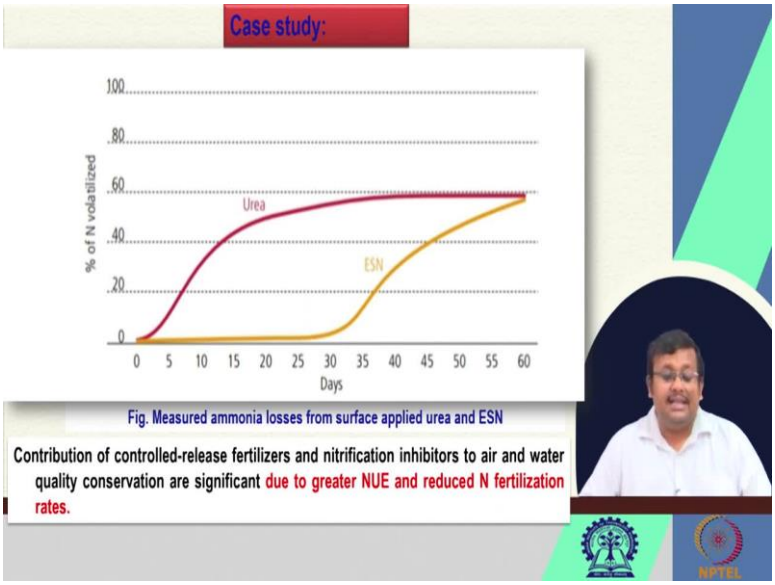

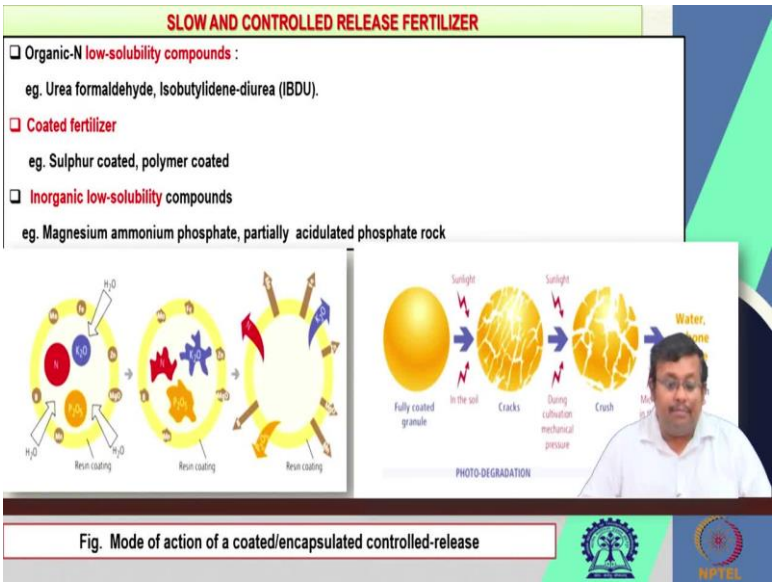

Also we can see this graph shows the ammonia losses from a surface applied urea and ESN. So you can see that this is also a controlled release fertilizer. So these contribution of these controlled release fertilizer and nitrification inhibitors. So you can see when we add using

urea there has been an increase in nitrogen volatilization, however, with the application of ESN that can reduce the nitrogen volatilization.

So contribution of controlled release fertilizer and nitrification inhibitors to air and water quality conservation are significant due to greater nutrient use efficiency and reduce nitrogen fertilizations rates.

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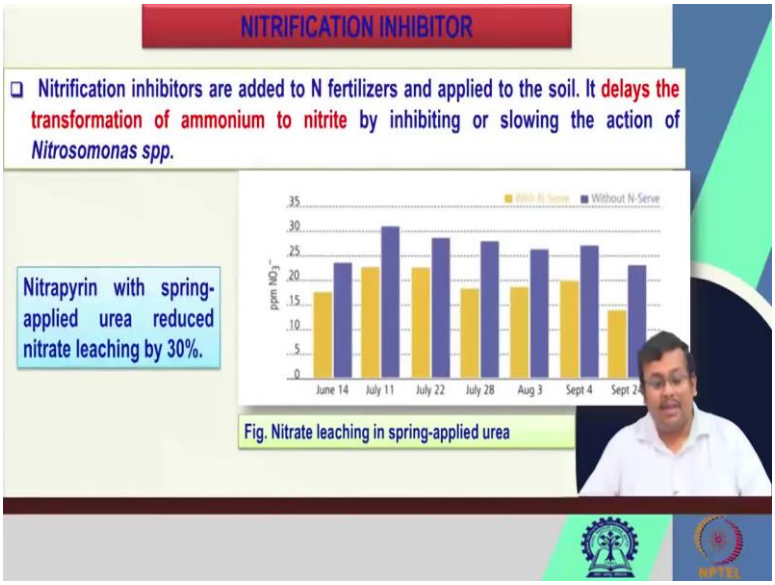

So also we can see use of nitrification inhibitors. So nitrification inhibitors are added to nitrogenous fertilizers and applied to the soil and it delays the transformation of ammonium to nitrite by inhibiting or slowing the action of Nitrosomonas. So you can see nitrapyrin with spring applied urea reduced nitrate leaching by 30 percent we can see from here. So when we are applying the nitrapyrin with urea that can reduce the nitrate leaching.

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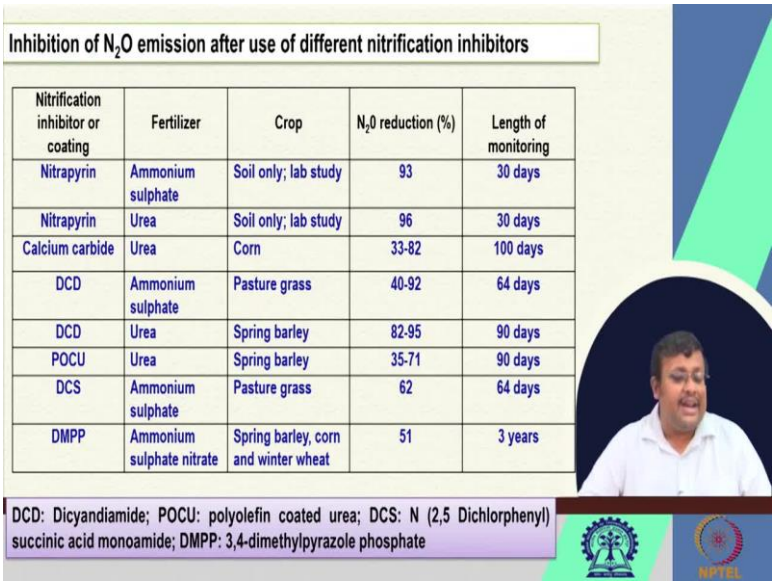

Nitrification inhibitor or coating	Fertilizer	Crop	N_2O reduction (%)	Length of monitoring
Nitrapyrin	Ammonium sulphate	Soil only; lab study	93	30 days
Nitrapyrin	Urea	Soil only; lab study	96	30 days
Calcium carbide	Urea	Corn	33-82	100 days
DCD	Ammonium sulphate	Pasture grass	40-92	64 days
DCD	Urea	Spring barley	82-95	90 days
POCU	Urea	Spring barley	35-71	90 days
DCS	Ammonium sulphate	Pasture grass	62	64 days
DMPP	Ammonium sulphate nitrate	Spring barley, corn and winter wheat	51	3 years

And also there has been an inhibition of nitrous emission after the use of different nitrification inhibitors you can see when nitrapyrin is applied with ammonium sulphate in that can reduce the nitrous oxide emission by 93 percent for 30 days incubation periods. So we can see for different combination, how these nitrification inhibitor can help in reduce nitrous oxide emission.

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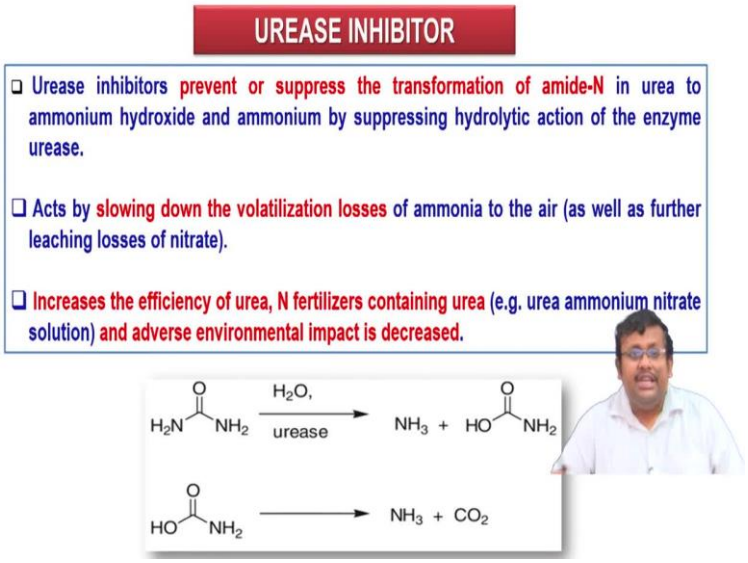

Urease inhibitor, we know that urease inhibitors prevents or suppress the transformation of amide-nitrogen in urea to ammonium hydroxide and ammonium by suppressing the hydrolytic action of the enzyme urease. And then it acts by slowing down the volatilization losses of ammonia to the air as well as further leaching losses of nitrate.

And it also increases the efficiency of urea nitrogen fertilizers containing urea, like urea ammonium nitrate and adverse environmental impact is decreased. So you can see these urease inhibitor has played an important role in reducing the loss of nitrogen through volatilization process.

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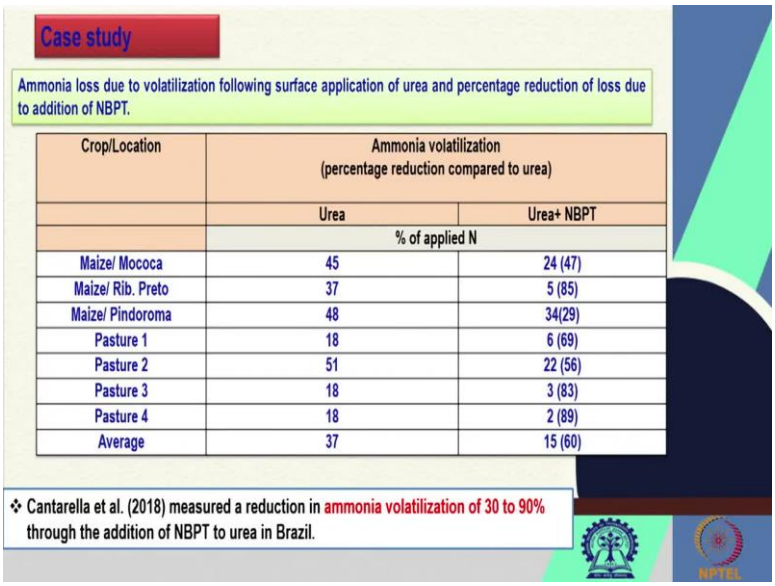

We can see the case study, one case study where ammonia loss due to volatilization following surface application of urea and percentage reduction of loss due to the addition of NBPT which is a urease inhibitor. So you can see that for different crops, when we are applying the urea, so this is an ammonia volatilization. So ammonia volatilization has drastically reduced when applied through an urease inhibitor.

So Cantarella et al. in 2018 measure the reduction in ammonia volatilization of 30 to 90 percent through the addition of these NBPT to urea in Brazil. So that shows the importance of this type of conjoint use of chemical and chemical fertilizer to increase the efficiency of different nutrients specifically nitrogen.

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Nanofertilizer are also very important. So nanofertilizer are synthesised or modified form of traditional fertilizer, fertilizer bulk material or extracted from different vegetative or reproductive parts of the plant, by different chemical physical, mechanical or biological methods with the help of nanotechnology used to and also they used to improve the soil fertility, productivity and quality of agricultural produce.

So nano-TiO2 or nano-titanium oxide treated seed product plant recorded more dry weight and higher photosynthetic rate and chlorophyll a formation compared to the control. You can see here nano chelated iron which contains 7 percent nitrogen and also you can still see nano chelated NPK with a grade of 2020. So there are different types of nano fertilizer available which can show higher nutrient use efficiency.

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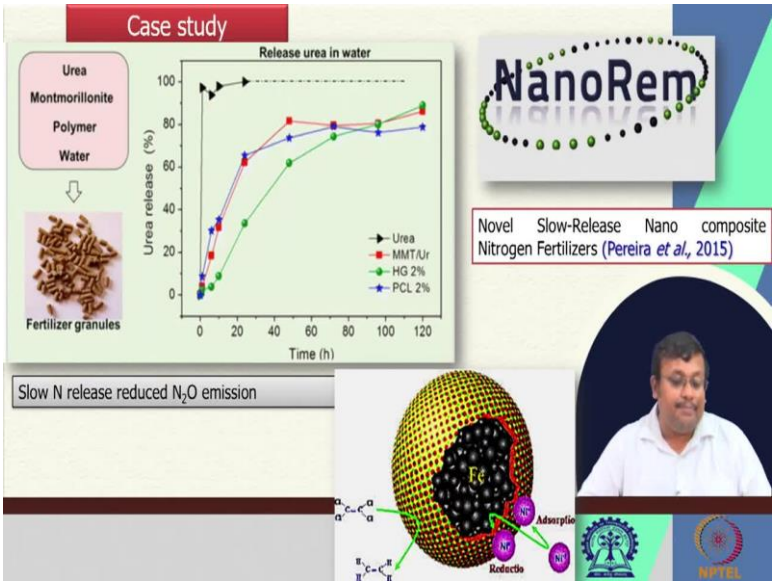

You can see here when urea is mixed with montmorillonite and polymer and water we can create different-different fertilizer granules and these granules were used and they showed a tremendous decrease in nitrogen release through nitrous oxide emission. So that shows the importance of different management adjustment which are required for reducing the loss of nutrients and also increasing the fertilizer, your nutrient use efficiency.

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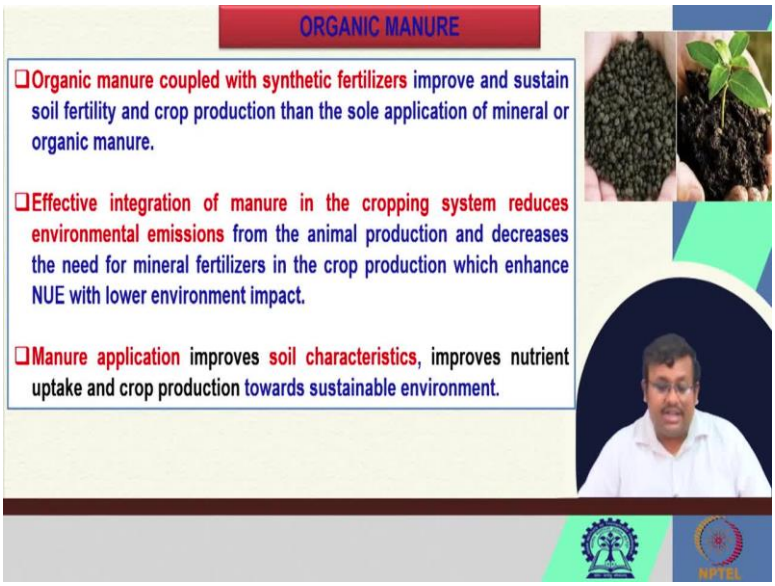

Organic manure we know we have discussed in details. Organic manure coupled with synthetic fertilizer can help in integrated nutrient management and it can improve and sustain the soil fertility and crop production. Then the sole application of mineral or organic fertilizer, organic mineral fertilizer or organic manure and in manure application also

improves the soil characteristics, improve nutrient uptake and crop production towards sustainable environment.

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We know the different types of sources of organic manure and when we apply these organic manure that can impact the soil fertility positively.

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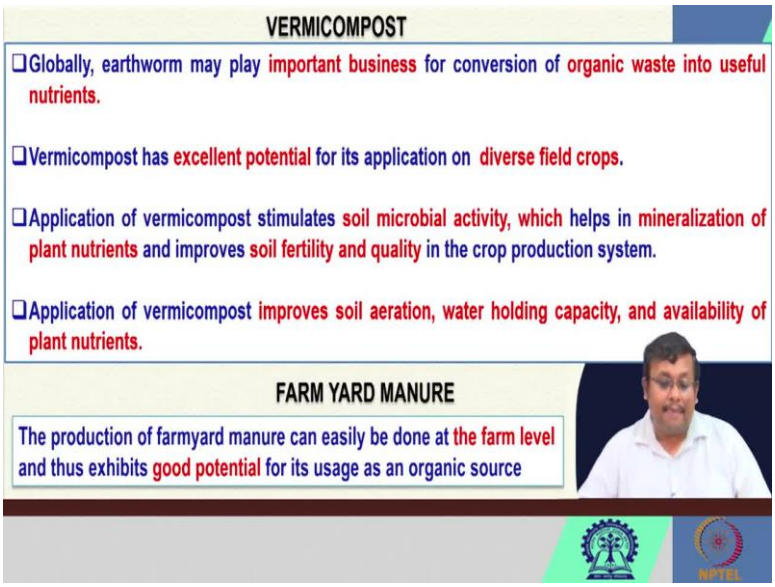

Vermicompost we know that globally earthworm may play an important business for the conversion of organic waste into useful nutrients. So vermicompost has excellent potential for its application on diverse field crops. And application of vermicompost stimulates soil

microbial activity. So these are the composted materials when you apply them in the soil they acts as a carbon rich substrate for the microorganisms.

So the microbial activity increases which helps in the mineralization of the plant nutrients and improve the soil fertility and quality in the crop production system. Remember that application of vermicompost improved soil aeration, water holding capacity and availability of the nutrients. And farmyard manure, so the production of farmyard manure can easily be done at the farm level we have discussed that already and thus exhibit good potential for its usage as an organic source.

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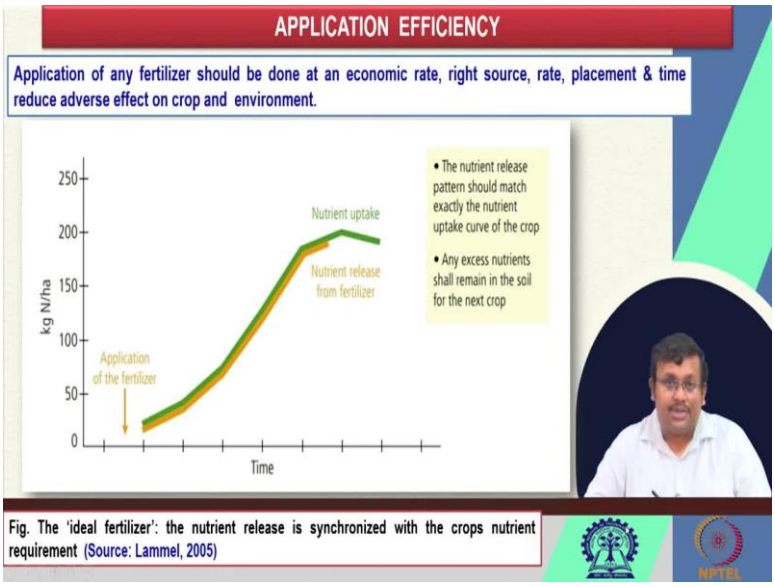

Application efficiency we know that we have already discussed this slide previously in our lectures. So application of any fertilizer should be done at an economic rate in using that 4-R concept which we have already discussed. And this is an ideal fight for we know that the this is basically the nutrient in case of ideal fertilizer, the nutrient release should be synchronized with the crops nutrient requirement.

So we can see with the passage of time we are applying the fertilizer at the beginning, but the yield should have the nutrient uptake and nutrient release from fertilizer should go side by side. So the nutrient release pattern should match exactly the nutrient uptake curve of the crop, any excess nutrient shall remain in the soil for the next crop. So this should be an ideal condition.

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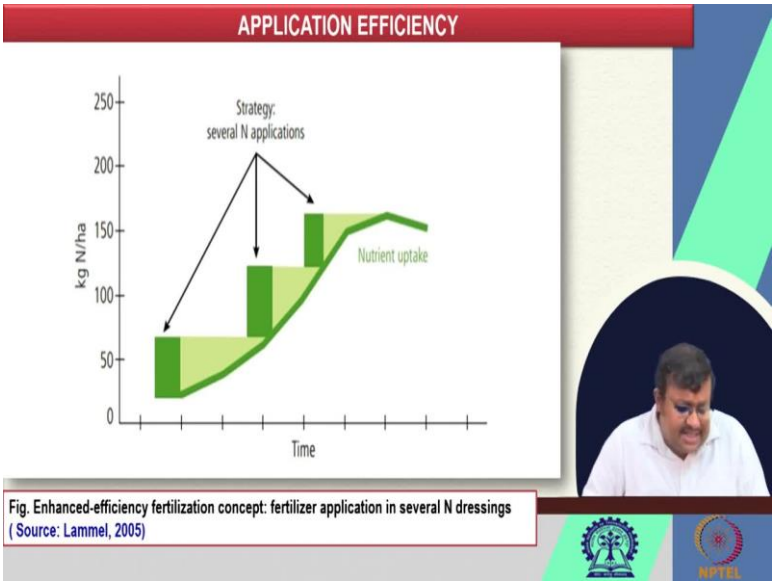

So our strategy can be several split nitrogen application we have also discussed that. So split nitrogen application can be a strategy to manage that to satisfy the nutrient uptake at different stages of the growth. So these different practices of application, of manure, application of nitrification inhibitor, application of urease inhibitor, and then split application of fertilizer can help in reducing the negative impact of all these excess fertilizer use and that can maintain or sustain the ecological functions and also they can reduce the environmental pollutions. So these are very important.

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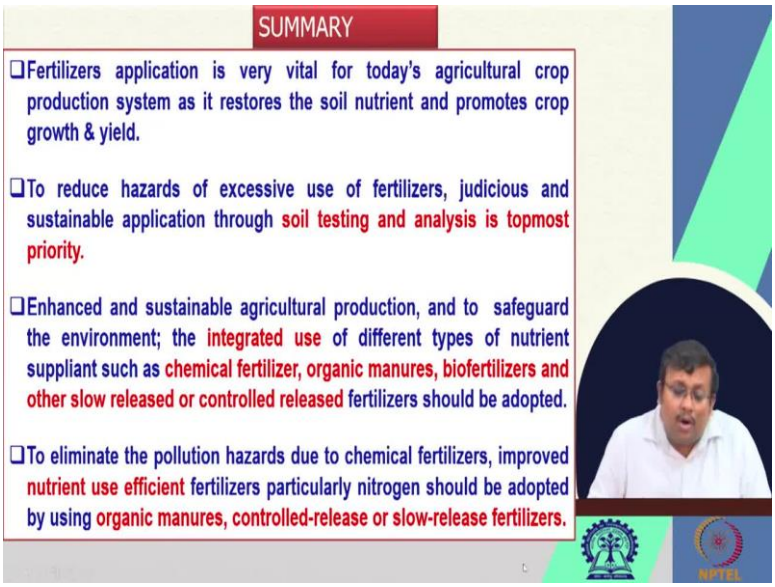

And summary we can see that fertilizer application is very vital for today's agricultural crop production system as it restores the soil nutrient and promotes crop growth and yield. And to

reduce the hazard of excessive use of fertilizer judicious and sustainable application through soil testing and analysis is topmost priority.

And also to eliminate the pollution, hazards and to enhance (())(25:48) and sustain the agriculture production and to safeguard the environment. We need these integrated use of different types of nutrients, supplements such as chemical fertilizer, organic manures, biofertilizer and slow released controlled release fertilizers.

So these points basically summarizes whatever we have discussed in this lecture and just remember that these strategies are very much important for countries like India to improve not only the productivity, farm productivity, but also to improve the profitability of the farmers.

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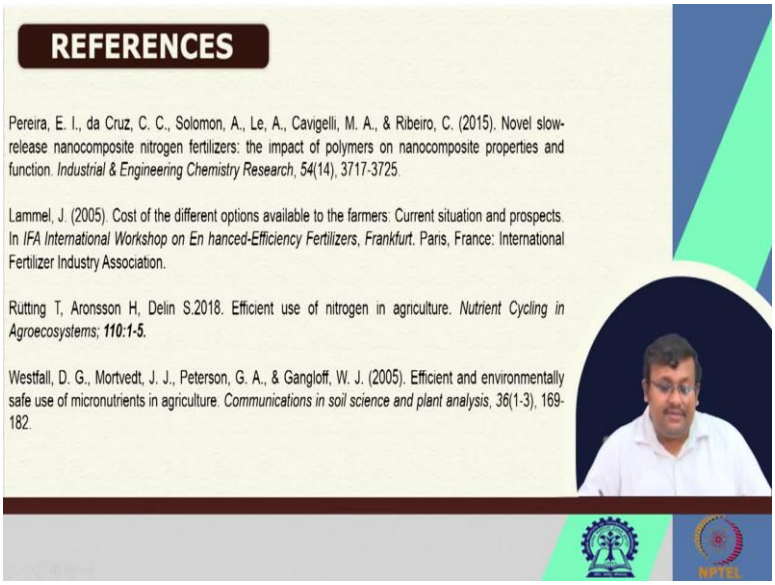

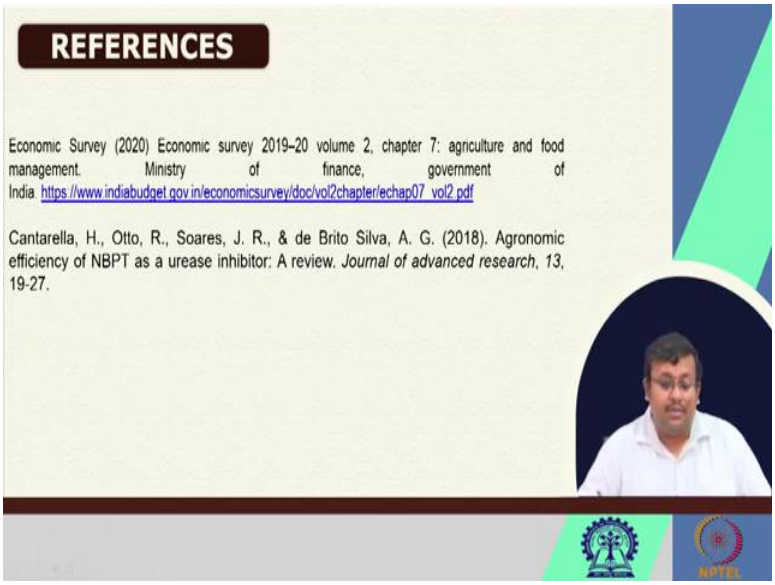

So guys, these are the references which I have used for this lecture. So please go through these differences if you want to have more comprehensive knowledge. And thank you let us meet in our next lecture to discuss other environmental issues which are related to agricultural production and fertilizer use. Thank you.