Soil Fertility and Fertilizers
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Week 3
Lecture 13
Soil P and K Plant Nutrition (Contd)

Welcome friends to this third week of NPTEL online certification course of soil fertility and fertilizers. And in this week 3 we are discussing soil phosphorus and potassium for plant nutrition. We are going to start our lecture 13. In the previous two lectures of this week, we have discussed about the basics of phosphorus nutrition for the plant. And also, we have discussed about the phosphorus cycle, and what are the important process, or factors of phosphorus availability to the plants.

And also, we have discussed about how pH and organic matter affects phosphorus availability, and we have also discussed what are the major forms of soil phosphorus, both organic forms as well as inorganic forms. We have also discussed different inorganic forms of soil phosphorus, and how phosphorus get lost from the soil through different processes we have discussed.

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So, in this lecture we are going to cover these following concepts. First of all, we are going to talk about the phosphorus fertilizers. And then we are going to talk about phosphorus manufacturing process and we are going to discuss our classification of phosphorus fertilizers.

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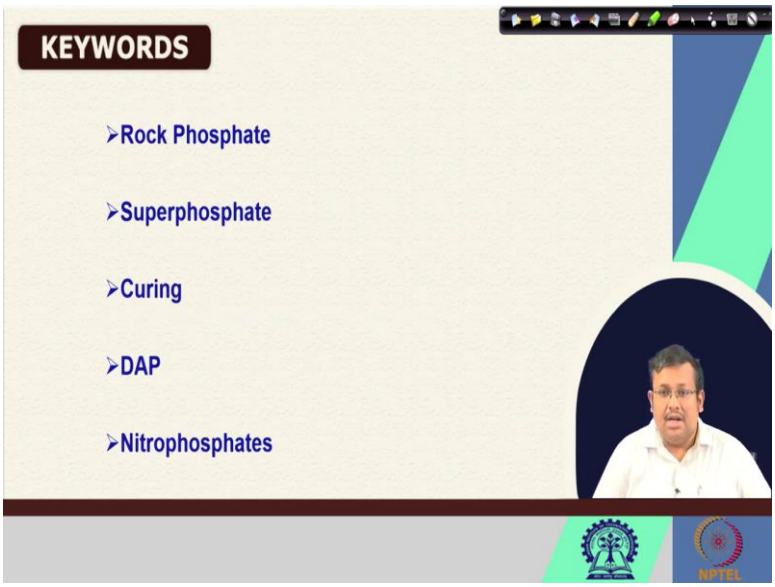

So, these are the key words of this lecture, rock phosphate, superphosphate, curing, DAP or diammonium phosphate and nitrophosphates. So, we are going to discuss all these in this lecture.

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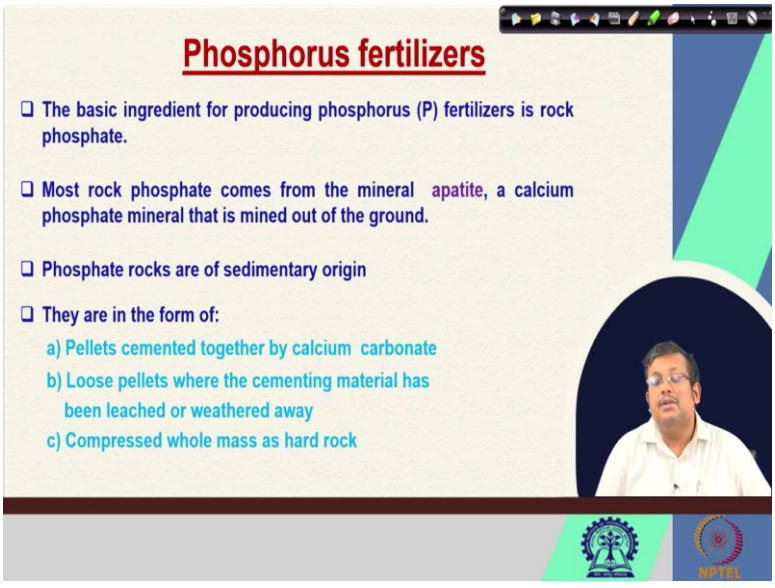

So, let us discuss about phosphorus fertilizers, or P fertilizers. So, the basic ingredient for producing phosphorus fertilizer is rock phosphate. So, we have already know what is rock phosphate. Now, most rock phosphate comes from the mineral apatite. So, we have discussed about apatite in our previous lectures, which is a calcium phosphate mineral that is mined out of the ground.

Now, phosphate rocks are of sedimentary origin, and they are in the form of either pellets or cemented together by calcium carbonate, or loose pellets where cementing materials has been leached or withered away, or they are compressed whole mass as hard rock.

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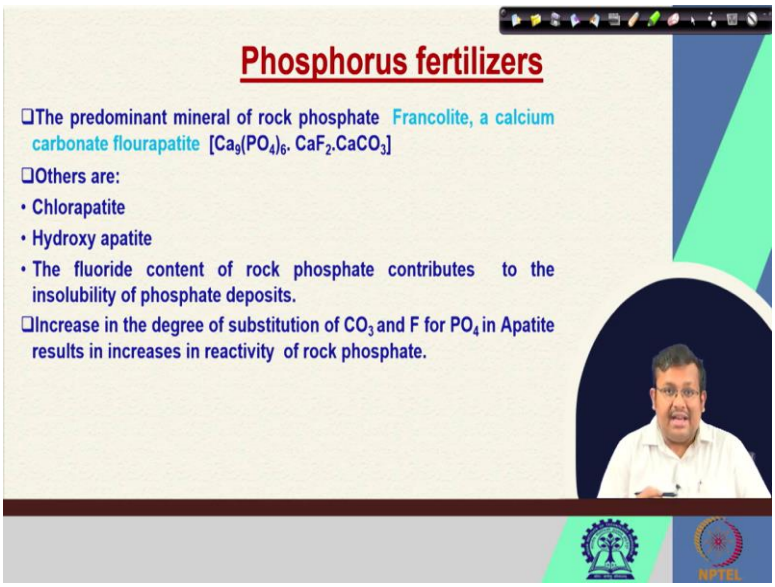

The predominant mineral is rock phosphate, which is Francolite, a calcium carbonate fluorapatite. As you know the name suggests, it has the fluorine, as well as the others are Chlorapatite as well as Hydroxyapatite. Now, the fluoride content of rock phosphate contributes to the insolubility of phosphate deposits, and increase in the degree of substitution of carbonate and fluorine for phosphate in apatite results in increase in reactivity of rock phosphate. So, as much as phosphate in the rock phosphate is being replaced by carbonate and fluorine, then it increases the reactivity of the rock phosphate.

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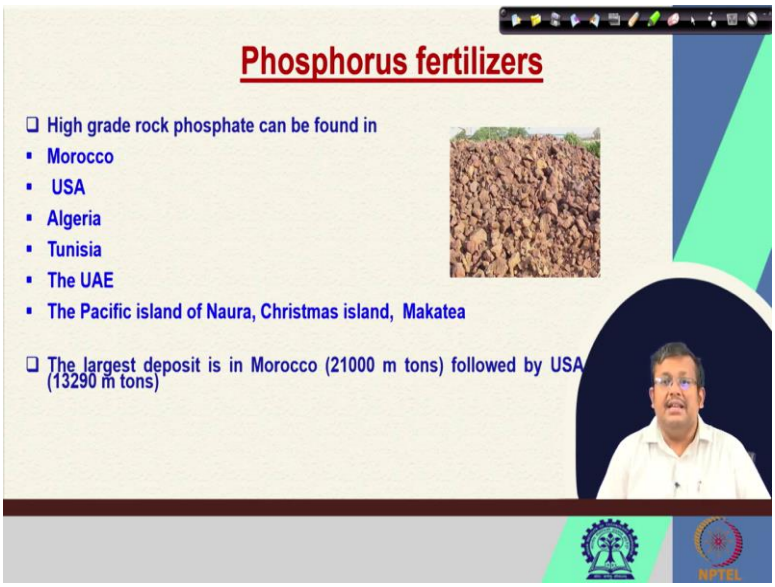

Now, high grade rock phosphate can be found in these countries, Morocco, USA, Algeria, Tunisia, the UAE and the Pacific Islands of Naura, Christmas Island and Makatea. So, the largest deposit of rock phosphate can be found in Morocco, which is around 21,000 million tonnes followed by USA which is 13,290 million tonnes. So, this rock phosphate is the major ingredient of phosphatic fertilizers.

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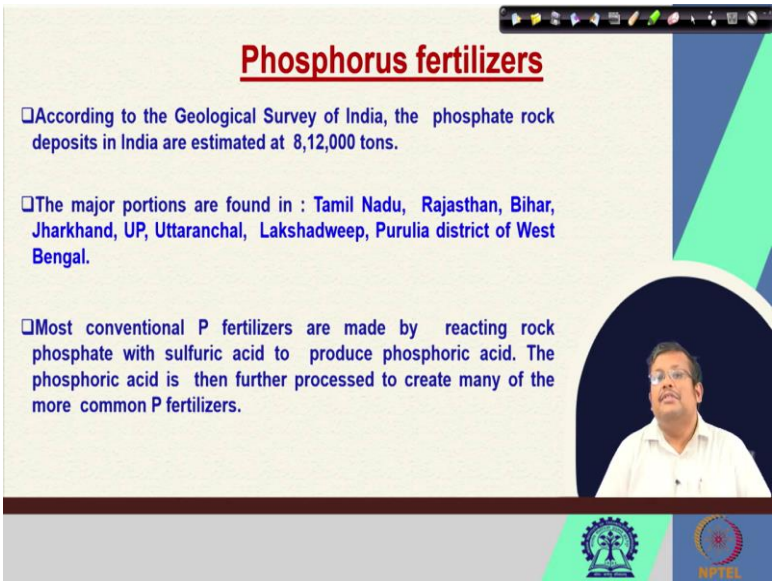

According to the Geological Survey of India, the phosphate rock deposits in India are estimated at 8,12,000 tonnes. And the major portions are found in in the following states: Tamil Nadu, Rajasthan, Bihar, Jharkhand, Uttar Pradesh, Uttaranchal, Lakshadweep, and

Purulia district of West Bengal. Now, most conventional phosphatic fertilizers are made by reacting rock phosphate with sulfuric acid to produce a phosphoric acid.

So, we have to produce first phosphoric acid. Now, how to produce this phosphoric acid? We have to react this rock phosphate with sulfuric acid. Now, the phosphoric acid is then further processed to create many of the more common phosphatic fertilizers.

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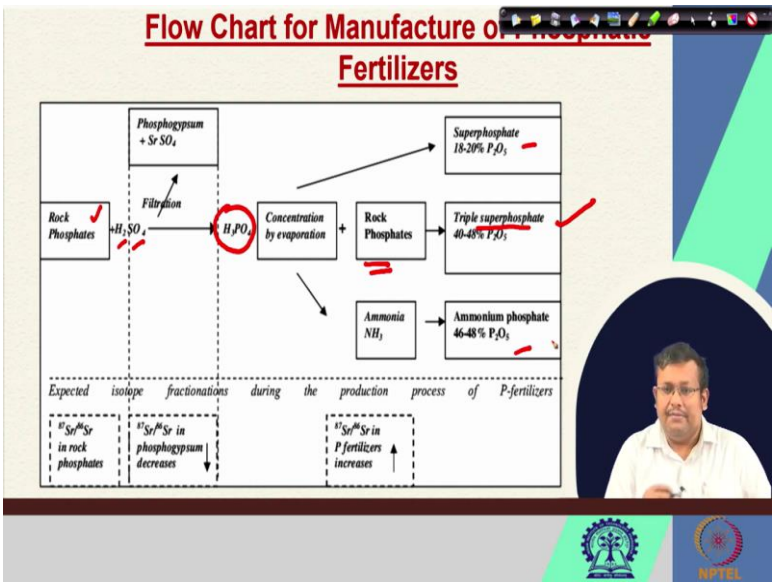

So, this flowchart shows the manufacturing of phosphatic fertilizer, it is quite clear that we start with the rock phosphate, and when it reacts with the sulfuric acid, and then phosphoric acid, it produced the superphosphate with the P2O5 content, remember in the phosphatic fertilizers, the phosphorus content is generally represented by phosphorus pentoxide percentage. So, in the superphosphate the P2O5 content is 18 to 20 percent. And, when this is concentration is done by evaporation, and we mix we further mix with the rock phosphate it will produce triple superphosphate.

Now, the P2O5 content of the triple superphosphate varies from 40 to 48 percent. Now, while rock phosphate is reacted with H2SO4, and H3PO4 when it reacts. So, actually what happens when we react rock phosphate with H2SO4 it produce this H3P04, and when from this H3PO4 we create this superphosphate by concentration by evaporation.

And, further, when we add these rock phosphates with these phosphoric acid it produced this triple superphosphate. And when is ammonia is added to this phosphoric acid it produce these ammonium phosphate, which contains 46 to 48 percent of P205. So, this is how the

manufacturing of phosphatic fertilizers can be achieved. So, this is a very basic overview we are going to discuss them in details.

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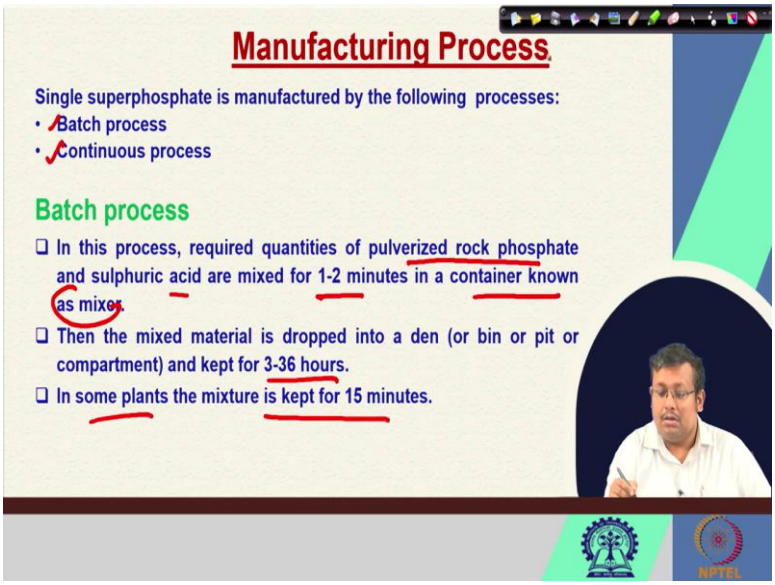

Now, so manufacturing process of phosphatic fertilizer. Let us consider only single superphosphate which is one of the most common phosphatic fertilizer. So, this single superphosphate is manufactured by the following process. There are two process one is batch process; second one is continuous process. So, let us discuss first the batch process, and then we are going to discuss the continuous process. Now, in the batch process, it required quantities of pulverized rock phosphate and sulfuric acid are mixed for 1 to 2 minutes in a container known as a mixer.

So, first of all, we are mixing the pulverized rock phosphate with the sulfuric acid for 1 to 2 minutes in a mixer, then the mix material is dropped in a den, or bin, or pit, or compartment and kept for 3 to 36 hours. This mixture of rock phosphate and sulfuric acid. Now, in some plant the mixture escaped for only 15 minutes. So, this the first step of manufacturing of single superphosphate through batch process.

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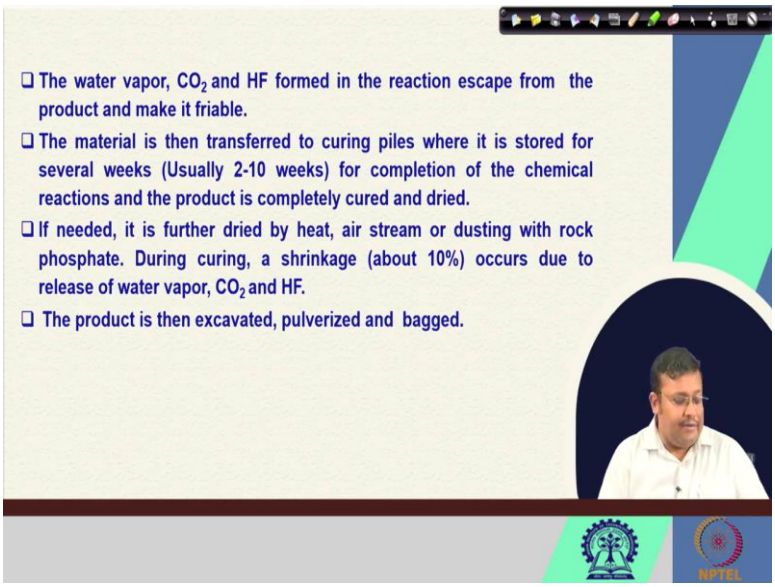

Now the water vapor, when we keep this mixture, the water vapor carbon dioxide and HF, or hydrogen fluoride formed in the reaction escaped from the product and make it friable. So, the whole mixture becomes friable, then the material is transferred to curing piles, where it is stored for several weeks. Generally, it varies from 2 to 10 weeks for completion of the chemical reaction, and the product is completely cured and dried.

Now, if needed, it is further dried by heat, air stream, or dusting with rock phosphate. Now during the curing process, a shrinkage about what is about 10 percent shrinkage occurs due to release of water vapor, carbon dioxide, and hydrogen fluoride. And, the product is then excavated, pulverized, and bagged. So, this is how the single superphosphate is generally produced.

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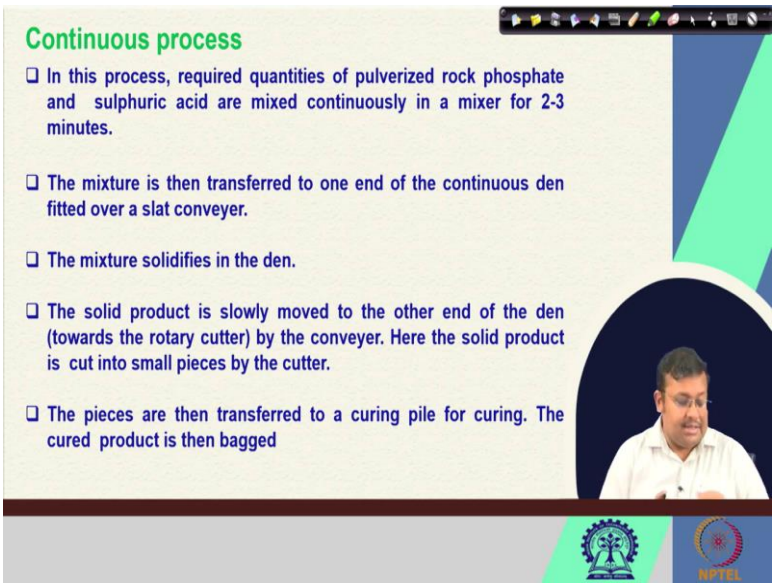

Now, let us discuss, also this is the batch process we have considered. Now we are going to discuss about the continuous process. Now, in this continuous process of single superphosphate production. It requires, required quantities of pulverized rock phosphate to react with sulfuric acid, and it is mixed continuously in a mixture for 2 to 3 minutes. Then this mixture is transferred to one end of the continuous den fitted over a slat conveyor. And, then the mixture solidifies in the den.

The solid product is slowly moved to the other end of the den towards the rotary cutter, by the conveyor, here the solid product is cut into small pieces by the cutter. The pieces are then transferred to a cutting curing pile for curing, and the cured product is then bagged. So, this is the difference between a batch process as well as the continuous process.

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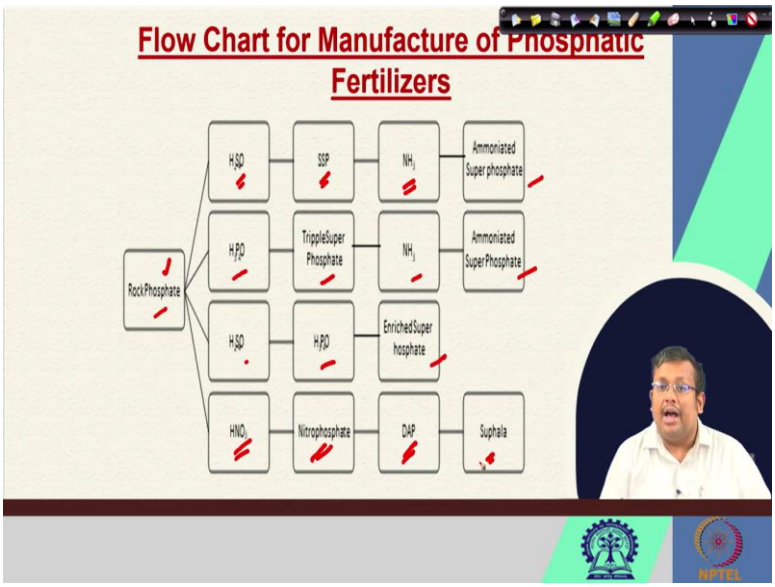

Now, if we see the flowchart for manufacturing of phosphatic fertilizer, it can be more clear how these different phosphatic fertilizers are formed. So, we start with, of course, the rock phosphate which is the basic ingredient of phosphatic fertilizers. So, when we react this rock phosphate with H2SO4, it produced the single superphosphate, when you mix the single superphosphate with ammonia, it produce ammoniated superphosphate. Now again when rock phosphate is reacted with the phosphoric acid, it produced triple superphosphate, and then it when we add ammonia, then it produce ammoniated superphosphate.

Rock phosphate mixed with the H2SO4 produce H3P04, and ultimately it can produce enriched superphosphate. And then, rock phosphate when it mixed with the nitric acid, it produce the nitrophosphate, we are going to discuss this nitrophosphate in our coming slides. And then, it produce the diammonium phosphate and Suphala in the next step.

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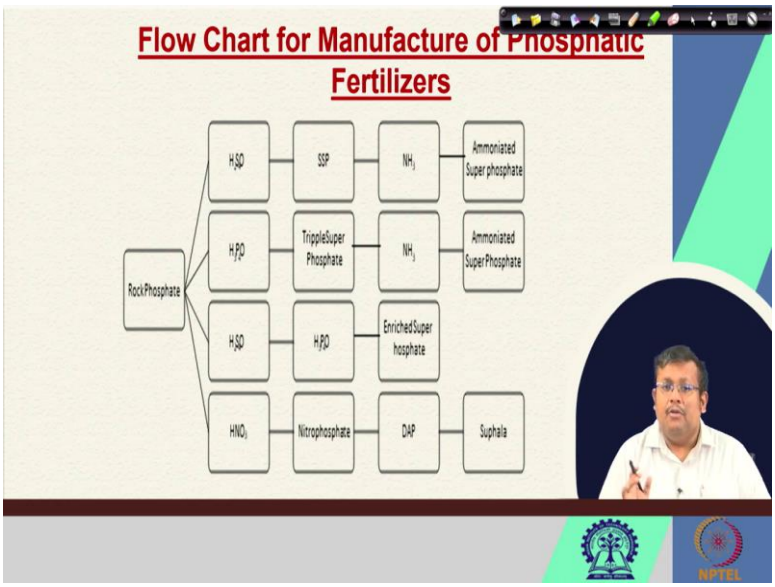

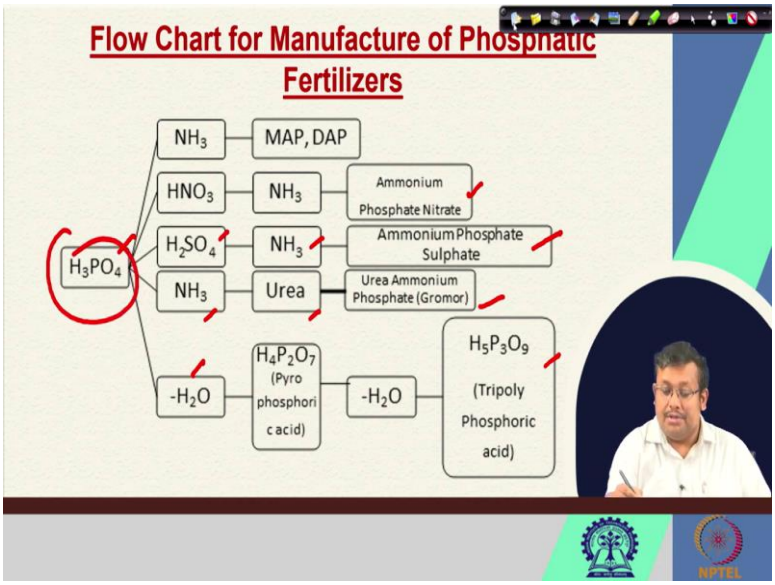

So, let us go ahead and see how these, what are the other phosphatic fertilizer which can be produced. So, H3PO4 when it reacts with ammonium, we know it produce, it will produce monoammonium phosphate, and then subsequently 2 diammonium phosphate. In the previous slide we have already discussed that when H3PO4 reacts with ammonia, it produce the so, here when rock phosphate and H2SO4 mix it produced the H3PO4, and H3PO4 a when it mix with the ammonia, it produces the ammoniated superphosphate.

So, this ammoniated superphosphate can be either monoammonium phosphate, or diammonium phosphate. So, this is how these monoammonium phosphate and diammonium phosphate. Diammonium phosphate is one of the major phosphatic fertilizers. Also, when

H3PO4 reacts with HNO3, and ammonia, it produce ammonium phosphate nitrate which is another fertilizer.

When a H3PO4 reacts with H2SO4 and ammonia, it reacts ammonium phosphate sulphate. When H3PO4 reacts with the ammonia it produce a urea, and then and also mix with the urea it produce urea ammonium phosphate, also known as Gromor which is one of the most common fertilizer in India.

And, when there is a removal of water molecule from H3PO4, it produce pyro phosphoric acid and further removal of H2O from the pyro phosphoric acid can produce tripoly phosphoric acid. So, this is how from the H3PO4 different types of phosphoric fertilizers can be produced.

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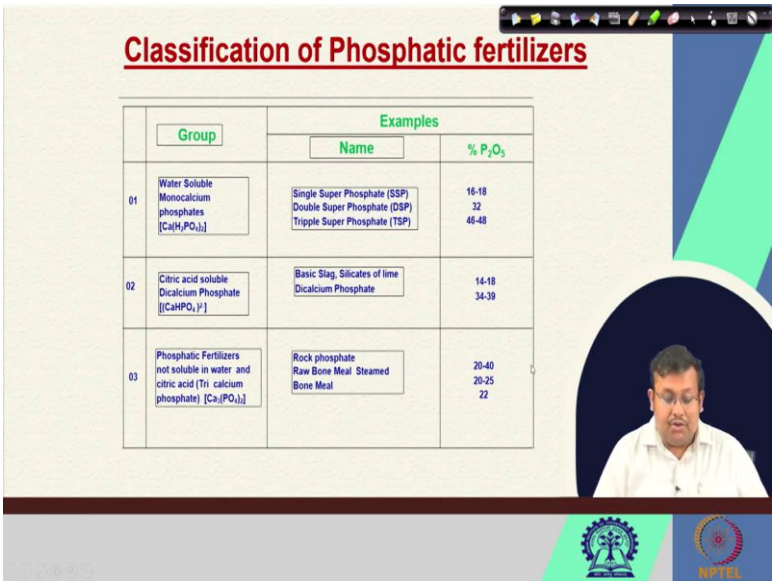

Now, let us see the classification of phosphatic fertilizers. So, generally the phosphatic fertilizers are grouped into three major categories, one is water soluble, another is cyclic acid soluble, and the third one is phosphate fertilizer not soluble in water and citric acid or insoluble. So, generally the monocalcium phosphate comes under the water-soluble phosphate dicalcium phosphate comes under the citric acid soluble phosphate, and tricalcium phosphate comes under the insoluble phosphatic compound. Now, some examples of water-soluble phosphates are single superphosphate, double superphosphate, and triple superphosphate.

In case of single superphosphate, we know the phosphate, P2O5 content varies from 16 to 18 percent. In case of double superphosphate, it varies it is around 32 percent. And in case of

triple superphosphate, it varies from 46 to 48 percent. In case of citric acid soluble phosphate, generally it comes it encompasses basic slag, then silicates of lime, and dicalcium phosphate, where the first P2O5 content varies from 14 to 18, and 34 to 39 percent. In case of insoluble phosphate, rock phosphate is an important, important example of insoluble phosphate which basically consists of tricalcium phosphate. So, rock phosphate contains 20 to 40 percent of phosphate P2O5, raw bone meal steamed content 20 to 25 percent, and bone meal content 22 percent of P2O5 content.

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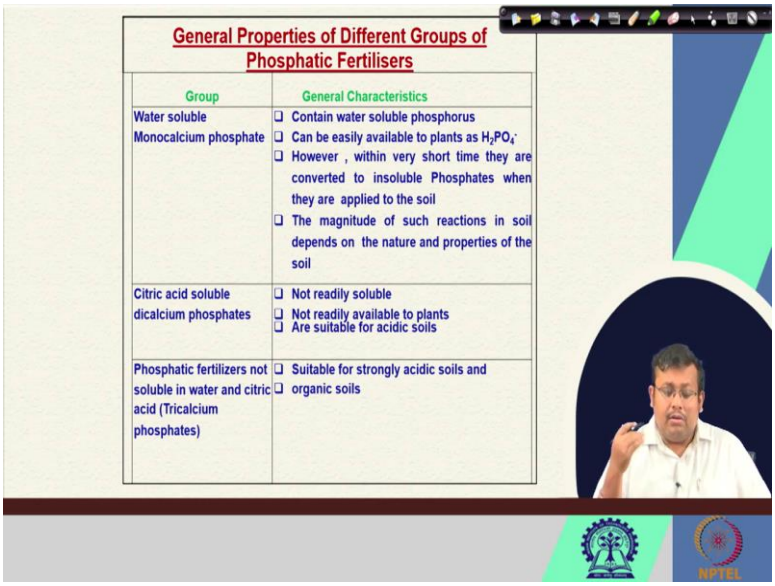

Now, if we consider the general properties of different groups of phosphatic fertilizers, water soluble phosphates are, they basically they, water soluble phosphatic fertilizer contain water soluble phosphorus, it can be they can be easily available to the plants as monocalcium the H2PO4 minus, or primary orthophosphate ion. However, within very short time they are converted into insoluble phosphate when they are applied to the soil, due to different types of fixation. The magnitude of such reaction in soil depends on the nature and properties of the soil.

However, citric acid soluble phosphate which is dicalcium phosphates, are not readily soluble and they are not readily available to the plants, and they are suitable for acidic soils. Because they are not, they are citric acid soluble so, of course, as the name suggests they are suitable for acidic soils. The third category that is insoluble phosphatic fertilizers are suitable for strongly acidic soils, and also the organic soil. So, these are the some of the differences in their general characteristics.

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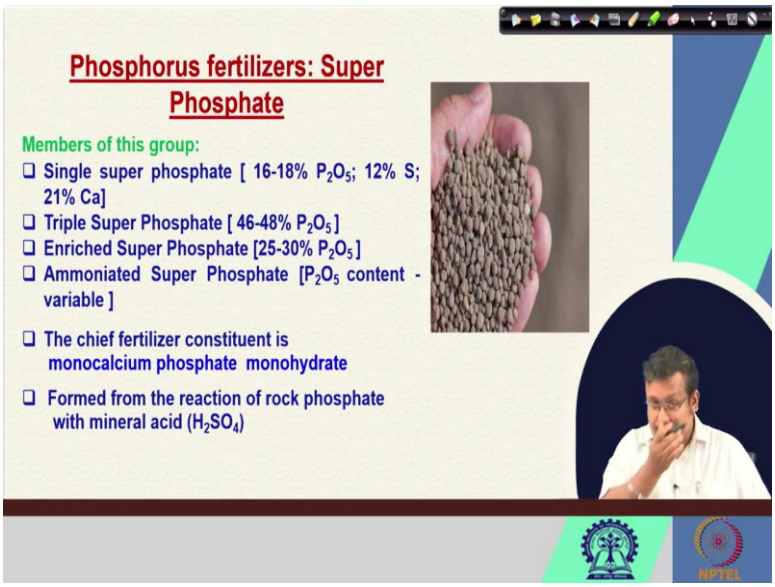

So, let us discuss about the superphosphate. So, members of these, there are several members of this group like single superphosphate, triple superphosphate, enriched superphosphate, we already know that. In case of single superphosphate, it contains 16 to 18 percent of P2O5. However, this particular phosphatic fertilizer also contains two secondary minerals, what are those? sulphur and calcium. So, it contains 12 percent sulphur, and 21 percent of calcium.

Triple superphosphate on the other hand consists 46 to 48 percent of P2O5. In case of enrich superphosphate, it contains 25 to 30 percent of P2O5. And in case of ammoniated superphosphate the P2O5 content is variable. So, the chief fertilizer constituent is monocalcium phosphate monohydrate, and formed from the reaction of rock phosphate with mineral acis H3SO4, we have already seen it in our previous slide.

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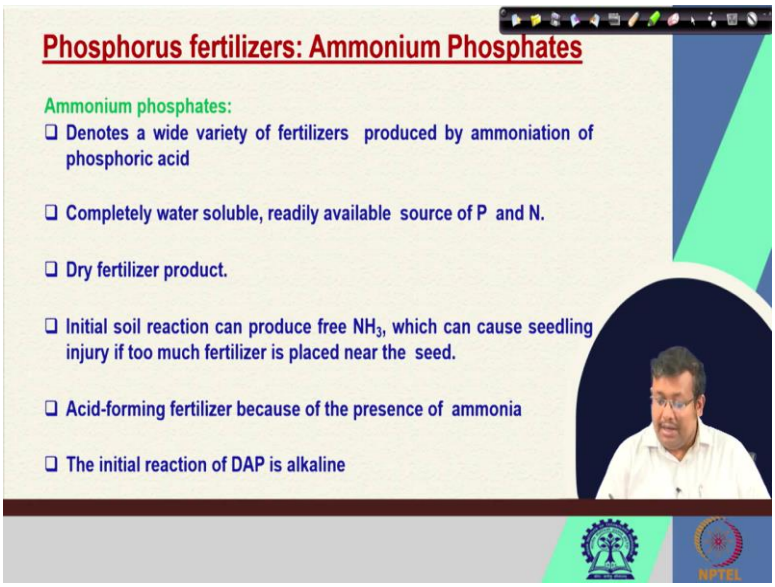

Now, let us consider the ammonium phosphates. So, this ammonium phosphate denotes a wide variety of fertilizer produced by ammoniation of phosphoric acid. So, when phosphoric acid reacts with the ammonia, will produce the ammonium phosphate. Now, completely they are completely water soluble, and readily available source of phosphorus and nitrogen, these ammoniated phosphate as the name suggests, contains ammonium as well as phosphorus. So, it can supply both phosphorus, and nitrogen. And, dry fertilizers, it is a dry fertilizer product.

Initial soil reaction can produce free ammonia which can cause seedling injury. If too much fertilizer is placed near the seed. It is an acidic forming, acid forming fertilizer because of the presence of ammonia and the initial reaction of DAP is generally alkaline. DAP is diammonium phosphate, which contains 18 percent nitrogen and 46 percent P2O5. It is a one of the major phosphatic fertilizer, however the initial reaction of DAP is alkaline.

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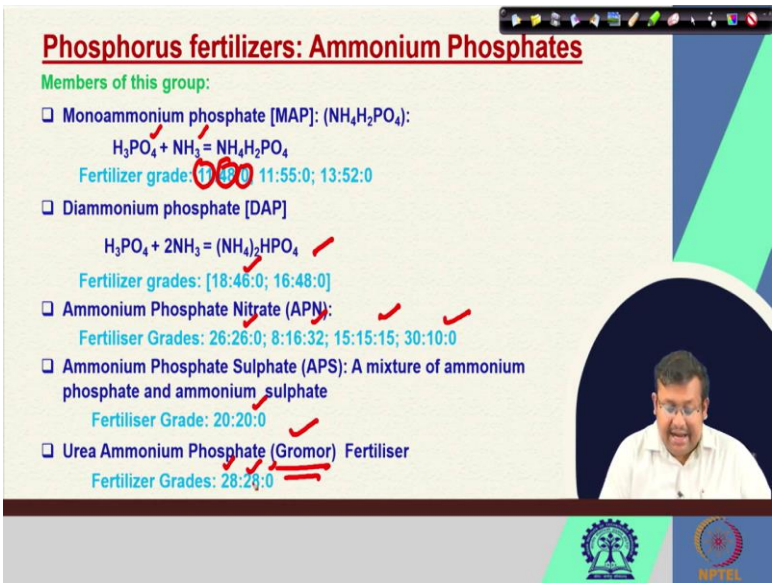

So, what are the members of these ammonium phosphates? The first member is monoammonium phosphate. So monoammonium phosphate as we know form from the reaction between H3PO4 and ammonia to produce this monoammonium phosphate. There are fertilizer grades, three fertilizer grades, 11 48 0, 11 55 0, and 13 52 0. Here, the first digit shows the nitrogen content, second digit shows the P205 content, and third digit shows the K2O content. So, the second one is diammonium phosphate DAP. You can see here this reaction two molecules of ammonia with H3PO4 produce these diammonium phosphate. Fertilizer grade are 18 46 0, and 16 48 0. However, the most common is 18 46 0.

Ammonium phosphate nitrate or APN. They have 3 to 4 fertilizer grades 26 26 0, then 8 16 32, then 15 15 15, and 13 10 0. Then ammonium phosphate sulphate or APS it is a mixture of ammonium phosphate and ammonium sulphate the fertilizer grade is 20 to 20 0. And urea ammonium phosphate which is also known as Gromor, very common fertilizer and it contains fertilizer grade 28 28 0, or N content is 28 percent, P2O5 content is 28 percent and there is no K2O content. So, these are some of the members of ammonium phosphate fertilizers.

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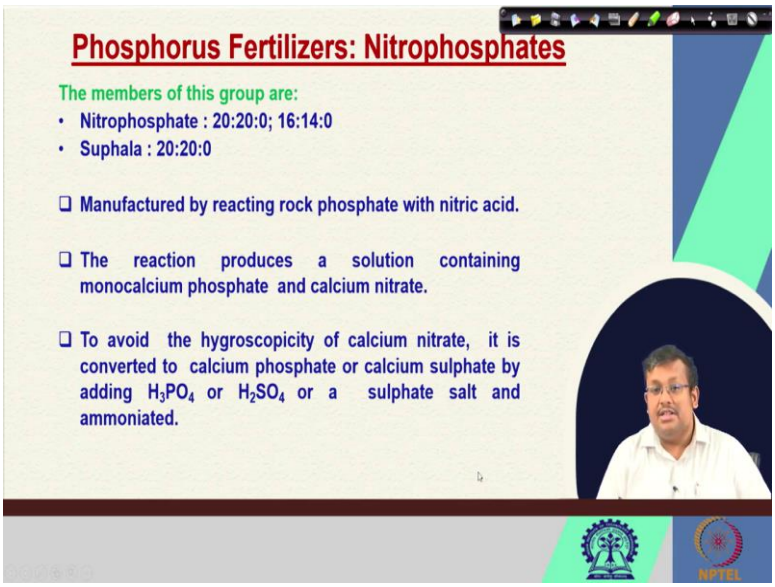

Let us discuss about the nitrophosphates. So, the members of these groups are nitrophosphate, there are two grades 20 20 0, and 16 14 0, and the Suphala. Suphala is also a nitrophosphate, which has the grade of 20 20 0. These nitrophosphates are manufactured by reacting rock phosphate with nitric acid, and the reaction produced a solution containing monocalcium phosphate and calcium nitrate. So, to avoid the hygroscopicity of calcium nitrate, so, calcium nitrate is a component of the, it is a product of this manufacturing process.

So, to avoid the hygroscopicity of the calcium nitrate, it is converted to calcium phosphate, or calcium sulphate by adding these phosphoric acid, or sulfuric acid, or as a sulphate salt, and ammoniated. So, this is how the physical condition of these nitrophosphates can be improved, or rectified.

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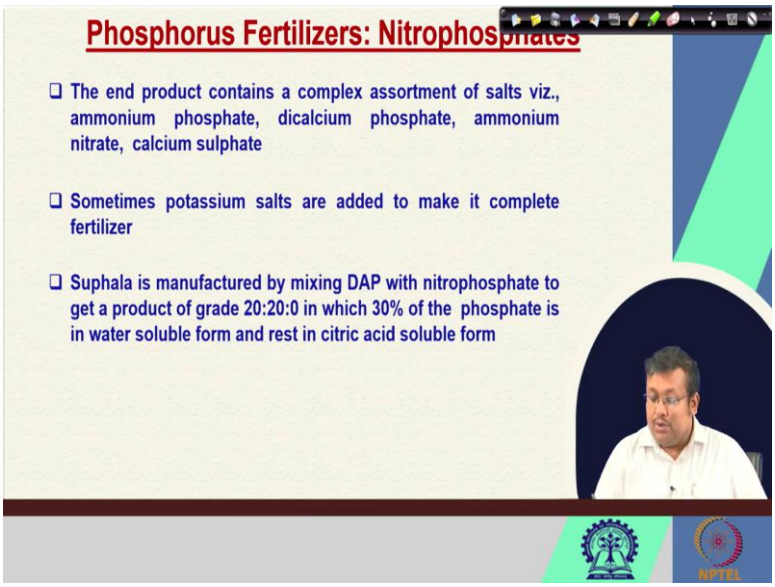

So, the end product of this nitrophosphate manufacturing process contains a complex assortment of salts, what are these? These are ammonium phosphate, dicalcium phosphate, and ammonium nitrate, calcium sulphate. So, sometimes potassium salts are also added to make it complete fertilizers.

Suphala which is a nitrophosphate is manufactured by mixing the diammonium phosphate with nitrophosphate to get a product of a grade of 20 20 0 in which 30 percent of the phosphate is water soluble form, and rest is in citric acid soluble form. So, Suphala is another very popular fertilizer in Indian subcontinent. So, this is also, it is a fertilizer which contains both nitrogen as well as phosphorus.

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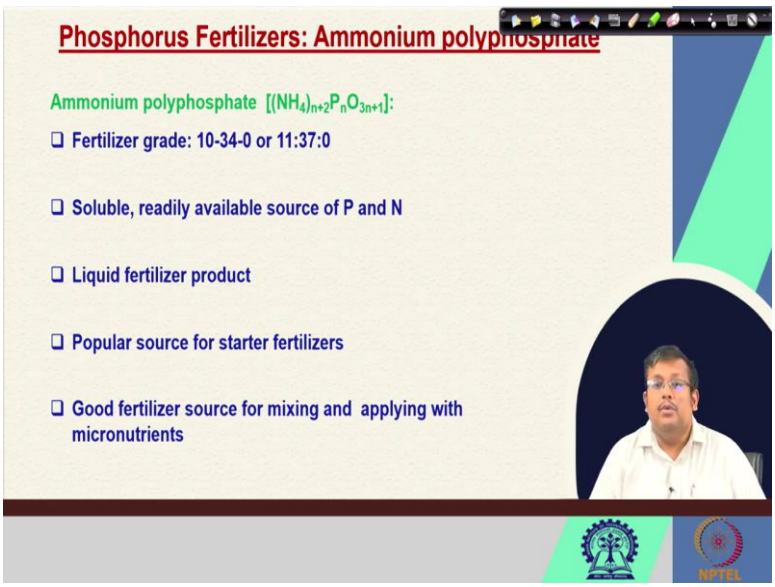

Ammonium polyphosphate, this is the formula, and the fertilizer grade, there are two fertilizer grade 10 34 0, or 11 37 0. So, it is they are soluble readily available sources of phosphorus and nitrogen, it is a liquid fertilizer product, and popular source for starter fertilizers, it is a very good fertilizer source for mixing and applying with micronutrients which is a liquid, it is a liquid fertilizer product and it can be mixed and applied with the micronutrient fertilizers also.

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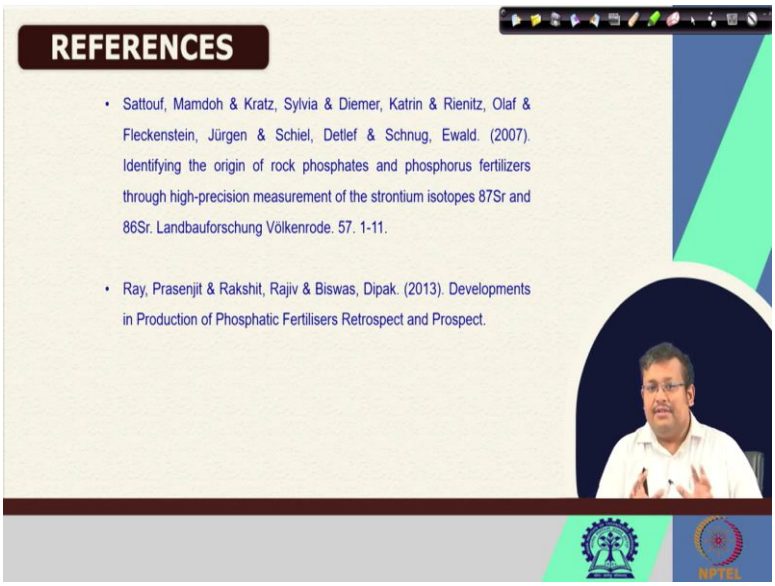

So, guys, we have discussed about all the most of the phosphatic fertilizers. So, let us wrap up this lecture, and let us start from here in the next lecture, where we will discuss about the potassium also. And, how it is important for plant nutrition. So, I hope you have got enough idea about different types of phosphatic fertilizers, we have seen that phosphate fertilizers can be differentiated based on their solubility in water as well as citric acid, or their insolubility. They are broadly classified into water soluble fertilizers, and the citric soluble fertilizer, or insoluble fertilizer. In case of water-soluble fertilizers, they are readily available to the plant however, they can be easily fixed by and becomes unavailable to the plant.

We have also seen the manufacturing process of single superphosphate through batch process as well as through continuous process. And, we have we have understood that the basic ingredient for manufacturing of phosphate fertilizer is a rock phosphate, and rock phosphate is available in different countries. And majorly it is available in Morocco followed by USA.

So, guys, I hope that you have got enough idea about the phosphatic fertilizers. We are going to discuss about these fertilizers in details in our upcoming weeks. But, let us wrap up here

and let us start a new lecture focusing on mainly the potassium, and is the importance in plant nutrition. Thank you very much.