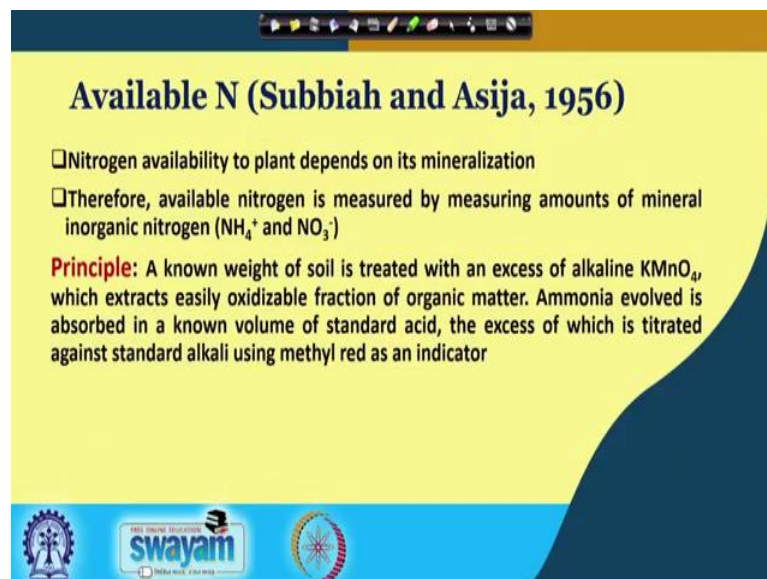


Soil Science and Technology
Prof. Somsubhra Chakraborty
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Indian Institute of Technology, Kharagpur

Lecture - 37
Soil Testing - II

Welcome to this new lecture of Soil Science and Technology and in this lecture we will be trying to finish this Soil Testing topic, which we have started in our last lecture. So, in the last lecture, we have covered soil pH, soil electrical conductivity and the soil organic carbon. Now in this lecture, let us start with the very important, that is available nitrogen.

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Available N (Subbiah and Asija, 1956)

- ☐ Nitrogen availability to plant depends on its mineralization
- ☐ Therefore, available nitrogen is measured by measuring amounts of mineral inorganic nitrogen (NH_4^+ and NO_3^-)

Principle: A known weight of soil is treated with an excess of alkaline KMnO_4 , which extracts easily oxidizable fraction of organic matter. Ammonia evolved is absorbed in a known volume of standard acid, the excess of which is titrated against standard alkali using methyl red as an indicator

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Now guys, you know that available nitrogen is basically the summation of both ammoniacal as well as nitrate nitrogen. Because plant can absorb, plant can avail both forms of nitrogen for their growth. Now, this measurement of available nitrogen in the laboratory is basically based on the method given by these two scientists called Subbiah and Asija in 1956. And now, remember that nitrogen availability to a plant depends on mainly on its mineralization and therefore, available nitrogen is measured by measuring amount of mineral inorganic nitrogen, that is ammonium and nitrate.

And the principle is basically, a known weight of soil is treated with an excess amount of alkaline potassium permanganate which extracts easily oxidizable fraction of organic

matter. And as a result, ammonia is evolved which is basically absorbed in a known volume of a standard acid and the excess of that acid will be titrated against a standard alkali using methyl red as an indicator. So, this is the simple principle of this method. And so, this, you know, let us see: what are the reactions which are involved in this method.

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Available N

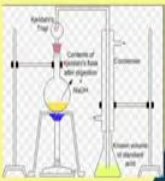
$$2 \text{KMnO}_4 + \text{H}_2\text{O} \xrightarrow{\text{Alkaline Medium}} 2 \text{MnO}_2 + 2\text{KOH} + 3\text{O}$$

$$\text{RCH.NH}_2\text{COOH} + \text{O} \xrightarrow{\text{Oxidative Decarboxylation}} \text{R.CO.COOH} + \text{NH}_3$$

$$\text{NH}_3 + \text{H}_2\text{O} \xrightarrow{\text{Distillation}} \text{NH}_4\text{OH}$$

$$2 \text{NH}_4\text{OH} + \text{H}_2\text{SO}_4 \xrightarrow{\text{Absorption}} (\text{NH}_4)_2\text{SO}_4 + 2 \text{H}_2\text{O}$$

$$\text{H}_2\text{SO}_4 + 2\text{NaOH} \longrightarrow \text{Na}_2\text{SO}_4 + 2 \text{H}_2\text{O}$$







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Available N- steps

1. All the reagents needed below are prepared first
2. 20g soil is taken in a distillation flask
3. 20 ml water and 100 ml 0.32% KMnO_4 solution is added to it
4. 25 ml of N/ 50 (0.02 N) H_2SO_4 is pipetted out in a conical flask. 2-3 drops of methyl red indicator is added and the end of delivery tube of distillation flask is dipped into it
5. 100 ml of 2.5% NaOH solution is added into the flask and corked immediately.
6. Ammonia gas is distilled from the distillation flask and collected in H_2SO_4 solution. Continue distillation till the evolution of ammonia ceases completely (test by bringing a moist red litmus paper near the outlet of the condenser, which will turn blue as long as ammonia is being evolved).
7. Titrate the excess of H_2SO_4 against N/50 (0.02 N) NaOH and note down the volume of NaOH used. The end point is reached when the colour changes from pink to yellow.





So, here are different methods. So, the first step; obviously, you can see here. In the alkaline medium which is basically created by adding sodium hydroxide, this is alkaline

in condition, this potassium permanganate basically produce this manganese dioxide and obviously, this nascent oxygen. And this nascent oxygen basically reacts with whatever organic nitrogen fraction present in the soil. So basically, you can see this is the formula of amino acids and from this amino acids they are releasing the ammonia. So, that is why this process is called oxidative deamination because we are using oxygen here.

So, in the oxidative deamination process, ultimately we are releasing the ammonia and remember that, this ammonia will be the source of both ammoniacal nitrogen as well as nitrate nitrogen for the plant growth. So, we have to basically measure these evolved ammonium. Now this ammonia will be further distilled to form ammonium hydroxide and this ammonium hydroxide will be reacting or will be absorbed by a standard acid that is H_2SO_4 to produce ammonium sulphate and this is called the absorption step.

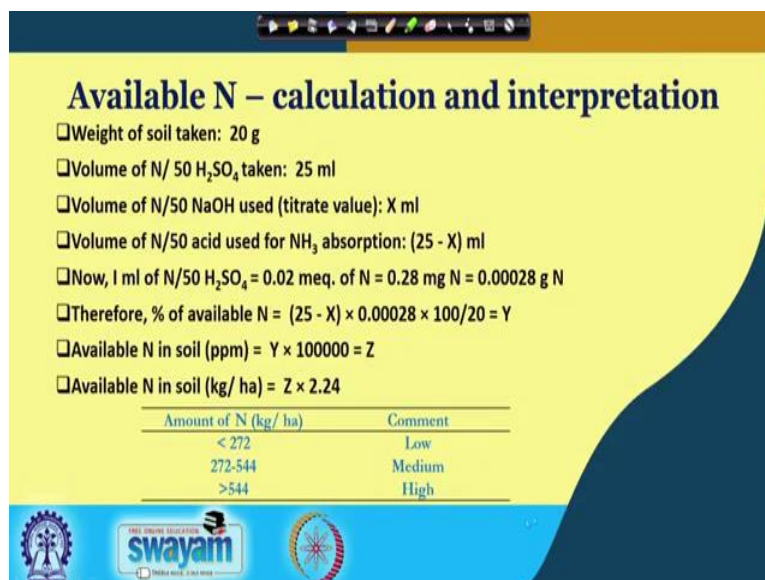
And in the final step, this unused H_2SO_4 will be titrated against sodium hydroxide which is another standard acid to calculate what the amount of unused H_2SO_4 is. So, when we calculate the amount of unused H_2SO_4 , obviously, we can calculate the amount of used H_2SO_4 and from that, we can calculate what is the amount of ammonia evolved and from that, we can calculate the available nitrogen in the soil because all this, we know, by weight. Now, this method is also known as Kjeldahl method and this total process in some time is, you know, we execute through a flask called Kjeldahl flask or Kjeldahl assembly.

You can see here I have given here; obviously, this is a round bottom flask, we call it Kjeldahl flask and in this Kjeldahl flask, we take first soil sample and then we mixed with potassium permanganate and sodium hydroxide, obviously, and then we heated and ultimately ammonia produced and this ammonia gets condensed within the condenser and ultimately it absorbed within this known volume of a standard acid, in our case it is H_2SO_4 . So, after we absorb and after we collect this ammonia which is evolved from this oxidative deamination, ultimately some amount of H_2SO_4 will remain unused. So, we will calculate this unused by using some titration against a standard alkali of sodium hydroxide. So, this total process is also known as Kjeldahl process.

So guys, these are the available nitrogen steps; obviously, these are very important and please keep this as a ready reference if you want to do any future testing of soil. However, I am not going to detail all these steps because it is not necessary at this point

of time and you do not need to remember all these steps for your exams and assignments also ok.

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Available N – calculation and interpretation

- Weight of soil taken: 20 g
- Volume of N/50 H_2SO_4 taken: 25 ml
- Volume of N/50 NaOH used (titrate value): X ml
- Volume of N/50 acid used for NH_3 absorption: (25 - X) ml
- Now, 1 ml of N/50 H_2SO_4 = 0.02 meq. of N = 0.28 mg N = 0.00028 g N
- Therefore, % of available N = $(25 - X) \times 0.00028 \times 100/20 = Y$
- Available N in soil (ppm) = $Y \times 100000 = Z$
- Available N in soil (kg/ha) = $Z \times 2.24$

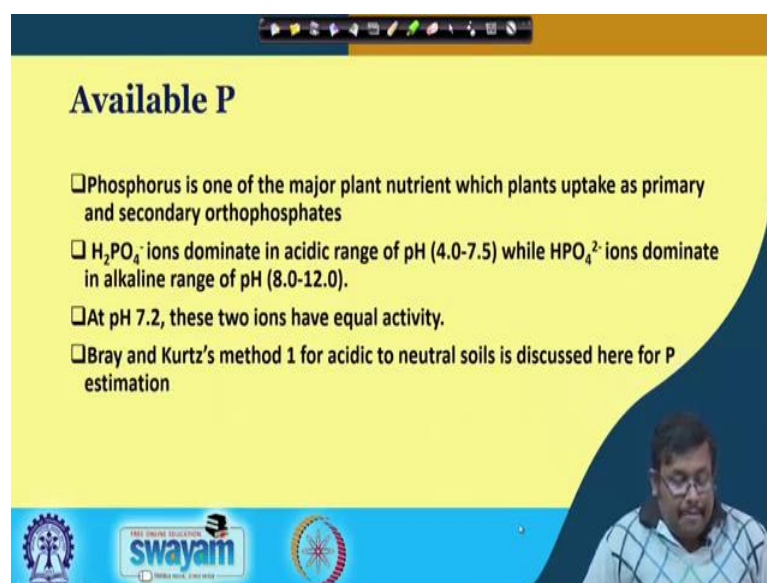
Amount of N (kg/ha)	Comment
< 272	Low
272-544	Medium
> 544	High

The slide includes logos for UGC, Swayam, and a circular emblem at the bottom.

So, let us go ahead and see what are the important. Let us see about the, you know, these are the calculation. So, I have already given the calculation. So, you can correlate the previous slide with this slide and see how we calculate this available nitrogen first in ppm and; obviously, this one point I would like to mention here. You can see first of all, when we are calculating the percentage, suppose it is Y% and from Y% to ppm, we have to multiply it to 1,00,000 to get Z. And finally, available nitrogen in soil is basically 2.24 multiplied by Z. So, this is very important, available nitrogen in kg per hectare, we have to multiply by 2.24.

Now, the interpretation of this available nitrogen is, if we can calculate the available nitrogen in kg per hectare which is the final value, is less than 272; obviously, it will be low. The medium range is 272 to 544, that is medium. If it is more than 544, it is high. So basically, the interpretation will be, when the soil contains medium amount of nitrogen, we may not want to go for further application. In case of high, we should not apply any further application because that will be toxic in nature and in case of low condition only, we will be applying the nitrogenous fertilizers. So, this will be the final interpretation.

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Available P

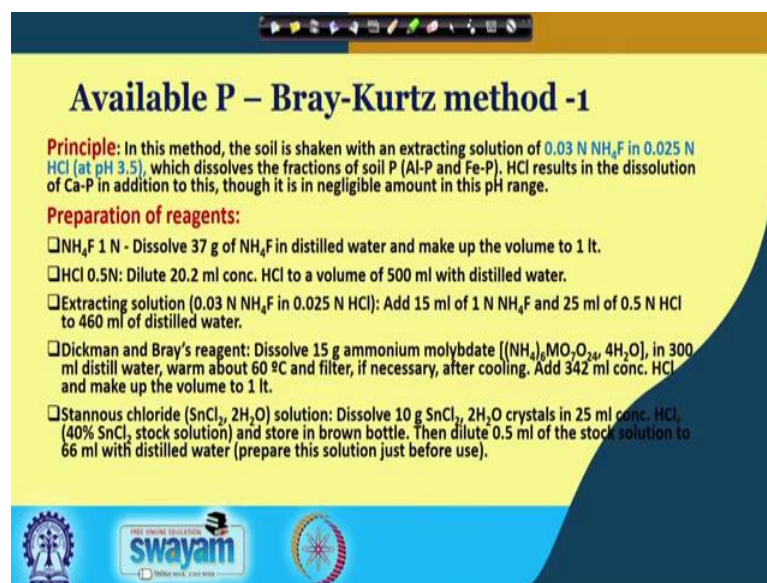
- ❑ Phosphorus is one of the major plant nutrient which plants uptake as primary and secondary orthophosphates
- ❑ H_2PO_4^- ions dominate in acidic range of pH (4.0-7.5) while HPO_4^{2-} ions dominate in alkaline range of pH (8.0-12.0).
- ❑ At pH 7.2, these two ions have equal activity.
- ❑ Bray and Kurtz's method 1 for acidic to neutral soils is discussed here for P estimation

swayam

Now available phosphorus; obviously, phosphorus is one of the major plant nutrient which plants uptake as primary and secondary orthophosphates. So, H_2PO_4^- ; obviously, ions dominate in acidic range, that is, 4.0 to 7.5 while HPO_4^{2-} ions dominate in alkaline range of pH, that is, 8.0 to 12.0. So, both these ions are present at around, you know, in neutral condition. Both these ions are present in equal concentration at a, you know, just like here mentioned that pH 7.2. These ions have equal activity and Bray and Kurtz number 1 method is useful for acidic and neutral soil. So, we will be discussing this only here.

However, remember that for alkaline soil, we will be it basically generally basically we use another extraction which is called Olsen extraction. And so basically, now you can understand why we measure pH at the first of any soil testing program because, it, you know, it helps us to take some major decision for selecting the appropriate extracting agents for subsequent nutrients.

(Refer Slide Time: 09:06)



Available P – Bray-Kurtz method -1

Principle: In this method, the soil is shaken with an extracting solution of 0.03 N NH_4F in 0.025 N HCl (at pH 3.5), which dissolves the fractions of soil P (Al-P and Fe-P). HCl results in the dissolution of Ca-P in addition to this, though it is in negligible amount in this pH range.

Preparation of reagents:

- ☐ NH_4F 1 N - Dissolve 37 g of NH_4F in distilled water and make up the volume to 1 lt.
- ☐ HCl 0.5N: Dilute 20.2 ml conc. HCl to a volume of 500 ml with distilled water.
- ☐ Extracting solution (0.03 N NH_4F in 0.025 N HCl): Add 15 ml of 1 N NH_4F and 25 ml of 0.5 N HCl to 460 ml of distilled water.
- ☐ Dickman and Bray's reagent: Dissolve 15 g ammonium molybdate $[(\text{NH}_4)_6\text{Mo}_7\text{O}_{24} \cdot 4\text{H}_2\text{O}]$, in 300 ml distill water, warm about 60 °C and filter, if necessary, after cooling. Add 342 ml conc. HCl and make up the volume to 1 lt.
- ☐ Stannous chloride ($\text{SnCl}_2 \cdot 2\text{H}_2\text{O}$) solution: Dissolve 10 g $\text{SnCl}_2 \cdot 2\text{H}_2\text{O}$ crystals in 25 ml conc. HCl, (40% SnCl_2 stock solution) and store in brown bottle. Then dilute 0.5 ml of the stock solution to 66 ml with distilled water (prepare this solution just before use).

Logos: IIT Bombay, swayam, and a circular emblem.

So, the principle behind this is you know that in the soil, phosphorus is basically fixed in three major forms. In acidic soil, it is mainly fixed in aluminium phosphate and iron phosphate and in alkaline soil, it is mainly fixed in as calcium phosphate. So, in this Bray and Kurtz method which is useful for acidic soil, basically we shake the soil with an extracting agent which is called Bray and Kurtz number 1 extractant.

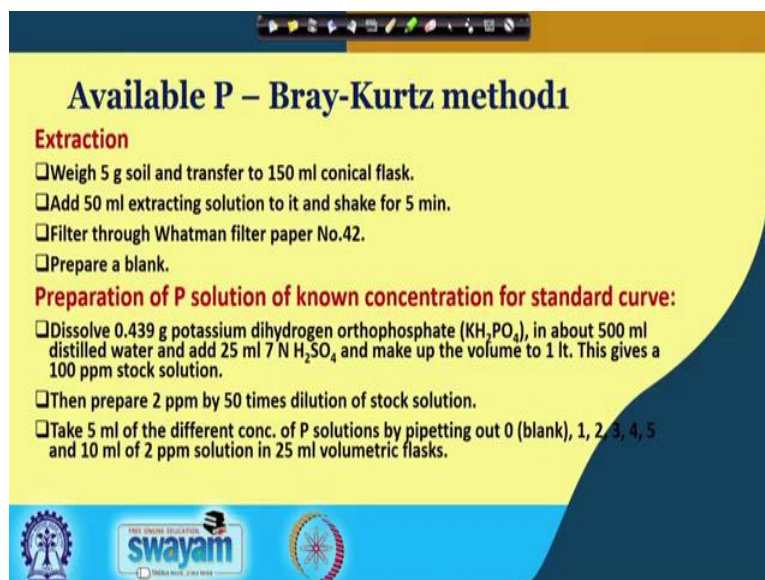
So, what is the composition? The composition is basically 0.03 N of ammonium fluoride in 0.025 N of HCl at pH 3.5. So, this is called Bray and Kurtz number 1 extractant and how it helps? Because, it contains both ammonium fluoride and, you know, and HCl, It basically dissolve the fractions of soil P that is aluminium phosphate and iron phosphate. So, ammonium fluoride is basically responsible for dissolving the aluminium phosphate and iron phosphate and HCl results in the dissolution of calcium phosphate in addition to this; however, this is very negligible amount in this pH range.

So, this is the principle behind this Bray and Kurtz number 1 method. So, the preparation of reagents: they have several reagents, you have to prepare like ammonium fluoride first, then HCl 0.5 N, then you have to create the extracting solution, then you have to create the Dickman and Bray's reagent which is basically ammonium molybdate and then you have to, you know, you have to prepare the stannous chloride because this is a colouring reagent.

And remember that, in this method basically when we extract the phosphate, we add different types of, you know, we add the stannous chloride for development of a colour. Generally in the presence of phosphorus, there will be development of blue colour and the concentration of blue colour will increase based on the concentration of the phosphorous which is present. So, the concentration of the phosphorus will be finally, measured through spectrophotometry or colorimetry and we will discuss that later on.

So, in the spectrophotometer, we will create first a standard curve using some standard phosphate solution and once you create the standard curve, from that standard curve we will be calculating the phosphate concentration of an unknown sample ok. So, the steps are given.

(Refer Slide Time: 12:11)



Available P – Bray-Kurtz method¹

Extraction

- ☐ Weigh 5 g soil and transfer to 150 ml conical flask.
- ☐ Add 50 ml extracting solution to it and shake for 5 min.
- ☐ Filter through Whatman filter paper No.42.
- ☐ Prepare a blank.

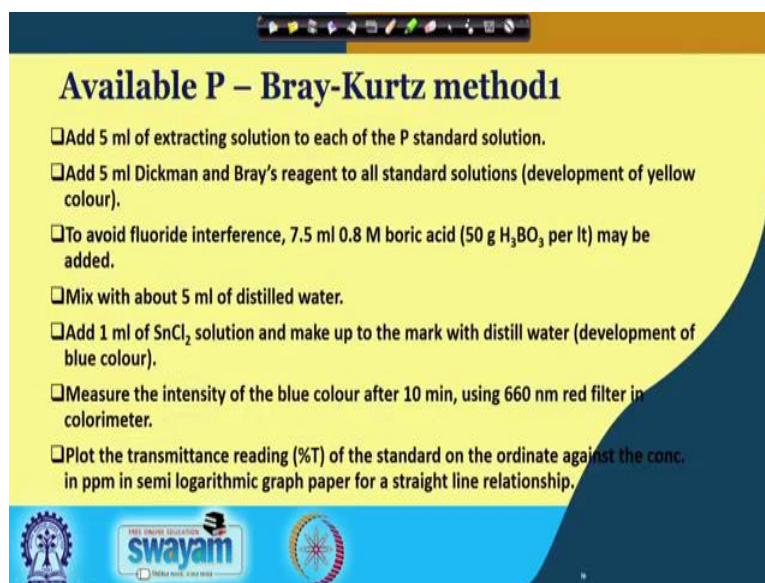
Preparation of P solution of known concentration for standard curve:

- ☐ Dissolve 0.439 g potassium dihydrogen orthophosphate (KH_2PO_4), in about 500 ml distilled water and add 25 ml 7 N H_2SO_4 and make up the volume to 1 lt. This gives a 100 ppm stock solution.
- ☐ Then prepare 2 ppm by 50 times dilution of stock solution.
- ☐ Take 5 ml of the different conc. of P solutions by pipetting out 0 (blank), 1, 2, 3, 4, 5 and 10 ml of 2 ppm solution in 25 ml volumetric flasks.

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You have known the principal now. So, the steps are given with 5 gram of soil, you know, you know how to extract and how to create the phosphate solution of known concentration for the standard curve and how to create the standard curve.

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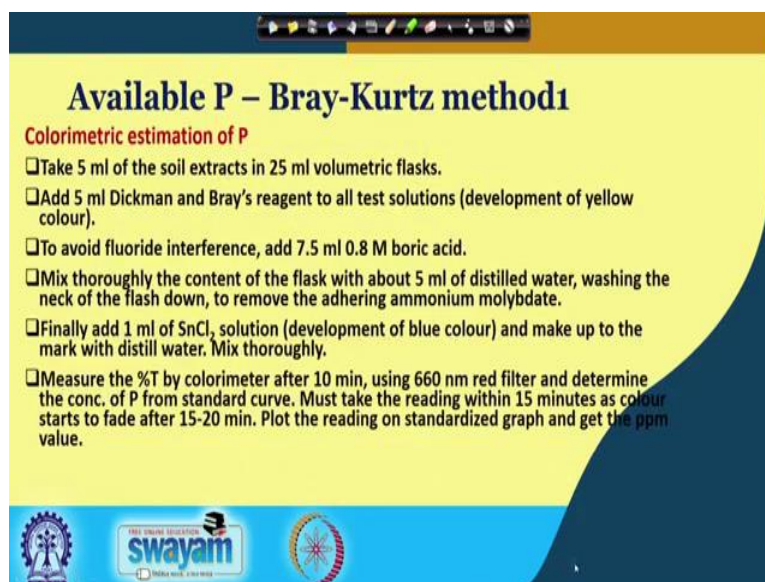
Available P – Bray-Kurtz method1

- ☐ Add 5 ml of extracting solution to each of the P standard solution.
- ☐ Add 5 ml Dickman and Bray's reagent to all standard solutions (development of yellow colour).
- ☐ To avoid fluoride interference, 7.5 ml 0.8 M boric acid (50 g H_3BO_3 per lt) may be added.
- ☐ Mix with about 5 ml of distilled water.
- ☐ Add 1 ml of SnCl_2 solution and make up to the mark with distilled water (development of blue colour).
- ☐ Measure the intensity of the blue colour after 10 min, using 660 nm red filter in colorimeter.
- ☐ Plot the transmittance reading (%T) of the standard on the ordinate against the conc. in ppm in semi logarithmic graph paper for a straight line relationship.

Logos: UGC, swayam, and a circular emblem are visible at the bottom.

All these are given and how to measure the available phosphate; all these are given here. So, please keep this as a ready reference for your future use.

(Refer Slide Time: 12:31)



Available P – Bray-Kurtz method1

Colorimetric estimation of P

- ☐ Take 5 ml of the soil extracts in 25 ml volumetric flasks.
- ☐ Add 5 ml Dickman and Bray's reagent to all test solutions (development of yellow colour).
- ☐ To avoid fluoride interference, add 7.5 ml 0.8 M boric acid.
- ☐ Mix thoroughly the content of the flask with about 5 ml of distilled water, washing the neck of the flask down, to remove the adhering ammonium molybdate.
- ☐ Finally add 1 ml of SnCl_2 solution (development of blue colour) and make up to the mark with distilled water. Mix thoroughly.
- ☐ Measure the %T by colorimeter after 10 min, using 660 nm red filter and determine the conc. of P from standard curve. Must take the reading within 15 minutes as colour starts to fade after 15-20 min. Plot the reading on standardized graph and get the ppm value.

Logos: UGC, swayam, and a circular emblem are visible at the bottom.

Now you remember that, once we develop these, you know, colour, we have to use a colorimeter or spectrophotometer to measure the concentration. And within the spectrophotometer or colorimeter, we use a monochromatic light to measure the concentration based on Beers and Lambert's law and what is Beers and Lambert's Law, we will discuss later on.

(Refer Slide Time: 13:00)

Available P – Bray-Kurtz method¹

Calculation

- Weight of soil taken: 5 g
- Volume of extractant added: 50 ml
- First dilution: 10 times (50/ 5)
- Volume of the extract taken for colour development: 5 ml
- Final volume made: 25 ml
- Second dilution: 5 times (25/ 5)
- Total dilution: $10 \times 5 = 50$ times
- Transmittance (%T) of test solution: T
- Conc. of P as read from standard curve: A ppm
- Available P in soil: $A \times 50 \text{ ppm} = A \times 50 \times 2.24 \text{ kg/ha}$
- Available P_2O_5 in soil: $A \times 50 \times 2.24 \times 2.29 \text{ kg/ha}$



These are the calculation, you do not need to remember all these things at this point of time; however, you must remember that, whatever phosphate we get here available P here in the soil is in kg per hectare; if you want to convert into P_2O_5 which is the standard, you know, conversion for measurement of different fertilizer requirement. Obviously, available P_2O_5 you can see here, you have to multiply with these factors. So, if you want to convert from P to P_2O_5 ; obviously, you have to use this 2.29 to convert into P_2O_5 .

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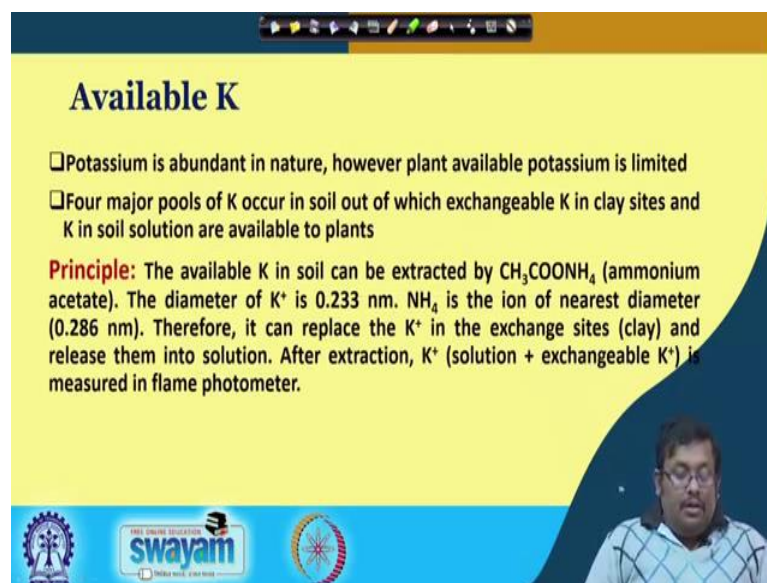
Available P

Amount of P_2O_5 (kg/ ha)	Comment
< 22.5	Low
22.5-56.0	Medium
>56.0	High



What is the interpretation? Obviously, again based on the available P_2O_5 in kg per hectare so; obviously, when it is in-between 22.5 to 56, it is considered medium and when it is less than 22.5, it is considered as low and when it is greater than 56, then it is considered high. So, this is the based on these we will recommend whether your test soil has low amount or medium amount or high amount of available phosphate.

(Refer Slide Time: 14:17)



Available K

- ❑ Potassium is abundant in nature, however plant available potassium is limited
- ❑ Four major pools of K occur in soil out of which exchangeable K in clay sites and K in soil solution are available to plants

Principle: The available K in soil can be extracted by CH_3COONH_4 (ammonium acetate). The diameter of K^+ is 0.233 nm. NH_4^+ is the ion of nearest diameter (0.286 nm). Therefore, it can replace the K^+ in the exchange sites (clay) and release them into solution. After extraction, K^+ (solution + exchangeable K^+) is measured in flame photometer.

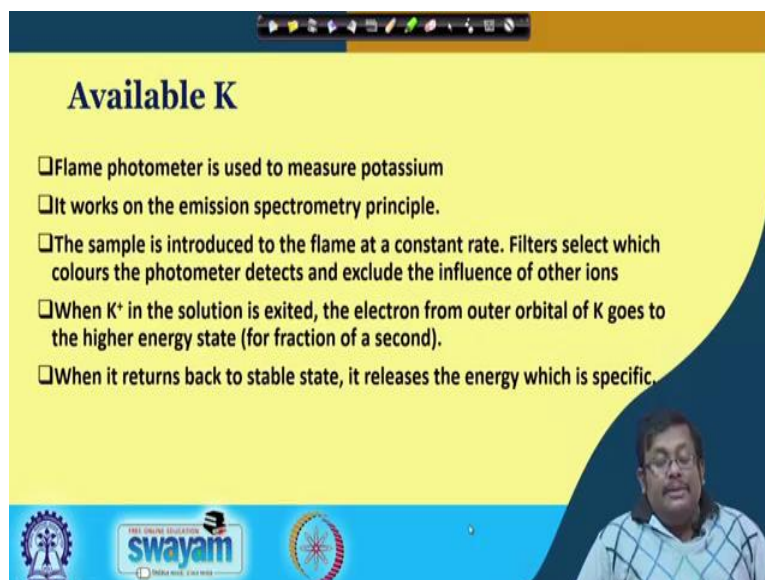
Logos at the bottom: IIT Bombay, swayam, and a circular logo.

Now, you know, the final major or macronutrient is I would say final, you know, primary nutrient I would say is potassium and available potassium is also very very important for measurement of the soil fertility status. So, potassium is abundant in nature; however, plant available potassium is always limited. You know that there are four major pools of potassium occurring in soil out of which only exchangeable potassium at clay sites and potassium in soil solutions are available to plants. We have already discussed it in our previous lecture.

Now the principle of potassium measurement is the available potassium in the soil is, basically we extract using a neutral normal ammonium acetate extractant because the ionic diameter of potassium and the ammonium is almost similar. In case of potassium, it is 0.233 nanometre where in case of ammonium it is 0.286 nanometre. So, both of them can easily replace them self. So, ammonium can easily replace potassium in the exchange site clay and release them into the solution. So after extraction, potassium that

is, solution plus exchangeable potassium, generally we measure through flame photometer.

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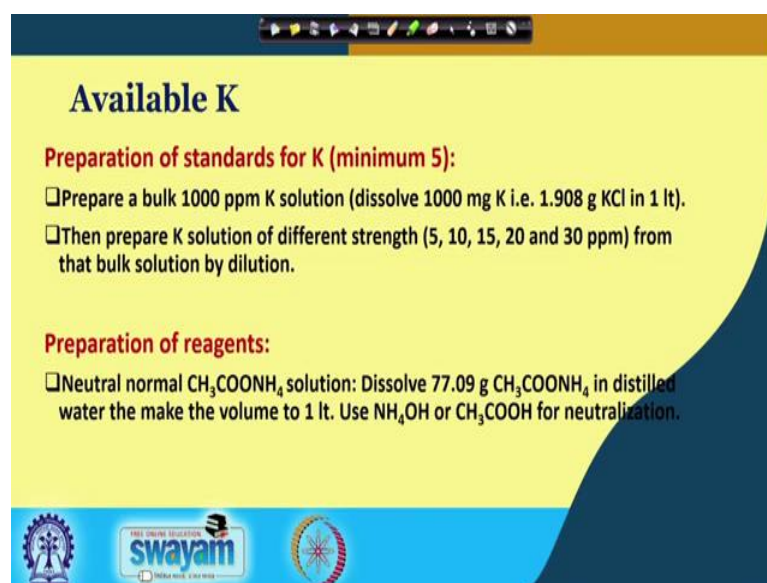
Available K

- ☐ Flame photometer is used to measure potassium
- ☐ It works on the emission spectrometry principle.
- ☐ The sample is introduced to the flame at a constant rate. Filters select which colours the photometer detects and exclude the influence of other ions
- ☐ When K^+ in the solution is excited, the electron from outer orbital of K goes to the higher energy state (for fraction of a second).
- ☐ When it returns back to stable state, it releases the energy which is specific.

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Flame photometer basically we generally basically used for measuring the potassium and it works on the emission spectrometry principle and the sample basically we introduce into the flame at a constant rate and filter selects which colour of the photometer detects and excludes the influence of other ions. And when potassium in the solution is excited, the electrons from outer orbital of potassium goes to the higher energy states for fraction of a second and when it returns back to stable state, it releases the energy which is a specific.

(Refer Slide Time: 16:23)



Available K

Preparation of standards for K (minimum 5):

- ☐ Prepare a bulk 1000 ppm K solution (dissolve 1000 mg K i.e. 1.908 g KCl in 1 lt).
- ☐ Then prepare K solution of different strength (5, 10, 15, 20 and 30 ppm) from that bulk solution by dilution.

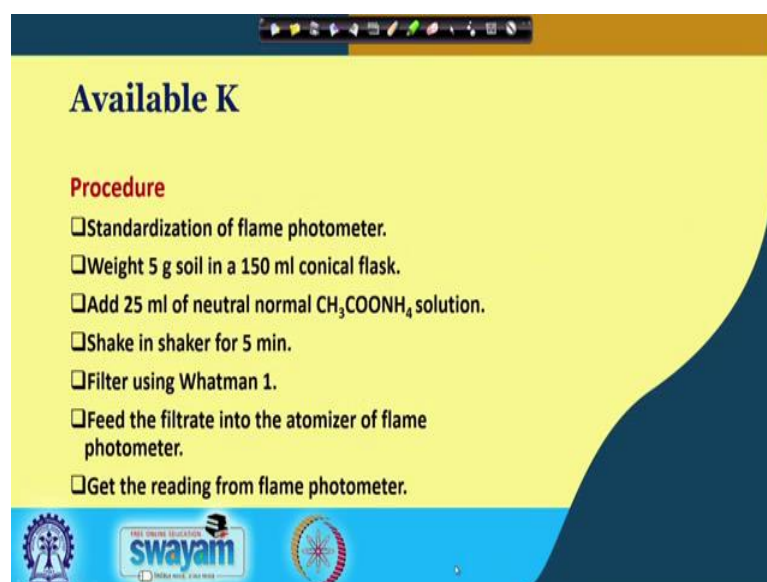
Preparation of reagents:

- ☐ Neutral normal $\text{CH}_3\text{COONH}_4$ solution: Dissolve 77.09 g $\text{CH}_3\text{COONH}_4$ in distilled water the make the volume to 1 lt. Use NH_4OH or CH_3COOH for neutralization.

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So, this is the principle. Now for that again, you have to create a measurement of potassium, you have to again create a standard curve of minimum five points and then you have to prepare the reagents. Here all this procedure is given.

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Available K

Procedure

- ☐ Standardization of flame photometer.
- ☐ Weight 5 g soil in a 150 ml conical flask.
- ☐ Add 25 ml of neutral normal $\text{CH}_3\text{COONH}_4$ solution.
- ☐ Shake in shaker for 5 min.
- ☐ Filter using Whatman 1.
- ☐ Feed the filtrate into the atomizer of flame photometer.
- ☐ Get the reading from flame photometer.

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Available K

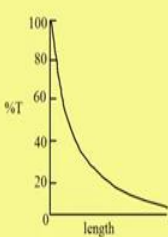
Amount of K ₂ O (kg/ ha)	Comment
< 136	Low
36-337.5	Medium
>337.5	High



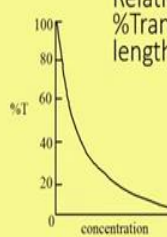
And finally, the available potassium recommendation will be, you know, low, medium, high you can see. If it is varying from, it should be 136 to 337.5, then we call it medium and when it is less than 136, we will call it low. When it is greater than 337.5, we will call it high. So, these are the different grades of available potassium in, you know, in kg per hectare.

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Colorimetry



length



concentration

Relationship between %Transmittance and light path length and concentration

$\text{Transmittance} = I_t/I_0 = e^{-\alpha c l}$ where
 α is an extinction constant, c is concentration and l is light path length



Now, before we discuss in details about, you know, about the flame photometry which is based on, you know, atomic emission spectrometry, let us discuss about colorimetry. Now colorimetry we basically use for measuring the concentration of phosphate and

colorimetry basically depends on some principle of relationship between percent transmittance and light path length and concentration.

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Absorbance increases linearly with concentration

From $I_t/I_0 = e^{-\alpha cl}$

α is used here to describe a constant that is proportional to the extinction coefficient.

taking logs of both sides and inverting

$$\ln(I_0/I_t) = \alpha cl$$

Converting to $\log_{10}$

$$\log_{10}(I_0/I_t) = \epsilon cl$$

Hence the Beer-Lambert Law

$$A = \epsilon cl$$

The slide includes a Swamyam logo and a small video inset of a man in the bottom right corner.

So, let us first see what is the basic parts of a colorimeter, then it will be lot clear to us.

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Colorimetry

Components of colorimetry

Light source → Collimator (Lens) → Monochromator (Prism or Grating) → Wavelength Selector (Slit) → Sample Solution (in Cuvette) → Detector (Photocell) → Digital Display or Meter

The diagram shows a light beam passing through these components, with a digital display showing '0.20'. The slide includes a Swamyam logo and a small video inset of a man in the bottom right corner.

So, if we go back and see what is the component of a colorimeter. So, in the colorimeter, first of all there will be a light source and from that light source, there will be a further a collimator or lens which will basically, you know, align on the light source directly into the monochromator which is prism or grating. And from that monochromator prism or

grating, that will grate the light and finally, there will be a wavelength selector which will select only a particular wavelength; that is why we call it monochromatic radiation. Now this particular wavelength will go through a particular sample.

So, for example, we have extracted the phosphate and we have developed, we have extracted the, you know, soil phosphorus and then we have developed the intense blue colour by adding the stannous chloride. Now for measuring the concentration of that blue colour or the phosphate, you have to basically take that solution into a cuvette which is basically quartz or, you know, fibre made container transparent container. And then basically what you have to do? You have to basically we are taking the sample solution here.

So, the monochromatic radiation is going through the sample solution. So, I_0 is basically incidence radiation and I_t is basically transmitted radiation and ultimately finally, there will be detector. At this detector we will finally, digitally display the result or basically this photocell will convert this, you know, the intensity of the radiation into electrical energy. So, that is why that is how a, you know, a colorimeter works. So, that is why we generally, you know, add different solutions here and based on their concentration, we will get their different transmittance or absorbance ok.

Now, what is the basic principle behind this? What is the basic, you know, basic principle which governs this colorimetry? This is governed by Beers and Lambert's law. So, let us see what Beers and Lamberts law is. Let us go back. So, the colorimetry says this is the relationship between the length of the solution or path length and the percentage transmittance. So obviously, as the length increases the percentage transmittance decreases exponentially. Similarly if the concentration increases, then the percentage transmittance decreases exponentially.

So, transmittance, you know, it is I_t / I_0 which is transmittance reaction by intensity of the of the incidence radiation which is generally we can denote by this, where α is an extinction constant and c is the concentration and l is the light path length, sorry, l is the light path length. So, you can see now one thing is very very clear that depending on the path length; that means, the width of that cuvette and concentration of the chemical which is present within that cuvette, this transmittance will vary. So, what we are doing? So, the observance is basically increases linearly with concentration. So, as the

concentration increases; obviously, it will absorb more light and it will transmit less amount of light.

So, here it is called the Beers, ok. So, when it depends on the length; obviously. So, when it depends on the length only, then we call it Lambert's law and when it depends on the concentration, we call it Beer's law. Now in case of cuvette, you see, we are only changing the concentration of the liquid inside the cuvette because the path length is always fixed because the cuvette size is almost fix. So, if we combine both beers and lamberts law, then we are only varying the concentration by keeping the length of the Lambert's; keeping the length of the, you know, path as constant.

So, that is why we call it Beer's and Lambert's law. So, you can see here we are taking the log of I_0 by I_t and then you can see, it is $\alpha c l$ and then it is $\log_{10}$. Converting into $\log_{10}$, we are getting ϵ and then $c l$. So, here basically the beers lamberts law says that A equal to absorbance will be equal to the equal to or, I am sorry, absorbance will be proportionate to the concentration and length. So, this is the combination.

So, in the Beer's and Lambert's law; obviously, when we are applying this Beer's and Lambert's law to colorimetry or colorimeter, we are nullifying this l and we are only playing with this c that is the concentration inside the cuvette. So, that is why we measure the concentration, that is how we measure the concentration of the liquid inside the cuvette and that is why we measure the concentration of phosphate. So, basically we will take some standard solution and using the standard solution we make a standard curve because we know their we know their.

So, for example, if you if you if you take 0 ppm and then for example, 1 ppm, 5 ppm, 10 ppm up to 100 and then we get their absorbance; obviously, as we increase the concentration, their absorbance will increase. So, we will draw a standard curve and from the standard curve, if there is an x sample for which we do not know.

So, we will extract that using the standard process and then we will use this standard curve to get the concentration from here. Because we will be getting the absorbance directly from the colorimeter and by plotting that, you know, absorbance value, we can directly measure the concentration. So, this is the basic principle behind, you know, behind this colorimetry.

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Flame Photometer

- Sodium, potassium, lithium, and calcium.
- Controlled flame test with the intensity of the flame color quantified by photoelectric circuitry.
- The sample is introduced to the flame at a constant rate.
- Filters select which colors the photometer detects and exclude the influence of other ions.
- Flame photometer works in the emission spectrometry principle.

Figure 2: Brief overview of the process

The diagram illustrates the process of flame photometry. It starts with 'Ions in solution' being aspirated into a flame. The process involves 'Vaporization in flame', 'Thermal dissociation in flame', and 'Excited State' formation. Energy is emitted in the form of light as the atoms return to the ground state.

At the bottom of the slide, there is a photograph of a flame photometer device and the Swayam logo.

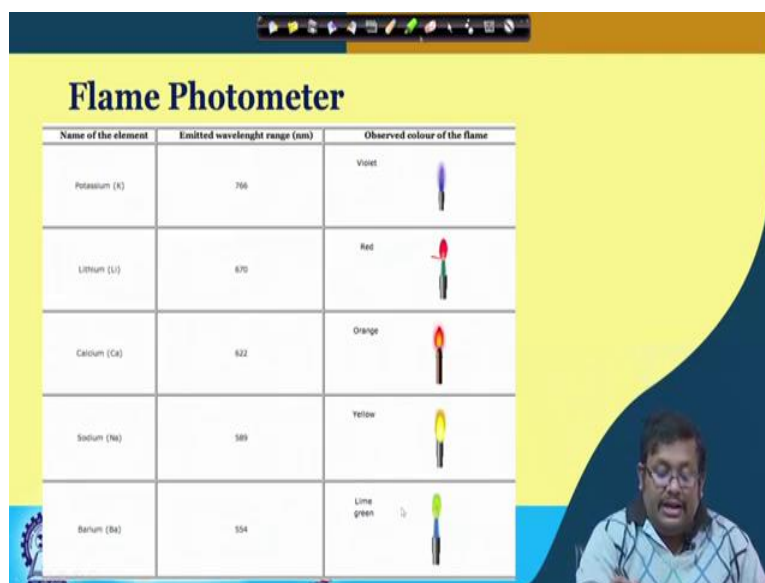
So, another important thing is flame photometer. Now using the flame photometer basically we measure sodium, potassium, lithium and calcium. And basically this flame photometer it is a control flame test with intensity of the flame colour quantified by photoelectric circuitry. Remembered that, it works on at emission spectroscopy and the sample is introduced to the flame at a constant rate and the filter selects which colours of the photometer. So, the basic principle is first of all we take the extracted, first of all we will take the extracted solution which contains the potassium ions in the extracted solution.

So, there is an aspirator here you can see, this is an aspirator. So, this aspirator will suck this solution and inside a chamber, it will create an aerosol and for creating the aerosol you need some kind of air. So, air is inserted from outside through this air pump and from this air pump, it will we create an aerosol. And this aerosol will be further vaporized, you know, in contact with a flame and there will be a flame inside and the flame will be and the fuel for this flame is basically LPG or liquid petroleum gas.

So, using the flame energy, this aerosol will the potassium which is present in the aerosol, will be going from, will be showing some thermal dissociation in flames. So, it will be, you know, if there is any electrons which is present in the ground states, it will be go to the exciting states. And then form the excited states when it will revert back to again its ground states, there will be some amount of energy in, you know, in the form of

light. And the particular wavelength of this emitted energy is basically very very specific for a specific element. So, by measuring that particular, you know, concentration of that or intensity of that emitted light, we can measure what is the concentration of that particular element within the solution. So, this is how a flame photometer basically works.

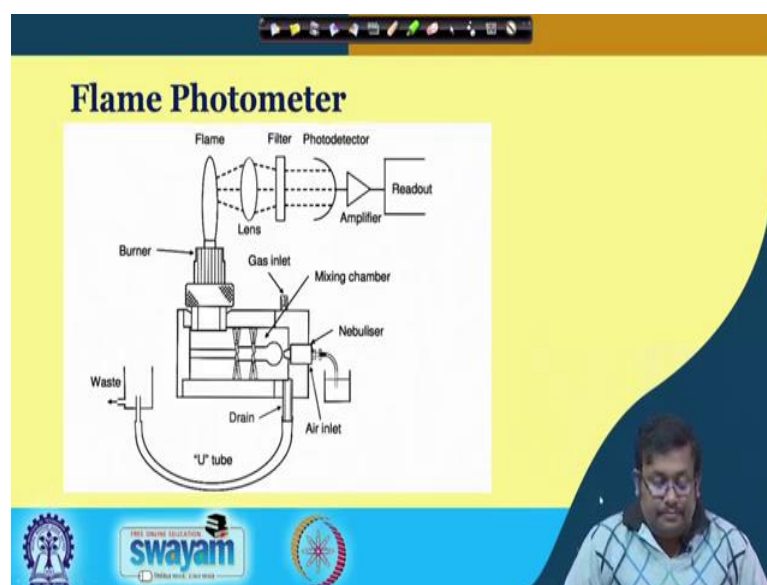
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Name of the element	Emitted wavelength range (nm)	Observed colour of the flame
Potassium (K)	766	Violet
Lithium (Li)	670	Red
Calcium (Ca)	822	Orange
Sodium (Na)	589	Yellow
Barium (Ba)	554	Lime green

So, for individual, you know, element the emitted wavelength range is different. You can see in case of potassium its 766, in case of lithium it is 670, calcium 622, sodium 589, barium 554 and; obviously, observed colour of the flame will also vary depending on the different elements. So, that is how it measure different these important elements using this flame photometry method.

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So, if you see the inside, you know, the schematic of in, you know, of the inside view of a flame photometer; obviously, you can see there is a nebulizer or aspirator which will aspirate. And, further it will mix and there is a mixing chamber and in the mixing chamber, it will create the aerosol and mix and further this will go to the burner. So, this is the burner and there is a gas inlet so, there will be a flame.

So, ultimately it will go to the flame and take the energy and finally, the emitted radiation will be goes will be going through this lens and this filter and finally, photodetector. And this photodetector will ultimately convert this electrical, sorry, this light signal into electrical signal through amplifier and read out. So, this and waste material will be going through this waste U tube. So, this is the inside view of a flame photometer.

So, I hope you guys you have learnt something new in this lecture and we will be stopping here and in the next lecture we will be still couple of slides are left for soil testing. So, I will be trying to finish; wrap up those slides in the next lecture first and then we will go to a new topic.

Thank you very much.