Penang Sangam High School
P.O. Box 44, Rakiraki
Year 13 Agriculture Lesson Notes Week 13

Strand	**AS 13.3 Agronomy**
Sub-Strand	**AS 13.3.1: Soils**
Content Learning Outcome	**AS 13.3.1.1 Demonstrate the assessment methods in determining the chemical properties of the soil.**

Lesson 8: Soil pH
Lesson Outcome: At the end of this lesson student should be able to
1. describe the sources of soil acidity and soil alkalinity
2. describe the effects of soil acidity and alkalinity on plant growth
3. explain ways of managing soil acidity and alkalinity

Sources of Soil Acidity
1. Respiration by plant roots and soil organisms produces carbon dioxide that reacts with water in soil to form weak carbonic acid (H_2CO_3). This contributes H^+ to the soil solution thus increasing soil acidity.
2. Mineralization of organic matter: nitrogen and sulphur are oxidized to nitric acid (HNO_3) and sulfuric acid (H_2SO_4), respectively adding more H+ ions to soil solution making the soil more acidic.
3. Natural or normal precipitation reacts with carbon dioxide of atmosphere to give a weak carbonic acid. The results of these conditions add acidity continuously to soils.

Sources of Soil Alkalinity
1. When calcareous soil is treated with dilute HCl, carbon dioxide is produced, and the soil is said to effervesce.
2. The hydrolysis of calcium carbonate produces OH^- which contributes to alkalinity in soils.
3. Mineral weathering - weathering of many primary minerals contributes to alkalinity. This is the result of the consumption of H^+ ions and the production of OH^- ions.

Effects of Soil Acidity on Plant Growth
1. Some plants simply do not grow well at a low pH.
2. The activities of many of the following organisms are reduced:
   - ✓ Nitrogen fixing bacteria that convert ammonium to nitrates
   - ✓ Organisms that break down organic matter
3. Low levels of Ca & Mg are present in soil.

Effects of Soil Alkalinity on Plant Growth
1. Excessive accumulation of salts decreases absorption of nutrients by plants and causes plasmolysis of cell cytoplasm in the plants. All these effects are responsible for stunted growth of plants.
2. Chloride salt of alkaline elements causes the death of trees. $BaCO_3$ and BaCl are toxic to all plants.
3. Excess salts in soil retards germination of seeds and growth of seedlings. Plants die before bearing fruits.

Management of Soil Acidity	**Management of Soil Alkalinity**
✓ addition of liming materials like calcium carbonate and magnesium carbonate ✓ addition of organic matter such as compost ✓ improving soil drainage	✓ addition of organic matter ✓ irrigating the field ✓ addition of gypsum or sulfuric acid to soil

Lesson 9: Ion Exchange
Lesson Outcome: At the end of this lesson student should be able to
1. define ion exchange
2. describe cation and anion exchange capacity
3. describe how cations and anions are formed in a soil solution
4. explain how micelles are formed
5. list the sources of ions in the ion pool and how ions are lost from the ion pool
6. discuss the importance of cation exchange capacity in nutrient management

1. Cation exchange capacity - is the interchange between a cation in solution and another cation on the surface of negatively charged particle material such as clay or organic colloid

2. Ion exchange - involves cations and anions that are adsorbed from the solution into negatively and positively charged surfaces respectively.

3. Anion exchange capacity - the sum total of exchangeable anions that the soil can adsorb.

4. Adsorption - exchangeable with another ion in soil solution e.g. Ca^{2+} is adsorbed to $So4^{2-}$ ions in soil solution.

5. Absorption - minerals or ions are taken up by roots from soil solution for their use.

6. Mineralization - the conversion of an element from an organic form to an inorganic state as a result of microorganism activity.

2019 – Distinguish between anion exchange and cation exchange. (2 marks)

***Of the two exchange processes, cation exchange is of greater abundance in soils than anion exchange.

2018 – List one way in which ions are supplied to the ion pool in the soil solution (1 mark)

Sources of Ions to the Ion Pool
- ✓ Weathering of minerals
- ✓ Decomposition of organic matter

Loss of Ions from the Ion Pool
- ✓ Plant uptake
- ✓ Leaching
- ✓ Precipitation
- ✓ Formation of secondary minerals

Student Activity

1. Explain why negatively charged surfaces repel anion.

Lesson 9: Ion Exchange
Lesson Outcome: At the end of this lesson student should be able to
1. describe how cations and anions are formed in a soil solution
2. explain how micelles are formed
3. discuss the importance of cation exchange capacity in nutrient management

Processes of Cation Exchange Capacity

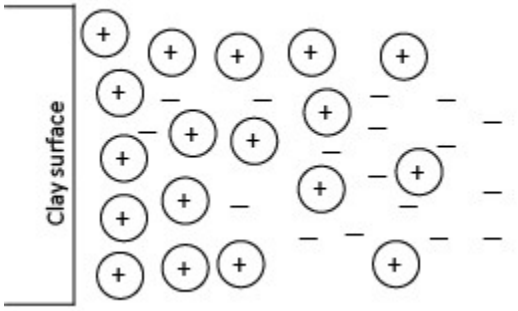
The cation exchange reactions in soils occur mainly near the surface of clay and humus particles called **micelles**. Each micelle may have thousands of negative charges that are neutralized by the absorbed or exchangeable cations.

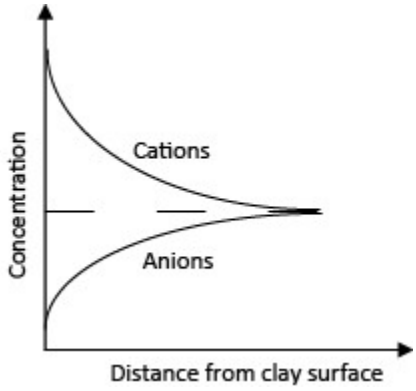
For illustration purpose assume that "X" represents a negatively charged exchange that has adsorbed a sodium ion (Na+), producing NaX. When placed in a solution containing KCl, the following cation exchange reaction occurs.

$K^+Cl^- + NaX = Na^+ Cl^- + KX$

In the reaction K^+ in the solution replaced or exchanged for adsorbed (exchangeable) cation resulting in putting the adsorbed Na^+ in solution and leaving K^+ adsorbed as KX.
Cations are adsorbed and exchanged on a chemically equivalent basis that is one K^+ replaces one Na^+ and two K are required to replace or exchange for one Ca^{2+}.

Clay Double Layer





2018 – Describe one feature of the relationship between cations and clay micelles. (2 marks)

2020 – Explain one major feature of the relationship between cations and anions and clay micelles. (2 marks)

1. Concentration of cations is greatest near surface of micelle surface (clay surface) where negative charges are the greatest.

2. Charge strength decreases rapidly with increasing distance away from micelle. This results in a decreasing concentration of cations and increasing concentration of anions.

3. At some distance from the micelle surface, the concentration of cations and anion is equal. Therefore equilibrium tends to be established

4. Roots absorb cations from the soil solution and upset the equilibrium.

5. The uptake of a cation is accompanied by excretion of H^+ from the roots and this restores the charge equilibrium in both the plant and soil.

Importance of Cation Exchange Capacity in Soil Nutrient Management

- ✓ It indicates the nutrient holding capacity of a soil.
- ✓ It determines how often and how much lime must be applied.
- ✓ It determines how crop nutrients other than lime can be applied.

On high cation exchange capacity soils anhydrous ammonia is the cheapest form of nitrogen fertilizer. On low CEC soils it may leach through the soils after heavy rain or escape in the atmosphere.

2018 – State one importance of Cation Exchange Capacity (CEC) in soil management. (1 mark)

Implications of Cation Exchange Capacity

1. The higher the CEC the more clay or organic matter present in the soil which means greater water holding capacity than low CEC (sandy) soils.

2019 – MC No. 9

2. Low CEC soils are more likely to develop potassium and magnesium deficiencies.

3. The lower the CEC, the faster the soil pH will decrease with time. So, sandy soils need to be limed more often than clay soils.

4. The higher the CEC, the larger the quantity of lime that must be added to increase the soil pH; sandy soils need less lime than clay soils to increase the pH to desired levels.

2020 – Explain one effect of cation exchange capacity on the water holding capacity on soils. (2 marks)

Anion Exchange

It is the adsorption of negatively charged anions onto anion exchange sites which arise from protonation of the OH^- ions on the edges of silicate clays.

2019 – Distinguish between anion exchange and cation exchange. (2 marks)