3

ELEMENT OF CONSTRUCT 1

(Appreciate science inquiry / process skills in biology)

Learning outcomes

By the end of this chapter, you should be able to:

- ✓ *Understand how to obtain data / results and analyse/interpret them during biological investigations.*
- ✓ *Apply science process skills in biological investigations.*

Introduction

In this unit, the following topics / subtopics that are assessed under the element of construct 1 will be considered, and these are;

1. Physical and chemical properties of soil
2. Nutrition types and nutrient compounds (food tests)
3. Nutrition in animals (enzyme activity)
4. Movement of materials in and out of a cell (diffusion and osmosis)
5. Application of anaerobic respiration
6. Growth in plants (Seed germination)

3.1 Physical and chemical properties of soil

Soil is the finely divided materials that cover the earth's crust, consisting of weathered rocks, organic matter, air, water, some living organisms and mineral salts. It is a medium in which plants anchor their roots and derive the nutrients.

❖ **Soil types**

According to composition, (mainly particle size) soil is classified into three.

a. Sandy soil.

This soil type is characterised by;

- Loosely packed soil particles whose sizes range from 0.2-2mm in diameter
- Have a coarse texture
- Large air spaces Low capillarity
- Highly drained
- Poor water holding capacity/ water retention
- Rough and not cohesive

b. Clay soil

This soil type is characterized by;

- Compact particles of sizes 0.2mm
- High capillarity Poor drainage
- High water holding capacity
- Very smooth when fine and dry but becomes hard and harsh on addition of water followed by subsequent drying
- Very little/ small air spaces

c. Loam soil

This soil type is characterized by;

- Equal proportions of sand and clay particles (average particle size)
- Good humus content
- Have much decomposed organic matter
- Average water holding capacity Moderate air spaces
- Moderate drainage
- Average capillarity

Note:

Practical experiments on soil commonly investigate:

- The proportion of different soil particles
- The proportion of air
- The water retention capacity
- The rate of drainage
- Capillarity of the soil samples
- Presence of organic matter/ humus
- Presence of living organisms in the soil
- Soil water content
- Soil pH

Examples on how to obtain results of some sample experiments on soil.

1. Experiment to determine the volume of air in a soil sample

Apparatus

- Three soil samples, **X** (loam soil), **Y** (sand soil), **Z** (clay soil)
- Two measuring cylinders,
- Clean water,
- Stirring rod

Soil aeration is the amount of air contained by a soil sample. The amount of air contained in a given soil sample is experimentally measured by:
Adding a known volume of water **(a)** into a known volume of soil sample **(b)** in a measuring cylinder and mixing the two until all the air has escaped from the soil sample, i.e. until bubbling stops. The final volume **(c)** of the mixture is then read and recorded.

Volume of air **(V)** in the soil sample is obtained from:
$V = (a + b) - c$
The percentage of air in the soil sample is then calculated from:

$$\text{Percentage aeration} = \frac{(a+b) - c}{b} \times 100$$

Procedure

- ✓ Place a sample of soil in a graduated cylinder so that the soil occupies less than one quarter of the volume of the cylinder.
- ✓ Tap the cylinder until the soil is compact and there are no visible air spaces.
- ✓ Note the volume, **V1**, of the soil.
- ✓ Half fill another cylinder, which is the same size as the one containing the soil, with water. Note the volume, **V2**, of the water.
- ✓ Pour this water completely into the soil to displace the air in the soil and stir carefully. You notice that bubbles of air escape as you pour the water onto the soil.
- ✓ Note the volume, **V3**, of the mixture after the bubbles have stopped coming from it.
- ✓ Record your results in the **table below.**

	X	Y	Z
Volume of soil added/cm^3			
Volume of water added/cm^3			
Volume of mixture/cm^3			
Volume of air in the soil sample/cm^3			
Percentage of air in the soil sample/%			

2. Experiment to find out the rate of drainage of water through a soil sample

Apparatus

- 3 different soil samples (clay, sandy and loamy soil)
- 3 measuring cylinders
- 3 filter papers
- 3 funnels
- Water, stop clock

Procedure

- ✓ Fit a filter paper in a funnel
- ✓ Place the funnel in the mouth of the measuring cylinder
- ✓ Transfer four (4) table spoonfuls of **S1** in the filter paper
- ✓ Add **30ml** of water carefully into the soil and start a stop clock.
- ✓ Record the time taken for the water to stop draining from the funnel.
- ✓ Measure and record the volume of water filtered out of the soil.
- ✓ Repeat the procedures above using soil sample **S2.**
- ✓ Record your results in the table below:

Soil sample	Time taken for the water to stop draining/ seconds	Volume of water filtered out of the soil/ ml
S1		
S2		

3. Experiment to compare the amounts of water retained by dry sandy, loamy and clay soils

Apparatus

- Three dry soil samples of sandy, loamy and clay soils
- Three filter funnels
- Four measuring cylinders
- Cotton wool

Water retention depends on the structure of the soil. Soils with small closely packed particles have poor drainage and therefore retain a lot of water. Soils with large spaced particles retain very little water. To determine the amount of water retained we subtract the water filtered from the amount of water added.

Percentage of water retained = $\frac{\text{water retained}}{\text{Water added}}$ X 100

Procedure

- ✓ Plug the neck of each of the filter funnels with cotton wool.
- ✓ Place about 25.0cm^3 of sandy soil in the first funnel, an equal volume of loamy soil in the second and an equal volume of clay soil in the third.
- ✓ Stand the funnels in the necks of three 100ml measuring cylinders.
- ✓ Pour 50.0cm^3 of water on to each soil sample and allow it to drain through.
- ✓ When no more water is dripping through from each funnel, measure the amount of water in each cylinder.

Results

Tabulate your results as follows

Type of soil	Volume of water added to soil/cm^3	Volume of water collected in cylinder/cm^3	Volume of water retained/cm^3
Clay soil	50.0		
Sandy soil	50.0		
Loam soil	50.0		

❖ Soil pH.

This is the degree of acidity or alkalinity of the soil. Most soils in the tropics are acidic but some are alkaline.

Soil pH affects the rate at which mineral salts e.g. nitrogen, phosphorous, iron are absorbed by plant roots. Most plants grow best in slightly acidic or neutral soil.

Aim: An experiment to determine the soil pH

Apparatus:

- Fresh soil sample,
- Distilled water,
- Universal solution and
- Indicator chart.

Procedure:

✓ Place about 3g of soil on petri dish and soak it with universal indicator. Leave it for about 2 minutes.

✓ Tilt the petri dish so that the indicator drains out of the soil and then compare th indicator colour with the indicator chat.

Alternatively:

✓ Soak the soil sample with distilled water.

✓ Drain off / filter off the water and test it wit the universal indicator solution or univers indicator papers.

+ Worked example

Item:

*An investor wishes to establish a commercial wetland rice growing scheme in Uganda. The government h two pieces of land **A** and **B** from which to allocate the investor for the scheme. The soil analysis experts hav carried out investigation on the soil samples obtained from the two pieces of land and established that the soi from both lands have good properties in terms of soil air, humus and microorganisms that can support th crop. However, more investigations and tests have been recommended on the soils to decide the best land fo the crop.*
*Soil samples **A** and **B** have been collected from the two pieces of land.*

Task:

*Carry out an investigation on the two soil samples **A** and **B** to determine which of the two is suitable for ric growing.*

Unknowns
***A** – sandy loam soi*
***B** – pure clay soi*

Expected responses:

Title:
An investigation on the two soil samples to determine one suitable for wetland rice growing.

Aim:
To determine the suitable soil sample for wetland rice growing.

Hypothesis:
*Both soil samples from lands **A** and **B** are suitable for growing wetland rice.*

Materials/ requirements/ apparatus:

- *Soil samples A and B.*
- *Measuring cylinder (100mls) (2)*
- *Funnels (2)*
- *Filter papers*
- *Water*
- *Beakers*

Procedures.

- ✓ *Two filter papers are folded into a cone and each placed in respective filter funnels.*
- ✓ *The filter funnels with filter papers are each mounted on a measuring cylinder.*
- ✓ *Soil sample **A** was poured into one of the filters up to half way the paper. The measuring cylinder and apparatus was labelled **set up A.***
- ✓ *Soil sample **B** was poured into the other funnel up to half way the paper. This is labelled **set up B.***
- ✓ *30cm^3 of water was poured into each filter funnel and the set up allowed to stand for 40 minutes*
- ✓ *After 40 minutes, the volume of water collected in each measuring cylinder are recorded.*
- ✓ *The results are recorded as below.*

Results / observation.

Set up/ soil sample	*Volume of water added (cm^3)*	*Volume of water collected (cm^3)*	*Differences in volume (cm^3)*
A	*30*	*25.5*	*5.5*
B	*30*	*10.5*	*19.5*

Analysis of results / interpretation.

*Soil sample **A** allowed much water to go through (25.5 cm^3) and retained very little water (5.5 cm^3). This soil has a low water retention and high capillarity. It also has good drainage.*
*Soil sample **B** allowed very little water to go through, and retained much water. This soil has good water retention, high capillarity but poor drainage.*
*Since wetland rice grows well in water logged areas, sample **A** would be a better soil for growing it, since soil sample A retains much water.*

Conclusion:

*Soil sample **B** is suitable for wetland rice growing than soil sample **A**.*

✦ Revision items

Item 1.1

As a result of rampant poor yields, a farmer decided to hire a new piece of land for growing beans which require well drained soils. Two soil samples A and B from different plots were brought to the farmer. However, he does not know which plot to plant which crop to avoid losses. Soil sample **A** and **B** were collected from the plots **A** and **B** respectively.

Task:
As a soil scientist, carry out an investigation on the two samples and advise the farmer accordingly.

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