For teachers

Growing plants – Does the soil make a difference?

Objectives/Competences

Objectives:

1. To have students prepare various samples of dry soil and record their observations.
2. To make student understand the role of pH for the growing of different plants.
3. To provide them with the knowledge and ability to check the pH of a soil and to modify the pH of a soil.
4. To provide students with a practical experience of examining the effect of the soil pH on the growing of a particular plant (beans).

Competences: investigative skills, team work, manipulative skills, communication skills.

Task description

In this Activity, students collect soil samples and characterize them by examining their physical appearance, water-holding capacity, sedimentation, and pH. Based on their observations, they can see that different samples of something as universal as soil can be quite different fro
m each other.

Phase 1

Do all samples look same? Do all have the same composition? In this phase, students will collect and dry samples of soil and they will examine their physical appearance.

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Is there a relation between plant growth and the pH of the soil? Yes, there is: some plants grow better in acidic soils and others in alkaline (basic) soils. This is the reason that farmers must check and modify if necessary the acidity of their farms before planting. The experimental procedure described here on the effect of soil pH on plant grow is based on Ho (1988).

Statements related to the following questions AND/OR questions such as the following must be formulated by the students at the start of the activity (Phase 1).

- Do all soils look/are similar? What is their macroscopic composition?
- Do plants grow the same in different soils?
- Does temperature, moisture, the climate and the season of the year play an important role too?
- Does addition of natural or synthetic fertilisers can improve the development of the plants?

Various soils can become acidic for various reasons. The decay of plants and dead animals has a result the formation of acidic, citric, oxalic and carbonic acids. Carbonic acid (H_2CO_3) can also result from the dissolution in rain water of carbon dioxide (CO_2) from the atmosphere. On the other hand, the soils in dry and barrow areas are usually alkaline (basic).

Phase 2

A. *Procedure for determining the pH of a specimen of soil*

The pH determination can be carried out using a variety of means. For smaller students it is instructive to prepare a series of solutions-indicators (see procedure below). The use of universal pH paper is simple and convenient. If available, a pH-meter can be used by the teacher as a demonstration, without explaining the principle of its function.

Procedure for preparing a universal indicator from red cabbage (Ho, 1988).

1) Within a beaker, we boil some finely-chopped red cabbage in de-ionised water. We keep to the boil for about 2 minutes, so that we take a deep-red extract. Then we transfer the clear liquid into another vessel, separating it from all solid residue.
2) We have ready 14 dry test-tubes, with unwritten labels attached to each one of them. We label these with numbers from 1 to 14.

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3) We add to test-tube #1 5 cm^3 of stock HCl solution with concentration 1/10 M (10^{-1} M). We mark on the label pH 1.

TAKE CARE! *When handling the acid solution, we must take care so that it will not come into contact with our skin, it should not go to the eyes. In addition, it should not be tasted, not it should be allowed to fall onto the clothes. If by any means it comes into contact with the skin, OR it goes into the eyes, we should wash immediately with plenty of water.*

4) Next, we put in a test-tube 45 cm^3 of de-ionised water, and we add to it 5 cm^3 of the above prepared solution 10^{-1} M of HCl (pH = 1). We shake the mixture carefully with a glass rod so that it becomes a homogeneous liquid (solution). We take 5 cm^3 from this and put it into test-tube #2, and mark pH =2 on the label.
5) In a similar fashion, we prepare solutions with pH = 3, 4, 5, and 6 by diluting ten times each previously solution. We mark the tubes accordingly
6) To test-tube # 7, we add just de-ionised water, and mark on it pH 7.
7) To test tube # 14, we add 5 cm^3 of stock 0.1 M NaOH solution. We mark the label pH 14.

TAKE CARE! When handling the basic solution, take exactly the same care with the HCl solution.

8) By diluting the stock NaOH solution ten times we take solution with pH = 13, and proceeding in similar fashion we prepare solutions with pH = 12, 11, 10, 9, and 8. In this way, we complete our collection of acidic and alkaline solutions, including the neutral solution.

NOTE 1: Because the above procedure is very time demanding, it is advisable to have ready in closed plastic bottles all solutions 1-14. We can show to students the preparation only of 1-2 solutions as demonstration.
NOTE 2. Because strong alkaline solutions are corrosive to glass, it is better to keep them in plastic bottles.
9) We arrange the 14 test-tubes in order from pH 1 to pH 14, and we add to each 1 cm^3 of the red-cabbage indicator. The student should record their observations in a suitable table on their notebooks.

Other indicators. We can use other vegetables instead of read cabbage or flowers or leaves, e.g. carrot, red turnip skin, onion skin, pear skin, apple skin, cherries, different kinds of tea, etc.

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B. *Procedure for modifying the pH of soil*

One way to modify the pH of acidic soil is by adding to them one of the following:

- Lime stone (*calclium carbonate*, $CaCO_3$)
- Lime (*calcium oxide*, CaO) ή
- Quick [*calcium hydroxide*, $Ca(OH)_2$].

In all cases, soil acidity is modified by an acid-base neutralization reaction. On the other hand, to modify the pH of alkaline soil we can add sulphur (S). Sulphur is acted upon by bacteria present in the soil and is turned into sulphuric acid (H_2SO_4) that neutralizes the basicity of the soil.

Phase 3

The answer to Question (c) [Which is the best pH range for the bean grow?], the instructor will lead a whole class discussion. First students should observe and compare the plant grow in the different cups, and determine the optimum pH range. Phase 3 may be concluded by a general brief discussion in class about various other factors that influence fertility of soil and the growth of plants: temperature, moisture, climate, season of the year, addition of natural or synthetic fertilisers, pesticides, genetically modified seeds. The purpose of using hothouses for plant growing in unfavourable climates or for out-of-season vegetables and fruits can be discussed too.

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