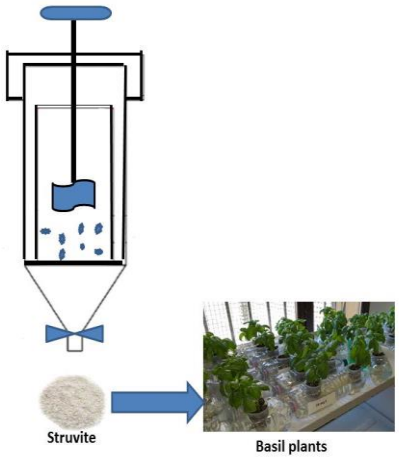
Teachers' Card

Growing hydroponic basil by using struvite



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General Introduction

The present activity is devoted to pupils **15-19 years old**. It concerns the nutrients recovery, in particular, **phosphorus** from a wide range of sources from industrial and urban wastewaters, as alternative to exploitation of **phosphate rock reserve**.

Phosphorus recovered from **mines** implicates negative environmental effects. These negative impacts occur at all stages of the **mining life cycle**, from mine development, extraction, handling, beneficiation, and waste disposal, to mine closure. However, phosphorus from **phosphate rock mining** is limited and **non-renewable resource**. Due to this, phosphate fertilizers are going to be limited in the future.

Phosphorus can be recovered from wastewaters in crystal form of **struvite** ($MgNH_4PO_4\,6H_2O$). This is also considered an ecological fertilizer. Plants have to uptake **phosphorus**, being a constituent of essential molecules such as nucleic acids, phospholipids and ATP, and, consequently, plants are unable to grow without a reliable supply of this nutrient.

Pupils are going to explore how the recovered **phosphorus** from wastewaters may be a valuable opportunity for hydroponic gardening at home. The activity is organized into 2 phases.

Link with https://ec.europa.eu/easme/en/horizon-2020-societal-challenge-climate-action-environment-resource-efficiency-and-raw-materials

Link with https://www.phosphorusplatform.eu/

Key words: basil plant, hydroponics, phosphorus, struvite, fertilizer.

Extended background information

Hydroponics is the cultivation of plants without the use of soil. Vegetables are cultivated in inert growing media rich in nutrients, oxygen and water. This system promotes the rapid growth of plants (Figure 1). Once a plant is cultivated in soil, its roots are constantly finding the nutrients needed to support the plant. If a plant's root system is directly exposed to water and nutrients, the plant does not need to exert any energy to sustain itself. Thus the hydroponic plant requires very little energy to find and break down food. In general, plants grown hydroponically are healthier and happier plants. Hydroponics is very beneficial for the environment because less water is used than soil as a result of the constant reuse of nutrient solutions. The recovery of nutrients from wastewaters and their utilisation in hydroculture, is surely the most efficient solution to preserve the environment.

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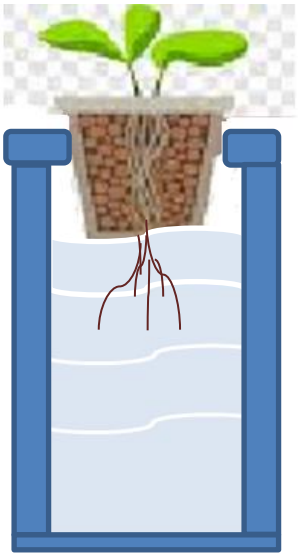

Figure 1. An example of hydroculture. The plant can rapidly absorb the nutrients contained in the solution *via* the root apparatus.

As part of the use and recycling of waste materials, it is possible to create a small hydroponic greenhouse using plastic water bottles.

It is a very simple idea, which does not need energy to power the hydroponics as it can be placed on a window sill. The aim of this experiment is to demonstrate the principles of **hydroponic cultivation** of **plants** fertilized with **struvite** obtained from previous laboratory experiment.

The use of plastic bottles, in addition to reducing costs, reinforces the concept of **circular economy** which implies recycling and reuse of products and materials.

At the end of this practical activity the students will be more responsible and interested for a variety of scientific disciplines: life and plant, ecology, sustainability, chemistry, nutrition, water and more.

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Key Competence European Framework

Literacy competence
S1. Ability to understand and interpret concepts, feelings, facts or opinions in oral and written form.
S2. Ability to express concepts, feelings, facts or opinion in written and oral form.
S3. Ability to interpret the world and relate to others.
S4. Ability to interact in an appropriate and creative way in any situation.
Multilingual competence
S1. Ability to understand and interpret concepts, feelings, facts or opinions in oral and written form.
S2. Ability to express concepts, feelings, facts or opinion in oral and written form.
S3. Ability to interpret the world and relate to others.
S4. Ability to interact in an appropriate and creative way in any situation.
S7. Ability to use technical language accordingly to the field of work.
Mathematical competence and competence in science, technology and engineering
S1. Ability to use constructed thinking in order to solve a problem in every situation.
S4. Readiness to address new problems from new areas.
S5. Capacity for quantitative thinking.
S6. Ability to extract qualitative information from quantitative data
S8. Ability to design experimental and observational studies and analyse data resulting from them.
S9. Ability to formulate complex problems of optimisation and decision making and to interpret the solutions in the original contexts of the problems
Digital competence
S1. Critical use of information technology for work
S2. Basic skills in ICT
S3. Understanding the role, opportunity and risks related to ICT in everyday life.

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Personal, social and learning to learn competence
S1. Ability to pursue and persist in different kinds of learning.
S2. Identifying available opportunities.
S3. Ability to gain process and assimilate new knowledge, skills and qualification required for career goals.
Citizen competence
S1. Ability to effective interaction with other people
S2. Ability to adapt to the changing situation, being flexible and work under pressure
S3. Ability to work effectively and collaborate with other team members
Entrepreneurship competence
S1. Awareness of local, national, European culture heritage and their place in the world
Cultural awareness and expression competence
S1. Ability to turn idea into action
S2. Creativity/innovation
S3. Ability to plan and manage tasks
S4. Independence, Motivation and Determination

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United Nations' Sustainable Development Goals

The Sustainable Development Goals are the blueprint to achieve a better and more sustainable future for all. They address the global challenges we face, including those related to poverty, inequality, climate change, environmental degradation, peace and justice.

Please indicate which goal/s can be linked to this activity

✓	Enable access to basic services		Equal access to global expertise
	Safe medical devices		Sustainable urbanization
	Access to education	✓	Responsible consumption and production
	Less hardship, more opportunities		Strengthen resilience, reduce disaster impact
✓	Safe and affordable water	✓	Reduce marine pollution
	Energy – the golden thread	✓	Sustainable use of terrestrial ecosystems
✓	Safety of workers and economic growth		Promote peaceful and inclusive societies
	Resilient infrastructure and sustainable industrialization	✓	Better access to technology and innovation

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Lab Procedure/Activity

The aim of this experiment is to demonstrate the principles of **hydroponic cultivation** of **basil plants** fertilized with **struvite** obtained from previous laboratory experiment (see Tool Kit: Struvite recovery, Module 1). Basil plants must be purchased by a nursery. It takes one or two days for acclimatization before treatment with struvite. After that, the basil plants must be flared and the roots have to be cleaned by the soil. For the growing of basil plants the special containers for hydroponic cultivation are not used. Conversely, plastic bottles that are obtained from the recycling at school or at home are reused. This procedure in addition to reducing the costs for the cultivation of basil will strengthen the concept of **circular economy.** A dosage of struvite is performed in order to evaluate the best amount of struvite useful for the basil plants. After a period of cultivation, about 3 weeks, the plants were removed by the hydroponic system and the fresh and dray weights of each treated plants were estimated.

Module 1

Learning Pathway

Step 1 - 15 minutes: Teachers do a short introduction how to manage the basil plants.

Step 2 - 60 minutes: Students are divided into groups (preferably the number of students in one group is 3 or 4). Each group is involved to prepare plants and hydroponics solution.

Step 3 - 60 minutes: Each group should evaluate the fresh and dry weight of treated plants

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Evaluation

1. To the naked eye, do all the basil plant seem grown in the same way?
   A: The plants grown with the addition of struvite should present a major growth.
   Does the root system of plants have a similar development in the three groups?
   A:Plants grown with struvite show an important development of the root system.
2. Why has a control group been inserted?
   A: In order to evaluate the outcome of the experiment and verify that the struvite affects the plants growth.
3. Which differences are detectable in the plants weight?
   A: The plants cultivated with struvite has a major growth.
4. Why has the dry weight also been determined?
   A: In order to evaluate the effective organic mass growth.
5. Try to plan an experiment in order to valuate which is the ideal struvite concentration for the basil plants growth.
   A: The control plants has got a minor fresh/dry mass than the ones cultivated with struvite, but there don't seem to be significant differences between the two groups with solutions at different concentrations. The experiment could be repeated using different concentrations, extending the cultivation for a major period.

Description of Student's Cards

Students' Card 1 *- Growing hydroponics basil by using struvite*

Sources

- Hydroponics A Practical Guide for the Soilless Grower (2016) Second Edition J. Benton Jones Jr. CRC PRESS Boca Raton London New York Washington
- Hydroponics in the Classroom.Sell, Merran School Science Review, v78 n284 p73-78 Mar 1997
- How-to hydroponics K Roberto - 2003 - http://www.futuregarden.com/
- Tutorial Video created by students after this activity

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