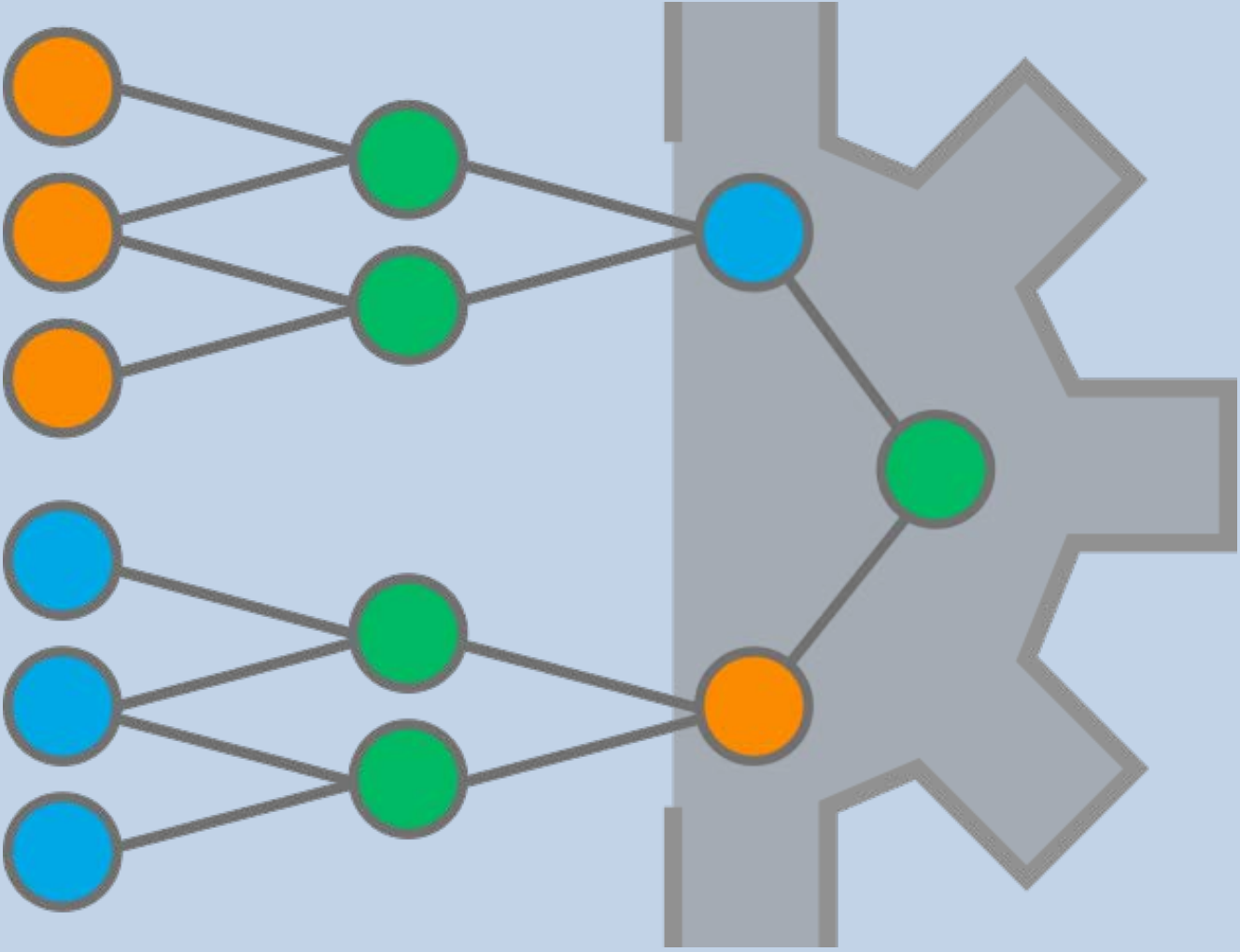

BAPR

Baltic Phytoremediation

Training module

for the BAPR Guidelines phytoremediation technologies and methods for cleaning polluted soil

BAPR BALTIC PHYTOREMEDIATION
Interreg South Baltic
EUROPEAN UNION
European Regional Development Fund

Training module

for the BAPR Guidelines phytoremediation technologies and methods for cleaning polluted soil

BAPR – Baltic Phytoremediation EU-project

Linnaeus University
Department of Biology and Environmental Science
Kalmar

2023

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Abbreviations

Ac	Activity
AF	Application Form
BAPR	Baltic Phytoremediation project
D	Deliverable
EU	The European Union
PP	Project partner
WP	Work Package

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1. Background and introduction

What is a training module? A training module is a segment of an overall e-learning course that focuses on a specific topic or objective. Each training module acts as a step in a learner's journey, each time edging closer to completing the overall course. Similar features have been faced during preparation of the BAPR training module.

It is important to have a basic platform of knowledge among all stakeholders to ensure the same level to understand the communication through networks using Triple Helix model[5] .

The basic platform of knowledge allows all stakeholders to develop and improve their knowledge and present their needs and viewpoints. Creating own training course may face the difficulties and challenges of its developing. An important residual education gap remains can be covered by university in order to strengthen the stakeholders training course. The main objective of the course will promote cooperation between the academia, industry and public sector based on the Triple Helix concept.

A graduate course in collaboration with the prominent and knowledgeable energy companies can be organized. Also a master's degree project at an advanced level could be provided and then a doctoral student position can be applied.

Entitlement

Baltic Phytoremediation – Training module

Course (module) **Learning Outcomes**

№.	**Learning Outcomes**	**Teaching / Learning Methods**	**Assessment Methods**
1	Knowledge and understanding of phytoremediation technologies	Interactive lectures, Scientific and technical material's analysis	Test, questionnaire
2	To be able to find and evaluate the situation and data required for an technological job, critically evaluate and present conclusions based on remediation technologies analysis	Case analysis (Pilot cases)	Test, questionnaire
3	To be able to deal with non-standard, loosely defined and incompletely described technological problems through innovative approaches	Case analysis (Pilot cases)	Test, questionnaire
4	To be able to work effectively independently and in a team	Case analysis (Pilot cases)	Test, questionnaire

Main aim

The main objective of the study course is to provide knowledge and understanding of phytoremediation technologies application.

[5] The Triple Helix model of university-industry-government relations was introduced in 1995 by Etzkowitz and Leydesdorff (Etzkowitz & Leydesdorff, 1995, 2000; Leydesdorff & Etzkowitz, 1996, 1998), https://doi.org/10.1002/asi.22931

Summary

Phytoremediation technology plays an important role in soil contamination's mitigation, contributes towards climate change goals' achievements and local/regional circular economy policy and practice. This course gives an overview of soil and water contamination issues as well as plants selection and use for phyto-technology. Different kind of soil pollution, its cleaning techniques and legal obstacles and perspectives will be also discussed. The course considers application of different "green" technologies combination with perspectives to contribute to biomass utilization problems. Finally, possibility to take in touch with pilot-cases design, data monitoring and analysis are given.

To understand the strategically political approach to installing pilot cases focusing on phytoremediation solutions and methods, PP1, PP3 and PP4 are responsible to set the structure of the training programs and coordinate the information for the cross-border distribution. The training program will aim at inviting external stakeholders as well, such as technology providers for BAPR solutions and energy companies in the region. The training module includes both educational elements with the industry´s top experts, as well as online tool for further increase of knowledge capacity. The module will be promoted through the website, as well as partners´ marketing channel.The module is based on the prior experiences in the WPs as well as activities 3.1, 3.2 and 3.3. in WP3.

Level of the training module: basic, bachelor or MSc, or practical/industrial stakeholders

Target groups: students, practitioners and professionals in gardening and environmental cleaning techniques, municipalities and waste management companies

Platform: Gdansk Tech e-Learning platform

Access to on-line BAPR Training module: The access to the on-line BAPR training module is open for everyone interested in this sustainable method of environmental and waste management. The access requires logging in the Gdansk University of Technology (Gdansk Tech) IT system which is possible upon contacting Gdansk Tech representatives (PP3) or LP of BAPR.

Link to on-line BAPR Training module:
Course: Baltic Phytoremediation - Training Module (pg.edu.pl)

2. Training module structure

The training module as an e-learning platform is developed at Gdansk University of Technology. It is a modern tool for on-line learning, such popular and useful during the pandemic situation. The general a plug-in module configuration webpage is shown in Fig. 2.1. The toolbar clickable icons enable to use various functions, including presentation of graphical materials, organizing on-line meetings/lectures, posting vides form YouTube, organize test or quizzes and manage a training module/course. The overview and general structure of the training module given in Figs.

2.2 and 2.3 and in Table 2.1

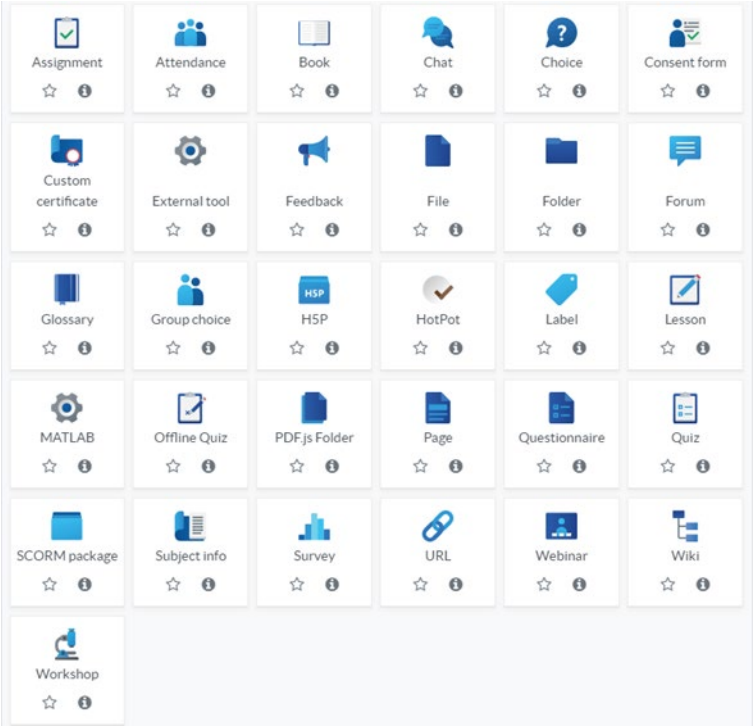


Figure 2.1. A plug-in module configuration webpage.

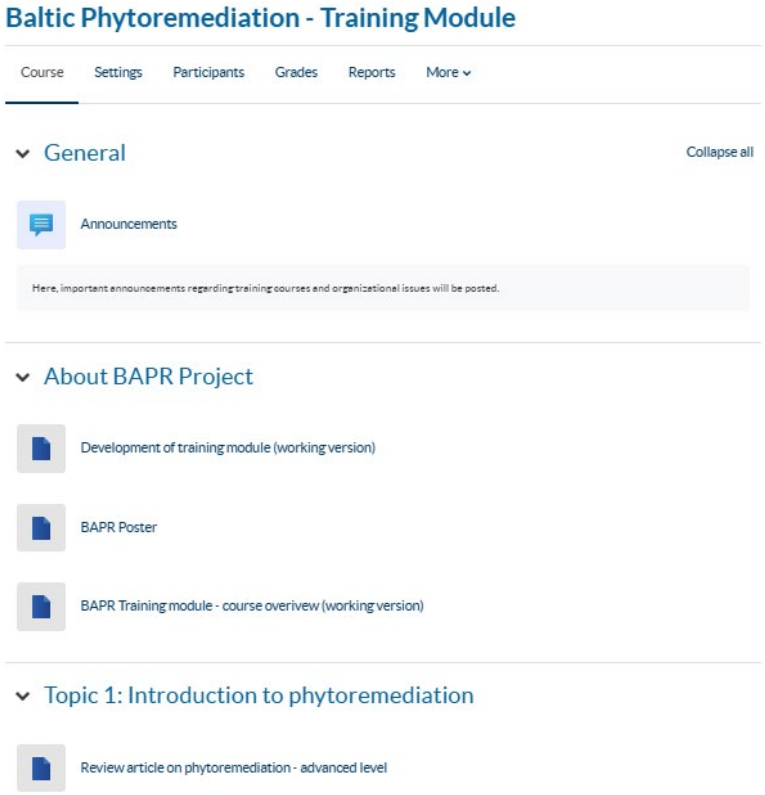


Figure 2.2. Overview of the module content (selected fragment).

Figure 2.3. General structure of BAPR Training module

Table 2.1 General content of BARP training module sections (proposal - under development)

No.	Section	Content
1	Background and aims	▪ Background of the training module ▪ About the BAPR project ▪ Aim of the training ▪ Phytoremediation – inviting short movie with expert (basics, advantages of the method, possible applications) – 2 min. ▪ Phytoremediation - general information (short notes orpresentation in pdf)
2	Instructure	▪ How to go through the training module? Instruction ofuse, short description of each section – what will be presented in each section
3	Outputs BAPR	▪ BAPR Guidelines ▪ Short introductory movie by LP about the BAPR Guidelines – 2 min. ▪ Guidelines in pdf (for download)
4	Phytoremediation in theory	▪ Here recorded lectures/presentations with written material will be presented; we may use the material we already have from the previous project seminars/workshops (these were recorded). Exemplarytopics could be as follows: o Phytoremediation in general (cleaning various compartments of environment) o Mechanisms of phytoremediation o Soil cleaning with phytoremediation: metal removal, excess nutrient removal, removal of organic pollution o Phytoremediation of post-industrials lands o Microbial-aided phytoremediation ▪ Each lecture should be for about 15 minutes, it should be about different 8-10 lectures, written material (pdf of presentation) should also be available
5	Phytoremediation in practice	▪ Here Pilot cases, success stories and industrial applications of phytoremediation will be presented. Interviews with experts, study tours in BAPR Pilot Cases will be presented (movies, written material) ▪ Solutions for phytoremediation should be presented – experts, companies or municipalities should present the available technical solutions with exemplary applications – movies, presentations or folders

		▪ Legal aspects and typical obstacles for implementation of phytoremediation, experiences from installing Pilot Cases – movie, interview, written pdf materials
6	Training courses	▪ Agendas for previous and future training courses (e.g. on-day training course) and workshops, organized within the scope of BAPR project, will be available here ▪ An offer for organizing future training courses on request of interested audience
	Forum: consultation-discussion	▪ Under this section, participants of training will have an opportunity to contact responsible persons as well as experts in phytoremediation for additional questions and discussions ▪ A forum for exchanging knowledge, news and ideas will be created
8	Supplementary materials	▪ Various materials related to phytoremediation will be available here ▪ Scientific papers, also published as a results of BAPR project, will be available ▪ QR code as associated tool for phytoremediation learning (BAPR)- LnuPlay link
9	Knowledge evaluation	▪ A test/quiz will be available for the training participants – test will be based on materials presented in sections 2,4 and 5 (QR codes quiz- Lnu- could be using) ▪ Participants who obtain more than 60% fromthe test will obtain a certificate of completion of a course under BAPR Training module

3. Materials for training module

3.1 Program of the training workshop

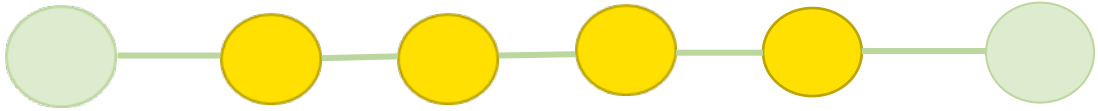
Teaching in all levels is an important way to increase the interest on remediation techniques. When selecting a plant for remediation, uptake of nutrients and targeted pollutants, lengths of roots, energy value of the crop, maintenance and final use in the circular economy or final disposal must be considered. Various techniques for remediation of soils, wastewater, surface waters, groundwater contaminated with organic chemicals or heavy metals exists. Among are those are excavation of the soil and further phytoremediation. A template schedule is given below for a one-day workshop (fig.3.1.1).

[Day, date] *[Organizer/organizers]*	
[Link to the meeting / training course or information on the place/location of the course]	
9.00 – 9.15	**Registration**
9.15 – 10.00	**Phytoremediation as a sustainable tool for cleaning environment**
10.00 – 10:30	**Removal of metal ions from soils using phytoremediation**
10.30 – 11.00	**Break**
11.00 – 11.30	**Phytoremediation for removal of organic pollutants from soils and wastewaters**
11.30 – 12.00	**Selected aspects of phytoremediation process (air cleaning, aesthetic aspects)**
12.00 – 12:30	**Phytoremediation and energy generation**
12.30 – 13.15	**Lunch Break**
13.15 – 14.00	**Formal aspects / law regulations on phytoremediation**
14.00 – 14.45	**Q&A session, discussions, closing of a course**

Figure 3.1.1. Agenda for one-day workshop.

The training course can be organized physically or in the online mode. The next template of the proposal one-day training course schedule below included several components:

15 min	45 min	30 min	30 min	60 min	45 min
(WP1-WP2)	(WP3)	(WP4)	(WP4)	(WP3)	



Introduction	Content	Content	Content	Content	Discussions
Welcome to course	Phytoreme-diation as a sustainable	Removal of metals	Removal of pollutants on phytoremediation	Legal aspects/ law regulations	Questions/ recommendations

tool

3.2 Sample annotated agenda

Which plant species and which heavy metals can be removed from the soil, initial results on the immobilisation of heavy metals in plants, whether plants used in phytoremediation can be edible, and whether it is feasible to reduce climate change using phytoremediation?

The structure of the training programs is also needed to understand the strategically political approach to installing pilot cases focusing on phytoremediation solutions and methods and to co-ordinate the information transfer for the cross-border distribution.

The training workshop is often combined of two parts: one of the information to the subject and the second part for follow-up actions and results. The experts in environmental science, practical microbiology and agriculture could possible to take part in the virtual or onsite workshops to have a possibility to dive deeper into the applications of phytoremediation to post-industrial lands and the application of microbes to aid phytoremediation process. The sample of the announcement is shown below (Fig. 3.2.1).

Fig. 3.2.1. Sample of BAPR training workshop invitation.

3.3 Laws and regulations

Stakeholder dialogues done under the project, both in Sweden[6] and in Lithuania, show some skepticism to the application of phytoremediation and other nature-based solution for the remediation of contaminated land. The predominant remediation technology in the countries involved in the project is digging up the contaminated soil and transport it to a treatment plant or a landfill.

The stakeholder dialogues touched upon legal aspects, economic incentives, and level of knowledge on phytoremediation as well as attitudes and opinions and were conducted with researchers, land-owners, consultants and public authorities.

Skepticism is rooted on uncertainties concerning the efficiency of phytoremediation, the relatively long time that the method requires, land-owners fears to be charge with liability if remediation does not work out according to plans and a lack of knowledge or availability of successful examples to be inspired on. These are some reasons why the practical implementation of phytoremediation is low in countries involved in BAPR.

With the purpose of addressing the fears on legal liability connected to the application of phytoremediation as a cleaning method, the BAPR project decided to look closer at laws and regulations in relation to phytoremediation. We hope to promote the use of phytoremediation through clarifying the actual legal issues connected to the technology.

Laws and regulations, as well as supervision and control authorities and even jurisprudence (courts decisions) tend to prevail stakeholders from applying phytoremediation for environmental protection and restoration. An interview study performed in Sweden found out that Sweden's environmental goals, the rules in the Environmental Code, liability legislation (responsibility for pollution) and the supervision authorities issuing permits (e.g. methodology for treatment of polluted areas, supervisory guidelines, etc.) influence the choice of treatment method. What scope does current legislation leave for choosing phytoremediation? Is the interpretation of laws changing as conflicts of interest between a non-toxic environment on the one side, and resource efficiency and climate challenge on the other, become more relevant?

This chapter presents a short description of some of the most important regulations in Europe and in participating countries concerning phytoremediation. The purpose is to provide an introduction to these issues and should not be seen as a comprehensive description. The chapter is based on a study produced in the frame of BAPR by an environmental law bureau in Sweden, an environmental law bureau in Lithuania and a meeting with a legal bureau in Poland.[7]

[6] White arkitekter AB and Hässleholm Miljö AB, Fytoremediering intervjustudie, 2021-09-14.
[7] Agnes Advokater, Juridisk utredning avseende möjligheten att tillämpa fytoremediering vid efterbehandling av förorenade områden, April 2022.

European legislation on soil and land treatment

While air and water protection regulations have existed for a long time in Europe, soil issues are still not comprehensively regulated. The new EU Soil Strategy for 2030, adopted by the Commission in November 2021, is therefore a big step forward. Earlier efforts to develop a comprehensive regulation on soil issues have been stopped in 2015 because of the opposition of a minority of countries in the Council[8] despite reports[9] recognizing the lack of coherent and strategic policy framework as a problem for the adequate protection of soils in Europe.

After renewed efforts, the European Commission presented a soil vision for EU in November 2021. The vision states that all EU soil systems are healthy and thus more resilient by 2050 and that the protection, sustainable use and restoration of the land must become the norm by then. Healthy land is seen as an important step towards solving all major environmental challenges in EU, e.g. achieving climate neutrality and becoming resilient to climate change, developing a clean and circular bio economy, protecting human health, reducing the loss of biodiversity and soil degradation.

The soil vision is connected to the Biodiversity Strategy for 2030 and to the Climate Adaptation Strategy. Therefore, it will contribute to several of the goals in the Green Deal as well as other EU goals. Contaminated land is only a part of the strategy. According to the goals for 2030 significant progress must be made in recovering contaminated soil. By 2050 no net land should be taken into use[10]. Soil pollution must be reduced to levels that are no longer considered harmful to human health and natural ecosystems and respect the limits of the planet.

The soil strategy presents a hierarchy for use of land. Excavated soils that are not contaminated should be reused. If reuse is not possible due to the levels of pollution, such land should primarily be recycled or reused rather than landfilled. To be able to separate contaminated soil from clean soil, a close monitoring throughout the value chain, with traceability and quality control ensured from the excavation site to the final recipient might be achieved by an “excavated land passport”, containing quantity and quality of the excavated soil.

As already stated above, the EU has so far not been able to establish a legal framework that provides soil with the same level of protection as water, air and the marine environment. Europe lacks a relevant legislation for protecting soils from contamination with two exceptions: the Industrial Emissions Directive (IED) regulating emissions from industries; and the Environmental Liability

[8] See EU Soil policy - Environment - European Commission (europa.eu), 2022.
[9] Ecologic Institute, Updated Inventory and Assessment of Soil Protection Policy Instruments in EU Member States, Berlin, February 2017.
[10] Land take is the loss of agricultural, forest and other semi-natural and natural land to urban and other artificial land development. This includes areas sealed by construction and urban infrastructure as well as urban green areas and sport and leisure facilities.

Directive that includes the polluters pay principle according to which the polluter has to pay for preventing and restoring environmental damage.

The IED regulates, among other things, emissions to air, water and land and aims to ensure that the establishment of an industry does not lead to a deterioration of land and groundwater. If the business has caused significant pollution in soil or groundwater and measures for restoration are technically feasible, the IED requires operators to restore the industrial area to the condition prior to the start of the operations according with the status report of the soil conditions. The Environmental Assessment Directive regulates environmental impact assessments in private and public projects that have a significant environmental impact. Environmental assessments must identify, describe and assess the direct and indirect effects of a project on, among other things, land.

Figure 3.3.1 - Land take hierarchy in the EU Soil Strategy 2030.

The European Commission plans to present a specific legislative proposal on soil health by 2023. The EU will also consider options for proposing legally binding provisions to identify contaminated sites, carry out an inventory and establish a register of those sites as well as recover sites that pose a significant risk to human health and the environment by 2050.

3.4. Smart teaching tools- QR code and mentimeter

To spread around information about phytoremediation and make it more popular among school children, students, citizens, tourists, stakeholders, and others, QR codes can be used. QR code, Quick Response code, invented in 1994 by the Japanese automotive company Denso Wave, 1994 a Toyota subsidiary[11]. In generally, QR code is as a label that contains information about the item to which it is attached.

[11] https://en.wikipedia.org/wiki/QR_code

QR codes have become common in consumer advertising and used over a much wider range of applications such as cashless payments, inventory checking or passenger control. It's no secret that smart phones are everywhere these days providing users with information, quickly and simply. Even kids today seem to be able to do things that are well beyond their age. The different kind of games based on to familiarize young kids with using a mobile device to scan QR codes and to be carried away from the physical world to the online world.

Creating own QR code could not be any easier. There are countless websites online that allow you to easily generate a QR code image. There are all sort of QR code generation tools online, just run them right from a website.

In 2015 a Phytoremediation/tourist Park in Orrefors in Sweden was designed on the heavy metals contaminated area. The Phyteco project, funded by Swedish Institute, was focused on an old glass landfill and remediation of the polluted soil underneath the glass dumps. Plants where used as a polishing step of the remaining soil after excavation and removal of the glass. Also to avoid wind and water erosion of toxic compounds and spreading to environment. Furthermore, the Park should also act as an educational park for school classes as well as for the tourists. The idea to using QR code, social media in a pedagogical way into the project, was suggested by prof. William Hogland at Linnaeus University. A QR-code system should have been used for dissemination of the information to the visitors so they can use mobile telephones to getting more information about the area/plants.

Some plants grown for its attractive appearance and suitable for the phytoremediation of heavy metals such targets patula, calendula officinalis or iris. Kalanchoe Blossfeldiana[12] (flaming Katy, Christmas kalanchoe, florist kalanchoe, Madagascar widow's-thrill) one of the plants that could be chosen for an educational purpose (Fig. 3.4.1). The PowerPoint of the Kalanchoe Blossfeldiana was intended to create a QR code (Fig. 3.4.2). Information will be established for dissemination information of the plants and the waste management.

The practical and learning collaborative strategy is conducted to revolve developing teaching, by formulating and answering questions. The study form of media activities could be using for a specific course at Linnaeus University- Industrial ecology. In this session, students are expected to read the material and watch the video lecture (on the topic of Phytoremediation) that is available in on the course page.

The 7 (seven) plants with the specific purification effects have been collected and coded and is available in the form of QR-code labels. Students need to access the reading material through QR codes for which it needs any suitable App that reads QR-codes. The goal of this assignment to demonstrate the relationship between mobile-based techniques and teaching, and to share some facts

[12] https://link.springer.com/article/10.1023/A:1008937417598
https://pubmed.ncbi.nlm.nih.gov/27826829/

about the plants mediated in decontamination technology using the QR code system, which is well-known for quick dissemination of the most important information.

When it comes to the test of knowledge the students will be involved in a game changer-digital voting. A web based pooling tool for online voting, Mentimeter, can be used to ask students the topic questions and get the answers. This activity is a fun and the easy-to-use online editor. Mentimeter is a web-based polling tool and is often used as it is a quick way to post questions and get answers from students´ seats, whatever they are. During the class activity, a test comprising of 5 questions (related to information that is available in QR codes) will be posed. In addition, students will discuss: what are the characteristics for the plant species used in phytoremediation? what factors should be reviewed in the phytoremediation process? In this case, more information found on the Internet or other sources might be useful. Furthermore, will discuss if the QR code can be a good means of communication idea towards students as well as stakeholders and what are the benefits and the problems when implementing the system?
Student's feedback on a successful lesson using mentimeter as an assisting tool shown in fig. 3.4.3. 16 students were actively participating during this lesson.

Figure 3.4.1. Kalanchoe Blossfeldiana (https://cibercactus.com/sv/kalanchoe-blossfeldiana/)

Figure 3.4.2. QR code for Kalanchoe Blossfeldiana (Photo: Jelena Lundström).

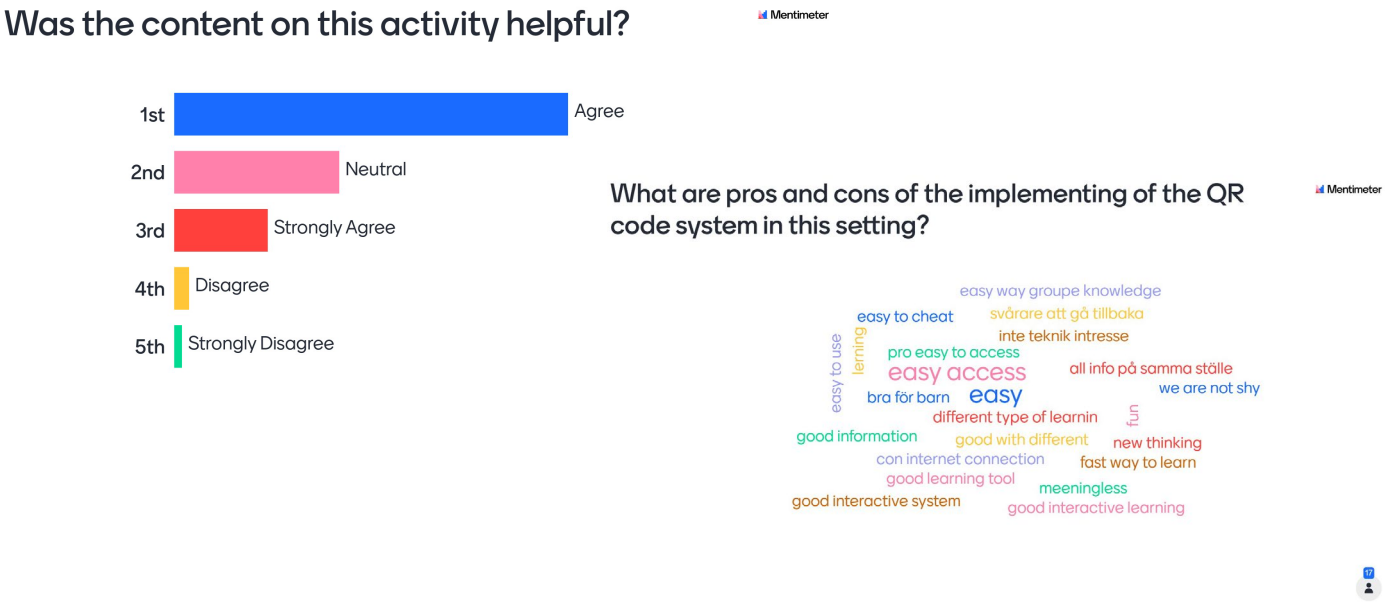


Figure 3.4.3. Student's feedback on a successful lesson using mentimeter (by Jelena Lundström).

4 Conclusions

Phytoremediation technology plays an important role in soil contamination's mitigation, contributes towards climate change goals' achievements and local/regional circular economy policy and practice. This course gives an overview of soil and water contamination issues as well as plants selection and use for phyto-technology. Different kind of soil pollution, its cleaning techniques and legal obstacles and perspectives will be also discussed. The course considers application of different "green" technologies combination with perspectives to contribute to biomass utilization problems.

Both theoretical and practical knowledge should be included in the course. The aim is to give an overview of the factors affecting soil quality, including heavy metal pollution and present the most suitable plant species for removing these pollutants from the soil. The practical and learning collaborative strategy is conducted to revolve developing teaching, by formulating and answering questions. The lessons learned how to balance macronutrients in the soil, how transfer plants from one environment outdoor to a greenhouse and select plants for specific pollutants should be included as well as specific plant cultivation methods and further use of contaminated biomass. Finally, possibility to take in touch with pilot-cases design, data monitoring and analysis are given.

Through history phytoremediation has been one of the cheapest options when compared to other remediation techniques (REF). However, in order to achieve a system that works, plant selection, maintenance and operation must be done carefully and for that, well-qualified staff is required.

5 Extra resources

1. Grzegórska, A., Czaplicka, N., Antokkiewicz, J., Rybarczyk, P., Baran, A., Dobrzyński, K., Zabrocki, D., Rogala, A. "Remediation of soils on municipal rendering plant territories using Miscanthus × giganteus", Environmental Science and Pollution Research (2022), https://doi.org/10.1007/s11356-022-23724-z

2. Grzegórska, A., Rybarczyk, P., Rogala, A., Zabrocki, D., "Phytoremediation—From Environment Cleaning to Energy Generation—Current Status and Future Perspectives", Energies 2020, 13(11), 2905; https://doi.org/10.3390/en13112905

3. Embedding a Module into an Article (Joomla 2.5) https://www.cloudaccess.net/joomla-knowledgebase/77-joomla-2-5/article-manager/113-embedding-a-module-into-an-article-joomla-2-5.html

4. Euroheat & Power

5. https://enauczanie.pg.edu.pl/moodle/course/view.php?id=22315&lang=en

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