GIG National Research Institute

Minimising coal mining's impact on biodiversity: Artificial soils for post-mining land reclamation at the example of Poland and Slovenia

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Green Mining Conference 2023

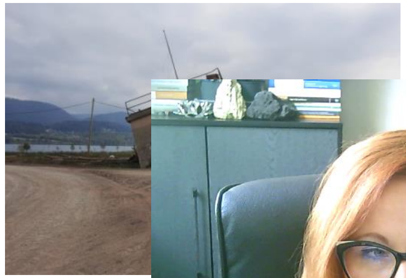
HR EXCELLENCE IN RESEARCH

INTRODUCTION

Coal mining and the energy industry generate large amounts of solid waste, which must be disposed of in landfills and lead to numerous environmental problems

Waste from coal mine or electric power plant

- Acid rock drainage (pH<3)
- Water and wind erosion
- Dust pollution
- Heavy metal pollution
- Subsidence area
- Negative impact on the landscape



AIM OF RESEARCH

The main idea of research is the safe use of coal combustion by-products, mining waste and organic waste as components for creating artificial soils for land rehabilitation of degraded areas

LAND REHABILITATION

The soil substitutes are intended to help transforming the difficult terrain of coal mine area into green ecosystems.

RFCS RESEARCH PROJECTS

Recovery of degraded and transformed ecosystems in coal mining-affected areas. Grant Agreement No 847205. www.recoveryproject.eu

The RECOVERY project focuses on land rehabilitation and ecological restoration of coal mining-affected areas, aiming to accelerate the recovery of degraded and transformed ecosystems to a good ecosystem status.

Leveraging the competitive advantages of end-of-life underground coal mines to maximise the creation of green and quality jobs. Grant Agreement No 101057789. www.greenjobsproject.eu

GreenJOBS focuses on repurposing end-of-life underground coal mines by deploying emerging renewable energy and circular economy technologies to promote sustainable local economic growth and maximise the number of green, quality jobs.

STUDY AREA OF PROJECTS

Janina Mine waste heap (Silesia, Poland), property of Tauron Wydobycie S.A. Restoration has already started in the Libiąż waste heap, being one of the most prominent objects of this kind in the eastern part of the Silesian Coal Basin. The wastes on the heap cover an area of 80 hectares, reaching a height of 35 metres.

The Velenje mining site is located in the north-eastern region of central Slovenia. It covers approximately 52 hectares and is surrounded by two artificial lakes. The land subsidence rehabilitation area was built with Stabilizat from the Šoštanj Power Plant.

COMPONENTS FOR SOIL SUBSTITUTES IN GIG LABORATORY

Recovery
RFCS RESEARCH PROJECT

WASTE MATERIALS FOR LAND REHABILITATION OF JANINA MINE WASTE HEAP IN POLAND

Coal combustion by-products + **Sludges** + **Agregate** + **Organic matter**

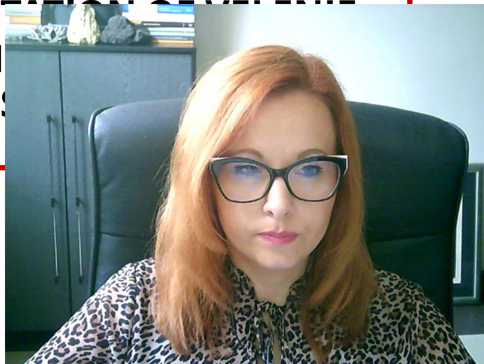
- **Coal combustion by-products**
  - **Fly ashes and slags** – *Power plant Jaworzno 3*
  - **Energetic slags** – *Power plant Łaziska*
  - **Biomass combustion ashes** – *Power plant Jaworzno 3*
- **Sludges**
  - **Sealing material** – *Sobieski coal mine*
  - **Decarbonistation lime** – *Power plant Łaziska*
- **Agregate**
  - **Mine wastes** (0-2 mm) – *Sobieski coal mine*
- **Organic matter**
  - **Sewage sludge** – *Waste water treatment plant*
  - **Spent mushroom compost** – *agricultural sector*

Green JOBS
RFCS RESEARCH PROJECT

WASTE MATERIALS FOR LAND REHABILI… SUBSI…

Coal combustion by-products + **Sludges** + **Organic matter**

- **Coal combustion by-products**
  - **Stabilizat** mixture of: fly ash (45-75 %), gypsum (10-55 %), slag (0-20 %), sludge (0-2 %) – *Šoštanj Power Plant, Velenje*
- **Sludges**
  - **Mud from technological water process** (sluges from sedimentation tank) – *Šoštanj Power Plant, Velenje*
- **Organic matter**
  - **Coal lignate** – *Premogovnik Velenje Coal Mine*
  - **Green compost from biological manufacturing process** – *Industral composting Facility*



PREPARING OF SOIL SUBSTITUTES IN GIG LABORATORY

Artificial soils suitable to several types of plant communities (A-D) as follows:

A- Soils for low vegetation of dry and poor habitats

B- Soils for low vegetation of fresh habitats

C- Soils for woody and shrub-like vegetation

D- Soils for vegetation of wet and humid habitats

In Slovenia, coal lignite from PV Coal Mine, due to its high organic matter content, is a valuable component of soil substitute. However, to improve soil characteristics such as texture, fertility, water-holding capacity and structure, it is essential to apply other organic materials in the form of ecologically friendly compost from a biological manufacturing process.

PHYSICOCHEMICAL ANALYSIS OF COMPONENTS AND SOIL SUBSTITUTES IN GIG LABORATORY

CHEMICAL ANALYSIS:

- ✓ Chemical composition [mg/kg]: *N, P, K, Ca, Mg, Na, S, Cl, Cu, Zn, Fe, Mn, Pb, Cd, As, Ni, Cr;*
- ✓ Dry matter [%];
- ✓ Organic matter [mg/kg].

ANALYSIS OF WATER LEACHATES:

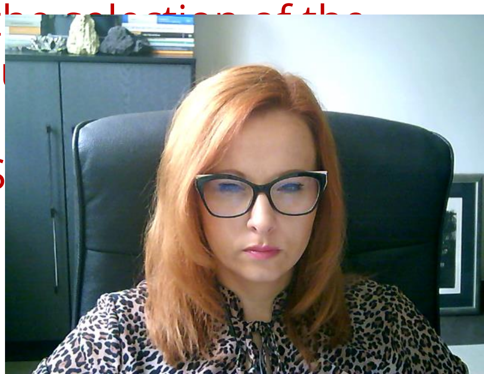
- ✓ pH;
- ✓ Electrical conductivity [ms/m]: EC (salinity);
- ✓ Metal and nonmetal ions [mg/l]: *N-NH_4, N-NO_3, $(PO_4)^{3-}$, K^+, Ca^{2+}, Mg^{2+}, Na^+, $(SO_4)^{2-}$, Cl^-, Cu, Zn, Fe, Mn, Pb, Cd, As, Ni, Cr.*

PHYTOTOXICITY TESTS OF SOIL SUBSTITUTES IN GIG LABORATORY

Phytotoxicity tests with **white mustard *(Sinapis alba)*** determined which of the components and developed soil substrates have the best plant growth-stimulating properties.

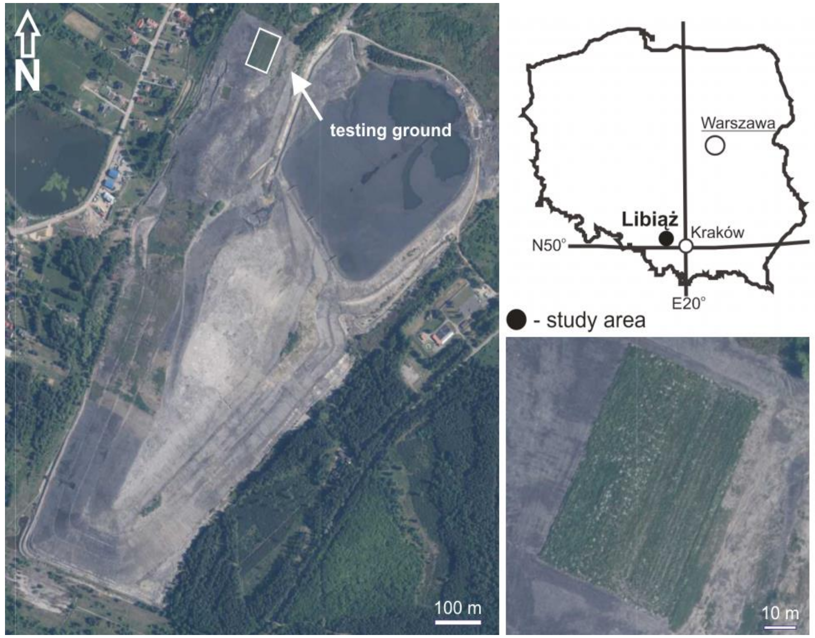
Elaborated soil substitutes have been subjected to further phytotests with ***flower meadows*** and ***calcicole plants***.

Observations and data gathered throughout the whole experimental process have finally enabled t
most promising soil s
land rehabilitation of
areas in Poland and S



POLYGON TESTS ON THE JANINA WASTE HEAP

Polygon tests were created in real acidified conditions and exposed to erosion Janina waste heap in Libiąż.
The area of the testing ground covers 4000 m^2.



Field work on testing ground was started in October 2020.

Materials for construction of the testing ground inclu

- Soil substitutes (800 m^3)
- Sealing material in the form of coal mud (200 m^3)
- dolomite aggregate (400 m^3)
- geotextil (2000 m^2)

THE CONCEPT OF MAKING EXPERIMENTAL RECLAMATION

Recovery
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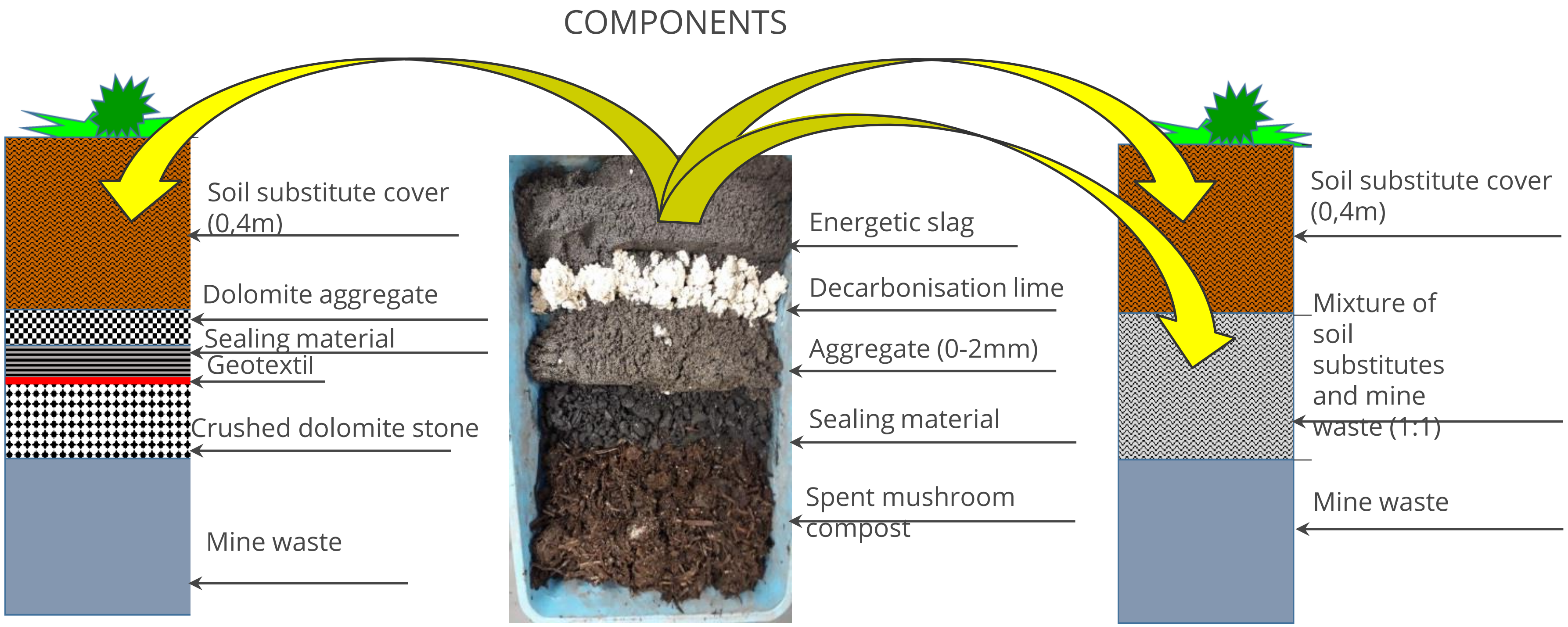
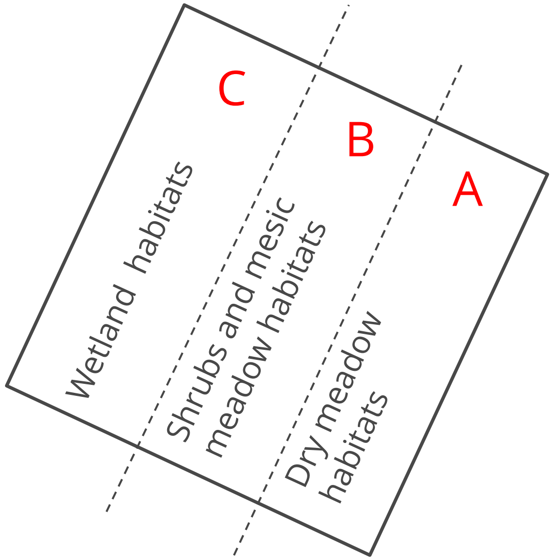
Model profiles of tested covering on the heap of Janina Mine



Technology of multi-layer cover

Technology of two-layer cover

ORGANIZATION OF TESTING GROUND



FIELD TESTS ON THE TESTING GROUND

Species	Soil cover	Height (cm)	Units
Wild privet *(Ligustrum vulgare)*	B	40±5	120
Common dogwood *(Cornus sanguinea*)	B	35±5	120
Sea-buckthorn *(Hippophae rhamnoides)*	B	25±5	120
Common hawthorn *(Crataegus monogyna)*	B	25±5	120
Common red *(Phragmites australis)*	C	-	1000

Recovery
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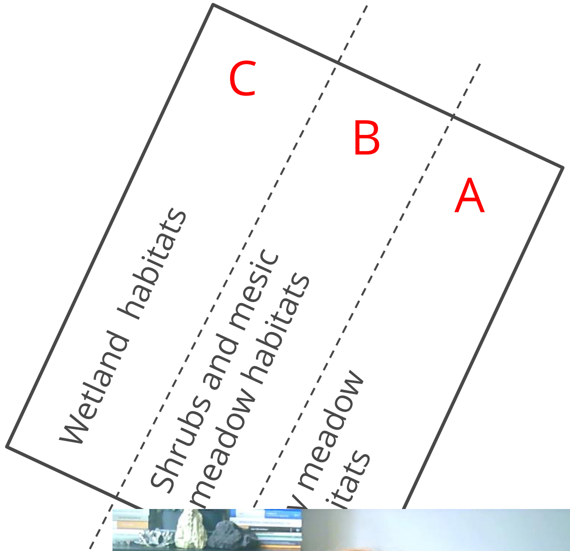
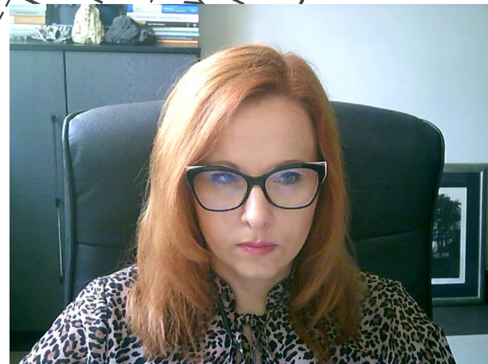
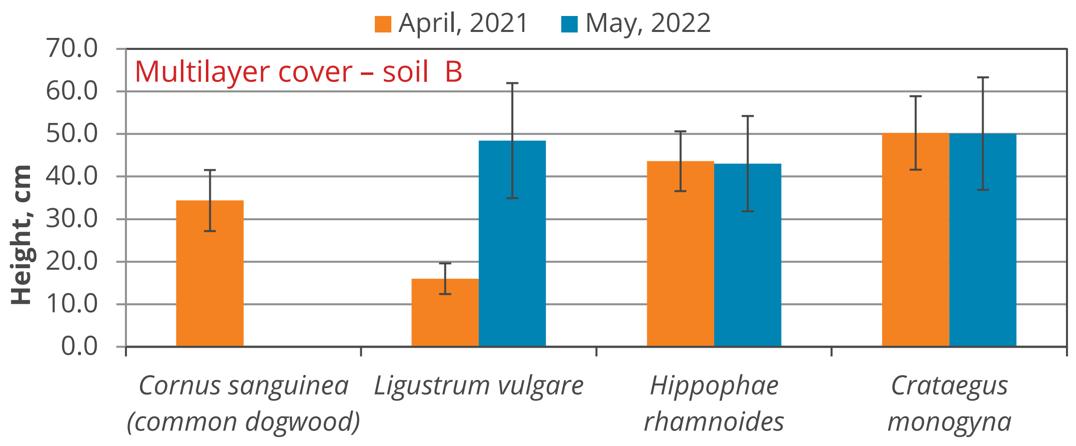
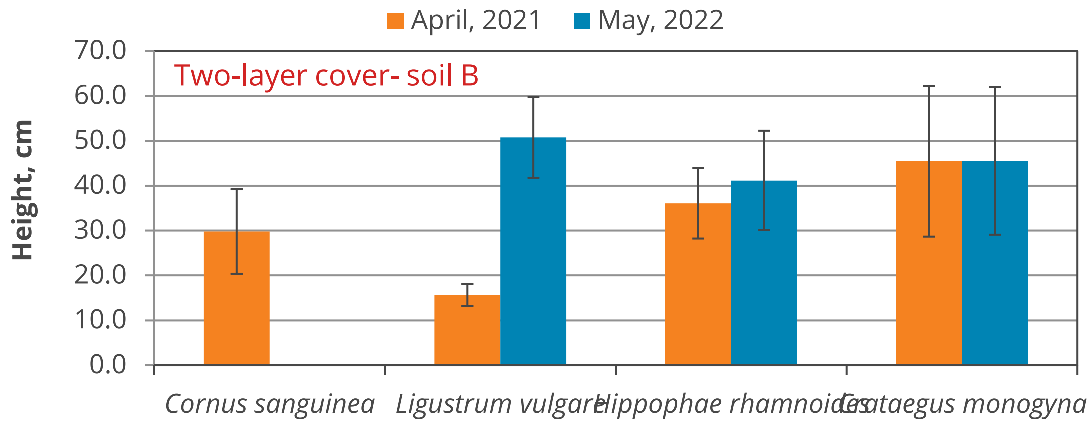
The plantation of shrubs and wetland vegetation, as well as the sowing of meadow sedes on the testing ground, was carried out in November 2020

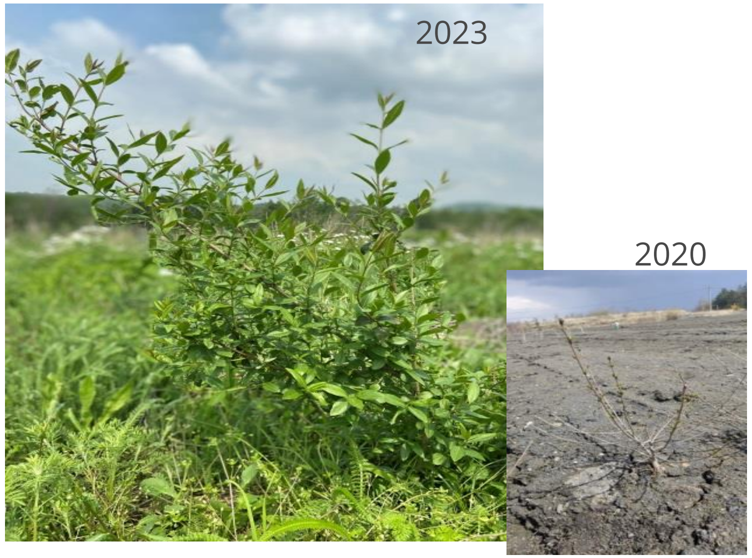




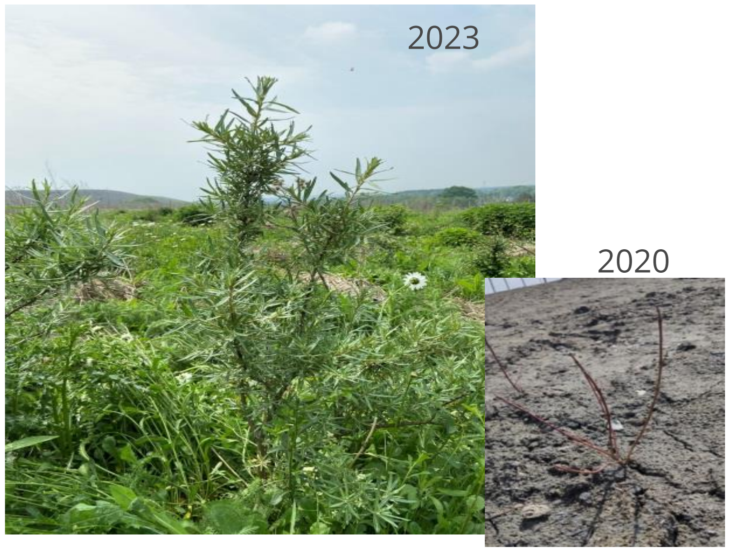
THE RESULTS OF THE SHRUB VEGETATION



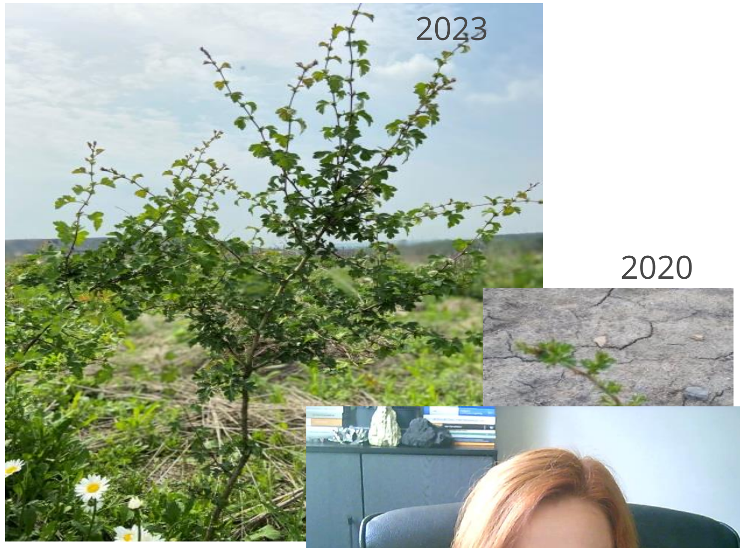




Ligustrum vulgare
Wild privet



Hippophae rhamnoides
Sea-buckthorn



Crataegus monog
Common hawth

THE RESULTS OF WETLAND VEGETATION

Common red *(Phragmites australis) in the first and after two years of vegetation* on soil cover C.

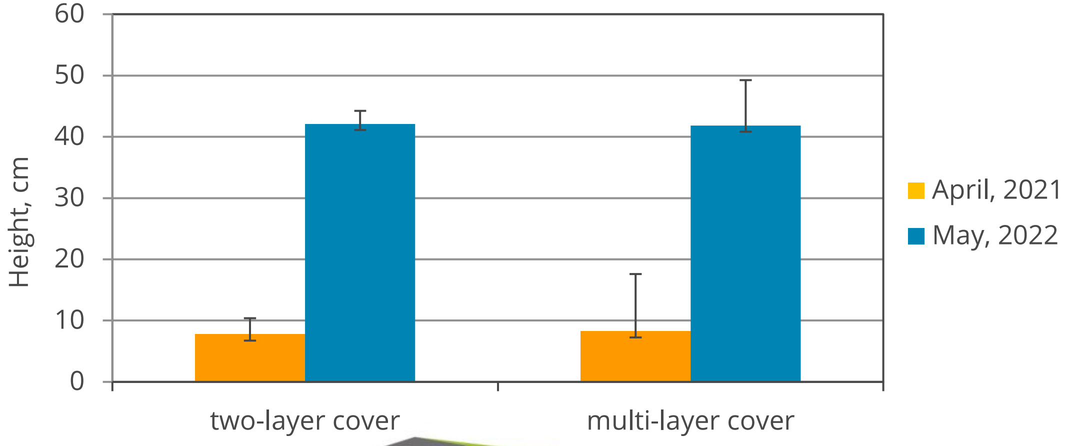
April 2021

June 2021

May 2022

August 2022

May 2023



There was no difference between the average height of the plant at the two-layer cover and the multi-layer cover.

THE RESULTS OF MEADOW VEGETATION

Recovery
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Mesic meadow vegetation
(soil substitute B)

Dry meadow vegetation
(soil substitute A)

Development of meadow vegetation using soil covers

The example of insects observed on the testing ground in Janina Mine waste heap after land reclamation

PHYSICOCHEMICAL CHARACTERISTICS OF SOIL SUBSTITUTES DURING VEGETATION

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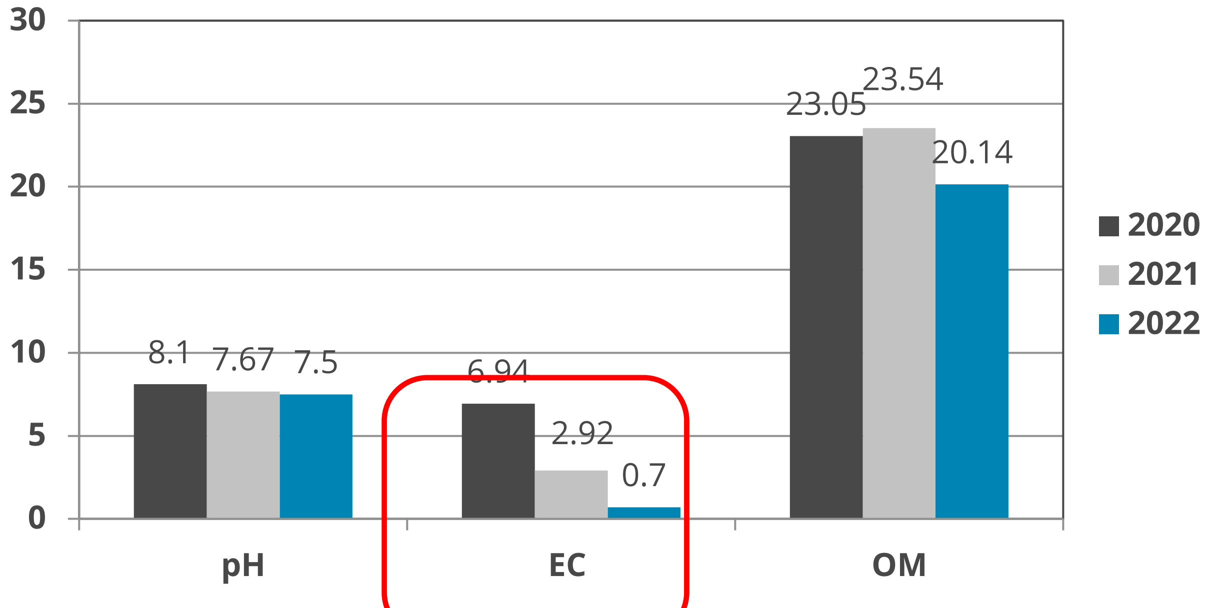
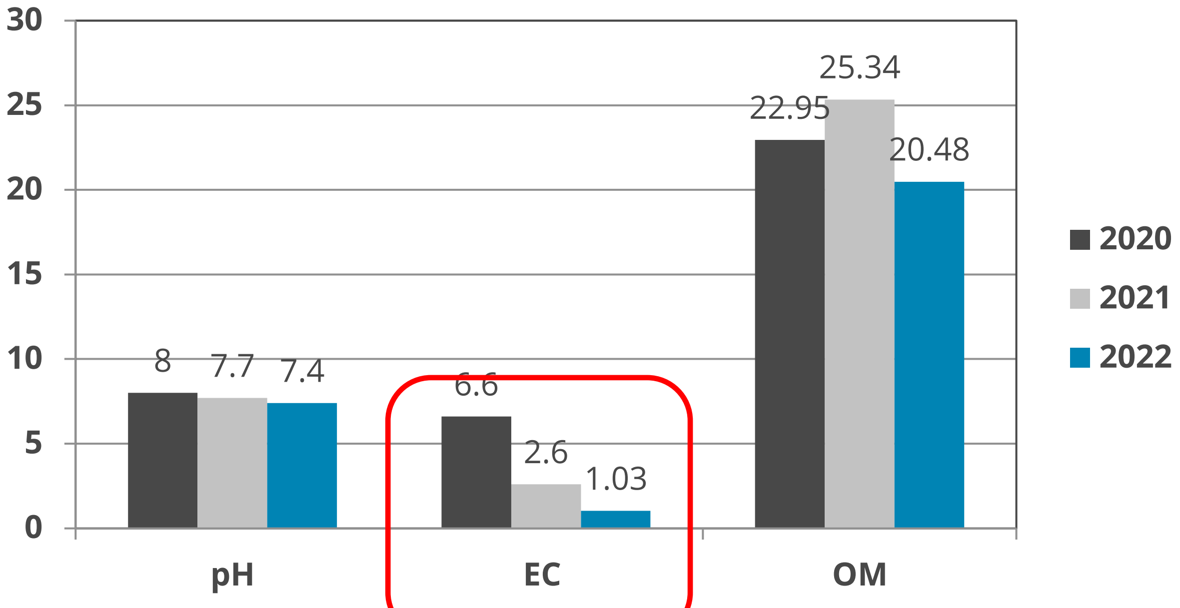
Soil substitute-A



Soil substitute-B

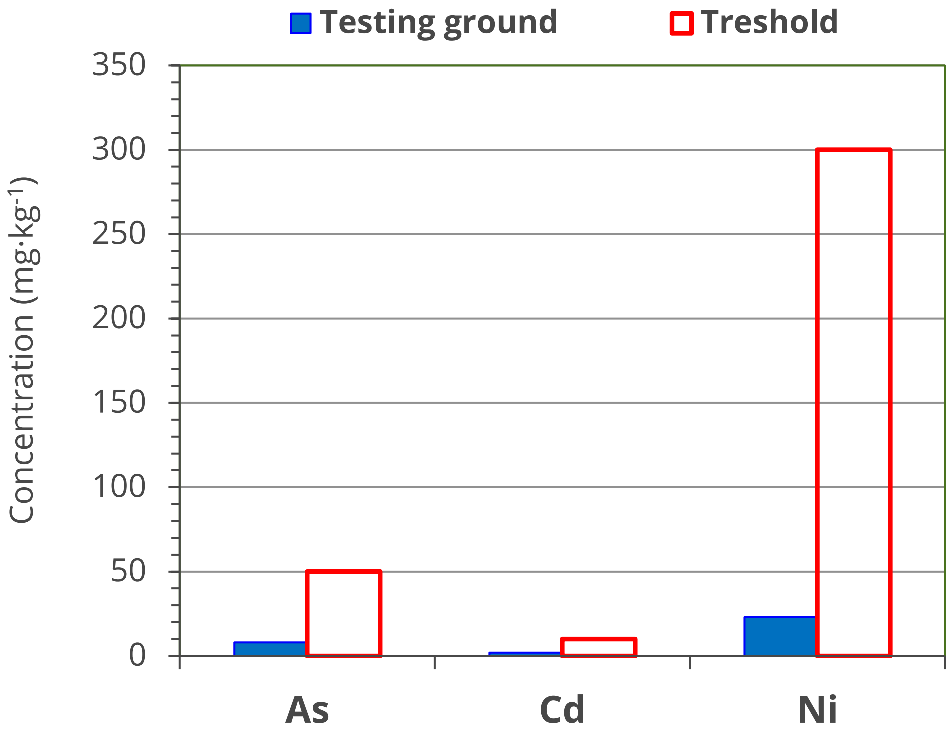


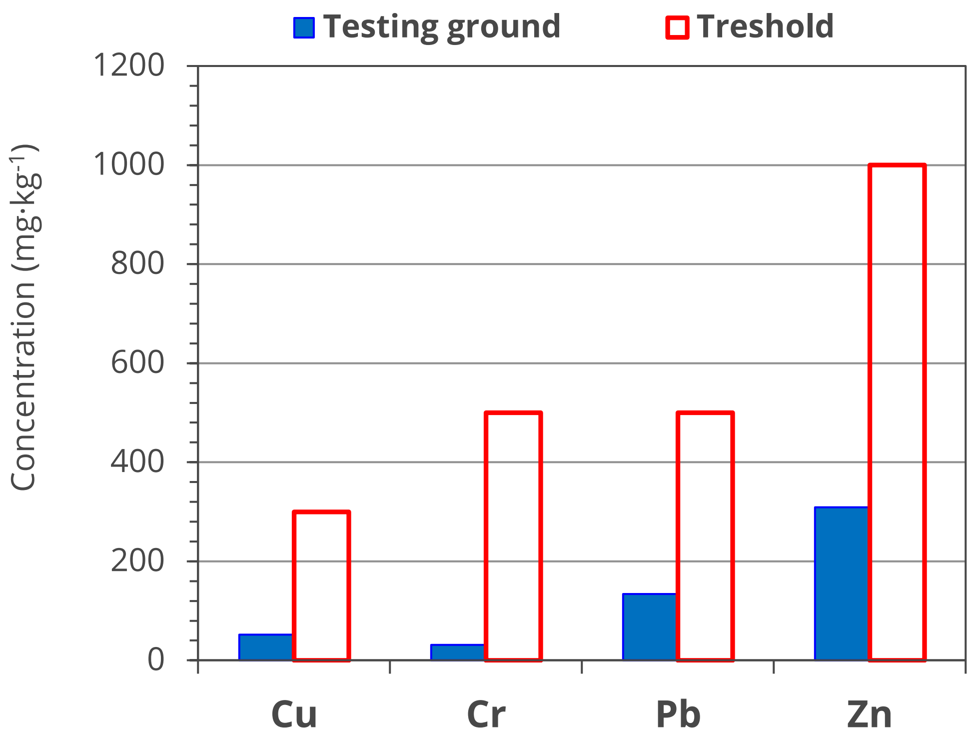
EC – electrical conductivity [mS·cm^{-1}]
OM- organic matter [%] → C, H,O, S, N, P

Eighteen months after the start of vegetation, the soil covers are characterised by a neutral pH and low EC values.

The analysis confirmed that decreasing soil salinity positively affected ruderal and dry meado
In contrast, high salinity levels did not adversely affect mesotrophic meadow vegetati

THE CONCENTRATION OF HEAVY METALS IN SOIL COVERS DURING VEGETATION





The concentrations of toxic heavy metals in soil covers did not exceed the permissible thresholds for soils classified in Group III, i.e., wooded and shrub lands as well as green areas *(Minister of Environmental Pro*

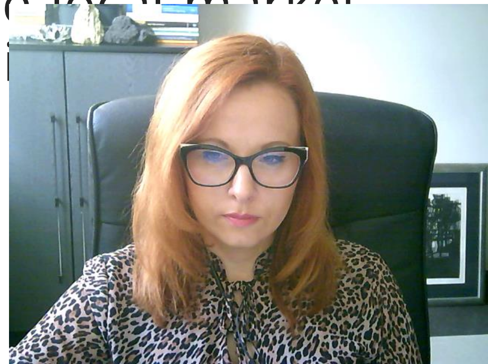
THE TESTING GROUND OF JANINA WASTE HEAP BEFORE AND AFTER LAND REHABILITATION

RECOVERY RFCS RESEARCH PROJECT

The results of land rehabilitation of the Janina Waste heap demonstrated that applying soil covers elaborated from industrial by-products is a valuable circular economy approach for recovering coal mine-affected areas.

CONCLUSIONS

- The results demonstrated that applying soil substitutes made from industrial by-products and organic waste is a valuable method for recovering coal mine-affected area.
- The obtained data on physicochemical parameters of the soil substitutes showed a promising opportunity for implementing them for the reclamation of high acidity coal mine waste heap.
- Applying the soil substitutes on the waste heap showed spontaneous successions of mesic and dry meadow species after the second year of vegetation.
- Vegetation with various flower species has high esthetic values of reclamation waste heap areas developed and the potential for delivering ecosystem services.
- More expensive multi-layer technology is recommended on the part of the heap where an intensive process of rainwater infiltration occurs and the risk of acid drainage appearance is high (e.g. flat top of the heap)
- Before developing soil substitute mixtures for land rehabilitation, exploring the local market for suppliers of their components (industrial by-products and waste and organi essential.



THANK YOU FOR YOUR ATTENTION