UTILIZATION OF ENERGY CROP's MISCANTHUS × GIGANTEUS BIOMASS CULTIVATED IN THE POST-MINING AND POST-MILITARY SOILS

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in Ústí nad Labem, the Czech Republic

International Conference Contaminated Sites 2022
Selec, Slovakia
October 12-14, 2022

TECHNISCHE UNIVERSITÄT DRESDEN

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FPT FOR PAPER TECHNOLOGY

END USER COMMITTEES: GERMANY AND THE CZECH REPUBLIC

07/2020 – 12/2022

PRODUCTION OF MXG BIOMASS AT THE POST-MINING SITES AND ITS UTILIZATION AS BIOPRODUCTS

THE MAIN GOAL OF THE PROJECT IS to ensure a complete Miscanthus value chain from sustainable land management at different marginal lands through cultivation, harvest, storage, to biomass processing to fibres, pulp, fibrous materials and packaging paper. Simultaneously, Miscanthus waste produced during processing and from contaminated plant tissues from the field is utilized by pyrolysis to energy and biochar used at the fields again.

WORKING PACKAGES:

WP 1: Ensuring sustainable miscanthus utilization at post-mining and marginal, including military lands

WP 2: Miscanthus biomass pre-processing for converting to fibres and pulp

WP 3: Miscanthus Waste Utilization

WP 4: Production of Miscanthus fibre and pulp

WP 5: Paper and packaging products from Miscanthus

WP 6: Materials based on natural fibres from Miscanthus

WP 7: Value chains for Miscanthus-based sustainable products

WP 8: Dissemination and coordination

END-USERS COMMITTEE

GERMANY

User committee consists of companies working in the following areas:

- Agriculture and bioenergy
- Mechanical engineering
- Paper production
- Wood-based material

CZECH REPUBLIC

Bioimpro s.r.o.
Lipská 4705, 430 03 Chomutov

Wekus spol. s.r.o.
Lipská 4705, 430 03 Chomutov

AGMECO LT s.r.o.
Türkova 828, 149 00 Praha 4, Chodov

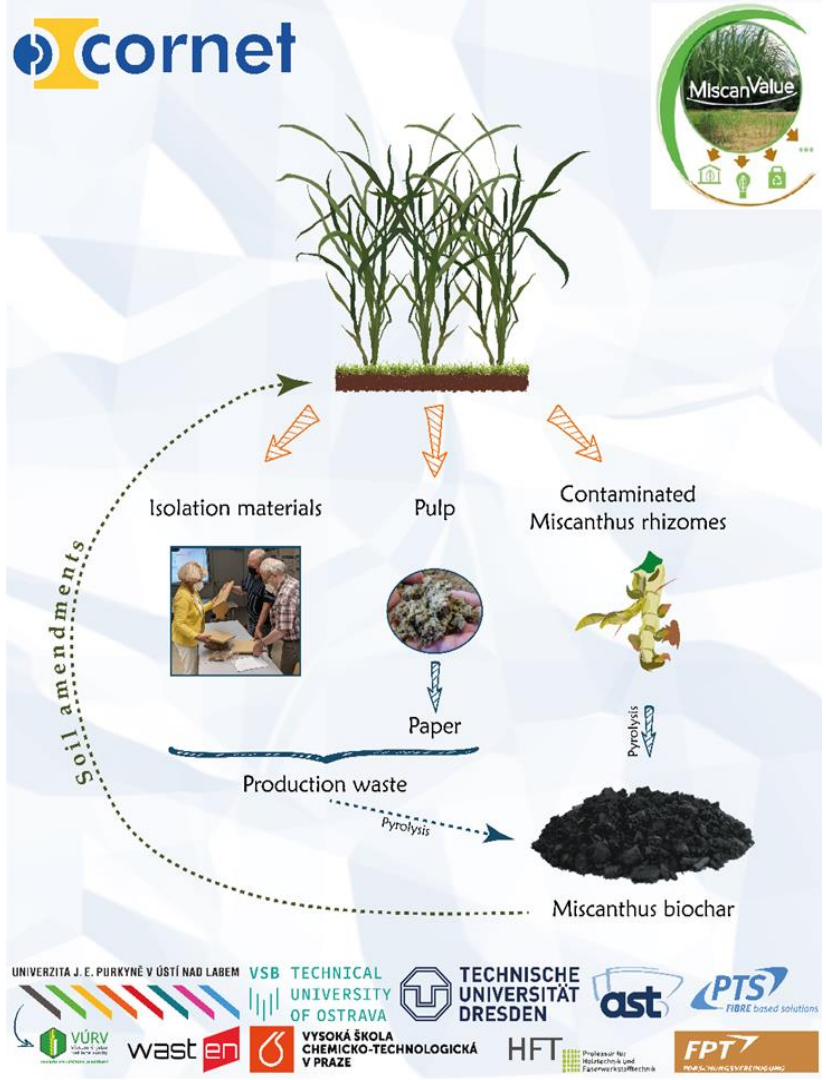
ENRESS s.r.o.
V zářezu 902/4, 158 00 Praha 5, Jinonice

VIA ALTA a.s
Nádražní 377, 675 21 Okříšk

Euroforum Group a.s.
K Roztokům 220/47, 165 00 Praha 6, Suchdol

E&H services a.s.
Žitná 1633/47, 110 00 Praha 1, Nové Město

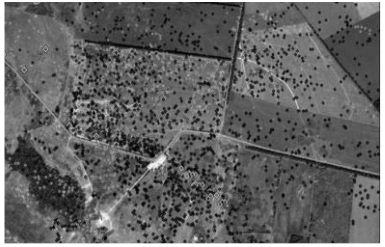
SAPRIL s.r.o.
Skyřická 221, 434 01 Most, Vteln



PRODUCTION OF MXG BIOMASS AT THE POST-MILITARY SITES AND ITS UTILIZATION FOR ENERGY (PROJECT SPS MYP G4687, 2016-2021)

Former military sites: after activities of the SU Army





Since beginning in 2014 a war for Ukrainian Independence against Russia numerous new military contaminated sites appeared at the Eastern part of the country polluted by metals, oils and products of their decompositions.

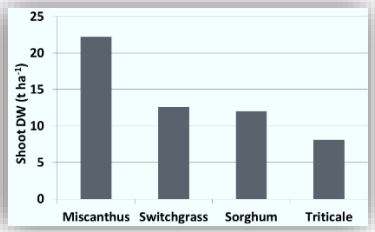
2014 - 24.02.2022

The military sector has recently become seriously engaged in environmental site investigation and remediation and often is technologically behind the civilian sector. Soil and groundwater deterioration is the most common problems and also the most expensive to rehabilitate. Hydrocarbons (petrol, diesel, kerosene) are the dominant pollutants found at military bases. Other common contaminants are chlorinated hydrocarbons and trace element, in some cases PCB and other chlorinated hydrocarbons are special problems.

MISCANTHUS × GIGANTEUS

- Perennial grass: growth up to 25 years
- Stem height: 3 - 4 m
- High shoot productivity: 15 - 30 t DW ha^{-1}
- Low production inputs
- Soil stabilization
- CO_2 sequestration
- Non invasive species

BIOMASS WITH MULTIPLE USES



Cadoux *et al*, 2013

Ivanivka, Ukraine

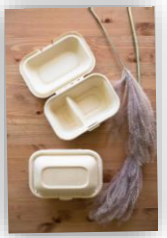
HEAT

BIOFUEL

MULCH

ANIMAL BEDDING

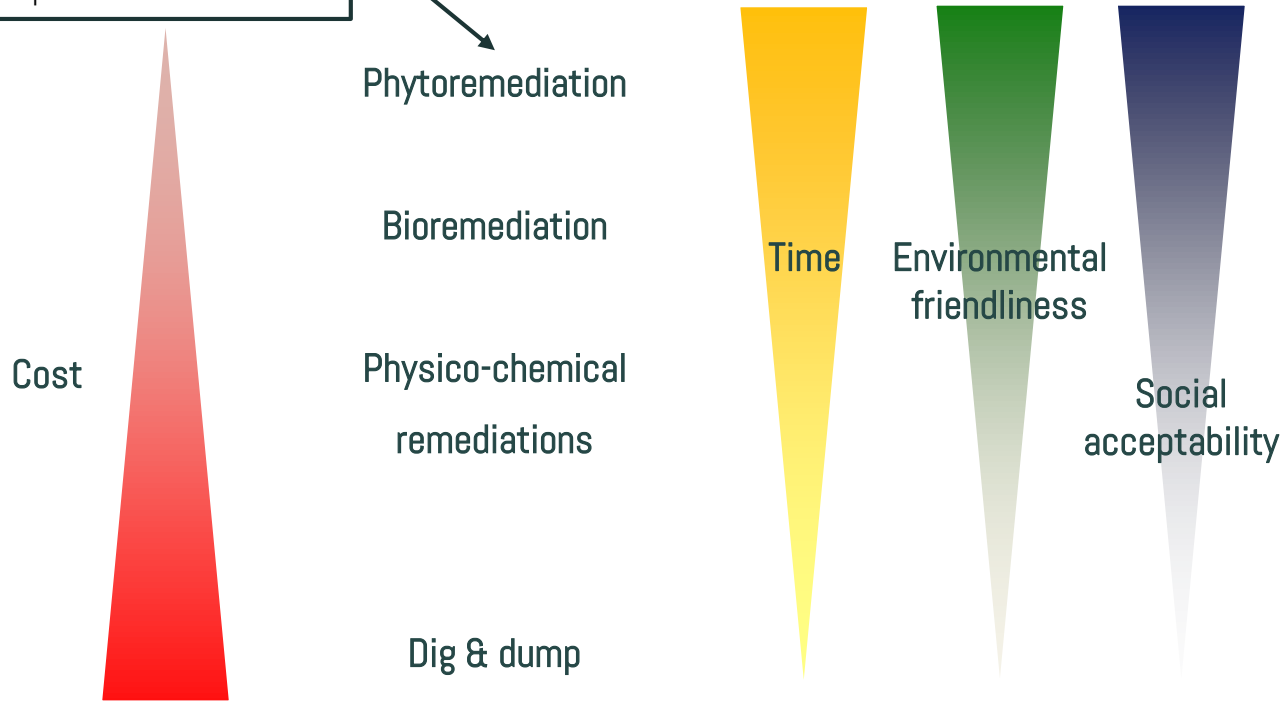
BUILDING MATERIALS



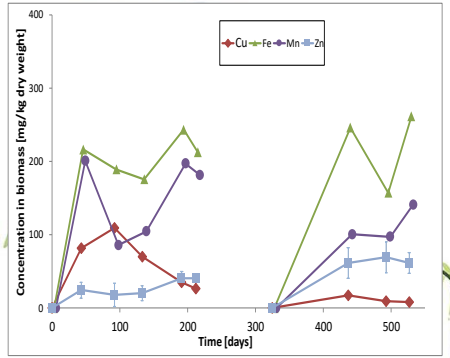
PACKAGING

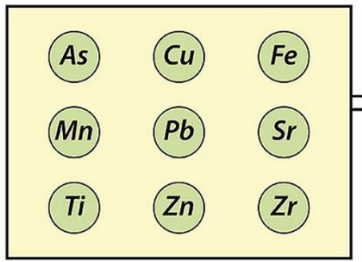
In case of insignificant pollution & damaging after post-military operations it is more profitable to apply the Phytotechnology with biomass production

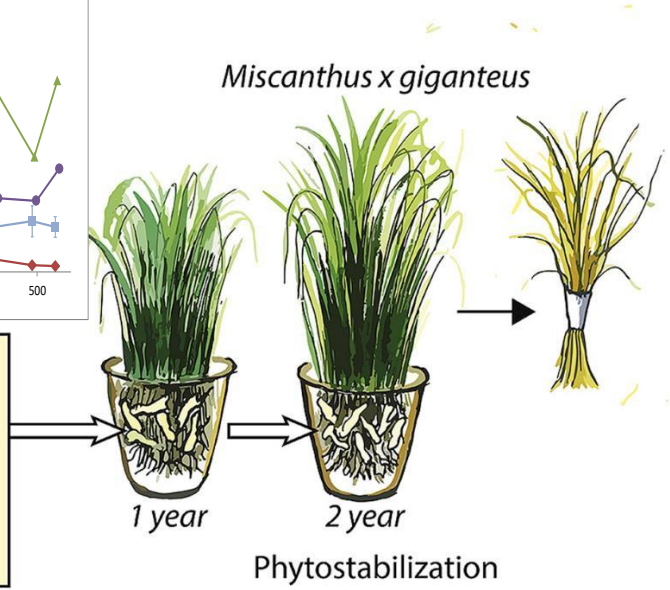
INTEREST OF PHYTOTECHNOLOGY

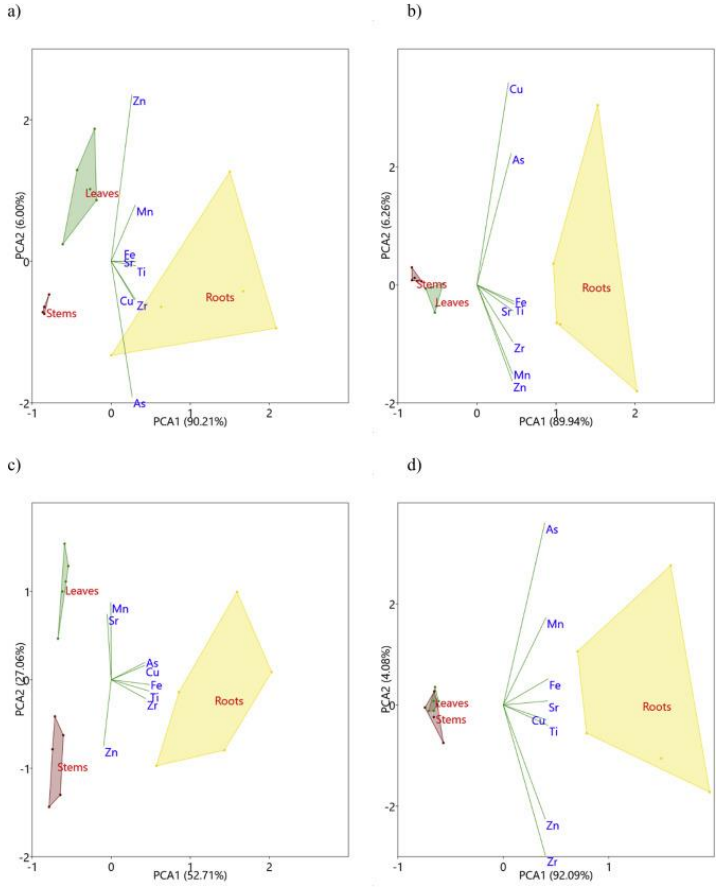


PHYTOREMEDIATION OF M×G IN THE POST-MILITARY TEs-CONTAMINATED SOILS (KAMENETZ, UKRAINE AND SLIAC, SLOVAKIA)









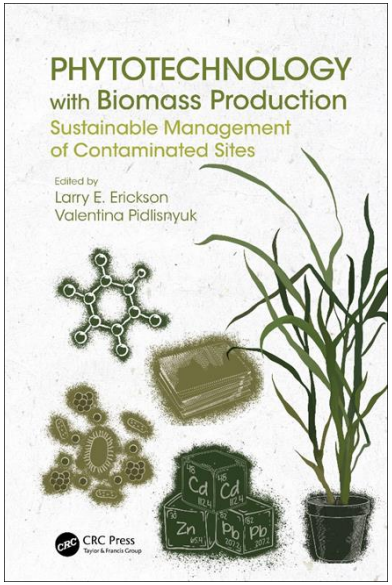
Pidlisnyuk et al., Environmental Pollution, 2019

NORTH ATLANTIC TREATY ORGANIZATION

SPS MYP G4687: NEW PHYTOTECHNOLOGY FOR CLEANING CONTAMINATED MILITARY SITES, 2016-2021

PROJECT'S RESULTS

- Developing M×g phytotechnology to enhance environmental security of post-military sites by production biomass on contaminated military lands such that the two goals of biomass production and soil improvement have been accomplished effectively and efficiently.
- Revealed the effect of M×g biomass production on soil quality and microbiology along with impact of agricultural practice to biomass quality
- Testing biomass produced at the TEs contaminated military soil as source of energy
- Establishing M×g plantations at the former military sites (USA, Ft. Riley; Dolyna and Kurakhove, Ukraine).
- Promotion phytotechnology to stakeholders: i.e., local government, business, farmers, educators. 3 training, 4 workshops and round-tables, Book and Guide-Books, 22 IF publications, new causes and PhD programs.



ENSURING SUSTAINABLE MISCANTHUS UTILIZATION AT THE POST-MINING AND MARGINAL LANDS

UNIVERZITA J. E. PURKYNĚ V ÚSTÍ NAD LABEM

Two research fields were established in Chomutov at the marginal land (2020 and 2021)

VÚRV
Výzkumný ústav rostlinné výroby

FIELD 2020

FIELD 2021

WP 1: ENSURING SUSTAINABLE MISCANTHUS UTILIZATION AT POST-MINING AND MARGINAL, INCLUDING MILITARY LANDS: UJEP

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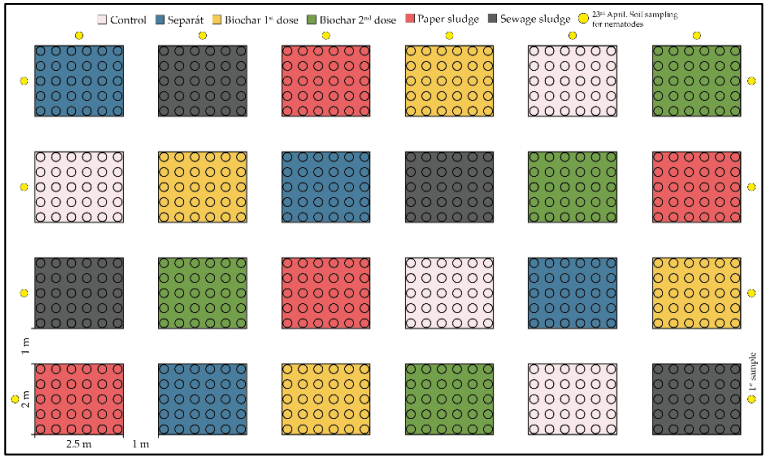
VÚRV
Výzkumný ústav rostlinné výroby

Field experiment (Chomutov, the Czech Republic), impact of soil amendments

1. Control
2. Fertilizer NPK
3. Biochar + NPK
4. Digestate
5. Sewage sludge

5 treatments × 4 plots = 20 plots

Date of establishing: 24th April, 2020

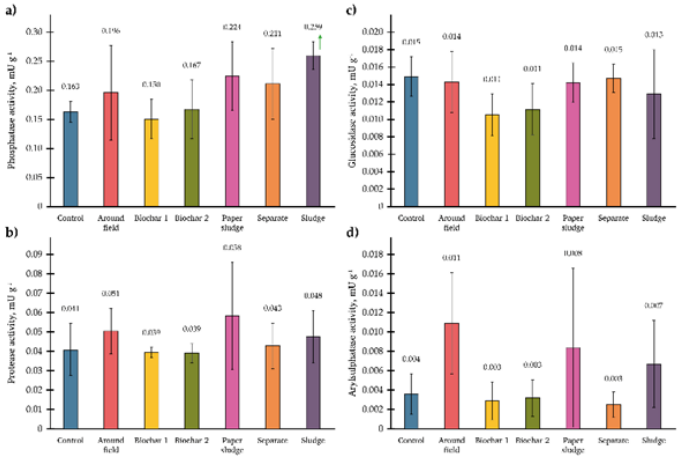


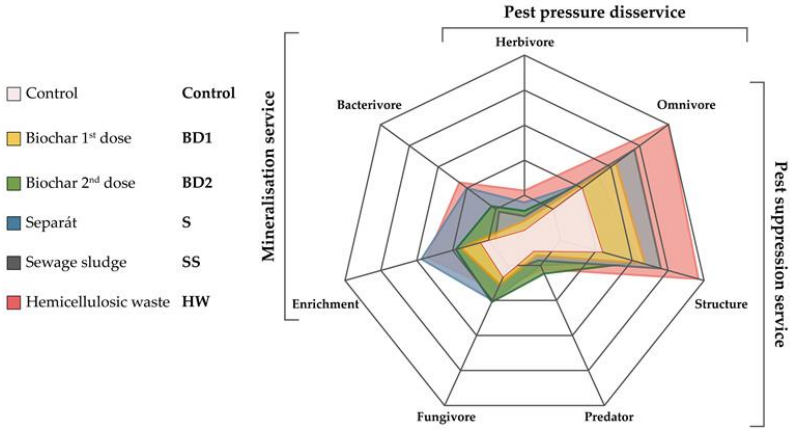
1. Control
2. Biochar (1st dose)
3. Biochar (2nd dose)
4. Paper sludge
5. Digestate
6. Sewage sludge

6 treatments × 4 plots = 24 plots
Each plot contains 30 rhizomes.
Field consists of 720 *Miscanthus × giganteus* rhizomes.

Date of establishing: 27th April, 2021

CHANGING IN THE SOIL MICROBIAL COMMUNITIES DURING MISCANTHUS GROWTH AT THE AMENDED SOILS (FIELD 2021, CHOMUTOV), IN COOPERATION WITH NULES, UKRAINE AND RESEARCH INSTITUTE, POLAND



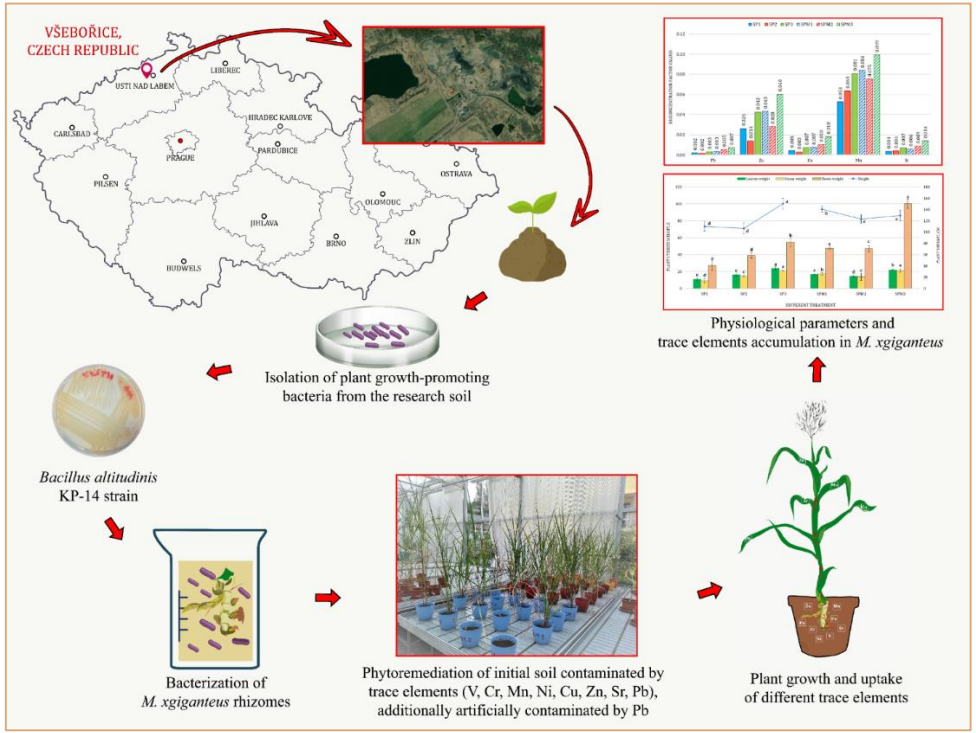


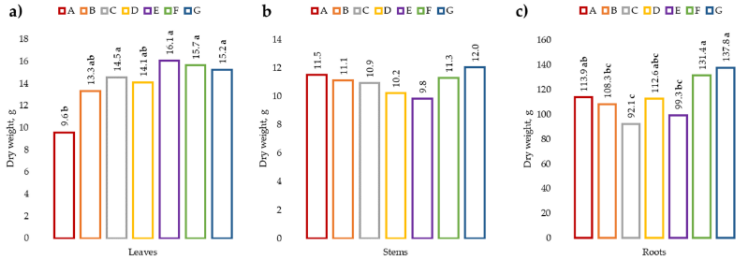
Radar chart of the metabolic footprint of each nematode trophic group in the different treatments and ecosystem services delivered.

- **BD2 10% positively impacted to the harvest value**.
- The soil nematode community associated with the cultivation of crops was sensitive to the type of applied organic amendments.
- SS favoured a more stable maturity status of nematode community compared to the application of S, providing a snapshot of soil health.

STEFANOVSKA ET AL., AGRONOMY 2022, 12, 2063.

SOIL FROM VŠEBORICE, ÚSTÍ N.L., FORMER LIGNITE POST-MINING SITE





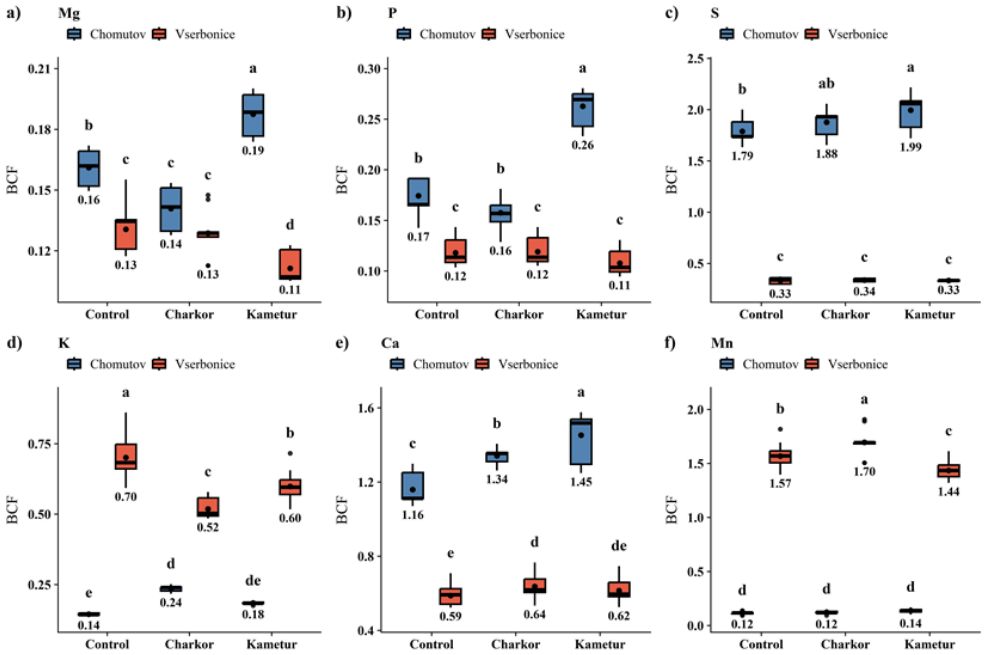
Biomass productivity of M×g produced in the TEs-contaminated soil in the presence of PGPB strains: a) leaves; b) stems; c) roots.

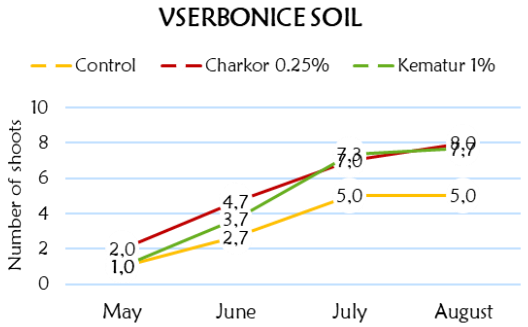
Using of PGPB isolated from the contaminated soil, assisted in increasing of M×g biomass

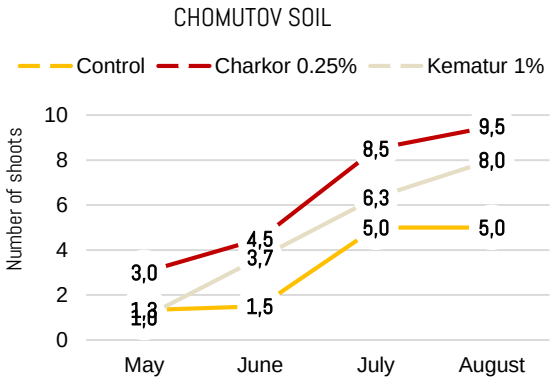
TE	MPC, mg kg^{-1}	Treatments		
		Pb < MPC	Pb = 4.6 × MPC	Pb = 33.9 × MPC
V	43	502.9 ± 161.1	460.2 ± 157.3	488.3 ± 160.0
Cr	90	201.4 ± 68.3	208.3 ± 66.4	243.2 ± 67.2
Mn	1500	492.4 ± 45.8	449.7 ± 44.7	440.1 ± 45.9
Ni	50	99.6 ± 17.4	104.9 ± 16.8	102.1 ± 17.2
Cu	60	73.5 ± 10.5	70.5 ± 9.9	68.9 ± 10.3
Zn	120	204.2 ± 7.1	206.3 ± 8.5	195.9 ± 8.4
Sr	7	418.5 ± 3.9	407.4 ± 3.9	400.7 ± 4.1
Pb	60	44.2 ± 3.7	293.4 ± 7.0	1969.8 ± 15.8

PIDLISNYUK ET AL., AGRONOMY, 2022, 12, 771; PRANAW ET AL., BIOLOGY, 2021, 9, 305;
PIDLISNYUK ET AL., INTERNATIONAL BIODETERIORATION & BIODEGRADATION, 2020, 155, 105103.

IMPACT OF PGRs



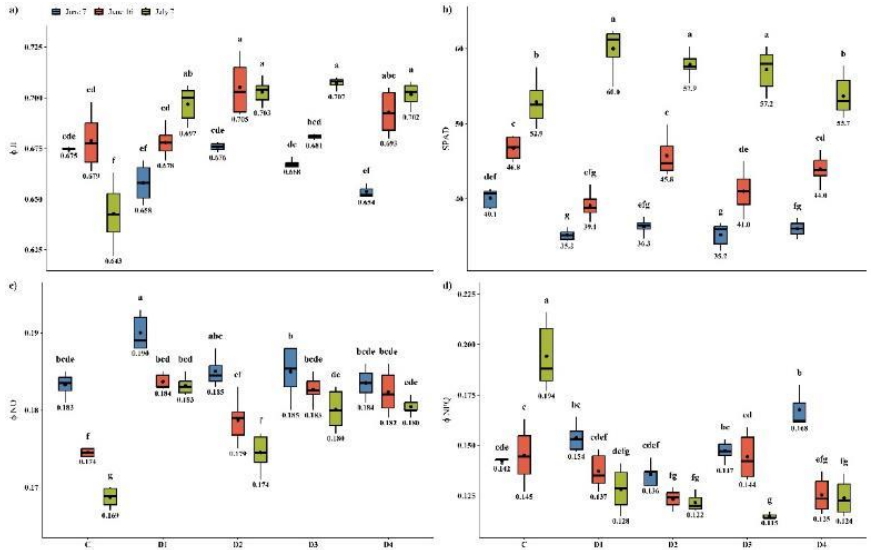




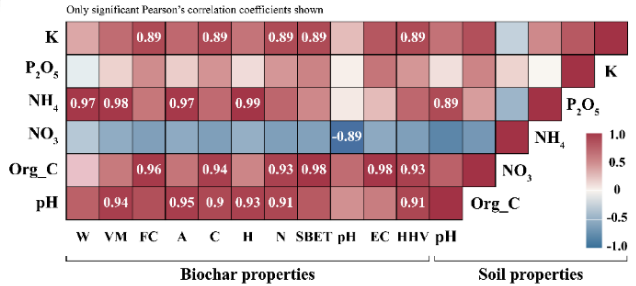
The impact of PGRs (Charkor and Kametur) on Miscanthus growing in soil from post-mining land in Všebořice and marginal land in Chomutov was evaluated. Charkor was more effective than Kametur for Mn and Zn in Chomutov soils, while Kametur was more effective for Sr and Zn in Všebořice soil.

BIOCHAR SUPPORTED M×G PHYTOTECHNOLOGY APPLIED TO THE PETROLEUM-CONTAMINATED SOIL (IN COOPERATION WITH TERNOPIL NATIONAL PEDAGOGICAL UNIVERSITY, UKRAINE)

Concentration of oil-products, mg kg^{-1}	No amendments	Biochar from sludge, 5%	Biochar from wood and biohumus, 5%
A:0	A1	A2	3
B:250	B1	B2	B3
C: 1000	C1	C2	C3
D:3000	D1	D2	D3
E:5000	E1	E2	E3



Changes in the photosynthesis parameters of *S. oleracea* during the experiment: a) ϕII; b) SPAD; c) ϕNO; and d) ϕNPQ. Different letters on the boxplots within one stress parameter indicate a significant difference between the values of the different treatments at (at least) p <0.05.



Heatmap of the Pearson correlation between biochar properties and soil agrochemical characteristics. Abbreviations: A—ash, EC—electrical conductivity, FC—fixed carbon, Org_C—organic carbon, VM—volatile matter, and W—moisture.

PIDLISNYUK V. ET AL., AGRONOMY, 2021, 111, 4, 798.

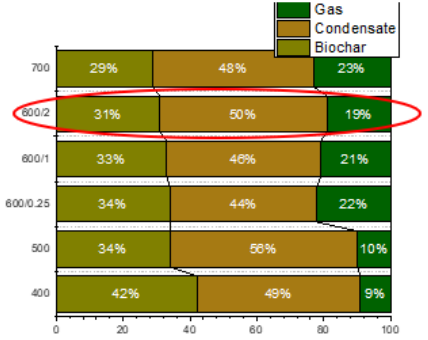
TEST FOR UTILIZATION OF MISCANTHUS BIOMASS TO BIO-PRODUCTS

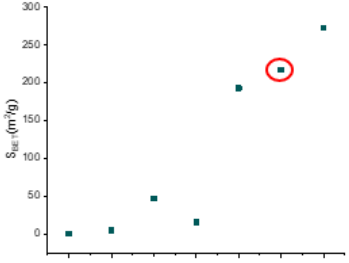
- Test is proposed for biomass verification depending of the aimed bioproduct: fiber, pulp, insulation material, paper, and biochar
- The test includes:
  - Stages of biomass utilization at the marginal land
  - Stages of harvesting, transportation and storing
  - Requirements for:
    - Biomass to fibers
    - Fibers to fibrous and insulation materials
    - Biomass to pulp
    - Miscanthus and industrial wastes to biochar
- Test is presented as a Guide for End-users

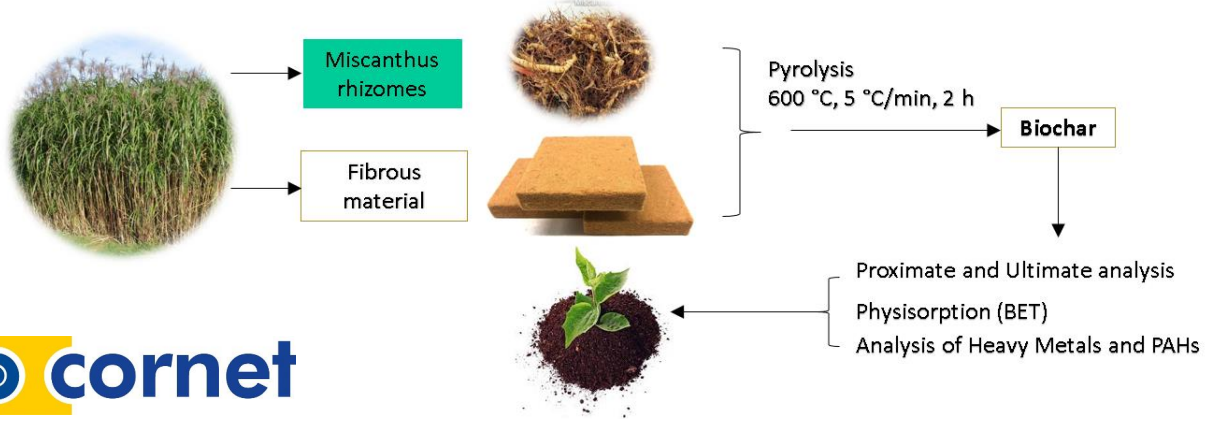
WP 3: MISCANTHUS WASTE UTILIZATION: VSB-TUO

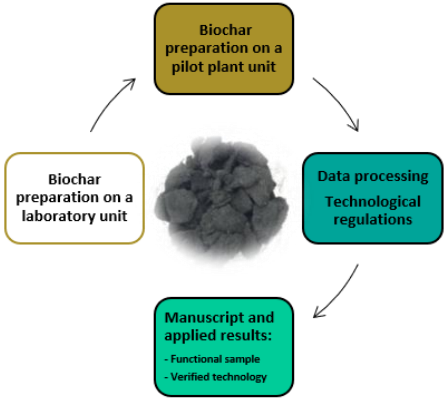
Setting of process conditions was done from the following conditions:
400, 500, 600, 700 – final temperature (°C); 0.25, 1, 2 – residence time (hour)

	Raw Miscanthus	Biochar 400	Biochar 500	Biochar 600	Biochar 700	Biochar 600/1	Biochar 600/0.25
Proximate analysis (wt.%)							
W	8.53	2.05	1.84	1.55	1.53	1.74	1.85
VM^d	76.00	22.82	15.78	9.92	7.30	11.07	13.13
FC^d	20.58	67.33	74.04	77.82	78.71	76.79	76.50
A^d	3.42	9.86	10.17	12.26	13.98	12.14	10.38
Higher heating value (MJ/kg)							
HHV^d	19.84	30.00	31.17	30.37	29.32	30.70	31.18
PAHs (Criteria IBI 6-300 mg/kg dry wt.)							
PAHs	nd	6.80	17.40	5.60	4.10	5.80	5.00









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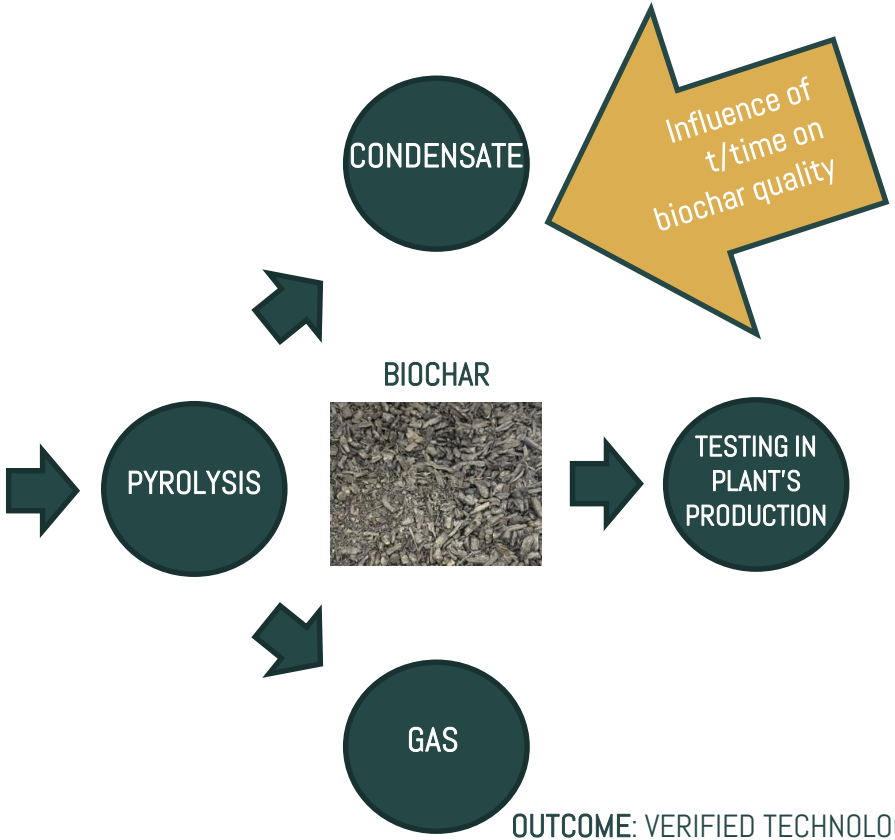
Miscanthus contaminated rhizomes

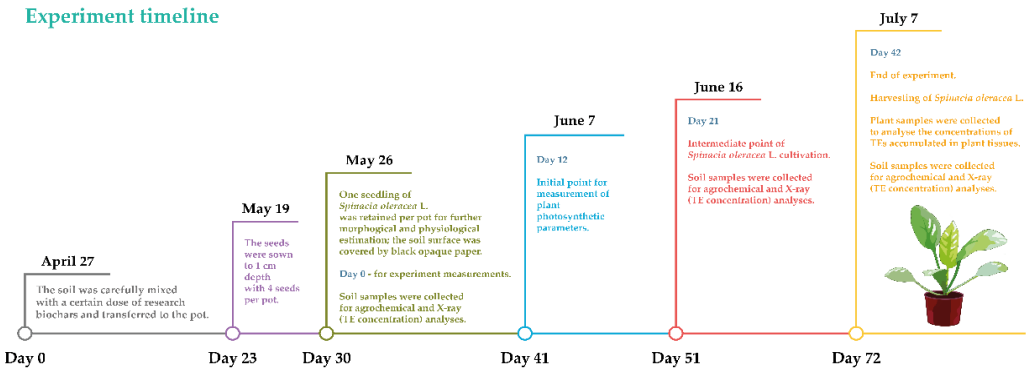
Miscanthus biomass from landfill

Miscanthus fibrous waste



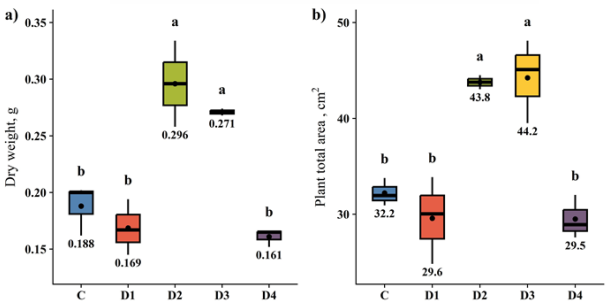
OUTCOME: VERIFIED TECHNOLOGY
OUTCOME: FUNCTIONAL SAMPLE

TESTING OF BIOCHAR FROM MISCANTHUS CONTAMINATED RHIZOMES/BIOMASS DURING *SPINACIA OLERACEA* L.'S GROWING (IN COOPERATION WITH TNPU, UKRAINE)



Testing biochars produced from contaminated rhizomes grown in Všebořice TEs-contaminated soil (Biochar 1), and biochar received from the aboveground biomass produced at the Chomutov field (Biochar 2), in the latter case three doses (1, 3, and 5%) were tested.

The highest biomass yield of *S. oleracea* was recorded **for 3% B2**. The photosynthetic parameters indicated that 3 and 5% B2 doses resulted in the dissociation of light-harvesting complexes. Increasing the biochar dose did not necessarily increase biomass yield or improve photosynthetic parameters.



Physiological parameters of *S. oleracea* at the end of the experiment: a) biomass DW and b) plant leaf total area.

KONONCHUK O.,PIDLISNYUK V., MAMIROVA A. ET AL, ENVIRONMENTAL TECHNOLOGY & INNOVATION, 2022, HTTPS://DOI.ORG/10.1016/J.ETI.2022.102898

WP4: PRODUCTION OF MISCANTHUS FIBER AND PULP: TUD-HFT
WP6: PRODUCTS BASED ON NATURAL FIBERS FROM MISCANTHUS: TUD-HFT

PROCESSING OF RAW MATERIAL

THERMO-MECHANICAL PULPING (TMP)

CHEMICAL THERMO-MECHANICAL PULPING (CTMP)

PARTICLE BOARD

INSULATING MATERIALS

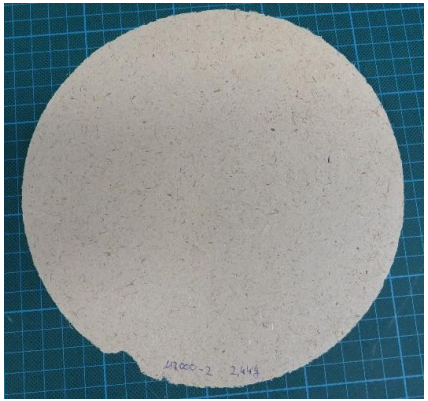
FIBRES FOR PAPER

BIOCHAR

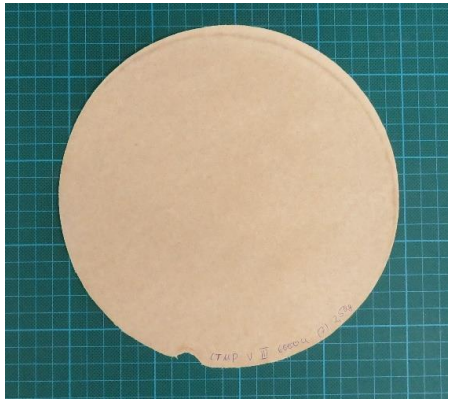
Outcome: functional samples of pulp/insulating material

WP5: PROCESSING OF MISCANTHUS PULP TO PAPER: PTS

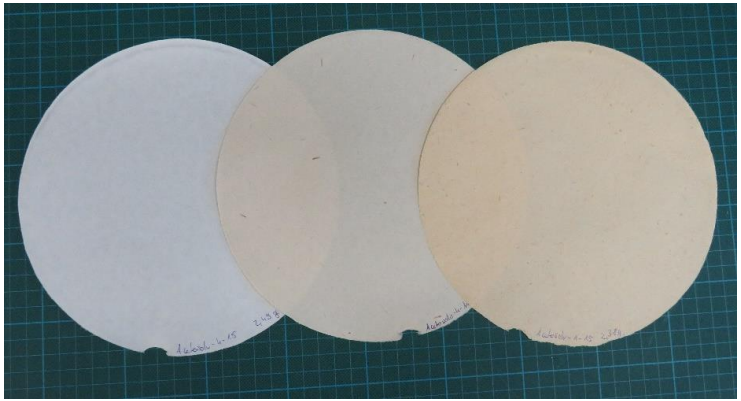
- Miscanthus fibres were not bleached -> higher lignin content
- Miscanthus Acetosolv pulps achieved significantly higher strength (Tensile Index) than pulps produced after sulphate digestion without refining.



MECHANICAL PULPING



CTMP



ACETOSOLV-PULPING

Outcome: verified technology
Outcome: functional sample

MAIN PRODUCTS (OUTCOMES) OF THE CORNET MISCANVALUE:

1. Verified technology for growing M×g at the post-mining soil with processing of raw materials to bioproducts (approved by UJEP)
2. Verified technology for production of biochar (under evaluation at VSB-TUO)
3. Functional Sample of biochar (approved by VSB-TUO)
4. Functional Samples of insulation materials and pulp (TUD-HFT)
5. Verified technology for production of paper (PTS)
6. Functional Sample of Paper (PTS)

VYSOKÁ ŠKOLA BÁŇSKÁ – TECHNICKÁ UNIVERZITA OSTRAVA
Centrum transferu technologií

POTVRZENÍ

ev.č.:015/05-05-2022_F

Potvrzení o převzetí „Evidenčního formuláře" s názvem:

„MiscantChar"

Původce(i): Pavel Lešetínský
Barbora Grycová
Kateřina Klemencová

Předané dokumenty:
Evidenční formulář (celkem 3 strany),
CD s Evidenčním formulářem.

Způsob předání:

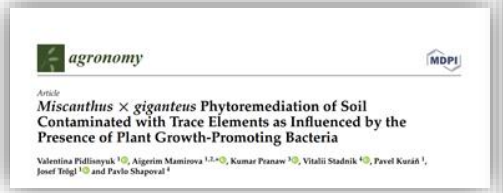
Paní Ing. Barbora Grycová, Ph.D. předala Evidenční formulář spolu s CD osobně pracovnici CTT Haně Janáčkové dne 5. května 2022.

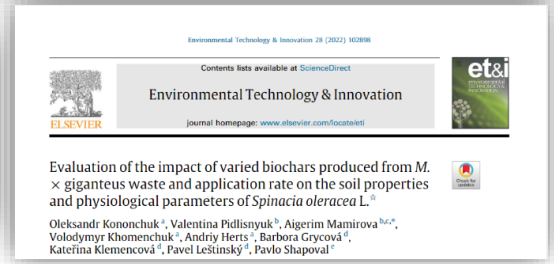
V *Ostravě*, dne 5. května 2022

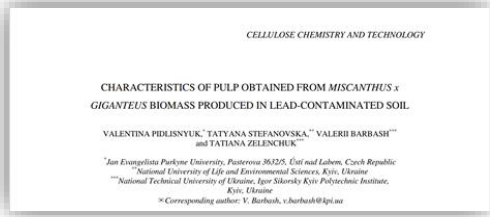
9720 NS 768 Centrum transferu technologií

původce

za CTT







Publications:

7 IF papers published

2 under preparation

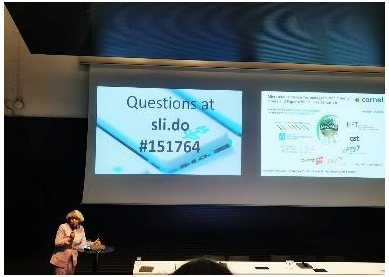
CONFERENCES AND MEETINGS

Reco-Mine, Freiberg, April 7, 2022

Innovation Day, Berlin, June 23, 2022

Vyshegrad 4+ workshop, Lutsk, Ukraine, October 6, 2021 (online)

TVIP 2021, Hustopece



International seminar, Kyiv, Ukraine, October 11, 2021 (online)
Conference "Energy from Biomass XXI, Lednice, September 14-16, 2021
9th International Conference on Chemical Technology, Mikulov, April 25-27, 2022

IFAT, München, June 1, 2022

ATNA solution, August 26, 2022

RemTech Europe, Ferrara, Italy, September 21, 2021 (online)

International Conference on Green Technology, Prague, September 2-3, 2021

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https://miscanvalue.wasten.cz

Thanks to the members of CORNET MiscanValue team

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NATO
OTAN

MILITARY SITES CLEANING
NEW PHYTOTECHNOLOGY FOR CLEANING CONTAMINATED MILITARY SITES

FUTURE GOALS

Broader implementation of *Mxg* phytotechnology for revitalization of military sites in Ukraine after Ukrainian Victory (as for June 2022 there were 82.000 military contaminated/damaged sites)