Plant-Soil Restoration UUKi Twinning Network Conference

LU-DUT Twinning collaboration in the sphere of Phytoremediation Technologies

Prof. Oleksandr Kovrov,
Dnipro University of Technology, Ukraine

Lancaster University

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Campus of Lancaster University in Leipzig (Germany)
July 4-5, 2023

Final Workshop «Plant-Soil Restoration UUKi Twinning Network»

Contents

- **Background of the Project and Plant-Soil Restoration challenges**
- Achievements in the sphere of *Plant-Soil Restoration and Phytoremediation technologies in Ukraine*
- New research horizons due to the Project implementation

11th December 2023

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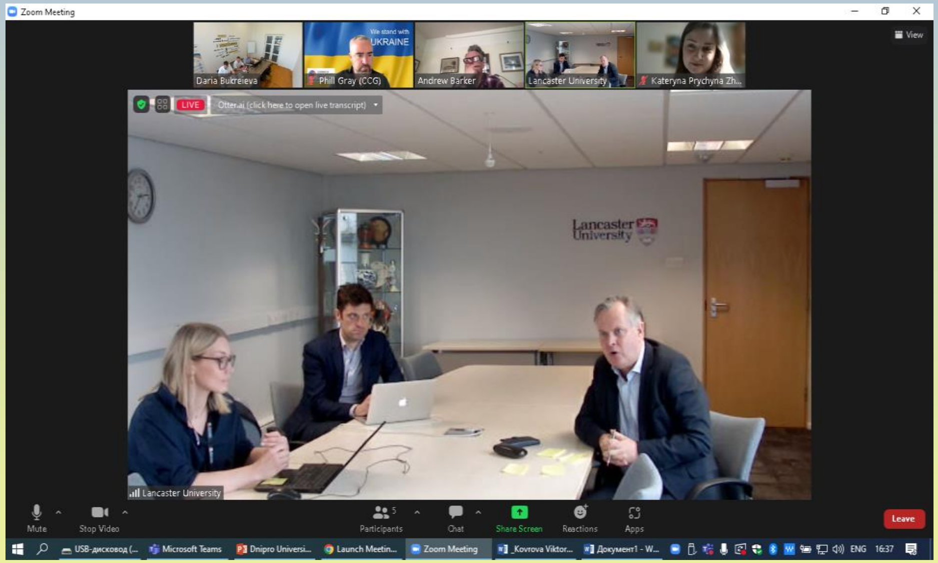
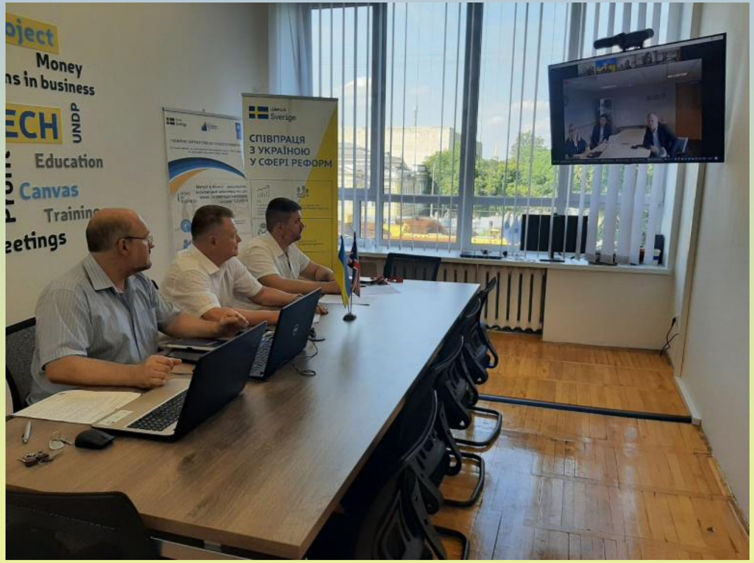
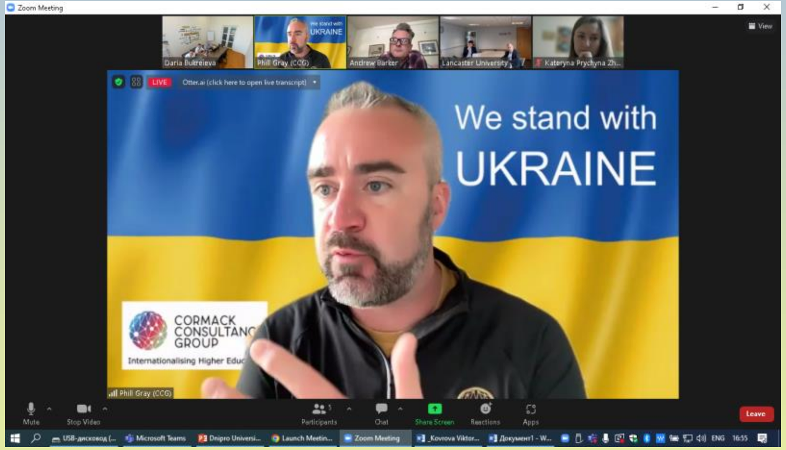
UK–Ukraine R&I twinning grants scheme

The partnership between Lancaster University (LU) and Dnipro University of Technology (DUT) has been started from the first Twinning call (29 June 2022), and the representatives of Universities discussed a lots of possible directions for collaboration, joint opportunities and perspectives in academia and research, student mobility programs etc.







First online meeting between LU and DUT representatives, 29.06.2022

Project Title: New eco-technologies for reclamation of technogenic and military lands in Ukraine

Universities UK International

Universities UK

UK Research and Innovation

Research England

UK–Ukraine R&I twinning grants scheme application form

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Eco-Mining team at Dnipro University of Technology

Prof. Dr. Oleksandr Kovrov,
- Phytoremediation technologies;
- Landslides risk assessment and slope stability geomechanical analysis;
- Environmental engineering technologies

Dr. Iryna Klimkina, Associate Professor
- Environmental Biotechnology;
- Bioleaching Technologies;
- Environmental Toxicology

Vyacheslav Fedotov,
Assistant Professor
- Fundamentals of Ecology
- Bioindication techniques
- Zoology

Serhii Krasovskyi, PhD student
- Physical-and-chemical analysis of soil substrates and plants for analysis of heavy metals and organic content;
- Phytoremediation technologies;
- Plant physiology and biochemistry

Kyrylo Zvoryhin, PhD student
- Phytoremediation technologies;
- Modelling and field experiments;
- Waste management technologies

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https://www.bbc.com/news/world-europe-60506682

War in Ukraine: historical challenge and future perspectives (February 24, 2022 - ….)

- Over 8.2 million refugees fleeing Ukraine have been recorded across Europe,
- 8 million people had been displaced within the country
- 132,000 sq km of Ukrainian lands have been occupied
- Russian invasion of Ukraine has led to widespread and long-term environmental damage. Explosions inflict toxic damage along with physical destruction. After every explosion particles of toxic substances; such as lead, mercury and depleted uranium; are released into air, water, and soils.
- War damage to nature
- Nuclear threats
- Damaged biologics systems and fertile soils, etc.

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Existent and possible war disasters: Kakhovka water reserve

Kakhovka water reserve presents the vast desert landscape with hazardous sediments being eroded in time

https://24tv.ua/kahovske-vodoshovishhe-sogodni-vono-peretvorilos-kalyuzhu-shozhe_n2340574

Satelite image of Kakhovka water reserve that is completely drained

https://24tv.ua/kahovske-vodoshovishhe-zaraz-vodoshovishhe-faktichno-ne-isnuye_n2338510

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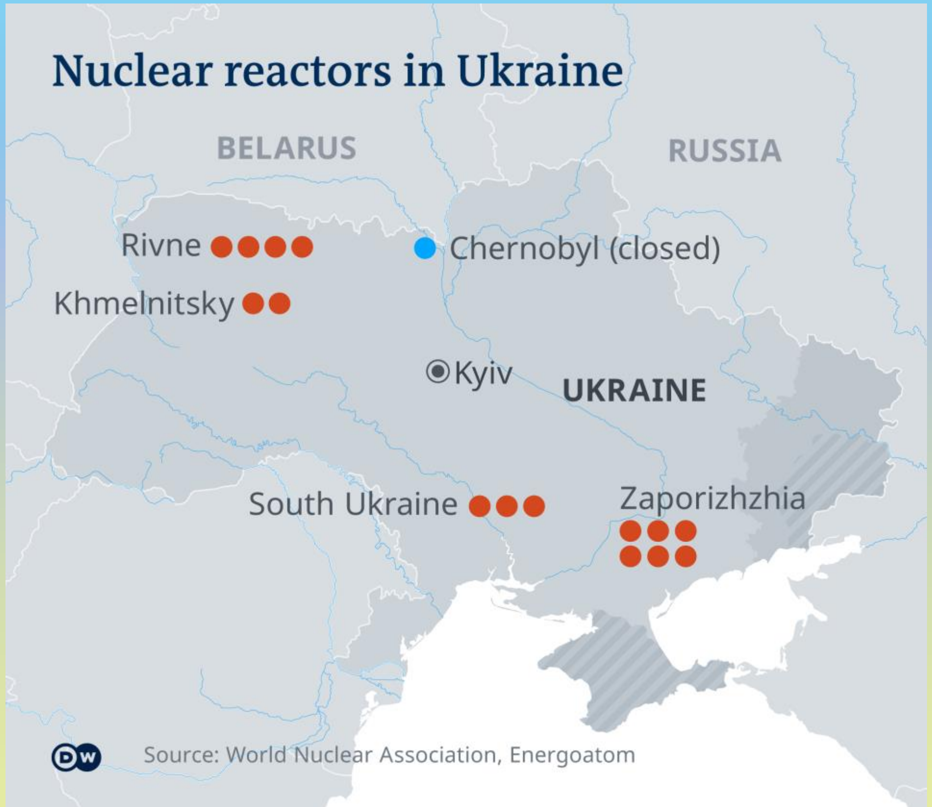
Existent and possible war disasters: Zaporizzhia nuclear power plant

Zaporizhzhya Nuclear Power Plant is under threat of explosion



https://www.energy.gov/ne/articles/us-helps-optimize-ukrainian-nuclear-reactor

https://www.dw.com/en/ukraine-un-head-calls-shelling-at-europes-largest-nuclear-plant-zaporizhzhia-suicidal/a-62698157

The power plant was "grappling with ... water-related challenges" after the destruction of the Kakhovka dam emptied the vast reservoir on whose southern bank the plant sits.

https://www.reuters.com/world/europe/russia-asks-iaea-ensure-zaporizhzhia-nuclear-plant-security-2023-06-23/

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Territories affected by war in Ukraine

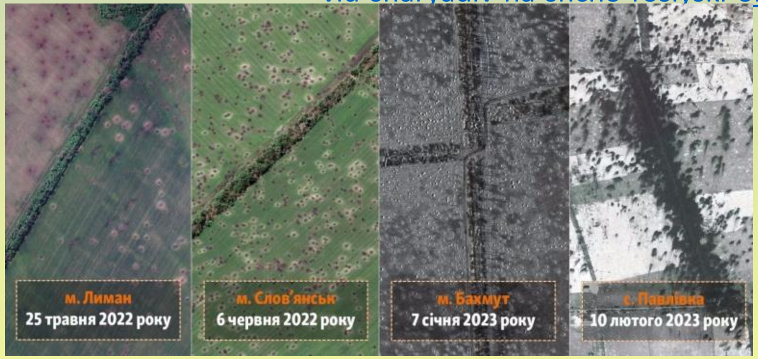
Thousands of missiles on territories

https://ecfr.eu/article/the-second-year-of-russias-war-scenarios-for-the-ukraine-conflict-in-2023/

Completely destroyed Bakhmut City

https://telegraf.com.ua/ukr/ukraina/2023-06-02/5794009-zgorili-budivli-vibiti-vikna-ta-virvi-vid-snaryadiv-na-shcho-rosiyski-obstrili-pe

https://pivdenukraine.com.ua/2022/07/22/na-polyax-novovoroncovshhini-utvorilisya-virvi-vid-snaryadiv/



https://gromada.group/news/statti/23995-yak-vijna-v-ukrayini-vplivaye-na-dovkillya-ta-pogliblennya-prodovolchoyi-krizi

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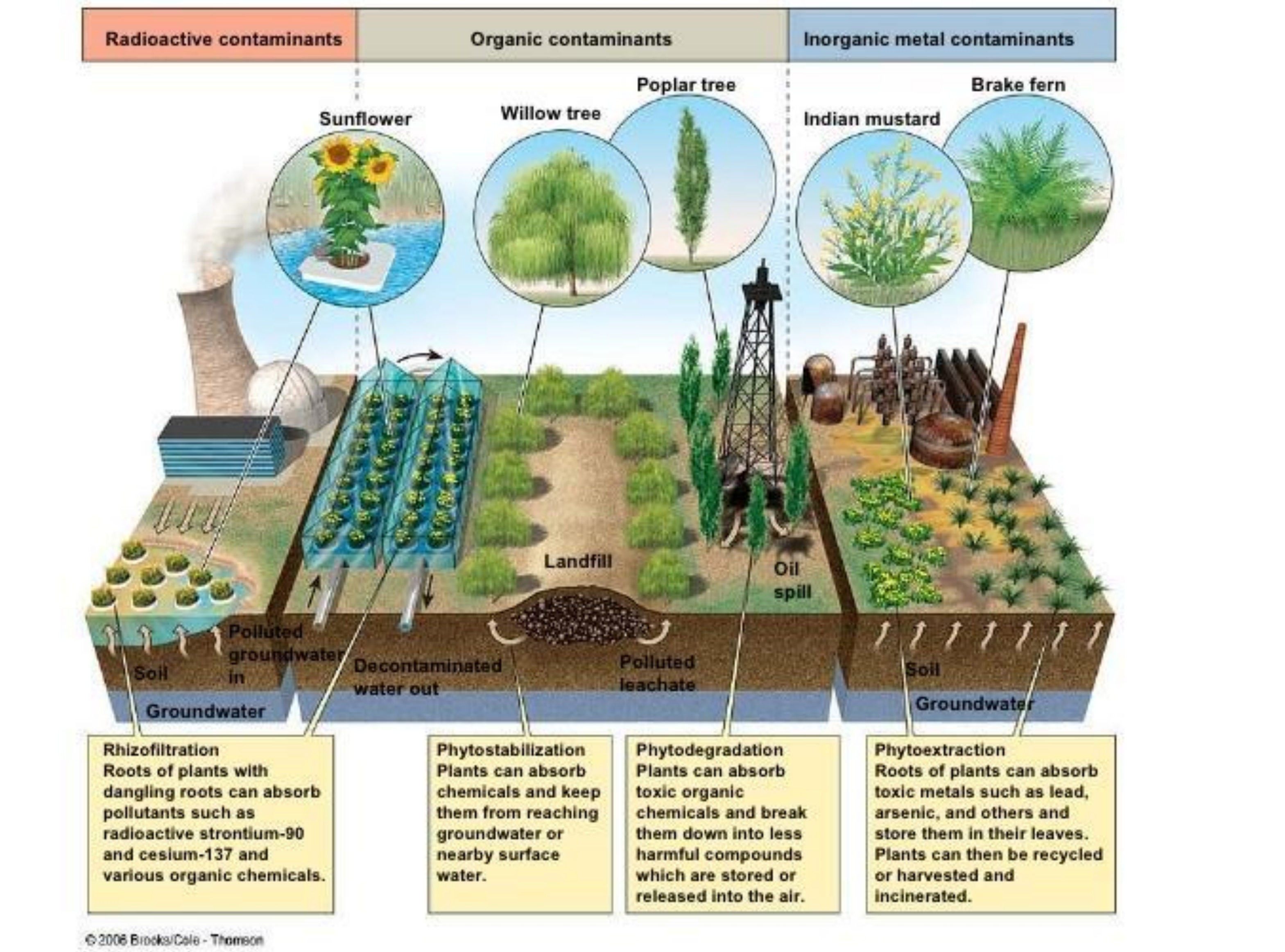
Phytoremediation: practical applications



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Chernobyl disaster and Phytoremediation

Mutant-sunflower in Chernobyl
www.dianuke.org

Caesium-137 and strontium-90 were removed from soils in the vicinity of Chernobyl using sunflower plants.

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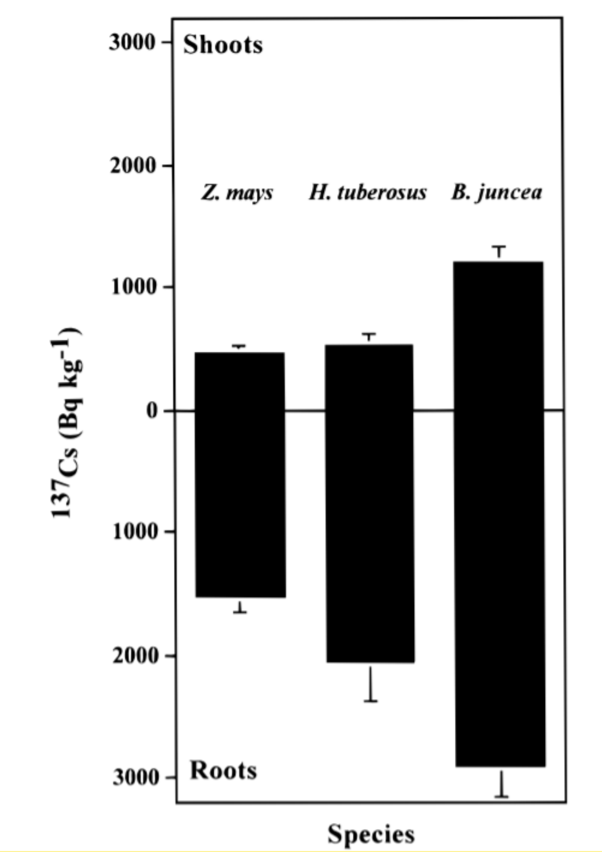
Removal of radionuclides from soil in Chernobyl area

species and cultivars	bioaccumulation coeff	total removal (Bq m^{-2})
Amaranthus retroflexus L. cv. PT-95	1.50	3225
Amaranthus retroflexus L. cv. aureus	1.90	2440
Amaranthus retroflexus L. cv. belozernii	1.41	1392
Amaranthus cruentus L.	1.32	1251
Helianthus tuberosum L. x *Helianthus annuus* L.	0.49	1221
Amaranthus caudatus L.	2.03	1144
Amaranthus cruentus L. cv. myronivka	1.07	1053
Helianthus tuberosus L.	0.30	846
Amaranthus hybridus L.	0.60	719
Amaranthus retroflexus L. cv. Antey	1.07	641
Amaranthus bicolor L.	0.59	417
Amaranthus cruentus L. cv. paniculatus	0.53	412
Zea mays L.	0.28	409
Helianthus annuus L.	0.24	319
Pisum sativum L.	0.48	244
Brassica juncea (L.) Czern.	0.47	194

[a] Plants were grown at the experimental plot at the Northwest border of Chernobyl, Ukraine, approximately 10 km south of the ChNPP fourth reactor that was damaged in 1986. Bioaccumulation coefficient was calculated as a ratio of ^{137}Cs specific activity in the plant versus ^{137}Cs specific activity in the soil.



Dushenkov S., Mikheev A., Prokhnevsky A., Ruchko M., Sorochinsky B. Phytoremediation of Radiocesium-Contaminated Soil in the Vicinity of Chernobyl, Ukraine. Environ. Sci. Technol. 1999, 33, 469-475.

Phytoremediation of lands contaminated by heavy metals (HM)

OJSC “Avdiivka Coke and Chemical Plant”

OJSC "Ukrzinc", Donetska oblast

Cichorium intybus

Melilotus albus

NATIONAL SCIENTIFIC CENTER «INSTITUTE FOR SOIL SCIENCE AND AGROCHEMISTRY RESEARCH NAMED AFTER O.N. SOKOLOVSKY http://www.issar.com.ua/en

Agropyron glaucum

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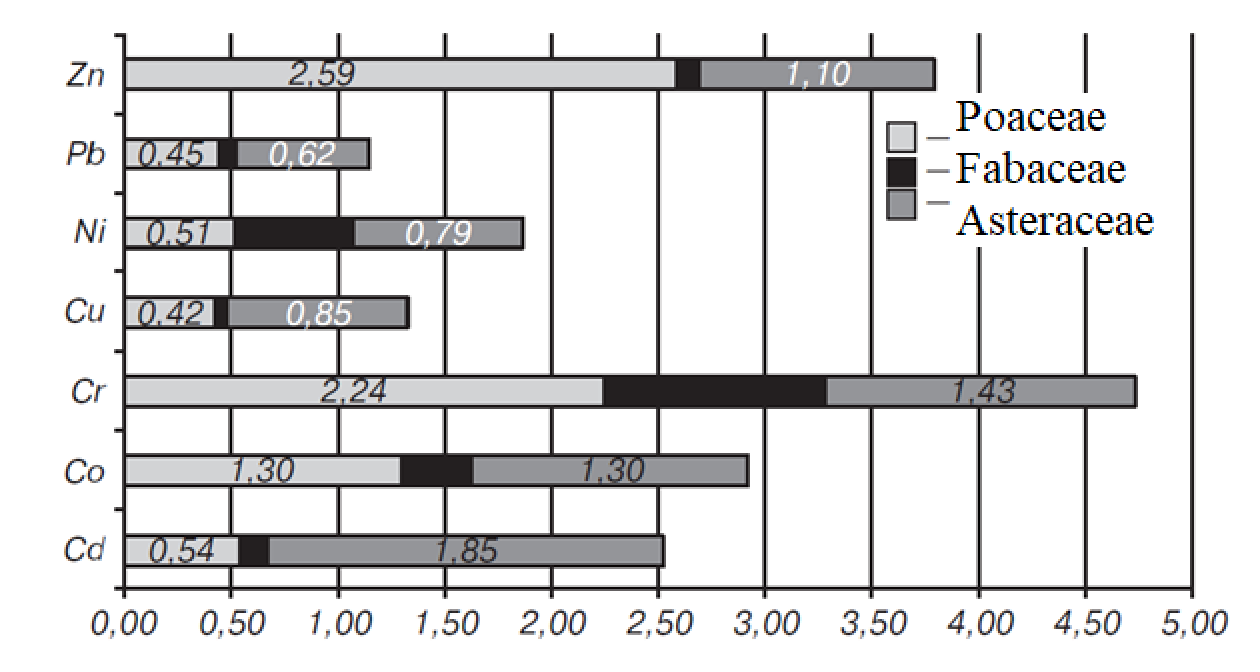
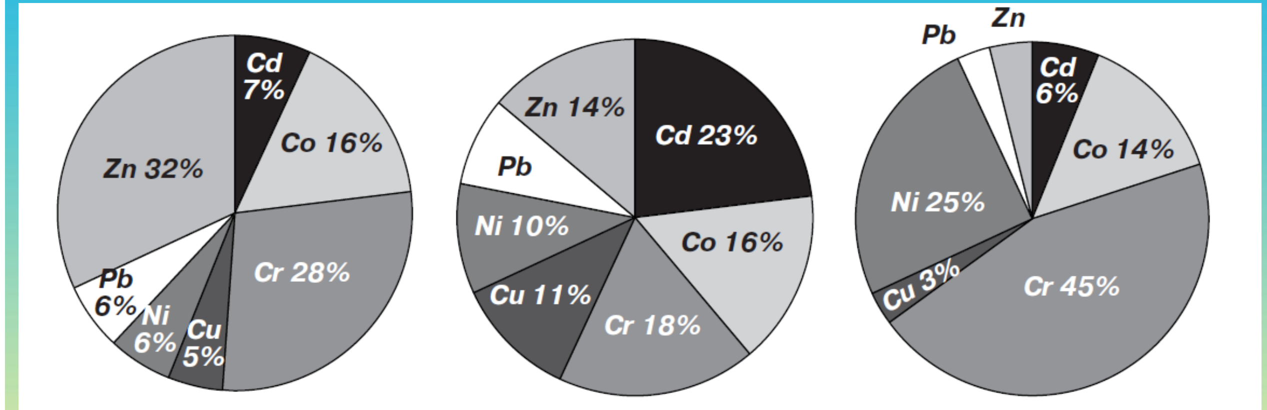
Application of Asteraceae, Fabaceae and Poaceae plants for Phytoremediation





Coefficient of HM accumulation for different plants of families Poaceae, Fabaceae, Asteraceae

V.L. Samohvalova, A.I. Fateev, S.G. Zuza, Ya.A. Pogromska, V.O. Zuza, E.V. Panasenko, P.Yu. Horpinchenko. PHYTOREMEDIATION OF TECHNOLOGICALLY CONTAMINATED SOILS. AGROECOLOGICAL JOURNAL, 1, 2015. p. 92-100.

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HM content in *Ambrosia artemisiifolia* and soil (µg/kg)

Ambrosia artemisiifolia

Samples	Soil						Biomass of *Ambrosia*		
	Before treatment			After treatment					
	Pb	**Ni**	**Cu**	**Pb**	**Ni**	**Cu**	**Pb**	**Ni**	**Cu**
Sample 1	2.0	4.9	8.8	0.7	0.9	10.8	3.9	39.6	11.1
Sample 2	15.2	10.2	10.1	2.8	1.9	1.8	29.8	51.1	15.7
Sample 3	12.5	8.3	4.6	1.9	1.8	0.6	25.5	31.7	13.5
Sample 4	7.1	4.2	4.0	1.8	0.8	0.6	20.0	61.0	10.1

Patent on the model 4726 UA. The method of cleaning technogenically contaminated soils from heavy metals / M.M. Dron, F.O. Chmylenko, N.M. Smityuk. — Publ. 15.02.2005, Bull. No. 2. - 4 p.

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Hyperaccumulation of HM in corn (*Zea mays*) and wheat *(Triticum L.)*

corn (Zea mays)

	HM content in soils, mg/kg				
	Zn	Cu	Cd	Pb	Hg
Soil sample 1	36.32	5.3	13.86	48.30	0.08
Soil sample 2	3.22	2.89	0.62	18.56	0.05
Control sample	1.01	0.41	0.30	6.24	0.08
Threshold	23.0	3.0	0.7	20.0	0.25

HM content in **wheat** on soil samples

	HM content, mg/kg				
	Zn	Cu	Cd	Pb	Hg
Sample 1	117.70	46.02	8.22	10.71	<0.01
Sample 2	94.18	21.51	3.15	7.15	<0.01
Threshold	50.0	30.0	0.3	5.0	0.1

HM content in **corn** on soil samples

	HM content, mg/kg				
	Zn	Cu	Cd	Pb	Hg
Sample 1	83.50	27.82	18.24	34.67	<0.01
Ssample 2	100.12	13.17	1.07	36.53	<0.01
Threshold	50.0	30.0	0.3	5.0	0.1

wheat
(Triticum aestivum L.)

Patent on the useful model 76416 UA. Phytoremediation method of soil purification from heavy metals / O.P. Korzh, I.H. Savchenko, N.O. Hura. - Publ. 10.01.2013, Bull. No. 1. - 6 p.

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Recultivation of the mine overburden dump in Lviv oblast

Recultivation works on the dump slopes

Complex fertilizer “Nitroammofoska” (NPK):

$NH_4H_2PO_4$+
NH_4NO_3+
KCL

Bushes and plants on the slopes

Brassica napus L.

Barbarea vulgaris

Brassica rapa

Patent on the useful model 50789 UA. The method of cleaning the soil of rock dump of coal mines from heavy metals / M.Ya. Havrylyak, V.I. Baranov. — Publ. 25.06.2010, Bul. No. 12. — 9 p.

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Results of HM biological accumulation by seedlings of *Cruciferous* crops

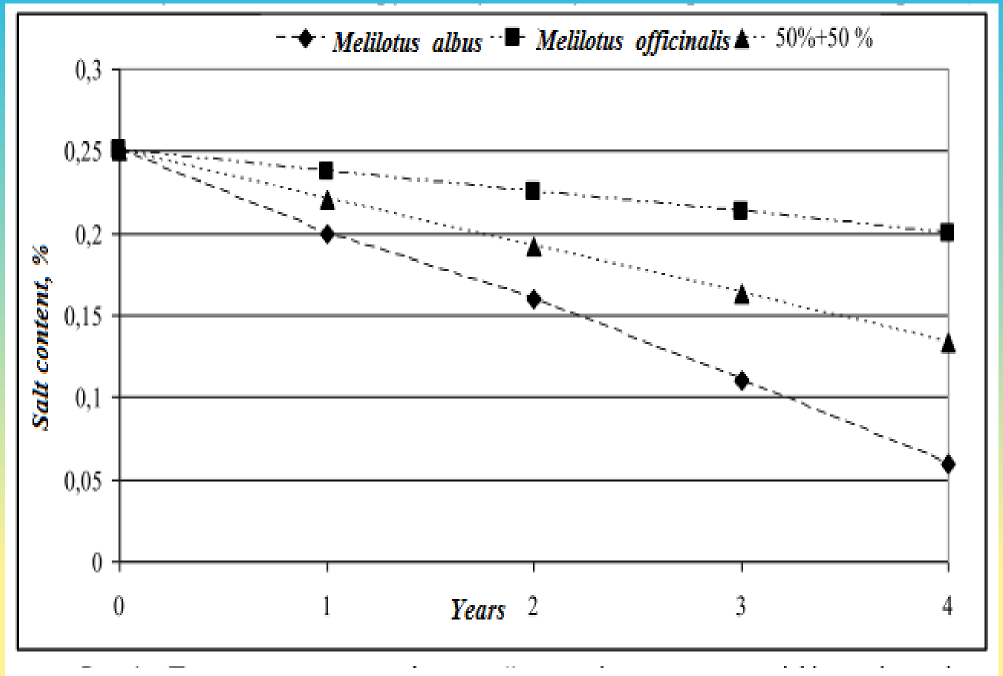
	Coefficient of HM biological accumulation							
	Cr	Cu	Pb	Fe	Co	Ni	Cd	Zn
	Brassica napus							
Red rock	13,5	22,15	7,77	7,08	0,21	0,63	5,73	22,48
Black rock	18,2	9,98	4,87	9,08	0,05	1,48	2,58	58,89
Red+NPK	1,02	14,80	6,99	5,67	0,12	0,62	5,74	15,41
Black+NPK	1,07	5,92	10,32	5,51	0,05	1,03	3,05	53,64
Red+NPK_{caps}	1,87	17,98	8,57	5,61	0,11	0,50	4,32	19,37
Black+ NPK_{caps}	2,22	6,45	4,10	4,33	0,03	1,18	2,53	60,95
	Barbarea vulgaris							
Red rock	6,97	23,46	2,08	8,49	0,14	0,52	6,49	21,40
Black rock	6,62	11,28	6,41	4,22	0,05	1,36	3.16	62,9
Red+NPK	2,61	15,83	4,69	3,28	0,14	0,59	3,46	20,17
Black+NPK	13,81	4,46	6,51	4,46	0,05	1,03	2,30	52,34
Red+NPK_{caps}	4,71	15,26	5,40	5,30	0,14	0,72	5,98	20,92
Black+ NPK_{caps}	6,96	6,57	6,12	5,24	0,04	1,08	2,2	49,58
	Brassica rapa							
Red rock	3,86	20,34	6,83	5,99	0,16	0,69	5,75	25,15
Black rock	11,86	11,83	10,45	5,69	0,05	1,33	2,63	58,43
Red+NPK	5,41	12,07	6,36	4,36	0,15	0,62	6,13	23,21
Black+NPK	6,35	6,46	9,50	4,16	0,06	0,97	2,74	50,11
Red+NPK_{caps}	7,85	19,10	6,41	5,97	0,16	0,07	7,19	18,63
Black+ NPK_{caps}	15,01	7,06	3,16	4,39	0,05	0,92	2,90	45,64

Patent on the model 50789 UA. The method of cleaning the soil of rock dump of coal mine from heavy metals / M.Ya. Havrylyak, V.I. Baranov. — Publ. 25.06.2010, Bul. No. 12. — 9 p.

Phytoremediation of saline soils in mining regions of Ukraine

№	$Na^{+}+K^{+}$	Ca^{2+}	Mg^{2+}	Σ *cathions*	Cl^{-}	SO_4^{2-}	HCO_3^{-}	Σ *anions*	Σ *salts* %
Salt content before									
1	1,8 0,0419	0,5 0,010	0,3 0,0036	2,6 0,0555	0,2 0,0072	2,1 0,1000	0,3 0,0183	2,6 0,1255	0,18
2	1,9 0,0443	1,0 0,020	0,2 0,0024	3,1 0,0667	0,2 0,0072	2,6 0,1248	0,3 0,0183	3,1 0,1503	0,22
3	2,0 0,0466	0,7 0,014	0,3 0,0036	3,0 0,0642	0,2 0,0072	2,5 0,1200	0,3 0,0183	3,0 0,1455	0,21
4	1,9 0,0443	0,6 0,012	0,3 0,0036	2,8 0,0599	0,2 0,0072	2,3 0,1104	0,3 0,0183	2,8 0,1359	0,20
5	2,5 0,0583	0,7 0,014	0,3 0,0036	3,5 0,0759	0,2 0,0072	3,0 0.1440	0,3 0,0183	3,5 0.1695	0,25
6	1,8 0.0419	0,5 0,010	0,4 0,0048	2,7 0,0567	0,2 0,0072	2,2 0,1056	0,3 0,0183	2,7 0,1311	0,19
Control									0,17
Average									0,21
Salt content after									
1	0,3 0,0070	1,1 0,022	0,4 0,0048	1,8 0,0338	0,5 0,0177	0,9 0,0432	0,4 0,0244	1,8 0,0853	0,12
2	1,5 0,0350	1,0 0,020	1,0 0,0122	3,5 0,0672	0,6 0,0213	2,6 0,1248	0,3 0,0183	3,5 0,1644	0,23
3	1,3 0,0303	0,8 0,016	0,6 0,0073	2,7 0,0536	0,6 0,0213	1,8 0,0864	0,3 0,0183	2,7 0,1260	0,20
4	1,3 0,0303	1,4 0,028	0,7 0,0085	3,4 0,0668	0,5 0,0177	2,6 0,1248	0,3 0,0183	3,4 0,1609	0,23
5	1,5 0,0349	1,0 0,020	0,6 0,0073	3,1 0,0622	0,5 0,0177	2,3 0,1104	0,3 0,0183	3,1 0,1464	0,21
6	0,5 0.0116	1,1 0,022	0,4 0,0048	2,0 0,0385	0,4 0,0142	1,3 0,062	0,3 0,0183	2,0 0,0949	0,13
Control									0,14
Average									0,17

Melilotus officinalis



(Melilotus albus)
sweet clover

Lavryk M.O., PhD student, Pavlychenko A.V., Doct. Of Tech. Sc.,
Department of Ecology and Environmental Technologies, National Mining University

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Phytovolatalization for removal petroleum products from contaminated lands in Poltava region

Black Poplar
(Populus nigra)

Sorghum vulgare

Medicago sativa

Oil-contaminated lands

Taraxacum officinale

Artemisia absinthium

Daucus carota

Elytrigia repens

Bulavenko R.V. Possibilities of using phytoremedial plants to protect the soils of the Poltava region from the activities of the oil industry facilities. Environmental safety, No. 1 (2013), 99-102.

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Application of *Hippophae rhamnoides* for phytoremediation of oil-contaminated lands

Impact of Hippophae rhamnoides on oil biodegradation in soils along the first year

Oil content in soil (initial contamination), g/kg	Oil content in soil after phytoremediation, g/kg	Cumulatve soil purification, %
97	15,5	84,6
123	26,5	77,5
150	34,9	76,7

Sea Buckthorn (Hippophae rhamnoides) are planted in holes 15-20 cm deep, 4 seedlings /10 m^2.

Impact of Hippophae rhamnoides along 1-4 years

	1 year	2 year	3 year	4 year
Oil content in soil (initial contamination), g/kg	123.0	26.5	13.9	9.0
Cumulatve soil purification, %	0	77,5	88.7	92.7

O.I. Romanyuk, L.Z. Shoemaker Use of sea buckthorn for phytoremediation of oil-contaminated soils. Biological Bulletin of Bohdan Khmelnytskyi MDPU 6 (3), 2016. 472-480.

Patent on the useful model 86572 UA. Method for cleaning man-made soils contaminated with oil / O.I. Romanyuk, L.Z. Shchevchyk, O.I. Terek - Publ. 10.01.2014, Bulletin No. 1-6 p.

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Impact of *Hippophae rhamnoides* on phytotoxicity of soils

Linum usitatissimum as a test plant

Impact of Hippophae rhamnoides on phytotoxicity of soils on the 4 year

	Toxicity on test plant *Linum usitatissimum*			Number of viable microorganisms in 1g of soil	
	Relative Seed germination, %	Relative root length, %	Relative shoot length, %	Heterotrophs	Oil destructors
Contaminated soil	0	0	0	$2x10^4$	$5x10^2$
Soil after 4 years remediation	100	100	100	$2x10^8$	$3x10^5$
Soil taken 4-6 m beyond the remediated site	88.57	100	52.37	$4x10^6$	$6x10^5$

Azotobacter, Achromobacter, Azospirillum, Rhizobium, Bradyrhizobium, Frankia, Azotomonas, Beijerinckia, Klebsiella, Derxia

Symbiosis of buckthorn with nitrogen-fixing microorganisms in oil-contaminated soil

Patent on the useful model 86572 UA. Method for cleaning man-made soils contaminated with oil / O.I. Romanyuk, L.Z. Shchevchyk, O.I. Terek - Publ. 10.01.2014, Bulletin No. 1-6 p.

O.I. Romanyuk, L.Z. Shoemaker Use of sea buckthorn for phytoremediation of oil-contaminated soils. Biological Bulletin of Bohdan Khmelnytskyi MDPU 6 (3), 2016. 472-480.

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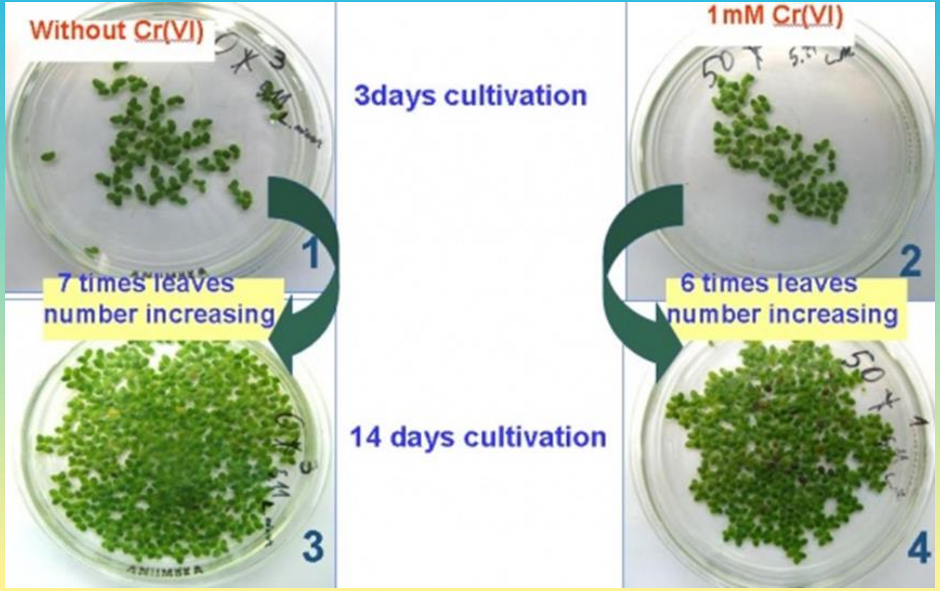
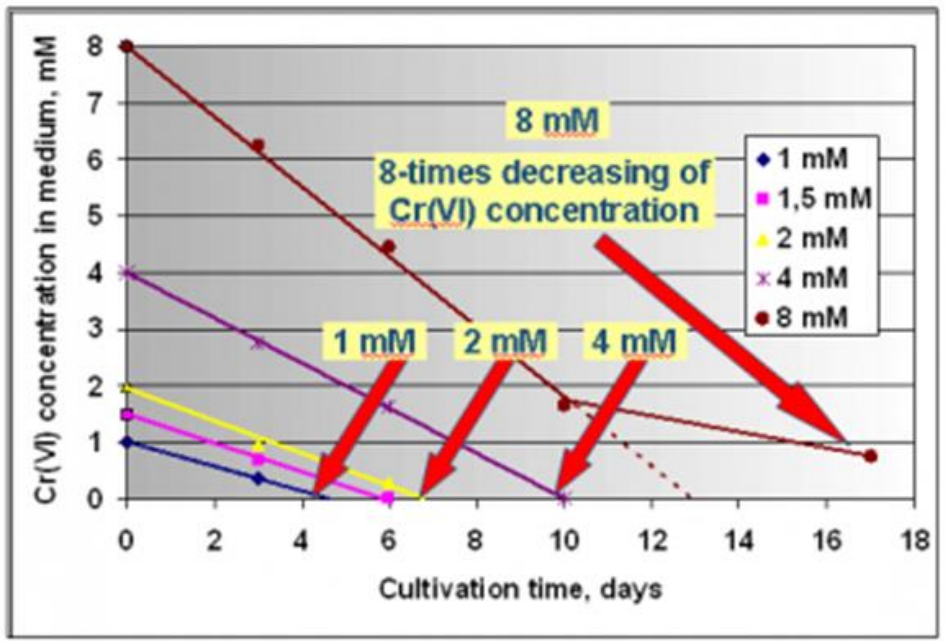
Plant Biotechnology for hyperaccumulation of HM from water

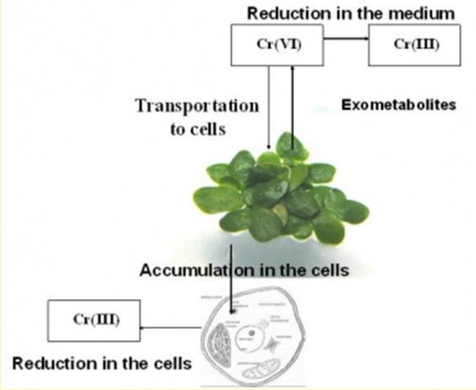
Decreasing of Cr(VI) in the medium



Institute of Cell Biology and Genetic Engineering NASU,
Laboratory of Adaptative Biotechnology

Development of the biotechnology for water purification from toxic hexavalent chromium by duckweed plants (*Lemna minor L.*)





www.icbge.org.ua

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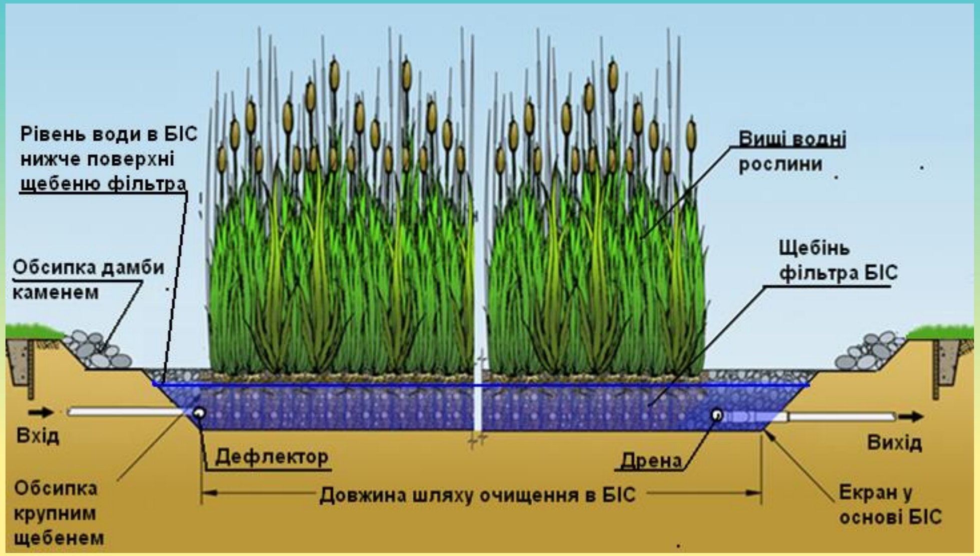
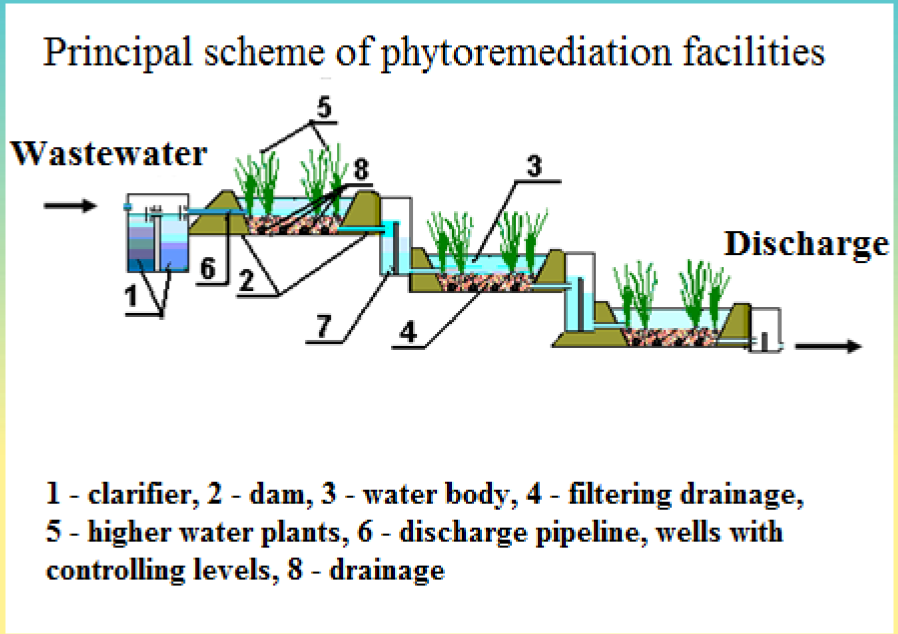
BIO-ENGINEERING TECHNOLOGY FOR PHYTOREMEDIATION AND WASTEWATER TREATMENT

(Ukrainian Research Institute of Environmental Problems)

http://www.phytoremediation.com.ua/en/glavnaya.html





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BIO-ENGINEERING TECHNOLOGY FOR PHYTOREMEDIATION AND WASTEWATER TREATMENT

(Ukrainian Research Institute of Environmental Problems)

Effectiveness

ammonium ions ....60 - 90%
phosphates ....20 - 60%
heavy metals ....20 - 80%
suspended matter .... 96 - 98%
ion sulfate .... 25 - 30%
ions of sodium, calcium, magnesium .... 10 -15%
petroleum products ....20 to 90%
bacteria E-Coli ....96 - 98%
organic substances (BOD, COD) ....65 - 90%

http://www.phytoremediation.com.ua/en/glavnaya.html

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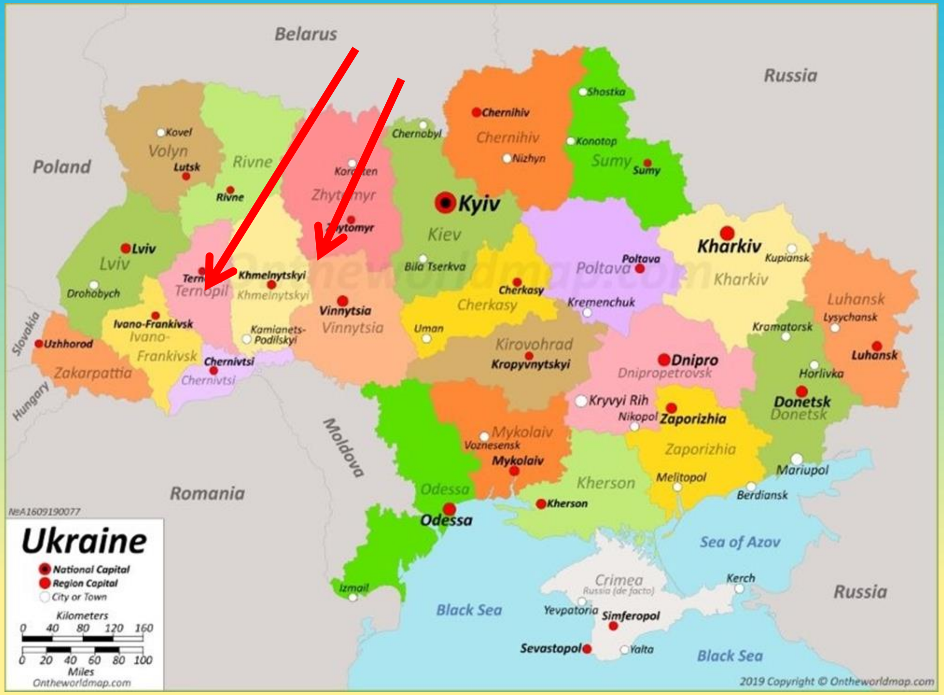
SPG company: Miscanthus cultivation



<u>Miscanthus giganteus application:</u>
- Solid biofuels - chips, briquettes, pellets.
- Cellulose production.
- Bio-gas production.
- Ecological building materials - bio-concrete.
- Composite material.
- Bio-additives.

Heat energy:
4300-4700 Ccal/kg !

http://www.miskantus.com.ua/about-us/

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“Energo-Agrar” company

1st year of cultivation

3rd year of cultivation

<u>Miskanthus gigantheus:</u>

- Annual yield (dry biomass) – 15-20 ton/hectare
- biofuels for heat and electricity generation;
- Raw materials for the production of construction materials and cellulose;
- Seedlings for further cultivation.

https://miscanthus-ukraine.com/nashi-proekty-miscanthus/proekt-2//

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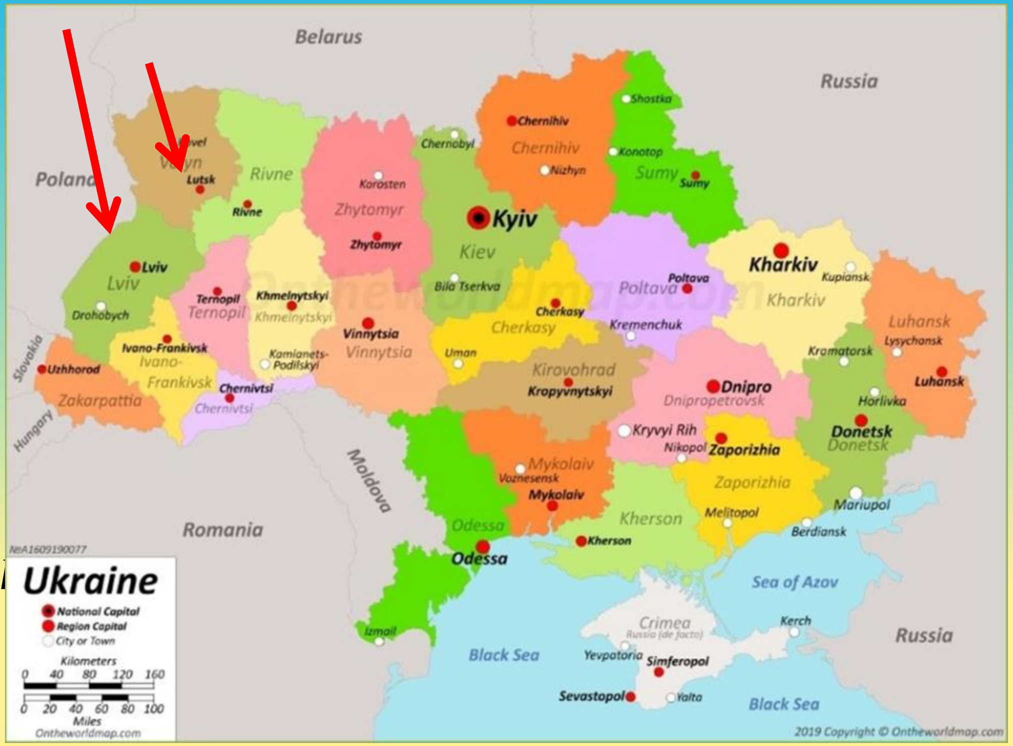
“Salix Energy” company (Ukraine)

Average growth - 1.5 meters per year.

- *Harvesting - every 2-3 years*

Demand for soil - the soil of average qual
with high humidity.



- *The number of harvest cycles from one planting – 7-8 times, then it is possible to make reclamation of land for planting other crops or to lay new willow plantation.*

https://www.salix-energy.com/pro-kompaniyu

Cultivation of **energy willow** (*Salix viminalis*) for biomass production

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“Salix Energy”: Cultivation of energy poplar

Cultivation of **energy poplar** (*Populus nigra*) for biomass production

https://www.salix-energy.com/pro-kompaniyu

- *Average growth characteristics – 16-25 t / ha per year in the time of harvest.*
- *Harvesting biomass – depending on cultivation technology every 2-4 years.*
- *Plantation remain productive 25 years, followed by reclamation and after 1-2 years can be re-planted perennial energy crops.*

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Energy plants for biofuel in Ukraine

Region	Area, hectares	Energy crops
Volynska	1700	Energy salix
Zhytomyrska	110	Miscanthus, salix, poplar
Kyivska	380	Miscanthus, salix
Rivnenska	67	Energy salix

https://miscanthus-ukraine.com/nashi-proekty-miscanthus/proekt-2//

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Final Workshop «Plant-Soil Restoration UUKi Twinning Network»

Contents

- Background of the Project and Plant-Soil Restoration challenges
- Achievements in the sphere of *Plant-Soil Restoration and Phytoremediation technologies in Ukraine*
- **New research horizons due to the Project implementation**

11th December 2023

Final Workshop «Plant-Soil Restoration UUKi Twinning Network»

Substantiation of controlled vermiculture ecotechnology for biohumus production

Anastasiia Hetta, PhD student, group 183A-23-10

Department of Ecology and Technologies of Environmental Protection, DUT

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Types of earthworms for vermitechnologies

Vermicomposts–these are organo-mineral materials that, as a result of the interaction of vermiculture and soil microorganisms during the processing of organic waste in mesophilic conditions (15-28 °C).

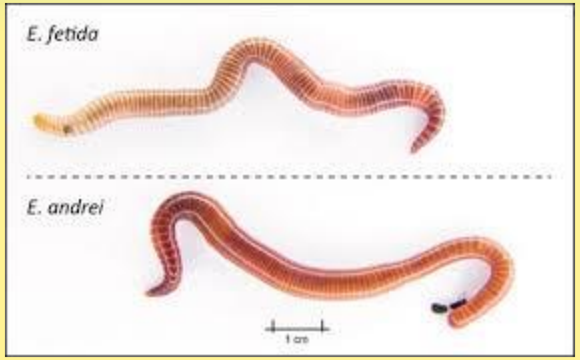
Vermicomposts are stabilized organic high-humus fertilizers with a low ratio C:N.They have high and diverse microbiological and enzymatic activities, an excellent chernozem-like structure, a high moisture-holding capacity, and also contain nutritious macro- and microelements *(N,R, K,Ca, Mg, Fe, Cu, Mn, Mo, Zn)*in a form accessible to plants.

Types of temperate climate

- *Eisenia fetida; E.f.fetida; E.f.andrei*
- *Eisenia andrei*
- *Dendrobena veneta*
- *Lumbricus rubellus*
- *Lumbricus terrestris*

Tropical species

- *Perionix excavatus*
- *Eudrilus eugeniae*
- *Lampito mauritii*



Dendrobena Veneta

Typical worm beds on designated lands

California worm
(**Eisenia fetida)**

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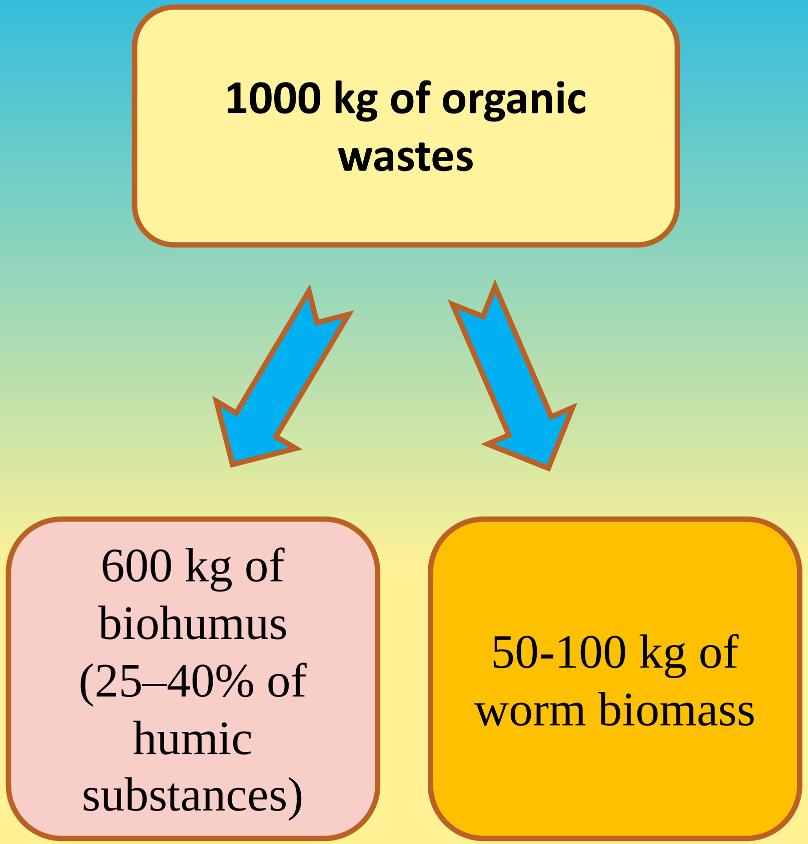
Advantages of biohumus over other types of fertilizers



- Biohumus is a 100% organic fertilizer
- A guarantee of receiving an ecologically clean harvest
- Biohumus stimulates the natural activity of useful microorganisms, enzymes and natural plant growth regulators.
- Allows to restore the fertility of degraded lands.
- After applying biohumus to the soil, a positive effect is observed for 3 years.
- It is 10-15 times more effective than any known organic fertilizers.
- Absolutely harmless in any concentration and on any soil. It is used as an independent soil.
- Does not contain pathogenic microflora, heavy metals.

Biotesting experiments with biohumus

Fig. 1. A week after the start of the experiment

Fig. 2. 14 days after the start of the experiment

Seeds germinated more actively in samples 3 and 4 than in other samples, which indicates that the ratio of components (40:60 and 60:40) was the most successful. These results can be seen in Fig. 1 (before) and Fig. 2 (after).

Sample No	**Components, gr**		
	Biohumus	loam	Seed
1	10	100	2
2	20	80	2
3	40	60	2
4	60	40	2
5	80	20	2
6	100	10	2

California worm
(**Eisenia fetida)**

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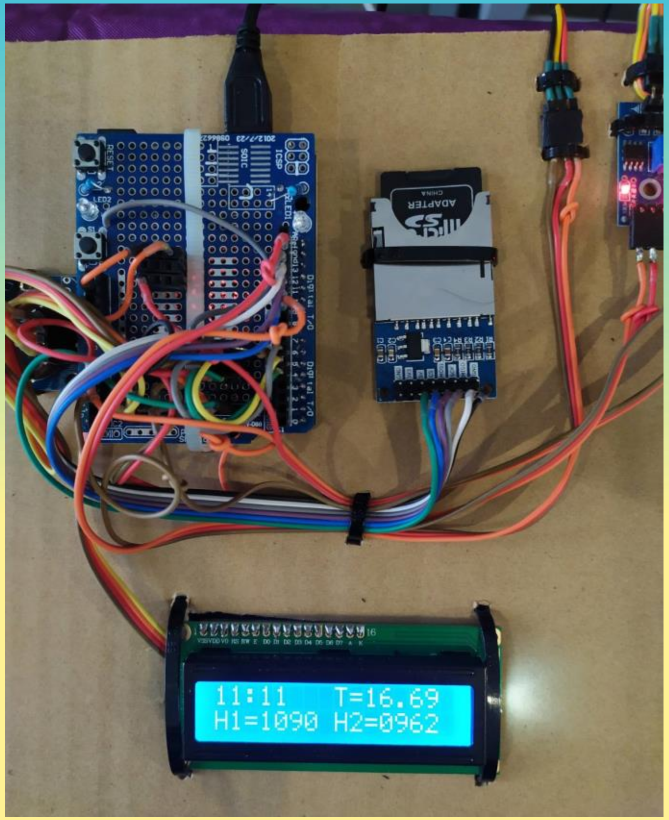
Controlled vermiculture ecotechnology for biohumus production

A volume with worms

A pilot automated system for controlling soil moisture



The continuous process of scanning soil parameters

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Conclusions

1. UK–Ukraine R&I twinning initiatives and the current Project related to eco-technologies for land reclamation has started successfully and opened the new opportunities for further bilateral collaboration.

2. Phytoremediation and other environmental technologies provide a range of options for effective dialogue towards more sustainable development, especially in the context of current situation in Ukraine.

3. The most common and reliable Phytotechnologies in the range of priority include:
- Reclamation and revegetation of technogenic territories and lands affected by military actions;
- Phytoextraction of HM and biodegradation of organic compounds
- Cultivation of energy crops for producing briquettes and pellets.

4. The Plant-Soil Restoration UUKi Twinning Network opened new horizons for effective bilateral collaboration in the field of Soil-Plant Restoration ecotechnologies.

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