



The impact of **EXtreme** weather events
on **MINing** operations

TE  **MIN**



New reclamation methodology and mitigation measures at Radovesice spoil heap, Most Basin, CZ

Michal Rehor, Pavel Schmidt, VÚHU; Arnostka Kostkova, North Bohemian Mines, j. s. c

Katowice, 4. 10. 2022

INTRODUCTION

- **The Most Coal Basin area is known for its largest Czech brown coal deposit. It is situated in the region of North Western Bohemia. 2 mining companies, 4 mining localities**
- **The Most Coal Basin is in general known as dry part of the Czech Republic**
- **Radovesice spoil heap is the second greatest spoil heap in Czech Republic (area about 1200 ha)**
- **Due to the long history of reclamation, the variety of soils deposited on the spoil heap, and the application of modern reclamation methods, this is the optimal case study area for research into the impacts of climate change**
- **The reclamation of the Radovesice spoil heap is the "flagship" of reclamation projects implemented in the area of the Most Basin**

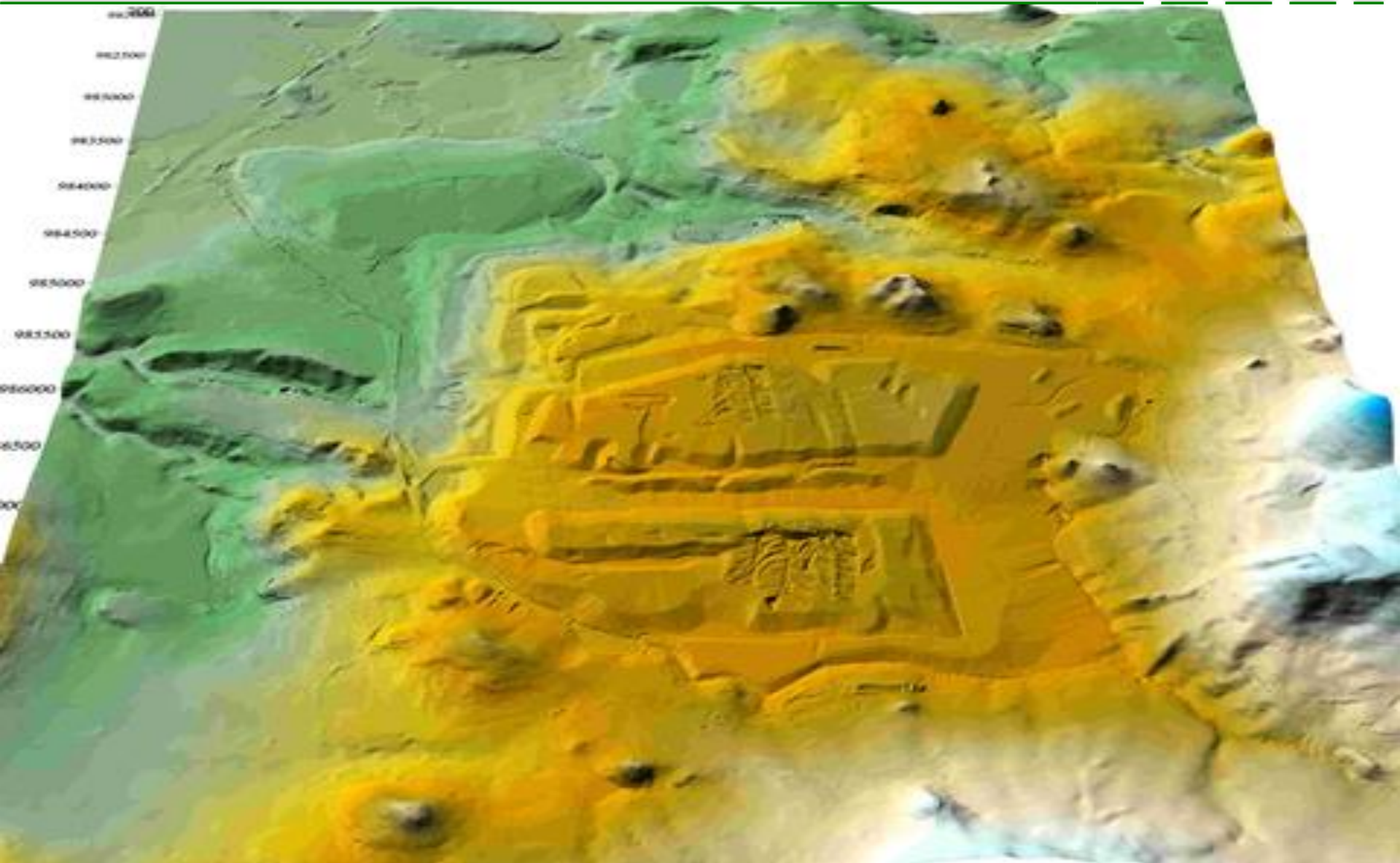
RADOVESICE DUMP SITUATION

- **The construction of the Radovesice spoil heap started in 1964**
- **It was situated in the cadastre area of Radovesice, Kostomlaty and Světec villages. It has an elongated form from the South-East to the North-West and the dump body connects the České Středohoří Mts.**
- **Most of the surface was reclaimed using local marl. A layer of 0.2 m was loaded and plowed into the surface of the terrain**
- **Two large areas were left to natural succession. These are the largest succession areas in the Czech Republic. Their age is 31 and 25 years, the area is 20 and 33 ha**
- **Two experimental sites with a long history of research were established on the spoil heap, which serve as a monitoring site for research into the impacts of climate change**

The total area and method of reclamation of individual reclamation stages

reclamation stage	total area (ha)	agricultural (ha)	forest (ha)	hydric (ha)	other (ha)
stage I	30,40		30,40		
stage II	110,40		11,45	0,70	98,25
stage III	52,00		49,40		2,60
stage IVA	8,98		8,98		
stage IVB	27,70		27,70		
stage V	8,92				8,92
stage VI	44,36		16,41	0,47	27,48
stage VII	82,75		45,19		37,56
stage VIII	116,33	67,44	48,48		0,41
stage IX	75,76	51,90	19,73		4,13
stage X	93,45		32,74	2,52	58,19
stage XIA	5,74				5,74
stage XIB	56,23		9,73	0,75	45,75
stage XII	85,23		58,48	1,83	24,92
stage XIII	96,06		16,66	1,38	78,02
stage XIV	50,74		21,13	0,90	28,71
stage XVA	6,81				6,81
stage XVB	5,39				5,39
stage XVI	5,66			0,08	5,68
stage XVIIA	19,51*			1,09	18,42
stage XVIIIB	33,90*			1,17	32,73

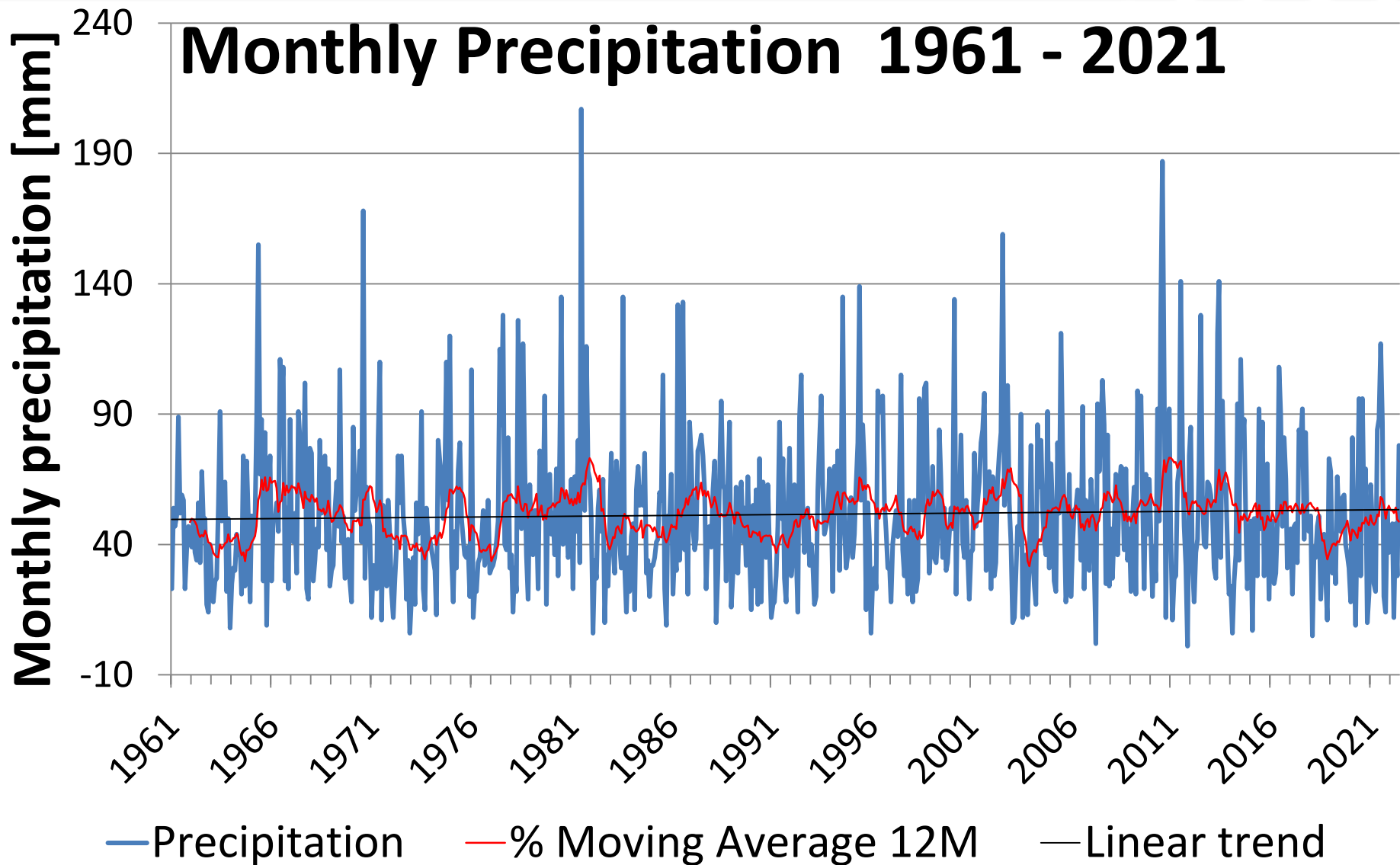
* research area left to long-term natural succession (including spontaneously water bodies formed)





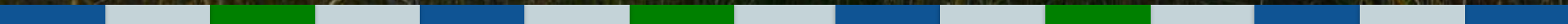
RESEARCH METHODOLOGY

- Available data of the Czech Hydro - meteorological Institute (ČHMU), regional weather stations Kopisty, Milesovka and Usti nad Labem - Kockov, data of mining companies and own data of VÚHU j. s. c. were used for the evaluation of the development of temperatures and precipitation
- For forecasting further development of temperature and precipitation, the outputs of the regional climate model ALADIN-CLIMATE / CZ operated in ČHMÚ, were used
- The selection of the suitable case study spoil heap areas, terrain pedological mapping, slope monitoring, sampling, photo documentation and large scale of laboratory analyses realisation
- A total of 5 sites were selected for monitoring and forecasting the development of temperature and climate in the Most Basin, two of which are located on the Radovesice spoil heap
- It is a succession area Radovesice XVIIA and a reclaimed area Radovesice VI



RESEARCH AREA RADOVESICE XVIIIA

- **The experimental succession area of Radovesice XVIIIA (about 20 ha) was selected in the northern part of the dump. The age of the area is about 31 years**
- **The predominant soil type here is a heterogeneous dump mixture of brown clay, grey claystone and grey sandy claystone with an increased content of brown clay**
- **There are also two large natural water reservoirs and several small bodies of water and wetlands in the territory**
- **The methodology of the research has already been described in more detail here. It is a combination of monitoring and modeling of precipitation and temperature and long-term monitoring of selected soil and biological parameters of the area**



Pedological parameters of anthropogenic soil profile - Radovesice

XVIIA

sampling interval (m)	Nc (%)	Cox (%)	CaCO ₃ (%)	pH KCl	acceptable nutrients (mg.kg ⁻¹)			sorption		
					P	K	Mg	S mmol/100 g	T	V (%)
2004										
0,00-0,60	0,05	2,1	0,4	6,8	2	184	724	15	15	100
2010										
0,00-0,60	0,08	2,5	0,5	6,8	3	330	860	17	17	100
2015										
0,00-0,60	0,06	2,4	0,6	6,9	3	325	844	16	16	100
2021										
0,00-0,60	0,11	2,8	0,6	6,8	8	361	880	17	17	100

Content of risk trace elements in soils of areas of interest

locality	content in sample (mg . kg ⁻¹)											
	As	Be	Cd	Co	Cr	Cu	Mo	Ni	Pb	V	Zn	Hg
Rad.XVIIA	7,0	2,8	0,2	16,8	21,4	27,5	0,85	37,3	30,1	88,3	51,3	0,18
Decree No. 153/2016	20	2	0,5	30	90	60	-	50	60	130	120	0,3

Other pollutants in soils of areas of interest

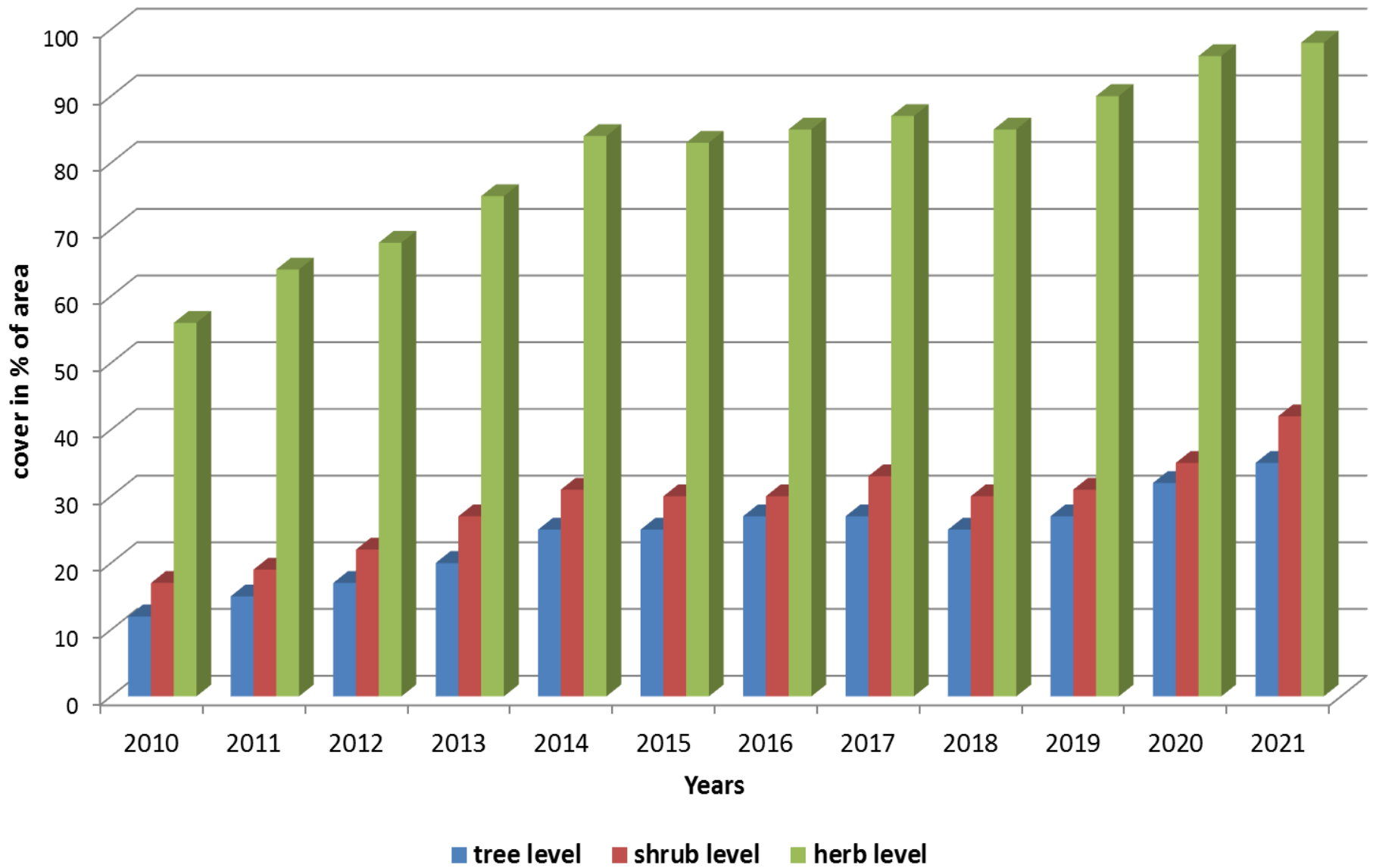
locality/ sampling interval (m)	S %	organic maas %	pH KCl	occurrence of sulphides Fe
Radovesice XVIIA	0,05	2,2	6,8	NO

Phytocenological snap of the area of interest in the Radovesice XXVIIA area

area – succession	Radovesice XXVIIA	Situation in 8/2021
<i>Acer platanoides</i> - r	<i>Betula pendula</i> – 2	<i>Betula pendula</i> - 2
<i>Astragalus glycyphyllos</i> - 1	<i>Salix caprea</i> - 2	<i>Populus canadensis</i> - 2
<i>Betula pendula</i> – 1		<i>Salix caprea</i> - 2
<i>Calamagrostis epigejos</i> - 2		
<i>Carpinus avium</i> ef. - +		
<i>Crataegus</i> sp.- +		
<i>Daucus carota</i> - +		
<i>Epilobium angustifolia</i> eg. - r		
<i>Epilobium</i> sp.- +		
<i>Festuca rubra</i> agg. - 1		
<i>Fradaria vesca</i> - +		
<i>Geum urganum</i> - +		
<i>Hieracium</i> - +		
<i>Chaerophyllum temulum</i>		
<i>Lotus corniculatus</i> - +	Area 3 - succession	
<i>Phragmites australis</i> - 1	Cover E1 – 98%	
<i>Picia abies</i> - +	Cover E2 – 42%	
<i>Pinus silvestris</i> – r	Cover E3 – 35%	
<i>Prunus avium</i> ef. - r		
<i>Pyrola minor</i> – 1		
<i>Quercus petraea</i> - +		
<i>Rosa canina</i> - r		
<i>Rubus fruticosus</i> agg. - +		
<i>Sorbus aucuparia</i> - r		
<i>Taraxacum</i> sect. <i>ruderalia</i> - 1		
<i>Trifolium repens</i> - +		
<i>Tussilago farfara</i> - 1		
<i>Veronica officinalis</i> - r		
<i>Vicia hirsuta</i> - r		

E1 – herb floor, E2 – shrub floor, E3 – tree floor

Biological cover in % of area in 2010 - 2021



RESEARCH AREA RADOVESICE VI

- **The experimental reclaimed area of Radovesice VI (about 44 ha) was established in the western part of the Radovesice dump**
- **Modified methodology for the application of marls has already been used here. A layer of marl with a thickness of 0.2 - 0.3 m was brought to the surface of the terrain and it was ploughed to a depth of up to 0.5 m**
- **The original dump soil consisted of sandy clays and sands**
- **The methodology of the research has already been described in more detail here. It is a combination of monitoring and modeling of precipitation and temperature and long-term monitoring of selected soil and biological parameters of the area**





Pedological parameters of anthropogenic soil profile -
Radovesice VI

sampling interval (m)	Nc (%)	Cox (%)	CaCO ₃ (%)	pH KCl	acceptable nutrients (mg.kg ⁻¹)			sorption		
					P	K	Mg	S	T	V
								mmol/100 g		
2010										
0,00-0,20	0,02	1,9	7,8	7,6	5	212	810	14	14	100
0,20-0,60	-	0,8	6,3	6,5	1	145	652	10	10	100
2015										
0,00-0,20	0,08	2,2	7,3	7,2	6	240	873	17	17	100
0,20-0,60	0,04	1,3	6,2	6,3	3	185	785	14	14	100
2021										
0,00-0,20	0,10	2,3	7,1	7,1	6	235	875	17	17	100
0,20-0,60	0,06	1,5	6,2	6,3	3	215	711	15	15	100

Content of risk trace elements in soils of areas of interest

locality	content in sample (mg . kg ⁻¹)											
	As	Be	Cd	Co	Cr	Cu	Mo	Ni	Pb	V	Zn	Hg
0,00-0,20	12,6	2,0	0,3	17,3	33,5	19,8	0,57	32,1	27,6	75,6	49,4	0,15
0,20-0,60	7,5	1,9	0,2	15,5	50,7	43,3	1,62	42,5	22,5	101	56,2	0,22
Decree N. 153/2016	20	2	0,5	30	90	60	-	50	60	130	120	0,3

Other pollutants in soils of areas of interest

sampling interval (m)	S %	organic maas %	pH KCl	occurrence of sulphides Fe
0,00-0,20	0	2,1	6,9	NO
0,20-0,60	0,07	1,7	6,1	NO

CONCLUSION

- **The Radovesice spoil heap is the largest and most important reclamation site of the Most Basin and modern reclamation technologies have been used here. That is why it was chosen as a case study area solution of the TEXMIN project**
- **Two monitoring stations were established on this spoil heap, where the development of temperature, precipitation and area parameters is monitored and forecasted**
- **Based on the results, adaptation measures will be proposed**
- **For the Radovesice spoil heap, the following measures are still under consideration - adjustment of care for reclaimed areas (protection of seedlings by grassland), adjustment of the assortment of seedlings (drought-resistant species) and improvement of soil infiltration capacity in clay parts of the site**
- **The future of the Radovesice dump will be a well-thought-out combination of forestry and agricultural reclamation and succession areas. Most of the site will serve as a suburban park for the citizens of Bílina town**



The impact of **EX**treme weather events
on **MIN**ing operations



TE MIN

Thank you for your attention

Michal Rehor
rehor@vuhu.cz
VÚHU a.s.
Budovatelů 2030
434 37 MOST
Czech Republic