Comparison of Differently Remediated Hard Coal Overburden and Tailings Dumps: Conclusions a Few Decades after Remediation

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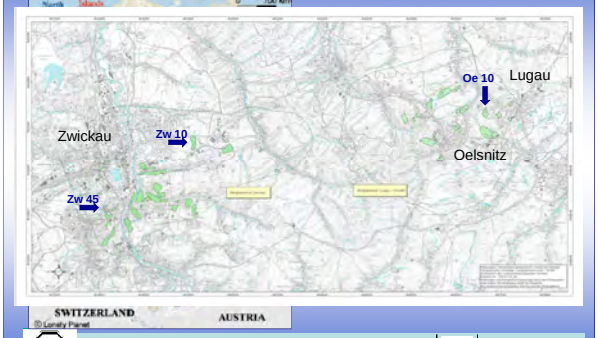
Content

1. Historical development in the area of Zwickau/ Oelsnitz in Saxony

- Beginning of hard coal mining around 1350
- Since 1830 „Industrial Age“ (steam engines, smelters, coal for heating, car factory (later „Audi“))
- Today: Contamination of ground and surface water by AMD formation

Area of investigations

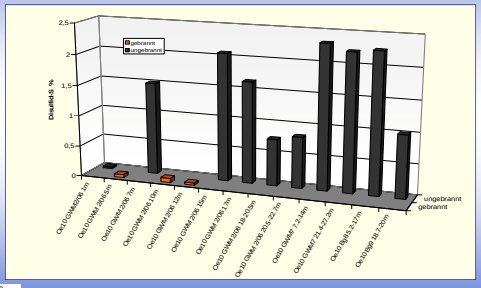


2. Material in the dumps

- Coarse material from coal processing, tailings from the washing process, overburden material from mining
- Red material with low C content, black (coal) material with higher C content (reason for burning dumps)

Disulfide content of the coal material

The dump material contains pyrite and marcasite, and other metal sulfides (sphalerite, galena, Cu-sulfides, arsenopyrite)



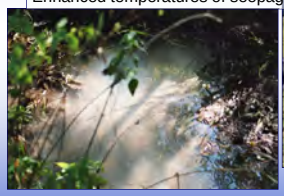
Environmental impact

Detrimental to the quality of ground and surface water

- decrease of pH
- enhanced salt concentration
- contamination with heavy metals and metalloids

AMD

Enhanced temperatures of seepage waters by coal burning processes



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3. Investigations during the „Dump project“

- Field surveying and mapping
- Sampling holes
- Small scale drillings
- Drillings, installation of ground water sampling wells
- Sampling and chemical analytics (soil, water, air, plants)
- Temperature measurements (thermal processes)
- Microbiological investigations
- Investigation of plants and soil formation

Improvement of knowledge about processes in and on the dumps after former remediation measures

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4. Results (3 different selected dumps)

		Oe 10	Zw 10	Zw 45
Dump operation time		1856-1954	1900-1977	1855-1933
Pyrite content	%	1.42-4.35	0.64-1.63	0.42-1.76
Total sulfur	%	1.71-4.07	0.83-2.09	0.36-0.97
Oxidation grade of sulfur	%	12.8-57.7	30.7-58.3	3.1-11.72
pH		3.61-5.12	4.4-7.42	6.4-7.15
E_h	mV	497-732	-254-533	104-355
Conductivity	mS/cm	0.96-9.91	0.96-11.79	0.856-3.23
SO_4^{2-}	mg/l	641-8538	187-5490	226-1840
Cd	µg/l	180-1950	<0.2-390	<0.2-20
Ni	µg/l	270-7358	2.8-1200	4.4-210
Zn	mg/l	10-337	<0.02-1000*	<0.02-16
As	µg/l	<1-17	<1-1.3	<0.1-86
Seepage water rate	mm/a	237 (BOWAHALD)	100 (covered) 350 (uncovered)	125 (natural) + 25 (irrigation)

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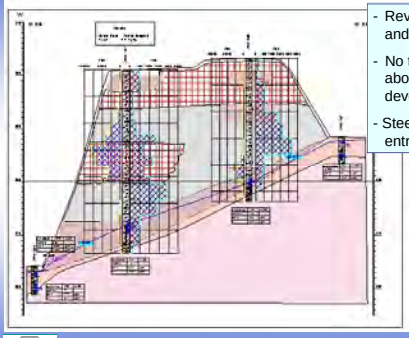
Dumps with no additional covering: Dump Oe 10



- Revegetation in 1950-ies and 1960-ies
- No topsoil addition (theory about natural soil development)
- Steep slopes (slides, air entry)

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General environmental conditions and microbial counts

Conclusions for the dump Oe 10:

- Lowest pH- data of all water samples and of the soil eluates
  Acidification process is in progress
- No distinct sulfate reduction
  Only at places with enhanced occurence of detritus
- Mostly predominant oxidizing processes
- Enhanced potential for acid generation with emission of dissolved salts (sulfate) and heavy metals

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Dump Zw 10 / Parts with no covering and covered parts

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Dump Zw 10 / uncovered part

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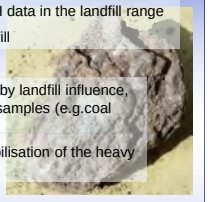
General environmental conditions and microbial counts

Conclusions for the dump Zw 10:

- Low redox potentials and more neutral pH data in the landfill range
  High conductivity by influence of the landfill
- High microbial counts of sulfate reducers by landfill influence, esp. in water (seepage) and in sediment samples (e.g.coal sludges)
- No acidification in the landfill area, immobilisation of the heavy metals
- Enhanced thermal processes in dump areas without influence of the landfill (oxidation of coal and pyrite) and release of acid, salts and heavy metals (see seepage- and ground waters)



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Dump Zw 45 / Dump with soil covers > 65 years

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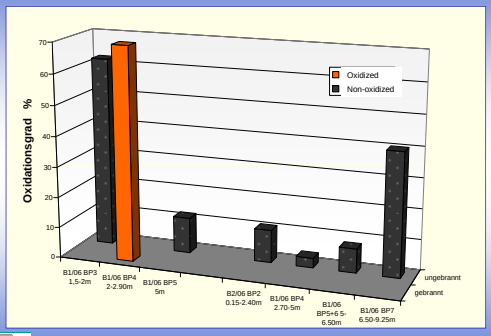
Oxidation grade of sulfur in different layers of dump Zw 45



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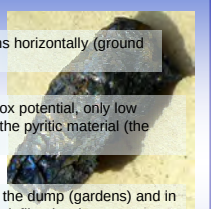
General environmental conditions and microbial counts

Conclusions for the dump Zw45 in Zwickau:

Cover of loam and topsoil, organic infiltrations horizontally (ground water) und vertikal (pit drainage)



- Relatively neutral pH data, moderate redox potential, only low conductivity and low oxidation grades of the pyritic material (the lowest of all sites)
- Many sulfate and iron reducers on top of the dump (gardens) and in the ground- and seepage waters (organic infiltrations)
- Only low release of heavy metals and salts, nearly no acidification

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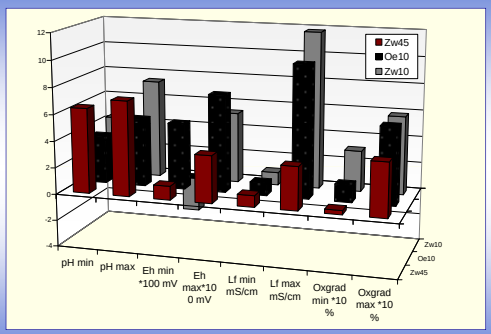
Comparison of general environmental conditions



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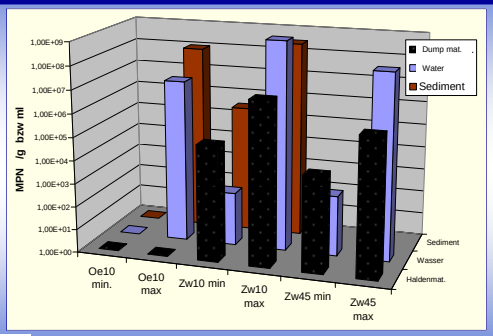
Microbial life – comparison of sulfate reducers at the different dump sites



Seepage water formation and loads

		Oe10	Zw10	Zw45
Seepage water rate	mm/a	237 (BOWAHALD)	100 (covered) 350 (no covering)	125 (natural) + 25 (irrigation)
SO_4^{2-} seepage water load	t/a	130	73	5
Zn seepage water load	t/a	6.8	0.46	0.025
Ni seepage water load	kg/a	150	18	0.6
Cd seepage water load	kg/a	40	7	0.002
SO_4^{2-} : reduction of seepage water load compared to Oe10	%	-	68	85
Zn : reduction of seepage water load compared to Oe10	%	-	96	98.6
Ni : reduction of seepage water load compared to Oe10	%	-	93	98.5
Cd : reduction of seepage water load compared to Oe10	%	-	90	99.98

5. Conclusions

1. Covering of dumps with loam and topsoil, reduction of slopes

➡ Long term reduction of weathering processes and of the emission of contaminants

2. Input of organic substance into the dumps and in seepage and ground water

➡ Stimulation of the microbial sulfate reduction

3. Simple revegetation without covering can **not** prevent AMD generation; no full natural topsoil generation

4. Good accordance of the measured microorganism counts with the chemical- physical Parameters and the nutrient content of the specific sites

➡ Microorganisms good suited for the complex biogeochemical characterisierung of the different positions

High diversity of the microorganisms depending on the specific site

Thank you for your attention!

The project was funded by the Saxonian State department of Environment and Geology