Sustainable Remediation of Radionuclide Impacts on Land and Critical Materials Recovery

GA No 101079345

The SURRI project: Developing new biorecovery approaches at legacy uranium and polymetallic mining sites

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Bioremediation/biorecovery challenges

1. Extreme pH and Redox Conditions
2. High Toxicity of Heavy Metals and Metalloids (As, Hg, Cd, Pb, Zn, Cu)
3. Low Nutrient Availability – C, N, P
4. Poor Oxygen Penetration and Mass Transfer
5. Maintaining Functional Microbial Communities
6. Scaling Up and Field Application

Element (limit)	Mine water (mg/L)	Tailings (mg/kg)	Tailings (mg/kg)	Sediment (mg/kg)
Al	26.5	9,658	5,024	1,252
As	18.7	63.1	147	<0.01
Ca	80.1	8,688	11,388	637
Cd	NA	8.8	33.9	<0.01
Co	0.26	15.7	32	<0.01
Cr	NA	21.6	9.9	<0.01
Cu	18.7	662	2,669	<0.01
Fe	34.4	39,646	66,703	454,464
K	0.94	683	507	<0.01
Mg	33.8	8,771	5,694	<0.01
Mn	7.56	844	765	446
Na	3.74	NA	NA	<0.01
Ni	NA	25.2	NA	<0.01
Pb	NA	549	2,584	806
V	<0.01	14.4	NA	<0.01
Zn	2.9	1,689	7,273	880

AIMs

- Describe the effect of mine water treatment on microbial diversity
- Characterize microbial isolates in terms of applicability for bioremediation and biorecovery
- Develop novel strategy combining chemical and bio-based approach and determine its efficiency

Tools

- Alpha/beta diversity, relative abundance changes, correlation of taxa with physico-chemical parameters
- Isolate, identify(sequencing), growth kinetics, MIC/tolerance tests, biosorption and bioaccumulation tests
- Recovery yield of target metals, microbial monitoring (amplicon sequencing and viability)

1945 – 1991
3 949 kt ore
0.237 % Sn
0.053 % W

1st:1300 BC
Zlaté Hory: **3.4 t**
Suchá Rudná: **6.3 t**
1590: 1.39 and 1.79 kg
1990-1993 1.5 t Au
17-19th century - Fe
from 1965-1990 – Cu

13.-19. century
~15 t Ag/a.
1958-1991: Zn- 44, 624 t

1957-2007: 20 t uraninite

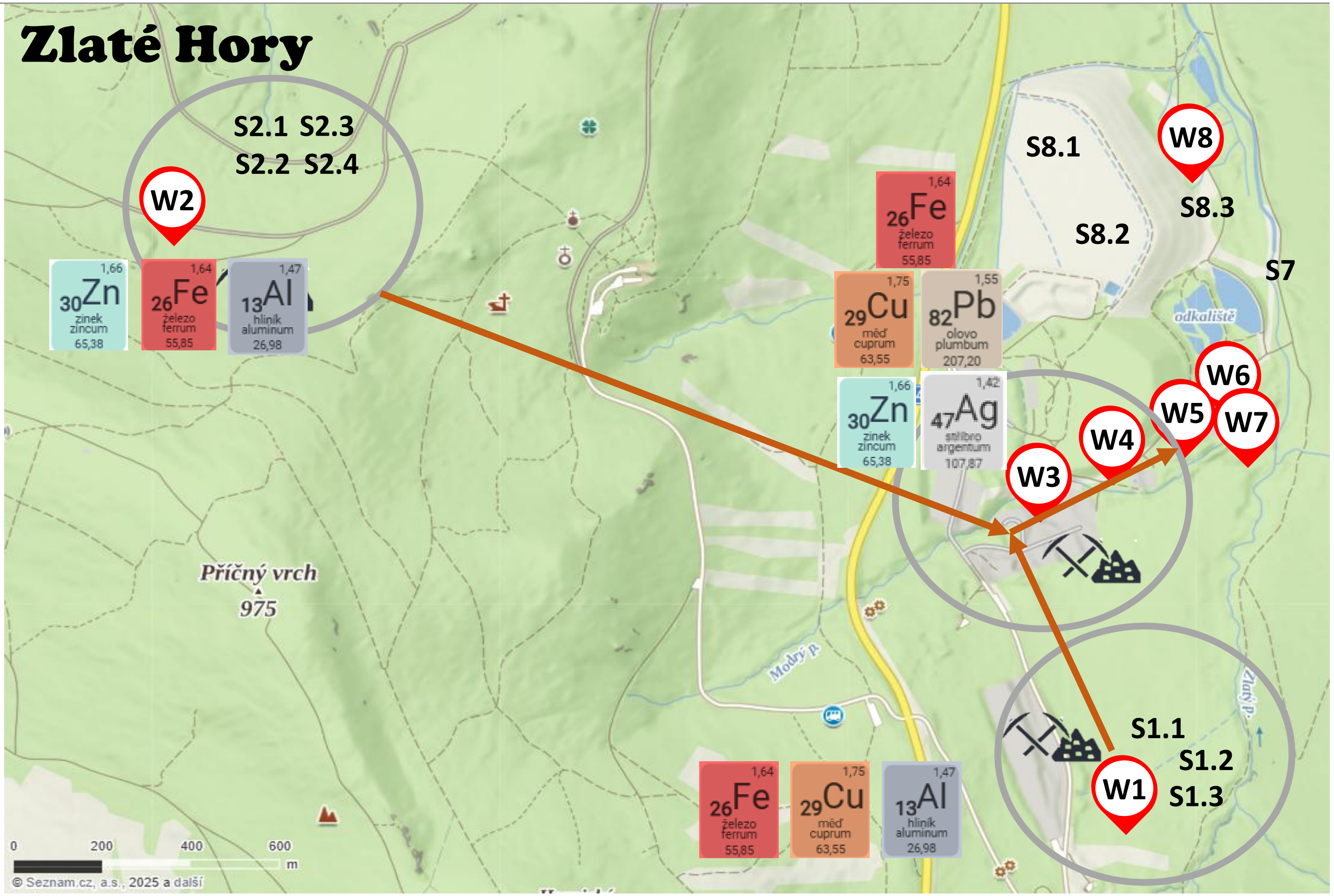
gold · silver · copper · iron · uranium · tin/tungsten · zinc


W1


W2


W3


W4


Zlaté Hory
S2.1 S2.3
S2.2 S2.4
W2
1,66 30 Zn zinek zincum 65,38
1,64 26 Fe železo ferrum 55,85
1,47 13 Al hliník aluminum 26,98
S8.1
W8
S8.3
S8.2
S7
odkaliště
1,64 26 Fe železo ferrum 55,85
1,75 29 Cu měď cuprum 63,55
1,55 82 Pb olovo plumbum 207,20
1,66 30 Zn zinek zincum 65,38
1,42 47 Ag stříbro argentum 107,87
W6
W5
W7
W4
W3
Příčný vrch
975
Modrý p.
Zlatý p.
S1.1
S1.2
S1.3
W1
1,64 26 Fe železo ferrum 55,85
1,75 29 Cu měď cuprum 63,55
1,47 13 Al hliník aluminum 26,98
0 200 400 600 m
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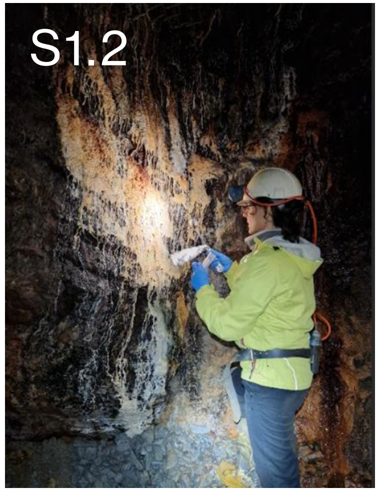
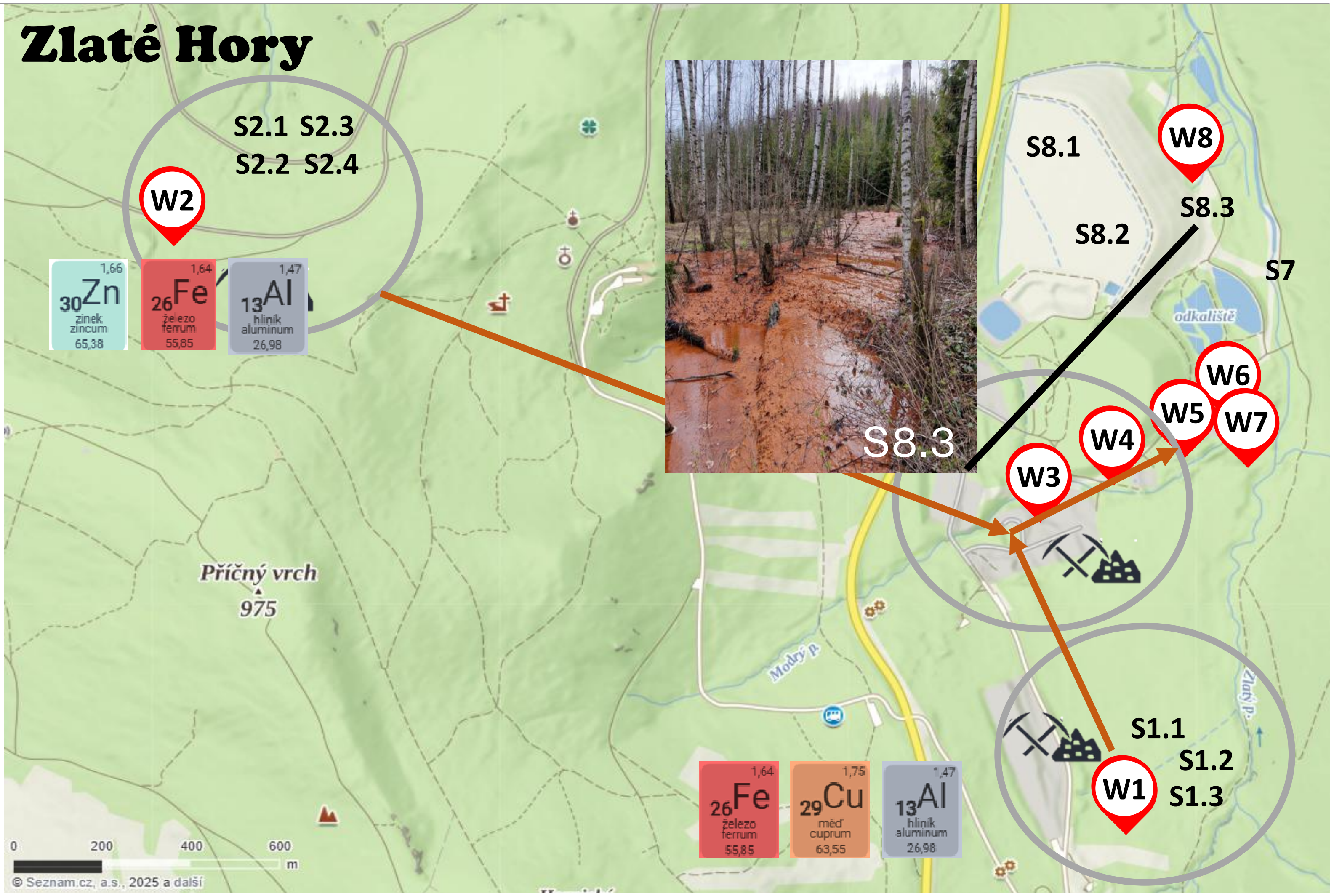
S1.1


S1.2


S1.3


S2.2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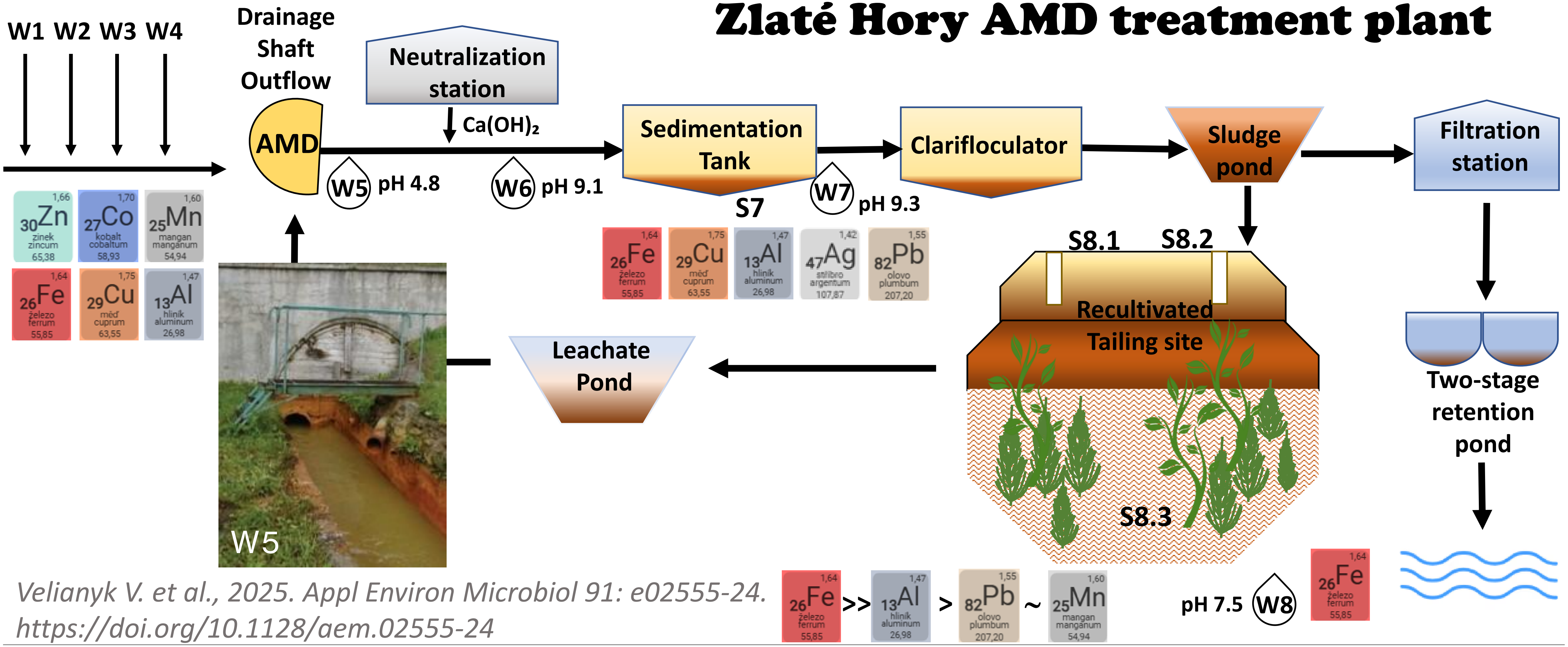
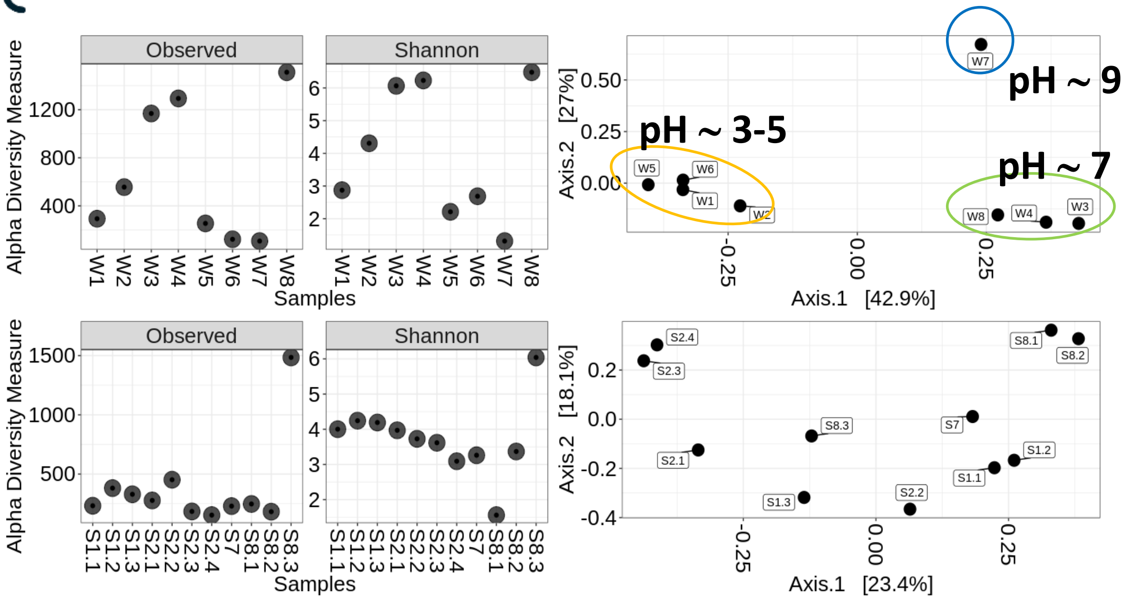
Zlaté Hory AMD treatment plant



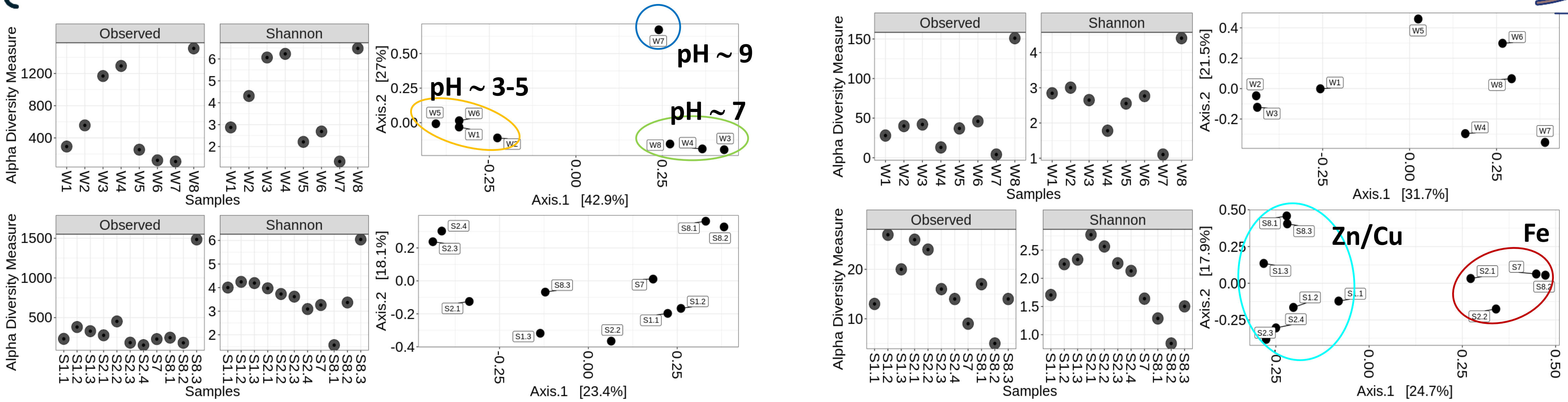
Velianyk V. et al., 2025. Appl Environ Microbiol 91: e02555-24.
https://doi.org/10.1128/aem.02555-24

Microbial diversity



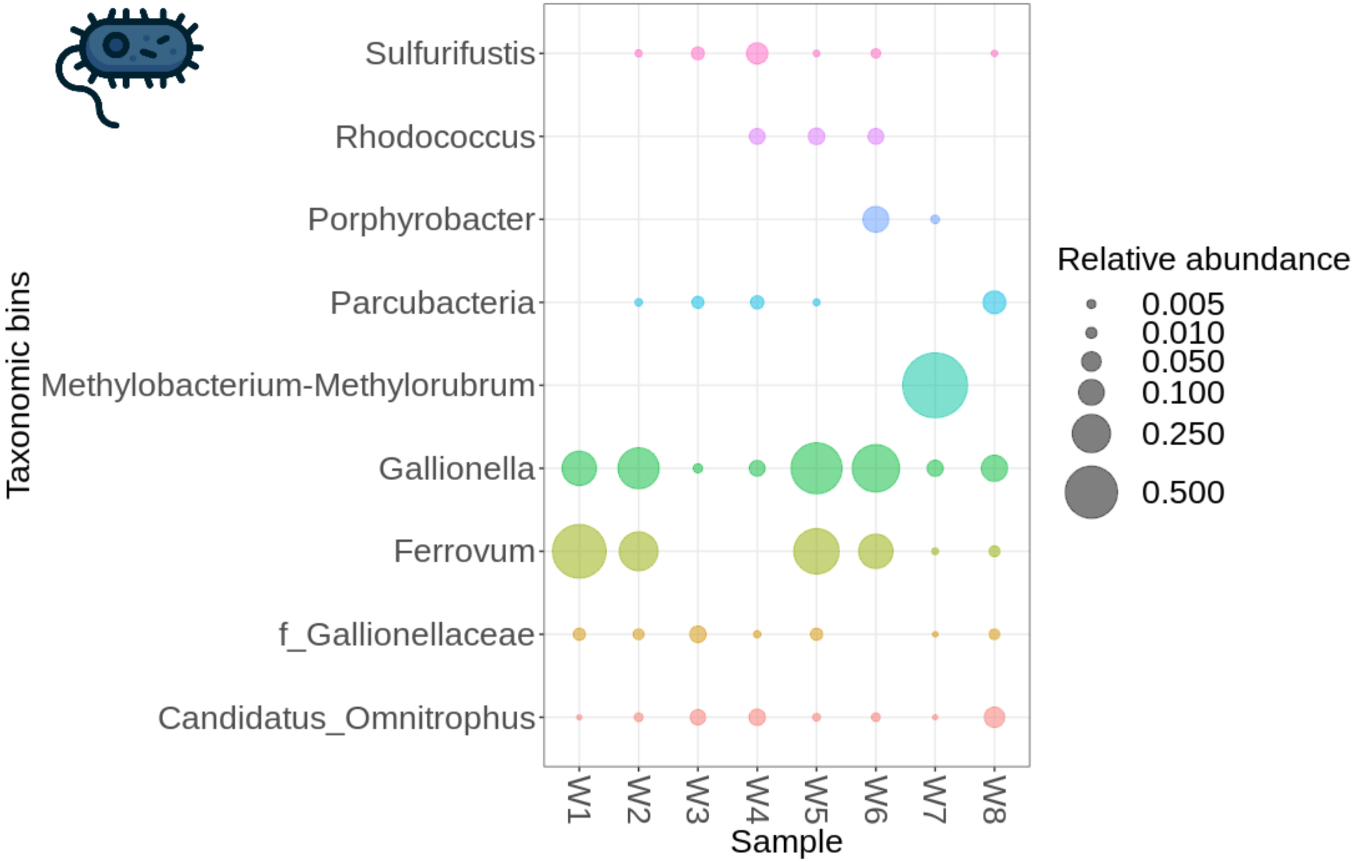
- Generally low microbial diversity was observed in all samples.
- High bacterial diversity was found in more neutral waters and sediment.
- The lowest microbial diversity was detected in sedimentation tank.
- PCoA showed clusters correlating with pH

Microbial diversity

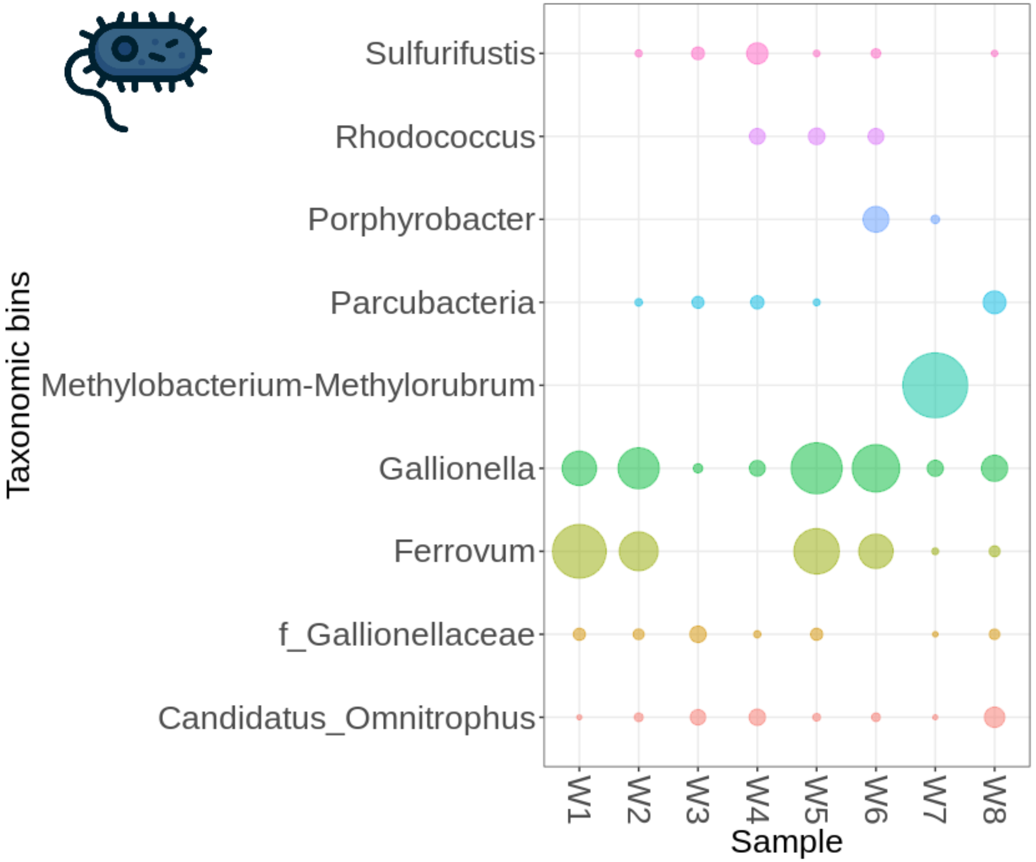


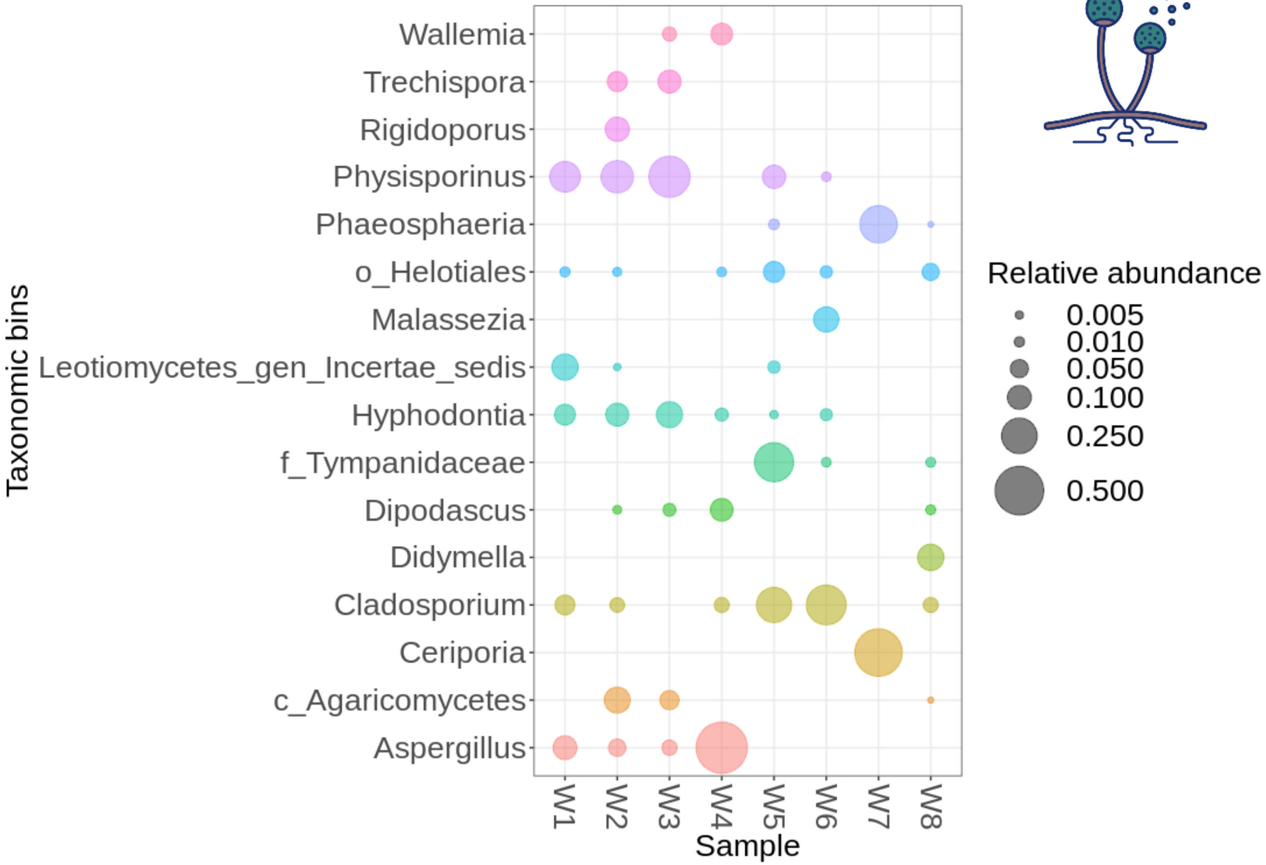
- Generally low microbial diversity was observed in all samples.
- High bacterial diversity was found in more neutral waters and sediment.
- The lowest microbial diversity was detected in sedimentation tank.
- PCoA showed clusters correlating with pH of waters or reflecting geochemical properties of sinters

Microbial community composition



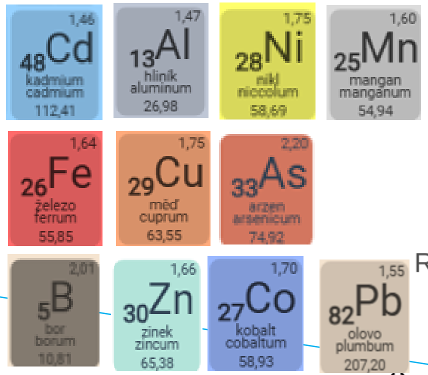
Microbial community composition

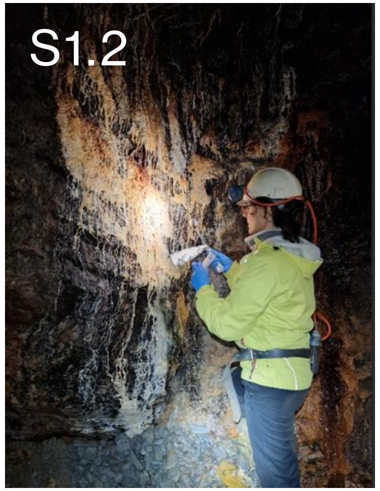


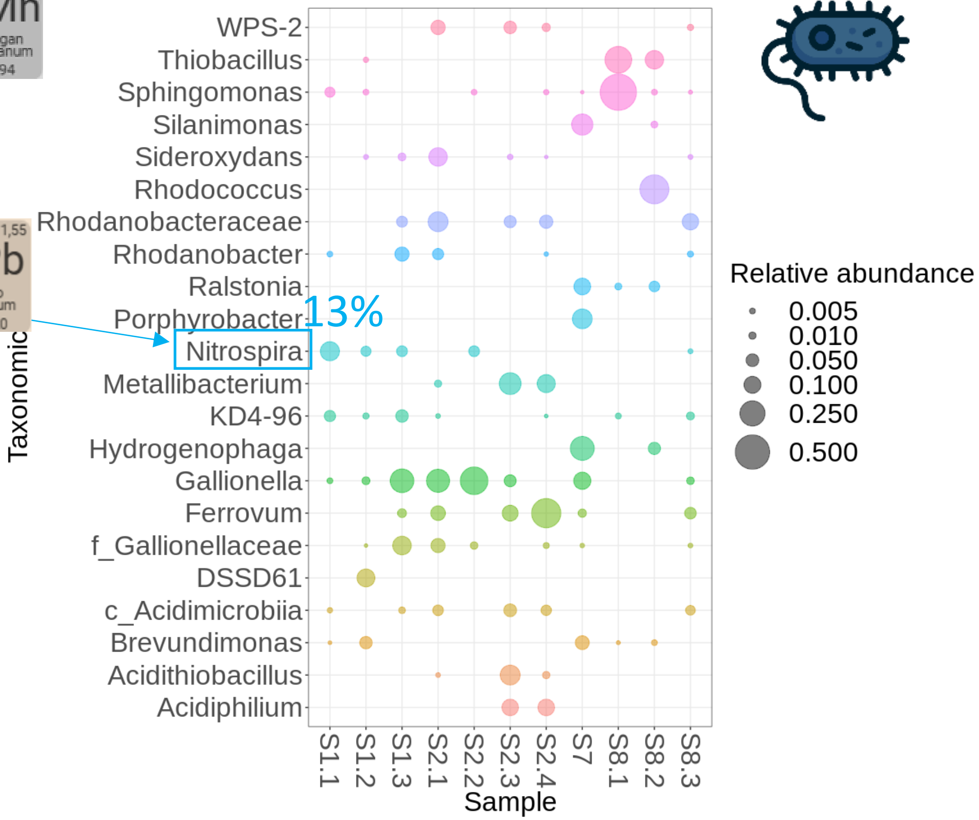


Microbial community composition

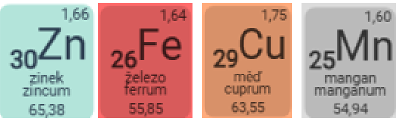
Solid samples: Bacterial community composition is dependent on geochemical characteristic of samples







Metallibacterium
Gallionella
Ferrovum
Acidithiobacillus
Acidiphilium



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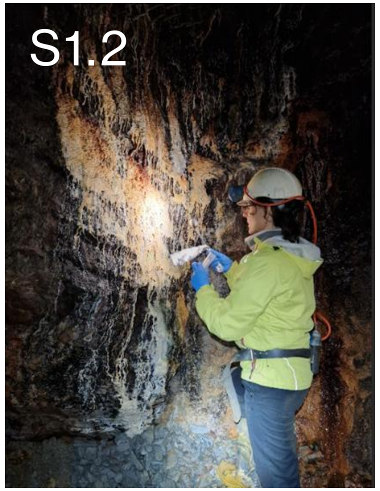
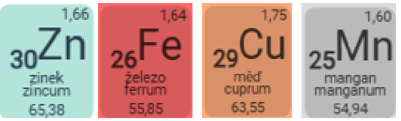
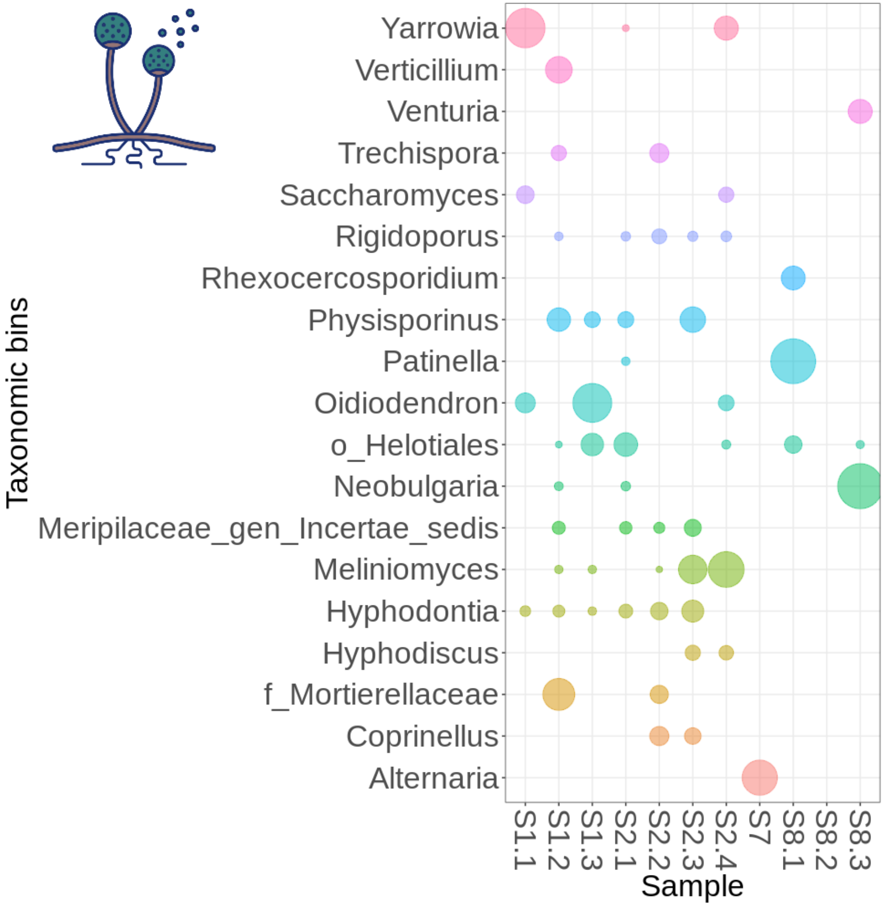
Solid samples: Bacterial community composition is dependent on geochemical characteristic of samples

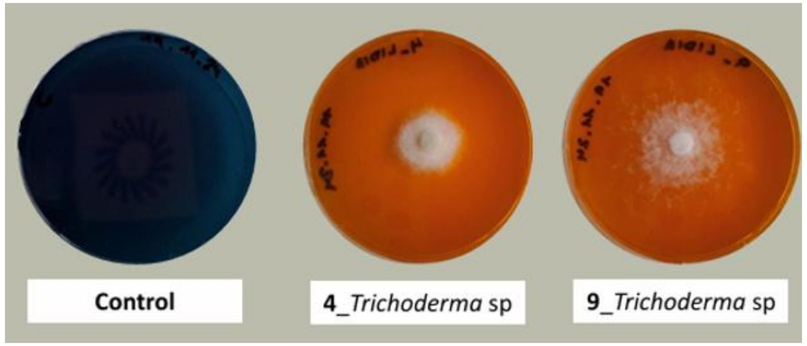






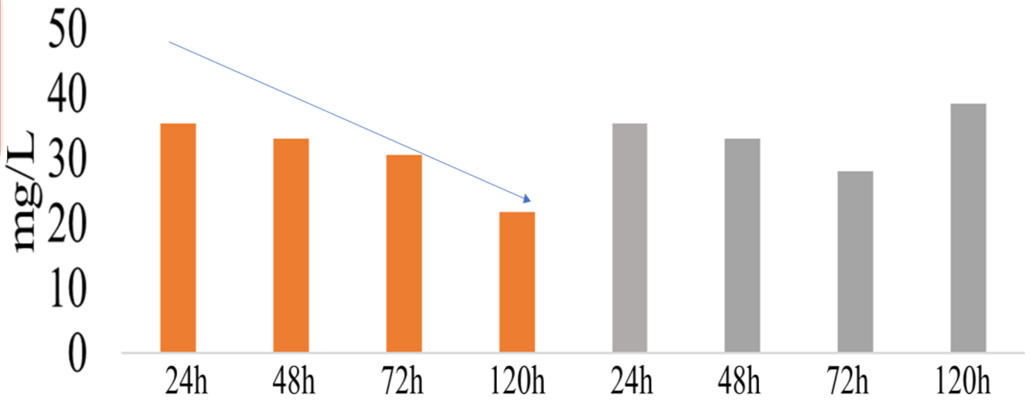
Coprinellus
Hyphodiscus
Hyphodontia
Meliniomyces
Physisporinus

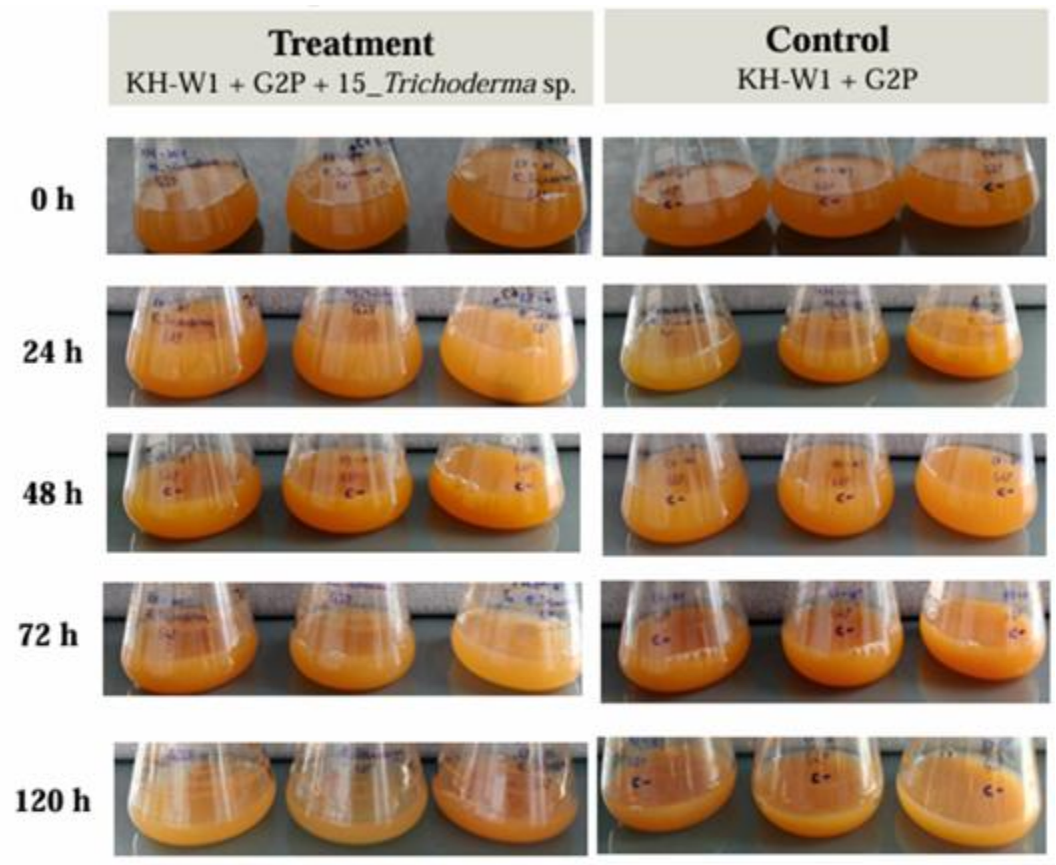
Removal of arsenic from mining water using *Trichoderma* sp.



S8.3 W1

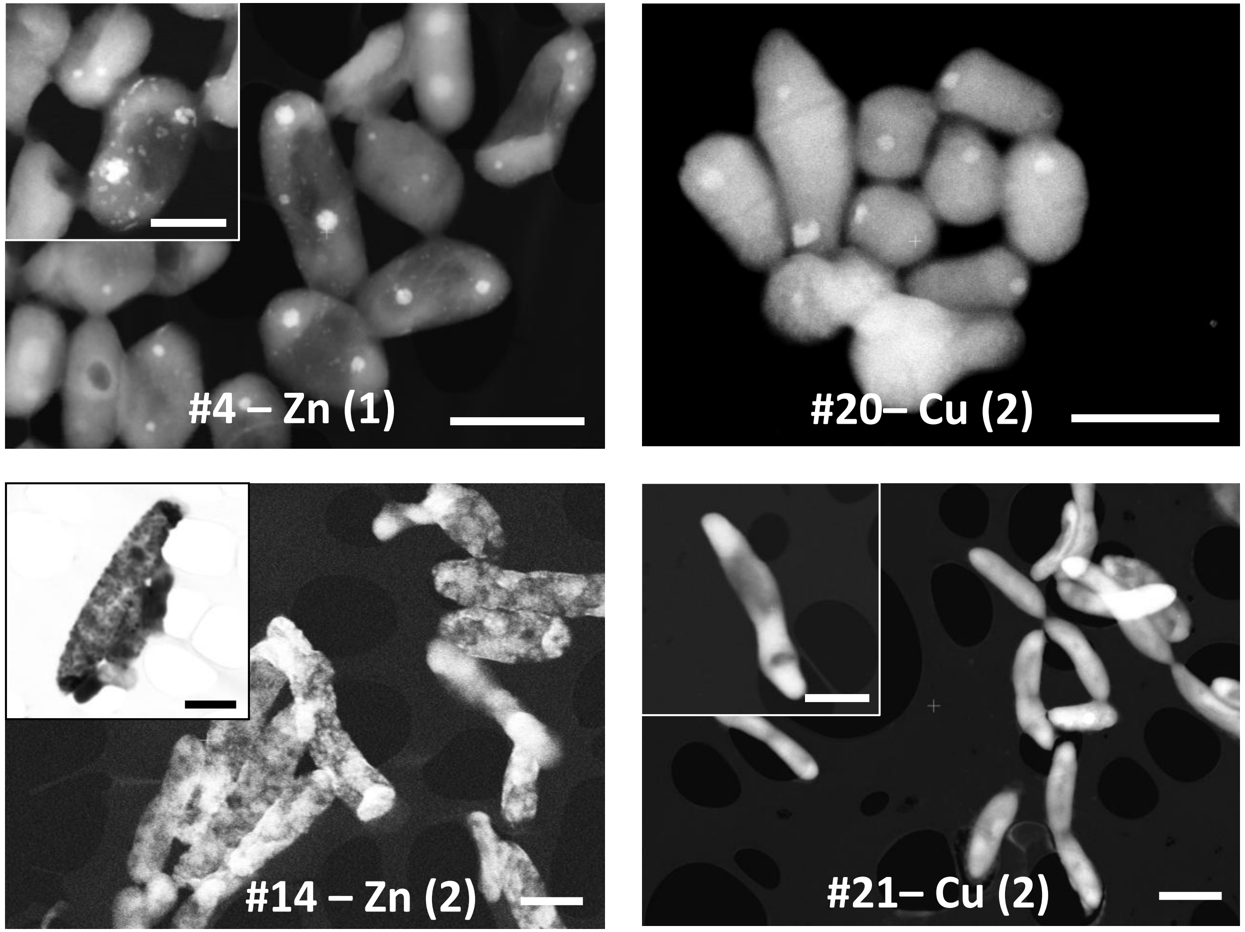
Bromocresol green assay → organic acid production
Initial pH: 6.5





Bioaccumulation and Biosorption

Culture #	Strain	% identity	Cu	Co	Zn	Pb	Se
4	*Variovorax* sp. SIB_Cd_R3	99.67	>4	n.d.	8	8	>8
14	*Microbaterium* sp. HaHa633	99.87	>4	>4	8	>8	>8
20	*Arthrobacter* sp. MB118	98.95	4	2	8	8	>8
21	*Pseudomonas mandelii*	100	>4	>4	8	8	16



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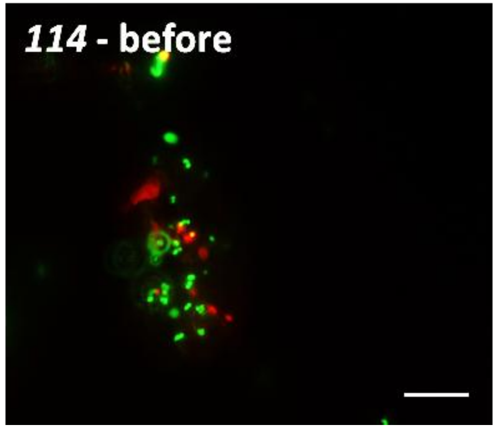
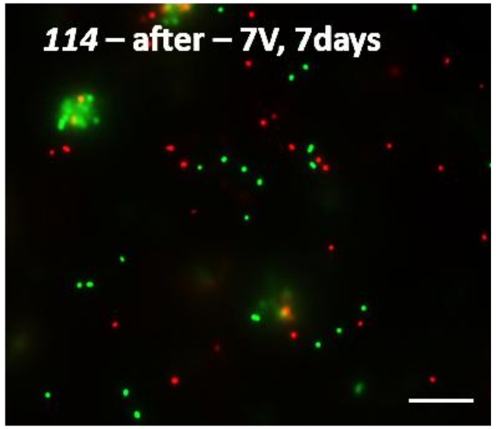
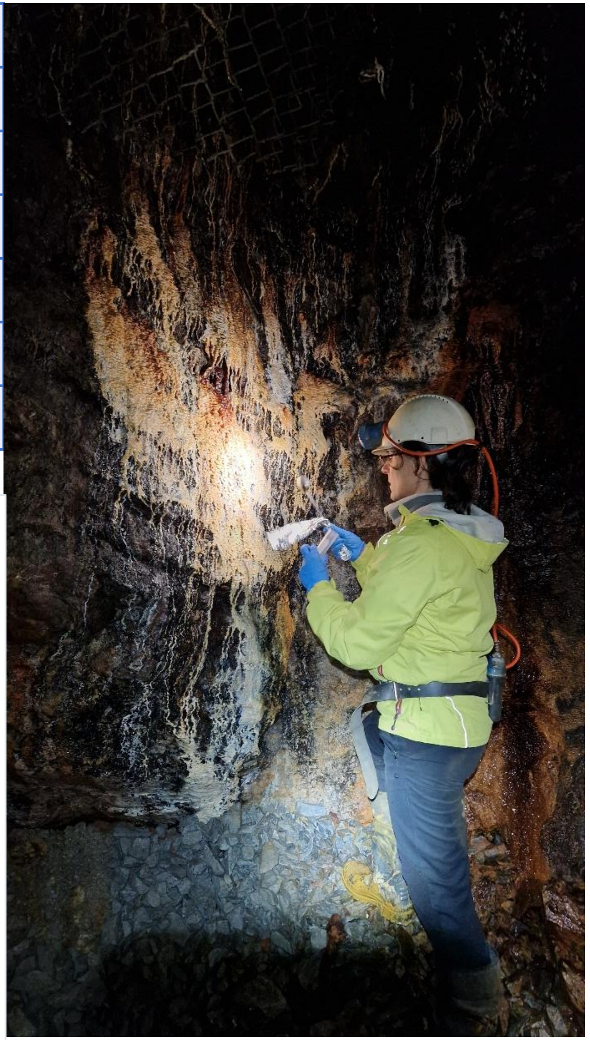
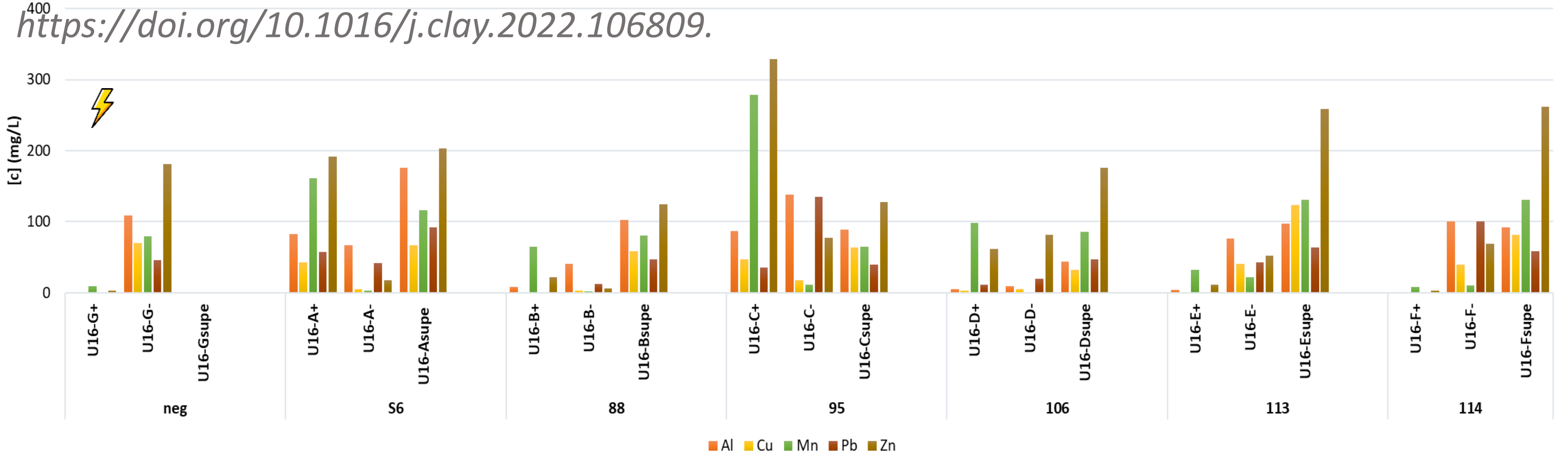




Bacteria	% Identity
Variovorax sp. SIB_Cd_R3	99.7
Variovorax boronicumulans	100
Variovorax sp. +	NA
Variovorax boronicumulans	100
Microbacterium profundi	99.8
Microbaterium sp. HaHa633	99.9



Hlavackova V. et al., 2023: Applied Clay Science, 232
https://doi.org/10.1016/j.clay.2022.106809.



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Conclusion

1. The microbial environment in postmining sites is highly selective and fragile.
2. Both microorganisms capable of leaching and bio-precipitation are already on site
3. Indigenous microbiome can be used for combined bio-electrochemical approaches
4. The comprehensive evaluation provides a framework for optimizing biorecovery technologies.

Thank you for your attention

J. Riha – bioinformatics
P. Kejzlar - SEM