

# Reducing water quality impacts from abandoned mines in Saxony - Challenges and benefits for passive treatment options

**Eberhard Janneck, Mirko Martin, Christine Stevens, Axel Hiller**

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2. Impact of abandoned mines on streams and rivers in Saxony
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Retention pond at the tin mine Ehrenfriedersdorf

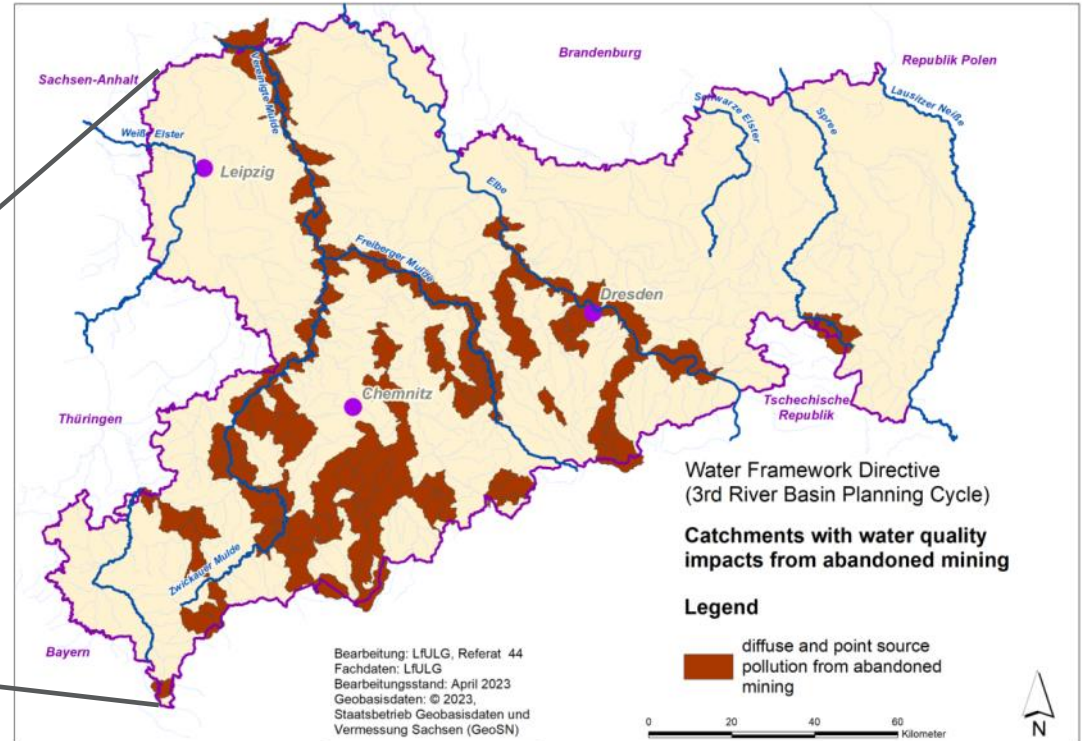
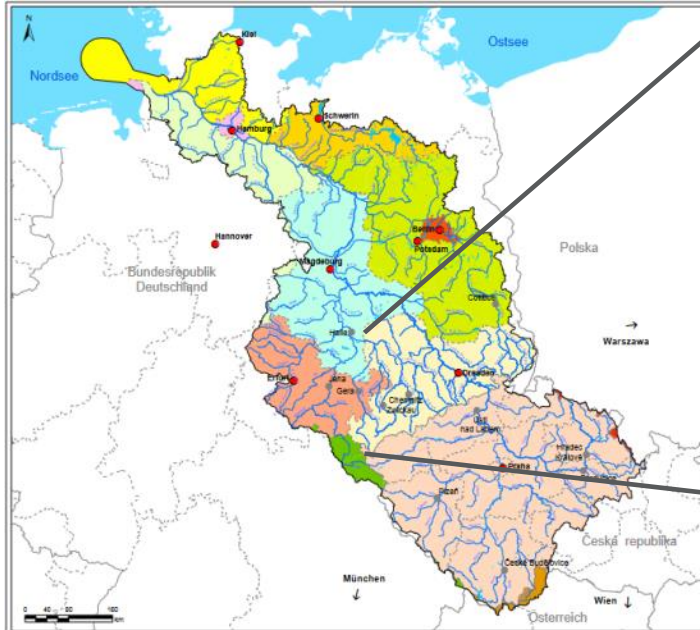


# Impacts from abandoned mines on rivers in Saxony

## Surface waterbodies impacted in Saxony

- Arsenic, Copper, Zinc, Cadmium and Nickel
- > 1,300 km river length affected by abandoned mines

### River Elbe catchment



# Applying the DPSIR approach on a catchment scale

## Driver – Pressure – State – Impact – Response

The Free State of Saxony has been launched a program of investigations in 2021 to identify and scale pollution sources as well as to determine suitable measures to achieve the highest possible status for the streams and rivers.

### Results for the Zwickauer Mulde catchment

Waterbody	Distance to target values for exceeded parameters					Kilometers of river polluted including downstream impacts				
	Cd	Ni	As	Cu	Zn	Cd	Ni	As	Cu	Zn
Schwarzwasser-2										
Große Mittweida-3										
Pöhlwasser-1										
Schwarzbach										
Oswaldbach										
Mulde-3										
Kleine Pyra										
Zschorlaubach										
Schlema										
Reinsdorfer Bach										
Planitzbach										
Marienthaler Bach										
Mulde-4										
Mulde-5										
Dorfbach Oberschindmaas										
Lungwitzbach-1										
Hegebach										
Lungwitzbach-2										
Zwönitz-1										
Gornsdorfer Bach										
Zwönitz-2										
Herrnsdorf-Bräunsdorfer Bach										
Langenberger Bach										
Frohnbach-2										
Mulde-6										

Colour key
Distance to Target
<= 2x EQS
<= 4x EQS
<= 8x EQS
> 8x EQS
Length affected
< 10km
10-40 km
41-80 km
81-120 km
> 120 km

\* River length based on all waterbodies in the Zwickauer Mulde catchment

EQS = Environmental Quality Standards

### Criteria for prioritizing measures to maximize their benefit on a river basin scale

- ❖ Distance to target / severity of pollution
- ❖ Length of river affected
- ❖ Multiple pollutants
- ❖ Load contribution to the total load of pollutants in the respective river section
- ❖ Impact on ecological status
- ❖ Feasibility / likelihood of implementation (e.g. environmental permits, successful land acquisition)

# Selected study sites in Saxony

. . .for development of passive treatment systems

	Unit	St. Christoph adit, Breitenbrunn
Q	L/s	4-6
pH	-	7.1
SO <sub>4</sub>	mg/L	40
Al	mg/L	0.066
Mn	mg/L	0.013
Zn	mg/L	<b>2.4</b>
As	µg/L	<b>41.1</b>
Cd	µg/L	<b>16.2</b>
Cu	µg/L	6
Fe	µg/L	<0.03
Ni	µg/L	3.1
Pb	µg/L	<0.5



## St. Christoph mine

- Located in the Western Ore Mountains
- Mining since 1870
- Minerals:  
magnetite, arsenopyrite, sphalerite, cassiterite, (uraninit - pitchblende).
- Mine closed: 1950
- Today: visitor mine

# Selected study sites in Saxony

...for development of passive treatment systems

	Unit	Spoil heap leachate Ehrenfriedersdorf
Q	L/s	4
pH	-	7.1
SO <sub>4</sub>	mg/L	1050
Al	mg/L	0.2
Mn	mg/L	7.5
Zn	mg/L	<b>4.5</b>
As	µg/L	<b>1500</b>
Cd	µg/L	8.3
Cu	µg/L	2.6
Fe	µg/L	<b>9000</b>
Ni	µg/L	270
Pb	µg/L	<0.5



## Ehrenfriedersdorf tin mine

- Located in center of the Ore Mountains
- Mining since the middle Ages
- Metals: tin, tungsten
- 1936: Construction of the most modern ore processing plant at the time
- 2 spoil heaps (26 ha) with tailings from the processing plant (sandy residue)
- Mine closed: 1990
- Today: visitor mine



# Selected study sites in Saxony

...for development of passive treatment systems

	Unit	Leachates from TMF Hammerberg, Freiberg
#		5
Q	L/s	4
pH	-	5.5-6.5
SO4	mg/L	1500
Al	mg/L	14
Mn	mg/L	17
Zn	mg/L	45
As	µg/L	5.1
Cd	µg/L	560
Cu	µg/L	860
Fe	µg/L	15
Ni	µg/L	130
Pb	µg/L	14



## TMF Hammerberg

- Located near Freiberg
- Mining since 1168 in the Freiberg region
- Metals: silver, lead, zinc,
- 2 tailings management facilities (TMF):
- Hammerberg and Davidschacht
- Mine closed: 1969
- Currently undergoing remediation work

Pilot project has started 2024 / Not yet results



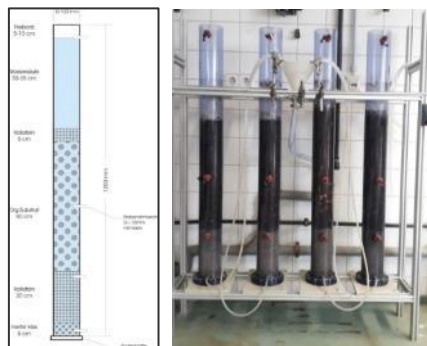
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# Selected study sites in Saxony

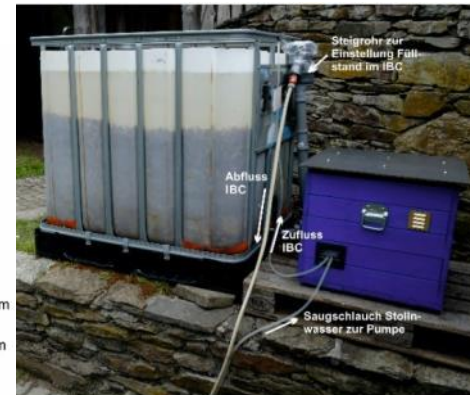
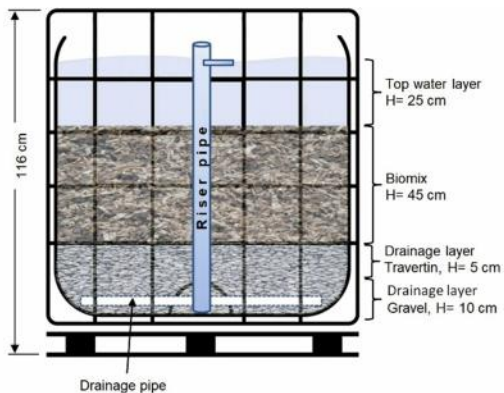
## Pilot study at St. Christoph Mine



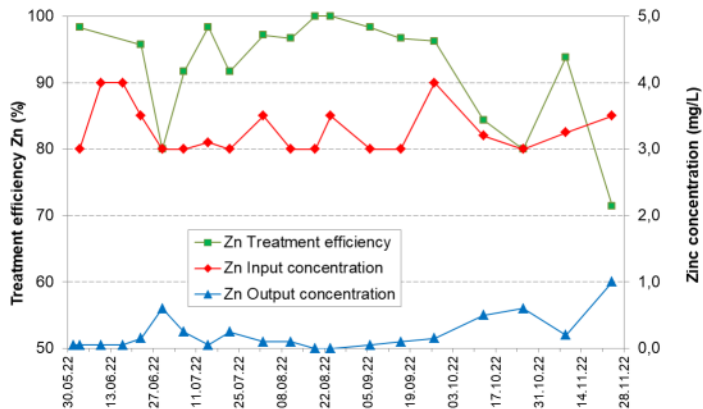
Column tests



VFBR

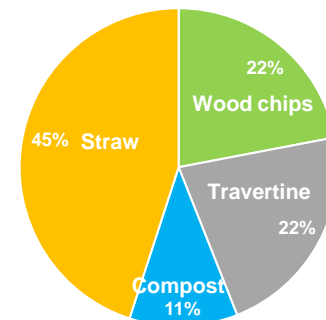


Results from the VFBR



Zn removal rate:  
2.43 g/(m<sup>3</sup> · d)

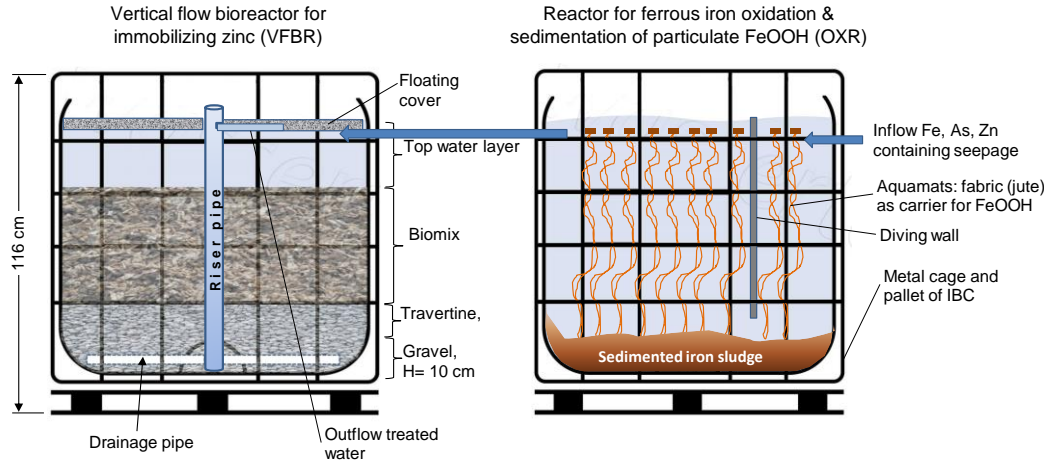
Biomix



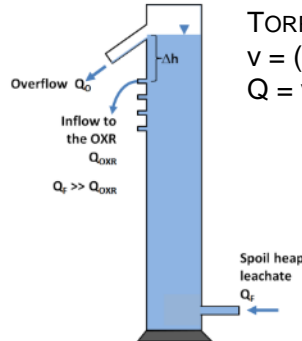


# Selected study sites in Saxony

## Pilot study at the spoil heap Ehrenfriedersdorf



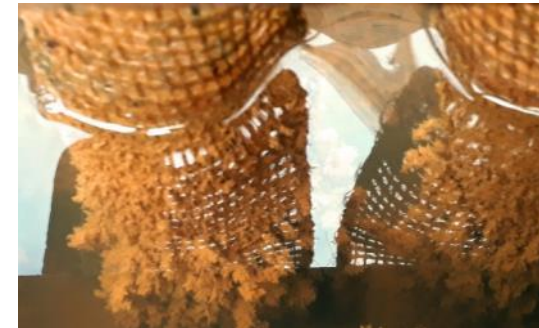
- Two reactors in series: OXR → VFBR
- Operating off grid
- OXR inflow uses a siphon line ( $\Delta h$  2.5m)
- Vertical tube as feeding device for the OXR
- Adjusting the feed flow to the OXR according to TORICELLI's theorem
- OXR contains strips of jute fabric
  - FeOOH particles stick to the jute fabric
  - it promotes Fe<sup>2+</sup> oxidation by the adsorption-oxidation mechanism



TORRICELLI's theorem:

$$v = (2 \cdot g \cdot \Delta h)^{0.5}$$

$$Q = v \cdot A$$



# Selected study sites in Saxony

## Pilot study at the spoil heap Ehrenfriedersdorf

VFBR



Leachate from the spoil heap:

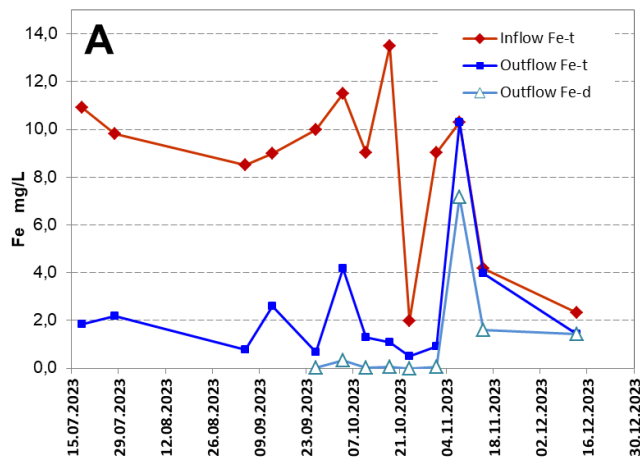
pH: 6.9 - 7.4 (net-alkaline)

Fe: 2 - 13 mg/L (5 - 80% ferrous iron)

As: 1 - 3 mg/L (33 - 50% as As(III))

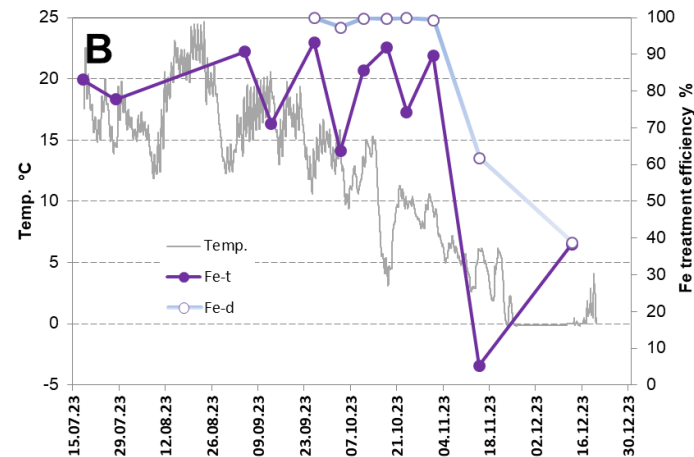
Zn: 3.5 - 6 mg/L

### Concentrations inflow /outflow



Results Fe treatment in the OXR

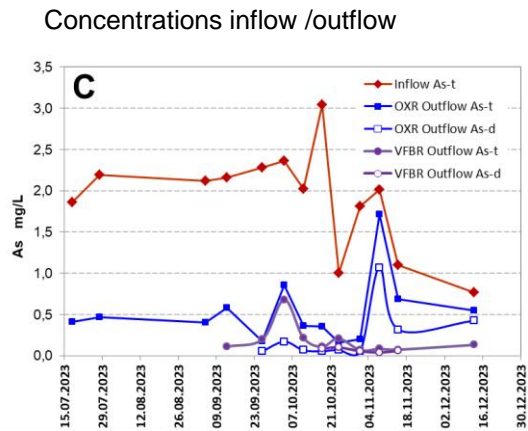
### Treatment efficiency



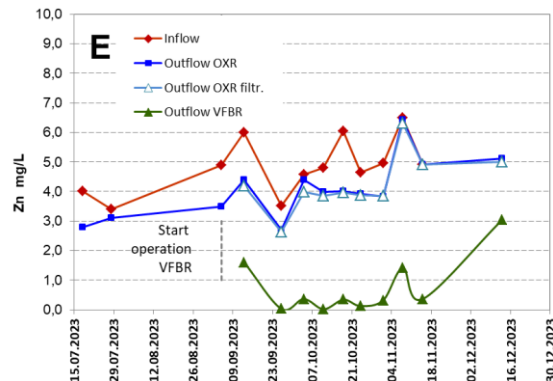
# Selected study sites in Saxony

## Pilot study at the spoil heap Ehrenfriedersdorf

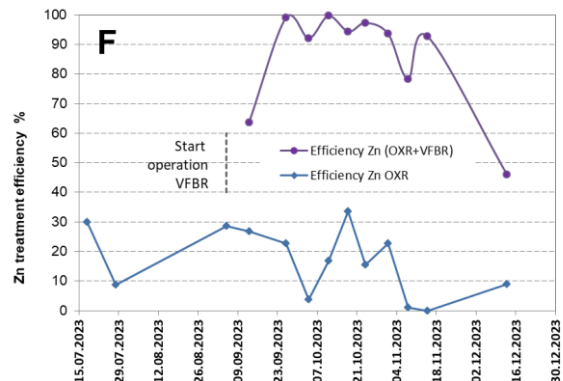
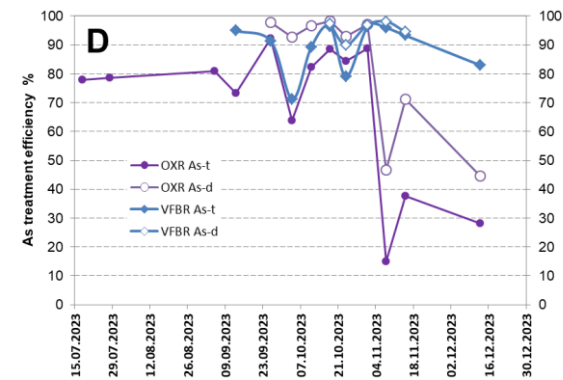
Results As treatment in the OXR and in the VFBR



Results Zn treatment in the OXR and in the VFBR



## Treatment efficiency





- Passive treatment systems have a considerable potential to treat effluents from abandoned mine sites in Saxony.
- Development of passive treatment systems is supported by the Saxon Ministry of the Environment.
- Mine water from the St. Christoph adit can be treated in an anaerobic system. Next step will be an real field test with a 50 m<sup>3</sup> VFBR (vertical flow bioreactor).
- Leachate from spoil heaps Ehrenfriedersdorf: further investigations to verify the results  
Potential treatment system: aeration cascade, oxidation/settling pond, aerobic wetland, vertical flow pond and polishing reed bed.
- At Hammerberg in Freiberg: The next pilot project has started in autumn last year. Concept for the pilot study has been confirmed. Construction work started this month.

# Thank you !

Co-authors:  
Mirko Martin, Christine Stevens, Axel Hiller

**Contact person:**

Dr. Eberhard Janneck  
Senior Advisor

phone: +49 15118827632

E-Mail: [e.janneck@geosfreiberg.de](mailto:e.janneck@geosfreiberg.de)

[www.geosfreiberg.de](http://www.geosfreiberg.de)