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Mansfeld – the contribution of a mining-affected catchment area to regional riverine pollution

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The Saale is one of the most polluted rivers in Germany and affects noticeably the water quality of the Elbe river down to the North Sea. Many and diverse anthropogenic sources are held responsible for the pollution of the Saale river: waste water from salt mining dumped into the tributaries Unstrut and Bode; seepage from uranium and base metal mining along Weisse Elster river and from the area of Mansfeld; effluent from the carbochemical, petrochemical, and metallurgical industries, from sewage treatment and from agriculture (Schreck, 1998; Müller, 2003). Although most of these sources of pollutants have been studied in detail (Müller, 1998; BMBF, 2000), very little is known about the environmental significance of restricted catchment areas and their share in regional riverine pollution. This deficit in knowledge may result from a lack of long-term studies on the intake of pollutants to the Saale river. In this study, a comprehensive estimation is given of the total metal and salt outputs of the Mansfeld mining district in Central Germany into the Saale, and the importance is shown of this catchment area for the regional riverine pollution.

The Mansfeld mining district is generally considered to be a source area for the release of heavy metals and salt. In this area, base metal and salt mining took place for many hundreds of years. Nowadays, low grade ore and smelting waste heaps mark the scene. The mining residues are eroded by extensive precipitation and the debris is flushed into local rivers and brooks (Schreck, 2004). Leachates from metallurgical waste products pollute the surface waters and lead to the formation of metalliferous precipitates. The Mansfeld lakes, fed by the surface water affected by mining, act as geochemical sinks for metals and stream sediment. The mining district is drained by two rivers and one major adit system: the Böse Sieben/Salza passes through the mining district and flows through the Mansfeld lakes. The Wipper has its source in the Harz Mountains, crosses the mining district between Mansfeld and Hettstedt and becomes enriched in pollutants from ore treatment. Both rivers run off to the East to feed the Saale. Ground water, contaminated by salt and metals is drained from the western and southern parts of the mining district by a major adit, the Schlüsselstollen, to the East, and flows into the Saale.

This survey is based on a 13-month sampling and monitoring campaign in 2002/2003. Included are the suspended and dissolved metal loads in the water of all significant rivers and brooks in the mining district, together with the major adits from metal mining. In detail, 18 sampling points were selected along the rivers Saale, Böse Sieben, Salza, Wipper and their tributaries. Water samples were collected on a monthly base and the river discharge rates determined. The water samples were analysed by ICP-OES, AAS graphite furnace and IC for 19 cations and 5 anions. Suspended matter was filtered (0.45 µm) from the samples, dissolved by total digestion, and analysed by ICP-MS for 43 elements.

The major results of the study are:

- By passing through the Mansfeld mining district, the Saale river water quality declines considerably. The content in NaCl increases by 60%, in Zn by 300% and in Cd by 35%.
- The discharges of the Salza and Wipper rivers vary on a short timescale, causing very variable loads of pollutants. In contrast, the flow rate of the adits remain almost constant over the year.
- The major source of pollutants in the mining district is ground water from the central drainage adit, the Schlüsselstollen, followed by the rivers Böse Sieben/Salza (salt) and Wipper (metals).
- Over the years 2002/2003, 4,900 t/a of suspended matter were flushed into the Saale river.
- More than 90% of the pollutants are transported as chemically dissolved components; only a few metals show affinities to suspended matter (Pb).
- The Böse Sieben, although passing through mining landscape, does not contribute significantly to the pollution of the Saale. Most of the dissolved and suspended load is immobilised by flowing through the Mansfeld lakes.
- The total annual contribution of the mining district (dissolved and suspended loads) to the pollution of the Saale river is about 310,000 t NaCl; 304 t Zn; 10.2 t Pb; 0.57 t Cd; and 0.42 t U (Table 1).

Table 1. Dissolved and suspended annual load of pollutants in drainage waters from the Mansfeld mining district (figures for 2002/2003) (n.d. = not determined).

<i>Water system</i>	<i>NaCl</i> [t/a]	<i>Zn</i> [t/a]	<i>Pb</i> [t/a]	<i>Cd</i> [kg/a]	<i>U</i> [kg/a]	<i>Zn</i> [t/a]	<i>Pb</i> [t/a]	<i>Cd</i> [kg/a]	<i>U</i> [kg/a]
Böse Sieben/Salza	28,000	62.15	0.05	6.57	n.d.	0.66	0.13	2.02	5.09
Wipper	10,000	4.80	0.15	23.24	n.d.	2.49	0.90	14.75	1.43
Schlüsselstollen (Central adit)	270,000	253.25	5.10	523.99	404.80	1.66	3.86	0.92	7.94
	Dissolved load					Suspended load			

The results make it clear that even 15 years after the cessation of mining, ore processing, and the complete flooding of the mines in the Mansfeld area, heavy metals and salts are still a threat to the local environment and contribute significantly to the pollution of the Saale river. The release of pollutants in the mining district depends mainly on local precipitation events and on ground water circulation. Suspended matter, seemingly, does not play a key role in the transport of pollutants.

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