Metal inventory of the floodplain of the mining-impacted Geul River, The Netherlands

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1. Geul River

The Geul is a 60 km long small river in the southern Netherlands and eastern Belgium, that has long been impacted byhistoric mining activities in its headwaters.

Zinc (Zn) and lead (Pb) mining took place since Roman times and reached its peak in the late 19th and early 20th century until the mines closed in the 1920s. This has resulted in widespread contamination of the floodplain due to overbank deposition of contaminated sediments.

This study aims to quantify the total metal inventory of a 20 km long floodplain reach between Cottessen at the Belgium-Dutch border and Meerssen (Fig. 1).

2. Field sampling and laboratory analysis

In 9 transects across the floodplain 74 corings were conducted to 1.7-2.5 m depth (Fig. 1). The cores were sampled every 10 cm. Of each of the resulting 1248 soil samples we determined total Zn and Pb using a Thermo Fisher Scientific Niton® XL3t-600 handheld XRF analyser. We subsequently calculated the excess metal inventory at each coring location.

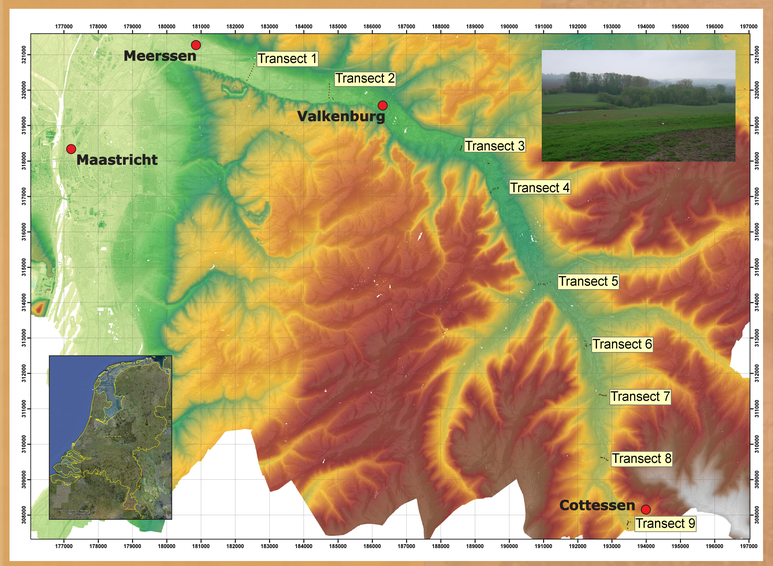

Fig. 1 Location of the coring transects. Inset: Geul valley

3. Metal depth profiles

Figure 2 shows two typical depth profiles for Pb and Zn. The majority of the metal contamination is concentrated in the top 0.5-1.0 m of the soil profile, which is likely related to the intense mining in the late 19th and early 20th century.

Many profiles show a second peak in metal concentrations deeper in the soil profile, probably reflecting earlier mining activities. Therefore, metal inventories were calculated for both the entire profiles and for the upper 1.7 m of the floodplain soil.

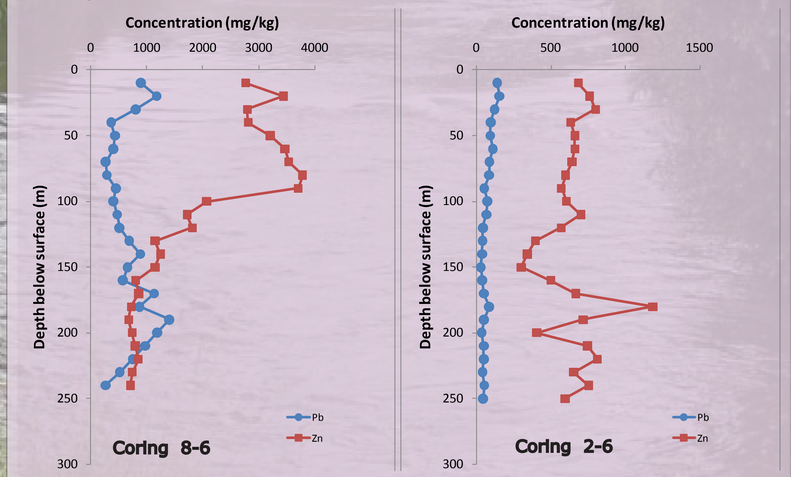

Fig. 2 Example depth profile for Pb and Zn concentrations

4. Metal inventories

Metal inventories in the Geul River floodplain show a significant decrease (table 1):

1) in downstream direction,
2) away from the river, and
3) with higher elevations relative to the local floodplain height.

Table 1 Regression parameters

	Intercept (ln(mg kg^{-1}))	Distance to border (ln(mg kg^{-1}) m^{-1})	Distance to river (ln(mg kg^{-1}) m^{-1})	Elevation (ln(mg kg^{-1}) m^{-1})	R^2	s.e.
Pb	6.73	-5.3 10^{-5}	-0.0041	-0.672	0.563	1.037
Pb (<1.7 m)	6.72	-5.8 10^{-5}	-0.0038	-0.668	0.541	1.019
Zn	7.93	-4.5 10^{-5}	-0.0048	-0.721	0.531	1.049
Zn (< 1.7 m)	7.89	-4.9 10^{-5}	-0.0049	-0.718	0.562	1.013

Total excess metal inventories in the investigated Dutch section of the river valley is 5500 tonnes for Pb and 20,000 tonnes for Zn. The regression predictions of the metal inventories in the Geul River floodplain are shown in Figure 3.

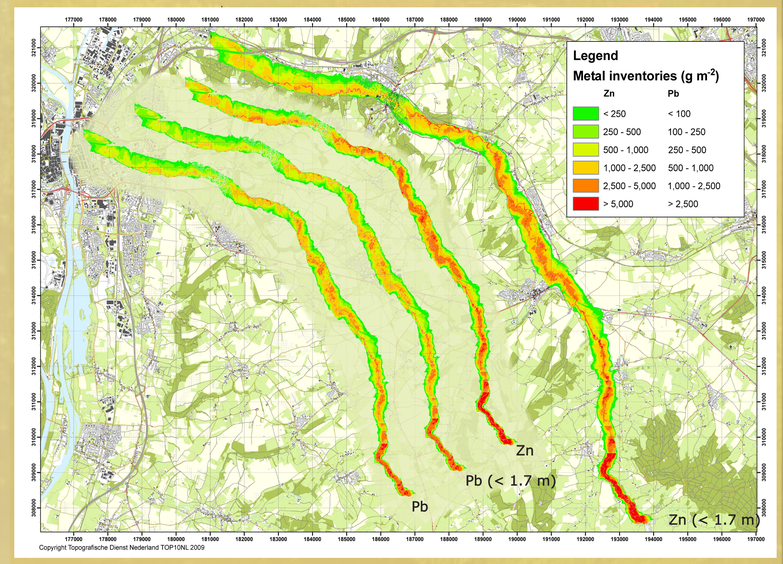

Fig. 3 Predicted metal inventories in the Geul valley

Table 2 Total Zn and Pb inventories in the Geul valley

	Total inventory (tonnes)
Pb	5472
Pb (< 1.7 m)	4986
Zn	19638
Zn (< 1.7 m)	16678

5. Conclusions and implications

- The majority of the mining-derived metals are stored in the upstream part of the valley. They remain a source of downstream contamination of fresh point-bar and overbank deposits.

- The maps of metal inventories can be used to assess and model past, current, and future sediment-associated metal transfer and redistribution in the Geul catchment.