# Trace metal transport in the river Elbe: An assessment of extreme hydrological events

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## Introduction

- Compared to other large Middle-European rivers, pollution levels of the river Elbe are high; heavy metals and arsenic are still of major concern (Fig. 1).
- Floods and low flows affect the transport of trace metals.

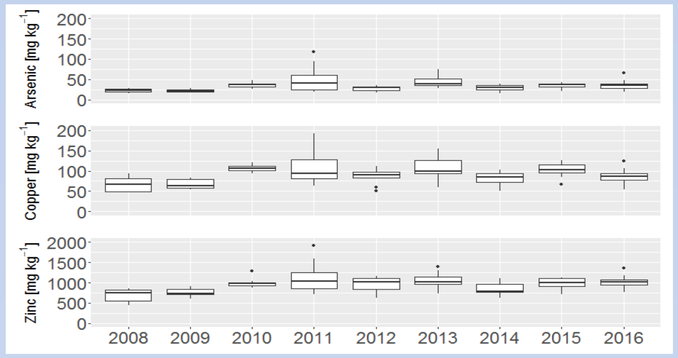


Fig. 1. Concentration of arsenic, copper and zinc in fresh sediments at Geesthacht, Elbe (monthly/biweekly mixed samples)

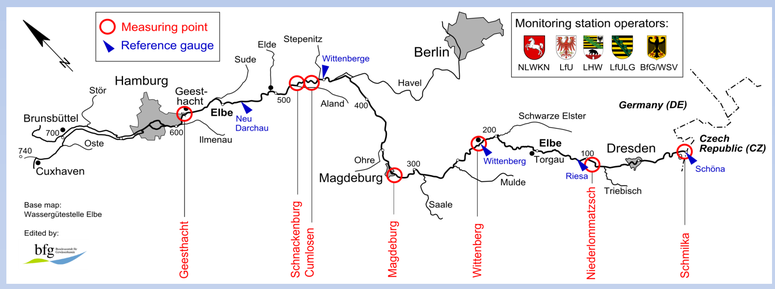


Fig. 2. Overview of considered water quality monitoring sites and gauges at the river Elbe

- We assess the trace metal transport during two extreme hydrological events: the 2013 June flood and the 2015 low flow.
- Our investigation concentrates
  a) on the accumulation / attenuation of loads along the river and
  b) on the contribution of point sources during low flows

- The investigation is based on preprocessed data for water quality models comprising of:
  - regular and specific water quality monitoring data from Federal States / River Basin Community
  - discharge and concentration of suspended solids from the Federal Waterways and Shipping Administration
  - emission data from the Pollutant Release and Transfer Register
  - emission estimates for abandoned mines [1][2][3]

Aforementioned point source emissions are regarded as constant throughout the year.

## Flood 2013 (3. - 18. Jun.)

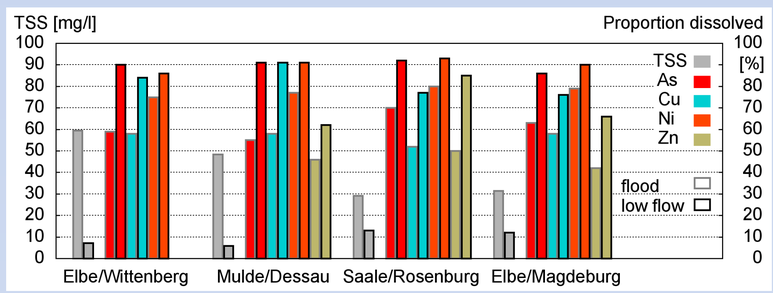


Fig. 3. Mean concentration of total suspended solids (TSS) and mean percentage of the dissolved fraction of trace metals during the flood and the low flow

Over the course of the June 2013 flood, the mean concentration of TSS was substantially higher compared to the low flow 2015 (Fig. 3). This results in a lower fraction of dissolved and a higher fraction of particulate trace metals during the flood.

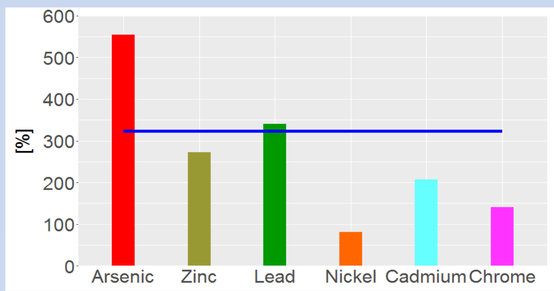


Fig. 4. Mean daily particulate load of trace metals at Cumlosen, Elbe during the 2013 flood event as a percentage of the mean daily load of 2013

Here, particulate load for most trace metals exceed mean annual daily loads by large (Fig. 4). However, the ratio of mean daily discharge to mean annual daily discharge is rarely surpassed.

Fig. 5. The river Elbe near Dömitz on 7. June 2013 (Photo: Norbert Grope)

Flooding leads to widespread sedimentation in floodplains. Increased flow velocities within the main channel promote remobilisation of sediment-bound trace metals. Modelling these processes with Delft3D/DELWAQ is in progress.

## Low Flow 2015 (20. Jul. - 5. Oct.)

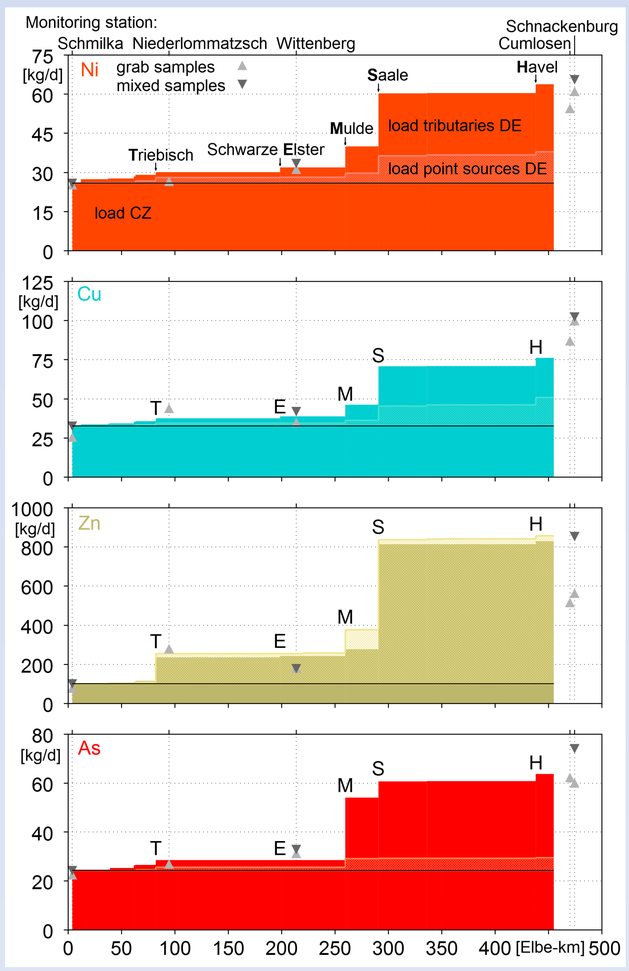


Fig. 6. Mean daily total load of nickel (Ni), copper (Cu), zinc (Zn) and arsenic (As) of the Elbe in Germany (DE) during the low flow on top of the load from the Czech Republic (CZ): accumulated load from tributaries versus measurements at monitoring stations and accumulated load from main point sources

Throughout the low flow period the accumulated loads for selected elements from tributaries correspond fairly well with calculated loads at monitoring stations (Fig. 6). Within Germany, the Saale river contributes the highest loads for the investigated trace metals but arsenic. Depending on the element, point sources are of high (Zn), moderate (Ni, Cu) or low (As) importance. Their relative contribution grows with declining discharge.

During low flow, mean daily discharge is approx. half of the annual mean daily discharge (Fig. 7). Compared to this discharge ratio, the load ratio of almost all trace metals at Schmilka is disproportionally lower. This can be linked to the high share of less polluted water from Czech reservoirs [4]. At Schnackenburg, the load ratio was disproportionally higher than the discharge ratio in particular because of the input of the rivers Mulde and Saale.

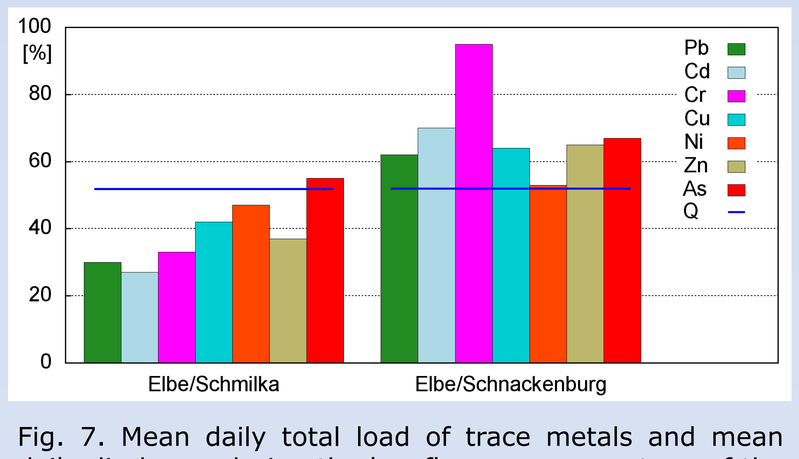


Fig. 7. Mean daily total load of trace metals and mean daily discharge during the low flow as a percentage of the mean daily load / discharge of 2015

The modelling of the transport of trace metals during the low flow 2015 using the water quality model QSim is in preparation.

## Literature

[1] LAF / PLEJADES (2013): Frachtreduzierung Schlüsselstollen
[2] Baacke, D. (2001): Geochemisches Verhalten umweltrelevanter Elemente in stillgelegten Polysulfiderzgruben am Beispiel der Grube „Himmelfahrt" in Freiberg/Sachsen, Freiberger Dissertationen online
[3] Greif, A. (2013): Studie zur Charakterisierung der Schadstoffeinträge aus Erzbergbaurevieren der Mulde in die Elbe, Fachstudie ELSA Elbe
[4] Hübner, G. & Schwandt, D. (2016): Wasserbeschaffenheit und Schadstofftransport beim extremen Niedrigwasser der Elbe von Juli bis Oktober 2015, Fachbericht FGG Elbe