Trends in suspended sediment fluxes across the Rhine river basin (1997-2014)

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Introduction

- It is estimated that 90% of river sediment is transported in suspension (Turowski et al., 2010)
- Fine sediments contribute to the creation of habitat for aquatic species, bond to nutrients
- They form riverbanks, floodplains and eventually for river deltas (Walling & Webb, 1996)
- In the past century, the delivery of fine sediment from the Rhine river basin to delta decreased (Asselman et al., 2003)
- The decreasing sediment flux together with sea level rise will create a major threat to river ecosystems and people in deltas (Cox et al., 2021)
- A quantitative temporal and spatial understanding of sediment distribution upstream of the delta is essential.
- We aim to quantify the temporal changes in annual loads of suspended sediments in the Rhine river basin during the past decades.

Method

- **Study area:** Rhine basin
- **Time periods:**
  - 1958-2016
  - 1985-2006
  - 1997-2014
- **Rivers**: Rhine and four major tributaries (Aare, Neckar, Main and Mosel)
- **Suspended Sediment Concentrations (SSC):**
  - 1958-2016: Monthly measurements, since 1980 daily
  - 1985-2006: Daily measurements
  - 1997-2014: Fortnightly or monthly measurements of 18 suspended sediment monitoring stations and corresponding daily discharge measurement stations

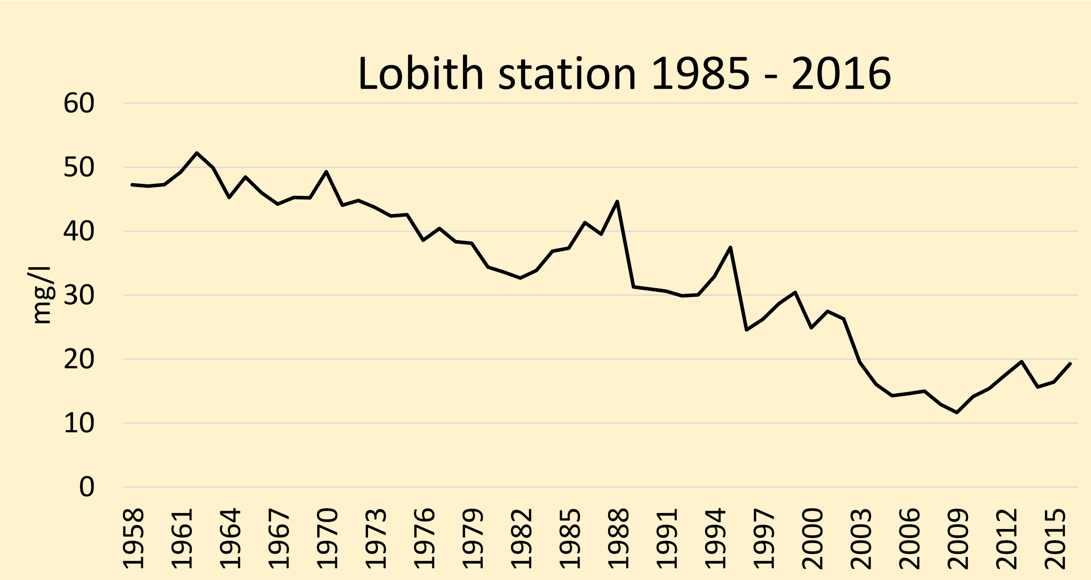

Figure 1: Absolute decrease suspended sediment concentrations

Calculations:

1. Daily loads
Rating curve method
$SSC = a\,Q^{b}$

2. Application of a scale-break
For better estimates on extreme events

3. Annual loads
Sum of daily loads

4. Difference between stations
Budget calculation of proceeding stations

1. Daily loads: The sediment rating curve method uses a log regression between measured suspended sediment concentrations and river discharge
2. Scale-break: Two-fold rating curve with a scale-break between the low and high discharge domain as proposed by Hoffmann et al. (2020) using a 5-year moving window. The scale-break was established at the arithmetic mean discharge.
3. Annual loads: These rating curves were subsequently used to calculate daily suspended sediment loads, which were summed to annual loads.
4. Map of difference in suspended sediment load between 1997-2014 at measurement stations. Green: increase; Red: decrease.

Results

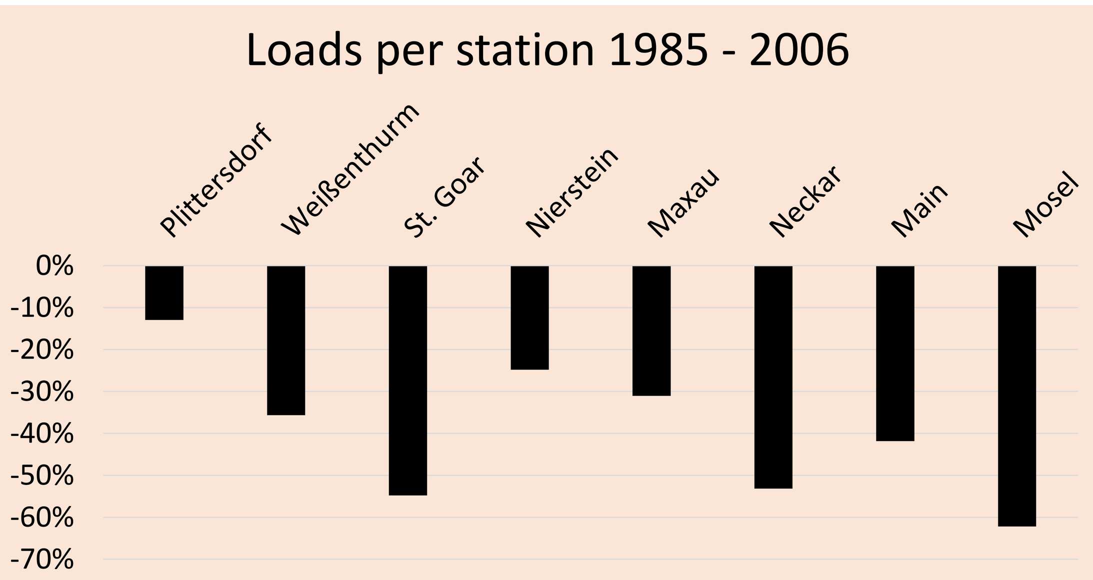

Figure 2: Load decrease in % per station

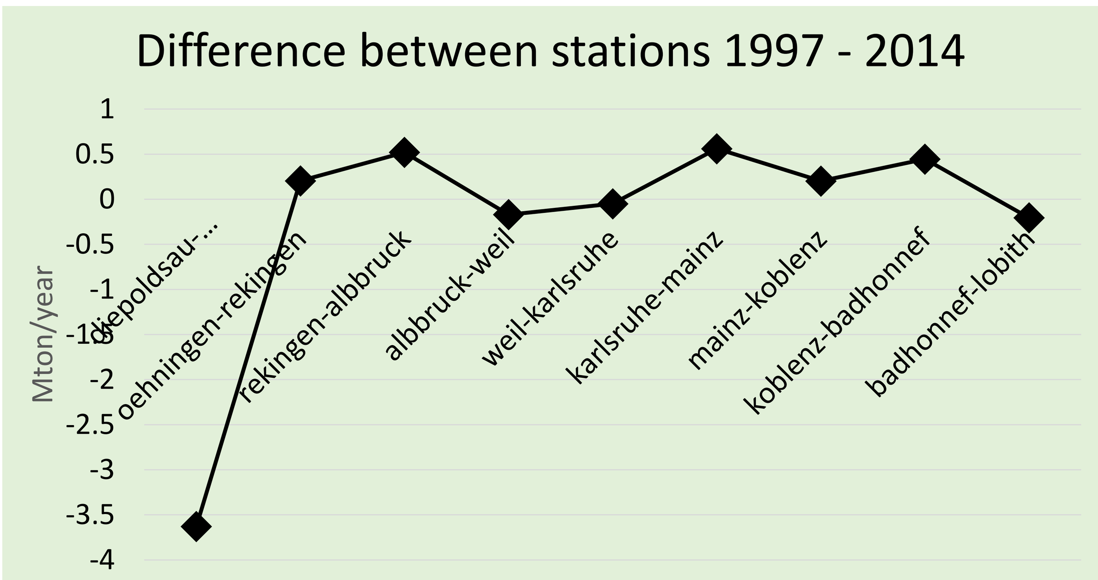

Figure 3: Section calculation
Info: Between two stations there is always a section. By subtracting the subsequent station from the preceding station, we receive the absolute difference between stations. This indicates whether a section is a source or a sink, depositing or eroding.

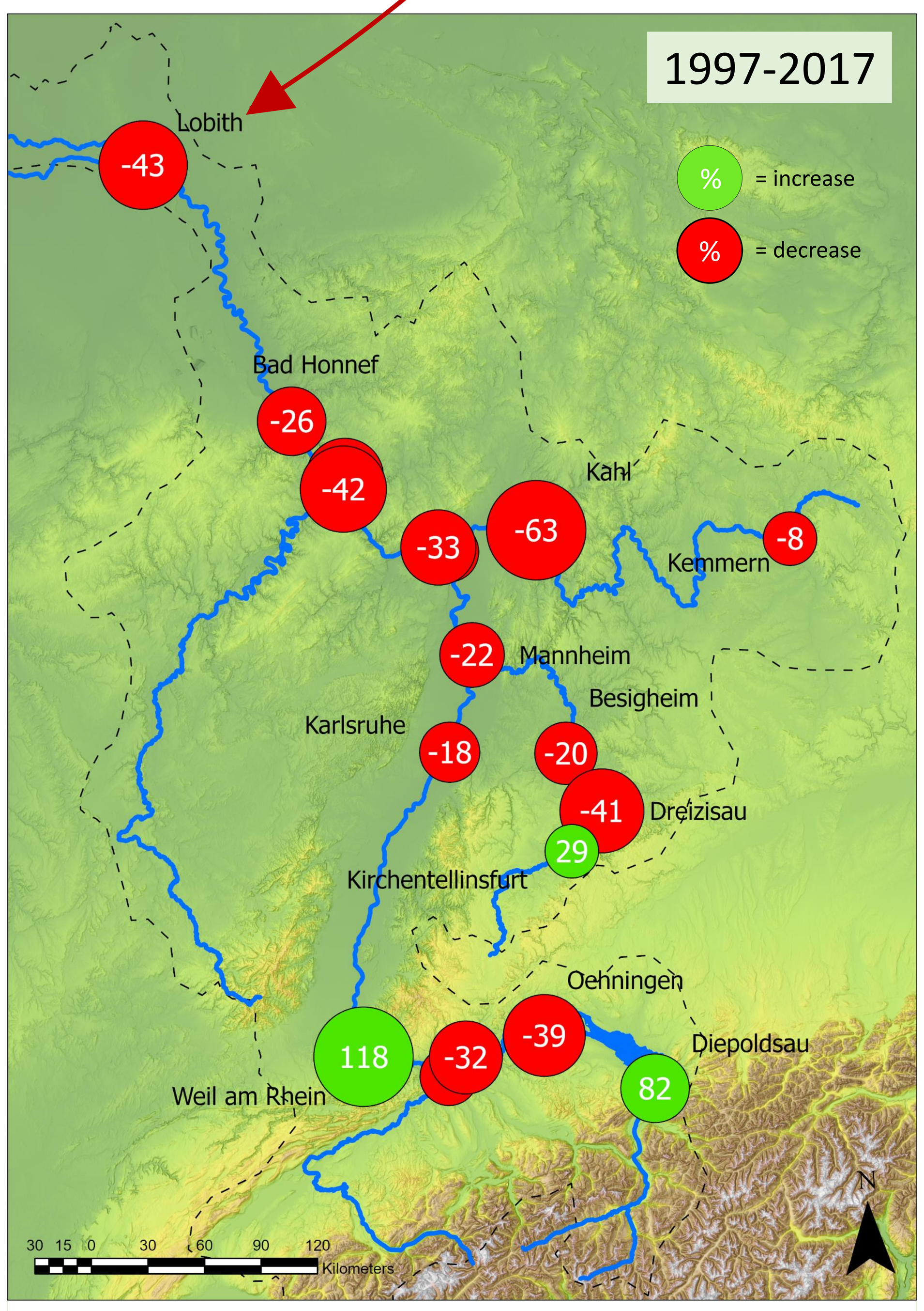

Figure 4: Change in % per station

Conclusions

1. Period 1958-2016
- Sediment concentration and loads at Lobith decreased by 60-70% in the given period

2. Period 1985-2006
- The stations in the Rhine river show a average decrease of 32%
- Similarly, the tributaries with -52% (Neckar), -42% (Main) and -62% (Mosel)

3. Period 1997-2014
- At most stations, the suspended sediment load in the Rhine river show a consistent decreasing trend between 1997-2014
- In the Neckar, Main and Mosel tributaries, a similar pattern of a negligible change in suspended sediment loads in the headwater stations and a substantial decrease in load in the downstream stations is observed
- This suggests that the decline in suspended sediment loads is primarily caused by engineering works and human interventions in or along the river channel.

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