Assessment of 2D hydro-morphological processes to support river restoration at Isola Serafini in the Po River (Italy)

Bossinia, Francesco; Mosselman, Erik; Penning, Ellis; Camporeale, Carlo; Latella, Melissa

Towards 2048:
the next 25 years of river studies

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Summer flood 2021 impacts overwhelm the long-term sediment balance of the River Meuse

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Highlights

- Highlight 1 Assessment of dynamics in sediment sources and sinks for the River Meuse
- Highlight 2 Main components sediment balance and its extent assessed from field measurements
- Highlight 3 Impacts of the summer flood of 2021 greatly exceed decadal changes under normal conditions

Overview

Establishing the dynamics of sediment budgets in rivers (see Fig. 1) is crucial in assessing the morphological impact of interventions and changes (Frings and Ten Brinke, 2018; Habersack et al., 2013). This study aims to assess such a sediment balance for sand and gravel for the Meuse River in the Netherlands over the last 25 years, to identify the impacts of human interference during this period, and to compare annual estimates of sediment balance components to erosion and sedimentation volumes observed during the extreme flood of July 2021.

Assuming that negligible volumes of sand and gravel pass the weir of Lixhe at the border with Belgium, bed level changes (erosion and deposition), dredging, riverbank erosion, deposition on floodplains and in lakes, tributaries and outflow to the delta are key components of the sediment balance. Available and collected data provide preliminary orders of magnitude of sediment balance components, and the impact of engineering works such as the river widening program Meuse Works (Looy van and Kurstjens, 2022).

Analysis of the morphological changes during the July 2021 flood (Flierman and Frings, 2023) show that the erosion and deposition volumes in a week overwhelmed the average annual values. The ongoing bed erosion in the Meuse River, caused by supply-limited conditions, geological composition of the Meuse valley and human interference (dredging, river engineering, Meuse Works) impacted the sediment balance, and increased the risk of massive morphological changes as experienced in July 2021. These observations highlight the need to terminate extraction of sand and gravel from the riverbed, to design sediment management strategies and to evaluate the morphological impacts of plans for the future.

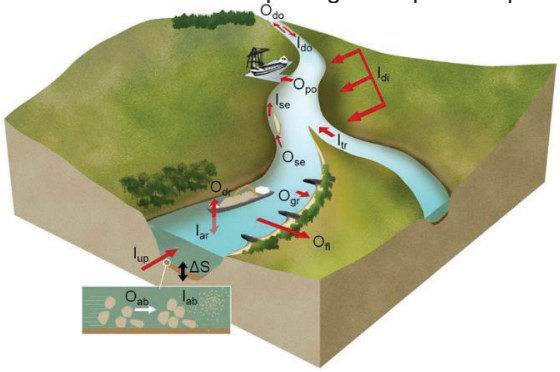

Figure 1. Representation of a channel sediment budget in a human-controlled river system, showing different sediment inputs (I),outputs (O) and the storage term (ΔS). Source: Frings et al. (2019).

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References

Flierman, M.W.T. & Frings, R.M. (eds) (2023): Sedimentatie en erosie tijdens het zomerhoogwater van de Maas in 2021. Ministerie van Infrastructuur en Waterstaat, Rijkswaterstaat, Maastricht.

Frings R.M. & Ten Brinke W.B.M. (2018). Ten reasons to set up sediment budgets for river management, Intern. Journal of River Basin Management, 16:1, 35-40, DOI: 10.1080/15715124.2017.1345916.

Habersack H., Jäger E. & Hauer C. (2013). The status of the Danube River sediment regime and morphology as a basis for future basin management, Intern. Journal of River Basin Management, 11:2, 153-166, DOI: 10.1080/15715124.2013.815191.

Houten Van J (2022). Quantifying erosion rates of the natural and nature-friendly banks of the Meuse river. BSc thesis WUR, July 2022.

Looy Van K. & G. Kurstjens (2022). 30 Years of River Restoration: Bringing the River Meuse Alive!

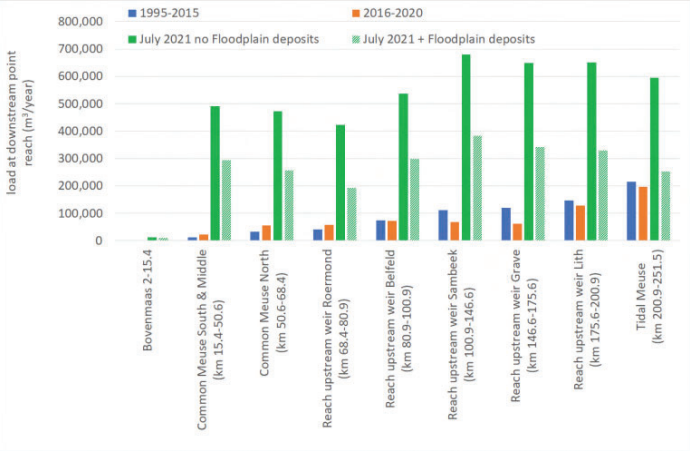
Method and Data

For the long-term development of the riverbed (main channel and floodplains) annual single-beam and multi-beam measurements in the main river, the Dutch Actual Altitude Database for different periods (AHN-1 to -4) and periodic soundings in lakes and harbours are available. For the bed changes in the main channel during the flood of July 2021, additional multi-beam measurements were taken during the falling limb of the flood wave. In addition, fieldwork on the floodplains by the Wageningen University & Research (WUR) and Vrije University Amsterdam (VU) was carried out, and laser altimetry surveys for the floodplains and echo soundings in several lakes became available. In addition to the data quantifying geometrical changes, a database has been constructed with all sediment management measures since 1995, such as dredging and implementation of engineering works.

The base data reveals the trends in (1) riverbed profiles and corresponding sediment volumes, (2) the annual volumes of eroded bank material, (3) the volumes of deposition on floodplains, in lakes and in harbours and (4) dredging and dumping volumes. The data from field work of the WUR in the proximal floodplain zone along the complete Meuse River in August 2021 was enriched by the data from the VU in the distal zone to estimate the background sand deposition and by the laser altimetry data for areas missed or not accessible during the fieldwork. The laser altimetry data had to be treated with care, as the images were collected during the growing season. The algorithms for identifying vegetation filtered out large areas from the elevation model, but also proved to be insufficiently accurate. The first sediment balance equations were constructed using the hypothesis of nil inflow from upstream, data on riverbed changes, dredging, dumping and bank erosion volumes.

Results and Discussion

The average annual sediment loads per river reach for the periods 1995-2015 (period of Meuse Works implementation) and 2016-2020 (Meuse Works largely completed) are limited compared to volumes during the 5 day flood period in 2021 (Fig. 2). The massive riverbed and riverbank erosion, especially in the Common Meuse during a few days of extreme discharges, produced sediment loads equivalent to those of multiple average hydrological years. The contribution of floodplain deposits to the sediment balance during such high floods shows to be significant. Differences between the multi-annual periods reveal the impacts of summer bed deepening of the Meuse Works between the weirs of Belfeld and Lith.



Component	Volume (10^3 m^3)
Riverbed level change	-575
Bank erosion	-210
Floodplain deposition	340
Dredging delta	-90

Figure 2. Left: sediment loads (sand and gravel) based on bed level changes, sediment management (dredging) in the main riverbed and bank erosion estimates (van Houten, 2022; assuming 10% sand in eroded banks) for 2 long-term periods and for July 2021 (load in 5 days!). Floodplain deposits are not indicated in long-term periods and presumably small. For July 2021 floodplain deposits are included in the light green bar. Right: Average volume components in the sediment balance for July 2021 (rounded values) based on measured data (Flierman and Frings, 2023), and dredged volumes. Negative values show erosion or dredging. Floodplain deposits relate to proximal zones (river banks, WUR) and distal zones (>80 m from river, VU).

The long-term sediment balance and resulting sediment load diagram will be extended with data on floodplain and lake deposits and tributary loads, for which analyses are ongoing.

Conclusions and Recommendations

The sediment balance clearly shows the supply-limited character of the river. The resulting eroding trends have increased the risk of massive morphological changes. Improved sediment management is recommended as well as morphological impact assessment of future plans. Data collection and analyses should continue and be extended, for example in tributaries and on sediment transports.