The sedimentary dynamics of embanked floodplains

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Abstract
Goal of the presented research is to get insight into the spatial variability of the floodplain sediments, and the processes causing this variability by (1) setting up a database of the spatial variability of the floodplain sediments along the river Rhine, and (2) reconstructing the sedimentary dynamics since normalisation.

The database is compiled of existing data about the lithology, the morphology, and the sediment characteristics, that are visualized in lithological profiles and thematic maps.

Reconstructing the sedimentary dynamics involves an assessment of sedimentation rates with three different methods: (1) ^{137}Cs-dating, which relies on correlation of peaks in a vertical soil profile to peak years of ^{137}Cs deposition, (2) OSL-dating, which uses the accumulated charge that is trapped in quartz minerals that are shielded from the light as a measure for burial time, and (3) heavy metal analyses, which enable to relate the varying metal contents in a vertical soil profile to the known pollution history.

Introduction
Future measures in the embanked floodplains of the Netherlands aim at the enhancement of the discharge capacity and the improvement of the ecological quality, and include mining of clay, sand and gravel. The efficiency and sustainability of such measures are strongly dependent on the sedimentary dynamics, which most importantly involves sedimentation and erosion processes causing spatial variability of floodplain sediments. Therefore, it is of importance to get insight into this variability and associated processes.

The presented research focuses on (1) mapping the spatial variability of the floodplain sediments along the river Rhine (database development), and (2) reconstruction of the sedimentary dynamics since normalization (assessment of sedimentation rates).

Database of the embanked floodplains in the middle Waal
In a database, existing data of the middle Waal (reach Nijmegen-Tiel) are compiled, about the lithological structure, the morphological development and the spatial distribution of sediment characteristics. The information is derived from TNO, Alterra and Utrecht University databases, and is visualized as lithological profiles and thematic maps (Fig. 1). The data will be used to reconstruct historical sedimentary dynamics, and may serve to select optimum locations for ecological rehabilitation or mining projects.

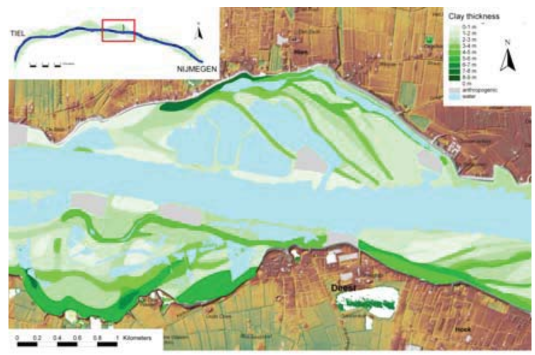

Figure 1. Map of the clay thickness in the Hiensche Uiterwaard, which is one of the thematic maps in the database of the middle Waal (Hebinck, in prep.).

Reconstructing sedimentation rates
In previous research by Maas et al. (2003) 15 cores were taken from three different undisturbed floodplains along the river Rhine (Fig. 2). The sedimentation rate was calculated using ^{137}Cs-dating. In the present project, two other methods are being applied to calculate the sedimentation rates in addition. These analyses are in process.

^{137}Cs-dating
The anthropogenic radionuclide ^{137}Cs entered the atmosphere as a result of nuclear bomb tests around 1960 AD and the Chernobyl accident in 1986 AD. Subsequently, it was deposited on the floodplains by atmospheric fallout and by deposition of fine suspended sediments to which it is bound. A vertical activity profile of a soil core can be measured by the PHAROS device (Rigollet en De Meijer, 2002) (Fig. 3). Peaks in activity correspond to the floodplain surfaces of 1960 AD and 1986 AD, and hence average sedimentation rates can be calculated.

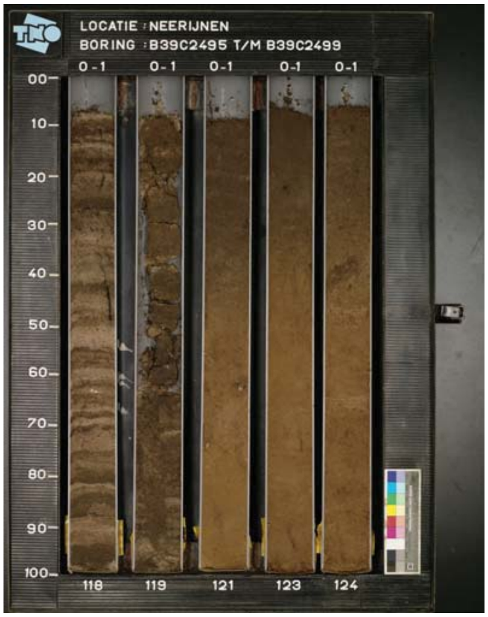

Figure 2. Undisturbed sediment cores from the Neerijnen embanked floodplain.

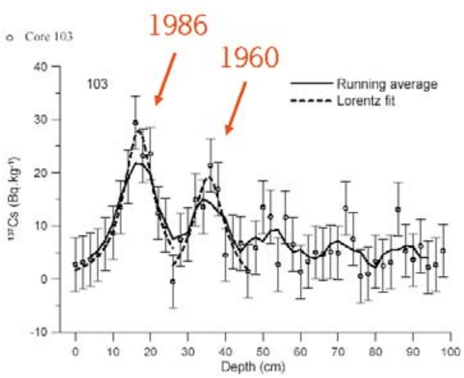

Figure 3. Peaks in ^{137}Cs concentration can be recognized in the activity profile of a soil core, and correspond to the surface in the peak years of atmospheric ^{137}Cs deposition (Maas et al., 2003).

OSL-dating

Optically Stimulated Luminescence (OSL) dating is a relatively new technique that makes use of the charge that is trapped in quartz- and feldspar minerals by natural ionising radiation from the environment. The charge acts as a clock that starts to count when a particle is deposited and shielded from light. When the particle is exposed to light again, it releases its charge and the clock is set to zero. Hence the accumulated charge is a measure for the burial time of the particle. When both the released charge and the ionising radiation from the environment are measured, the age of fluvial deposits can be calculated (Wallinga, 2001).

Heavy metal analysis

Heavy metals are occurring naturally in river waters. Since approximately 1860 AD however, urban and industrial activities led to a significant increase in the heavy metal concentration of the Rhine water. In the water, heavy metals are bound to the fine suspended sediment particles, and enter the floodplain during flooding events. The amount of heavy metal pollution has varied in history (Fig. 4). Comparison of a vertical profile of heavy metal contents in a soil core with the known pollution history enables the calculation of sedimentation rates (Middelkoop, 1997).

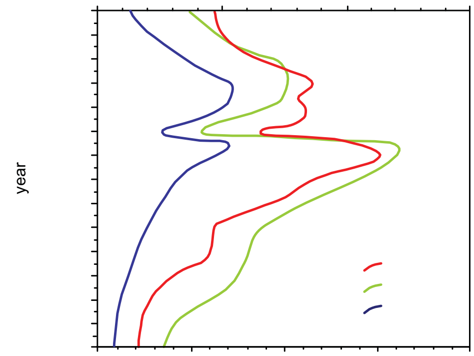

Figure 4. History of heavy metal pollution in the river Rhine. Pollution started to increase around 1860 AD and reached a maximum in the 1930s. After a temporary decrease during WW II a new peak was reached in the 1960s, followed by a strong decrease in the 1970s as a result of the Rhine Action Plan (after Middelkoop, 2000).

Acknowledgements

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