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# Sorting out flood sediments: the role of grain shape in overbank deposition

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## Introduction

The last decades have shown an increase in the frequency and magnitude of floods (Blöschl et al. 2020). The intensification of flood regimes will likely enhance rivers' capacity to erode and transport sediment. Sedimentary properties, such as texture, porosity and geochemistry are crucial factors that affect the economic and ecologic values of overbank zones. Moreover, understanding of sediment fluxes and pathways is also key in predicting the distribution of adhesive heavy metal contaminants, microplastics and forever PFAS chemicals. Yet, modelled estimates of sediment transport and overbank deposition are notoriously inaccurate. A recent experimental study of bed load transport suggested up to a factor 5 attributable to the shape of particles (Deal et al., 2023).

Here we show that the shape of sand grains is probably also a critically overlooked factor in suspended sediment transport. Its effects are observed from lateral-distance sorting in overbank deposits from different catchments. We used hydraulic modelling to further test our initial observations and to explore the magnitude of changes in sediment transport that are potentially caused by grain shape.

## Methods

Fresh overbank deposits were gathered immediately after floodwater receded: for the Meuse, Geul and Roer in summer 2021, and for the IJssel and the Overijsselse Vecht in winter

2024. A total of 199 samples was collected mainly along lateral transects to investigate the trends in grain shape properties. Digital Image Analysis (DIA), measured at the Sedimentary Laboratory at the VU Amsterdam, was used to gather information about the aspect ratio (Eq. 1) of individual grains between 20-1600  $\mu\text{m}$ .

$$(1) \text{ aspect ratio} = \left( \frac{\text{min. Feret diameter}}{\text{max. Feret diameter}} \right)$$

To further test the plausibility of shape-based sediment sorting, fall velocity calculations were performed using different shape parameters (cf. Ferguson and Church, 2004). The effect on suspended sediment concentrations was calculated using Rouse profiles, using varying shape characteristics while keeping flow depth, slope and reference sediment at constant values (Rouse, 1938).

## Results

Our results demonstrate that for all studied catchments comparable trends in the mean aspect ratio of the sand fraction could be observed. In general, coarser particles had more elongated shapes compared to smaller-sized particles at similar locations. Notably, the aspect ratio of similarly-sized particles declines when the distance to the active river channel increases (Fig. 1). Sample transects along highly variable topography, such as point-bar relief indicate that elevation affects sediment sorting. The topographic highs demonstrated significantly higher aspect ratios and increased coarseness compared to low-lying areas (Fig. 2), suggesting deposition to be limited to peak flow conditions with maximum transport capacity.

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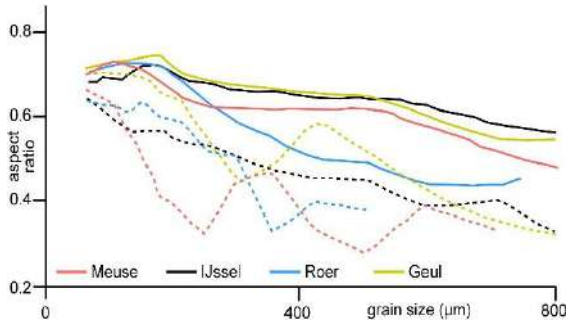


Figure 1: Changes in grain shape versus grain size, plotted for different rivers and grouped for proximal sample locations (solid line) and distal sample locations (dashed).

Explorative hydraulic modelling on the effect of grain shape suggests an increase in fall velocities for the fine sand fraction (Fig. 3 – upper frame). Likewise, the Rouse profiles (Fig. 3 – lower frame) demonstrate that the concentration of suspended fine sands increases for in-channel transport when particles have a higher aspect ratio.

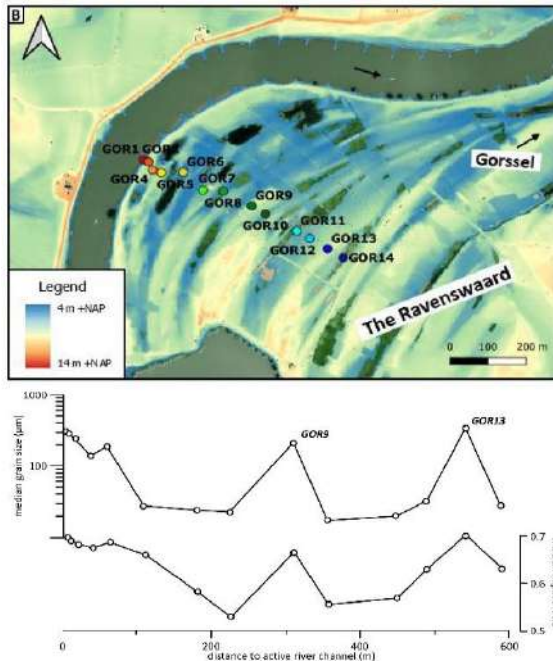


Figure 2: Sample transect over point-bar morphology of the IJssel at the Ravenswaard near Gorssel (Reijmers, 2025) – the coloured dots are indicative for an increasing distance. The median grain size and aspect ratio are plotted versus distance to the active river channel.

**Conclusions**

The combination of field measurements after recent flood events and explorative testing using hydraulic models indicates that selective sorting based on shape is a significant factor in fluvial transport. The more elongate shape of particularly larger sand grains causes an enhanced buoyancy, and susceptibility to turbulence, that enables such grains to travel further from its source compared to their spherical cousins.

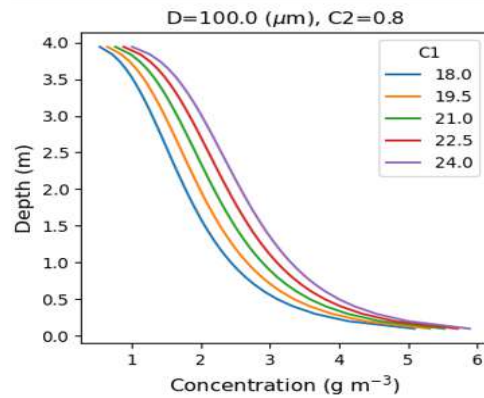
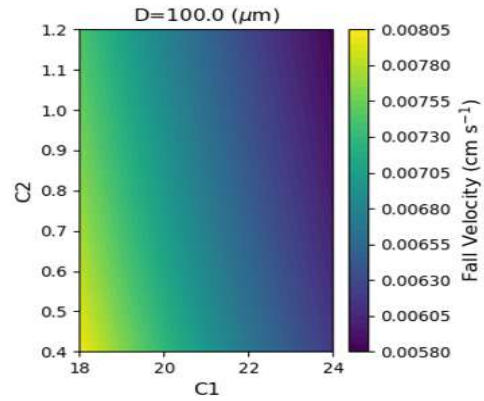


Figure 3: Conceptual testing of the effects of grain shape (example shown for 100 µm particles) on fall velocities (upper frame) and sediment concentration (lower frame). C1 is a constant in Ferguson in Church (2004), to represent grain elongation (C1=18 represent a sphere). C2 represents a constant asymptotic value of the drag coefficient (C2=0.4 represents a sphere).

Similar trends in shape-based sorting are observed for different catchments, despite variations in settings that may affect the results, such as valley morphology, flood conditions and sediment mineralogy. This implies that there is an overall driving physical mechanism determining the observed pattern, which is likely universally applicable, at least to low-gradient alluvial systems.

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