

New laboratory techniques to determine the grain size distribution of a sand-gravel bed surface and substrate.

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1. Introduction

Grain size changes in a river dominated by mixed sediment are the outcome of sedimentary grain size-selective processes. Progress in the measurement techniques that define the spatial and temporal variation in grain size is necessary to provide new insights in this field. Techniques as image analysis and acoustic methods have emerged in the last years as rapid, reliable and repeatable methods in field and laboratory studies. Three laboratory techniques were evaluated in this project for application in later flume experiments: (1) particle coloring in combination with photogrammetric analysis (providing data on the grain size distribution of the bed surface); (2) core sampling combined with three-dimensional imaging (providing data on the grain size distribution of the bed surface and substrate); (3) ultrasonic imaging (providing a classification of the bed surface sediment).

2. Methods

The techniques were evaluated reproducing the conditions of the later flume experiments using three non-overlapping grain size fractions within the range of coarse sand to fine gravel.

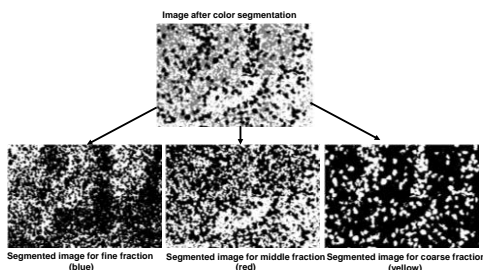


Figure 1: Image after color segmentation and segmented images for the three colors (Method 1).

For the image analysis techniques (Method 1) the three grain size fractions were painted in different colors and installed in various patches with different combinations of color and grain sizes. The pictures were taken with and without water to study the influence of water depth on the results. The images of the bed surface were processed with an image analysis algorithm to segment the three grain size fractions. This is based on color segmentation (Figure 1) and provides the areal fraction of the bed surface covered by a certain color, i.e. a size fraction.

The second method (Method 2) is based on three dimensional imaging and was combined with core sampling. Samples were taken using tube cores, fixed with wallpaper glue and analyzed using a micro computed tomography scanner (CT scanner). The sampling technique was designed to fulfill the

requirements of the CT scanner analysis. The CT scans were processed creating a 3D reconstruction of the sample in which the grains were segmented (Figure 2). The volumes and position of each grain were measured, from which the variation of the grain size distribution over the vertical is derived. In addition, the grain size distribution of the bed surface is determined by analyzing the top scan of the sample.

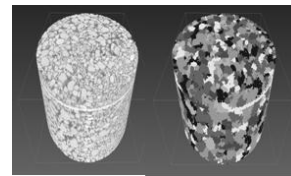


Figure 2: Micro CT scanner images: left 3D reconstruction, right segmentation of the grains (Method 2).

The third method (Method 3) is based on determining the different sediments using acoustic remote sensing, as it is well established that different mean grain sizes result in different received acoustic signals. For this purpose, a novel instrument (Figure 3) was used consisting of a broadband omnidirectional transducer that generates signals with frequencies ranging from 10 kHz to 140 kHz and an array of seven receivers that record waves reflected at nearly normal incidence. The instrument is computer-driven robot designed to ensure accurate positioning in x, y, and z directions and fast scanning.



Figure 3: Acoustic instrument placed on a pool (Method 3).

3. Conclusions

The image analysis method provides the relative presence of each grain size on the bed surface and can be effectively applied to a submerged bed in a laboratory flume. The three-dimensional imaging using the CT scanner combined with a sampling method suitable for wet sediment provides highly detailed measurements of the vertical variation of the grain size distribution under laboratory conditions. Finally, the acoustic technique successfully captures the different sediments present on the bed surface.

In conclusion these approaches can be efficiently applied to research that examines and describes grain size-selective sediment transport, bed resistance, sorting processes and bedform evolution.