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An experimental method to produce reproducible artificial sediment mixtures with cohesive properties for erosion experiments

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The erosion process of cohesive sediments and non-cohesive/cohesive sediment mixtures is characterized by complex interactions between various involved physical, chemical and biological parameters. To reveal these interactions, it is necessary to control the variety of involved parameters in order to conduct erosion experiments under defined and reproducible conditions. Therefore, a method is developed to produce artificial sediment mixtures with cohesive properties to conduct erosion experiments for selected sediment layers using the SETEG-erosion flume and the measurement technology PHOTOSED. For this purpose, intended compositions of clay, silt and sand are mixed in PVC-tubes with a length of 30 cm and a diameter of 10 cm, using a rotary stirrer of precise fit. During the mixing process, the tube is rotated in counter direction to the stirrer and the entire device is moved around the horizontal axis to break the rotational movement to minimize sorting effects. The mixing process is divided into pre-mixing at dry conditions, intermediate mixing while adding water and post-mixing at saturation level to achieve a homogenized mixture of constant cohesiveness. Direct mixing in the PVC-tubes has the following advantages: (i) systematic errors during decanting and deposition are reduced, (ii) consolidation effects can be controlled in the PVC-tubes by the application of hydrostatic pressure during post-processing, (iii) the tubes containing the mixtures can be directly used for depth-dependent erosion experiments in the SETEG erosion flume, and (iv) the length provides a certain variability in the selection of identical sediment layers to be eroded. The homogeneity and reproducibility of the mixtures is ensured by measurements of the vertical bulk density using a gamma-ray densitometer and of the radial grain size distribution using laser diffraction.
In a first series of experiments, four compositions of non-cohesive/cohesive sediments made of sand and clay are investigated. They are characterized by different clay contents (16%, 25%, 35%) and five different water contents for each composition (25%, 30%, 35%, 45%, 55%). Moreover, two replicas are made to test the reproducibility leading to a total of 30 mixtures. The measurements of the vertical bulk density profiles show relatively constant values over depth with an average standard deviation of 0.024 gcm-3 for all mixtures (corresponds to 1.4% compared to the average mean). The radial grain size distribution is analyzed for the center and two orbits consisting of three subsamples and results in an average standard deviation for the d50 of 22.9 μm (corresponds to 8.4% compared to the average mean). The low variability in both vertical and lateral direction confirms homogeneity and reproducibility of the mixtures. Based on these verification measurements, it can be concluded that the method has proven its applicability to produce consistent artificial non-cohesive/cohesive sediment mixtures with low spatial and depth-dependent variability. In addition, quality assurance is ensured by means of continuous measurements of bulk density and grain size distribution. This makes it possible to conduct comparable erosion experiments to investigate interactions between varying physical, chemical and biological parameters and their impact on the erosion behavior of cohesive and non-cohesive/cohesive sediment mixtures.