

Morphological changes after sequential experimental floods: the case study of the Spöl River, Switzerland

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Introduction and goals: Floods significantly reshape rivers' morphology, causing channel avulsions, riverbank and widening [1], changes in conveyance capacity, and sediment redistribution [2]. These transformations may persist long after the flood water recedes and may accumulate after several flood events, leading to complex responses. Although these changes create habitats and sustain rivers' health, they may also pose hazards to adjacent infrastructure and population [3]. Despite its importance, predicting these changes is still quite difficult for both managers and scientists. Understanding river morphological dynamics better is crucial for preventing flooding [4], protecting infrastructure, and encouraging river restoration. This knowledge is essential for reducing the likelihood of future floods and safeguarding ecological and human systems. This is the aim of this work, to shed light on the morphological response of rivers after several floods, quantifying the patterns of erosion and deposition combining high-resolution topography and geo computation techniques.

Study Area and Methods: This study analyzed the geomorphological changes in the Spöl River, an alpine river partially regulated by two dams, Punt dal Gall and Ova Spin. The study site is located in the lower reach of the Spöl River, where it receives additional flow and sediment input from unregulated tributaries, contributing to its dynamic geomorphological processes. Experimental floods are released annually as part of a restoration program making the River Spöl a natural laboratory for studying and analysing river morphological changes after floods [5].

We employed high-resolution digital surface models (DSMs) derived from structure from motion based on drone-acquired data to assess the geomorphic changes during a series of floods, in terms of sediment erosion and deposition using the Geomorphic Change Detection 7.5.0 standalone software [6]. Between 2018 and 2024, these DSMs have been obtained using pre- and post-drone surveys. For our area of interest, we were able to quantify the volumetric and areal changes brought about by erosional and depositional

processes by computing Digital Terrain Models of Difference (DoD).

Results: The Spöl River experienced substantial morphological transformations that affected both area and volume. The results from 2023 showed about 24% of the entire region had a positive elevation change (deposition) while 16% had a negative elevation change (erosion). In the area of interest, sedimentation outweighed erosion, according to areal and volumetric changes. While the downstream region exhibits a general pattern of deposition, the upper portion of the reach showed significant erosion.

The study emphasizes continuous monitoring and adaptive management to balance restoration goals with infrastructure protection and flood resilience, with future research focusing on predictive models.

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Influence of pre-existing bed on diluted turbidity current propagation

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Introduction: Turbidity currents are a subclass of gravity currents where a particle-laden fluid flows through a relatively lighter fluid under the effect of gravity. The particles in this case are mostly suspended by the turbulence created due to the forward motion of the current along the boundary of the domain [1]. Turbidity currents are an inevitable part of any dredging or deep-sea mining activity. They have a potential impact on the local ecosystem [2]. They have the tendency to propagate further from the area of operation before settling down.

This study examines the behavior of turbidity currents which are quite dilute in nature, as they flow over different bed types both pre-existing and freshly deposited ones. The pre-existing bed here refers to the ocean, river or channel bed while the freshly deposited bed consists of a layer of materials deposited from previous run, which has loose materials on its surface.

Methods: Experiments were carried out in a lock - exchange flume of 3m*0.4m*0.2m dimension (see Fig 1). A bed of 5mm was laid on the flume bottom using quartz flour. All the experiments were run on top of this bed which was renewed after every run. The experiments were conducted using illite clay and sediments from the Clarion Clipperton Zone (CCZ) in the Pacific ocean. Additionally, a synthetic organic matter (polyacrylamide flocculant Zetag 4120) was also used to form flocs with illite clay as it does not form flocs on its own.

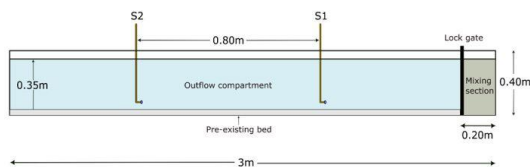


Fig. 1: Lock exchange flume with pre-existing bed.

An Ultrasonic Velocity Profiler (Met-Flow) and a Go Pro camera were used to measure particle velocity and record the front velocity of the turbidity currents, respectively. Two siphons were installed to collect samples from the body of the turbidity current to analyze flocs. The samples were analyzed using FloCCAM and Malvern Mastersizer 3000.

Results: The effect of a pre-existing bed on the turbidity current propagation was evident from the video analysis. The bed with a layer of illite clay on top of it reduced the front propagation velocity of turbidity current compared to both the no-bed condition and quartz bed (see Fig 2). Beds with traces of Zetag alone or a combination of illite and Zetag further reduced the front velocity of the propagating turbidity currents, thus highlighting the influence of organic matter. Additionally, floc analysis also proved that larger flocs were formed in presence of a bed.

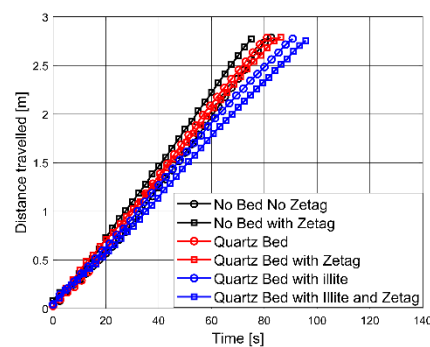


Fig. 2: Front position of Turbidity current under different bed conditions for 5g/L sediment concentration

Discussion: The results highlight the relationship between turbidity current velocity under varying bed conditions while taking flocculation into account. In case of CCZ sediment cases, the presence of a bed reduced the propagation speed significantly especially in cases of lower sediment concentrations. These findings emphasize the importance of bed roughness imparted by the freshly deposited sediments to the turbidity currents, thus reducing their velocities.

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Investigating Sources and Transport Dynamics of Suspended Sediments in a Mediterranean Forested Catchment

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Conference theme number: 2. Sediment Flows

Introduction: Suspended sediment is vital for stream morphology and ecology, and its concentration is essential for catchment management and risk assessment (Ghimire et. al, 2024). However, its transport dynamics and spatial sources in forested mountain catchments remain poorly understood (Matos et. al, 2024). Therefore, this study aims to investigate the main sources and the space-time dynamics of suspended sediment transport in a small forested mountain catchment.

Methods: This study was carried out in the Re della Pietra experimental catchment located in the Tuscany Apennines, Central Italy, characterized by a Mediterranean climate. The catchment area is 2 km², with elevations ranging from 643 m to 1320 m a.s.l.. Suspended sediment was measured at the catchment outlet using a turbidimeter set at 5-min temporal resolution coupled to a water level logger for the stream stage. Soil moisture was measured at two depths on a hillslope nearby, while key meteorological variables were recorded from a weather station in the upper part of the catchment.

Results: Preliminary results reveal a significant correlation ($p < 0.05$) between cumulative turbidity per event, runoff event duration ($\rho = 0.65$), storm duration ($\rho = 0.63$), and peak stream stage ($\rho = 0.59$). Pronounced turbidity peaks during moderate to intense storms occurred during wet conditions (Fig. 1). From the analysis of the hysteretic loops between turbidity and stream stage, excluding the complex loops (70%), clockwise events were the most frequent (16%; anticlockwise 5%; figure-of-eight 9%), suggesting that the main sources of suspended sediment are local

(Long et. al, 2024).

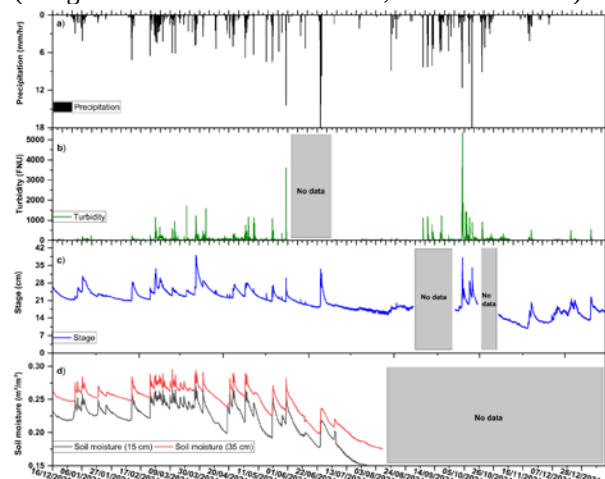


Fig. 1: Time series of rainfall, turbidity, stream stage and soil moisture at 15 cm and 35 cm of depth data.

Discussion: Preliminary findings highlight that the characteristics of rainfall-runoff events, as stream stage, rainfall intensity, and peak stream stage, strongly influence both amount and dynamics of suspended sediment in this catchment. Meteorological variables alone did not fully explain turbidity peaks, suggesting that other controls (e.g., localized bank failures or erosion scars, failure of log steps) influence short-lived turbidity peaks. Future work will convert raw turbidity data into suspended sediment concentration and a flow rating curve is currently under development.

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Continuous Sediment Transfer – Restoring Sediment Continuity in impounded Waters

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Abstract: The retention of sediment in reservoirs exacerbates issues related to sediment balance, leading to a deficiency of sediment in the lower reaches. This deficiency affects nutrient levels for fish and other organisms, diminishes silt for alluvial forests, disrupts sediment equilibrium, and ultimately impacts river deltas.

As of now, sustainable sediment management in reservoirs is almost non-existent. 'Sustainable' in this context denotes a solution that benefits both the environment and reservoir use. Traditional practices involve recurrent dredging, permanently removing sediment from the river course and resulting in a negative sediment equilibrium. Flushing, while removing small sediment quantities around the bottom outlet, is unsustainable, often leaving a substantial amount below the dam to the detriment of ecology.

Ensuring technical passability of the reservoir for sediment would be sustainable, similar to a scenario without a dam element. This necessitates a large-scale, managed, and controlled transport of sediment from upstream to downstream waters to restore the natural sediment balance. Continuous sediment transport emerges as a technical and sustainable solution for sediment continuity.

In this approach, sediment is continuously and automatically transferred from headwaters to lower reaches in a parameter-controlled process using fully automatic dredges. The operation is feasible 24/7 and requires no personnel. Real-time measurement and monitoring of volume, mass flow, and other parameters enable precise control of sediment transport. This ensures removal by the downstream water flow, preventing direct sedimentation in the water. Due to the unique nature of each reservoir, ongoing technological development is essential to address new challenges and find tailored solutions.

As a prospect for further development of this process, research is currently being carried out on an integrated methane gas collector to collect, separate, and utilize the methane gas bound in the sediment. This can reduce the negative impact of methane gas on the climate, which can be released during desedimentation.

The presentation will delineate the environmental impact of sediment retention, introduce desedimentation methods, and elucidate the continuous sediment transport approach and the integration of a methane gas collector.

Assessment of bioavailable metal/loids in metal-rich estuarine sediments using passive samplers and sequential extraction techniques

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Conference theme number(s): Theme II Sediment Flow

Introduction: Diffusive Gradient in Thin-Films (DGTs) are increasingly recognized as an alternative to conventional methods for assessing metal(loid) exposure in benthic organisms. By simulating the absorption of metal(loids) through biological membranes, DGTs offer sensitive and reliable measurements of DGT-labile metal species. This study aims to analyze the distribution of metal(loids) in estuarine sediments of the Ria of Huelva and evaluate their bioaccessibility using DGT devices alongside sequential extraction procedures.

Methods: Sediment cores were collected from the margin channels at selected sampling point using 25 cm PVC tubes. The cores were sealed, transported to the lab, sliced into 3 cm layers, frozen at -80°C, and freeze-dried before analysis. Pore water samples were also analyzed. DGT passive samplers were installed in each point. These devices retain the labile metal fraction through a Chelex-100 resin, where free cations and labile metal complexes diffuse through a filter and gel before being trapped by the resin. The LSPX-NP Loaded DGT used in this study features a mixed binding layer of Chelex and Ti oxide, designed to measure up to 40 metals. After 24 hours of sediment exposure, the devices were retrieved, rinsed, and taken to the lab. Resin gels were segmented, acid-treated, and shaken before dilution for metal analysis. Sequential extraction was performed to study the labile metal/loid fraction in sediments. Acid-extractable metals were obtained using 0.11 M acetic acid, while the exchangeable fraction was extracted with 1M MgCl₂ at pH 7. After centrifugation, supernatants were filtered, acidified, and preserved for analysis.

Results: The estuarine sediments are mostly silty loam (60% silt, 36% sand, 4.8% clay), except at the outer part, which has a sandy loam texture due to coastal influence. They contain high metal concentrations, with Fe averaging 9.0% and peaking at 18%. Al, S₂O₃, and P₂O₅ also show notable variations, with maximum values of 15%, 5.7%, and 3%, respectively. Sediment porewaters are characterized by high contents in Fe, with maximum concentrations of 5826 µg/L, followed by Mn (470

µg/L), Zn (210 µg/L), Al (189 µg/L), Cu and As (22 µg/L). DGTs accumulated high concentrations of Fe (maximum value of 24090 µg/L) and other metal/loids such as Al (1601 µg/L), Mn (1186 µg/L), Zn (684 µg/L), Cu (193 µg/L), Cr (35 µg/L), Pb (22 µg/L) or As (5.5 µg/L). Labile fractions obtained by sequential extractions also provide high concentrations of metal/loids such as Al (maximum of 31503 µg/L), Fe (17715 µg/L), Zn (1990 µg/L), Cu (1330 µg/L), Mn (668 µg/L), Pb (183 µg/L) or As (55 µg/L)

Discussion: The elevated Fe concentrations in porewater could be attributed to predominant Fe-reduction processes occurring under low-oxygen conditions. Iron oxides and oxyhydroxysulfates carried by the river settle and become buried in the sediment, where they undergo microbial dissolution in these reducing environments. The interaction between dissolved ferrous Fe and sulfide results in the formation of Fe monosulfides and pyrite, which serve as the ultimate sink for both elements in the deeper, oxygen-depleted sediment layers. During these reactions there is a flux of metals between reduced and oxidized phases. The elevated concentrations observed in DGTs for Fe and Al suggest that colloids may pass the membrane and contribute to this pool. Labile fractions observed by DGTs and sequential extractions were not well correlated in this study, suggesting further investigation.

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