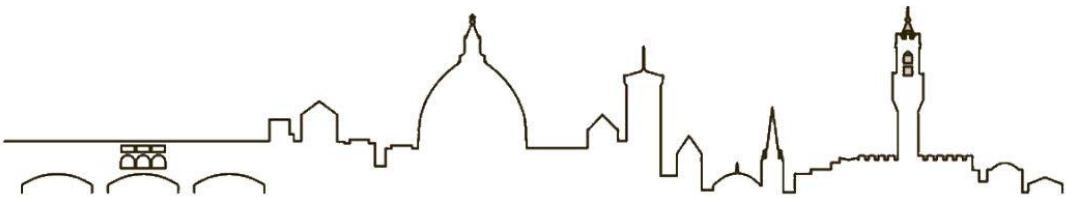
ISRS 2023

15th International Symposium on River Sedimentation

Sustainable Sediment Management in a changing Environment

Florence, 5-8 September 2023



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Abstract Book

Main theme and topics

The main theme of ISRS 2023 is *'Sustainable Sediment Management in a Changing Environment'*. The conference will be organized with parallel sessions that include these topics:

1. Sediment and pollutant transport;
2. Morphodynamics;
3. Ecohydraulics;
4. Sediment related disaster and climate change;
5. Reservoir sedimentation, interactions between sediment and hydraulic structures;
6. Sustainable sediment management at the river- coastal basin scale;
7. Social, economic & political issues related to sediment and water management.

Keynote Speakers

Delta development and artificial land creation with sediment

Wang Zhaoyin and Xu Mengzhen

Professor in Tsinghua University (China) and the Chairman of the Advisory Council of the International Research and Training Center on Erosion and Sedimentation (UNESCO).

Role of bed level variability on tracer dispersal in an equilibrium bed

Enrica Viparelli

Professor in the Department of Civil and Environmental Engineering at the University of South Carolina (USA).

Entrainment, transport and mixing of fine iron mine tailings in the Paraopeba River, Brazil

Marcelo H. Garcia

M.T. Geoffrey Yeh Chair in Civil Engineering and Professor and Director of the "Ven Te Chow" Hydrosystems Laboratory at the University of Illinois Urbana-Champaign (USA).

Modelling river beform evolution

Guo Junke

Associate Professor in the Department of Civil and Environmental Engineering at the University of Nebraska-Lincoln, USA

Accounting natural variability in 1D bedload prediction: a field case study

Alain Recking

Research Engineer at INRAE, France, and currently carries out his research at the Institute for Geoscience and Environment (IGE) in the Grenoble Alps University.

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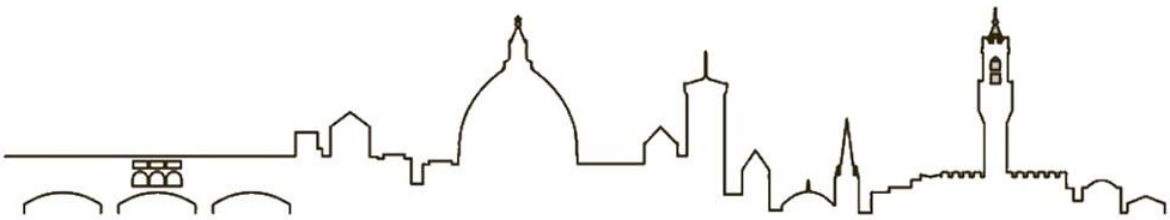
Topic 1:

Sediment and Pollutant transport



Reservoir Sedimentation of the Xiaolangdi Reservoir and Channel Erosion in the Lower Yellow River

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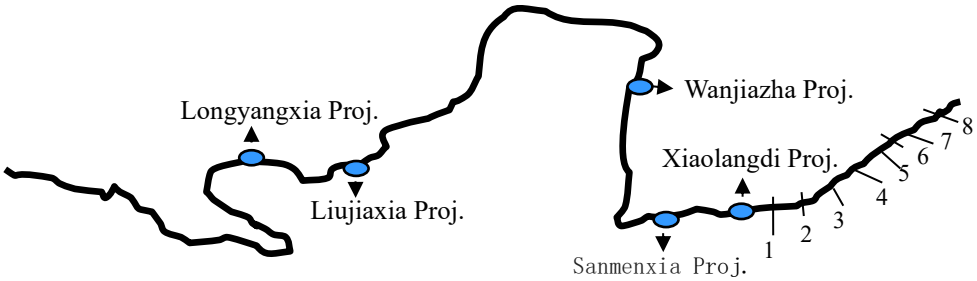
Abstract

Based on the field data of the Xiaolangdi Reservoir and the Lower Yellow River from 1999 to 2021, this paper analyzes reservoir sedimentation and its Influence on channel erosion in the Lower Yellow River during the 22 years operation of the Xiaolangdi Reservoir. The result shows that from 1999 to 2021, the total deposition of Xiaolangdi Reservoir reached $3.347\times10^9 m^3$， only 26.0% of the incoming sediment load could be sluiced out of the reservoir. In the post-flood season of 2021, the vertex of deposition delta of Xiaolangdi Reservoir reached 7.74 km away from the dam.

From Oct. 1999 to Oct. 2021, the Lower Yellow River unavoidably suffers erosion, the whole erosion of the river amounted to 3.08×10^9t. The erosion in flood season is 61.1% of the annual erosion, about 84.6% of the erosion occurs in upper reach of the river covering a length of 468 km (the wandering reach and the transition reach), in which, 69.0% is in its upper part of 286 km (the wandering reach). The efficiency of channel erosion (amounts of erosion caused by unit water out of the reservoir) in 2000 and 2001 reached to 7.44 kg/m^3 and 7.19 kg/m^3, while in 2018 the erosion efficiency was only 1.97kg/m^3. The channel erosion made the cross-section narrower and deeper, dropped the water level at the same discharge and increased the bankfull discharges from 1800 m^3/s in 2002 to 4600 m^3/s in 2021. The bed armoring has been apparently appeared, the surface bed materials in 2021 were nearly two times as coarse as those in 1999.

Furtherly, research shows that, the increased flow energy coursed by 1m^3 sedimentation in the Xiaolangdi Reservoir are capable to scour 0.92 ton sediment in the downstream channel, therefore, the sediment detention by reservoirs are still one of the most effective measures for sedimentation reduction in the Lower Yellow River.



1.Huayuankou station 2.Jiahetan station 3.Tongwaxiang (Dongbatou) 4.Gaocun station

5.Sunkou station 6.Aishan station 7.Luokou station 8.Lijin station

Figure 1. Sketch for locations of large hydro-projects on the Yellow River.

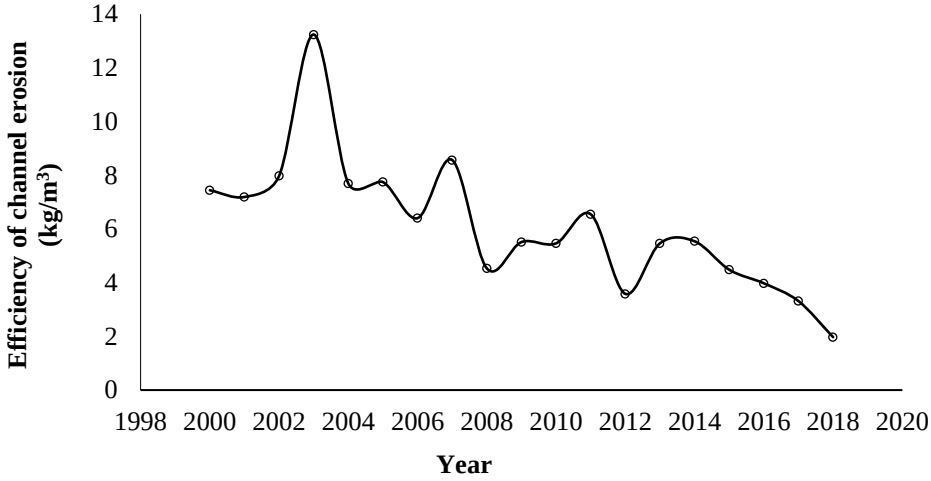


Figure 2. Efficiency of channel erosion in the Lower Yellow River from 1999 to 2018.

Keywords: Reservoir sedimentation; Channel erosion; The bankfull discharge; Water level; Efficiency of channel erosion

Acknowledgment

This study is supported by the National Natural Science foundation of China (Grant No.U2243237).

References

[1] Chen, J. G., Zhou, W. H., Sun, G. H.,Hong, J. (2008). "Initial operation of the Xiaolangdi Reservoir and responses of sedimentation in the Lower Yellow River." Journal of sediment research, 5, 1-8.

[2] Chen, J. G., Zhou W. H., Han S. S., Sun G. H. (2017). "Influences of retrogressive erosion of reservoir on sedimentation of its downstream river channel-A case study on Sanmenxia Reservoir and the Lower Yellow River." International Journal of Sediment Research, 32, 373-383.

[3] Chen, J. G., Zhou, W. H., & Deng, A. J. (2006). "Channel shrinkage and its instability in the Lower Yellow River." International Journal of Sediment Research, 21, 16-26.

[4] Chen, J. G., Zhou, W. H., & Chen, Q. (2012). "Reservoir sedimentation and transformation of morphology in the Lower Yellow River during 10 years initial operation of the Xiaolangdi Reservoir." J. Hydrodynamics, 24, 914-924.

[5] Ma, H. B., Zhang, J. H., & Chen, S. K. (2011). "Analyses on patterns of deposition since operation of the Xiaolangdi Reservoir." Journal of Yellow River, 11, 16-17.

Review of sediment's characteristics of carbon sink and potential value on carbon neutrality in river ecosystem

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Abstract

Carbon neutrality has become a topic of global consensus. To achieve carbon neutrality, it is also important to enhance carbon sequestration and sink capabilities, apart from the development of new energy to minimize carbon emissions. Carbon sinks can be divided into aquatic and terrestrial types. As a geographical unit with unique contributes on ecological and humanistic services, rivers are an important part of the freshwater ecosystem in the waters. Figure 1 shows the flow and morphological changes of carbon between water body - atmosphere, water body - sediment and lake – river, in which, the evolution of sediment erosion and deposition and its ecological environmental effects brought by the development of renewable hydropower resources have an important impact on the carbon sink of the river ecosystem. According to relevant research results, river sediment erosion and deposition shows potential carbon neutralization value with a series of carbon sink characteristics. On the one hand, the calcium and magnesium minerals in the sediment will dissolve and consume the CO_2 in the water body. The evolution of sediment erosion and deposition caused by hydropower development may change the mineral composition and temporal and spatial distribution of the transported sediment, greatly affecting its direct carbon sink function. On the other hand, sediment particles play an important role of "source" and "sink" in the process of water element adsorption and desorption, and sediment organic carbon is the main way of carbon deposition in the water ecosystem. If a large amount of sediment is deposited in the reservoir, it will not only delay the transport process of carbon source materials in the basin and significantly reduce the carbon source output of the river to the downstream, forming a "retention effect", but also change the distribution of the original carbon reserves of the river, which has a certain role of "blocking sediment and fixing carbon". Thirdly, changes in water and sediment conditions, nutrient retention, etc. will also lead to an increase in the biomass of phytoplankton, microorganisms and other organisms. The interaction between the secretion biofilm of its metabolic activities and sediment particles will also affect the absorption, degradation and transport of carbon source materials ("biofilm effect"), thus bringing about the indirect carbon sink effect of sediment erosion and deposition. In summary, the evolution of sediment erosion and deposition has a profound impact on the development of carbon sinks in river ecosystems, and is an important link in achieving carbon neutrality that cannot be ignored. In order to meet the climate challenge and achieve the long-term goal of reaching the carbon peak, it is necessary to clarify the carbon sink connotation and mechanism of sediment erosion and deposition in the river ecosystem, and develop the carbon sink accounting method of sediment erosion and deposition under the influence of natural and human factors, so as to correctly evaluate the carbon neutralization value of sediment in the river ecosystem.

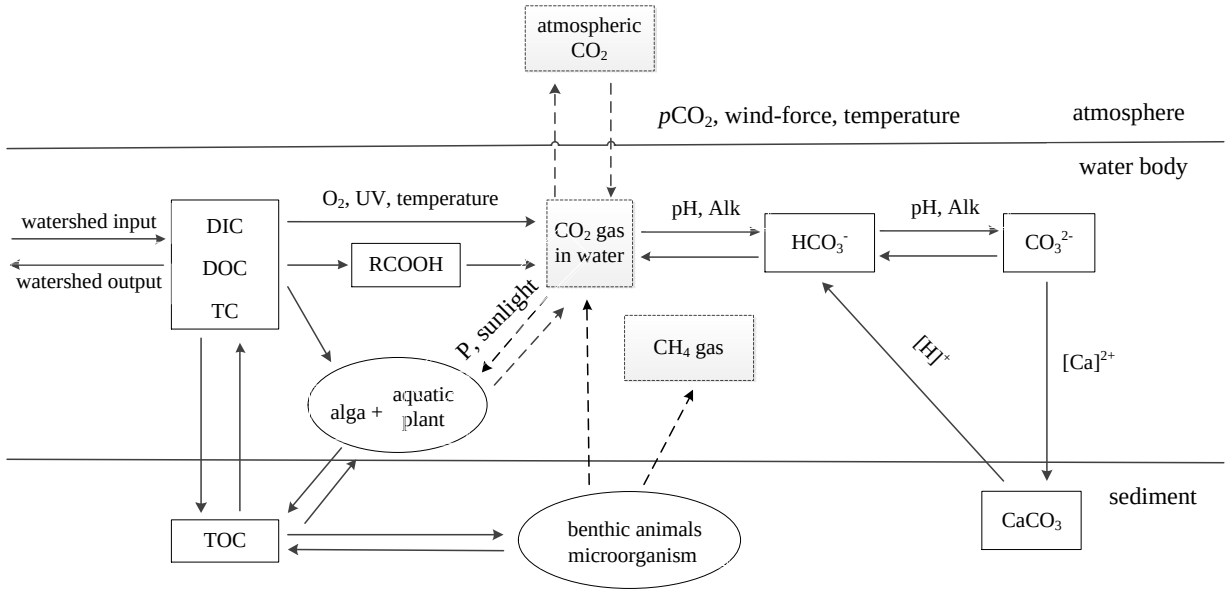

Figure 1. The overview of carbon cycling in freshwater ecosystem

Keywords: Sediment; River ecosystem; Carbon sink; Carbon neutrality

Acknowledgment

The authors would like to express appreciation for the support of the National Natural Science Foundation of China (Grant No. 52279078), the special fund of State Key Laboratory of Simulation and Regulation of a Water Cycle in a River Basin, China Institute of Water Resources and Hydropower Research (Grant No. SKL2022TS10), Program for Innovative Research Groups During 14th Five Year Plan Period of China Institute of Water Resources and Hydropower Research (Grant No. SE0145B022021).

References

[1] Yao Cheng, Wang Qian, Jiang Xia, et al. (2023). “Rivew of lake ecosystem’s characteristics of carbon sink and potential value on carbon neutrality”. Acta ecologica sinica, 43(3), 1–17.
[2] Gudasz C, Sobek S, Bastviken D, Koehler B, Tranvik L J. (2015). “Temperature sensiticity of organic carbon mineralization in contrasting lake sediments”. Journal of Geophysical Research: Biogeosciences, 120(7): 1215-1225.
[3] Yang Weidong, Zeng Lianbo, Li Xiang. (2023).“Advances in Research of Carbon Sinks and Their Influencing Factors Evaluation”. ADVANCES IN EARTH SCIENCE. 38(2), 1–17.
[4] DEB S, MANDAL B. (2021). “Soils and sediments of coastal ecology: A global carbon sink”. Ocean & Coastal Management, 214: 105937. DOI:0.1016/j.ocecoaman.2021.105937.
[5] Zhang Xinbao, Luo Jingcheng, Wang Xiaoguo, et al. (2022). “A preliminary study on the inorganic carbon sink function of mineral weathering during sediment transport in the Yangtze River mainstream”. Acta Geologica Sinica, 2022, 96: 1-8.
[6] BROEK M, VANDENDRIESSCHE C, POPPELMONDE D, et al. (2018). “Long-term organic carbon sequestration in tidal marsh sediments is dominated by old-aged allochthonous inputs in a macrotidal estuary”. Global Change Biology, 24(6):2498-2512.

Sediment storage control of fluvial sediment transport in gravel bed streams

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Abstract

Estimations of bedload transport in gravel bed rivers have been dominated by the capacity of the stream to transport sediment. Prediction of sediment transport based on flow characteristics are often more than one order of magnitude different than measured rates. The capacity approach is not suitable for gravel bed streams because the stream capacity can change with sediment supply and storage, the texture of the supplied sediment and bed surface and subsurface, bed armouring, and channel morphology. The discrepancy between the calculated and the measured bedload has been attributed to the state of the bed (texture and structure) and the sediment supply regime. The difference in performance is also because of the assumptions that underlie the models: uniform sediment and unconstrained movement of sediment, as well as little consideration for the role of sediment supply, storage within the channel, and sediment mobility.

It has been long recognized that sediment storage and bed surface composition (state) play an important role in controlling sediment transport and channel stability of streams and are hence the focus of this presentation. Bed state and sediment storage have not been adequately incorporated into sediment transport research. In mountain streams these are important factors due to episodic sediment inputs that can dominate the morphology of the system. The transport capacity of a channel may appear constant at both short and very long timescales, but is dynamic at intermediate timescales corresponding with the passage of sediment waves that cause fluctuations in channel storage.

The main objective of this presentation is to investigate sediment transport-storage relations. To achieve our goals, we conducted a field observation in several creeks in British Columbia, Canada, with flume experiments under a wide range of sediment supply and flow regimes, and developed a model to describe the relation between storage and sediment transport. Regardless of the hydrological regime, our field results yielded cycles of aggradation and degradation that were apparent over time. In transport-limited reaches of the channel, small-scale cycles were observed (~ 5-10 years). In reaches closer to colluvial sediment sources, the dominant cycle duration and magnitude were a function of episodic supply events (15-30 years). Cycle characteristics appear related to the position of a channel segment relative to colluvial sediment sources, glacial history and resulting watershed organization. Our flume experiments revealed that accumulated sediment storage before a flood largely predicts sediment transport during the flood. To describe this observation, we developed a mathematical model which represents sediment transport and storage as a coupled dynamical system.

This work indicates that the history of within-channel sediment storage is key to predicting sediment export across a series of floods, and contributes to a fundamental understanding for predicting channel dynamics in natural flow and sediment supply regimes.

Hydrological and sedimentological responses of an Alpine river to the 2022 summer drought

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Abstract

In fluvial systems, mountain river basins control the water and sediment fluxes delivered downstream, influencing the physical processes and configuration of lowland rivers (Picco et al., 2014). Mountain basins feature an interplay between geological, topographic, climatic, and ecological factors that results in complex relationships between flow and sediment transport conditions (Rainato et al., 2020). This complexity is further exacerbated by the ongoing climate change that is strongly impacting the rainfall regime, increasing the frequency of drought periods as well as extreme events (Peleg et al., 2020). Such conditions are making it challenging to ecologically preserve mountain basins and manage sustainably the river corridors. In light of this, this work aims at analyzing the response of an Alpine river to the drought conditions that occurred in 2022. Specifically, the relationships between rainfall, water discharge, and sediment transport were investigated in the Cordevole River, which is one of the main tributaries of the Piave River (NE of Italy). The Cordevole River was analyzed in the proximity of Saviner village, where it closes a basin of ~ 109 km^2.

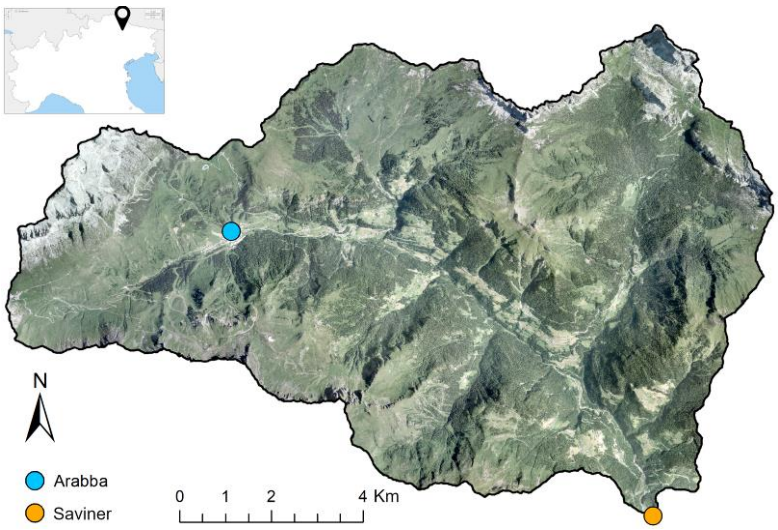

Figure 1. The Cordevole River basin. Blue and orange circles identify Arabba (meteorological station) and Saviner (ultrasonic level sensor, multiparameter sonde, and tracers), respectively.

In the basin, air temperature and rainfall were measured hourly by a meteorological station located in Arabba, while water discharge (Q) was recorded every 30-min by an ultrasonic water level sensor installed in Saviner (Figure 1). Both devices are managed by ARPA Veneto. In the same site of the ultrasonic water level sensor, a multiparameter water quality sonde (OTT Hydrolab MS5) was installed to measure the suspended sediment (turbidity *Tu*, in NTU) every 30-min. Also, 95 coarse sediment tracers (i.e., clasts equipped with Passive Integrated Transponders) were seeded in the study site to analyze the dynamic of bedload transport. Particularly, sonde and tracers were used to monitor

the sediment fluxes between 25 August and 1 December 2022. In the Cordevole River basin, the mean temperature and the total rainfall amount recorded in 2022 were 6.36 °C and 873 mm, respectively, which were 27.7% higher and 24.7% lower than the relative 1994-2021 average values. During the study period, the abovementioned conditions resulted in limited water fluxes, with only one event with Q > median Q being recorded in 2012-2021 (2.33 m^3 s^{-1}). In fact, the event of 8 September featured a peak of Q (Q_{Peak}) = 3.66 m^3 s^{-1} with a peak of Tu (Tu_{Peak}) equal to 737 NTU. Interestingly, a ~ 4 times greater Tu_{Peak} (2732 NTU) occurred on the 31 August event (Q_{Peak} = 2.45 m^3 s^{-1}), suggesting that Tu could be driven more by rainfall than by Q. In fact, the 31 August event featured a rainfall amount in the antecedent 24h (R_{24}) = 21.8 mm, while on 8 September this value was 13.8 mm. Such tendency was observed also in the other events recorded. Finally, it is worth noting that the analyzed flow conditions induced no effects on bedload tracers.

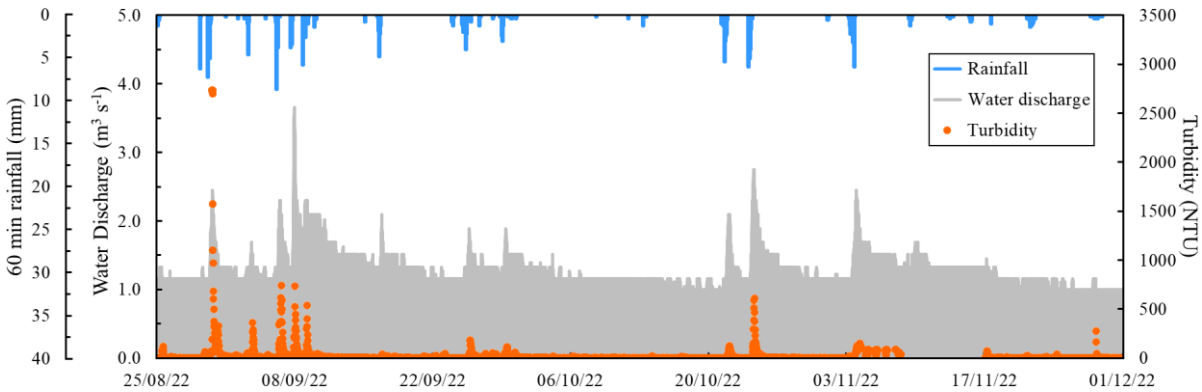

Figure 2. Rainfall (60-min), water discharge (30-min), and turbidity (30-min) measured during the study period.

Keywords: Alpine basin, climate change, suspended sediment load, sediment transport.

Acknowledgment

This work was funded by the University of Padova in the frame of the "CAM.SI.FLU.AL" and "DOR2224210" research projects.

References

[1] Picco, L., Ravazzolo, D., Rainato, R., Lenzi, M.A., 2014. "Characteristics of fluvial islands along three gravel-bed rivers of North-Eastern Italy". Cuadernos de Investigacion Geografica 40(1), 53-66.
[2] Rainato, R., Mao, L., Picco, L., 2020. "The effects of low-magnitude flow conditions on bedload mobility in a steep mountain stream". Geomorphology 367, 107345.
[3] Peleg, N., Skinner, C., Fatichi, S., Molnar, P., 2020. "Temperature effects on the spatial structure of heavy rainfall modify catchment hydro-morphological response". Earth Surface Dynamics 8, 17–36.

Sediment stratification and mixing in the Qiantang Estuary in September 2019

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Abstract

Sediment transport with in the Qiantang tidal bore causes intensive morphological change in the estuary(Wang et al., 2022; Pan et al., 2023). The interaction between tidal bores and sediment is of great concern and a growing number of research is investigating the hydrodynamics of tidal bores and its turbulence(Simpson et al., 2004; Xie and Pan, 2013; Tu et al., 2019). Studies are mainly focused on the turbulent process during the passage of tidal bores by employing field data on a single station while little attention is addressed to sediment stratification and mixing along the longitudinal estuary.

The variability of suspended sediment concentrations are complex in estuaries, especially during the passage of tidal bores(Pan and Huang, 2010; Wang and Pan, 2018; Putra et al., 2019). In the present study, the basic characteristics related to sediment transport by tidal bore were investigated. It is best to view the Qiantang tidal bore in the Autumnal equinox period, when tidal bores becomes maximum within a year. The field data during the Autumnal equinox period covering the estuary is used to analyze sediment stratification and mixing. Sediment concentration along water depth introduces stratification, significantly affecting turbulence dynamics. Therefore, sediment stratification and mixing indicate the variation of the turbulence in the estuary. It could be a parameter to quantify the change of tidal energy in the Qiantang Estuary.

In this study, we present field data collected in the estuary from Ganpu to Zhakou, including the formation, development and dissipation process of tidal bore. The measurement with regard to tidal flows and sediment concentration was deployed in September, 2019. Tidal currents were recorded using a Teledyne/RDI acoustic Doppler current profiler (2000kHz). Sediment concentration was determined by bottle sampling and optical backscatter sensors. The temporal and spatial variation of flow and sediment was identified, and sediment stratification and its dependence on tide are analyzed. The effect of sediment concentration on turbulent dynamics was assessed. The tidal bore Froude number is 1.79 in September 2, 2019, indicating a breaking bore formation in the reach. Sediment concentration was characterized by an amplitude ranging from 0.1kg/m^3 to 20kg/m^3 along the estuary. Moreover, sediment concentration is highly variable along water depth. The flux Richardson number was calculated at the stations and its effect on the turbulence was discussed. The current study aims at providing an interpretation of sediment stratification and mixing on the tidal energy loss in the estuary. Based on field data deployed in September, 2019, the locations of the measured stations are shown, and sediment concentration with vertical layers at Ganpu station is depicted in Fig.1.

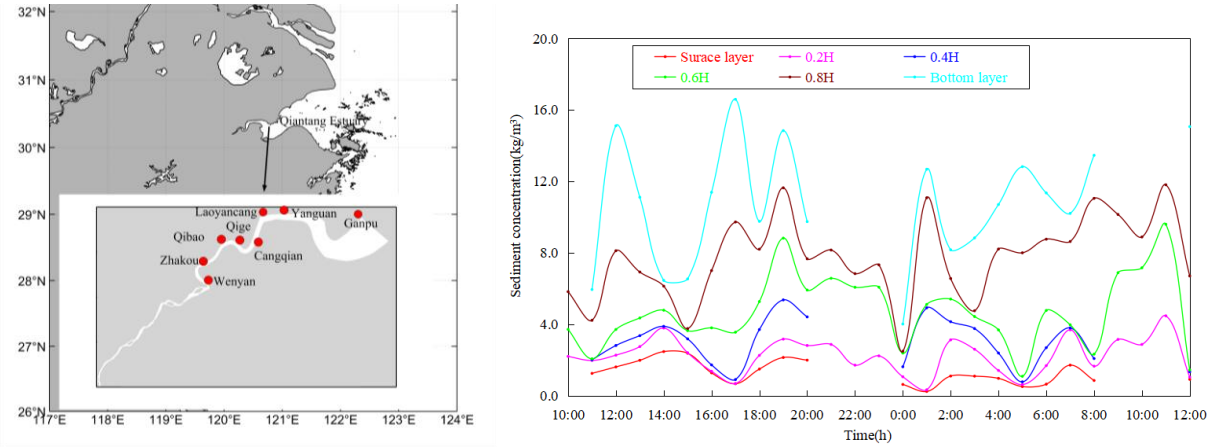

Figure 1. Sketch of the Qiantang Estuary and locations of the field station (left), measured sediment concentration along water depth at Ganpu during September 1-2, 2019 (right)

Keywords: Sediment transport; Qiantang Estuary; Tidal bores; Tidal energy; Sediment concentration; Field data

Acknowledgment

This work was financially supported by the National Natural Science Foundation of China (Grant Nos. 42276176, 41706099), the Joint Fund of the Zhejiang Provincial Natural Science Foundation of China (Grant No. LZJWZ23E090006).

References

[1] Pan, C. H. and Huang,W. R. (2010). "Numerical Modeling of Suspended Sediment Transport Affected by Tidal Bore in Qiantang Estuary." Journal of Coastal Research, 26(6): 1123-1132.

[2] Pan, C. H. and Wang Q.S., et al. (2023). "Characteristics of river discharge and its indirect effect on the tidal bore in the Qiantang River, China." International Journal of Sediment Research, 38(2): 253-264.

[3] Putra, Y. S., et al. (2019). "2D numerical contributions for the study of non-cohesive sediment transport beneath tidal bores." Comptes Rendus Mécanique, 347(2): 166-180.

[4] Simpson, J. H. , et al. (2004). "Reynolds stress and TKE production in an estuary with a tidal bore." Estuarine, Coastal and Shelf Science, 60(4): 619-627.

[5] Tu, J. , et al. (2019). "Turbulence, Sediment‐Induced Stratification, and Mixing Under Macrotidal Estuarine Conditions (Qiantang Estuary, China)." Journal of Geophysical Research: Oceans, 124(6): 4058-4077.

[6] Wang, Q.S. and Pan, C.H.(2018). "Three-dimensional modelling of sediment transport under tidal bores in the Qiantang estuary, China." Journal of Hydraulic Research, 56(5): 662-672.

[7] Wang, Q.S., et al. (2022). "Tidal Bore Dynamics Around the Similar Right-Angle Shoreline in the Qiantang Estuary, China." China Ocean Engineering, 36(5): 827-838.

[8] Xie, D. F. and Pan, C. H. (2013). "A preliminary study of the turbulence features of the tidal bore in the Qiantang River, China." Journal of Hydrodynamics, 25(6): 903-911.

Responses of COD Distribution to Floods in Jinmeng Bay, China

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Abstract

To achieve coastal development, massive coastal engineering structures have been constructed in China. Unfortunately, some projects fail to bolster local economy, and incurs excessive expenses for subsequent restorations. Jinmeng Bay (JMB) has been faced with recurrent green tides since 2015 for constructions of coastal projects [1]. These structures alter local hydrodynamics significantly and result in deterioration of water quality [2]. In previous researches in JMB, we revealed that the artificial structures would rise Chemical Oxygen Demand (COD) concentration. As one of the important environment factors of macroalgal blooms, the increase of COD could rise the risk of green tide further [3]. Under this circumstance, it is necessary to focus on COD distribution for high inputs from the east branch (EB) and the west branch (WB) of Tanghe River.

In the present study, a hydrodynamic-transport coupled model is utilized to investigate the tempo-spatial distributions of COD in two scenarios (Table 1). The first scenario is based on a real flood in August 2022, and a 50-year flood process is designed for the other scenario. The numerical results indicate that: (1) littoral currents maintain a reciprocating trend during a flood process along Jinmeng Beach, where the flood currents are intensified significantly for the confluence of floods. (2) A high COD concentration zone is generated at the estuary for flood inputs, and extends along Jinmeng Beach by the prevailing flood currents. (3) Compared with the real flood, the 50-year flood bring about an intensive offshore transport of COD, so the high concentration zone is enlarged. (4) During the real flood process, the core of high COD concentration remains at the estuary, while the 50-year flood generates additional cores around the artificial islands. Thus, water quality monitoring should cover the estuary and the structures, and tracking on high concentration zones is necessary for early-warning of green tides. The above results can provide a scientific basis and prevention of green tide in JMB.

Table 1. Details about the scenarios for the investigation

Scenario	River	Maximum discharge	Duration	Maximum COD concentration
Real flood	EB	253 m^3/s	192 h	31.9 mg/L
	WB	43 m^3/s	192 h	5.4 mg/L
Designed flood	EB	1618 m^3/s	192 h	204.3 mg/L
	WB	598 m^3/s	192 h	75.5 mg/L

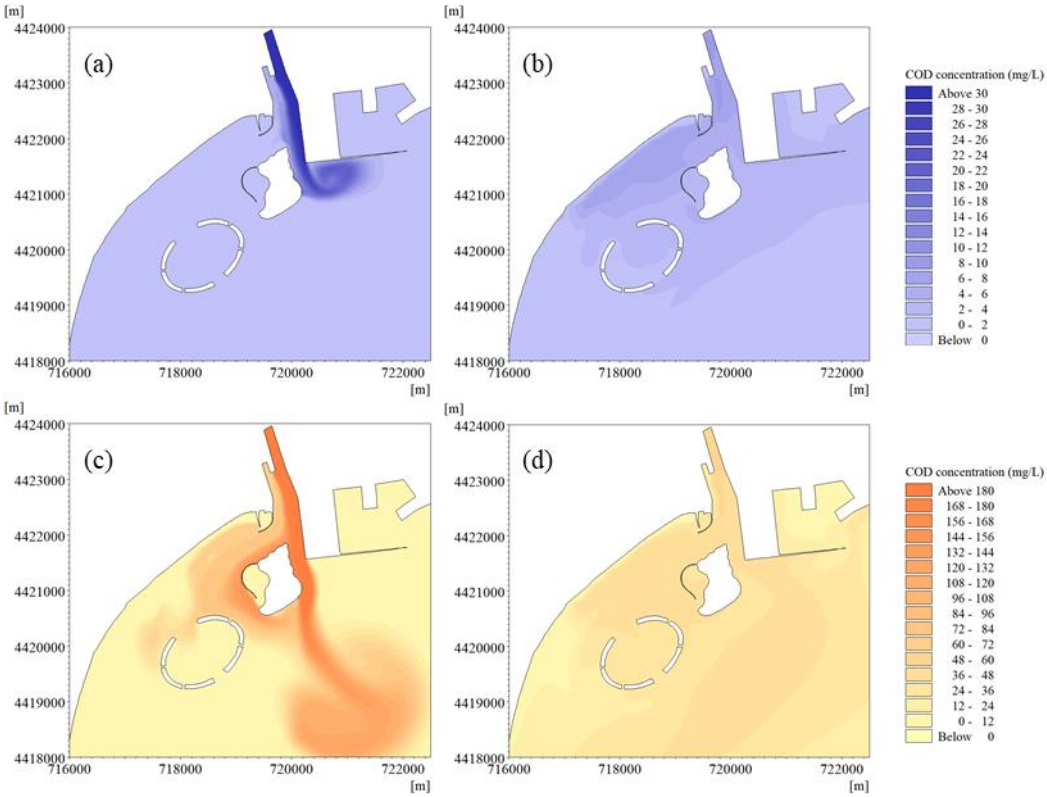

Figure.1 COD distributions after (a) peak discharge and (b) flood process of the real flood; (c) peak discharge and (d) flood process of the designed flood.

Keywords: COD; Flood; Water quality; Estuary; Coastal structure

Acknowledgment

This research was funded by the National Key Research and Development Project of China, under contract no. 2022YFC3106205 and 2019YFC1407902, and the National Natural Science Foundation of China, under contract no. 41976159. We are sincerely grateful to Key Laboratory of Marine Eco-Environmental Science and Technology, First Institute of Oceanography, Ministry of Natural Resources of People's Republic of China for supporting the fieldwork and measured data for the model validation.

References

[1] Zeng, B., Sun, Y., Song, W.,Wang, Z., Zhang, X. (2023) "Recurrence of the green tide in the Bohai Sea, China: A green tide caused by coastal reclamation projects." Journal of Sea Research, 191.
[2] Han, X., Kuang, C., Li, Y., Song, W., Qin, R., Wang, D. (2022). "Numerical Modeling of a Green Tide Migration Process with Multiple Artificial Structures in the Western Bohai Sea, China." Applied Sciences, 12(6).
[3] Zhang, Y., He, P., Li, H., Li, G., Liu, J., Jiao, F., Zhang, J., Huo, Y., Shi, X., Su, R., Ye, N., Liu, D., Yu, R., Wang, Z., Zhou, M., Jiao, N. (2019). "Ulva prolifera green-tide outbreaks and their environmental impact in the Yellow Sea, China." National Science Review, 6(4).

Sedimentological variability in influence of the Itumbiara Dam

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Abstract

Monitoring sediment transport is important to have tools that seek to prevent problems caused by sediment transport and deposition, such as erosive processes and siltation [1]. By quantifying the suspended sediments related to the erosive processes present in a watershed it is a tool that analyzes how they affect hydraulic works, reservoirs, and navigation [2].

The Itumbiara dam reservoir (Figure 1) is in the hydrographic basin of the Paranaíba River, on the border of the States of Goiás and Minas Gerais, formed by the damming of the Paranaíba River and its main tributaries.

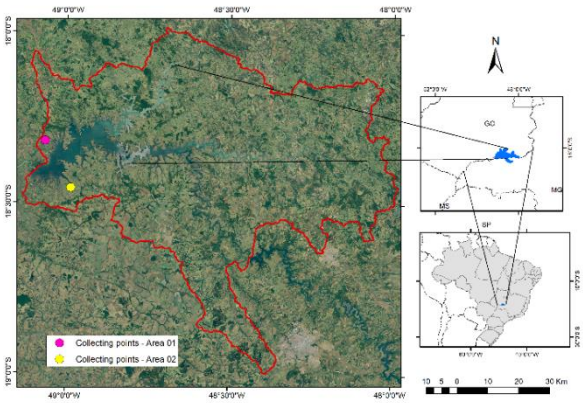

Figure 2. map of the reservoir location and monitored areas

For the monitoring, two tributaries were selected on both sides of the reservoir, far from the backwater areas, for the collection of samples. The analyses of the collected materials took place in the laser diffraction analyzers MASTERSIZER 2000 MU, in the equipment also passed through ultrasound, with the intention of disaggregating soil particles that may have agglomerated. Four samples were collected in the monitored areas, with two samples from each area collected in the month of November 2021 and two from each area in January 2022, the period of precipitation in the region.

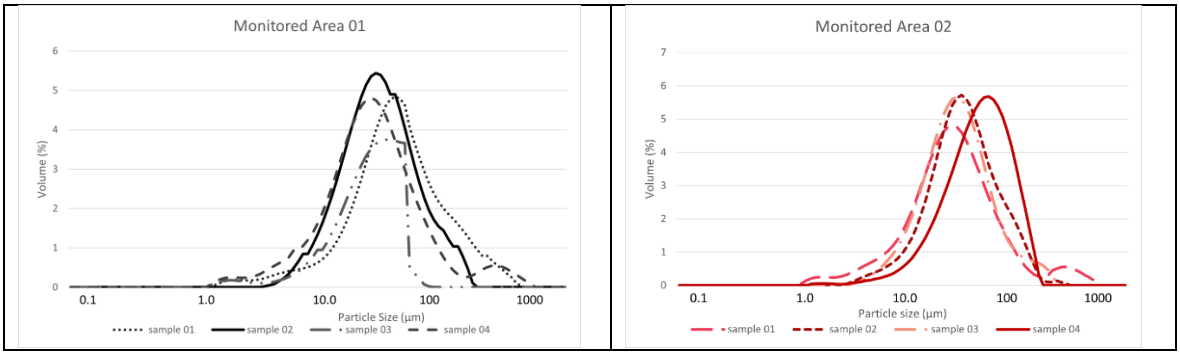

Figure 3. Particle size distribution by granulometer

In area 01 silt was the class with the highest representation, followed by clay, fine sand, medium sand and coarse sand. The data collected in area 2 found a silt predominance on the samples collected, but fine sand was the second most present in the samples. The particle size classification used to represent the results was the ISO 14688-1 -2002 [3] (Table 1).

Table 1.: Percentage of particles sampled for the rainy season.

Percent of particles sampled - Area 01				
Soil	Sample Nov.. 01	Sample Nov. 02	Sample Jan. 01	Sample Jan. 02
Clay	20%	19%	0%	28%
Silt	45%	44%	86%	62%
Fine Sand	17%	15%	14%	10%
Medium Sand	15%	15%	0%	0%
Coarse Sand	3%	7%	0%	0%
Percent of particles sampled - Area 02				
Soil	Sample Nov. 01	Sample Nov. 02	Sample Jan. 01	Sample Jan. 02
Clay	22%	4%	20%	6%
Silt	53%	59%	43%	60%
Fine Sand	22%	22%	15%	23%
Medium Sand	4%	14%	15%	11%
Coarse Sand	0%	0%	7%	0%

The results are directly related to the uses and occupation of the soil present in the watersheds of each tributary. Area 01 is predominated by pastures that share the space with native vegetation, while in area 02 the riparian forest has been considerably reduce, besides the agricultural practices of the region leave the soil more exposed, subject to sediment drag. The anthropogenic actions present in the region quantify the sediments produced, transported and deposited in the channels.

Keywords: Sediment Transport; Erosive Processes; Particle Size.

Acknowledgments
This research was supported by funding from P&D Project from ANEEL – National Agency, “Modelling at Different Scales of Sediments Generation in Erosions and Sediments Input in Hydroelectric Power Plant Reservoirs” – PD-ANEEL 0394-1705/2017, supported by Furnas Centrais Elétricas S.A. and Agência Nacional de Energia Elétrica with UFG and UnB cooperation.

References

[1] Borrelli, P., Märker, M., Panagos, P., & Schütt, B. (2014). Modeling soil erosion and river sediment yield for an intermountain drainage basin of the Central Apennines, Italy. Catena, 114, 45-58.
[2] Xu, H., Muste, M., & Demir, I. (2019). Web-based geospatial platform for the analysis and forecasting of sedimentation at culverts. Journal of Hydroinformatics, 21(6), 1064-1081.
[3] ISO 14688-1 (2002). Geotechnical Investigation and Testing-Identification and Classification of Soil-Part 1: Identification and Description.

The applicability of the analytic solutions for suspended sediment in waves with different boundary conditions and diffusivity

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Abstract

Sediment transport induced by waves is of great significance to coastal engineering. Due to the great influence of the vertical distribution of suspended sediment on sediment transport, many theoretical researches focus on the vertical distribution of suspended sediment concentration in waves, in which some studies ignore the unsteady characteristic[1-2]. In addition, several theoretical studies pay attention on the unsteady characteristic of suspended concentration of sediment, but the model is given by numerical method rather than an explicit formula or lacks discussion on the applicability[3-4]. Theoretical analysis of time-dependent suspended sediment concentration induced by waves need to be further research.

At present study, the theoretical solutions of suspended sediment equations for four different conditions with two types of boundary conditions of reference concentration approach and pickup function approach and with two types of sediment diffusion coefficients of constant and linear varying with z have been derived through Laplace transform. The ability of the theoretical solutions of the four conditions to describe the profiles of sediment concentration have been discussed by comparing with experimental data of different situations[5-7].

Figures 1-4 present the comparison between the theoretical results (line) of the four conditions with different β and experimental data (circle). Results shown that the theoretical results of the four conditions are capable of describing the vertical profile of periodic averaged suspended sediment concentration near the bottom and the results of linear varying diffusion coefficients are more appropriate to predict the profile of suspended sediment concentration away from the bottom than that of constant diffusion coefficients, including amplitude of fluctuation and phase. In addition, the solutions combined with pickup function approach can provide a better results in phase of periodic variation of concentration than that of reference concentration approach.

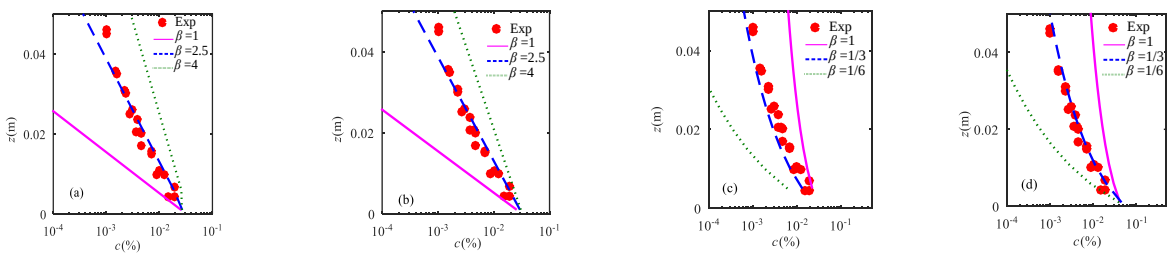

Fig. 1. Comparison between theoretical results and experiment of oscillatory flow.

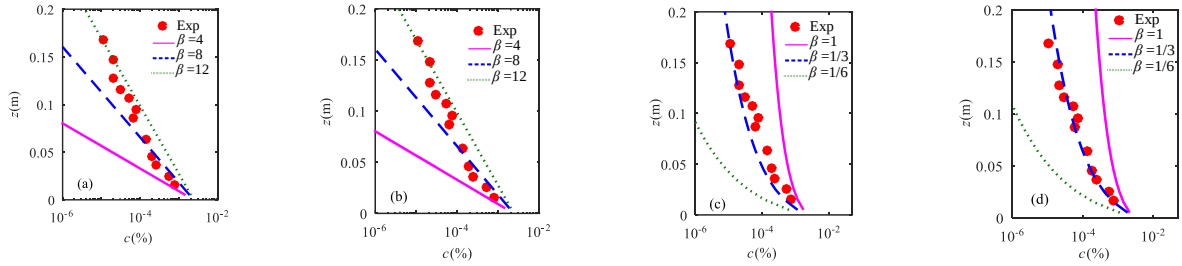

Fig. 2. Comparison between theoretical results and experiment of reduced-scale wave flume.

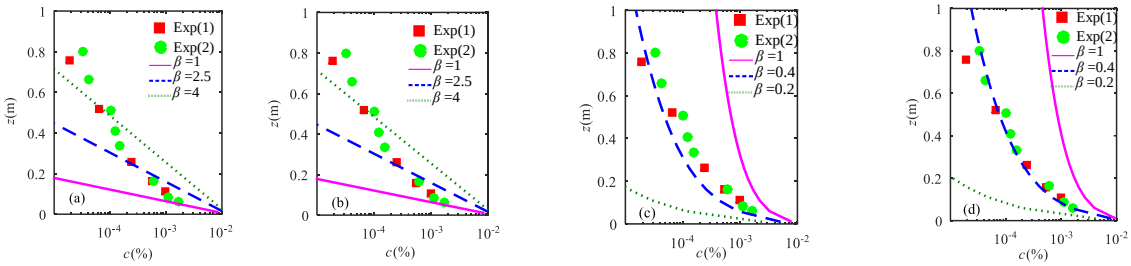

Fig. 3. Comparison between theoretical results and experiment of large-scale wave flume.

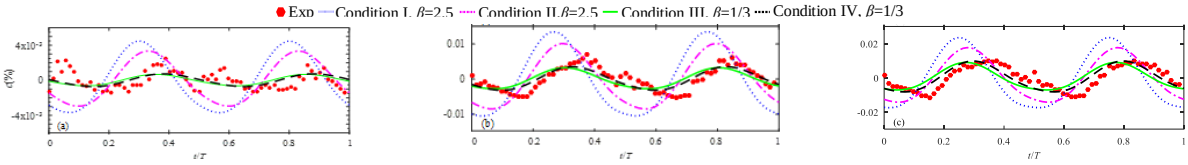

Figure 4. Comparison of periodic variation of sediment concentration between theoretical results and experiment of oscillatory flow. (a)-(c) represent the results at z=2.1cm, z=1.1cm and z=0.5cm.

Keywords: analytic solutions; sediment transport; diffusion coefficients; boundary conditions

Acknowledgment

We very much appreciate the financial support of the National Natural Science Foundation of China (12202503, U2040217) and the National Key R&D Program of China (2022YFC3204303).

References

[1] G. Galappatti, C.B. Vreugdenhil, A depth-integrated model for suspended sediment transport, J. Hydraul. Res. 23(4) (1985), 359–377.
[2] X. Liu, Analytical solutions for steady two-dimensional suspended sediment transport in channels with arbitrary advection velocity and eddy diffusivity distributions. J. Hydraul. Res. 54(4) (2016), 389–398.
[3] J. Fredsoe, O. H. Andersen, S. Steen, Distribution of suspended sediment in large waves, J. Water way, Port, Coast. and Ocean Eng. 111 (6) (1985), 1041-1059.
[4] Yiqin Xie,Jifu Zhou,Xu Wang,Yanrong Kuai,Yongjun Lu.Analytical solutions for sediment concentration in waves based on linear diffusivity[J].Theoretical & Applied Mechanics Letters,2021,11(02):77-80.
[5] S.Q. Li, Y.J. Lu, Sediment transport process in wave-current boundary layer, Hohai University Press, Nanjing, China, 2016. (in Chinese)
[6] J.S. Ribberink, A.A. Al-Salem, Sheet flow and suspension of sand in oscillatory boundary layers, Coast. Eng. 25(1995), 205–225.
[7] L.O. Amoudry, P.S. Bell, P.D. Thorne, et al, Towards representing wave-induced sediment suspension over sand ripples in RANS models, J. Geophys. Res. Oceans, 118 (2013), 2378–2392.

Study on vertical distribution of sediment concentration in the Qiantang Estuary

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Abstract

The vertical distribution of sediment concentration is the core issue of sediment transport in estuaries. At present, many scholars at home and abroad have made many research results on the vertical distribution of sediment concentration in river equilibrium transportation (Rouse, 1938; Qian, 1983; Zhang, 1998; Ni, 1991). However, natural rivers are usually in no-equilibrium sediment transport, and the vertical distribution of sediment concentration in no-equilibrium sediment transport is quite different from that in equilibrium sediment transport. Han et al. (2010) studied the vertical distribution of no-equilibrium sediment concentration, deduced the theoretical solution of vertical distribution of sediment concentration in non-equilibrium transportation, and proposed the calculation method of unsaturated coefficient. The vertical distribution of sediment concentration in tidal estuary is relatively complex due to the influence of oscillatory tidal current, waves, sediment flocculation and other factors. Many scholars usually use the methods of equilibrium sediment transport for analysis (Tang, et al., 2009; Li, et al., 2012), which fails to reflect the impact of no-equilibrium sediment transport in strong tidal estuary on the vertical distribution of sediment concentration.

The Qiantang Estuary (QE) is a typical macro-tidal estuary with strong scouring and silting. Under the action of oscillatory tidal flow, the suspended sediment transport shows significant time-varying characteristics and no-equilibrium transport characteristics, and the vertical distribution of sediment concentration is significantly different from that of ordinary rivers. This paper makes theoretical discussion and statistical analysis on the vertical distribution of sediment concentration in the estuary based on the previous research results and the diffusion theory sediment transport, and finds that the vertical distribution of sediment concentration in the estuary basically follows the exponential or power distribution laws using the measured water and sediment data in the QE. The vertical distribution coefficient (c) is different from the Karinsky exponential formula and Rouse formula of vertical distribution in equilibrium sediment transport. Based on this, the multivariate correlation among the vertical distribution coefficient (c), the suspended index (ω/ku_*) and the sediment saturation (s_*/s) is established (Figure 1). The correlation coefficient R^2 is 0.64~0.82, which has a good correlation and has a certain reference value for the simulation of sediment transport in the QE.

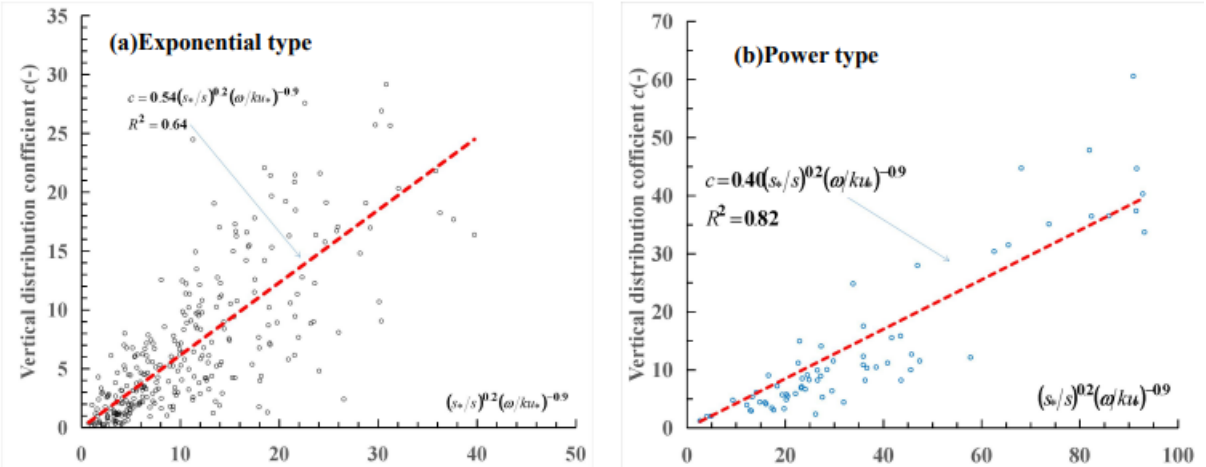

Figure 1. Correlation among the vertical distribution coefficient, suspended sediment index and sediment saturation.

Keywords: Sediment concentration; Vertical distribution; Sediment saturation; Suspended index; Sediment carrying capacity; The Qiantang Estuary(QE)

Acknowledgment

The authors gratefully acknowledge the support of the National Natural Science Foundation of China (No. U2006227).

References

[1] Rouse, H. (1938). “Experiments on the mechanics of sediments suspension.” Proc. ,5th International congr. for Applied Mech., 550-554
[2] Qian Ning, Wan Caohui. (1983) . “Sediment movement mechanics”. Beijing, Science Press, China.
[3] Zhang Ruijin. (1998). “River sediment dynamics”. Beijing, China Water Conservancy and Hydropower Press.
[4] Ni Jinren, Wang Guangqian, Zhang Hongwu. (1991). “Basic theory of solid-liquid two-phase flow and its latest application”. Beijing ,Science Press, China.
[5] Han Qiwei, Cheng Xujian, Xue Xiaochun. (2010). “On the vertical distribution of sediment concentration in no-equilibrium transportation”. Advances in water science ,21(4), 512-523.
[6] Tang Jianhua, Li Ruohua, Liang Bin. (2009). “Dicussion on the vertical structure of suspended sediment concentration of macro-tidal estuary during spring tide-taking Zhapu of Hangzhou Bay as an example”. Hydro-Science and Engineering ,2,39-43.
[7] Li Ruijie, Feng Qing, Zheng Jun, et al. (2012). “Analysis of vertical distribution of nearshore fluid velocity and sediment concentration”. Marine Science Bulletin, 31(6), 607-612.

Sediment Transport and Associated Pollutant Release in Rivers and Lakes

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Abstract

Sediment, widely existing in natural waters, is a reservoir of toxic and harmful pollutants, and plays an important role in causing extreme pollution such as eutrophication. Due to the disturbance of external forces, sediment transport occurs including bed load and suspended load transport [1], which further results in internal pollutants release that requiring interdisciplinary research. Based on the knowledge of sediment transport, the associated pollutant release is studied from theoretical analysis, flume experiment and numerical simulation, to explore pollutant release characteristics accompanied by sediment transport in rivers and lakes.

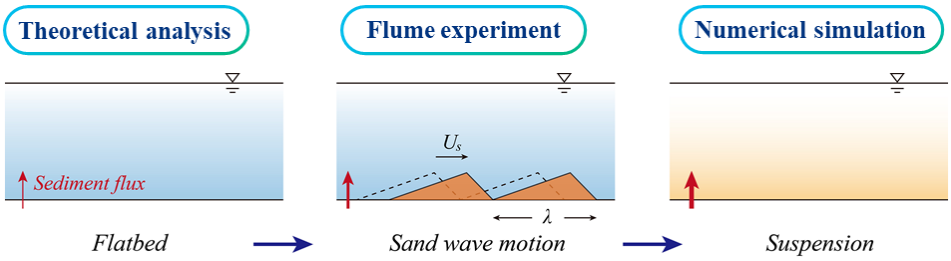

Figure.1 Sediment dynamics affecting pollutant release at the sediment-water interface

Theoretical analysis: According to the bed shear stress, the controlling modes of sediment nutrient flux can be divided into diffusion, sand wave motion and bed erosion [2]. Sediment nutrient flux due to diffusion can be expressed as a product of mass transfer coefficient and concentration difference, and bed erosion may lead to a significant increase in the flux. The analytical expression for sediment nutrient flux due to bedform migration is derived by integration, assuming an ideal two-dimensional periodic sand wave which migrates downstream with a velocity of *Us*. Results show that sediment nutrient flux may experience an increase of 2-3 orders of magnitude from flatbed to sand wave motion and then sediment suspension, and a unified expression for the sediment nutrient flux under the controlling modes of diffusion, sand wave motion and bed erosion is preliminarily proposed [3].

Flume experiment: A 16 m long circulated flume is used to examine the mobility of phosphorus (P) induced by sediment resuspension [4]. Three groups of size-fractionated sediment, i.e., 0.05-0.1 mm, 0.02-0.05 mm and less than 0.02 mm, are sequentially used, with an initial sediment P concentration of about 0.4 mg/g. During the flume experiment, water samples are collected to analyze the changes in sediment and P concentrations. Results show that coarse sediment has a smaller incipient velocity due to the adhesion between fine sediment, leading to a larger amount of sediment erosion. Accordingly, a faster P release is observed for coarse sediment bed. In general, there is a strong correlation between the loads of total P and sediment, and a bridge between the small-scale adsorption experiment and the field observation of natural scale is established through flume experiment.

Numerical simulation: A dynamic pollutant transport model is then proposed with a detailed modeling and rigorous coupling of sediment and pollutant dynamics, including adsorption and desorption, pollutant deposition and release at the bed surface along with sediment dynamics. The proposed model is applied to predict the P behavior in the shallow Taihu Lake under the influences of wind waves and lake currents [5]. Results show that sediment resuspension and the resultant P release play a major role in controlling P levels in the overlying water, and P distribution in Taihu Lake is the result of the combined effects of wind waves and lake currents. Specifically, wind waves affect the release of sediment P which is the key controlling factor for the water quality of Taihu Lake; and lake currents are the main driving forces for P transport in the overlying water which is crucial to P distribution in the lake.

In the future, it is necessary to pay more attention to the adsorption and metabolic activity of microorganisms on particle surfaces, i.e., the pollutant release characteristics under the influence of biological processes such as biofilm growth (including both biofilm growth changing sediment dynamics, and the environmental effects of biofilm itself) [6]. Meanwhile, the remediation of contaminated sediment also needs to be comprehensively considered from the perspective of bed stability.

Keywords: Sediment dynamics; Pollutant release; Theoretical analysis; Flume experiment; Numerical simulation

Acknowledgment

The authors would like to express appreciation for the financial support by National Key Research and Development Program of China [No. 2022YFC3201803].

References

[1] Chien, N. & Wan, Z.H. (1999). “Mechanics of Sediment Transport.” American Society of Civil Engineers, Reston, VA.
[2] Thomas, D.B. & Schallenberg, M. (2008). “Benthic shear stress gradient defines three mutually exclusive modes of non-biological internal nutrient loading in shallow lakes.” Hydrobiologia 610, 1-11.
[3] Huang, L., Gao, Q.F., Fang, H.W., et al. (2021). “Effects of bedform migration on nutrient fluxes at the sediment-water interface: A theoretical analysis.” Environmental Fluid Mechanics, doi: 10.1007/s10652-021-09816-3.
[4] Huang, L., Fang, H.W., Fazeli, M., et al. (2015). “Mobility of phosphorus induced by sediment resuspension in the Three Gorges Reservoir by flume experiment.” Chemosphere 134, 374-379.
[5] Huang, L., Fang, H.W., He, G.J., et al. (2016). “Effects of internal loading on phosphorus distribution in the Taihu Lake driven by wind waves and lake currents.” Environmental Pollution 219, 760-773.
[6] Fang, H.W., Huang, L., Zhao, H.M., et al. (2020). “Mechanics of Bio-Sediment Transport.” Springer, Berlin, Germany.

Evolution and distribution characteristics of flow channels and branches in the Yellow River Estuary

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Abstract

The branching is the key to affect the stability of the flow path. The research on the branching mechanism is of great significance for the comprehensive control of the stability of the flow path. Based on the analysis of satellite remote sensing images in the Yellow River estuary area from 1984 to 2017, the evolution characteristics of the Yellow River estuary flow path, delta, sand spit and distribution of branches and gullies were summarized respectively. According to the analysis of typical bifurcation phenomenon, there are three conditions: failure of bifurcation (still go to the old channel), success of bifurcation (change to the new channel) and coexistence of multiple channels (new and old channels run together). The Yellow estuary delta shoreline is affected by the combined action of runoff power and ocean power. After the bifurcation of the current channel occurs, the change of shoreline near the new channel is dominated by silting and supplemented by erosion. It can be seen from the statistical results of the proposed data that there is basically a positive correlation between the length of the river channel and the formed land area and the accumulated sediment inflow, and the bifurcated river channel will lead to abrupt changes in the length of the river channel and the area of the sand spit. From 1984 to 1995, the Yellow River estuary sand spit was in a rapid development stage, and both the length of the river channel and the area of the sand spit showed an increasing trend. From 1996 to 2017, the amount of sediment entering the sea decreased significantly, coupled with the enhancement of Marine erosion, and the Yellow Estuary sand spit was in the stage of erosion retreat. The area of the new sand spit increased with the increase of the accumulated sand inflow, while the old southeast sand spit was in the stage of erosion retreat due to the loss of sediment inflow from runoff and the dynamic erosion of the ocean. The number of runoff ditches in the flow path decreased before the diversion of the branch in 1996. The tidal current gully on the north side of sand spit changes frequently, while the tidal current gully on the south side changes little. After 1996, there were few runoff ditches in the flow path. The tidal gullies in the north, northeast and south of sand spit were stable, while the number of tidal gullies in the southeast changed frequently.

Keywords: Flow channel evolution; Yellow River Estuary; Sediment inflow; Sand spit

Acknowledgment

It was supported by the National Key Research and Development Program of China (grant No.2022YFC3204303) and the National natural science foundation of China(grant No. 51879282).

Assessing the Effects of Flash Floods on Wadi Geomorphological Changes Induced by Sediment Transport in Oman

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Abstract

Monitoring and assessing sediment transport in a dry environment is essential to understanding the interaction between the hydrology of the ephemeral stream (Wadi) and the geomorphology of the channel bed and its impacts in the dry dam reservoir. The dry channel bed exposed directly to high shear stress occurs during sharp and rapid hydrographs of a flash flood, thereby high sediment transport and supply (Hooke, 2019). The fluvial processes play a significant role in the deformation of the channel beds associated with per flood events.

In general, dams are constructed in the wadi system for multiple functions, for instance, flood control and groundwater recharge. The dry dam reservoirs suffering from several problems as result of sedimentation, such as storage capacity losses, reservoir bed clogging, and downstream channel degradation. Approximately 1% of dam capacity is lost per flood event in the Wadi Assarin (Al-Mamari et al., 2022). While the annual soil loss in Japanese reservoir range from 1.0 to 0.1 % (Sumi & Kantoush, 2018). In the arid region, Wadi flash floods are common, but their occurrence and processes are not scientifically understood. However, quantifying sediment yield is challenging, and our scientific understanding of sediment yields in arid environments remains incomplete due to the lack of observed data and in-depth research. Therefore, this research aims to analyze and understand the impacts of flash flood magnitudes in the sediment dynamics by calculating values of difference of multi cross-section surveys for different flash floods.

The Wadi Samail catchment is the second largest catchment in Oman, with a drainage area of 1670 Km^2 and two main types of channel bed materials: gravel and sand. The catchment is set entirely within a high drainage network and topographic altitudes. In the last decade, the flash floods frequency with extreme events were increased in the Wadi Samail as shown in figure.1.

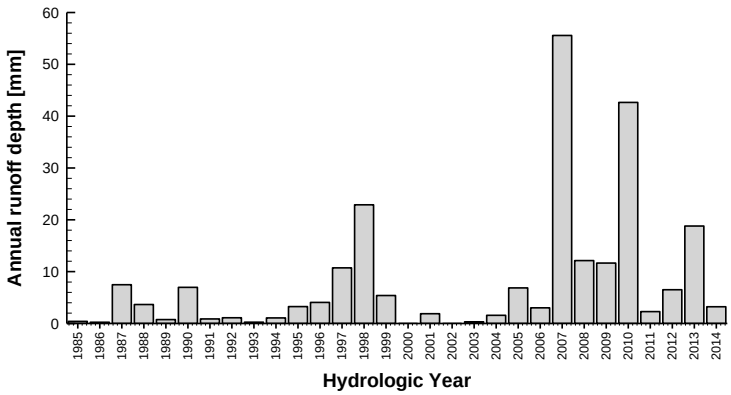

Figure.1 Annual runoff depth in the Wadi Samail catchment at the downstream gauging station

Eleven cross-section campaign were established from 1997 to 2010 with three topography section for each period. Additionally, multiple floodmarks were collected through the reach using leveling instrument. All floodmarks collected from the both side of wadi reach and crest-stage indicators (CSI) that installed near monitoring point to compute the peak discharge using the slope-area method

(Dalrymple & Benson, 1967). The flow velocity calculated based on the Manning equation, the slope between three cross-sections, the lowest elevation points in each cross-section, and n values of 0.038. There are possible ranges of uncertainty of collecting elevation values between cross-sections and floodmarks, these uncertainties are associated with the accuracy of the leveling instrument. The floodmarks heights and water gradients have checked by fixed CSI and water level transducer. The average width of the cross-sections is about 115 m. The fluvial process was detected by the changes in the channel bed elevation. The average velocities of these flash flood events ranged from 1.3 to 3.68 m/s.

The total average erosion and deposition of channel bed level change values equal 2.3 and 2.5 m, respectively, through all cross-sections with an average discharge 446 m^3/s were calculated. The average flow velocity estimated by using Manning equation is about 2.1 m/s, which is relatively high for dry channel bed that cause high sediment transport. The erosion and deposition processes for the discharge above 100 m^3/s have a similar pattern of channel bed level changes.

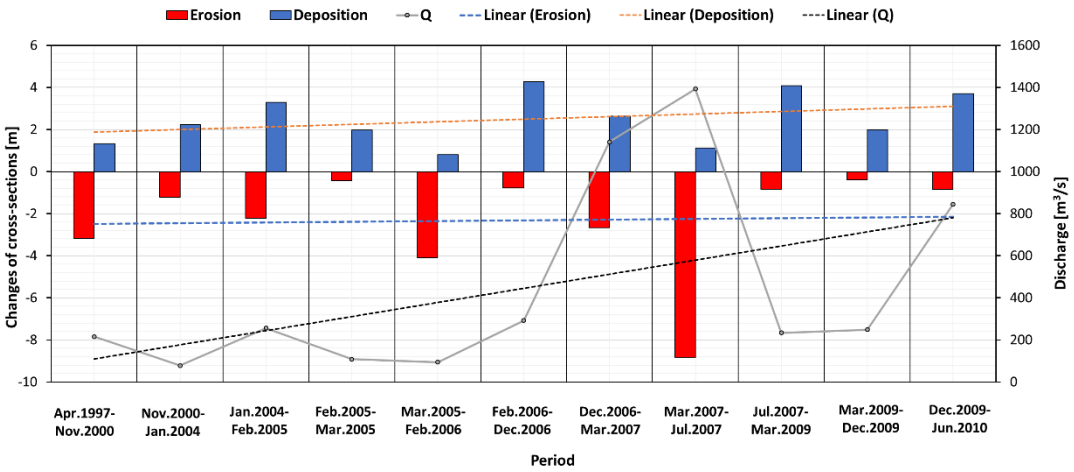

Figure.2 Dry channel bed level changes for multi cross-sections surveys from 1997 to 2010 catchments at the downstream of the Wadi Samail catchment.

Keywords: sediment transport; wadi; channel bed; arid region

References

[1] Al-Mamari, M. M., Kantoush, S. A., Al-Harrasi, T. M., Al-Maktoumi, A., Abdrabo, K. I., Saber, M., & Sumi, T. (2022). Assessment of sediment yield and deposition in a dry reservoir using field observations, RUSLE and remote sensing: Wadi Assarin, Oman. Journal of Hydrology, 128982.
[2] Dalrymple, T., & Benson, M. A. (1967). Measurement of peak discharge by the slope-area method. US Government Printing Office.
[3] Hooke, J. (2019). Extreme sediment fluxes in a dryland flash flood. Sci Rep 9: 1686.
[4] Sumi, T., & Kantoush, S. A. (2018). Innovative strategies for managing reservoir sedimentation in Japan.

Hydraulic Model Tests on Accumulation and Removing of Driftwood in Continuous Channel

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Abstract

In recent years, the number of harms including inundation and damage to houses caused by driftwood has been increasing due to the increased heavy rainfall related to climate change. In order to reduce these damages, countermeasures against driftwood have become an urgent issue. In this study, hydraulic experiments with 1/70 scale model on the movable bed was conducted as a target for the middle reaches of the Totsutabetsu River, a secondary branch of the Tokachi River, in order to understand the behavior of driftwoods and the response of river channel during flood. In Totsutabetu River, a large amount of driftwood was deposited in the river channel during the largest flood in history, which occurred in August 2016.

In order to simply observe the behavior of driftwood in the model, we supposed terrain model without erosion control weirs. The following three runs were conducted. Run 1 was conducted to create a river channel shape at the time of flooding from a flat initial riverbed, Run 2 was conducted to understand the driftwood transport and deposition during flood, and Run 3 was conducted to understand the removing of the deposited driftwood during flood. Table 1 shows the discharge and duration of flow for each run. The discharge for Runs 1 and 2 assume the historical maximum discharge of the Totsutabetsu River, while Run 3 assumes flow rate with 20 years return period. In Run 2, woods were fed from the upstream end of the channel and from along the side banks. Details of the driftwood models used in the experiment are shown in Table 2. Note that two lengths were prepared because it was assumed that some driftwood would break in half. In addition, for simplicity, all driftwood shapes were assumed to be logs in this study. Furthermore, some of the driftwood deposited at the site after the 2016 flood had a specific gravity of more than 1 (“Dw1”) and some less than 1 (“Dw2”). The ratio was 9:1, and this ratio was also used in the experiment. Mixed sand with the grain size distribution shown in Fig.1 was used as the riverbed materials. Sand fed from the upstream end of the channel was the same as the riverbed material at the equilibrium sediment discharge.

The bed configuration after Run1 has 2 portions which differs in the feature of river channel change. And these portions exist alternately in longitudinal direction. One is a portion called “Node” not changing to a transverse direction. Another is a portion called “Anti-node” at where channel changes to transverse direction sharply. The channel alternation changes occur at the “Node” and it forms “Anti-node”. Figure 2 shows the number of “Dw1” deposited within a certain area (/2500m²). “Dw1” was deposited at the upstream end of the bar formed at “Anti-node”, and then was transported to downstream with subsequent flood and redeposited on the side bank and the back of the terrace where the flow velocity becomes slow. As for “Dw2”, most of the driftwood flowed out to the downstream end of the channel, regardless of the supply location. Then, we summarize the response of the river channel. In Run 1, alternation mainstream changes in bifurcated channels occurred at the “Node” of the river channel. But in Run 2, when driftwood was supplied, “Dw1” accumulated at the upstream end of the sandbar induced channel stabilization and made it harder to happen alternation mainstream changes. In Run 3, when the driftwood was stopped supplying, channel perturbation was

more likely to occur due to the removing of the driftwood. As a result, the alternation mainstream changes in bifurcated channels were confirmed again.

Table 1. Flow rate and Water supply time (Prototype)

	Flow Rate	Water Supply Time
Run 1	650m³/s	32h
Run 2	650m³/s	16h
Run 3	500m³/s	24h

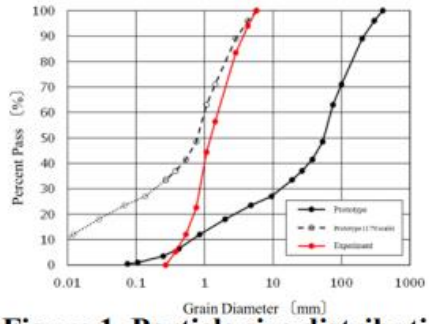

Figure 1. Particle size distribution

Table 2. Driftwood model details

	Specific Gravity	Prototype	Shape	Volume Ratio	Supply Period
"Dw1"	1.20	Length : 16m, 8m Diameter : 0.3m	Cylindrical	9	Run2
"Dw2"	0.98	Length : 16m, 8m Diameter : 0.3m	Cylindrical	1	Run2

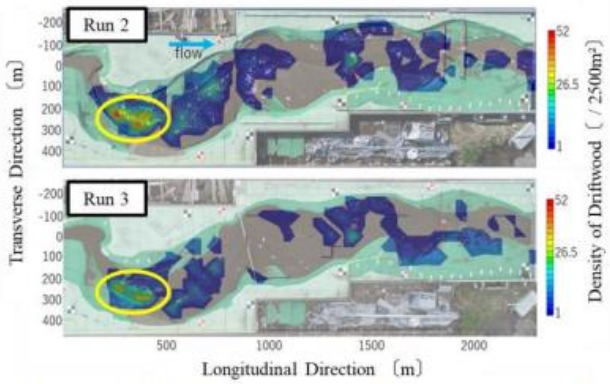

Figure 2-1. Comparison of the number of "Dw1" (long type) supplied from the upstream end

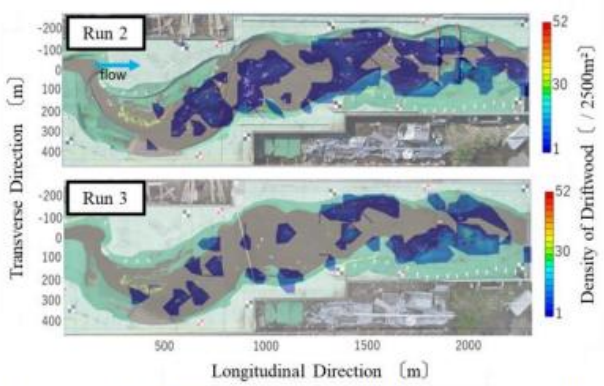

Figure 2-2. Comparison of the number of "Dw1" (long type) supplied from the side bank

Keywords: Driftwood; Flow; Deposition; Removing

References

[1] T. Kudo, N. Nagano, A. Matsuoka et al. (2021)."Estimation of the behavior of coarse woody debris in an intense storm in August 2016 and its budget for the Tottabetsu River Catchment, Eastern Hokkaido",Japan Society of Erosion Cntrol Engineering, Vol. 73, No. 6, p.3-11

[2] S. Ohtaka, Y. Watanabe, T. Itoh, H. Watabe, T. Kudo (2021)."Experimental study on behavior and accumulations of driftwoods during a large flood at the Tottabetsu River", PROCEEDINGS OF ANNUAL CONFERENCE OF THE JAPAN SOCIETY OF CIVIL ENGINEERS, Vol. 76, p. II -16

Microplastic retention by lagoons surrounded by vegetation in wetland areas

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Abstract

Plastic production has increased exponentially over the last 70 years [1], resulting in the accumulation of plastics and microplastics (MP hereafter) in environmental ecosystems: atmosphere [2], water [3], and sediments [4]. Wetlands are shallow water systems that can be covered by vegetation and also present interspersed lagoons. Flooding from rivers or from the sea transports MP into wetlands. The role of a lagoon surrounded by emergent aquatic vegetation (*Juncus maritimus*) with varying patch lengths (L_{patch}) in the retention of MP is compared with a lagoon without surrounding vegetation in a laboratory set up flume. A particle laden plume with MP and sediment transported by a unidirectional flow was considered, given that MP particles are expected to be suspended in natural environments alongside sediment particles. Four different L_{patch} scenarios were considered and compared to the non-vegetation and no-lagoon scenarios. 22 sediment traps were placed on the flume's bed at various locations along the x-axis. Four different MP were considered (PET-fibres of 6 µm and 3 µm of length and 45 µm of diameter, and PA-fragments ranging from 125 µm to 500 µm, and from 500 µm to 1000 µm), resulting in 22 experiments. The presence of aquatic emergent vegetation surrounding the lagoon enhanced the MP sedimentation, sheltering the lagoon from the MP contamination.

Keywords: aquatic vegetation, lagoon, wetlands, microplastics, sediment transport

Methodology

Experiments were carried out in a laboratory flume of 500 cm x 40 cm x 50 cm. Two platforms measuring 129 cm long at the base, 100 cm long at the top and 10 cm height, were placed in the flume and separated 20 cm at the base to create a deep zone or lagoon surrounded by two shallow zones. The height of the water column in the shallow zones was h_w=10 cm. The shallow zones presented a distribution of vegetation of 2.5% of solid plant fraction. Different patch sizes of vegetation of in the shallow zone were considered (L_{patch}=10 h_w, 7.5 h_w, 5 h_w, 2.5 h_w and 0 h_w). 22 sediment traps were distributed along the base of the flume. Sediment particles and MP were injected at the entrance of the flume. Two types of MP were considered (PET-fibers and PA-fragments, both types with different lengths). The injection lasted approximately the same time that it took for the plume to reach the end of the second platform, and at that point a gate was deployed and the flow switched off to retain all the plume of MP and sediment in the study zone (shallow zone and lagoon). Ten minutes were afterwards leaved for particles to settle and after this a lid was situated on each sediment trap. Traps were analyzed with a particle size analyzer and the concentration of each particle type was determined except for the case of PET- fibers and large PA-fragments. In these cases, particles were counted by a microscope.

Results

The concentration of MP particles decreased with the distance from the source following an exponential trend with distance. The rate of decrease of MP depended on the plastic type and shape and also on the length of the vegetated patch in the shallow zone (L_{patch}). The longer the length of the patch the faster the sedimentation rate. The largest PA-fragments were retained in the shallow zone. However, small PA-fragments reached the lagoon. Fibers were transported in suspension along the flume. For L_{patch} greater than 5 hw, the lagoon was protected and received the lower amount of MP, with concentrations close to those obtained for the full (L_{patch}=10 h_w) and for the L_{patch}=7.5 h_w. However, small PA-fragments reached the lagoon for the cases when the length of the vegetated patch was small (L_{patch}<5 h_w). However, for the cases when L_{patch}>5 h_w the lagoon remained protected again.

Conclusions

MP particles distribute along the wetland with greater concentrations close to the source. In front of a flooding event with a mixture of MP and sediments, the current study demonstrates that lagoons without surrounding vegetation are expected to remain unprotected and MP reach the lagoon. In contrast, lagoons with surrounding vegetation will remain protected and MP particles will reach the lagoon depending on the length of the vegetated patch surrounding the lagoon. For the lengths of the vegetation patches where L_{patch}>5 h_w the same capacity to protect the lagoon was obtained. However, for L_{patch}<5 h_w, the smaller L_{patch} the lower the capacity of the vegetated patch to protect the lagoon.

Acknowledgements

This work was supported by the “Ministerio de Economía y Competitividad” of the Spanish Government through the grant PID2021-123860OB-I00.

References

[1] Ostle, C., Thmpson, R.C., Broughton, D., Gregory, L., Wootton, M. & Johns, D.G. (2019). “The rise in ocean plastics evidenced from a 60-year time series”. Nature Communications, 10, 1622.
[2] Abidli, S., Antunes, J.G., Ferreira, J.L., Lahbib, Y., Sobral, P. & El Menif, N.T. (2018) Microplastics in sediments from the littoral zone of the north Tunisian coast (Mediterranean sea). Estuarine, Coastal and Shelf Science, 205, 1-9.
[3] Zhang, H. (2017) Transport of microplastics in coastal seas. Estuarine, Coastal and Shelf Science, 199, 74-86.
[4] Habibi, N., Uddin, S., Fowler, S.W. & Behbehani, M. (2022) Microplastics in the atmosphere: a review. Journal of Environmental Exposure Assessment, 1, 6.

Gravity currents as a pathway to segregate transport of microplastics

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Abstract

Environmental pollution caused by anthropogenic activity is nowadays occurring at an unprecedent rate [1]. The monitoring of the release of plastics and microplastics (MP) (< 5 mm) in fresh-water and marine environments has proven that plastic contamination is a major issue, still to be fully investigated. Analysis of sediment beds have proven to be contaminated by MP [2], increasing their degradation time and therefore increasing their life in the ecosystem. The environmental pollution from plastics is increasing constantly, due to the increase of plastic production from 250 million tons in 2009, to 368 million tons in 2019 and to 390.7 million tons in 2021 [3]. Among the worldwide production, between 2% and 5 % of MP may ultimately end up in the ocean [4]. Therefore, plastic pollution has resulted [5] one of the most serious anthropogenic emerging pollutants affecting aquatic ecosystems. Plastics and MP are incorporated to the sediment beds by particle laden gravity currents, known as turbidity currents [6]. Turbidity currents potentially distribute and bury large quantities of microplastics in seafloor sediments. This study adds knowledge on how turbididy currents drive the transport of MP and distribute them producing a spatial segregation of MP.

Content

The experiments were carried out in a methacrylate flume (4.0 m long, 0.3 m high and 0.3 m wide) filled with water to a height H=12 cm and with a removable vertical lock gate that separated the flume into two sections (125.5 and 315.9 m respectively). The shorter section was filled with a mixture of sediment, MP and water that would form the turbidity current, while the longer section was filled with fresh water only. A volume of 3 L of water from the shorter section was collected in a container and the mixture of sediments and plastics was introduced into it. The sediment-MP-water mixture was then stirred vigorously for five minutes to ensure a homogeneous sediment suspension and then returned to the left-hand section of the flume and mixed with the remainder of the water therein to give an initial sediment concentration for each run, C_0. Five values of C_0 = 1.0, 2.0, 3.0, 4.0 and 5.0 g L^{-1} – in which MP fragments and fibres were added. The sediment used in the experiments was composed by 80% silica and 20% of heavy metals (ρ = 2.65 g/cm^3). Three MP types were used: melamine fragments (ρ =1.57 g/cm^3), PVC fragments (ρ = 1.37 g/cm^3) and PET fibres (ρ = 1.38 g/cm^3). The sediment had a median grain-size of d50 = 31 µm. The melamine fragments had a median size of 340 µm, the PVC fragments a median size of 750 µm and the PET fibres had a length of 2 mm and an equivalent diameter of 91 µm. Prior to each of the experimental runs, the 3 L sediment-water mixture was introduced into the short section of the flume and was well mixed with the rest of the water therein. Following that, the lock gate was lifted to develop the turbidity current into the longer flume section. Thirteen sediment traps, were located along the flume bed at intervals of 20 cm. For each sediment concentration, two experimental runs were carried out, one with the mixture of sediment and melamine, and the other with sediment and PVC fragments and PET fibres. In the first case sediment and melamine collected in each trap, were analysed with a particle sizer (Lisst-100x) to obtain the particle distribution and concentration. In the second case, sediment with melamine and fibres deposited at each sediment trap was placed on a glass Petri disc, immediately covered, and dried for further analysis by optical microscopy. To analyse the hydrodynamics, the speed of the

current front was determined from images taken by four CCD cameras, mounted on stationary tripods over the tank (with a precision of 0.1 cm in edge detection).

The front of the turbidity current with distance evolved through different hydrodynamical regimes (Inertial Regime and Self-Similar Regime). For C_0 = 1, 2, 3 and 4 g L^{-1}, the turbidity current developed first in the Inertial Regime, with constant speed along the flume, with the front position, x, depending on g´and H according to $x \sim (g'H/4)^{1/2}$ t, where g' is the reduced gravity.

At a second stage, the loss of sediment caused by deposition drove the propagation of the turbidity current to the Self-Similar Regime, where the time front propagation was dependent on x~t2/3. For the experimental run with the greatest concentration, C_0=5 g L^{-1} only the Inertial Regime was found. Denser gravity currents transported and deposited MP at further distances. For the greater sediment concentration of 5 g L^{-1}, the distances at which MP deposited were greater (1.5 times for melamine fragments and 1.25 times for PVC fragments) than those for sediment concentration of 1 g L^{-1}. As such, MP presenting lower settling velocities were transported and deposited at higher distances, producing a segregation of MP.

Keywords: Microplastics segregation, turbidity current, flume experiments

Acknowledgements

The authors would like to express appreciation for the support of the 'Ministerio de Economía y Competitividad' of the Spanish Government [PID2021-123860OB-100].

References

[1] MacLeod, M., Arp, H.P.H., Tekman, M.B., Jahnke, A., 2021. The global threat from plastic pollution. Science 373, 61–65.
[2] Hengstmann, E., Weil, E., Wallbott, P.C., Tamminga, M., Fischer, E.K. 2021. Microplastics in lakeshore and lakebed sediments-External influences and temporal and spatial variabilities of concentrations. Environmental Pollution, 197, 111141.
[3] PlasticsEurope, 2022. Plastics- the Facts 2022. An analysis of European plastics production, demand and waste data.
[4] Townsend, K.R., Lu, H., Sharley, D.J., Pettigrove, V. 2019. Associations between microplastic pollution and land use in urban wetlands sediments. Environmental Science and Pollution Research, 26, 22551–22561.
[5] Carpenter, E.J., Anderson, S.J., Harvey, G.R., Miklas, H.P., Peck, B.B. 1972. Polystyrene spherules in coastal waters. Science, 178, 749-750.
[6] Pohl, F., Eggenhuisen, J.T., Kane, I.A., Clare, M.A. 2020. Transport and burial of microplastics in deep-marine sediments by turbidity currents. Environmental Science and Technology, 54, 4180-4189.

A Multiphase Flow Modeling of Gravity Currents on Slope

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Abstract

The gravity current is a primarily horizontal flow of one fluid within another ambient fluid that is driven by density difference. Gravity currents propagating down a slope have been commonly encountered in geophysical environments and engineering applications, such as turbid water flowing in the river and into the reservoir (Sparks et al., 1993; Bonnecaze et al., 1996). Experimental works have shown that the dense fluid, released on a slope, moves down first through an acceleration phase followed by a deceleration phase and the head of gravity current experiences a significant upheaval and enrolment by ambient fluid in the late deceleration phase (Dai, 2013). There is a self-similar behavior of the gravity current profile with a nearly linear decrease of the head height from the start of the slope to the bulk of the distance to the nose as it decelerates on relatively steep slopes (Marleau et al., 2017).

We numerically investigate the gravity currents generated by an instantaneous release of a finite volume of dense fluid, i.e. lock-exchange flow, on slopes using a multi-fluid simulation approach for modeling the mixing of dense and ambient fluids and the interaction with the free surface. The present multi-fluid approach solves three phases, i.e. dense fluid, less dense ambient water, and air phases, with separated flow equations for each phase. The turbulent flow is simulated by a hybrid RANS/LES approach. The three-dimensional gravity currents are simulated using OpenFOAM open-source software, which has been successfully applied to the gravity currents of fixed volume on the flat rectangular channel (Kim & Paik, 2019).

In this work, we consider the gravity current reproduced by Dai (2013) on a slope of $\theta = 2°$ and 9° and with the densities of the heavy and light ambient fluids of 1,015 kg/m^3 and 997.5 kg/m^3, respectively. The Reynolds number of the flow is approximately 8,500. The computational mesh of the flow domain is generated using about 18 million cells. The momentum equations of the flow are solved by the central differencing schemes and the advection terms of multi-fluid transport equations are solved by the van Leer TVD scheme.

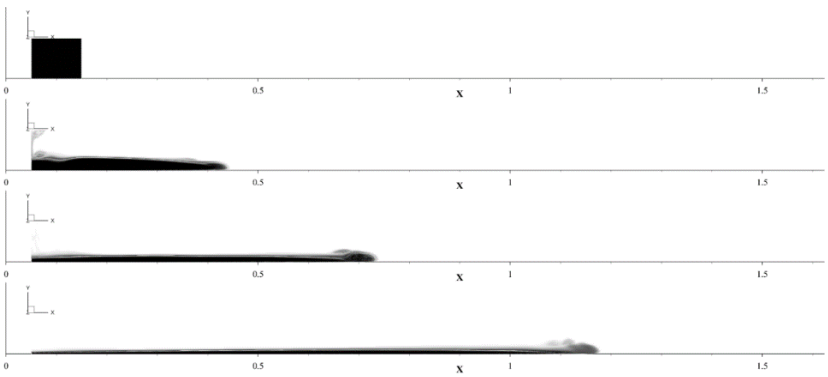

Figure 1. Computed gravity current with a buoyancy source with a reduced gravity of approximately 0.172 m/s^3 propagating over the slope of 2°.

Our preliminary numerical results show that the present numerical simulations successfully reproduced the flow behavior of gravity currents on steep slopes and the computed speeds of gravity current heads are in good agreement with previous experimental measurements in most of

computational time. Details of the dynamic behaviors of gravity currents and the resulting vortical structures that dramatically increase the mixing of the dense and ambient fluids will be presented in the conference.

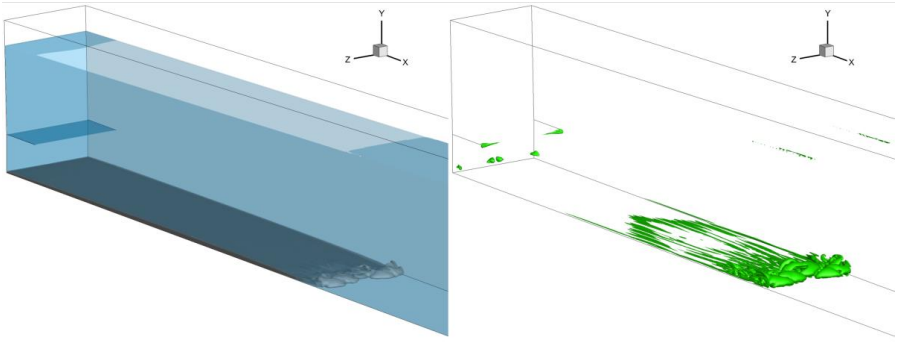

Figure 2. Computed gravity current visualized by iso-surfaces of three different density and coherent structures visualized by iso-surface of q-criterion.

Keywords: Gravity current; Density difference; Slope; Numerical simulation, Turbulence

Acknowledgment

This work was supported by Basic Science Research Program through the National Research Foundation of Korea (NRF) funded by the Ministry of Education (2021R1A6A1A03044326) and partially supported by Inst. Disaster Prevention of Gangneung-Wonju Natl. Univ.

References

[1] Bonnecaze, R. T., Huppert, H. E., Lister, J. R. (1996). "Patterns of sedimentation from polydispersed turbidity currents". Proc. R. Soc. Lond. A, 452. 2247-2261. https://doi.org/10.1098/rspa.1996.0120
[2] Dai, A. (2013). "Experiments on gravity currents propagating on different bottom slopes". J. Fluid Mechanics, 731, 117–141. doi:10.1017/jfm.2013.372.
[3] Sparks, R. S., Bonnecaze, R. T., Huppert, H. E., Lister, J. R., Hallworth, M. A., Mader, H., Phillips, J. (1993). "Sediment-laden gravity currents with reversing buoyancy." Earth Planet. Sci. Lett. 114(2-3), 243-257. https://doi.org/10.1016/0012-821X(93)90028-8
[4] Kim, B., Paik, J. (2019). "A multiphase flow modeling of gravity currents in a rectangular channel". J. Korea Water Resource Association. 52(10), 697–706. doi: 10.3741/JKWRA.2019.52.10.697.
[5] Marleau, L. J., Flynn, M. R., Sutherland, B. R. (2014). "Gravity currents propagating up a slope". Physics of Fluids, 26, 046605. https://doi.org/10.1063/1.4872222
[6] Negretti, M. E., Flòr, J.-B., Hopfinger, E. J. (2017). "Development of gravity currents on rapidly changing slopes". J. Fluid Mechanics, 833, 70-97. https://doi.org/10.1017/jfm.2017.696

Suspended sediments open the way to microplastic sedimentation in shallow aquatic systems

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Abstract

Plastic particles represent an emerging contaminant in aquatic ecosystems, causing a global environmental crisis. Seas and oceans represent the final receptors for the macro- and microplastics (MPs) entering in the freshwater environment. Many studies have focused on the quantification of plastic debris in the marine environment [1] and on their residence time in rivers [2]. The end of water courses can also be a buffer for MPs.

Shallow water environments (e.g., floodplains and wetlands) represent areas where MP can accumulate [3]. They are totally or partially enclosed areas with low energy zones and stagnant water, with low flow velocities and low channel slopes enhancing MP accumulation. Currents, flooding events and turbulence produced by wind promotes the presence of suspended sediments [4] that are expected to be transported alongside with MP particles. However, to date, the knowledge of the transport of MP in such transitional environments is limited, and the retention mechanism of MP and the time scales of MP processes remain unknown as well as the interaction with suspended sediment particles. In addition, the contribution of floodplains, wetlands, lagoons, intertidal zones, saltmarshes, and generally shallow water areas, is rarely taken into account within the MPs mass balance models.

In this work we investigated the transport of a particle laden (MP and sediment) plume in a simulated shallow water system under a unidirectional flow. Three of the most common MP will be considered under study, PA fragments, PVC fragments and PET fibers. The interaction between sediment particles and MP will be studied through flume experiments with different sediment and MP concentrations in order to obtain the sedimentation rates of the different MP considered along the system.

Keywords: Microplastics, Sediment interaction, Shallow aquatic system, Scavenging, Sedimentation rate

Methodology

Experiments were carried out in a laboratory flume of 500 cm x 40 cm x 50 cm. One platform measuring 258 cm long at the base, 238 cm long at the top and 10 cm height, was constructed and placed in the flume to simulate a shallow zone resulting in a water height (H) of 9 cm. 22 sediment traps were distributed along the base of the platform. Sediment particles and MP were injected at the entrance of the flume at the same time. Three types of MP were considered (PVC-fragments, PA-fragments, and PET-fibers). For each type of MP four experiments were carried out varying the sediment concentration in the mixing chamber (C_{sed} = 0g/l, 15g/l, 30g/l and 45g/l). Once the plume (MP and sediments) was at the end of the shallow water zone a gate was closed and ten minutes were afterwards leaved for particles to settle. Traps were analyzed with a particle size analyzer and the concentration of each particle type was determined except for the case of PET fibers that were counted

by a microscope. A geometrical characterization of the particles was made and the settling velocity of the particles was also calculated.

Results

The normalized concentration of MP (C/CMAX) decreased along the flume with exponential decay rates in all the experiments conducted, independently on whether experiments were carried out with or without sediment. For the experiments carried out without sediment, the decay rates of MP depended on the type of MP considered, with the greatest rate of decrease for PVC fragments, whereas PA-fragments presented the lowest rate of decrease. In the experiments carried out with sediment, the rate of decay of MP also depended on the presence of suspended sediment. For all the MP investigated their rate of decay along the x axis increased with C_{sed}. However, the rate of decay of MP for the different C_{sed} depended on the type of MP. PA fragments presented a gradual increase in the rate of decay as C_{sed} increased whereas the rate of decay of PVC fragments presented a slight change with C_{sed}. However, fibers presented a behavior with C_{sed} between than observed for PVC- and PET-fragments.

Conclusions

In the current study, the longitudinal transport of MP particles from a particle laden plume was found to depend on the type of MP. But not only this, fast settling sediment particles scavenged MP particles increasing their settling rates. Therefore, the current study demonstrates that there is a heterogeneous distribution of MP with distance and that MP segregate as they are transported. This indicates that fast sinking MP will not be transported far from their source, accumulating in the wetland sediment bed. In contrast, slow settling MP can travel further but their extension will depend on the concentration of suspended sediment in the particle laden plume. Thus, their extension will decrease as the sediment concentration increases.

The findings during this work suggest the importance of taking suspended sediment concentration into account as an additional fundamental parameter in the development of new MP transport models in low-energy aquatic environments, due to its capacity of significantly modifying the mass balance of plastic particles discharged into aquatic ecosystems

Acknowledgements

This work was supported by the “Ministerio de Economía y Competitividad” of the Spanish Government through the grant PID2021-123860OB-I00 and developed in collaboration with the International Doctoral Program of the University of Florence founded by Regione Toscana Pegaso Scolarship.

References

[1] Hidalgo-Ruz, V., Gutow, L., Thompson, R. C., & Thiel, M. (2012). Microplastics in the marine environment: A review of the methods used for identification and quantification. Environmental Science and Technology. https://doi.org/10.1021/es2031505

[2] van Emmerik, T., Strady, E., Kieu-Le, T. C., Nguyen, L., & Gratiot, N. (2019). Seasonality of riverine macroplastic transport. Scientific Reports, 9(1), 1–9. https://doi.org/10.1038/s41598-019-50096-1

[3] Pinheiro, L. M., Britz, L. M. K., Agostini, V. O., Pérez-Parada, A., García-Rodríguez, F., Galloway, T. S., & Pinho, G. L. L. (2022). Salt marshes as the final watershed fate for meso- and

microplastic contamination: A case study from Southern Brazil. Science of the Total Environment, 838. https://doi.org/10.1016/j.scitotenv.2022.156077
[4] Smoak, J. M., Breithaupt, J. L., Smith, T. J., & Sanders, C. J. (2013). Sediment accretion and organic carbon burial relative to sea-level rise and storm events in two mangrove forests in Everglades National Park. Catena, 104, 58–66. https://doi.org/10.1016/j.catena.2012.10.009
[3] Zhang, H. (2017) Transport of microplastics in coastal seas. Estuarine, Coastal and Shelf Science, 199, 74-86.
[4] Habibi, N., Uddin, S., Fowler, S.W. & Behbehani, M. (2022) Microplastics in the atmosphere: a review. Journal of Environmental Exposure Assessment, 1, 6.

Using principles of fluvial sedimentology to investigate microplastic distribution in fluvial deposits: insights from the Arno River (Italy)

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Abstract

Rivers are known to efficiently transport large amounts of macro- and microplastics into the oceans since they drain urban and industrial areas (Wagner et al., 2019; Morritt et al. 2014; Gasperi et al., 2014), which are the main sources of plastic pollution. Although rivers transport microplastics to the sea, microplastic particles can be trapped in sediments where biological and physical processes can cause further fragmentation (Sekudewicz et al., 2021).

Mechanisms controlling the transport and deposition of microplastics in river sediments have rarely been studied according to fluvial sedimentology principles, which consider processes of sediment distribution in different parts of a river channel during a flood event.

Aiming to shed light on processes that control microplastic sedimentation in river channels, we analyse here deposits of the Arno River (central Italy). Sampling was conducted after two major floods, which occurred in December 2019 and February 2021, respectively, and focused on deposits accumulated in different parts of alternate bars. These bars regularly occur at opposite sides of the river channel and are submerged when the river rises ca. 3.5 m. Alternate bars are ca. 300-450 m long and consist of gravels and subordinate sands. Gravels occur in the bar head zone, impacted during stronger flood flows, whereas sand occurs in the bar tail, which is shaded from the major flows.

We have considered microplastics associated with floating plant debris as well as those entrapped in clastic suspended and bedload deposits. The total concentration of microplastic ranges between 0.44 and 5.68 items per gram, and fibres are ubiquitous. Results show that microplastics can be easily trapped by floating plant debris and stored on the bar top and along river banks (Figure 1). Sand incorporates a similar amount of microplastics both when it is transported as bedload, and during the waning flood, when settling processes dominate. Gravel deposits are extremely efficient in incorporating microplastics during waning flood stages when water infiltrates between clasts dropping its suspended load. Application of principles of fluvial sedimentology to schedule sampling and investigate deposits can provide crucial insights to explain mechanisms controlling the transport and storage of microplastics in river sediments.

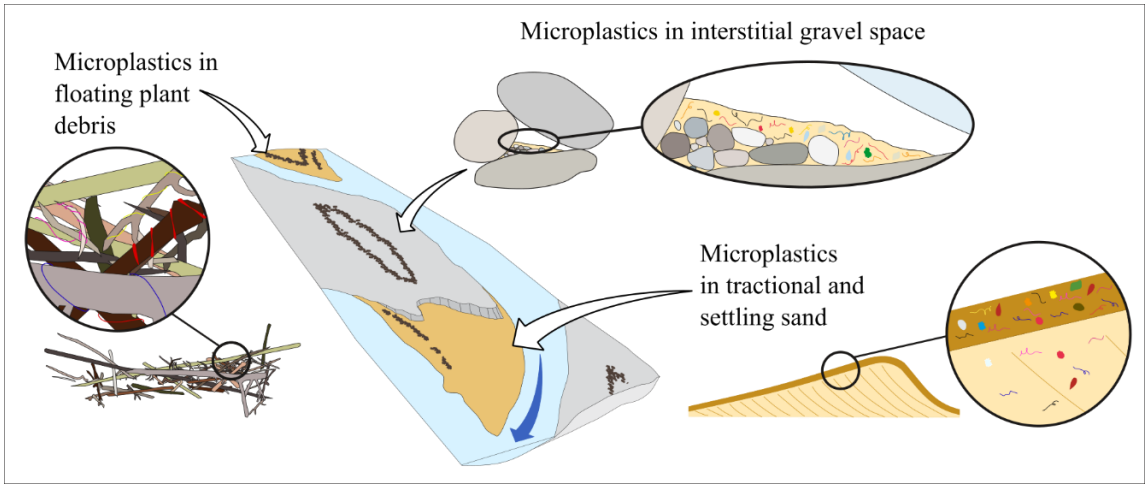

Figure 1. Graphical representation of microplastics deposition within fluvial deposits. Microplastic particles were found in association with floating plant debris, gravels and tractional and settling sand.

Keywords: Microplastics; River flood; Fluvial sedimentology; Fluvial gravel; Waning flood stage

References

[1] Gasperi, J., Dris, R., Bonin, T, Rocher, V., Tassin, B. (2014).“ Assessment of floating plastic debris in surface water along the Seine”. Environmental Pollution. 195, 163–166.
[2] Morritt, D., Stefanoudis, P.V., Pearce, D., Crimmen, O.A., Clark, P.F. “Plastic in the Thames: A river runs through it”. Marine Polluition Bulletin. 78, 196–200
[3] Sekudewicz, I., Dąbrowska, A.M., Syczewski, M.D. (2021). “Microplastic pollution in surface water and sediments in the urban section of the Vistula River (Poland)”. Sci. Total Environ. 762
[4] Wagner, S., Klöckner, P., Stier, B., Römer, M., Seiwert, B., Reemtsma, T., Schmidt, C. (2019). “Relationship between discharge and river plastic concentrations in a rural and an urban catchment”. Environ. Sci. Technol. 53, 10082–10091

Effect of Freeze-Thaw Action on Bedload Sediment Transport Rate of Rivers in Cold Regions

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Abstract

There is about 50% of permafrost and seasonal permafrost in the northern Hemisphere(Hayashi & Masaki, 2013), and many rivers originate from or flow through these cold regions. These rivers undergo a seasonal change of winter and spring, which is equivalent to a freeze-thaw phenomenon. The freeze-thawing effect destroys the structure and properties of soil, which makes the soil easy to become the material source of many kinds of erosion forms(Bullock, Nelson, & Kemper, 1988; Liu, Yang, Zhang, & Sun, 2017). However, there are relatively few studies on river evolution in cold regions, and the influence of freeze-thaw on river sediment transport is still unclear.

In this work, we designed a flume with a movable bottom and adopted a constant temperature and humidity test chamber to simulate the freezing and melting process of the river bed in the cold region. Laboratory flume test was carried out in which uniform sand and non-uniform sand were used as bed material respectively to simulate the initiation and transport process of bed material under different flow and bed material gradation conditions after freeze-thaw action. The variation of bedload erosion was analyzed, and the influence mechanism of freeze-thaw action on bedload transport was preliminarily discussed.

The experimental results showed that for uniform sand, the transport rate of bedload was higher after freeze-thaw than that under non-freeze-thaw condition. Under the condition of low flow shear rate, the effect of freeze-thaw on the sediment transport rate of bedload is more obvious. The ratio of freeze-thaw transport rate to non-freeze-thaw transport rate decreases with the increase of flow shear rate. For non-uniform sand, it showed that its total sediment transport rate was similar to that of uniform sand. The freeze-thaw transport rate and non-freeze-thaw transport rate both increased with the increase of flow shear rate, and the ratio of them gradually decreased. For sediment of each group of particle size, the smaller the particle size, the greater the influence of freeze-thaw on the transport rate of bedload. The larger the particle size of the grouped sediment, the less the influence of freeze-thaw on the sediment transport rate of bedload.

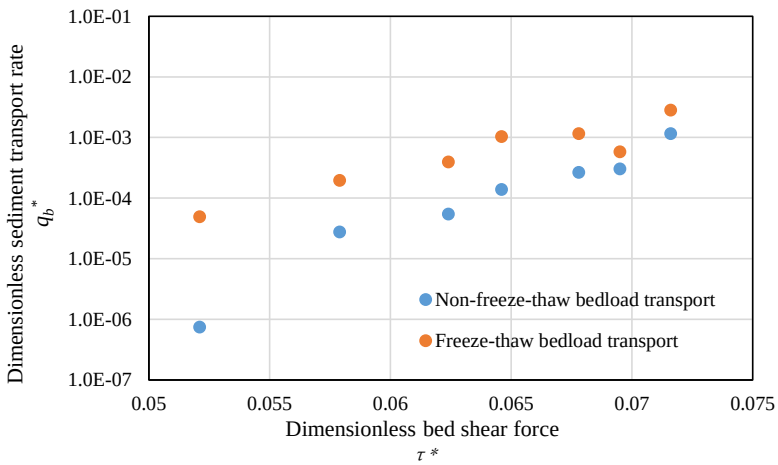

Figure.1 Variation of non-freezing-thawing and freezing-thawing bedload transport rate for uniform sand and dimensionless shear force

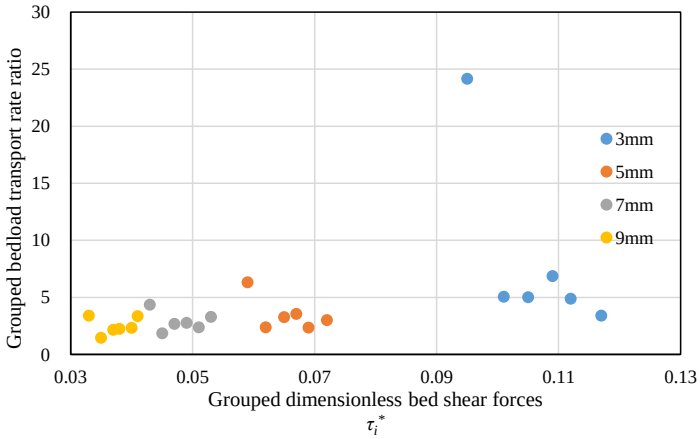

Figure.2 Relationship between the ratio of freeze-thaw and non-freeze-thaw transport rates and dimensionless shear forces of grouped particle size for non-uniform sand

Keywords: Freeze-thaw action; Bedload transport rate; Cold regions; Rivers

Acknowledgment

The authors would like to express appreciation for the support of the sponsors [Grant Number: SE 110145B0022021].

References

[1] Bullock, M. S., Nelson, S. D., & Kemper, W. D. (1988). Soil Cohesion as Affected by Freezing, Water Content, Time and Tillage. Soil Science Society of America Journal, 52(3), 770-776.
[2] Hayashi, & Masaki. (2013). The Cold Vadose Zone: Hydrological and Ecological Significance of Frozen-Soil Processes. Vadose Zone Journal, 12(4), 37-49.
[3] Liu, H., Yang, Y., Zhang, K., & Sun, C. (2017). Soil Erosion as Affected by Freeze-Thaw Regime and Initial Soil Moisture Content. Soil Science Society of America Journal, 81(3), 459.

Numerical modelling of hyperconcentrated flows in the Xiliugou River

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Abstract

China's loess plateau is an arid/semi-arid area, and, historically, summer rain have caused severe erosion and hyperconcentrated flow frequently (Wan and Wang 1994). At some measuring stations, concentration in excess of 1000 kg/m^3 were recorded and resulted in serious sedimentation disasters. Numerical modelling of hyperconcentrated flow is difficult because high sediment concentration increases the density of the water-sediment mixture in which turbulent mixing can be significantly damped by vertical density gradients (Winterwerp and van Kessel 2003). Moreover, the rheological behaviour of hyperconcentrated flow, in terms of the relationship between shear stress and shear strain rate, is different from that of low concentration flow (Barnes, H.A., Hutton, J.F., and Walters, K. 1989).

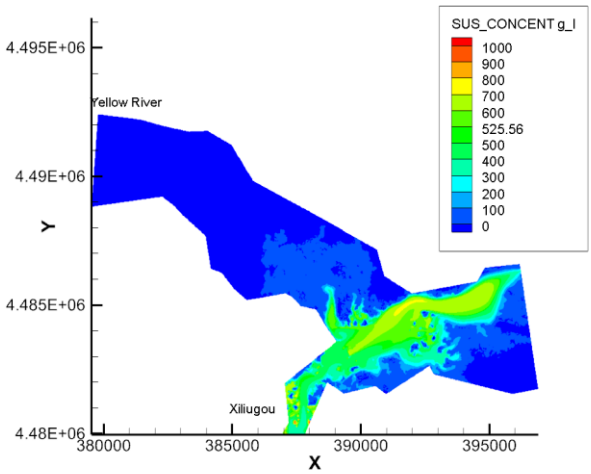

Figure. 1. Suspended sediment calculated from the confluences of the Xiliugou River with the Yellow River

For these reasons, a numerical model based on the classic two-dimensional hydro-sediment-morphological model was developed to model hyperconcentrated flows. In the model, the generation, transport and dissipation of turbulence is simulated with a $k-\varepsilon$ model while the apparent viscosity of the water-sediment mixture derived from the hyperconcentrated flow is calculated by Papanastasiou's formula (1987). The near-bed equilibrium concentration is determined by empirical functions of the Zhang Ruijin's formula (Fang and Wang 2000; Tan et al. 2018). To account for the effect of sediment on flow, the settling velocity is determined using the method of Richardson and Zaki's (1954). The performance of the erosion and sedimentation model was validated using data from Yen and Lee (1995) while the stress of the hyerconcentrated flow was validated using data from Komatina (1997).

The numerical model was applied to simulate the hyperconcentrated flow, which occurred on July 21, 1989, from the confluences of the Xiliugou River with the middle Yellow River (China). A brief domain review was introduced first and the suspended sediment modeling results were analyzed (Figure 1). It is concluded that the numerical model can be used to model the hyperconcentrated flow of the domain although some model parameters should be calibrated using more field data.

Keywords: Hyperconcentrated flow; hydro-sediment-morphological model; Viscosity; Xiliugou River

Acknowledgment

This work was partially funded and supported by the National Natural Science Foundation of China (Grant No. 42041006) and Special Foundation for Public-interest Institutes of China (HKY-JBYW-2020&2023).

References

[1] Barnes, H.A., Hutton, J.F., and Walters, K. (1989). An Introduction to Rheology. Amsterdam: Elsevier.
[2] Fang, Hong-Wei, and Guang-Qian Wang. (2000). "Three-Dimensional Mathematical Model of Suspended-Sediment Transport." Journal of Hydraulic Engineering 126 (8): 578–92. https://doi.org/10.1061/(ASCE)0733-9429(2000)126:8(578).
[3] Komatina, D., and M. Jovanovic. (1997). "Experimental Study of Steady and Unsteady Free Surface Flows with Water-Clay Mixtures." Journal of Hydraulic Research 35 (5): 579–90. https://doi.org/10.1080/00221689709498395.
[4] Papanastasiou, Tasos C. (1987). "Flows of Materials with Yield." Journal of Rheology 31 (5): 385–404. https://doi.org/10.1122/1.549926.
[5] Richardson, J.F. and Zaki, W.N. (1954). "Sedimentation and Fluidisation, Part I." Transactions of the Institution of Chemical Engineers 32 (1): 35–53.
[6] Tan, Guangming, Hongwei Fang, Subhasish Dey, and Weiming Wu. (2018). "Rui-Jin Zhang's Research on Sediment Transport." Journal of Hydraulic Engineering 144 (6): 02518002. https://doi.org/10.1061/(ASCE)HY.1943-7900.0001464.
[7] Wan, Zhaohui, and Zhaoyin Wang. (1994). Hyperconcentrated Flow. IAHR AIRH Monograph. Rotterdam: Balkema.
[8] Winterwerp, Johan C., and Thijis van Kessel. (2003). "Siltation by Sediment-Induced Density Currents." Ocean Dynamics 53 (3): 186–96. https://doi.org/10.1007/s10236-003-0038-7.
[9] Yen, Chin-lien, and Kwan Tun Lee. (1995). "Bed Topography and Sediment Sorting in Channel Bend with Unsteady Flow." Journal of Hydraulic Engineering 121 (8): 591–99. https://doi.org/10.1061/(ASCE)0733-9429(1995)121:8(591).

Impacts of ice cover on river sediment transport

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Abstract

Rivers in high latitude areas usually forms ice cover. The ice cover changes velocity profile of the river and increases wetted perimeter remarkably, and then influences the threshold velocity of the sediment. So the sediment transport of the river during ice period will have its unique characteristics.

The formation of ice cover changes the flow velocity distribution structure of the river (as shown in Figure 1), resulting in the increase of the wetted perimeter of the flow section. Prattle(1979) found that under the same water level, after the formation of ice cover, water flow energy loss can increase 62% compared with the open flow, and the discharge can be reduced about 29%. So the sediment transport of rivers during the ice period is different from open flow conditions. Smith and Ettema(1997), Sayre and Song(1979), Wueben(1986), Muste, et al(2000) analyzed the experimental results of flume under the condition of floating ice cover, and gave a similar conclusion: the appearance of ice cover increased water level and decreased the flow rate. Decker Hains(2004) and Wang(1998, 2012) thought that the maximum velocity point moved towards the riverbed after the appearance of the ice cover, so that the sediment was easier to move compared with that in the open flow. Tsai and Ettema(1994) studied riverbed of the bend and thought that the horizontal circulation strength and the cross slope of riverbed were reduced after the appearance of ice cover. Wu et al.(2014) conducted experiments in a largescale flume to study the impact of ice cover roughness and non-uniform sediment on the local scour around semi-circular abutments. Under ice cover, the average scour depth is always greater compared to that in open channels. The average scour depth under rough ice cover is 35% greater than that under smooth ice cover.

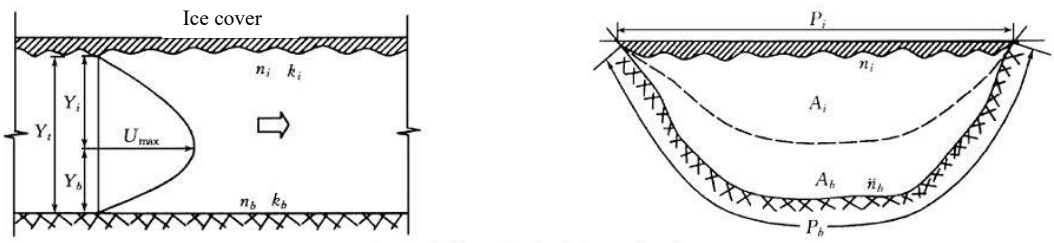

Figure 1. Flow velocity distribution under the ice cover

This paper introduces the recent development in the sediment transport under ice cover and emphasizes on sediment transport and velocity distribution under ice cover. Some suggestions for future studies are also given.

Keywords: Ice period; Ice cover; Sediment transport; Ice roughness

Acknowledgment

This study was supported by the National Key Research and Development Program of China (grant numbers 2022YFC3202503).

References

[1] Prattle, B. (1979). Review of flow resistance of consolidated smooth and rough ice cover. Proceedings Canadian hydraulic symposium[C]. Vancouver, 52-92.
[2] Smith, B.T., Ettema, R. (1997). Flow resistance in ice covered alluvial channels. Journal of Hydraulic Engineering. 123, 592-599.
[3] Sayre,W. W., Song,G. B. (1979). Effects of Ice Covers on Alluvial Channel Flow and Sediment Transport Processes, Iowa Inst of Hydraulic Research Iowa City.
[4] Wuebben, J.L. (1986). Laboratory Study of Sediment Transport Under Ice. Proceedings of the Fourth Federal Interagency Sedimentation Conference, Las Vegas, Nevada. 361-369.
[5] Muste, M., Braileanu, F., Ettema, R. (2000). Flow and sediment transport measurements in a simulated ice-covered channel. Water Resources Research. 36, 2711-2720.
[6] Hains, D., Zabilansky, L. (2004) Laboratory Test of Scour Under Ice: Data and Preliminary Results. 1-182.
[7] Wang, J. (1998). A laboratory study of starting velocity of noncohesive sediment under ice cover. Journal of Nanjing Hydraulic Research Institute. 2, 164-169.
[8] Tsai, W., Ettema, R. (1994). Ice cover influence on transverse bed slopes in a curved alluvial channel. Journal of Hydraulic Research. 32, 561-582.
[9] Wang, J., Sui, J.Y., Zhang, H.Y., Chen, P.P., Hirshfield, F. (2012). Mechanisms of ice accumulation in a river bend – an experimental study. International Journal of Sediment Research. 27, 521-537.
[10] Wu, P., Hirshfield, F., Sui, J.Y., Wang, J., Chen, P.P. (2014). Impacts of ice cover on local scour around semi-circular bridge abutment. Journal of Hydrodynamics, Ser. B. 26, 10-18.

Characteristics of sediment concentration in Yanguan section of Qiantang River Estuary based on measured data before the main flood season

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Abstract

The water and sediment movement in the Qiantang River estuary is extremely complex. The problems of sediment transport have always been concerned by scholars. However, it is very difficult to observe the sediment concentration in the tidal reaches of estuaries, and there is a relative lack of systematic measurement analysis and research on the law of sediment concentration. In order to improve the understanding of water and sediment characteristics in the Qiantang River estuary and to support the cofferdam project to be built in Haining section on the north bank of Qiantang River before the main flood season, the measured sediment concentration at Yan Guan tidal gauge station for several consecutive days from April to June 2022 was analyzed and studied. Firstly, the sediment concentration data were divided and analyzed according to the tidal range level (spring tide, middle tide, neap tide) and tidal time (before flood tide, flood tide, slack tide, ebb tide). Secondly, the measured sediment concentration was fitted with the turbidity data obtained from Yan Guan tidal gauge station in the same period. Two groups of fitting curves were obtained according to the level of tidal and turbidity range, and the correlation degree was 0.9 or above. The fitted curve was verified and then applied in the analysis of relationship between the tidal level and the sediment concentration in July. The results showed that the dispersion degree of sediment concentration during spring tide was the largest, followed by middle tide and neap tide. There was little change in sediment concentration during neap tides. The sediment concentration increased obviously during middle tide and spring tide, and decreased during slack tide at high level before returning to the original sediment concentration during ebb tide. Overall, sediment concentration curve and tidal curve had similar periodic process. It was noted that the sediment concentration was witnessed a small rise during ebb tide period, which may be because the flow velocity increased after the slack tide period and some settled sediment moved again with flow. This study will enhance the understanding of sediment transport in the Qiantang River estuary, which helps to solve the sediment problems in the estuary engineering.

Keywords: Qiantang estuary; sediment concentration; turbidity; fitting; tide level

Acknowledgment

This research was funded by the Natural Science Foundation of Zhejiang Province [Grant Number: LZJWZ23E090010] and National Natural Science Foundation of China [Grant Number: 12002310].

Suspended sediment monitoring in a river with a hyperband acoustic profiler, example on the Rhône and Isère river in France

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Abstract

Suspended Particulate Matter (SPM) measurements are a very important challenge of operational flow monitoring. The ANR project MESURE (ANR-16-ASMA-0005) proposed to advance further regarding the SPM metrology (sediment concentration, size and flux) using multifrequency hydro-acoustic observations. A dual-frequency ABS (Acoustic Backscattering System) prototype was first developed by Ubertone and tested in laboratory and field campaigns. This prototype was then upgraded to allow a larger range of emission frequencies.

The UB-SediFlow is a multi-frequency acoustic profiler (Fig. 1), which measures backscattered echo profiles along 4 acoustic beams of 4 wideband transducers (covering the full range 300kHz to 6MHz).

Figure.1 The UB-SediFlow on a floating board, the acoustic module and the user interface

The acoustic module UB-Sediflow was installed on a CNR floating board (Fig. 1) which was deployed with a rope from the bridge on the river at a fixed position or moving to get a transect.

The acoustic backscattered intensities measured by acoustic profilers can be inverted through different methods to get concentration and grain size information [1]. All the methods derive from the sonar equation [2], which includes the necessity of a calibration.

During the sediment managing operations APAVER of May 2021 on the Rhône river, France, the UB-SediFlow was set with 6 acoustic configurations: 0.5 ; 1.0 ; 1.5 ; 2.3 ; 4.5 and 5.2 MHz. The inversion of the acoustic data has been compared with pycnometer samples and the CNR's reference measurement over 5 days (May 19 to 21, 25 and 26th, 2021).

When analysing the acoustic data, the distinction between fine (<100µm) and coarse particles (>100µm) is made. The fine sediment concentration estimator was calibrated with a pycnometer near the water surface at the very beginning of the campaign. The coarse sediment concentration estimator is calibrated near the water surface during a peak of concentration.

The acoustic measurement of the concentration of fine sediments has an uncertainty close to the 20% of the reference pycnometer. Fig. 2 shows concentration evolutions on May 20th according to different measurement methods, including the reference value computed by the CNR from several methods.

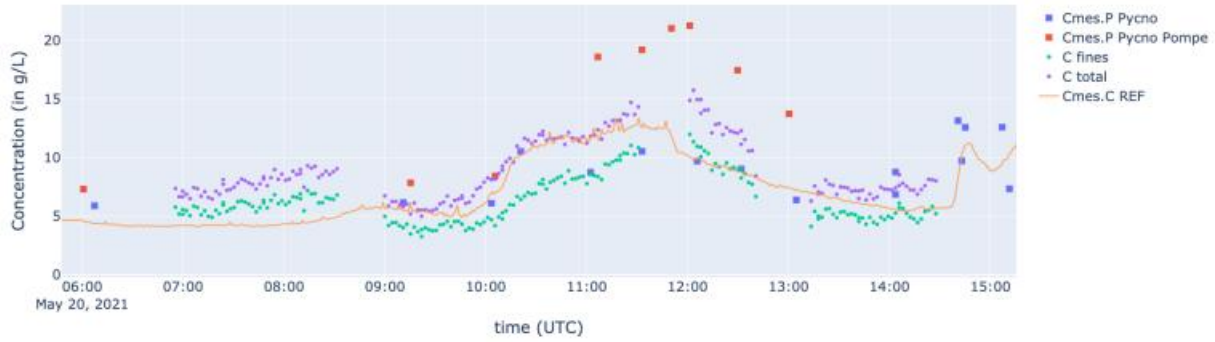

Figure.2 Concentration measurements, in the first meter under the surface, by UB-SediFlow (dots) and pycnometer (squares) compared to reference value (line).

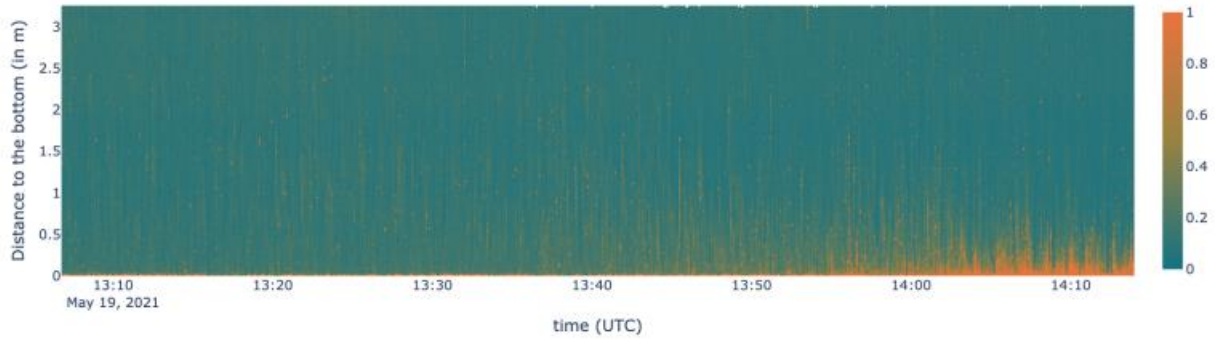

Figure.3 Coarse particles concentration profiles (in g/L) measured by acoustic method.

Coarse particle concentration measurements allow a quantification of the concentration along the depth (see Fig. 3 on May 19th PM). The data show a high temporal variability. This measurement could be improved with two calibration points at the surface and near the bottom.

The UB-SediFlow gave quality data over a large frequency range and showed an easy deployable instrument allowing real time data visualization. The first result led the CNR team to improve the knowledge of sand flux spatially and temporally. The advantage of this sensor is the optimization of the number of samples on site to estimate SPM flux. A laboratory calibration campaign on the DEXMES facility is planned to confirm consistency of the field in-situ calibration. The next step will be to qualify this instrument with more SPM reference values.

References

[1] Vergne, A., LeCoz, J., Berni, C., & Pierrefeu, G. (2020). Using a down-looking multifrequency acoustic backscatter system (ABS) for measuring suspended sediments in rivers. Water Resources Research, 56, e2019WR024877. https://doi.org/10.1029/2019WR024877

[2] Hurther, D., Thorne, P. D., Bricault, M., Lemmin, U. & Barnoud, J.-M. (2011). A multifrequency Acoustic Concentration and Velocity Profiler (ACVP) for boundary layer measurements of fine-scale flow and sediment transport processes, Coastal Engineering, vol. 58, p. 594–605.

Recovery characteristics of suspended sediment in the downstream reaches of the Three Gorges Reservoir

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Abstract

Since the Three Gorges Reservoir was commenced operations in 2003, sediment input from upstream was suppressed and suspended sediment concentration in the downstream reaches was unsaturated in long-term. The resulting longitudinal suspended sediment recovery causes long distance erosion in downstream reaches and lead to channel deepening and widening, which might lead to negatively influences on shipping, water intake, and ecological environment (Schmidt et al., 2008). Therefore, it is necessary to study the characteristics and internal mechanism of suspended sediment recovery in downstream reaches of the *TGR*.

At present, scholars have carried out studies about suspended sediment recovery based on the field surveyed data (Guo et al., 2020; Yang et al., 2022). However, most of the previous studies focused on the results of sediment recovery and paid relatively little attention to recovery efficiency. In this work, the Yichang, Zhicheng, Shashi, Jianli, Luoshan, Hankou, and Datong hydrological stations were analyzed to investigate recovery characteristics of suspended sediment in the six reaches (YC-ZC, ZC-SS, SS-JL, JL-LS, LS-HK, and HK-DT) which are located downstream of the *TGR* (Figure 1). Firstly, the sediment saturation degree (ξ) was was defined as $\xi = C_{post}/C_{pre}$ (where C_{pre}, C_{post} are sediment concentrations during pre-operation and post-operation of the *TGR*, respectively), and the efficiency coefficient of suspended sediment recovery (η) was defined as $\eta = (\xi_{out} - \xi_{in})/(\xi_{in}L)$ (where ξ_{in}, ξ_{out} are sediment saturation degree of the outlet and inlet hydrological stations, respectively, and L is the length of the reach).

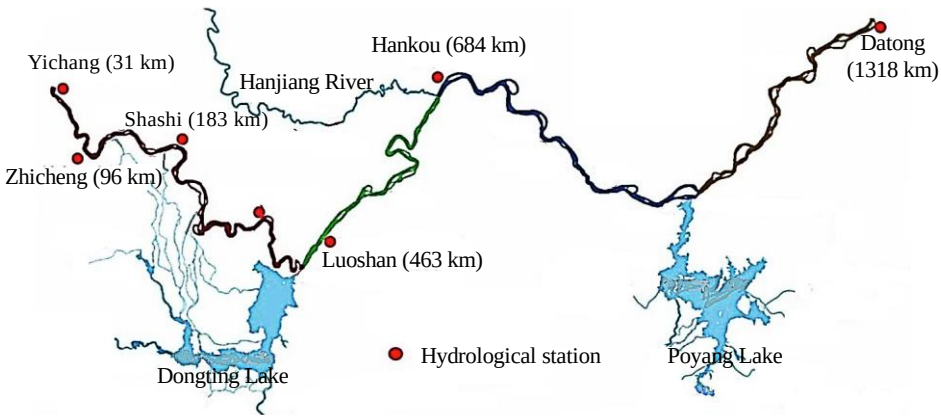

Figure 1. Overview of the study area (the reach from Yichang to Datong section).

ξ and η can reflect the degree and rate of suspended sediment recovery respectively. Analysis of the spatio-temporal variations of ξ and η (Figure 2) show that, in the same period, duo to the supply form riverbed, the sediment recovery degree increases along the river, but the sediment recovery rate decreases. For the same reach, the coarse degree of riverbed increases with the increase of erosion

duration and the reduction in supply capacity leads to reduced sediment recovery degree, while there was no consistent pattern of efficiency coefficient (η) with the increase of duration. In addition, the effects of inlet sediment saturation degree, flow intensity and supply capacity of riverbed on sediment recovery were analyzed. The result show that the rate of suspended sediment recovery decreases with the increase of inlet sediment saturation, and increases with the increase of flow intensity and riverbed supply capacity. Finally, an empirical formula was established for calculating the efficiency coefficient of suspended sediment recovery in the downstream reaches of the *TGR*.

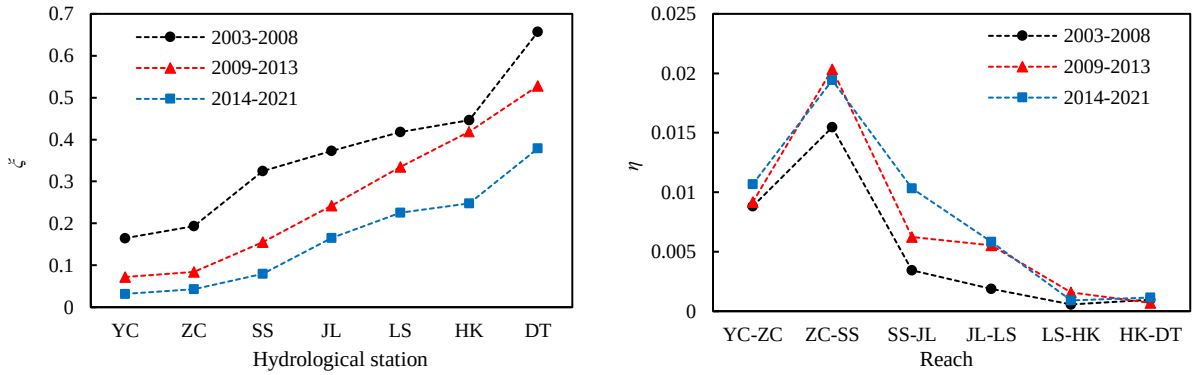

Figure 2. Longitudinal change rules of sediment saturation degree (ξ) and efficiency coefficient (η) in different periods.

Keywords: Three Gorges Reservoir; Downstream reaches; Sediment saturation degree; Suspended sediment recovery

Acknowledgment

The authors would like to express appreciation to the National Key Research and Development Program of China [Grant Number: 2016YFC0402101] and the Research Program on Major Sediment Problems of the Three Gorges Project [Grant Number: 12610100000018J129-03] for the support and sponsors.

References

[1] Schmidt, J. C., Wilcock, P. R. (2008). "Metrics for assessing the downstream effects of dams". Water Resources Research, 44(4): W04404. https://doi.org/10.1029/2006WR005092.

[2] Guo, XH., Qu, G., Liu, Y., Liu, XY. (2020). "Sediment transport of different particle size groups in the downstream channel after operation of the Three Gorges Project". Journal of Lake Sciences. 32(2):564-572. https://doi.org/10.18307/2020.0226.

[3] Yang, Y., Zheng, J., Zhu, L., Zhang, H., Wang, J. (2022). "Influence of the Three Gorges Dam on the transport and sorting of coarse and fine sediments downstream of the dam". Journal of Hydrology, 615, 128654. https://doi.org/10.1016/j.jhydrol.2022.128654.

Numerical study of pollutant transport considering the flow–sediment–bed-contaminant interactions in river channel under heavy rain

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Abstract

The frequent occurrence of extreme rainfall due to global warming causes strong water and sediment movement and water pollution in river channels, which affects the sustainable development of urban rivers. In this study, considering the strong alluvial process in small and medium rivers under heavy rain, the field measurement of water and sediment movement and bed deformation of an urban river channel in Hangzhou was carried out, and the concentration of pollutants was determined in the laboratory with the representative index of total phosphorus. Meanwhile, the coupled shallow water hydro-sediment-pollutant-morphodynamic model was established. The model not only involves the influence of rainfall and lateral inflow on the pollutant concentration, but also considers the phosphorus adsorption/ desorption by suspended sediment and bed sediment and the influence of bed deformation on the phosphorus transport. The governing equations were numerically solved by the operator splitting method and a well-balanced shock-capturing finite volume method with the Slope LImiter Centred (SLIC) approximate Riemann solver. The model was first calibrated and validated by an experimental case and the field observations, and then was applied to simulate and predict pollutant transport based on forecast hydrological conditions. The proposed mathematical model takes into account the physical processes of the interaction among river flow, sediment, bed deformation and pollutant transport in strong alluvial rivers. It shows a good agreement with the measured data and facilitates the pollutant transport simulation, which may help to support the forecast and management of water pollution in urban rivers.

Keywords: Pollutant transport; Shallow water hydro-sediment-pollutant-morphodynamic model; Water pollution control; Extreme rainfall

Acknowledgment

This research was funded by the National Natural Science Foundation of China [Grant Number: 12002310] and the Natural Science Foundation of Zhejiang Province [Grant Number: LZJWZ23E090010].

Assessing Model Accuracy for a Stratified Small Bay using Radar and Drifters: Validation Results

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Abstract

Validation procedures are critical for ensuring the reliability of numerical models. These procedures require measurement data to evaluate the reproducibility of the model, and the data should be selected to address physical processes affected by boundary conditions. Estuarine models, in particular, require diverse in-situ data due to the complex physical phenomena resulting from external forces acting in rivers and offshore.

In this work, we evaluate an estuarine model in a stratified small bay using spatiotemporal in- situ data for various physical variables, specifically the estuaries of the Hyeongsan river located inside Yeongil bay, South Korea. The hydrodynamic model is coupled with a wave model and a physical-based watershed model, both online and offline, to consider external forces from the watershed to offshore (Deltares, 2011, Holthuijsen et al., 1993; Neitsch et al., 2011). The in-situ data, including surface ocean currents, density gradients, tides, and waves, were acquired through the Eulerian and Lagrangian perspective field surveys to tune and evaluate the model, which are high-frequency radar, GPS drifter, and YODA profile system (Masunaga and Yamazak, 2014; Lumpkin et al., 2017). The dynamically coupled model accurately reproduces the variability of physical variables controlled at the open boundaries.

The well-validated model was applicated to study the sediment transport and morphological bed changes in the estuary. Sediment properties used in the coupled model were measured from field surveys. Results (Figure 1) show seasonal changes in the river topography.

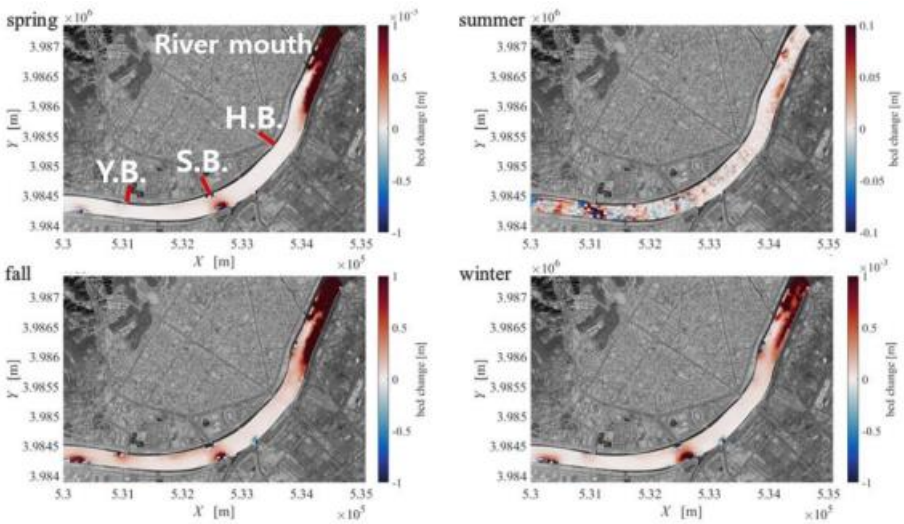

Figure 1. Seasonal variability in the Hyeongsan River topography

The river bed was mainly changed by bedload during flood season, especially upstream of S.B. The pattern of bed changes can be divided into the upstream and downstream areas at 4~5 km from the upstream, near the confluence of a small stream (Figure 2). Downstream of H.B., sedimentation

occurs rather than erosion due to the accumulation of silts from the river mouth. In the upstream area of S.B., the bedload transport causes erosion and deposition of the river bed during maximum discharge. Conversely, the area near H.B. is more stable than others, with low bedload and suspended sediment transport.

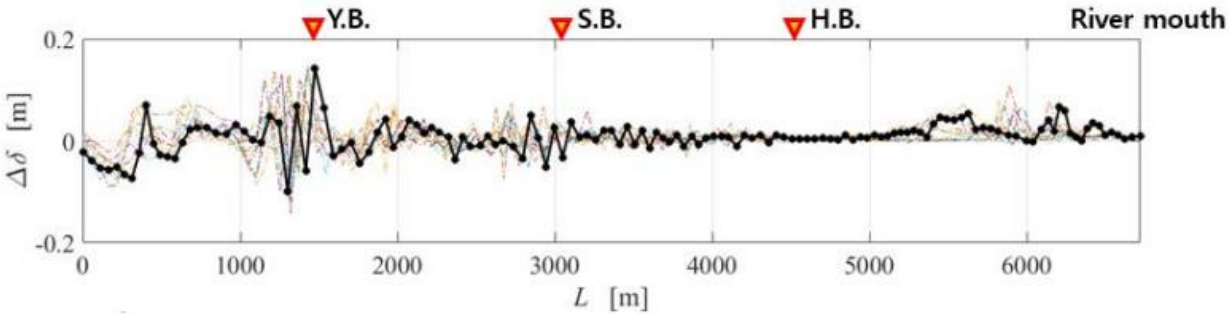

Figure 2. Bed level changes for one year from the weir to the river mouth.

Keywords: Validation, Hydrodynamic model, High-frequency radar, GPS drifter, Sediment transport

Acknowledgment

This research was supported by Basic Science Research Program through the National Research Foundation of Korea (NRF) funded by the Korean Government Ministry of Science, ICT and Future Planning (NRF-2023R1A2C2006034).

References

[1] Deltares. (2011). “Delft3D-FLOW. Simulation of multi-dimensional hydrodynamic flows and transport phenomena, including sediments”. Delft.
[2] Holthuijsen, L. H., Booij, N., Ris, R. (1993, July). “A spectral wave model for the coastal zone”. In Ocean Wave Measurement and Analysis. 630-641
[3] Neitsch, S. L., Arnold, J. G., Kiniry, J. R., Williams, J. R. (2011). “Soil and water assessment tool theoretical documentation version 2009”. Texas Water Resources Institute.
[4] Masunaga E, Yamazaki H. (2014). “A new tow-yo instrument to observe high-resolution coastal phenomena”. Journal of Marine System, 129, 425–436
[5] Lumpkin, R., Ö zgökmen, T., Centurioni, L. (2017). “Advances in the application of surface drifters”. Annual Review of Marine Science, 9, 59-81.

Influence of suspended sediment diameter on the sediment concentration profile

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Abstract

In the sediment-laden flow, the distribution of flow fluctuation intensity and turbulence structure change significantly compared with those of clear water [1]. Experimental studies and field observations have showed that the coarse particles in the sediment-laden flow always cause enhancement of turbulence intensity, and the fine particles may tend to weaken the turbulence intensity. The difference of sediment particle size results in different characteristics of sediment concentration profile near the bottom, which may have a physical phenomenon of trend adjustment and transformation with the change of sediment concentration [2].

In this work, the dominate factors affecting the distribution of flow fluctuation intensity and turbulence structure are compared and analyzed according to multiple sets of measured date. A vertical distribution expression of flow fluctuation is established by analogy with the expression of clear water, and a sediment concentration profile appropriate for different trend characteristics is derived based on the diffusion equation. The formula is verified by several sets of classical experimental data (Table 1).

The results show that the sediment diameter is the primary factor affecting the vertical distribution of flow fluctuation and sediment concentration in the low sediment concentration flow. While in the high sediment concentration flow, the concentration become to the controlling character leading to strongly transform in the type of vertical distribution of sediment concentration and then in the state of the sediment transport. As shown in Figure1, the derived formula can well reflect the vertical distribution of sediment fluctuation intensity and sediment concentration of different particle sizes and sediment concentrations. The variations of the factors exhibit that (Figure 2) in the low sediment concentration flow, when the form of the distribution of turbulence intensity is approximate to that in clear water, the secondary turbulence caused by particles is closely related to the sediment diameter and there exists the critical diameter that makes the turbulence intensity of the sediment-laden flow basically consistent with that of clear water. The critical diameter is not a constant value, but directly associated with the ratio of sediment density and particle size to water depth. In the high sediment concentration flow, critical sediment concentration analogously exists for different profile type of sediment concentration, that is, beyond a certain threshold, the vertical distribution and transport characteristic may change notably. Preliminary analyses indicate that the critical sediment concentration is determined by sediment properties and the viscosity coefficient of sediment-laden flow near the bottom boundary layer.

Table 1. Experimental data source for formula validation.

Case	Type	Diameter	Density	Source
1	Mixed plastic	0.1-1.5mm	1056 kg/m^3	LI D. X.[3]
2	Plastic particle	2.0-9.0 mm	1190 kg/m3	Sumer, Muller[4]
3	Sand	0.4-0.7mm	2650 kg/m3	M. A. Michalic[4]

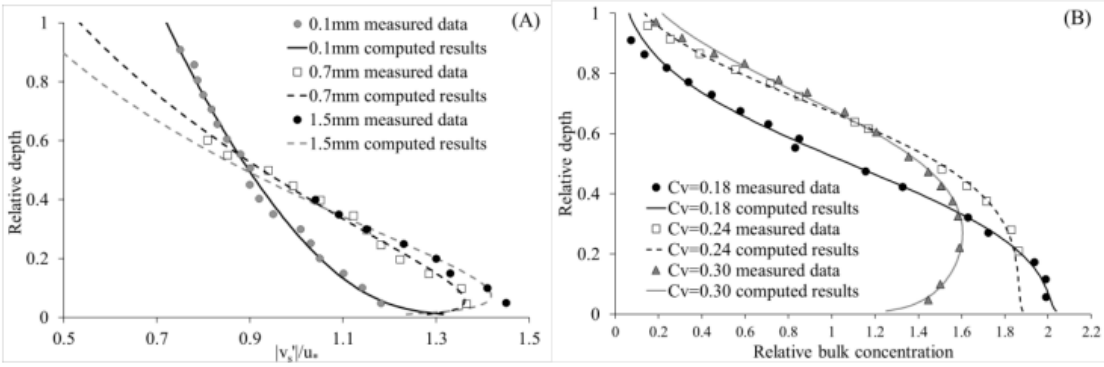

Figure 1. Comparison between measured data and calculated values (A is the sediment particle velocity fluctuations, and B is the relative bulk concentration).

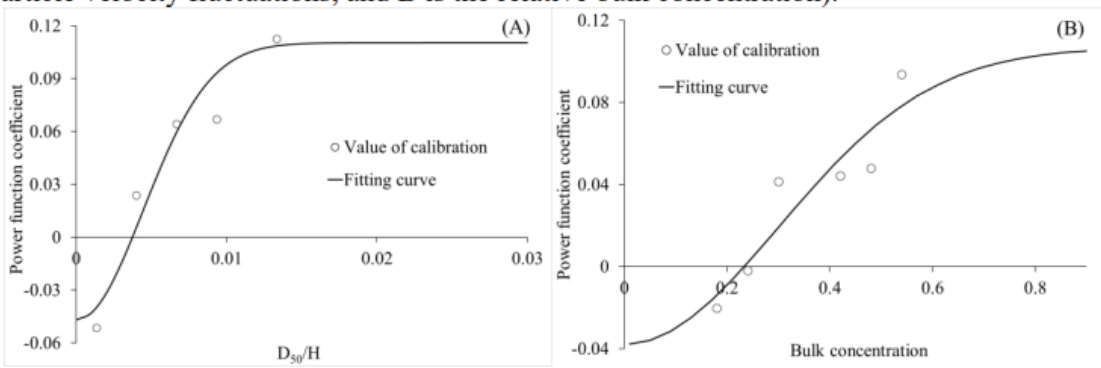

Figure 2. Comparison between values of calibration and fitting curve (A is the trend of power function coefficient in the lower sediment-laden flow, and B is the trend of coefficient in the hyper-concentrated flow).

Keywords: Sediment concentration profile; Sediment diameter; Particle velocity fluctuations; Secondary turbulence; Fluctuation component

Acknowledgment

The work was supported by the National Natural Science Foundation of China (No. 52009047, 51909100), the Foundation of special project of scientific research fund of the Yellow River Institute of Hydraulic Research in China (No. HKY-JBYW-2020-03, No. HKY- JBYW-2023-24). Major science and technology project of MWR of China (No. SKS-20222061)

References

[1] Kirca, V. S. O., Saghebian, S. M., Roushangar, K., & Yagci, O. (2020). "Influence of surface roughness of dune bedforms on flow and turbulence characteristics." International Journal of Sediment Research, 35(6), 666-678.
[2] Graf, W. H., & Cellino, M. (2002). "Suspension flows in open channels; experimental study." Journal of hydraulic research, 40(4), 435-447.
[3] Li D. X. (1999). "Study on the motion characteristics of suspended particles." Doctor Dissertation Research Paper, Beijing: Tsinghua University 1999, 10-12.
[4] B. Mutlu Sumer, & A. Muller (2020). "Mechanics of Sediment Transport." Taylor & Francis.

Contribution of field observations on sand-bed open-channel flows in Haiti to the study and prediction of the value of Coles' wake-strength parameter Π

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Abstract

In open channel flows (natural or artificial), the flow velocity distribution along the depth is determinant in many fluvial characteristics and processes, including sediment transport (Ferro 2003; Mahananda et al., 2019). For this, during several decades, the flow velocity distribution along the depth has been widely studied and several analytical and numerical models have been proposed. However, in narrow open channel flows (width/depth<5), modeling the vertical velocity distribution remains complicated because the maximum velocity occurs below the water surface, a feature designated as the velocity dip-phenomenon (Guo & Julien, 2008). In the literature, many analytical, semi-analytical and empirical equations have been proposed to predict the vertical velocity distribution and the velocity dip-phenomenon position in narrow open channel flows (Absi, 2001; Guo & Julien, 2003; 2008; Guo, 2014; Kundu & Ghoshal, 2012; Mahananda et al., 2019). However, in all these models, the extent of the wake-strength parameter Π, which is not universal and which can take negative or positive values, remains difficult to predict and, to our knowledge, there are only limited experimental efforts trying to address the issue.

In this doctoral research work, we compare three vertical velocity distribution models (Kundu & Ghoshal, 2012; Guo, 2014 & Mahananda et al., 2019) for the description of sand-bed channel flows investigated in Haiti, namely the Rouyonne river and the Fosse Naboth Est- Artibonite irrigation canal. In this contribution, we propose a method to predict the value of Coles' wake parameter (Π) based both on reference laboratory experimental data widely used by most researchers and on our own velocity field observations collected *in situ* in Haiti.

Figure 1. Exploration of velocity profiles in the Rouyonne river (left) and in the FNE-irrigation canal (right)

The first results (Figure 2) are encouraging and strongly suggest that we could establish a dependency relationship between the parameter λ (calculated from the relative experimental position of the velocity dip-phenomenon) and Coles' wake strength Π as it appears, respectively, in the Kundu

& Ghoshal (2012) and Mahananda et al. (2019) models. The final outcome of our study will be presented during the conference.

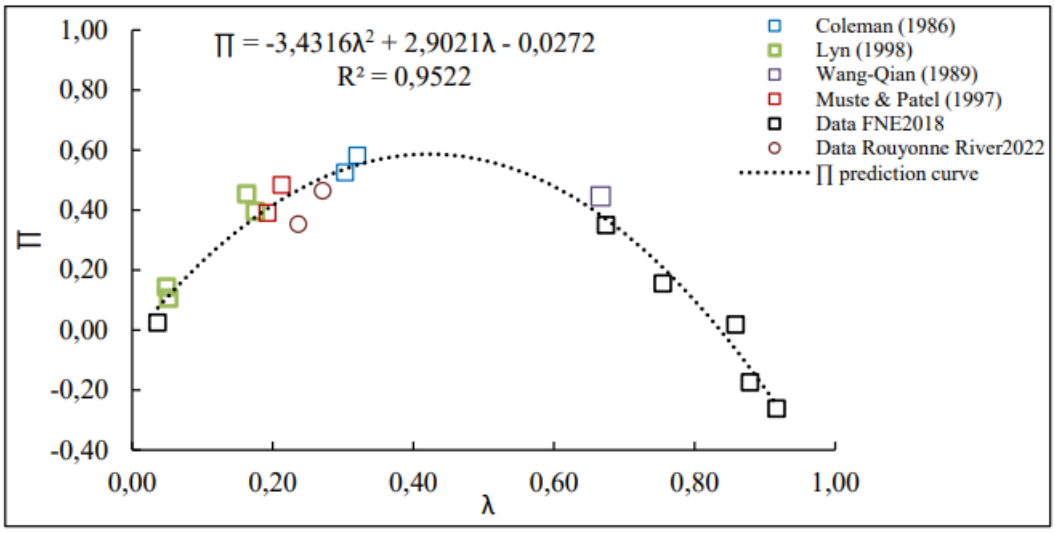

Figure 2. Prediction of the wake-strength parameter Π in the case of the Kundu & Ghoshal (2012) model.

Keywords: Vertical velocity distribution; Dip-phenomenon; Coles' wake strength Π; Parameter

Acknowledgment

Julien Schneider of the Laboratory Water Pollution Control is greatly thanked for his help in digitizing the experimental reference data.

References

[1] Absi, R. (2011). An ordinary differential equation for velocity distribution and dip-phenomenon in open channel flows. Journal of Hydraulic Research, 49(1), 82-89.
[2] Coleman, N. L. (1986). Effects of suspended sediment on the open‐channel velocity distribution. Water Resources Research, 22(10), 1377-1384.
[3] Ferro, V. (2003). ADV measurements of velocity distributions in a gravel‐bed flume. Earth Surface Processes and Landforms, 28(7), 707-722.
[4] Guo, J. (2014). Modified log-wake-law for smooth rectangular open channel flow. Journal of Hydraulic Research, 52 (1), 121-128.
[5] Guo, J., & Julien, P. Y. (2008). Application of the modified log-wake law in open-channels. Journal Applied Fluid Mechanics, 1(2), pp. 17-23.
[6] Kundu, S., and Ghoshal, K. (2012). An analytical model for velocity distribution and dip-phenomenon in uniform open channel flows. International Journal of Fluid Mechanics and Research, 39(5): 381–395.
[7] Mahananda, M., Hanmaiahgari, P. R., Ojha, C. S. P., & Balachandar, R. (2019). A new analytical model for dip modified velocity distribution in fully developed turbulent open channel flow. Canadian Journal of Civil Engineering, 46(8), 657-668.

Introduction to a New Book "Sediment Transport Dynamics" by Weiming Wu

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Abstract

Sediments are solid particles that are broken down from rocks by processes of weathering and erosion. They may be transported to depositional sites by the actions of water, air, ice, or gravity. Among the four agents, transport by water contributes the majority of sediment fluxes on the Earth's surface. Sediment erosion on uplands includes interrill, rill, and gully erosions caused by rain splash, sheet and concentrated flows. The eroded sediments are transported downstream by river flows, and then deposited in channels, reservoirs, lakes, estuaries, and seas. Sediments move in coastal zones by waves and currents. Sediment deposition occurs at water intake structures and navigation facilities, whereas erosion occurs along river banks and coastal shores, around instream structures such as bridge piers, abutments, spur dikes and weirs, as well as downstream of dams, weirs and sluice gates. Fine sediments, such as clay and silt, can absorb pollutants and cause significant water quality issues to the receiving water bodies.

Graf (1971), Yalin (1972), Vanoni (1975), Xie (1981), Chien and Wan (1983, 1999), Simons and Senturk (1992), van Rijn (1993), Yang (1996), Soulsby (1997), Julien (2010), and Dey (2014), among others, had published books that cover sediment transport dynamics. The new book authored by Weiming Wu focuses on the processes of sediment transport in surface waters. It complements and updates the existing books by including the early classical works and recent developments of sediment transport theories and methods from English and non- English literature. It merges the knowledge and experience gained by sediment scholars all over the world. It is inclusive, while it balances the breadth, depth, fundamental importance, practical applicability, and future advancement of the covered knowledge. It serves as a reference book for sedimentation engineering professionals and also a textbook for graduate and senior undergraduate students.

The new book is in press by Taylor & Francis / CRC Press. It has about 750 pages. The subjects are organized into the following fifteen chapters:

Chapter 1. Introduction
Chapter 2. Properties of Water and Sediment
Chapter 3. Open Channel Flows
Chapter 4. Settling of Sediment Particles
Chapter 5. Incipient Motion of Sediments
Chapter 6. Bed Forms
Chapter 7. Bed-Load Transport
Chapter 8. Suspended-Load Transport
Chapter 9. Total-Load Transport
Chapter 10. Cohesive Sediment Transport
Chapter 11. Sediment-Laden Two-Phase Flows
Chapter 12. Hyperconcentrated and Debris Flows
Chapter 13. Coastal Sediment Transport
Chapter 14. Turbidity Currents
Chapter 15. Physical Modeling and Similitude

Chapter 1 presents a general introduction, including the origins and classifications of sediments, a brief overview of sediment transport processes in surface waters, sediment loads in the world's rivers,

and the development history of sediment transport dynamics. Chapter 2 introduces the properties of water and sediment. Chapter 3 provides an overview of open channel hydraulics, including turbulence characteristics, velocity distribution, channel resistance, secondary flows, and coherent structures. Chapter 4 describes the affecting factors and often-used formulas of sediment settling velocity.

Chapter 5 presents the deterministic threshold criteria for incipient motion of uniform and nonuniform sediments, as well as the probability of incipient motion. Chapter 6 explains the characteristics, regimes, and dimensions of bed forms, as well as the empirical formulas of movable bed resistance. Chapters 7–9 introduce the transport of bed load, suspended load, and total load in rivers, respectively, as well as measurements of sediments. These five chapters cover the fundamentals of river sedimentation.

The remaining six chapters cover special topics on different aspects of sediment transport. Chapter 10 describes the physical processes and empirical formulas of cohesive sediment transport, which often occurs in estuaries and reservoirs. Chapter 11 applies two-phase flow theories to study sediment-laden flows. Chapter 12 outlines the classifications, rheological relationships, velocity distributions, resistance, sediment transport, and morphological features of hyperconcentrated and debris flows. Chapter 13 describes the movable bed roughness, bed load, suspended load, and nearshore transport induced by waves and currents in coastal waters. Chapter 14 introduces the basic characteristics of uniform, gradually-, and rapidly-varied turbidity currents, as well as the special features of turbidity currents in reservoirs, channels, and seas. Chapter 15 presents the similitude theories for designing scale models of flow and sediment transport in rivers.

The chapters are arranged in a sequence for teaching purposes. However, the presented materials are much more extensive than a college course text. Homework problems are prepared, which help instructors to select important topics. Solutions to homework problems are available from the author by request.

References

[1] Chien, N. and Wan, Z.H. (1983, 1999). Mechanics of Sediment Transport, China Science Press (in Chinese), Translated to English, ASCE in 1999.
[2] Dey, S. (2014). Fluvial Hydrodynamics, Springer, Germany.
[3] Graf, W.H. (1971). Hydraulics of Sediment Transport, Water Resources Publications, USA.
[4] Julien, P.Y. (2010). Erosion and Sedimentation, 2nd Edition, Cambridge Univ. Press, UK.
[5] Simons, D.B. and Senturk, F. (1992). Sediment Transport Technology – Water and Sediment Dynamics, Water Resources Publications, USA.
[6] Soulsby, R. (1997). Dynamics of Marine Sands, Thomas Telford, UK.
[7] Van Rijn, L.C. (1993). Principles of Sediment Transport in Rivers, Estuaries and Coastal Seas, Aqua Publications, The Netherlands.
[8] Vanoni, V.A. (1975). Sedimentation Engineering. ASCE Manuals and Reports on Engineering Practice No. 54, ASCE, Reston, VA, USA.
[9] Xie, J.H. (1981). River Sedimentation Engineering, Vol. 1 and 2, Water Resources Press, China (in Chinese).
[10] Yalin, M.S. (1972). Mechanics of Sediment Transport, Pergamon Press, UK.
[11] Yang, C.T. (1996). Sediment Transport, McGraw-Hill, New York.

Mud Transport in Rivers – Settling Velocity and Interactions with the Bed

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Abstract

The context for understanding the erosion, transport, and deposition dynamics of sediment classified as mud (a mixture of inorganic and organic particles in the silt and clay size range) has historically focused on estuarine environments. This focus is understandable as estuaries, bays, ports, and navigation channels are filled with fine muddy sediment. Yet, mud also exists in rivers starting from first-order headwater streams all the way out to the deepest basins of the ocean. Mud is present in the water column, bed, and floodplains throughout the entire fluvial system and beyond. Some have regarded mud as morphologically insignificant, "washload," due in part to the very low settling velocities calculated when considering clay sized sediment. In some cases, this designation may be warranted and in others not. Regardless, it is inaccurate to consider that suspended mud simply washes out through the fluvial system with a residence time similar to that of water with little to no exchange of mud between the water column, bed, banks, and floodplains. One reason for this is that mud rarely exists as isolated clay-sized particles due to the inter-particle forces that lead to the coalescence and binding of organic and inorganic clay, silt, and fine sand sized particles into aggregates known as flocs (Fig. 1). Flocs have settling velocities that can reach up to nearly a millimeter per second, and more and more evidence is pointing to the nearly ubiquitous presence of flocs within river systems. Furthermore, even in cases where average friction velocity is high for a given reach, there exist many locations and flow paths where the lift and drag forces felt on a particle fall below that needed to maintain the particles in suspension, leading to deposition of mud on or within the bed and floodplain of a river.

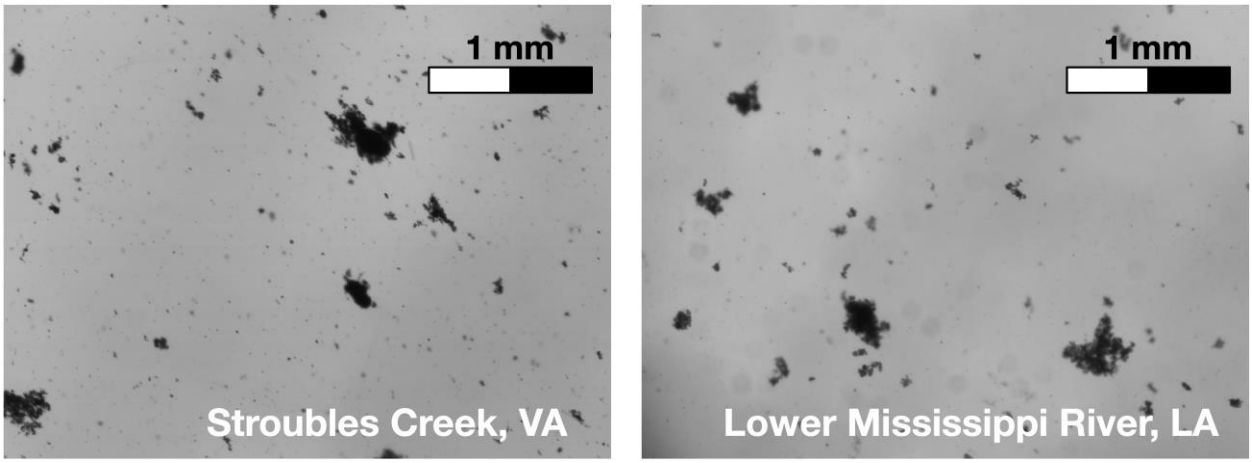

Figure. 1 Mud is flocculated even in freshwater. In situ images of suspended mud in a headwater creek of the Mississippi River in the Appalachian Mountains of Virginia USA (left panel) and the lower-most freshwater reach of the Mississippi River in Louisiana USA (right panel).

In this presentation, we draw on a range of field observations made with a new in situ floc imaging device and laboratory experiments we have performed over the past few years that seek to explore questions surrounding the transport dynamics of mud in rivers. We show results on (1) the flocculation

state and settling rate of mud in a headwater creek of the Mississippi River Basin (Virginia, USA) and the terminal freshwater reach of the main stem of the river near the Gulf of Mexico (Osborn et al. 2023); (2) discuss how the bed state in gravel bed rivers can influence capture and retention of fine sediment (Mooneyham and Strom, 2018); and (3) show data that suggest how mud transport could potentially be altered by seasonal changes in water column properties such as temperature and low amounts of salt from roadway deicing (Abolfazli and Strom, 2022). Drawing on these and other results we offer suggestions regarding how mud transport could be conceptualized and modeled in river systems.

Acknowledgment

The authors would like to express appreciation for the support of the sponsors [National Science Foundation through grant EAR-1801142 and ExxonMobil Upstream Research Company through grant LAW-20190-3444].

References

[1] Abolfazli, E. and Strom, K. (2022). Deicing road salts may contribute to impairment of streambeds through alterations to sedimentation processes. *ES&T Water*, 2(1):148–155.

[2] Mooneyham, C. and Strom, K. (2018). Deposition of suspended clay to open and sand-filled framework gravel beds in a laboratory flume. *Water Resources Research*, 54:323–344.

[3] Osborn, R., Dunne, K.B.J., Ashley, T., Nittrouer, J.A., and Strom, K. (2023) "The flocculation state of mud in the lowermost freshwater reaches of the Mississippi River: spatial distribution of sizes, seasonal changes, and their impact on vertical concentration profiles", in review Journal of Geophysical Research - Earth Surface.

Flow Competence and Critical Shear Stress in Coarse-Bed Streams

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Abstract

A classic concept in the study of sediment transport is the flow strength at which sediment movement begins, which is usually expressed in terms of critical shear stress or threshold shear stress τ_c. This incipient motion problem can be viewed as the minimum shear stress needed to move a given particle or as the largest grain size that a given shear stress can move. The latter notion is termed flow competence by geologists.

From initial movement experiments carried out flumes with beds composed of nearly uniform cohesionless sediments characterized by a reference diameter D, Shields [1] graphed the nondimensional critical shear stress $\tau_c^* = \tau_c/[(\rho_s - \rho)gD]$, now called the Shields parameter, against the grain Reynolds number $Re_g = u_* D/\nu$, where ρ_s = sediment mass density, ρ = water mass density, g = gravitational acceleration, $u_* = \sqrt{\tau/\rho}$ = bed friction velocity, and ν = water kinematic viscosity. Shields found that $\tau_c^* \cong 0.06$ for fully turbulent flow with $Re_g > 500$, although many subsequent studies report that $0.02 \leq \tau_c^* \leq 0.065$ for uniform sediments.

However, natural streambeds, particularly those composed primarily of gravel and cobbles, usually contain a mixture of diverse sediment sizes. The smaller grains in such streambeds tend to hide between the larger particles making them harder to move. In contrast, the larger particles protrude more into the flow, exposing them to greater velocities and shear stresses. The net result is a mild tendency for coarser grains to be more difficult to move than finer grains.

Letting $\tau_{ci}^* = \tau_{ci}/[(\rho_s - \rho)gD_i]$ and $\tau_{c50}^* = \tau_{c50}/[(\rho_s - \rho)gD_{50}]$ denote the critical Shields stress for diameter D_i and the median size D_{50} of sediment forming the surface of a coarse-bed stream, the following equation provides a general relationship between them [2]:

$$\tau_{ci}^* = \tau_{c50}^* \left(\frac{D_i}{D_{50}}\right)^{-b} \tag{1}$$

where the exponent b must be <1; otherwise, the critical shear stress would be the same for all grain sizes, an equal mobility condition, which is unlikely in a natural stream. Many analyses of various coarse-bed streams show that $0.6 \leq b < 1$.

Bedload collected at 75 different coarse-bed stream sites is evaluated in this study to determine a relation between the largest sized particle of diameter D_{max} from a single measurement to the applied bed shear stress $\tau_{c\,max}$ and longitudinal stream slope S in m/m. Replacing τ_{ci} and D_i in Eq. (1) by $\tau_{c\,max}$ and D_{max}, respectively, and rearranging gives

$$\tau_{c\,max} = \tau_{c50}^*(\rho_s - \rho)gD_{50}^b D_{max}^{1-b} \tag{2}$$

The empirical coefficients τ_{c50}^* and b in Eq. (2) found from a nonlinear regression for each of the 75 measurement sites are graphed against each stream's longitudinal slope in Figures 1 and 2, respectively. Figure 1 shows the expression

$$\tau_{c50}^* = 0.030 + 2.3 \times S \tag{3}$$

To provide a strong relation between τ_{c50}^* and S, with a coefficient of determination $R^2 = 0.664$ for values of S ranging from 0.0003 to nearly 0.06 m/m. The graph in Figure 2 shows that b ranges from about 0.6 to 0.94 with an average value of 0.8 and no dependance on S.

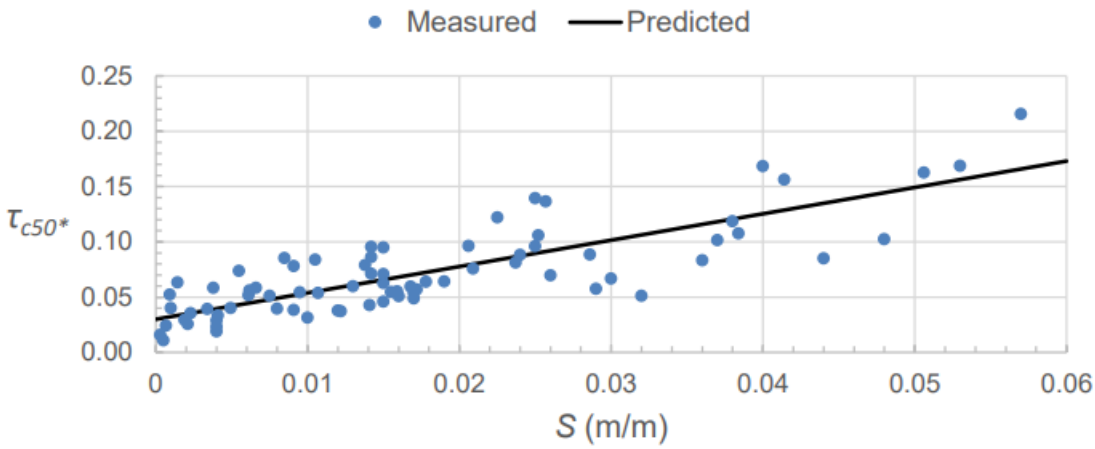

Figure 1. Measured and predicted (expected value) dimensionless critical shear stress τ_{c50*} as a function of the longitudinal stream slope *S* for the 75 samples evaluated in this study.

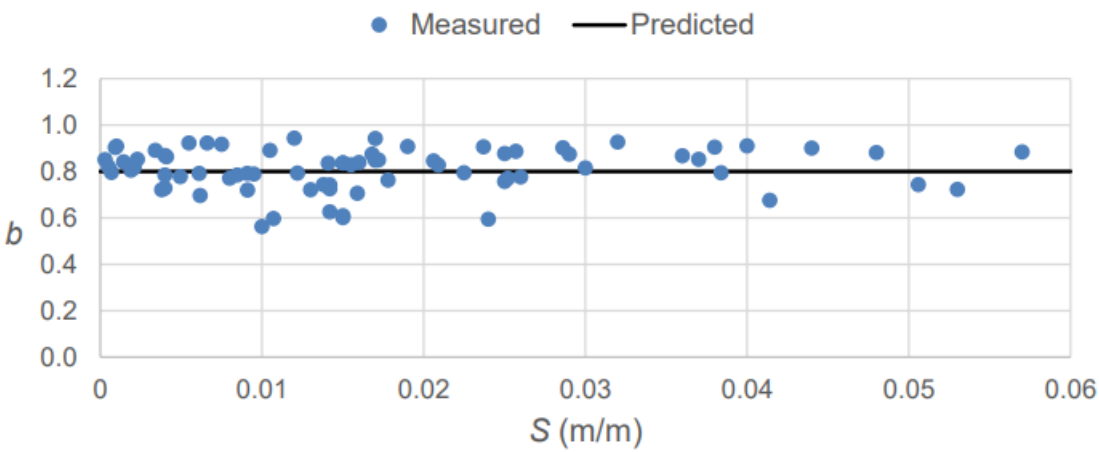

Figure 2. Measured and predicted (expected value) exponent *b* as a function of the longitudinal stream slope *S* for the 75 samples evaluated in this study.

Keywords: Coarse-bed streams, critical shear stress, flow competence.

References

[1] Shields, A. (1936). "Application of similarity principles and turbulence research to bedload movement." Translated from German by W. P. Ott and J. C. van Uchelen. Hydrodynamics Laboratory Publication No. 167, California Institute of Technology, Pasadena, California.

[2] Parker, G. (2008). "Transport of Gravel and Sediment Mixtures." in Garcia, M. (ed.), Sedimentation Engineering. ASCE Manual 54, Chapter 3, American Society of Civil Engineers, Reston, Virginia.

An Investigation of Incipient Motion through the Euler-Lagrange Equations

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Abstract

In this presentation, we explore a new way to conceptualize the incipient motion condition of a single grain of sediment sitting on a river bed. Our specific research question is: given an equation of motion of a sediment particle, can a threshold quantity be found that delineates all possible reactions ending in entrainment from all other motions without resorting to an integration of the equation with a specific force time history? To date, approaches have relied on a kinetic analysis which necessarily generates an ill-formed initial value problem. Here we apply Hamilton's Principle of Least Action. This framework reveals an analytic connection between the classic force-balance (review in Dey and Ali, 2018) and contemporary impulse methods (e.g., Diplas et al., 2008, Celik et al., 2010, Valyrakis et al., 2010) of describing the initiation of sediment motion and suggests that both, under simplifying assumptions, are reduced-order descriptions of this Least Action concept. Numerical simulations performed to verify this claim suggest that much of the broadly observed "scatter" surrounding the prediction of entrainment conditions is an artifact of errors introduced through this order reduction process.

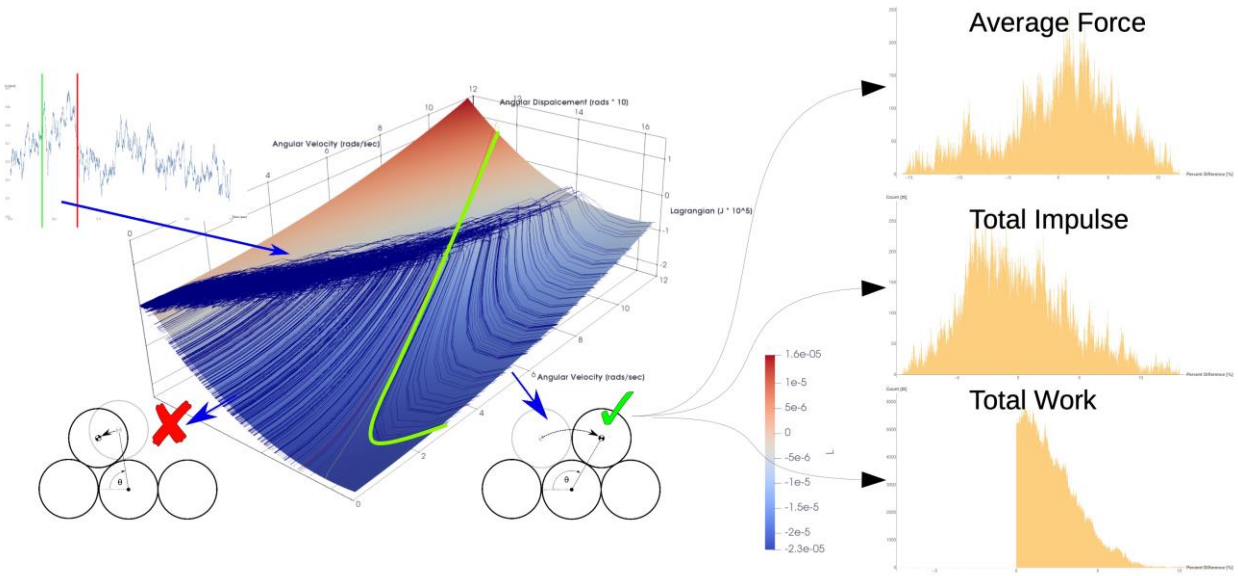

Figure. 1 Results of a numerical experiment are mapped onto the space described by the Euler-Lagrange problem. Dark blue lines are the state-space paths that each particle took under the effects of random forcing. The thin green line is the threshold condition for the Least Action principle. The three histograms to the right depict the total number of positive entrainment events from the numerical experiment. The distributions show the frequency of mobilization associated with force, impulse, or work relative to the critical value (i.e., 0% difference on the horizontal axis).

The simulations also suggest an incipient motion criteria based in the framework of Least Action could be more exact in its prediction of entrainment conditions (Figure 1). As measured stochastically from the simulations, the likelihood of this framework to predict entrainment events exceeds 0.99.

References

[1] Dey, S. and Ali, S. Z. (2018). Review article: Advances in modeling of bed particle entrainment sheared by turbulent flow. Physics of Fluids, 30(6):061301.

[2] Diplas, P., Dancey, C. L., Celik, A. O., Valyrakis, M., Greer, K., and Akar, T. (2008). The role of impulse on the initiation of particle movement under turbulent flow conditions. Science, 322(5902):717–720.

[3] Celik, A. O., Diplas, P., Dancey, C. L., and Valyrakis, M. (2010). Impulse and particle dislodgement under turbulent flow conditions. Physics of Fluids, 22(4):046601.

[4] Valyrakis, M., Diplas, P., Dancey, C. L., Greer, K., and Celik, A. O. (2010). Role of instantaneous force magnitude and duration on particle entrainment. Journal of Geophysical Research: Earth Surface, 115(F2).

Experimental study on sheet flow sediment transport of fine silt

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Abstract

Sheet flow normally happens under strong dynamics, which has attached much attention (Nielsen and Callaghan, 2003). Sheet flow plays an important role in geomorphology processes, port and waterway facilities, and ecological protection etc. Most of the studies of sheet flow focused on sand, with many experimental datasets, theories and models (Dohmen Janssen and Hanes, 2002; Ribberink et al, 2014; Tan and Yuan, 2021). There are many silty coasts in the world, such as Caofeidian sea area of Bohai Bay and Jiangsu coasts in China. Little attention is addressed to the sheet flow sediment transport of silt.

We carried out flume experiments on silt sediment (with medium sediment size of 24 μm) under waves and currents. The CCM (Conductivity Concentration Meter) and OBS (Ocean Bottom Seismometer) was combined to measure high sediment concentration from the bed bottom to water surface (Figure 1). The sediment transport was observed under different dynamic conditions, from relatively weaker to stronger wave dynamics.

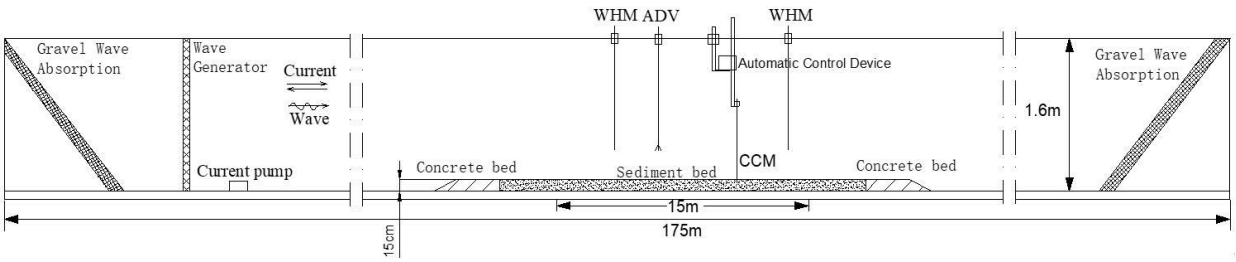

Figure 1. Sketch of the flume.

Results show that, there are ripples on the bed surface under relatively weak dynamic conditions (Figure 2), the ripples were eroded and sheet flow happens with increasing wave dynamics (Figure 3). Compared to sand, the sheet flow of silt happens easier and the thickness of the sheet flow layer is thicker. A formula for the critical conditions of sheet flow for silt sediment was proposed, which could be used for sand as well. This study helps to better understand sediment transport near the bottom of fine sediment, and is expected to be further used to explain the mechanism of sudden scouring and silting of silty coasts under storm conditions.

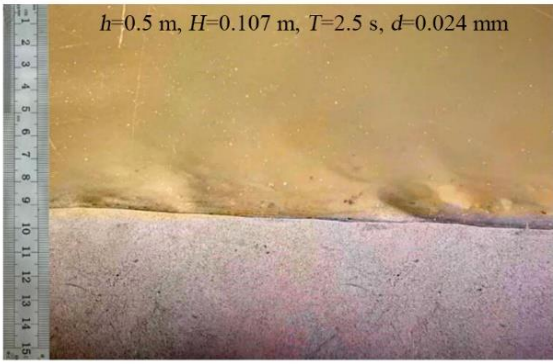

Figure 2. Ripples under weak wave conditions

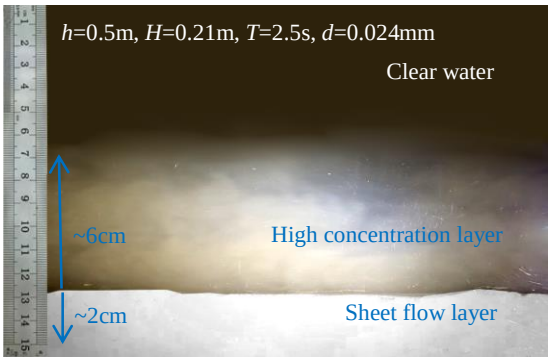

Figure 3. High concentration near the bottom under sheet flow conditions

Keywords: Fine silt; Sheet flow; Flume experiment; Wave-current

Acknowledgment

The study is financially supported by the National Key R&D Program of China (2022YFC3204302), the National Natural Science Foundation of China (No. 52071221) and National Youth Talent Funding project of China (GO222001)

References

[1] Dohmen Janssen C.M. & Hanes D.M. (2002). “Sheet flow dynamics under monochromatic nonbreaking waves”. Journal of Geophysical Research: Oceans (1978–2012), 107(C10): 11-13.
[2] Nielsen P. & Callaghan D. P. (2003). “Shear stress and sediment transport calculations for sheet flow under waves”. Coastal Engineering, 47(3): 347-354.
[3] O'Donoghue T. & Wright S. (2004). “Concentrations in oscillatory sheet flow for well sorted and graded sands”. Coastal Engineering, 50(3): 117-138.
[4] Ribberink J.S., van der Zanden J, O'Donoghue T. & Thorne P.D. (2014). “SandT-Pro: sediment transport measurements under irregular and breaking waves”. Coastal Engineering Proceedings, 1(34): 1-14.
[5] Tan W. & Yuan J. (2021). “A Two‐Layer Numerical Model for Coastal Sheet‐Flow Sediment Transport”. Journal of Geophysical Research: Oceans, 126(6): e2021J-e17241J.

Suspended sediment monitoring using acoustic backscatter in rivers

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Abstract

Following the success of the Acoustic Doppler Current Profiler (ADCP) technology for monitoring river discharge, there has been a growing interest in the last decade in extracting information on Suspended Sediment Concentration (SSC) from acoustic backscatter in rivers. One major advantage of using sonar systems such as ADCPs or Acoustic Backscatter Systems (ABSs) for monitoring SSC in rivers is the capacity of these instruments to provide measurements at a much higher spatial and temporal resolution than traditional water sampling techniques. Thanks to substantial efforts in marine science, the acoustic response of a suspension of sand particles is now relatively well understood and modeled so that accurate inversion methods can be applied [1, for a review]. Compared to marine science, the understanding of river suspension backscattering is much less advanced [2]. Solid particles may not be the predominant scatterers and the diversity of the other scatterers (bubbles, flocs, organic matters…) induces large errors [3]. The complex shape of fine sediment and the difficulty in defining their grain size is another major issue in applying inversion methods to retrieve fine sediment suspension from acoustic monitoring without calibration [4].

In this study, we explore some new possibilities offered by the down-looking deployment of a multifrequency ABS in order to obtain information on the suspension throughout an entire river cross-section. The acoustic signal was processed using multifrequency inversion methods. Both water sample calibration data and modeling were used for retrieving the acoustic properties of the suspended particles. The system was deployed at the Isère-Rhône confluence (France) with high sediment concentrations (~10 g/L). Both fine and sand SSCs throughout the river cross-section were successfully obtained, except in some areas close to the bottom where the acoustic signal was totally attenuated due to distance and high concentration of fine sediments [5]. SSC fields are presented in Figure 1, revealing the high concentrated Isère flow plunging beneath the Rhône River. This work confirms the capacity of hydro-acoustic technology for providing spatial information on river suspensions. It pushed us to develop a free software to apply this method more easily so it can be shared with a broad public.

Acknowledgment

The authors thank G. Dramais, M. Lagouy and F. Lacroix of INRAE technical staff, as well as X. Martin of the Compagnie Nationale du Rhône (CNR) for their assistance with the experimental work. Adrien Vergne's PhD was partly funded by CNR. This study contributes to the Rhône Sediment Observatory (OSR), a multi-partner research program funded through the Plan Rhône by the European Regional Development Fund (ERDF), Agence de l'eau RMC, CNR, EDF and three regional councils of France (Auvergne-Rhône-Alpes, PACA and Occitanie).

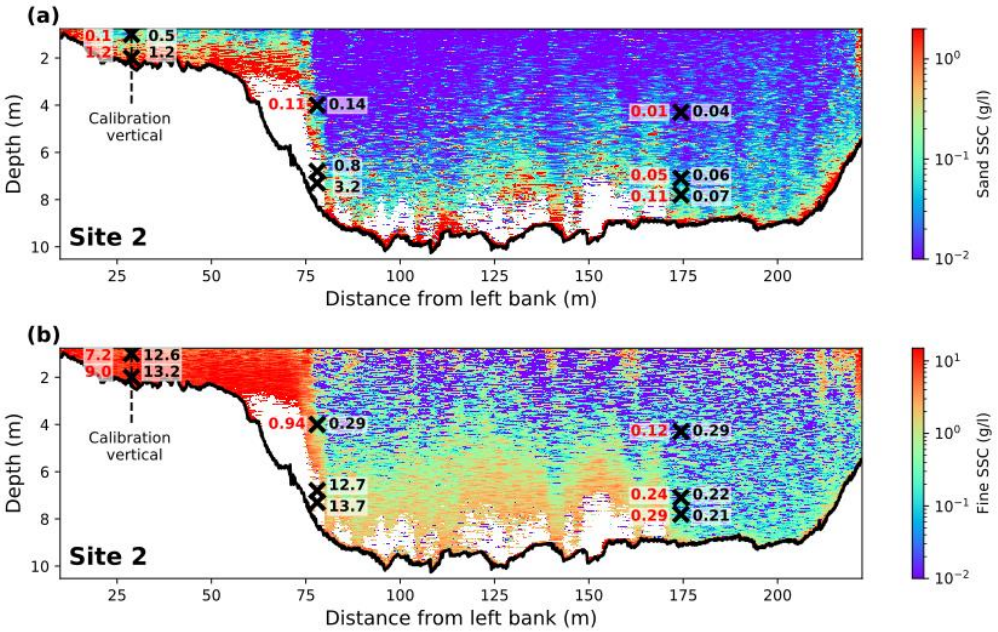

Figure.1 Inverse SSC outputs throughout a cross-section downstream of the Rhône-Isère confluence: (a) sand SSC and (b) fine SSC. Crosses show sampling locations, black labels show SSC data from water samples in g/L, and red labels show inverse SSC around the sampling point in g/L. Missing data close to the bottom of the cross section are due to high concentration of fine sediments that led to strong acoustic attenuation [from 4].

Keywords: Sediment transport, Multi-frequency acoustic backscattering, signal acoustic inversion, bimodal sediment distribution

References

[1] Thorne, P. D., & Hurther, D. (2014). "An overview on the use of backscattered sound for measuring suspended particle size and concentration profiles in non-cohesive inorganic sediment transport studies." Continental Shelf Research, 73, 97–118.

[2] Szupiany, R., Lopez Weibel, C., Guerrero, M., Latosinski, F., Wood, M., Dominguez Ruben, L., & Oberg, K. (2019). "Estimating sand concentrations using ADCP-based acoustic inversion in a large fluvial system characterized by bi-modal suspended-sediment distributions." Earth Surface Processes and Landforms, 44, 1295–1308.

[3] Vergne, A., Le Coz, J., Berni, C., (submitted). "Some backscatter modeling issues complicating the sonar-based monitoring of suspended sediments in rivers." Water Resources Research.

[4] Vergne, A., Berni, C., Le Coz, J., & Tencé, F. (2021). "Acoustic backscatter and attenuation due to river fine sediments: Experimental evaluation of models and inversion methods." Water Resources Research, 57, e2021WR029589.

[5] Vergne, A., Le Coz, J., Berni, C., & Pierrefeu, G. (2020). "Using a down-looking multifrequency acoustic backscatter system (ABS) for measuring suspended sediments in rivers." Water Resources Research, 56,e2019WR024877.

Evaluation of continuous sand flux time-series downstream of a dam during a flushing event

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Abstract

Many gravel-bed rivers in Europe are highly engineered with the presence of dikes preventing from lateral erosion and dams for hydropower purpose that strongly affect the sediment dynamics. Therefore, such rivers lost most of their dynamics and are mostly affected by fine sediments, especially sands. Sands are generally trapped in dam reservoirs but can be transported through the dams during specific events, for which dam bottom gates are opened (Lai & Shen, 1996). One significant issue is then to be able to measure the sand fluxes downstream of the dam for a sand supply-limited system over a gravel bed and for conditions beyond the recommendation limits of samplers (Gray & Gartner, 2009). Following the work of Camenen et al. (2019), the purpose of this work is to provide some experimental tools to evaluate the sand flux continuously. It was experimented during the 2021 flushing event of the Lower-Isère river dams just downstream of the Beaumont-Monteux dam, France.

The hydro-sedimentary station at Beaumont-Monteux includes a pressure gauge, a turbidity sensor and ISCO sampler; all these instruments are positioned on the right bank of the River Isère. Samples taken from the ISCO sampler were sieved at 63 µm and both fine and coarse fraction concentrations were evaluated using standard procedure. Sand fluxes throughout the river cross-section were measured thanks to suspended sand gaugings using a US-P72 or a Delft bottle sampler from a cable way located at the station. These campaigns are time-consuming however (about 3 hours), and only 13 campaigns could be achieved during the event. In addition, regular samples were taken at the dam, close to a dam gate where a homogeneous suspension could be assumed, using a balling pump.

The concentration index method (Santini et al., 2019) was proposed to evaluate the section-averaged concentration C_{sm} based on a single concentration measurement C_{sk}on the side of the river, i.e. $C_{sm} = \alpha_{sk} C_{sk}$. It was applied for both the samples taken at the dam ($C_{sm,dam}$) and near the bank ($C_{sm,ISCO}$) using sand gaugings as a reference ($C_{sm,P72}$ and $C_{sm,DB}$). By calibrating the turbidity measurements to both fine (<63 µm; $C_f = \alpha_{Tf} T$) and total (fine + sand; $C_{tot} = \alpha_{Ttot} T$) concentrations measured near the bank, we also applied the concentration index method on the sand estimates based on turbidity, i.e. $C_{sm,T} = \alpha_{sk}(\alpha_{Ttot} - \alpha_{Tf})T$. This allowed us to evaluate the sand concentration time-series during the flushing event (Figure 1). The total sand mass transported during this event was then evaluated at 1.5×10^6 tons (from 1.3 to 1.7×10^6 tons depending on the methods), which is of the same order of magnitude as the fine sediment mass transported during this event (1.9×10^6 tons). It appears that the proposed methodology is robust and relatively easy to deploy if the sampling site (on the side of the river) can capture sand suspension.

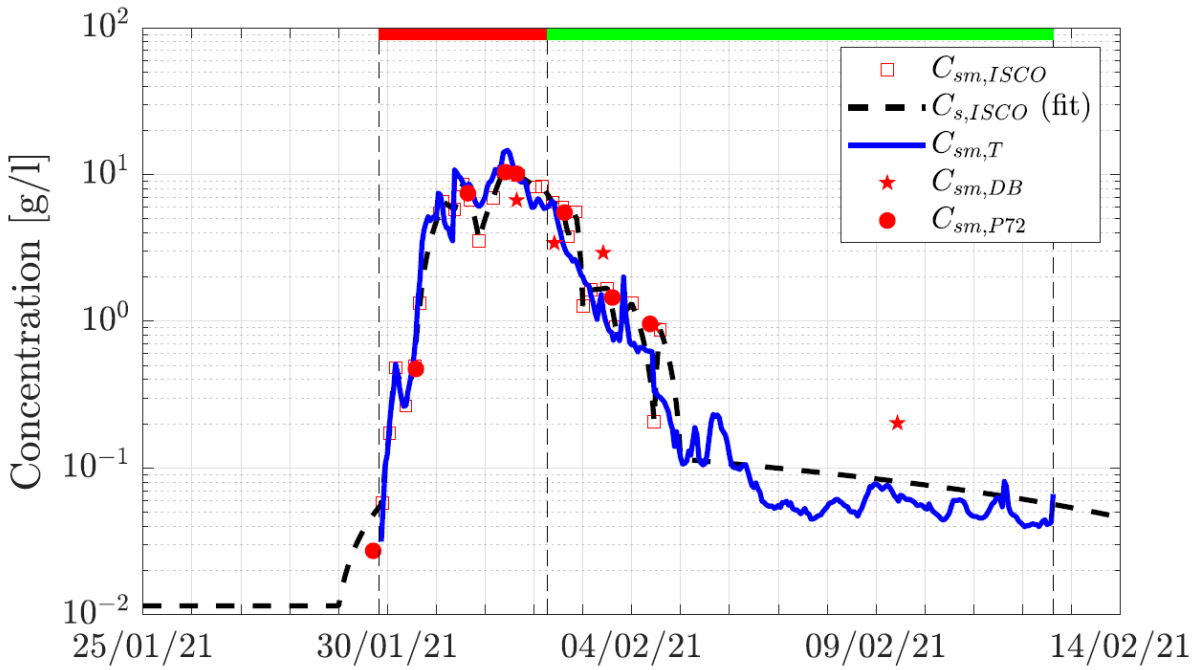

Figure.1 Sand concentration time-series of the River Isère at Beaumont-Monteux based on ISCO samples and turbidity measurements, respectively, during the 2021 flushing event; cross-section-average concentration obtained from suspended sand gaugings using US-P72 or Delft bottle samplers, respectively, are also plotted. The red and green tick lines indicate the flushing and filling periods, respectively.

Keywords: Sand flux; Index concentration; Field sampling; Turbidity; dam flushing

Acknowledgment

This study was conducted within the Rhône Sediment Observatory (OSR), a multi-partner research program funded through the Plan Rhône by the European Regional Development Fund (ERDF), Agence de l'Eau RMC, CNR, EDF and three regional councils (Auvergne-Rhône-Alpes, PACA and Occitanie)..

References

[1] Camenen, B., Naudet, G., Dramais, G. Le Coz, J & Paquier A. (2019). "A multi-technique approach for evaluating sand dynamics in a complex engineered piedmont river system." Sci.Total Environ., 657:485-497. doi: 10.1016/j.scitotenv.2018.11.394

[2] Gray, J.R. & Gartner, J.W. (2009). Technological advances in suspended-sediment surrogate monitoring. Water Resour. Res. 45, 1–20. doi: 10.1029/2008WR007063.

[3] Lai, J.S. & Shen, H.W. (1996). "Flushing sediment through reservoirs". J. Hydraul. Res. 34, 237-255. doi: 10.1080/00221689609498499.

[4] Santini, W., Camenen, B. , Le Coz, J., Vauchel, P., Guyot, J.-L., Lavado, W., Carranza, J., Paredes, M., Pères-Arévalo, J. J., Arévalo, N., Espinoza-Villar, R., Julien, F. & Martinez, J.M. (2019). "An index concentration method for suspended load monitoring". Earth Surface Dynamics, 7(2): 515-536. doi: .5194/esurf-7-515-2019.

Sediment entrainment in two urban gravel bed rivers

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Abstract

Predicting the rate and frequency of sediment entrainment within rivers is of importance from an ecological, social and engineering viewpoint and are defined by complex relationships of various variables (Feng et al, 2020). Understanding these relationships helps to explain natural river dynamics, channel stability and river management strategies (Andrews, 1983). The aim of this research is to investigate thresholds of entrainment, incipient motions and sedimentology within two large upland urban gravel bed rivers by examining various particle sizes within each river system at various time periods.

In this research an alternative method is offered utilising repeat UAV (unmanned aerial vehicles) imagery of two gravel-bed river reaches to identify individual sediments and monitor movement over an 18-month period. By observing the UAV imagery and determining whether a sediment has moved or stayed and comparing this to a maximum flow rate during the interval between surveys, derived from hydraulic modelling, a maximum local shear stress value can be established for when each grain is mobilised. Thus, establishing a threshold for mobilisation for sample of approximately 10000 sediments; exceeding many other sediment entrainment studies (Mao et al, 2007).

Figure 1. High resolution UAV imagery of the two study sites (River Kent in Kendal and the River Greta in Keswick) used in the research.

Results show that as flow increases so does the amount of sediment moved. However, sediments over a certain size (0.3 m B-Axis length) display little movement despite rising shear stress values. Shielding and exposure are shown to have a significant impact upon entrainment of these sediments. Bi-modal sediments in gravel-bed rivers can heavily impact transportation as it alters resistance and exposure to shear stress forces (Ferguson, 1994).

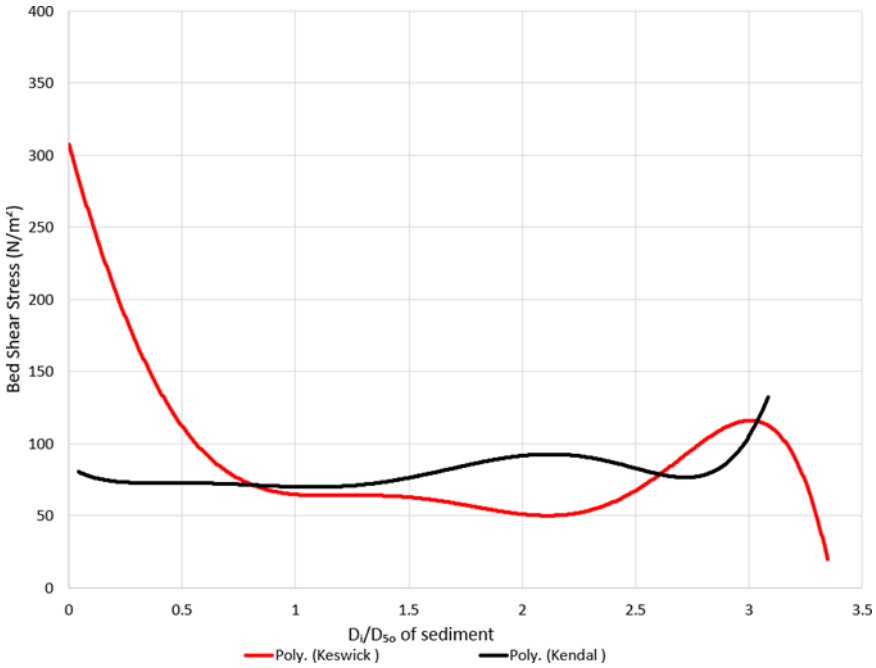

Figure 2. Bed shear stress and relative size of sediment (D_i/D_{50}) for entrained sediments within the Rivers Greta and Kent showing the significance of hiding and exposure factors.

Keywords: Incipient motion; Sedimentology; Sediment entrainment; Imbrication; Shielding and Exposure; Shear Stress

References

[1] Andrews, E. D. (1983). Entrainment of gravel from naturally sorted riverbed material. Geological society of America bulletin, 94, 1225-1231.
[2] Ferguson, R. I. (1994). Critical discharge for entrainment of poorly sorted gravel. Earth surface processes and landforms, 19, 179-186.
[3] Feng, Z., Tan, G., Xia, J., Shu, C., Chen, P., & Yi, R. (2020). Two-dimensional numerical simulation of sediment transport using improved critical shear stress methods. International journal of sediment research, 35, 15-26. Doi: 10.1016/j.ijsrc.2019.10.003
[4] Mao, L., Uyttendale, G. P., Iroume, A., & Lenzi, M. A. (2007). Field based analysis of sediment entrainment in two high gradient streams located in Alpine and Andine environments. Geomorphology. Doi: 10.1016/j.geomorph.2007.03.008

Experimental investigation on the effect of turbulence on sediment transport: set-up and preliminary results

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Abstract

In a recent paper about the state of art of 3D Numerical Modeling of local scour, Lai et al. (2022) concluded that "*it is sediment transport theory, not flow modeling, currently acting as the weakest link in accurate prediction of local scour*". That is, the effect of non-fully-developed turbulence on sediment transport is still an open problem, despite many authors performed experiments considering the effect of *modified turbulence* on bed material load. For example, Sumer et al. (2003) employed a horizontal pipe and a series of grids to induce different turbulence structures, Yang and Nepf (2018) studied the effect of the turbulence generated by the presence of different vegetation volume fractions on bed load, and Cheng et al. (2020) considered the following scenarios: unobstructed flow over a bed with fixed dunes, flow obstructed by a horizontal pipe, and flow obstructed by a vertical pipe.

We carried out a series of fixed- and movable-bed experiments at the LWI Hydraulic Laboratory (Braunschweig), in a 32-m long, 0.4-m deep, 0.6-m wide, tilting flume. Gravel (median size = 4 mm) was glued on a series of plates for a length of 17.5 m. Starting from a boundary-layer condition without any additional turbulence generator than the rough bed, we modified turbulence using different configurations of cylinders (the height was 14 cm and the diameter was 2 cm, as shown in Fig.1) screwed on a 15-cm long and 60-cm wide plate, positioned at about 11 m from the inlet. Between 10.3 and 12.8 m from the inlet, water flowed below a covering lid that ensured good visibility of the bed from above the water surface.

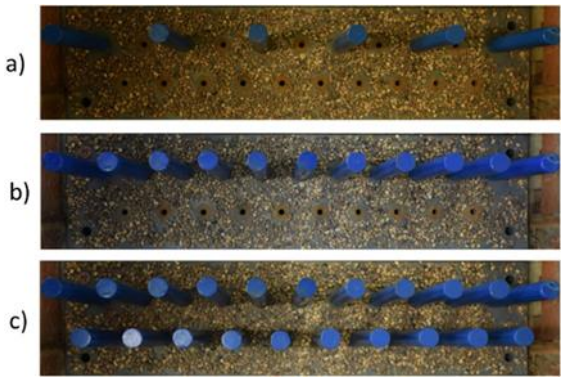

Figure 1. Turbulence generator used in the experiments, with a) 6 cylinders, b) 11 cylinders, and c) 21 cylinders in a staggered arrangement.

We performed asynchronous measurements of bed-load motion, water velocity distribution, and bed shear stress; in all three cases the testing zone was a 20 cm × 20 cm area positioned at about 70 cm downstream of the cylinders' location. The hydro-dynamic conditions were designed in order to have different turbulence structures with a same value of the mean bed shear stress. In the first case, a 1-m long, 40-cm wide, and 8-cm thick layer of sediment was positioned in the flume. The bed

elevation was measured using 4 distance sensors (Sonometer05). Furthermore, at each location, we positioned a lifting mechanism (Fig. 2a): each electrical motor moved a screw connected to a threatened sleeve, whose vertical motion enabled the sediment layer to be uplifted to ensure the mean stability of the bed elevation that tended to be reduced by the progressive entrainment of sediment. Particle motion was recorded using a camera positioned above the testing section, and videos were analysed using image-processing techniques to obtain concentration and velocity of the transported particles. Second, we performed velocity measurement using Laser Doppler Velocimetry. To ensure similarity with respect to the flow over the erodible bed (Fig. 2b), we built a porous layer of the same size, mixing gravel and epoxy resin (30:1 ratio by mass). Eventually, we took bed shear stress measurement using a shear plate (see Fig 2c) developed by Niewerth et al. (2021). The shear plate was composed of a drag force sensor (vertical cylinder) connected to a small structure that transferred the horizontal force of the fluid to the vertical cantilever beam positioned within the cylinder, thus enabling a mean shear stress acting over the plate to be determined.

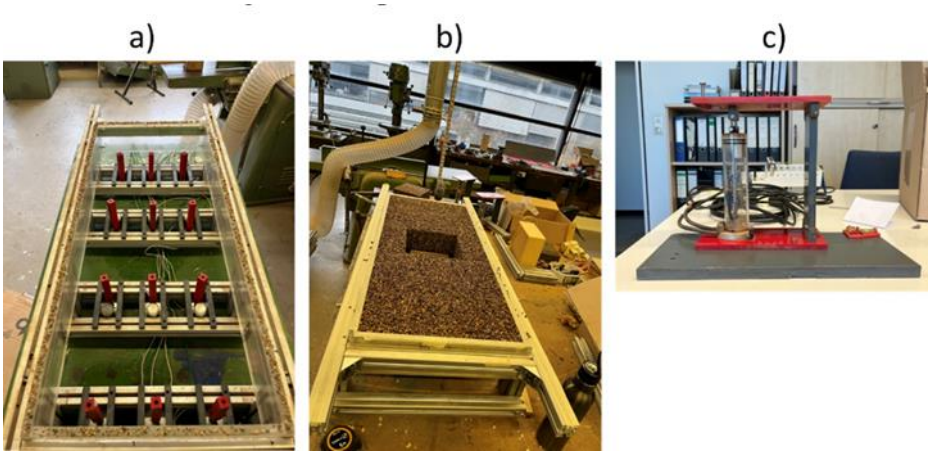

Figure 2. Different experimental components prior to installation into the flume. a) electrical motors used to adjust the sediment bed elevation in the movable-bed runs. b) fixed bed used for the flow measurements, where the hole represents the testing zone that could be filled with either another block of porous material (for Laser-Doppler measurements) or the shear plate. c) shear plate.

Keywords: Bed-load, turbulence, shear stress measurements

Acknowledgment

The present research has been financially supported by M.U.R., that funded the Ph.D. scholarship of D.R. We thank U. Ecklebe and C. David for their help in building the experimental apparatus. The assistance from J. Aliaga relative to the experiments is highly acknowledged.

References

[1] Cheng, Nian-Sheng & Wei, Maoxing & Chiew, Yee-Meng & Lu, Yesheng & Emadzadeh, Adel. (2020). Combined Effects of Mean Flow and Turbulence on Sediment Pickup Rate. Water Resources Research. 56. 10.1029/2019WR026181.

[2] Lai, Yong & Liu, Xiaofeng & Bombardelli, Fabián & Song, Yalan. (2022). Three-Dimensional Numerical Modeling of Local Scour: A State-of-the-Art Review and Perspective. Journal of Hydraulic Engineering. 148. 10.1061/(ASCE)HY.1943-7900.0002019.

[3] Niewerth, S., Núñez-González, F., Llul, T., & Lempa, S. (2021). A Novel Shear Plate for Direct Measurements of Bottom Shear Stress Induced by a Model Ship Propeller. Publications of the Institute of Geophysics, Polish Academy of Sciences; Geophysical Data Bases, Processing and

Instrumentation, 434(E-11), 47–49. https://doi.org/10.25171/instgeoph_pas_publs-2021-016

[4] Sumer, B. & Chua, Lloyd & Cheng, Nian-Sheng & Fredsoe, Jorgen. (2003). 2003 Influence of Turbulence on Bed Load Sediment Transport. Journal of Hydraulic Engineering, 129. 10.1061/(ASCE)0733-9429(2003)129:8(585).

[5] Yang, Judy & Nepf, Heidi. (2018). A Turbulence-Based Bed-Load Transport Model for Bare and Vegetated Channels. Geophysical Research Letters. 45. 10.1029/2018GL079319.

Laboratory investigation on the evolution of silty beach profile beneath the piled wharf considering ship berthing

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Abstract

Pile wharfs are developing rapidly and extensively on the coast of China (Wang & Wen,2001) because of their good adaptability to soft soil foundations (especially on silty-clayey coast). However, there is a serious sediment deposition under and in front of the wharf and it would pose a risk to the security of wharfs (Li & Hou, 2016) or ships and block the channel. In terms of coastal sediment transport, it is simply divided into two directions: longshore and cross-shore sediment transport (Dean & Dalrymple, 2001). Some scholars have shown that the reason for the sediment deposition problem under the pile wharf is that the pile foundation would change the tidal current or wave-induced current movement under the wharf. In this paper, the influence of wharf structure and ship berthing on cross-shore sediment transport below the pile wharf was discussed by the laboratory wave flume experiment.

The experiment was conducted in a 60 m long, 2.0 m wide, and 1.8 m deep wave flume. The sediment used in this experiment was natural silt sand with a median diameter D_{50} = 0.038 mm. The experimental measuring instruments included wave gauges, acoustic doppler velocimeter (ADV) and near-bottom sediment concentration measuring instrument (ASM). The specific shape of the experimental beach profile (see Figure.1) and the hydrodynamic conditions such as water level and wave condition were based on the measured data of a pile wharf in China. According to the wave-maker system ability and the maximum working water depth of the experimental wave flume, the scale of the model in this experiment was determined as: $\lambda_l = \lambda_h = 1/20$; $\lambda_t = \sqrt{\lambda_h} = 1/4.47$. The experimental conditions are shown in Table 1. The wave effect of each test condition lasted for one hour. Time series of water surface elevations, current velocity and sediment concentration were collected. The initial, intermediate (after wave action 30 minutes) and final beach profile data were also recorded by using a Laser rangefinder.

Based on the data, it was found that on account of the particle size of sediment being finer, most of the sediment particles were mainly suspended. Under the action of undertow caused by wave breaking, sediment was transported and deposited offshore and very few coarse particles in the experimental sediment were dominated by bedload motion and tend to be transported to the shore. When only the wharf structure existed, the average wave height $\bar{H}$ on the beach of the region a (see Figure 1 upward) decreased by 40.9 %. Ship berthing could significantly reduce the wave energy at the region a, and $\bar{H}$ is reduced by 28.5 % ulteriorly. With the influence of pile wharf structure and ship berthing, most of the sediment would fall below the wharf panel because of the existence of the two. However, the decrease of wave energy would cause deposition in the partial area such as the junctional zone between regions a and b (see Figure. 1 below) of the profile, and the total sediment volume still decreased when the offshore sediment transport was considered.

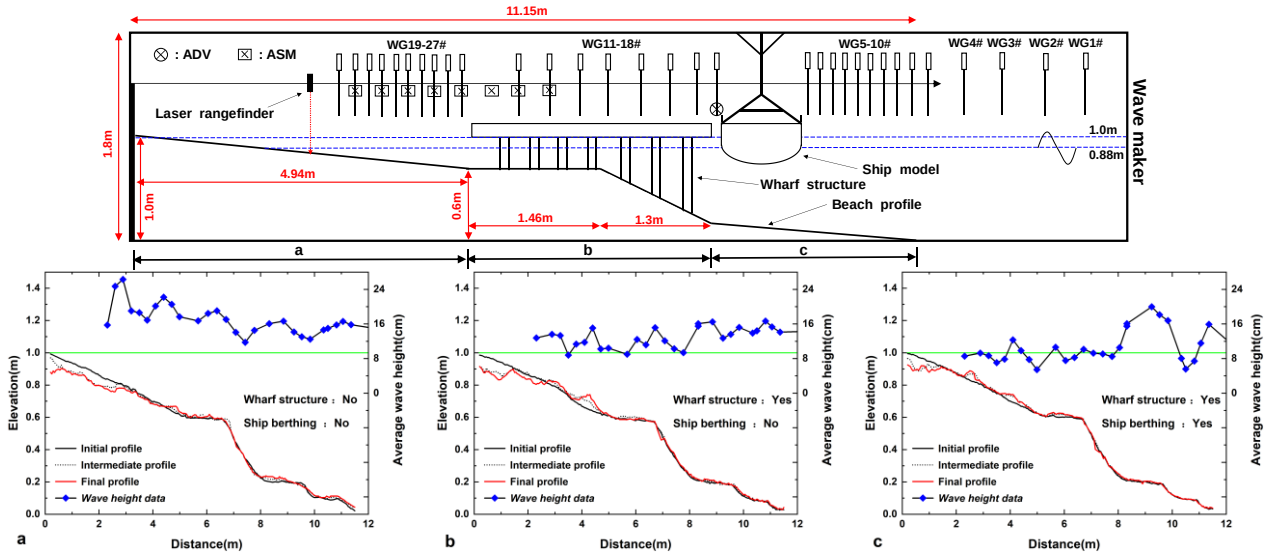

Figure.1 The beach-wharf-ship system setup (upward); Wave height distribution for extreme high water level (below).

Table 1. Test conditions (case number "R" represent the regular wave; "IR" represent the irregular wave; "✕" or "✔" denote the existence of the structure)

Case	Wave height(cm)	Wave period $\bar{T}(s)$	Water lever(m)	Wharf structure	Ship berthing
R1-R10 R13-R17	$\bar{H}$ =5, 7.5, 10, 12.5, 15	1.5, 2, 2.5	0.88	✕	✕
R11	$\bar{H}$ =15	2	1	✕	✕
IR12	H_S =21.2	2	0.88	✕	✕
R18-R27 R30-R34	$\bar{H}$ =5, 7.5, 10, 12.5, 15	1.5, 2, 2.5	0.88	✔	✕
R28	$\bar{H}$ =15	2	1	✔	✕
IR29	H_S =21.2	2	0.88	✔	✕
R35-R44 R47-R51	$\bar{H}$ =5, 7.5, 10, 12.5, 15	1.5, 2, 2.5	0.88	✔	✔
R45	$\bar{H}$ =15	2	1	✔	✔
IR46	H_S =21.2	2	0.88	✔	✔

Keywords: silty coast; pile wharf; sediment deposition; ship berthing

Acknowledgment

The authors would like to express appreciation for the support of the sponsors [Grant Number: 2021YFB2601100].

References

[1] Jianbo, W., & Xuesong, W. (2001). "Pile foundation wharf and its development trend." Chian Water Transport, 02,41-42(in Chinese).

[2] Rongqing, L., & Yongwei, H. (2016). "Three-dimensional finite element analysis of pile supported wharf considering sediment deposition." Port & Waterway Engineering, 520,95-99.

[3] Dean, R. G., & Dalrymple, R. A. (2001). "Coastal Processes with Engineering Applications." Chapter 8. Cambridge University Press.

An update of the *in-situ* coastal experiment to continue assessing the performance and design of geotextile sandbag structure

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Abstract

Storm-induced coastal erosion is one of main natural hazards in China, along which 70% of Chinese largest cities are located and more than 50% of the Chinese population live and work. How to protect the valuable coastline form extensive erosion is of enormous economic and social values. In the meanwhile, the failure of traditional coastal protection measures could accelerate the erosion of beach, especially during the storm surge events [1]. Over the past decades, geotextiles have been extensively used in coastal engineering [2] because of the low- cost and simple-construction [3]. However, the design of geosystems is often based on rather vague experience than on generally accepted calculation methods. Previous studies focus on the hydrodynamic characteristics of the single sandbag with the implementation of physical model experiments [4], and the design parameters of stability of sand-filled geosystems under wave loading were discussed, in which the degree of filling, the properties of the material, and the friction properties of geotextile. And the existing equation of geotextile sand containers has been verified for the stability analysis in the laboratory experiments, but it is lack of evaluation of sandbags structure performance in the field conditions, in particular during extreme wave conditions. In the previous study, the protection performance of geotextile sandbag structure (GSS) had been evaluated in terms of material duration and the stability of the structure on the erosive coast of Chudao [5] and the results have shown that geosystems could be an alternative to conventional coastal structures, and the use of the high-strength and durable geogrids, which are used to wrap several layers of sandbags together as a large geotextile tube, has significantly increased the stability of the sandbag revetment. Furthermore, flat polypropylene woven fabric is more suitable for the out layer of the sandbags in the shoreline protection. However, there is still a lack of reasonable design parameters for GSS.

In this study, the experimental station has been restored with three new test segments (S4, S5 and S6) in different geotextile material, geogrid and design height, to continuously assessing the performance of geotextiles sandbags and design parameters. There are two types of geotextile bags used for this *in-situ* station (Tab 1). All the test sections were reinforced with geogrids and the top elevation of the test segments in Figure 1 was designed to be 2.75 (m, MSL) which was maximum height of the wave runup measured in the field during the past two years. The test segment-4 in Figure 1 has more than three sand-bags laid horizontally in one- layer with a width of 1.4~2.1m. The test segment-5 has only a single-layer sandbag with a width of about 0.7m, but an eco-bag (containing vegetation seeds) is newly introduced to assess the feasibility of revetment with vegetation. The test section-6 has two layers of sandbags wrapped with the geogrid with a width of 0.7m.

Before and after the *in-situ* station has been built, the essential field data are collected: 1) monthly survey of 9 permanent beach profiles on protected and unprotected shorelines with RTK-GPS and collection of the sand samples for analysis; 2) collection of hydrodynamic data with Acoustic Doppler Current Profiler (ADCP) from a gauge less than 600 m apart from the station; 3) monthly monitoring stability of the three segments. At the same time, the numerical simulation of wave near-coastal

propagation is carried out by using the three-dimensional hydrodynamic transport model SWAN. According to the field observation, friction properties at geotextile interfaces play an important role in the stability of GSS, and the existing sandbag stability equation has its limitations, which overestimates the design size of sandbag. And then, the general stability equation of geotextile sandbag structure is derived to satisfy coastal protection schemes. The characteristic curves compared with the existing equations are also obtained between the design length of the sandbag and the wave height.

Table 1. Main characteristics of geotextile bags

Material property	Main material	Mass/m^2	Longitude strength	Latitude strength	Opening size	Raw material
Surface bag outerlayer Type-I	Flat polypropylene wovenfabric	≥ 180 g/m^2	35 KN/m	25 KN/m	0.1 mm	UV polyester
Eco-bag (containing vegetation seeds) Type-II	Polyesterneedle-punched fabric	≥ 200 g/m^2	6.5 KN/m		0.12 mm	UV polyester

Figure 1. the three in-situ test segments (S4, S5, S6)

Keywords: geotextile sandbag, coastal protection, beach profiles

References

[1] Oh, Y. I. and E. C. Shin (2006). "Using submerged geotextile tubes in the protection of the E. Korean shore." Coastal Engineering 53 (11): 879-895.
[2] Corbett, B. and N. Wellford, et al. (2016). Case Study: Stabilisation of a Rapidly Eroding Point Using an Insitu-Filled Geotextile Container Groyne Field. 35th International Conference on Coastal Engineering.
[3] Neves, L. D. and M. L. Lopes, et al. (2009). "Experimental Stability Analysis of Geotextile Sand-filled Containers for Dune Erosion Control." Journal of coastal research SI (56): 487-490.
[4] Elias, T. and K. G. Shirlal, et al. (2021). "Physical model studies on damage and stability analysis of breakwaters armoured with geotextile sand containers." Geotextiles and Geomembranes 49 (3): 604-618.
[5] Li, Y. and Z. You, et al. (2023). "Quantitative assessment of the shoreline protection performance of geotextile sandbags at an in-situ coastal experimental station." Geotextiles and geomembranes.

Turbulent Characteristics of Flow in Wide and Narrow Alluvial Channels

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Abstract

Based on the generalized Physical Model, experimental studies were conducted on both narrow and wide channels to measure the three-dimensional instantaneous velocity using the acoustic Doppler velocimeter. The data obtained were then analyzed to compare the distribution of stream-wise velocity, Reynolds shear stress in wide and narrow channel. Further studies were conducted employing quadrant analysis, to reveal the flow characteristics. The results of the studies, for wide and narrow channel are then compared to understand the difference in flow behaviour in both scenarios. The results confirmed that the streamwise velocity gradient of near the bank of narrow channel is steeper than that measured at bank of wide channel. Similar observation can be made for normalized transverse velocity profiles, depthwise velocity profiles and Reynolds Shear Stress profiles. The transverse velocity profile and depthwise velocity profile of the wide channel have been observed to be of the positive values whereas, it has been found to be negative values for the narrow channel. Analysis of bed shear stress at bank of narrow and wide channel confirmed that the bed shear stress for wide channel near the bank is much higher than the narrow channel. Quadrant analysis reveals that contribution of all the events decrease progressively with an increase in hole size. It was also observed that when the hole size 'H' becomes large, only contributions due ejections Q2 and sweeps Q4 exists. Thus, predicting that the ability of sediment to get transport as bedload is more near the bank in both narrow and wide channel due to rush of high streak flow towards the bed causing higher momentum exchange near the bed.

This study examines the nature of turbulence and morphological changes in a narrow channel as compared to a wide channel. This will help understand the hydrodynamic behavior of the flow in a deep channel.

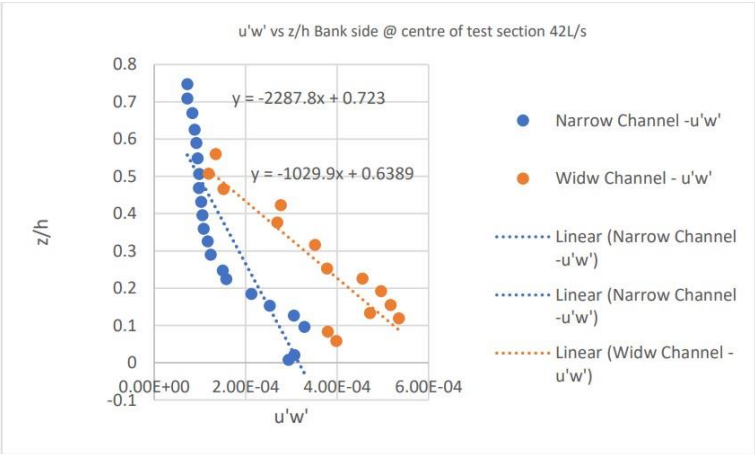


Figure 4: Reynolds shear stress for Narrow bed cannel and Wide bed channel

The Reynolds shear stress near the bank for wide channel is 1.5 times higher than the narrow channels. The bed shear stress for narrow channel is found to be 0.00032 (m^2/s^2) while for wide channel is 0.00062 (m^2/s^2). Thus, confirming that the bed shear stress for wide channel near the bank

is 93.75 % higher than the narrow channel. The bedload transfer will be more near the bank of narrow channel than in wide channel.

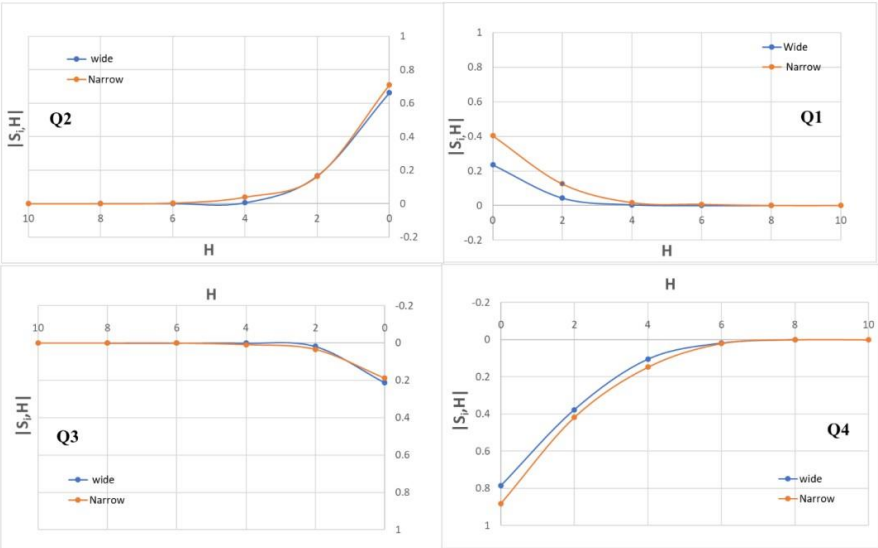


Figure 5: Distributions of |Si, H| as a function of hole size (H) at the near bed region in narrow and wide channel flow

Keywords: Wide Channel, Narrow Channel, Reynolds shear stress, Quadrant analysis

References

[1] Bai, Y., Ji, Z., & Xu, H. (2012). Stability and self-adaption character of turbulence coherent structure in narrow-deep river bend. Science China Technological Sciences, 55(11), 2990–2999. https://doi.org/10.1007/s11431-012-4977-4

[2] Goring, D. G., & Nikora, V. I. (2002). Despiking acoustic doppler velocimeter data. Journal of Hydraulic Engineering, 128(1), 117–126. https://doi.org/10.1061/(ASCE)0733- 9429(2002) 128:1(117)

[3] Kara, S., Stoesser, T., & Sturm, T. W. (2012). Turbulence statistics in compound channels with deep and shallow overbank flows. Journal of Hydraulic Research, 50(5), 482–493. https://doi.org/10.1080/00221686.2012.724194

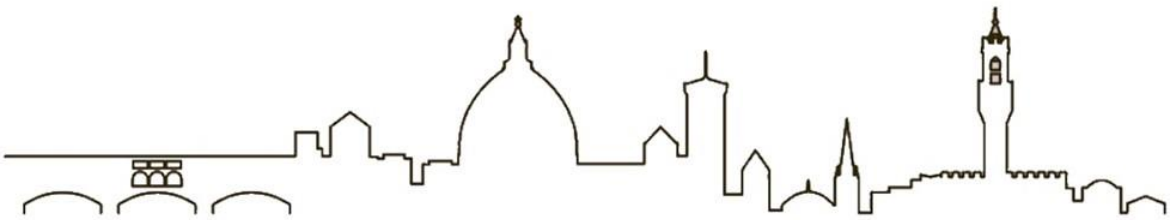
[4] Li, X., Zhong, D., Zhang, Y. J., Wang, Y., Wang, Y., & Zhang, H. (2018). Wide river or narrow river: Future river training strategy for Lower Yellow River under global change. International Journal of Sediment Research, 33(3), 271–284. https://doi.org/10.1016/j.ijsrc.2018.04.001

[5] Qin, F., Tao, G., Liu, W., Wu, C., Qi, L., & Li, J. (2020). Comparative Study on Energy Dissipation Numerical Simulation of Different Energy Dissipators in Wide and Narrow Alternated Channels. IOP Conference Series: Earth and Environmental Science, 526(1). https://doi.org/10.1088/1755-1315/526/1/012109

[6] Sharma, A., & Kumar, B. (2018). High-Order Velocity Moments of Turbulent Boundary Layers in Seepage Affected Alluvial Channel. Journal of Fluids Engineering, Transactions of the ASME, 140(8), 1–8. https://doi.org/10.1115/1.4039253

Topic 2:

Morphodynamics



Derivation and Evaluation Empirical Formulae for Geometric Characteristics of Meandering

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Abstract

One of the common techniques for river restoration within meandering reaches is creation meander until reach to the equilibrium state to achieve stabilization of river alignment and to recover its environmental value. In present research, an experimental study was conducted to derive new empirical formulae relating the geometric characteristics of the meandering at the equilibrium state. Through the experimental work, a series of forty eight experimental runs have been carried out through combining different hydraulic and geometrical parameters at different conditions. The experimental runs conducted for free meandering evolution until achieving the state of equilibrium. Sixteen new power form formulae have been created via regression analysis with determination coefficients ranged between 0.83 and 0.97, classified into four sets depends on the initial channel geometry. These empirical formulae include the essential practical parameters involved, channel width and meandering characteristics (wave length, belt width, and radius of curvature). The derived formulae have been evaluated using the standard error of estimate as a statistical indicator. The new derived formulae showed reasonable agreement with measured characteristics compared with more attempting formulae which proposed by Leopold and Wolman's (1960) and Williams (1986).

The present study aims to presenting new formulae for calculating the geometric features of river's meandering by providing experimental data through laboratory work on a physical model. The proposed formulae considered as a useful tool can be implemented for estimation the equilibrium alignment of meandering river which needs in the restoration works.

The experiments were carried out in a concrete flume having length= 7 m, depth=0.22 m, and width= 1.5 m. The water is circulated by centrifugal pump, with discharge levels being determined by calibrated flow meter. The discharge is varied by a controlling valve which can be controlled manually by means of a leveras shown in Figure .1.

Forty eight experimental runs at different conditions have been conducted in this study. Different initial incised and wide channel for rectangular and trapezoidal sections, four flow rates, and two initial sand slopes, were combined to make various experimental conditions, as listed in Table 1.

Figure.1 (a) initial Straight channel with an initial bend (b) the experimental flume from the side with water supply system

Table 1. Experimental conditions

Discharge(l/sec)	Initial bed Slope	Initial Channel cross section	No. of Experimental run

1.33 3 4 5	0.005 0.01	Initial incised rectangular and Trapezoidal channels Width/bank depth < 5	24 (12-runs for each shape)
1.33 3 4 5	0.005 0.01	Initial wide rectangular and Trapezoidal channels Width/bank depth > 5	24 (12-runs for each shape

Keywords: Meandering; Wave length; Belt width; Radius of curvature; River geometry; Empirical formulae

Acknowledgment

The authors would like to express appreciation for the support of the staff member of Hydraulic Laboratory in Civil Engineering Department, University of Technology, through the preparing of physical model equipped with all measuring devices.

References

[1] Auel, C., Albayrak, I., and Robert M. Boes. (2013)" Turbulence Characteristics in Supercritical Open-Channel Flows: Effects of Froude Number and Aspect Ratio. Journal of Hydraulic Engineering.
[2] Bridge J. (2003). Rivers and Floodplains - Forms, Processes and Sedimentary Record, Blackwell Science Ltd, Oxford, UK; 504 pp., ISBN 0632064897.
[4] Maatooq, J. S., and Mahmoud, E. S. (2018). "Local Scour around Single Central Circular Bridge Piers Located Within 180o Bend" ARPN Journal of Engineering and Applied Sciences, 13(5), 1639-1648.
[5] Maatooq J.S., Hameed L. (2019) “Identifying the pool-point bar location based on experimental investigation” Journal of Water and Land Development. No. 43 (X–XII), 106–112. DOI: 10.2478/jwld-2019-0068.
[6] Maatooq J.S., Hameed L.K. (2020) “2D Model to Investigate the Morphological and Hydraulic Changes of Meanders” Engineering and Technology Journal, 38 Part A(1), 9-19, DOI: https://doi.org/10.30684/etj.v38i1A.95.
[8] Nezu, I., and Rodi, W. (1985). “Experimental study on secondary currents in open channel flow.” Proc. 21st IAHR Congress, Melbourne, Australia, 114–120.
[9] Park, Y. P., Chang, K. A., Chen, H.C., Briaud, J. L., (2009). Maximum migration distance of a meander channel in sand using a hyperbolic function approach. J. Hydraulic Eng. 135(8), 629–639.
[11] Rinaldi, M. and Johnson. A. (1997). "Stream meander restoration". Journal of the American water resources association. Vol. 33, No.4. :855-866.
[12] Rosgen, D.L. (1994). A classification of natural rivers. Catena 22, 169–199.

Hydraulic characteristics and simulation of river ice processes in the Yellow River

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Abstract

Because of the influence of human activities and climate change in recent decades, the ice situation in the Inner Mongolia reach of the Yellow River has taken on new characteristics, with abrupt river ice phenomena appearing frequently (Guo et al., 2018, 2021). There is an urgent need to establish a numerical model of dynamic ice regime development that can reflect the physical characteristics of the progress of river ice.

However, due to limited field data on river geometry and hydrological and meteorological information, predicting ice processes in rivers during winter periods using numerical simulation is challenging (Wang et al., 2021). Based on measured data, this study explored the temporal and spatial variations of ice conditions in the Inner Mongolia section of the Yellow River, solved the challenges of incomplete channel and tributary flow data, determined the location of ice bridges, and determined the relevant thermal and dynamic coefficients according to the ice conditions of the Yellow River. A one-dimensional ice condition numerical model was used to simulate the ice condition development process during the ice flood period from 2012 to 2013. Based on the solution of the problem of partial incompleteness of hydrological and meteorological measurement information, the simulated values of water temperature, ice thickness, ice front progression, and discharge agree with the measured values, (Figure 1-3). The hydrodynamic characteristics were analyzed during river ice processes in the Yellow River. This research provides a scientific basis and a method of support for the prevention of ice disasters in the Yellow River and provides research directions and technical means for the simulation of ice conditions for all processes in natural rivers and artificial channels.

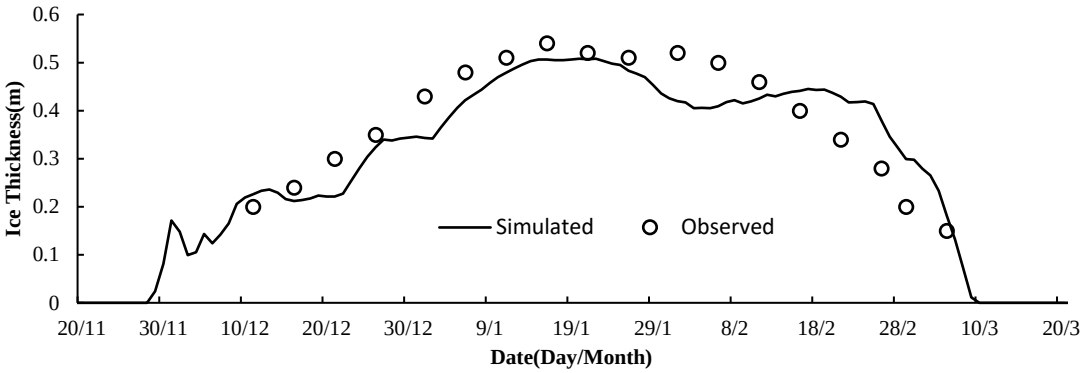

Figure 1. Development process of ice thickness at the Sanhuhekou hydrological station

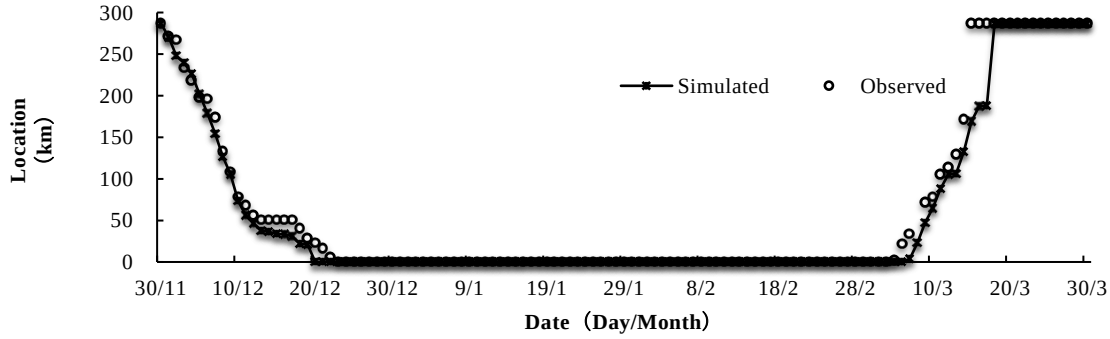

Figure 2. Simulated and observed ice front progression

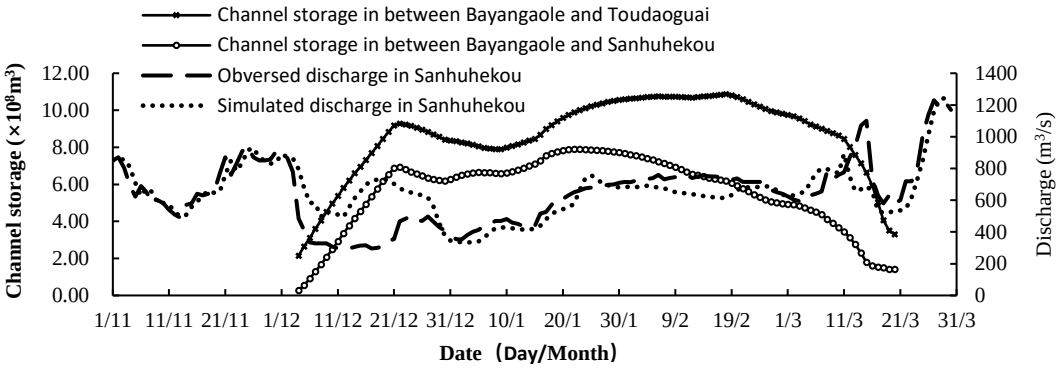

Figure 3. Comparison of the Sanhuhekou discharge simulation and channel storage change in the Inner Mongolia reach

Acknowledgements

The authors would like to thank the Second Tibetan Plateau Scientific Expedition and Research Program (2019QZKK020706), National Natural Science Foundation of China (grant numbers U2243221, U2243239, 51979291, 52009144), IWHR (China Institute of Water Resources and Hydropower Research) Research & Development Support Program (HY110145B0012021, HY0145B032021), and Independent Research Project of State Key Laboratory of Simulations and Regulation of Water Cycle in River Basin (SKL2022TS04). The authors also appreciate the support from the Hydrographic Bureau of the Yellow River Conservancy Commission in providing hydrological and meteorological data.

References

[1] Guo, X. L., Wang, T., Fu, H., Guo, Y. X., Li, J. Z.(2018). “Ice-jam forecasting during river break up based on neural network theory”. J. Cold Reg. Eng. 32, 04018010, doi: 10.1061/(ASCE)CR.1943-5495.0000168.

[2] Guo, X. L., Wang, T., Fu, H., Pan, J. J., Lu, J. Z., Guo, Y. X., Li, J. Z.(2021). “Progress and trend in the study of river ice hydraulics”. China. J. Theor. Appl. Mech. 53, 655–671, doi: 10.6052/0459-1879-20-407.

[3] Wang, T., Guo X. L., Chen Y. Z., Liu J. F., She Y. T., and Pan J. J. (2021). “Numerical modeling of winter ice process in natural rivers with limited data”. J. China Institute of Water Resources and Hydropower Research, 19(1), 138–147, doi: 10.13244/j.cnki.jiwhr.20200137.

Storm-driven sedimentation sustains the accretion of salt marshes and shapes their topography

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Abstract

Salt marshes are intertidal coastal landforms which support valuable ecosystem services but the fragile equilibrium on which their existence relies is challenged by sea-level rise and climate change (Kirwan & Megonigal, 2013). Salt-marsh resilience to sea-level rise depends on the relationship between marsh elevation, relative sea-level changes and sediment supply (French and Stoddart, 1992; Kirwan et al., 2010). Episodic sedimentation pulses may alter the sediment budget made available by the everyday tidal flooding, thus influencing the elevation of mars platforms and their response to future sea-level rise (Tognin et al., 2021). Understanding the morphodynamic processes that control sedimentation and offset marsh drowning is of utmost importance to preserve salt marshes and the ecosystem services they deliver.

To shed light on the temporal and spatial dynamics of sedimentation on salt marshes, we monitored sediment supply at event and monthly time scale through field observations in the salt marshes of the Venice Lagoon, Italy (Figure 1). Sediment accumulation was measured by collecting sediment settled in sediment traps deployed in 72 measurement stations, grouped in 12 transects.

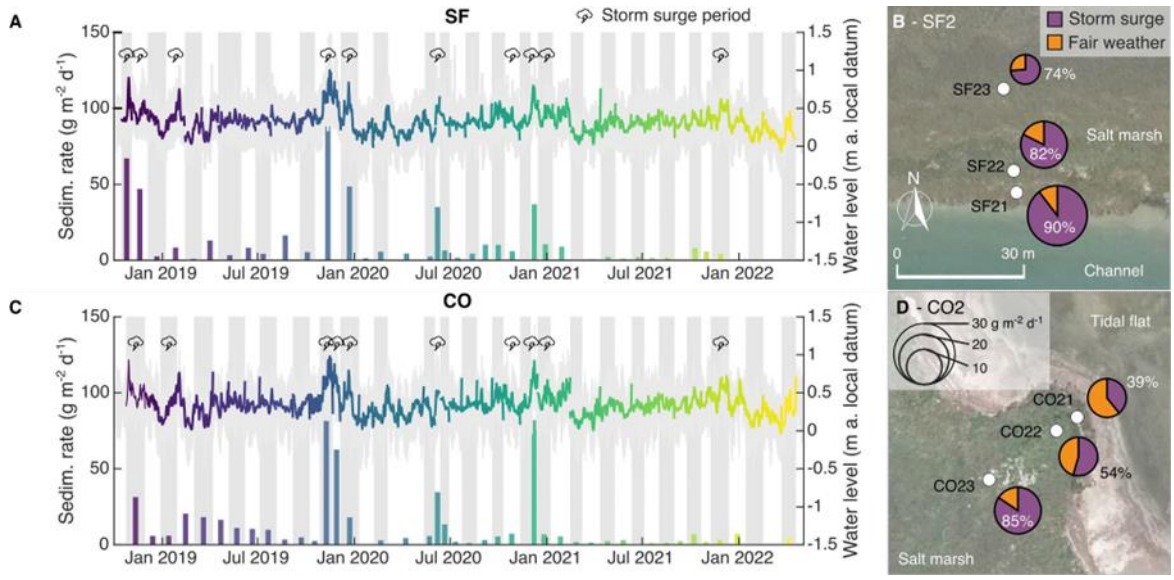

Figure 1. Salt marsh spatial and temporal sedimentation dynamics. Sedimentation rate (bar) and daily water level (line) for the San Felice-SF (A) and Conche-CO (C) study areas. Cloud symbols indicate storm periods. Sedimentation associated with storm surges (purple) and fair-weather conditions (orange) in transect SF2 (B) and CO2 (D). Pie chart diameter is proportional to the mean sedimentation rate.

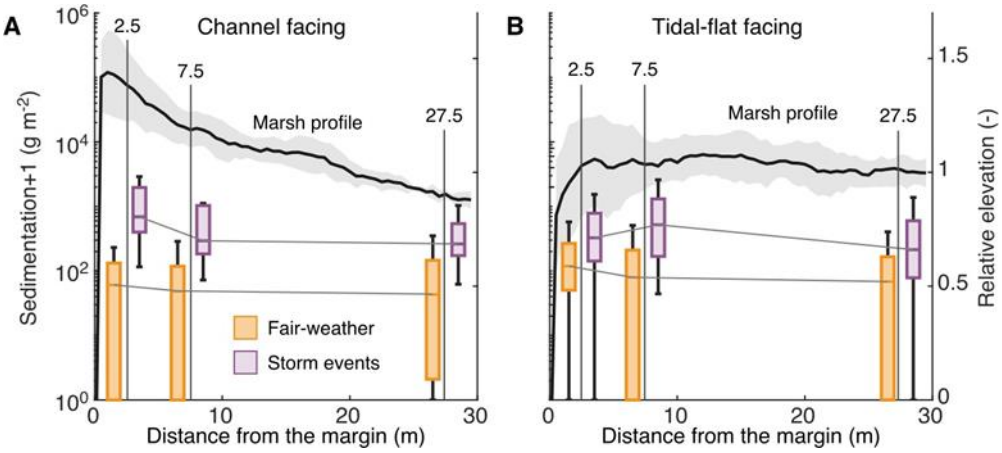

Figure 2. Sedimentation and topographic profiles of transects facing a channel (A) and facing a tidal flat (B). Sedimentation related to fair weather is in orange, to storm surge events is in purple.

Measurements carried out from October 2018 to March 2022 reveal that sediment accumulation rates greatly vary over time, largely depending on marsh flooding (Figure 1A,C). On average, sediment settled during storm surges account for about 70% of the total annual sedimentation, even though storm duration rarely exceeds 25% of the time (Figure 1B,D). Moreover, differences in the spatial pattern of sedimentation can be observed depending on marsh exposure (Figure 2). On marshes bordering channels, sedimentation rapidly decreases with the distance from the marsh margin (Figure 2A). On the contrary, sedimentation on marshes facing tidal flats displays an inland displacement of the maximum sedimentation, likely associated with the action of the wind waves (Figure 2B). These two different spatial sedimentation patterns result in two different topographies: levee-shaped on marshes facing channels and with more gentle sloping on marshes facing tidal flats.

Our results highlight that storm-driven sedimentation substantially contributes to the sediment budget of salt marshes and shapes their morphology.

Keywords: Salt marshes; Storm surges; Tide; Sedimentation; Marsh Topography

Acknowledgment

The authors thank the technical staff of the Department of Biology and the Department of Geosciences, University of Padova, for fieldwork and laboratory analysis support.

References

[1] Kirwan, M. L., & Megonigal, J. P. (2013). Tidal wetland stability in the face of human impacts and sea-level rise. Nature, 504(7478), 53-60.
[2] French, J. R., & Stoddart, D. R. (1992). Hydrodynamics of salt marsh creek systems: Implications for marsh morphological development and material exchange. Earth surface processes and landforms, 17(3), 235-252.
[3] Kirwan, M. L., Guntenspergen, G. R., D'Alpaos, A., Morris, J. T., Mudd, S. M., & Temmerman, S. (2010). Limits on the adaptability of coastal marshes to rising sea level. Geophysical research letters, 37(23).
[4] Tognin, D., D'Alpaos, A., Marani, M., & Carniello, L. (2021). Marsh resilience to sea-level rise reduced by storm-surge barriers in the Venice Lagoon. Nature Geoscience, 14(12), 906-911.

Using Terrestrial Laser Scanner To Validate The Performance Of Low-Cost UAV On A Monitoring Sedimentological Change In An Urban Channel

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Abstract

Soil erosion is one of the main physical processes impacting the stability of stream banks and altering riverbed morphology [1]. Riverbank erosion can lead to the widening of channels and the increase of sediments in the channel bed, leading to siltation. The human activity on the environment interferes and accelerates sediment generation and displacement, either due to the removal of native vegetation, leaving its surroundings without natural protection, or caused by increasing surface runoff due to soil sealing [2, 3]. The most accurate method for measuring erosion is 3D laser scanning. Laser scanning allows the measurement of millions of points with millimeter accuracy [4,5]. Unmanned Aerial Vehicles (UAV) offer a remote sensing alternative for high temporal and spatial resolution mapping. UAV is a low-cost option compared to other data acquisition methods (e.g., total station surveying, manned photogrammetry, and airborne laser).

The Geomorphic Change Detection (GCD) analysis (Figure 1) using high-resolution DEM was conducted following the methods presented by Wheaton [6] (http://gcd.riverscapes.xyz/).

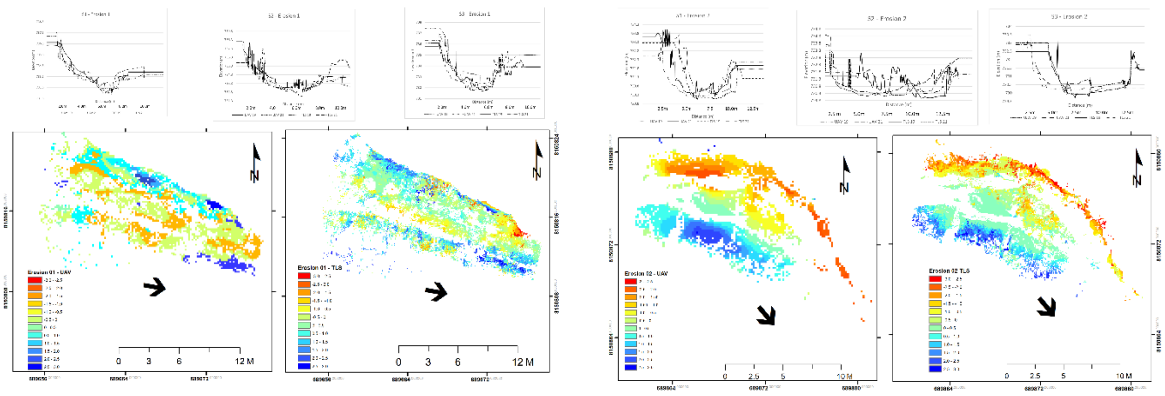

Figure.1 Analysis in two riverbank erosion located on the urban channel Barreiro brook, using UAV and TLS data.

The volumetric changes in the monitored areas pointed to distinct values (Table 1) of area and volume for the same banks.

Table 2: Calculated volume by equipment.

Year	Equipment	Erosion	Area (m²)	Volume (m³)	Error (m)
2019	UAV	E01	110.22	211.90	0.100
	TLS		112.54	227.46	0.036

2021	UAV	E01	51.12	138.83	0.120
	TLS		80.84	148.53	0.046
2019	UAV	E02	116.22	167.49	0.100
	TLS		117.3	135.47	0.036
2021	UAV	E02	89.78	205.14	0.120
	TLS		124.68	176.33	0.046

This abstract presented a comparative multitemporal analysis of TLS and UAV by monitoring a stretch of an urban stream. Within an urban environment, the dynamics of the watershed are modified, accelerating and transforming the scenario in the short and medium term, these changes cause increased runoff and flooding, modifying the shape and meanders of water bodies.

Keywords: Erosion; Geomorphology; DEM of Difference (DoD).

Acknowledgments

This research was supported by funding from National Council for Scientific and Technological Development of Brazil (CNPq) and P&D Project from ANEEL – National Agency, "Modelling at Different Scales of Sediments Generation in Erosions and Sediments Input in Hydroelectric Power Plant Reservoirs" – PD-ANEEL 0394-1705/2017, supported by Furnas Centrais Elétricas S.A. and Agência Nacional de Energia Elétrica with UFG and UnB cooperation.

References

[1] Dutta, S.; Karmakar, T. Erosion Processes in Composite Riverbanks: Experiments and Modelling. Int. J. Res. Eng. Technol 2015, 4, 85–92.
[2] Rinaldi, M.; Simon, A. Bed-level adjustments in the Arno River, central Italy. Geomorphology 1998, 22(1), 57-71. https://doi.org/10.1016/S0169-555X(97)00054
[3] Ortega, J. A.; Razola, L.; Garzón, G. Recent human impacts and change in dynamics and morphology of ephemeral rivers. Natural Hazards and Earth System Sciences 2014, 14(3), 713-730. https://doi.org/10.5194/nhess-14-713-2014
[4] Rosser N.J.; Brain M.J.; Petley, D.N.; Lim, M.; Norman, E.C. Coastline retreat via progressive failure of rocky coastal cliffs. Geology 2013, 41(8), 939–942. https://doi.org/10.1130/G34371.1
[5] Hayakawa, Y. S.; Obanawa, H. Volumetric change detection in bedrock coastal cliffs using terrestrial laser scanning and uas-based SFM. Sensors 2020, 20(12), 3403.
[6] Wheaton, J.M. Geomorphic change detection software, 2010. Available online: http://gcd.riverscapes.xyz/.

On the eigenvalues of the Saint-Venant and Exner system of equations

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Abstract

The hydro-morphologic evolution of bed and water elevation in one-dimensional open-channel flow is depicted by a system of partial differential equations, including two Saint-Venant equations and one Exner equation. In the pioneering study of De Vries (1965), approximate expressions of the eigenvalues (λ_1, λ_2 and λ_3) of the hyperbolic system were provided for a simplifying assumption of negligible concentration of the transported sediment, c. In the following decades, several scholars have contributed to this research line. While the De Vries' approximations are considered valid for Froude numbers (*Fr*) lower than 0.8 or higher than 1.2, Lyn and Altinakar (2002) presented new approximations for near-critical flows. Furthermore, Goutière et al. (2008) and Armanini (2018) provided approximate expressions for the eigenvalues that are valid for any value of *Fr*. While all the mentioned studies considered simplified equations assuming negligible c, Morris and Williams (1996) argued that this assumption is not appropriate for many natural streams. They expanded the governing differential equations without neglecting the terms related to c, obtaining a new cubic equation for determining the three eigenvalues of the system.

A first aim of the present study is to compare the determinations from the above-mentioned approximations and exact solutions for a case with non-negligible *c*. The considered case comes from a laboratory experiment with bed aggradation due to sediment overloading. Table 1 lists the properties of the aggradation experiment (T = duration of experiment, Q = flow rate, $Q_{s,in}$ = sediment feeding rate, Q_{s0} = sediment transport capacity at initial flow, u = bulk water velocity, and h = water depth).

Table 1. Properties of the aggradation experiment

T (s)	Q (m^3/s)	$Q_{s,in}$ (m^3/s)	Q_{s0} (m^3/s)	u (m/s)	h (m)
315	0.007	4.28×10^{-4}	1.33×10^{-4}	0.728	0.031

The parameters of the experiment were used to provide values for the needed quantities involved in the approximate or exact determinations of the eigenvalues. However, while the experiment had its own range of variation of *Fr*, following an approach already used in prior literature studies, the eigenvalues were determined for *Fr* varying between 0.1 and 2. Figure 1(a) presents the variations of the eigenvalues estimated by the different approaches (exact_lowc = solution of the cubic equation for negligible *c*; DV = De Vries; LA = Lyn and Altinakar; Gal = Goutière et al.; A = Armanini; MW = solution of the cubic equation with finite *c* as proposed by Morris and Williams); the results are similar to one another for λ_1; for λ_2, estimates are more scattered and may indicate that using the equations proposed for the cases with negligible c in cases of non-negligible solid concentration would result in an underestimation of the eigenvalue. Furthermore, for λ_3 the different determinations are also not always consistent.

Literature analyses of the eigenvalues of the system are frequently based on synthetic plots like that in Figure 1(a). A second objective of the present study is to use the large amount of information obtained during the experiment to provide a local and instantaneous experimental determination of the λ values. Figure 1(b to d) thus shows an uncommon depiction of how the eigenvalues of the

system varied in time and space during the experiment (determination based on the MW approach that should be more appropriate than the others for this experiment).

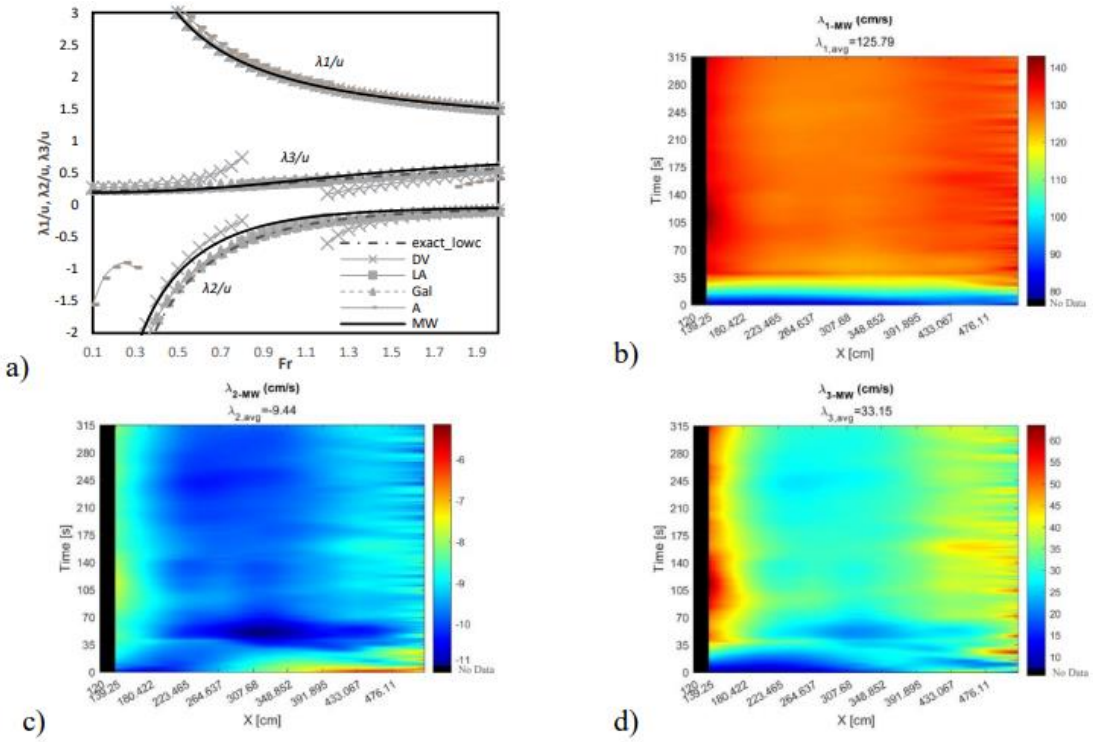

Figure.1 a. Comparison between eigenvalues obtained using different approaches. **b**, **c**, **d**. Variation of λ_1, λ_2 and λ_3 with time and space according to the MW approach.

Keywords: Sediment transport; Hydro-morphologic modelling; Eigenvalues

References

[1] Armanini, A. (2018). Principles of River Hydraulics. Springer International Publishing. https://doi.org/10.1007/978-3-319-68101-6_7.

[2] de Vries, M. (1965). "Consideration about non-steady bed-load-transport in open channels". Proc. of the 11th Congress of IAHR, Leningrad.

[3] Goutière, L., Soares-Frazão, S, Savary, C, Laraichi, T, & Zech, Y. (2008). "One-dimensional model for transient flows involving bed-load sediment transport and changes in flow regimes". J. Hydraul. Eng. https://doi.org/10.1061/ASCE0733-94292008134:6726.

[4] Lyn, D.A., & Altinakar, M. (2002). "St. Venant-Exner equations for near-critical and transcritical flows". J. Hydraul. Eng. https://doi.org/10.1061/ASCE0733-94292002128:6579.

[5] Morris·, P.H., & Williams, D.J. (1996). "Relative celerities of mobile bed flows with finite solids concentrations". J. Hydraul. Eng. https://doi.org/10.1061/(ASCE)0733 9429(1996)122:6(311).

Human impact and Channel Planform Changes of a Pseudomeandering River

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Abstract

This presentation reports about the channel planform changes of the Cecina River in Tuscany, Italy, from 1954 to present. The low sinuosity (<1.5), the lack of neck cutoffs, the occurrence of a low flow sinuous channel wandering between alternate lateral bars within a generally straight streambed make the Cecina a typical example of pseudomeandering [1] (or wandering [2]) rivers. Pseudomeandering rivers are considered unstable and in a stage of transition between braided and meandering channels. This kind of rivers are rather common in Italy and in Tuscany as well. Few studies have documented the channel dynamics of pseudomeandering rivers and none, to the authors knowledge, has investigated the response of a pseudomeandering river to human impact.

Old reports, narratives and more recent aerial photos and satellite images indicate that river flow, sediment supply and channel planform have changed substantially through time. The Cecina catchment has been sparsely inhabited and cultivated only in the lower flood plain, as far as the mid-19th century when agriculture slowly expanded and it was paralleled by a modest, though increasing, forest clearing, especially in the foothills. Traditional cropping systems were replaced by a modern, mechanized agriculture since the early 1950s but, shortly after, many farmers abandoned the cultivated land to join the growing industrial sector and the urban reconstruction after the destructions of WWII. All over Italy, and in the Cecina area as well, the need for huge amount of building material caused the fast and large scale, uncontrolled exploitation of huge volumes of streambed material, which caused substantial river channel changes. After bed material mining was halted by a regional law, in the mid-1980s, the river channel showed a tendency to recover a new dynamic equilibrium. In order to document all these changes four representative sites of the Cecina River were selected and the channel changes monitored by the comparison of aerial phots of 1954, 1976, 1986 and 1998 and Google Earth images of 2002, 2013, 1014, 2019, 2020, 2021, and 2022. Bed material sampling campaigns were also carried out in 1991, 1992 and 1993 after one or two in a row moderate to higher than bankfull floods. The sediment samples were collected from bar surface, bar sub-surface, riffle and pool of 12 sites almost uniformly distributed along the alluvial part of the river. The sediment data were used to investigate the sediment dynamics of the four main morpho-sedimentary units and its influence in the channel changes processes.

The data of channel width variation from 1954 to present indicates a modest change, with opposite sign, from 1954 to 1986. After 1986, channel width decreases substantially in every site until 1998-2002 and then moderately increase again until 2022 (Fig. 1). During the 1954 - 2022 interval the largest ever recorded flood (1030 m^3s^{-1}) of November 4, 1966 (the same day of the great flood of Florence) hit the Cecina. In the following five years other high floods with peak discharges of 360-670 m^3s^{-1} occurred but their effect on the channel morphology were relatively modest in terms of channel width, sinuosity and planform. Much more important appears the effect of the gravel mining which in the Cecina started in the late-1960s and reached it maximum expansion in the mid-1980s. Hereafter it was abruptly stopped by law.

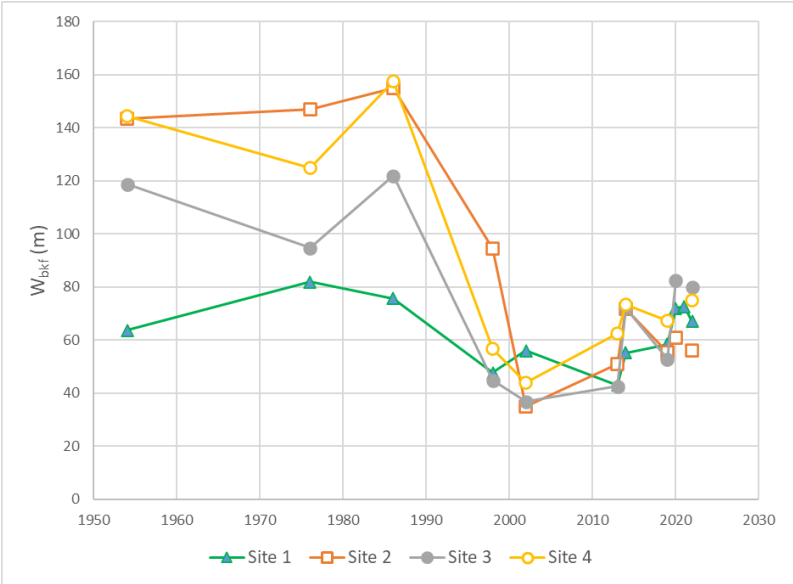

Figure 1 Study sites bankfull width variation through time.

Though no ground survey data is available, field evidence and the comparison with old ground photographs confirm that the narrowing process was matched by a ubiquitous streambed incision of 2-4 m. A marked change of the thalweg line sinuosity is also observed after 1998 with an overall increasing trend in all the study sites. These data sets indicate that streambed mining is a major controlling factor in the Cecina river morphology and that a short time of 12-15 years was enough to reverse the channel degradation processes. In the last two decades, another change in the land management with the onset large scale land properties and the development of agritourism led to the unprecedented attention to the environment preservation and in particular to the forest conservation. This probably contributed to a reduction of sediment supply and to slow down the channel recovery phase.

The river sediment data demonstrates that pools are the most active morpho-sedimentary units. In the 1991-1993 interval, pool D_{50} and sand content experienced the widest variations, whereas the bar sub-surface material is the most stable and maintains an almost constant grain size and sand content. The sediment dynamics of the pools is also associated with scour and fill processes. Field observations suggest that the filling of a pool is commonly a precondition for channel shifting during the next flood and that even a smaller than bankfull flood may be capable of substantially reworking a reach of the Cecina River.

Keywords: pseudomeandering river, gravel mining, channel changes, streambed degradation

References

[1] Hickin, E.J. (1969). A newly-identified process of point bar formation in natural streams. “American Journal of Science”, 267, 999-1010.
[2] Church, M. (1983) Pattern of instability in a wandering gravel bed channel. In: Collison, J. D., Lewin, J. (eds) Modern and ancient fluvial systems, IAS, Spec. Publ., 6, 169-180.

An experimental analysis of channel bed aggradation due to sediment overloading in near-critical flow conditions

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Abstract

It is well known that floods can cause major economic losses and casualties, and can be even more dangerous with the presence of intense sediment transport since the morphologic response of a river can determine erosion and deposition in different areas. In the present work, we experimentally investigated bed aggradation process. When a channel is overloaded with sediment, an aggradation wave propagates along the reach, determining a corresponding increase of the water surface elevation. In a real context, the latter would be important for hazard assessment.

Bed aggradation has been studied during decades, from the pioneering works of, for example, by Soni (1981), Yen et al. (1992), to most recent ones of Zanchi and Radice (2021) and Eslami et al. (2022). In the present study, five aggradation experiments were performed at the Mountain Hydraulics Laboratory of the Politecnico di Milano, and corresponding numerical simulations have been run. The experiments were performed in near-critical flow conditions. Bed and water profiles were obtained for different times along the process. Based on these profiles, one can obtain other related quantities, like the water depth (h), water velocity (vv) and Froude number (FFF). Table 1 lists the properties of the experiments (T = duration of experiment, Q = flow rate, $Q_{s,in}$ = sediment feeding rate, Q_{s0} = sediment transport capacity at initial flow, Lr = Loading ratio = $Q_{s,in}$ / Q_{s0}).

Table 1. Properties of the aggradation experiments

Experiment	T (s)	Q (m^3/s)	Qs,in (m^3/s)	Qs0 (m^3/s)	Lr	Fr
AE1	260	0.007	2.30E-04	1.33×10-4	1.73	0.93
AE2	364	0.007	1.43E-04	1.33×10-4	1.08	0.89
AE3	234	0.007	2.55E-04	1.33×10-4	1.92	0.97
AE4	181	0.007	4.16E-04	1.33×10-4	3.13	1.19
AE5	179	0.007	4.10E-04	1.33×10-4	3.08	1.23

The aggradation process, due to sediment overloading ($Lr > 1$) expectedly resulted in a progressive increase of the bed slope towards a morphodynamic equilibrium. Furthermore, in this study we are particularly interested in the time scales of propagation of a sediment aggradation wave; therefore, in order to estimate the celerity of propagation of sediment aggradation, the following definition of a propagation celerity c was applied to the bed elevation z:

$$\frac{dz}{dt} = \frac{\partial z}{\partial t} + \frac{\partial z}{\partial x}\frac{dx}{dt} = 0 \rightarrow c = \frac{dx}{dt} = -\frac{\partial z/\partial t}{\partial z/\partial x}$$

(with x and t as the spatial and temporal coordinates). Finally, while performing the numerical simulations to reproduce the experimental results, an equivalent Manning coefficient and a bed- load factor were calibrated.

Our experiments are a homogeneous series with just the loading ratio being varied. Thus, Figure 1(a to d) depicts how Lr affected the slope of the bed profile at the final time (initial slope of the flume was 1.35 %), the dimensionless celerity ($c' = c/\sqrt{gh}$), the dimensionless equivalent Manning coefficient ($n' = nv/(h)^{2/3}$) and the calibrated bed-load factor (α). Differently from the other quantities, c had a different value for any location and time, as it was estimated using the derivatives of bed elevation; therefore, an average value was computed to be representative of a global behavior during an experiment. All the parameters presented an increasing trend with the loading ratio.

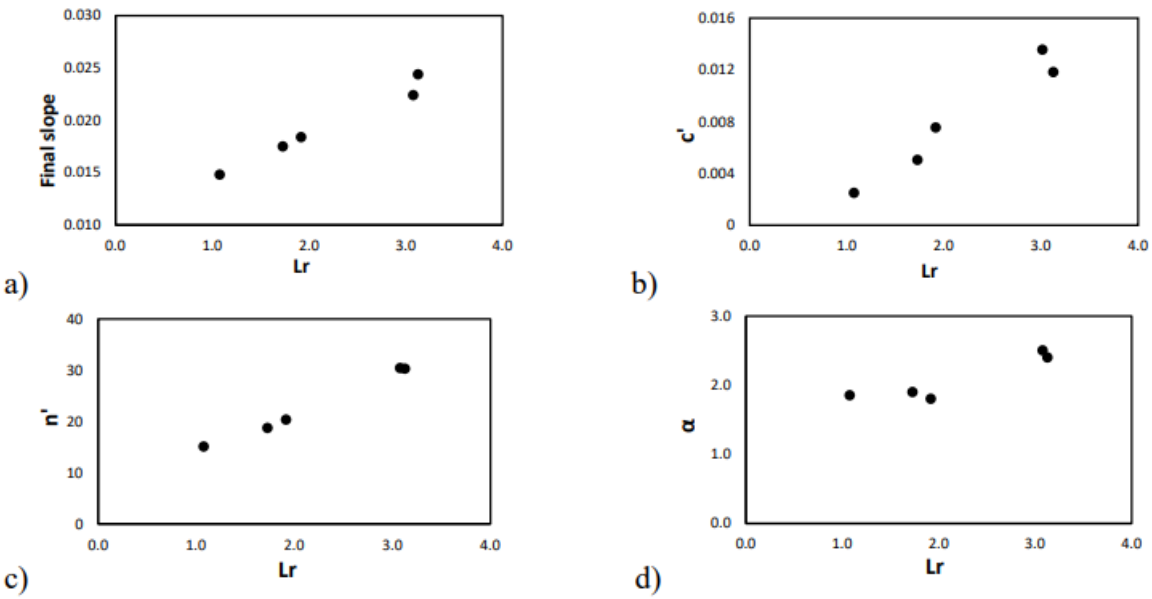

Figure 1. Correlation between **a.** final slope of the bed, **b.** dimensionless local celerity, **c.** dimensionless Manning coefficient, and **d.** calibrated bed-load factor, and the loading ratio.

Keywords: Sediment aggradation; Celerity of propagation; Equivalent roughness

References

[1] Eslami, H., Yousefyani, H., Yavary Nia, M., and Radice A (2022). On how defining and measuring a channel bed elevation impacts key quantities in sediment overloading with supercritical flow. Acta Geophysica, 70: 2511–2528.

[2] Soni, J.P. (1981). Laboratory study of aggradation in alluvial channels. Journal of Hydrology, 49(1‐2): 87‐106.

[3] Yen, C.L., Chang, S.Y., and Lee, H.Y. (1992). Aggradation‐degradation process in alluvial channels. Journal of Hydraulic Engineering, 118(12): 1651–1669.

[4] Zanchi, B., and Radice, A. (2021). Celerity and height of aggradation fronts in gravel-bed laboratory channel. Journal of Hydraulic Engineering, 147(19): 04021034.

How is the length of symmetrical branches affecting the stability of riverine bifurcations?

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Abstract

Riverine bifurcations play a crucial role in controlling the flow and sediment distribution in the downstream branches and may lead to channel avulsion.

Previous studies on the morphodynamic equilibrium and stability of these bifurcations have relied on a quasi-2D model approach originally developed for gravel bed rivers by Bolla Pittaluga et al. (2003) and later extended to the case of suspended dominated rivers by Bolla Pittaluga et al. (2015), hereafter BCK, finding that bifurcation stability is crucially dependent on the Shields stress (**ϑ**) and the half-width to depth ratio (**β**) of the upstream channel. The Authors were able to include a nodal point condition for the transverse flow at the bifurcation under the assumption that the water levels between the upstream channel and downstream branches at the node are all equal. Here we relax the latter hypothesis proposing a new nodal condition that conserves energy rather than free surface elevation at the bifurcation node. Therefore, through a linearization procedure, we study the stability of river bifurcation closing the problem with the Strickler relation for the friction coefficient and employing the total sediment discharge relation of Engelund and Hansen. The linear solution is obtained performing a Taylor expansion around the basic state (i.e., the uniform flow conditions in the upstream channel and symmetrical water and sediment discharge

partitioning in the branches).

The procedure allows for an algebraic relation for the critical aspect ratio β_{cr}, reading:

$$\beta_{cr} = \frac{4}{3}\frac{\alpha r}{\sqrt{\theta}}\frac{(6L + 3Fr^3 + 4LFr^2)}{({}^{7}/_{3}\,L - {}^{3}/_{2}\,Fr^2)}$$

where two new parameters appear, the dimensionless branch length **L** (scaled with the backwater length) and the Froude number in the upstream channel **Fr**.

The dependence of critical aspect ratio β_{cr} on the branch length **L** is plotted in Figure 1a for fixed values of the other parameters. Results suggest that the stability of the bifurcation increases as the length of the branches decreases. Note that the stabilizing effect of relatively short downstream channels in loop systems has been already pointed out by Ragno et al. (2021).

Figure 1b shows the equilibrium diagram of the symmetric bifurcation in terms of the discharge asymmetry **ΔQ** between the branches for different values of **L**. Noteworthy, configurations where final **ΔQ** is equal to 0 are stable, while final **ΔQ** equal to 1 indicates that one branch closes completely, and channel avulsion occurs.

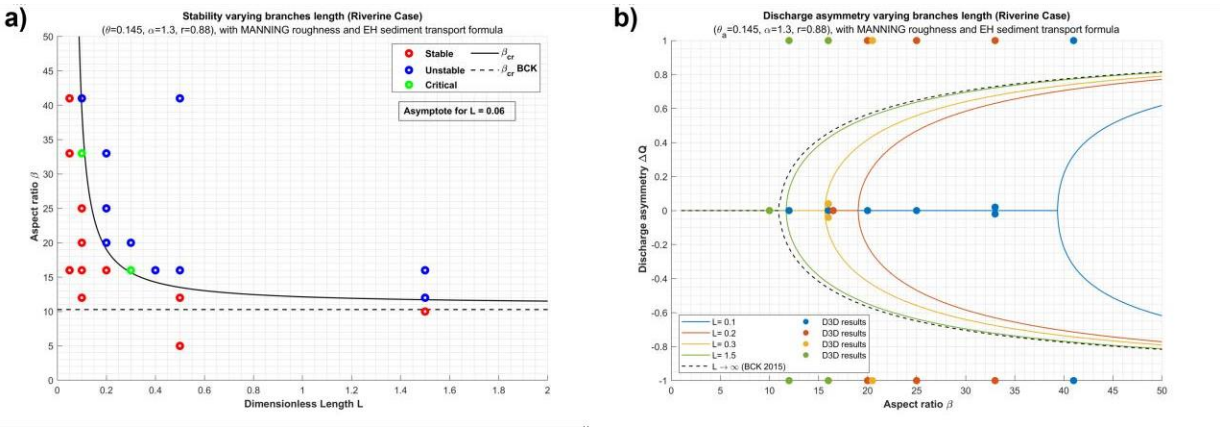

Figure 1. Panel a) shows the neutral stability diagram as function of aspect ratio β and dimensionless length L for the present theory and BCK (2015). The theory has been verified through numerical simulations, with stable configurations shown as red dots, unstable configurations as blue dots, and critical configurations as green dots. Panel b) depicts the equilibrium diagram of a symmetrical bifurcation with equal-length branches, where various dimensionless lengths (L) are represented by different colored lines. The numerical results are displayed as filled dots of the corresponding color for each configuration.

To validate the theory, we performed systematic numerical simulations using Delft3D (Lesser et al., 2004) considering different configurations. In particular, the upstream flow discharge per unit width, slope, and sediment diameter were kept constant, while the width and length of the branches were varied to consider different values of the parameters **β** and **L**. We observed a good agreement between the theoretical predictions and the numerical results.

Further implications of the results will be discussed at the conference

Keywords: Morphodynamics; River bifurcations; Deltas; Sediment transport; Equilibrium; Avulsion

References

[1] Bolla Pittaluga, M., Repetto, R., & Tubino, M. (2003). Channel bifurcation in braided rivers: Equilibrium configurations and stability. Water resources research, 39(3).

[2] Bolla Pittaluga, M., Coco, G., & Kleinhans, M. G. (2015). A unified framework for stability of channel bifurcations in gravel and sand fluvial systems. Geophysical Research Letters, 42(18), 7521-7536.

[3] Lesser, G. R., Roelvink, J. V., van Kester, J. T. M., & Stelling, G. S. (2004). Development and validation of a three-dimensional morphological model. Coastal engineering, 51(8-9), 883-915.

[4] Ragno, N., Tambroni, N., & Bolla Pittaluga, M. (2020). Effect of small tidal fluctuations on the stability and equilibrium configurations of bifurcations. Journal of Geophysical Research:Earth Surface, 125(8), e2020JF005584.

[5] Ragno, N., Redolfi, M., & Tubino, M. (2021). Coupled morphodynamics of river bifurcations and confluences. Water Resources Research, 57(1), e2020WR028515.

Pool-riffle morphodynamics in response to varying sediment supply

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Abstract

Downstream width variations can generate pool-riffle morphology under experimental condition, in numerical simulations and in natural river channels (Chartrand et al., 2018; de Almeida and Rodríguez, 2012). The present understanding of how pool-riffle morphology varies with sediment supply and caliber, however, is insufficient due to the limited range of sediment supply rates explored in previous experiments (Nelson et al., 2015; Morgan and Nelson, 2021). In addition, little attention is paid to the sand supply and sediment size distribution. We develop a river morphodynamics model that can consider the width-variation effect on channel morphology and validate it with experimental data. We find that the one-dimensional model with a deterministic sediment transport relation can well mimic the pool-riffle morphodynamics. We then apply the validated model to study the effect of sediment supply (both amount and fractions) on the steady-state pool-riffle morphology. We conduct numerical simulations with constant flow and sediment feed rates until steady-state pool-riffle morphology is reached. We find that pool-riffle morphology is resilient to the range of sediment supply (i.e., five-fold the sediment amount, 41-fold the sand amount and coarsening the gravel supply) tested in our numerical simulations (Figure 1). We find that bed slope and water surface slope are sensitive to all types of change of sediment supply, whereas the sensitivity of sediment grain sorting characteristics of the bed surface relies on the type of change of sediment supply (Table 1). Our findings support prior research emphasizing the role of downstream width variations on the development/maintenance of pool-riffle morphology. Our results can support regulation and recovery of impacted pool-riffle gravel-bed rivers.

Table 1. The change of variables in different numerical groups.

Sediment supply		Increasing amount	Increasing sand		Coarsening gravel
			2.1	2.2	
Flow hydraulics	Surface slope	+66.7%	-24.3%	+8.6%	+106.9%
	Flow velocity	+18.1%	-8.7%	+4.4%	+15.0%
	Water depth	-14.7%	+7.7%	-3.4%	-11.9%
	Bed shear stress	+43.6%	-18.8%	+4.3%	+91.9%
Bed slope		+63.4%	-23.6%	+8.0%	+101.4%
Bed surface grain size distributions	d_{90}	-4.7%	-3.3%		+185.8%
	Sand content	+1.5%	+34.2%		-2.4%
	d_g	-12.9%	-71.5%		+152.7%
	σ_g	+3.2%	+58.2%		+34.9%

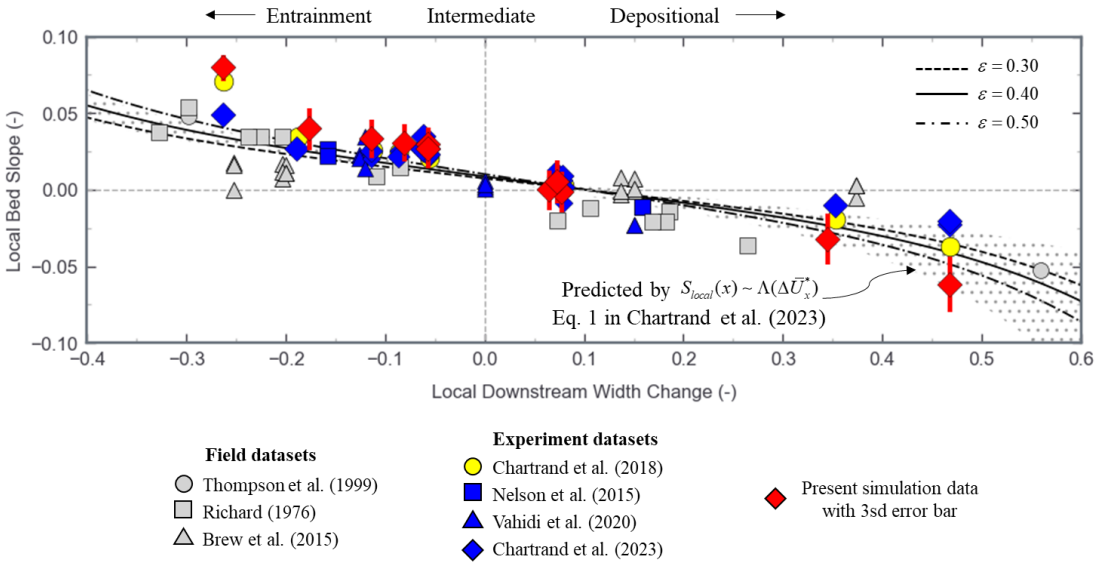

Figure 1. The spatial gradient of width vs. local slope for all numerical simulations. The local slope in this figure is calculated as the mean slope of all numerical simulations. Figure modified from Chartrand et al., (2023).

Keywords: Pool-riffle; Morphodynamics; Sediment supply; Numerical model; Maintenance

Acknowledgment

The authors would like to express appreciation for the support of the China Scholarship Council, and the National Natural Science Foundation of China (Grant Nos. 91747207, 52009063).

References

[1] Chartrand, S. M., Jellinek, A. M., Hassan, M. A., & Ferrer-Boix, C. (2018). Morphodynamics of a Width-Variable Gravel Bed Stream: New Insights on Pool-Riffle Formation From Physical Experiments. Journal of Geophysical Research: Earth Surface, 123(11), 2735–2766. https://doi.org/10.1029/2017JF004533

[2] de Almeida, G. A. M., & Rodríguez, J. F. (2012). Spontaneous formation and degradation of pool-riffle morphology and sediment sorting using a simple fractional transport model: formation and degradation of pool-riffle. Geophysical Research Letters, 39(6), n/a-n/a. https://doi.org/10.1029/2012GL051059

[3] Morgan, J. A., & Nelson, P. A. (2021). Experimental investigation of the morphodynamic response of riffles and pools to unsteady flow and increased sediment supply. Earth Surface Processes and Landforms, 46(4), 869–886. https://doi.org/10.1002/esp.5072

[4] Nelson, P. A., Brew, A. K., & Morgan, J. A. (2015). Morphodynamic response of a variable-width channel to changes in sediment supply. Water Resources Research, 51(7), 5717–5734. https://doi.org/10.1002/2014WR016806

Describing of dunes washing out process

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Abstract

Whenever in river reaches the sediment and liquid flows change, the channel tends to adjust its sediment and water transport capacity to a new equilibrium condition by scouring the bed, by depositing sediment or by changing its plan and bed morphology. Considering that bedforms are ubiquitous features in alluvial sand-bedded channels, and strongly control the flow hydraulics, related processes like resistance to flow, sediment transport and bed level dynamics are of fundamental importance in the engineering science for river management (Best 2005). Estimating hydraulic roughness in alluvial channel has been an intriguing problem over years due to its complexity: large-scale bedforms such as dunes increase flow resistance and thus affect the hydraulic conditions and sediment transport which in turn are dependent on the bed configurations. In case of presence of bedforms, Meyer-Peter & Mueller (1948) underlined that the channel sediment transport capacity over an undulated bed is directly related to the shear stress associated with the skin friction (τ') while the additional bed shear stress associated to the form drag (τ'') has only a dissipative role. Both the components, τ' and τ'', counterbalance the total bed shear stress generated by the flow and can be linearly separated as (Einstein and Banks 1950; Yen 2002):

$$\tau = \tau' + \tau'' \tag{1}$$

The relationship between the dimensionless total shear stress and the dimensionless skin friction was provided by Vanoni (1974) resulting in a graph that shows how the bed configuration evolves with increasing the flow velocity. Flow resistance increases significantly to a maximum that coincides with the threshold from which the dunes begin to washout (Morvan et al. 2008).

Several studies focused on investigating the transition between the different main bedforms: ripples, dunes and anti-dunes. The dune formation process develops with enlarging the dune shape, and rising the crest of the dune, until a critical state is reached where the stream power tends to wash out, i.e., dunes become much longer and flatter and finally disappear. The study of this critical state was in the focus of much past researches that highlighted the role of the bed load transport as the main responsible for the process of erosion and deposition that is at the basis of the dunes dynamics, while the suspended load is mainly affecting the dune height (Naqshband et al. 2014). Raudkivi (2006) claimed that dunes tend to grow as long as they do not reach a maximum steepness value, once this value is reached the dunes start to flatten. More recently, Reesink et al. (2018) investigated the dune adaptation to imposed flow highlighting that the dunes height seems not to have a strong dependence with flow velocity, while throughs increase with increasing flow velocity. Bradley & Venditti (2019) presented a model to predict dune geometry evolutions through time by imposing flow condition.

To date, the knowledge about how dune dynamic reacts to changes in hydraulic conditions is limited. Most of the studies on dunes evolution and adaptation to changes in flow conditions were describing only qualitatively the phenomenon. In addition, there are no available models that describe the evolution of bedforms from dunes to upper plane bed in terms of shear stress.

In the present study, a new model is presented to reproduce the evolution of bedforms with increasing the flow discharge. This two-dimensional model is based on the hypothesis of subcritical uniform flow at equilibrium conditions, i.e., the sediment transport capacity equals the rate at which

the sediment is being supplied. In addition, a new dissipative equation in terms of τ'' is provided to properly reproduce the critical state for dunes, and so the evolution of bedforms through the transition between sub- and super-critical flows. This concept relies on the dune transfer mechanism of bed shear stress through which only a fraction of the total shear stress is responsible for grain motion, while the remaining part τ'' is transferred via drag form (see Equation 1). The proposed approach has been tested using available experimental data from literature.

Keywords: Bedform transition; Dunes; Form drag; Sediment continuity; Sediment transport; Shear stress

References

[1] Best, Jim. 2005. "The Fluid Dynamics of River Dunes: A Review and Some Future Research Directions." *Journal of Geophysical Research: Earth Surface* 110(F4): n/a-n/a. http://doi.wiley.com/10.1029/2004JF000218.
[2] Bradley, Ryan W., and Jeremy G. Venditti. 2019. "The Growth of Dunes in Rivers." *Journal of Geophysical Research: Earth Surface* 124(2): 548–66.
[3] Einstein, H A, and R B Banks. 1950. "Fluid Resistance of Composite Roughness." *Eos Trans. AGU* 31(4): 603–10.
[4] Meyer-Peter, E., and Müller, R. 1948. "Formulas for bedload transport". In Proceedings of the 2nd Meeting of the International Association for Hydraulic Structures Research (pp. 39– 64). Stockholm: IAHR.
[5] Morvan, Hervé et al. 2008. "The Concept of Roughness in Fluvial Hydraulics and Its Formulation in 1D, 2D and 3D Numerical Simulation Models." *Journal of Hydraulic Research* 46(2): 191–208. https://www.tandfonline.com/doi/full/10.1080/00221686.2008.9521855.
[6] Naqshband, S., J. S. Ribberink, D. Hurther, and S. J. M. H. Hulscher. 2014. "Bed Load and Suspended Load Contributions to Migrating Sand Dunes in Equilibrium." *Journal of Geophysical Research: Earth Surface* 119(5): 1043–63. http://doi.wiley.com/10.1002/2013JF003043.
[7] Raudkivi, A. J. 2006. "Transition from Ripples to Dunes." *Journal of Hydraulic Engineering* 132(12): 1316–20. http://iberaula.es/Temas/DisplayTema?id_tema=1003.
[8] Reesink, A. J.H. et al. 2018. "The Adaptation of Dunes to Changes in River Flow." *Earth-Science Reviews* 185(September): 1065–87.
[9] Vanoni, V. A. 1974. "Factors determining bed forms of alluvial streams", *Journal of the Hydraulic Division*., Am. Soc. Civil Eng., 100(3), 363-377.
[10] Yen, Ben Chie. 2002. "Open Channel Flow Resistance." *Journal of Hydraulic Engineering* 128(1): 20–39.

Characteristics of drag forces acting on a step-pool unit

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Abstract

Knowledge on the morphology and stability of step-pool features has been greatly advanced in the last 20 years based on numerous studies on this topic (Zimmermann et al., 2020). However, knowledge gap still remains for the flow forces acting on step-pool features. This gap hinders precise prediction for the channel responses to changes in flow and sediment supply regimes (Wang et al., 2021), and hampers the attempts to better design artificial step-pool system for river restoration (Zhang et al., 2023).

The objective of this study is to examine the distribution of drag forces coming from both the shear and pressure forces of the flow in a step-pool unit and quantify the drag partition between grain and form drag. We used the combined approach developed in an earlier work of ours (Zhang et al., 2022), which reconstructed the 3D high-resolution hydraulics of a step-pool unit by combining physical experiment and computational fluid dynamics (CFD) simulation. A step-pool unit was evenly split into 24 topography components transversely, with each covering the whole unit length. The flow forces acting on each topography component were obtained numerically, with the shear and pressure forces in X direction representing the grain and form drag respectively. The transverse distributions of the shear and pressure force in X direction show significant spatial heterogeneity after the discharge reached 22.8 L/s (Fig. 1). At the highest two discharges, the highest values of the two forces in X direction emerge mainly at the locations with the highest flow velocities in the step-pool unit (Zhang et al., 2022). The troughs of shear and pressure forces in X direction are distributed in the topography components passing the contact points of step stones with the relatively low elevations in the step crests.

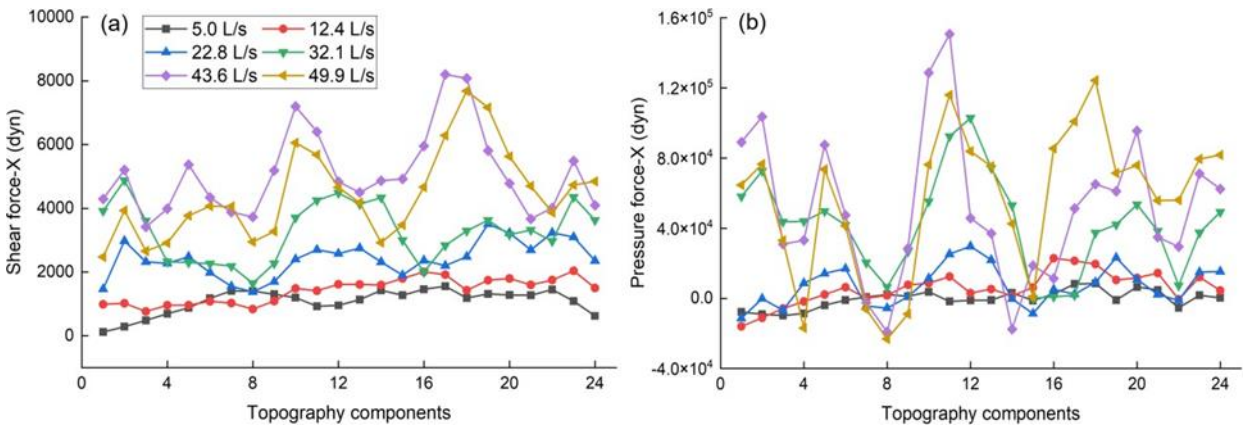

Figure 1. Transverse distributions of the (a) shear and (b) pressure forces in X direction in a step-pool unit. The water flows downwards.

The statistics of the ratios between shear and pressure forces exerted on the topography components shows that the magnitude of the resultant shear force is about 2 orders smaller than that of the resultant

pressure force (Fig. 2a). The ratio of the shear force to pressure force in X direction varies in a large range at low flows but shows a limited variation range at high flows with fully developed pool feature (Fig. 2b). The limited range lies mainly between 0.05 to 0.1, indicating that the grain drag is generally one order smaller than the form drag for a developed step-pool unit.

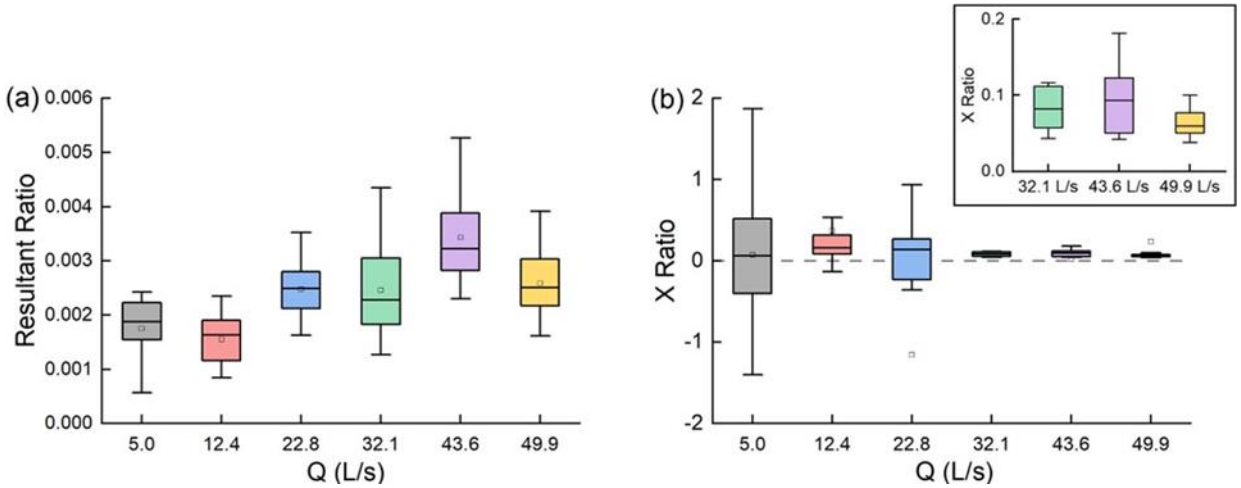

Figure 2. The ratios (a) between the magnitudes of resultant shear and pressure forces and (b) between shear and pressure forces in X direction exerted on the topography components. The inset plot in panel (b) gives an enlarged view for the ratios at the three highest discharges.

Keywords: Step-pool; Computational fluid dynamics (CFD); Form drag; Grain drag; Flow forces

Acknowledgment

This research was supported by the Second Tibetan Plateau Scientific Expedition and Research Program (STEP) (Grant No. 2019QZKK0903) and the National Natural Scientific Foundation of China (No. 42077238, 52209103, U2243222).

References

[1] Wang, J., Hassan, M. A., Saletti, M., Chen, X., Fu, X., Zhou, H., & Yang, X. (2021). "On how episodic sediment supply influences the evolution of channel morphology, bedload transport and channel stability in an experimental step‐pool channel." Water Resources Research, 57(7), e2020WR029133.
[2] Zhang, C., Xu, Y., Hassan, M. A., Xu, M., & He, P. (2022). "A combined approach of experimental and numerical modeling for 3D hydraulic features of a step-pool unit." Earth Surface Dynamics, 10(6), 1253-1272.
[3] Zhang, C., Hassan, M. A., Saletti, M., Zimmermann, A. E., Xu, M., & Wang, Z. (2023). "A Unit-Scale Framework for Designing Step-Pool Sequences." Journal of Hydraulic Engineering, 149(1), 04022033.
[4] Zimmermann, A. E., Saletti, M., Zhang, C., & Hassan, M. A. (2020). "Step–pool channel features." In E. Wohl (Ed.), Fluvial geomorphology (2nd ed., Vol. 6.1, pp. 565–586). Academic Press.

The hydro-morphodynamic adaptation in a sediment starving estuary

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Abstract

Fluvial sediment supply has been decreasing significantly in estuaries worldwide, leading to sinking deltas, wetland loss, and navigational and ecological problems [1, 2]. The Yangtze Estuary has experienced a gradual decline in riverine sediment supply since the mid-1980s, followed by an accelerated decline to the present-day amount of 75% since 2003 [3]. Consequently, the hydro-morphodynamic changes in the estuary have raised much concern.

To understand the hydro-morphodynamic response systematically, we have collected the long-term tidal water levels, water and sediment discharges, suspended sediment concentrations (SSC), and bathymetry maps in the Yangtze Estuary. We also set up Delft3D numerical models to gain insights into the underlying mechanisms. The results indicate strong spatial and temporal changes from the watershed to the estuary. We found that the mainstream and the two large lakes (Poyang and Dongting Lake) in the watershed shifted from sedimentation to erosion at the initial stage, acting as a buffer zone for the lower estuary. In the Yangtze Estuary, the mouth zone sustains high sediment concentration and accretion for a long term, whereas simultaneous erosion is detected in the upper estuary and subaqueous delta. Particularly, the morphological response in the mouth zone suggests a time lag of 30 years in response to reduced sediment supply.

Our modeling results suggest the controlling effects of riverine sediment supply and local engineering works on the changes in tidal evolution in the upper estuary and mouth zone, respectively. In the upper estuary, the tidal damping is weakened due to deepening and narrowing in the main channel from 1990 to 2010, followed by a slightly enhanced tidal damping due to increased friction induced by reduced sediment stratification from 2010 to 2020. In the mouth zone, the local engineering works caused enhanced tidal damping during the construction period of 1997–2010. Afterwards, the high near-bed sediment concentration in the navigation channel results in a decrease in friction due to turbulence damping and therefore weakens tidal damping. The high near-bed concentration induces strong sediment-induced density effects in the longitudinal and vertical directions. The longitudinal sediment-induced density gradients favor extension of the estuarine turbidity maximum (ETM) due to the opposite effects of the baroclinic pressure gradients upstream and downstream of the maximum SSC of the ETM. The vertical sediment-induced density gradients strengthen stratification, estuarine circulation, and salinity- induced density gradients, forming a positive feedback effect on increasing near-bed sediment concentrations.

Overall, the hydro-morphodynamic response to reduced sediment supply in the Yangtze Estuary suggests significant time lag effects, which should be considered in a systematic way, and future work still needs further close monitoring

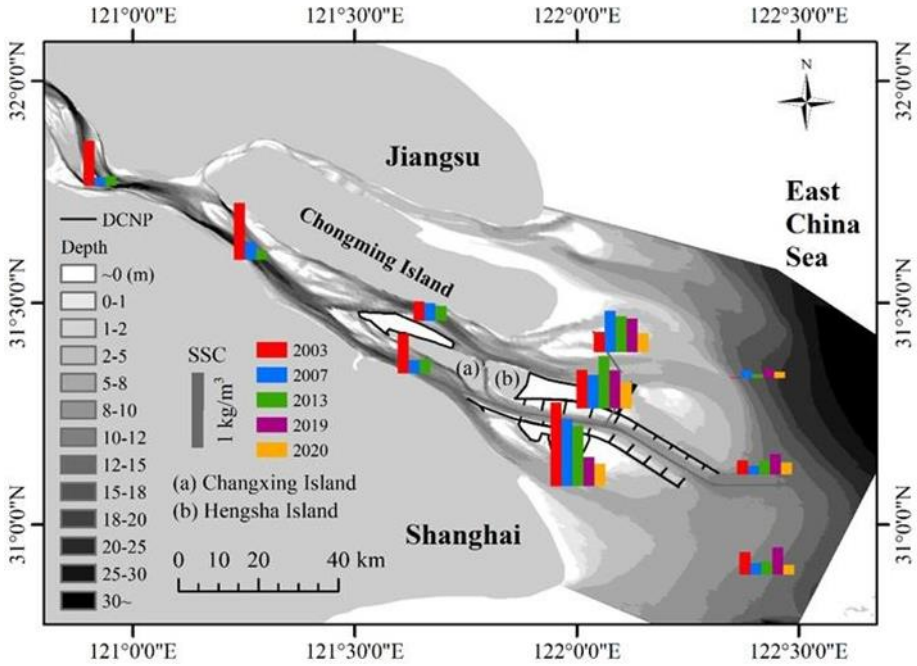

Figure 1. Tidal and depth averaged suspended sediment concentrations (SSC) during the wet season in 2003, 2007, 2013, 2019 and 2020.

Keywords: sediment supply; Yangtze Estuary; time lag; mouth zone; sediment dynamics, morphodynamics

Acknowledgment

The authors would like to express appreciation for the support of the sponsors [Grant Numbers: 2016YFE0133700, PSA-SA-E-02, 42206169, 51739005, U2040216, 41876091, 19QA1402900; 20DZ1204700, 21230750600].

References

[1] Syvitski, J., Ángel, J. R., Saito, Y., Overeem, I., Vörösmarty, C. J., Wang, H., & Olago, D. (2022). Earth's sediment cycle during the Anthropocene. Nature Reviews Earth & Environment, 3(3), 179-196.
[2] Besset, M., Anthony, E. J., & Bouchette, F. (2019). Multi-decadal variations in delta shorelines and their relationship to river sediment supply: An assessment and review. Earth-science reviews, 193, 199-219.
[3] Zhu, C., Guo, L., van Maren, D. S., Tian, B., Wang, X., He, Q., & Wang, Z. B. (2019). Decadal morphological evolution of the mouth zone of the Yangtze Estuary in response to human interventions. Earth Surface Processes and Landforms, 44(12), 2319-2332.

Rationalizing the differences among hydraulic relationships through a process-based model

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Abstract

The use of power law forms to describe hydraulic geometry is a classic subject with a history of over 70 years. Two distinct forms of power laws have been proposed: at-a-station hydraulic geometry (AHG) and downstream hydraulic geometry (DHG). Although the utility of these semiempirical expressions is widely recognized, they remain poorly understood in terms of the mechanisms underlying the differences between AHG and DHG, as well as the variability among different systems. In this study, we attempt to address these basic issues. Two hypotheses are proposed: (a) the different geomorphic relationships represented by AHG and DHG result from the control of lateral adjustment of the bank and flow turbulence over short and long timescales, respectively; and (b) the systematic variability of the AHG and DHG exponents is related to the description of the frictional resistance. These two hypotheses are embedded in our theoretical models and lead to explicit functional forms for AHG and DHG. The verification of our hypotheses is based on a large data set consisting of over 550 b-f-m exponents and 120 power law hydraulic relations. The analysis highlights the role of uncertainties in data acquisition and theoretical/statistical explanations. In addition, the theoretical expressions of AHG also provide an explanation of at-many-stations hydraulic geometry (AMHG) in a physical sense. Overall, our work provides new insights into the fundamental theory of power laws and hydraulic geometry.

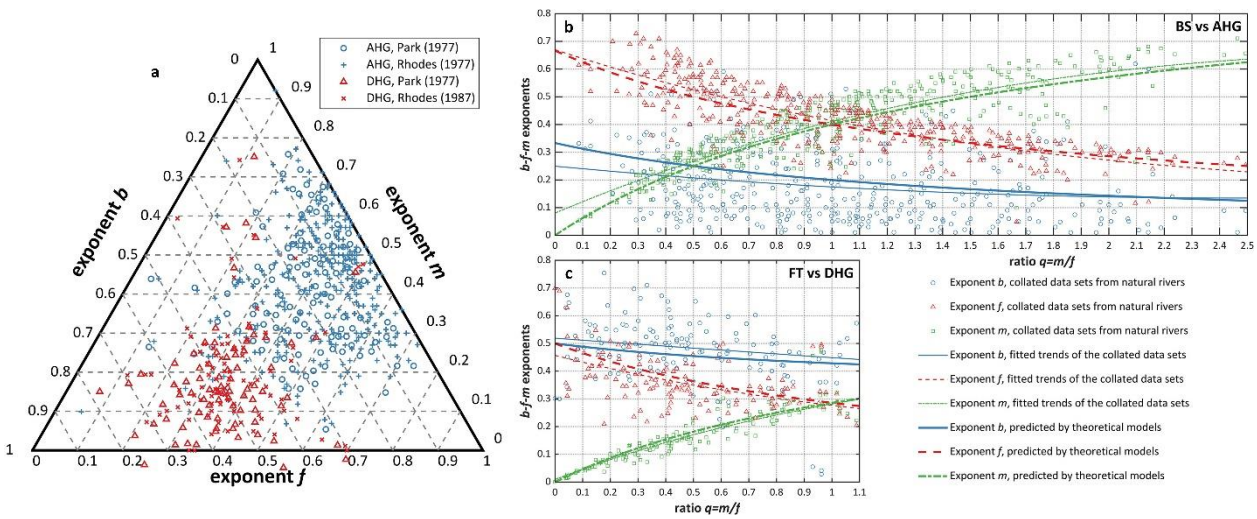

Figure.1 (a) b-f-m ternary diagram of the at-a-station hydraulic geometry (blue dots) and downstream hydraulic geometry (red dots) exponents, redrawn from Park (1977) and Rhodes (1977, 1987). (b-c) Variability of the collated at-a-station hydraulic geometry (AHG) and downstream

hydraulic geometry (DHG) exponents with the ratio q = m/f, and those predicted by BS and FT models.

Keywords: Hydraulic geometry; Regime theory; River

Acknowledgment

This study is supported by the National Natural Science Foundation of China (Grant Nos. 42006150, 51739005), Key Program for International S&T Cooperation Projects of China (Grant No. 2016YFE0133700).

References

[1] Park, C. C. (1977). World-wide variations in hydraulic geometry exponents of stream channels: An analysis and some observations. Journal of Hydrology, 33(1–2), 133– 146.
[2] Rhodes, D. D. (1977). The b-f-m diagram; graphical representation and interpretation of at-a-station hydraulic geometry. American Journal of Science, 277(1), 73– 96.
[3] Rhodes, D. D. (1987). The b-f-m diagram for downstream hydraulic geometry. Geografiska Annaler—Series A: Physical Geography, 69(1), 147– 161.
[4] Xu, F., Coco, G., Zhou, Z., Townend, I., Guo, L., & He, Q. (2020). A universal form of power-law relationships for river and stream channels. Geophysical Research Letters, 47, e2020GL090493.

Planform Dynamics and cut off of the wandering reach in Lower Yellow River After 1999

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Abstract

The Lower Yellow River is a heavy sediment load river, with irregularly channel bend migration producing cutoffs usually. The wandering reach of Lower Yellow River has formed some irregular river bends after 1980s. The water and sediment discharge have decreased after the construction of Xiaolangdi Reservoir in1999, which influence the planform migration rates and river bend radius and bending coefficient. Based on remote sensing and river planform map produced by survey department, a comparison analyses of planform dynamics of irregular river bend cut-off before and after Xiaolangdi Reservior construction is presented. After the Xiaolangdi reservoir has been construction, the sediment load is decreased sharply. It is clear water almost time, except water and sediment regulation period. The peak flood discharge is only half of value before 1999. The channel is erosion, with deepen and widen. The migration rates of channel is decreased to 236m/a, the bend radius is decreased to 1900m. However, the bending coefficient is increased to 1.18, with maximum bending coefficient is 1.6. The duration of irregular channel bends is rise, which suggesting that a artificial cut-off should be taken, to prevent the significant impact on river control works or resident at floodplain.

Keywords: The wandering river, Irregular bend cut-off, Lower Yellow river

Periodic Analysis on Morphology Evolution of the South Channel in Changjiang Estuary, China

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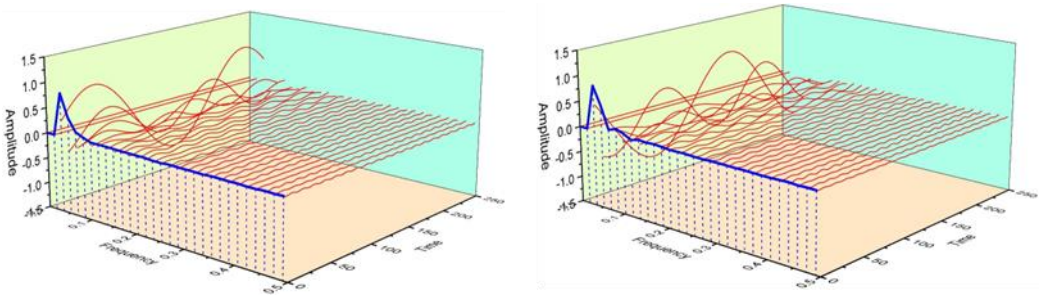
Abstract

Estuaries always serve as transitions of seas and rivers. In general, their morphology evolution are often dominated by runoffs, sediment loads, tides and waves, which often have independent change cycles. Then, we may face with such question: dose the estuarine morphology have its variation cycle? The answers maybe in a wide variety, owing to different acting factors in different estuaries. Hence, in order to answer this question, we take the Changjiang Estuary in China as a typical one to answer in detail.

Actually, lots of works have been done on morphologic evolution of the Changjiang Estuary for decades. In summary, the estuarine evolution may affected by fluvial water and sediment loads from upstream basin (Jiang et al., 2013), water and sediment exchanges between inner estuary and outside sea (Liu et al., 2011; Wu et al., 2012), and human activities in estuaries (Dai et al., 2013). It should be noted that human impacts also depend on natural laws, thus in a long enough time scale, the estuarine evolution are actually dominated constantly by natural powers. However, there are lack of attentions on the periodicity of estuarine morphologic evolution over the past decades.

Hence, in this work, we take the South Channel of the Changjiang Estuary as the study area and focus on its periodicity of morphology. In order to reveal its long term evolution characteristics, many topography maps in different periods during past decades have been compiled (Table 1). And then, its periodicity of morphology as channel volume, thalwegs and shoal are analyzed by FFT method.

Results (Figure 1) show that, there are obvious periods for the geomorphology of the South Channel including channel volume, thalwegs elevation and shoal elevation in past decades, and their first-order dominant period are very similar being about 30 years, which is close to variation period of the Pacific Decadal Oscillation.



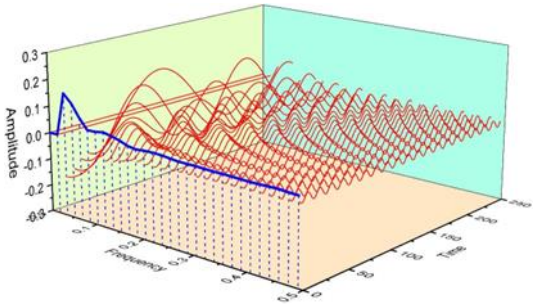


Figure 1. Spectrum diagram of the channel volume (upper left), main thalweg elevation (upper right) and shoal crest elevation (down middle).

Table 1. Summary information of compiled topographic maps.

Year	Map Name
1958	Wusong-Xuliujing
1964	Hengsha to Wusong, Tongsha and their approaches
1973	Sheshan to Hengsha, Hengsha to Nanmen Port
1981	Sheshan to Hengsha, Hengsha to Nanmen Port
1998	Changjiang Estuary and adjacent area
2004	North and South Channel of the Changjiang River Estuary
2007	North and South Channel of the Changjiang River Estuary
2016	Changjiang Estuary and adjacent area

Keywords: Morphology; Periodicity; FFT method; Changjiang Estuary; South Channel

Acknowledgment

This study was supported by the National Natural Science Foundation of China [Grant Number: 51979096], the National Natural Science Foundation of China [Grant Number: U2040203], the Key Laboratory of Coastal Disaster and Defence, Ministry of Education, Hohai University Program [The influence of the deepwater channel regulation project on saltwater intrusion in the Yangtze River Estuary], the Fundamental Research Funds for the Central Public Welfare Research Institutes, Nanjing Hydraulic Research Institute [Grant Number: YN912001].

References

[1] Jiang, X., Lu, B., He, Y. (2013). “Response of the turbidity maximum zone to fluctuations in sediment discharge from river to estuary in the Changjiang Estuary (China).” Estuarine, Coastal and Shelf Science, 131, 24-30.
[2] Liu, G., Zhu, J., Wang, Y., Wu, H., Wu, J. (2011). “Tripod measured residual currents and sediment flux: Impacts on the silting of the Deepwater Navigation Channel in the Changjiang Estuary.” Estuarine, Coastal and Shelf Science, 93, 192-201.
[3] Wu, J., Liu, J., Wang, X. (2012). “Sediment trapping of turbidity maxima in the Changjiang Estuary.” Marine Geology, 303-306, 14-25.
[4] Dai, Z., Liu, J., Fu, G., Xie, H. (2013). “A thirteen-year record of bathymetric changes in the North Passage, Changjiang (Yangtze) estuary.” Geomorphology, 187, 101-107.

Numerical study of sediment transport and hydro-morphology of the Clain river using a hydro-sedimentary 2D numerical model for different scenarios

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Abstract

The presence of man-made hydraulic structures, such as dams, on rivers can interfere with the natural bedload transport of sediments, leading to alterations in the river channel and degradation of habitats [1]. This disruption of sediment continuity is a limiting factor in achieving good ecological and chemical conditions in many river ecosystems. In France, there are approximately 60,000 man-made hydraulic structures that segment rivers [2], with a majority classified as low head dams. These dams, which do not exceed the elevation of the top of the channel banks, are poorly studied in comparison to larger dams. Therefore, two questions arise: how do low head dams disrupt bedload transport, and what solutions can be used to restore sediment continuity?

The Clain river is classified under French environmental regulations for the preservation and restoration of Ecological and Sediment Continuity, which prohibits construction of new structures or development of existing ones if they interfere with Sediment Continuity. The Clain river's waterbody has been divided into three sections for Restoration of Ecological Continuity (RCE), The Îlot Tison weir, located in the highly urbanized RCE 3 section of the Clain river, is considered impassable for sediments. To restore Sediment Continuity, numerical morphodynamic models can be used to predict the evolution of bed configuration over time, due to recent advancements in computational methods.

The 2D unsteady flow and sediment transport model in HEC-RAS will be employed to simulate the different scenarios to assess the ecological continuity of sediment transport [3]. The results of the model will be analyzed to evaluate the flow, sediment transport, and morphological change within the river for different structures and flow rates. The model will be calibrated based on terrain measurements such as the flow rate, the water velocity at different sections and the granulometry of sediments all along the studied river.

Using HEC-RAS, a study will be conducted on the transversal structures "Moulin des Cours et Scierie de Tison" and the weir of Saint Benoit, located 8 km to the south of Tison. The future modifications of the transversal structures will be numerically studied to provide a clear conclusion on the ecological continuity state of the Clain river. This research will aid in ensuring the compliance of the transversal structures with the good ecological status of the water body and contribute to the restoration of ecological continuity in the Clain river.

Figure.1. Bed elevation morphological change (erosion and deposition) over 24 hours flood obtained with Hec-Ras for a flow rate Q = 156 $m3/s$.

Keywords: Sediment transport; CFD numerical modeling; Multi-phase flow; Hydro-morphology; ecological continuity

Acknowledgment

The authors would like to express appreciation for the support of the University of Poitiers as well as the Urban Community of Grand Poitiers.

References

[1] Graf, W. L. (2005). "Geomorphology and American dams: The scientific, social, and economic context". Geomorphology 71(1-2): 3-26, https://doi.org/10.1016/j.geomorph.2004.05.005.

[2] Askeyev A., Askeyev O., Askeyev I., Monakhov S. (2021). "Predatory fish species as indicators of biodiversity: their distribution in environmental gradients in small and mid-sized rivers in Eastern Europe". Environmental Biology of Fishes 104(7): 767-778, https://doi.org/10.1007/s10641-021-01113-8.

[3] Nelson, A., S. Gibson, and A. Sanchez. (2022). "Development of a Two-Dimensional HEC-RAS Sediment Model for the Chippewa River, Wisconsin for Software Development and Sediment Trend Analysis". ERDC/TN RSM-22-2. Vicksburg, MS: US Army Engineer Research and Development Center. http://dx.doi.org/10.21079/11681/44561.

Effect of Fixed Weir Removal on River Bed Variation: Preliminary results

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Abstract

Many weirs have been constructed in rivers to conduct an irrigation, water intake, river bed stabilization etc. They have also induced hydraulic and habitat problems due to disturb a longitudinal continuity of water, sediment transport and migration of fish. Since they have often negative impacts on the sediment management and eco-system, total and partial removal works of weirs have been promoted in various places in the world (Maclin et al., 2002, Takamura et al., 2014). Many studies on effects of weir removal and modified have been conducted, it is in particular very important to know the response of river bed in the upper and lower reaches of the weir.

The Hojo weir, which is a fixed weir in the Ogamo River located in east central Tottori Prefecture, Japan is planned to be removed or reconstructed to a movable weir in the river improvement plan of the Tenjin River system. However, effects of weir removal on river bed variation are not fully understood. In this study, effects of removal of the Hojo weir on river bed variation are investigated by means of flume experiments and numerical simulations. These results and methods can apply to the other removal work of weir.

Experiments were conducted in a straight open channel with a length of 10 m and a width of 0.5 m. A weir with a height of 0.06 m, a width of 0.01 m and a length of 0.5 m (same as the channel width) was placed at the 4.2 m from the downstream end of the channel. The initial difference between the upper and lower bed elevations of the weir was set in 0.02 m, which was an approximately 1/20 scale of the Hojo weir. The uniform and non-uniform sediments were used in the experiments. The mean grain sizes of the sediments were 1.60 - 1.65 mm and were also approximately 1/20 scale of the mean grain size of the bed sediment near the Hojo weir. The experimental conditions are listed in Table 1. In the table, Q = flow rate, h_m = mean flow depth, Fr = Froude number, τ^* = dimensionless bed shear stress, suffix L and U mean lower reach and upper reach of the weir, respectively. The value of Q corresponds with the mean annual maximum flow rate (370 m^3s^{-1}) of the Ogamo River. The experiment consisted of two steps. The first step (U20A3, M20A1) was conducted by placing the weir. After the river bed had been reached dynamic equilibrium, the second step (U20A4, M20A2) was conducted by removing the weir.

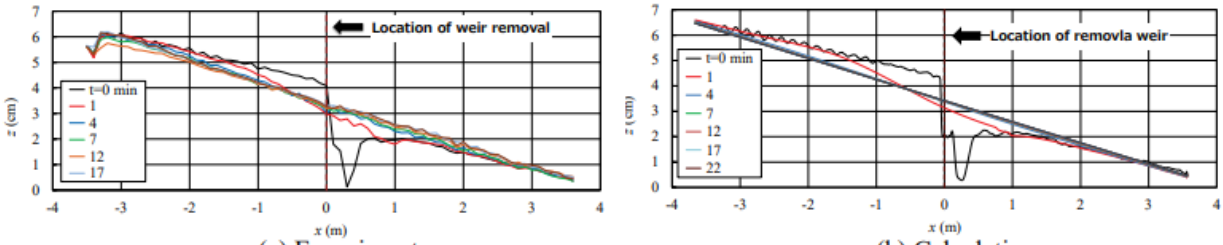
Numerical simulations were conducted not only to reproduce the flume experiments but also to further investigate a removal method of weir. A two-dimensional shallow water model (Kajikawa and Hinokidani, 2013) was partially modified by introducing a thickness of bed-load layer (Luu et al., 2004). The calculation conditions were same as the experiments.

Figure 1 shows the temporal variations in longitudinal bed elevations after removing the weir. The upper and lower reaches of the weir were gradually degraded and aggraded, respectively. This phenomenon found to be proceeded fast in early stage of the experiment. The calculated results reproduced this tendency in the experiment. The temporal and spatial variations in the degradation and aggradation rates from the initial bed are shown in Fig. 2. These rates were standardized by the height of weir D_{wm}. The degradation area reached approximately 160 times of weir height and the aggradation area reached approximately 140 times of it. The calculated results also reproduce these tendencies of the experiment. These results correspond to approximately 70 m in upstream and

approximately 60 m in downstream from the Hojo weir in the Ogamo River. The degradation and aggradation areas in the experiment of the non-uniform sediment bed were relatively small compared with the uniform sediment bed. The calculation results also showed this tendency.

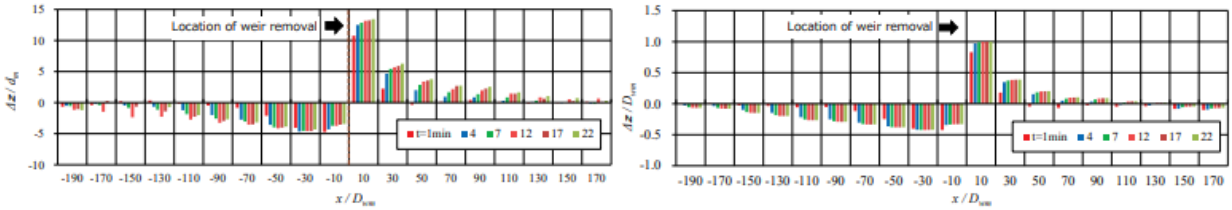
Table 1. Experimental conditions

Case	Weir	Sediment	Q (m^3s^{-1})	h_{mL} (cm)	h_{mU} (cm)	F_{rL}	F_{rU}	τ*L	τ*U
U20A3	Existence	Uniform	0.0085	3.48	3.22	0.84	0.94	0.053	0.065
U20A4	Removal		0.0085	3.09	2.94	1.00	1.08	0.086	0.088
M20A1	Existence	Non-uniform	0.0085	2.88	2.94	1.08	1.11	0.054	0.068
M20A2	Removal		0.0085	3.27	2.61	1.29	0.92	0.099	0.078



(a) Experiment (b) Calculation

Figure 1. Temporal variations in longitudinal bed elevation after removing weir (UA20A4).



(a) Experiment (b) Calculation

Figure 2. Variations in degradation and aggradation rates after removing weir (UA40A4).

Keywords: Removal of weir; Rive bed variation; Flume experiment; Numerical simulation

References

[1] Kajikawa, Y., Hinokidani, O. (2013). "Numerical simulation of 2-D bed deformation in a slit sabo dam". Proceedings of the 35th IAHR World Congress, Chengdu, China, A11452.

[2] Luu, L.X., Egashira, S., Takebayashi, H. (2004). "Investigation of Tan Chau Reach in lower Mekong using field data and numerical simulation". Ann. Journal of Hydraulic Engineering, JSCE, Vol.48, 1057-1062.

[3] Maclin, E., Bowman, M., Bednarek A. (2002). "The Ecology of Dam Removal, A summary of Benefits and Impact". American Rivers.

[4] Takamura, Y., Akamatsu, Y., Nagano, H. (2014). "A study on river bed variation after the consolidation of the weir in Saba River". Jour. of Japan Society of Civil Engineering, Ser. B1 (Hydraulic Engineering). Vol. 70, No. 4, I_1069-I_1074 (in Japanese with English abstract).

Cumulated morphological evolution of the urban area when considering the levee failure

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Abstract

In the urban area, extreme rain caused flooding and led to the levee failure. However, the effect of the urban levee failure on the morphological process of the urban area is not clear. This paper, using a two-dimensional hydro-morphological numerical model, simulates the morphological process of an urban area where buildings are considered non-erodable. In the model, the morphological process was modelled using the van Rijn formula while the erosion and sedimentation performance was validated using data from Yen and Lee (1995). Data from the physical model of the New Orleans inner river levee breach was used to validate the flood routing process (Sattar et al. 2008). The simulated velocity at the breaching entrance was compared with the measured data. The results show that the flow velocity at the breach ranges from 0.1 m/s to 0.5 m/s. The erosion area occurs at the entrance of the levee where a relatively high velocity is observed (Figure 1). Moreover, erosion also occurs at the corner of buildings because of the block of the non-erodable area (such as buildings) (Figure 2).

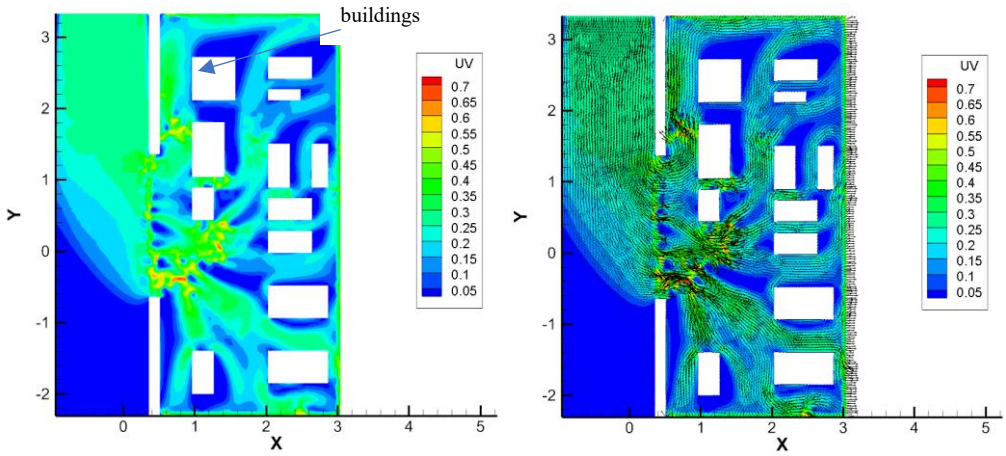

Figure 1. Velocity field of the levee failure

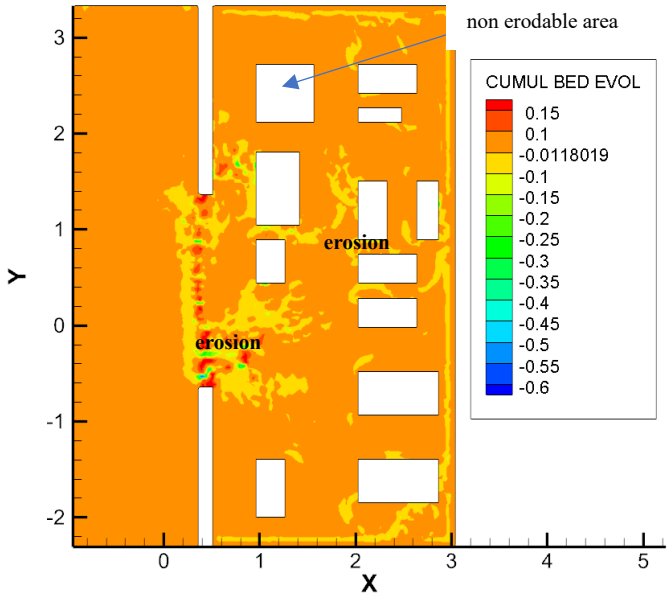

Figure 2. Cumulated morphological evolution

Keywords: Urban levee failure; non-erodable area; morphological evolution

Acknowledgment

This work was partially funded and supported by the Special Foundation for Public-interest Institutes of China (HKY-JBYW-2020&2023).

References

[1] Elalfy, E., Tabrizi, A., & Chaudhry, M. (2018). Numerical and Experimental Modeling of Levee Breach Including Slumping Failure of Breach Sides. Journal of Hydraulic Engineering, 144(2). doi: 10.1061/(asce)hy.1943-7900.0001406.

[2] Sattar, A., Kassem, A., & Chaudhry, M. (2008). Case Study: 17th Street Canal Breach Closure Procedures. Journal Of Hydraulic Engineering, 134(11), 1547-1558. doi: 10.1061/(asce)0733-9429(2008)134:11(1547).

[3] Viero, D., D'Alpaos, A., Carniello, L., & Defina, A. (2013). Mathematical modeling of flooding due to river bank failure. Advances In Water Resources, 59, 82-94. doi: 10.1016/j.advwatres.2013.05.011.

[4] Yafei, J. (2010). Numerical Modeling of Flow Through A Breached Levee and During Levee Closure. Retrieved from http://ascelibrary.org

[5] Yen, Chin-lien, and Kwan Tun Lee. (1995). "Bed Topography and Sediment Sorting in Channel Bend with Unsteady Flow." Journal of Hydraulic Engineering 121 (8): 591–99. https://doi.org/10.1061/(ASCE)0733-9429(1995)121:8(591).

Temporal scour evolution at wood bundles under clear water condition

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Abstract

In the current scenario, there is a rapid degradation of the various water resources due to a host of climatic and anthropogenic factors. Natural river channels are particularly destabilized, leading to recurrent siltation and flood problems. Low-head eco-friendly hydraulic structures are a viable option to recreate the natural flowing conditions in a river which consequently leads to a stabilized channel morphology [1]. In this regard, low-head structures such as log frames [2], block ramps [3], and wood bundles [4] are typically used to control the sediment load in rivers as well as to create localized scour holes in the stilling basin, also promoting biodiversity in the channel.

Among the above-mentioned structure typology, wood bundles are placed both in straight and curved channels to provide perching sites for various invertebrates and to enhance bank safety. In channel curves, they redirect strong velocity gradients away from the outer bank towards the channel center thereby protecting the riverbank from failure due to excessive erosion. On the other hand, the scour holes in the stilling basin of wood bundles serve as an ideal spot for growth of various aquatic organisms including fishes. The equilibrium scour characteristics associated to these structures have been recently investigated by [4], however the temporal evolution of the scour hole still poses a serious gap in knowledge. Therefore, this paper focuses on the temporal evolution of the scour hole at wood bundles in straight channels and presents some preliminary findings on the topic.

A set of experiments were performed on wood bundles for a large range of hydraulic conditions and structure geometry under clear water conditions. Several factors like discharge and tailwater, structure height, number of structures in series combination and spacing between consecutive structures in series were varied. Data analysis showed that the scour depth evolution is considerably dependent on the inflow conditions which can be modelled by a novel densimetric Froude number. Moreover, the results also indicate that the scour development is usually faster for higher densimetric Froude number. Therefore, this paper provides insights on the evolution of scour hole at wood bundles in various stages of its growth which can facilitate the design of such structure typology in future.

To aid in comparison, Fig. 1a shows the flow characteristics and eddy formation at a wood bundle during the scour evolution process whereas Fig. 1b shows the equilibrium scour morphology for the same structure after test completion.

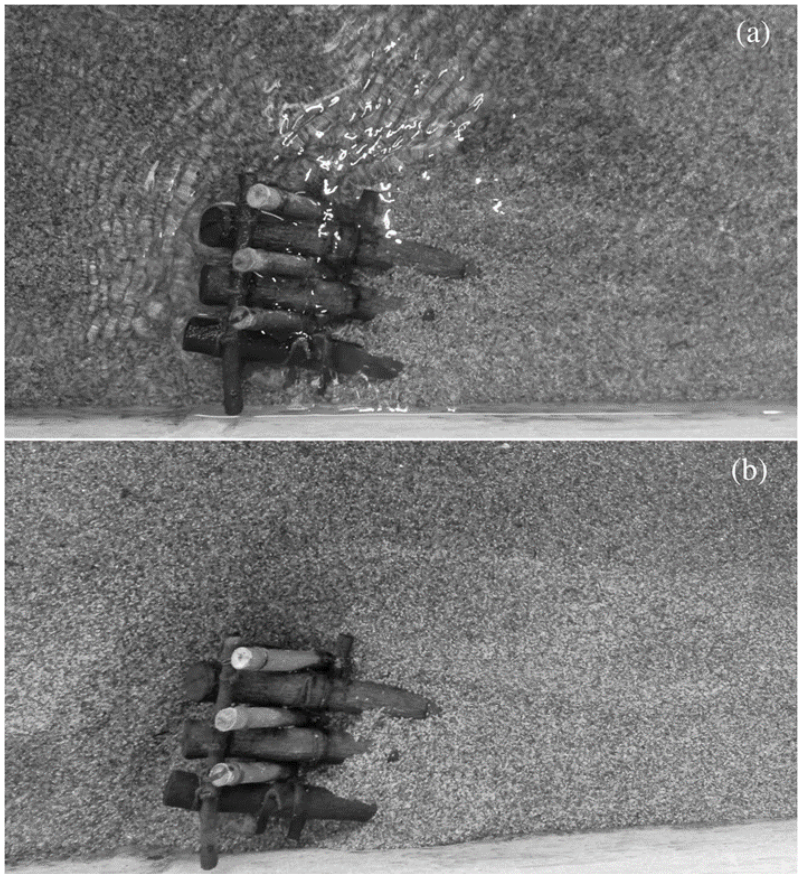

Figure 1. a) Flow characteristics during scour evolution and b) equilibrium scour morphology due to a wood bundle. The flow is from left to right.

Keywords: wood bundles; scour evolution; discharge; Froude number

Acknowledgment

This research did not receive any specific grants from funding agencies.

References

[1] Rosgen, D.L. (2001). "The cross-vane, W-weir and J-hook vane structures: Their description, design and application for stream stabilization and river restoration". Proceedings of Wetland Engineering and River Restoration Conf. (CD-ROM), AmericanSociety of Civil Engineers, Reston, VA. https://doi.org/10.1061/40581(2001)72

[2] Pagliara, S., Palermo, M., & Roy, D. (2020). "Scour around double-winged log frames under clear water condition". Journal of Irrigation and Drainage Engineering, 146(12), 1-11, 04020038. https://doi.org/10.1061/(ASCE)IR.1943-4774.0001517

[3] Palermo, M., Roy, D., & Pagliara, S. (2021). "Morphological characteristics of eco-friendly protected basins downstream of block ramps in river bends". Geomorphology, 377,107587. https://doi.org/10.1016/j.geomorph.2020.107587

[4] Pagliara, S., Roy, D., & Palermo, M. (2021). "Scour features at wood bundles". Water, 13(15), 2118. https://doi.org/10.3390/w13152118

Kinematic characteristics of blunt nosed chevrons in movable bed channels

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Abstract

Rivers are a crucial component of freshwater ecosystems. Nevertheless, they are increasingly threatened by anthropogenic activities, resulting in environmental degradation, and affecting the sediment transport capacity and channel stability. Active restoration of such ecosystems can be achieved by implementing low-head eco-friendly structures, e.g., cross vanes, J-hooks, W-weirs [1], block ramps [2] and, more recently investigated, wood bundles [3], and chevrons [4], which modify the sediment load and create low-velocity localized scour zones. In particular, blunt nosed chevrons are U-shaped structures facing upstream used to divert the flow and to promote scour processes in order to allow navigability in rivers. In addition, it has been found that such structures are also effective in enhancing the habitat for fish species, promoting biodiversity [5]. In this regard, different species of macroinvertebrates have been found in proximity of the rock body of chevron structures, providing nourishment for aquatic species. Despite the availability of guidelines for the design of blunt nosed chevrons for a long time ([6], [7]), information concerning the effects of such structures on the surrounding morphology is fragmented. Recently, [5] investigated the effects of blunt nosed chevrons on the equilibrium scour characteristics in a straight channel, while [4] extended the analysis to the temporal scour evolution for both straight and curved channels, as well as the equilibrium morphology in curved channels.

Despite the advancements in predicting the equilibrium morphology and its temporal evolution in proximity of blunt nosed chevrons, the characterization of the flow kinematics in proximity of such structures has not been fully assessed yet, especially in proximity of the generated scours. Therefore, the present study focuses on the velocity fields occurring around blunt nosed chevrons at selected vertical positions below the water surface, with particular focus at the maximum scour location.

To this end, a set of experimental tests were performed under clear water conditions for a range of hydraulic (i.e., water discharges between 0.008 and 0.016 m3/s; tailwater depths between 0.06 and 0.12 m) and geometrical configurations of blunt nosed chevrons inserted in a straight channel (i.e., different combinations of structure height, number of structures and spacing for series combination, position along the curved channel). Punctual velocity measurements at selected locations were performed by means of an Acoustic Doppler Velocimeter (ADV). Preliminary data analysis showed that flow velocities steeply decrease along the vertical depth at the location of maximum scour created downstream of the chevron structure, allowing favorable nursing conditions for aquatic species.

Finally, Figure 1 shows an exemplary configuration of two chevrons in series arrangement, under dynamic (left) and static (right) conditions.

Figure 1. Series arrangement of blunt nosed chevrons installed in a straight channel: (left) dynamic conditions; (right) static conditions. Water flows from bottom to top.

Keywords: Acoustic Doppler Velocimeter (ADV); densimetric Froude number; kinematic field; river restoration

Acknowledgment

This research did not receive any specific grants from funding agencies.

References

[1] Rosgen, D. L. (2001). The cross-vane, w-weir and j-hook vane structures... their description, design and application for stream stabilization and river restoration. In Wetlands Engineering & River Restoration 2001 (pp. 1-22). https://doi.org/10.1061/40581(2001)72
[2] Pagliara, S., & Chiavaccini, P. (2006). Energy dissipation on block ramps. Journal of Hydraulic Engineering, 132(1), 41-48. https://doi.org/10.1061/(ASCE)0733- 9429(2006)132:1(41)
[3] Pagliara, S., Roy, D., & Palermo, M. (2021). Scour features at wood bundles. Water, 13(15), 2118. https://doi.org/10.3390/w13152118
[4] Roy, D., & Pagliara, S. (2022). Equilibrium morphology and scour evolution at blunt nosed chevrons. River Research and Applications, 38(3), 499-512. https://doi.org/10.1002/rra.3911
[5] Roy, D., Pagliara, S., & Palermo, M. (2021). Experimental analysis of scour features at chevrons in straight channel. Water, 13(7), 971. https://doi.org/10.3390/w13070971
[6] Davinroy, D.R., Redington, L.S. and Stauser, N.C. (1996). Design of blunt-nosed chevrons in the Mississippi River for sediment management. Proceedings of 6th FISC, Las Vegas, NV.
[7] U.S. Army Corps of Engineers, (USACE, 2012). Upper Mississippi river restoration environmental management program environmental design handbook. Rock Island District.

Experimental Study on Mega-cusps and Dune Erosion Caused by Intersecting Storm Waves

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Abstract

Intersecting wave trains can be created by two or more storm systems and cause mega-cusps (Dalrymple, R. A. and Lanan, G. A., 1976) and severe dune erosion (Thornton et al, 2007).

In this study, a laboratory experiment was conducted to study the beach cusps formed by intersecting waves. The wave basin was made of an offshore flat and a sand beach with equilibrium profile formed by normal incident regular waves. Two intersecting wave trains with the same period 1.5 s and opposite angles were generated by a segmented wavemaker consisting of 70 boards and basin boundaries perpendicular to the shoreline were set at the anti-nodal lines. Cusp bays was scoured out by the high waves at the anti-nodal lines and apices and shoals were formed at the nodal lines by the backwash and rip currents under the region of low waves. The height of the apices and the offshore shoals and the depth of the bay continued to change. The change of still water line was measured every 10 minutes (Figure 1). The cross-shore distribution of wave heights at the anti-nodal and nodal lines were also measured by wave gauges.

When the shoreline changed little, the bathymetry between the swash zone and shoaling zone were surveyed by a topographic measuring system. Sand waves were found to form in the front of cusp bays in the shoaling region (Figure 2). Xbeach model was used to simulate the experimental phenomena and validated by the measured data.

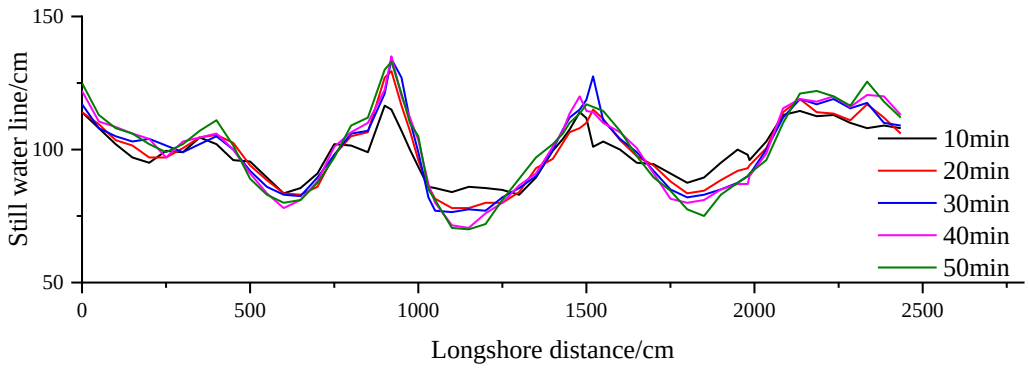

Figure 1. The measured still water line.

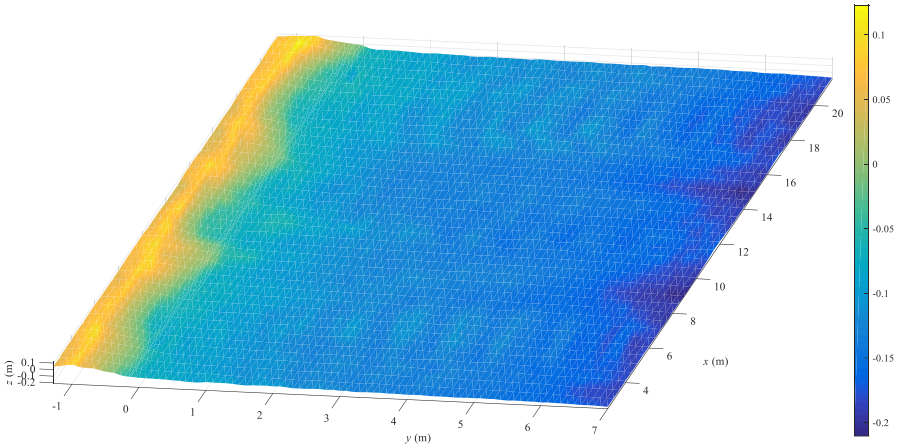

Figure 2. The measured bathymetry between the swash zone and shoaling zone.

Keywords: Intersecting waves; Beach cusps; Dune erosion

Acknowledgment

The authors would like to express appreciation for the support of the sponsors [Grant Number: 51879033].

References

[1] Dalrymple, R. A., Lanan, G. A. (1976). "Beach cusps formed by intersecting waves". Geological Society of America Bulletin, 87(1), 57-60.
[2] Thornton, E. B., MacMahan, J., Sallenger Jr, A. H. (2007). "Rip currents, mega-cusps, and eroding dunes. Marine geology", 240(1-4), 151-167.

Dynamic changes of environmental flow of riparian habitat with channel evolution on the main stem of Middle Yangtze River

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Abstract

Aquatic ecosystem supports our livelihoods, life styles and ethical values, whereas the complex conflicts between the demands for water and energy sources, and their conservations challenge the decision makings and practical actions of water allocation and regulation (Arthington et al., 2018). The assessment of environmental flow (EF) is of great significance to the river ecosystem conservation and restoration (Wang et al., 2016; Arthington et al., 2018). However, most of EF assessments are based on an underlying assumption that the river channel is under an equilibrium state (Arthington et al., 2018; Ban et al., 2022), which is not applicable to large alluvial rivers such as the Middle Yangtze River (MYR), as shown in Fig.1.

Figure 1. Sketches of Yangtze River Basin and the Jingjiang Reach: (a) Yangtze River Basin; (b) Jingjiang Reach.

The EF is related to not only the hydrological and biological processes, but also the dynamically change owing to the evolution of river channel. This study provides the evidence for the impact of channel evolution on the EF of riparian habitat in the main stem of the MYR, based on the field measurements, and highlights the uncertainty in the calculated EF because of annual and inter-annual variations of the hydraulic conditions due to unsteady incoming flow, intensive channel erosion and tributary confluence, which thus requires a more thoughtful consideration.

It is found that the required threshold environmental flows for four guilds of larval fish, juvenile fish, hygrophytes and macro-invertebrate increased by 1200 m^3/s-2600 m^3/s in the study reach during the period 2002-2020 (Fig.2). The satisfaction rates of the threshold-combined EF showed the maximum differences of 50% and 80% during the spring-summer period and during the autumn period, respectively, when considering the dynamic change of the EF. In addition, it was highlighted that the necessity of taking the sediment transport process and channel evolution into account when conducting the overall design of the ecosystem conservation in the MYR, because they will not only

obviously change the physical settings of the MYR, but also influence the transport of other biochemical particles.

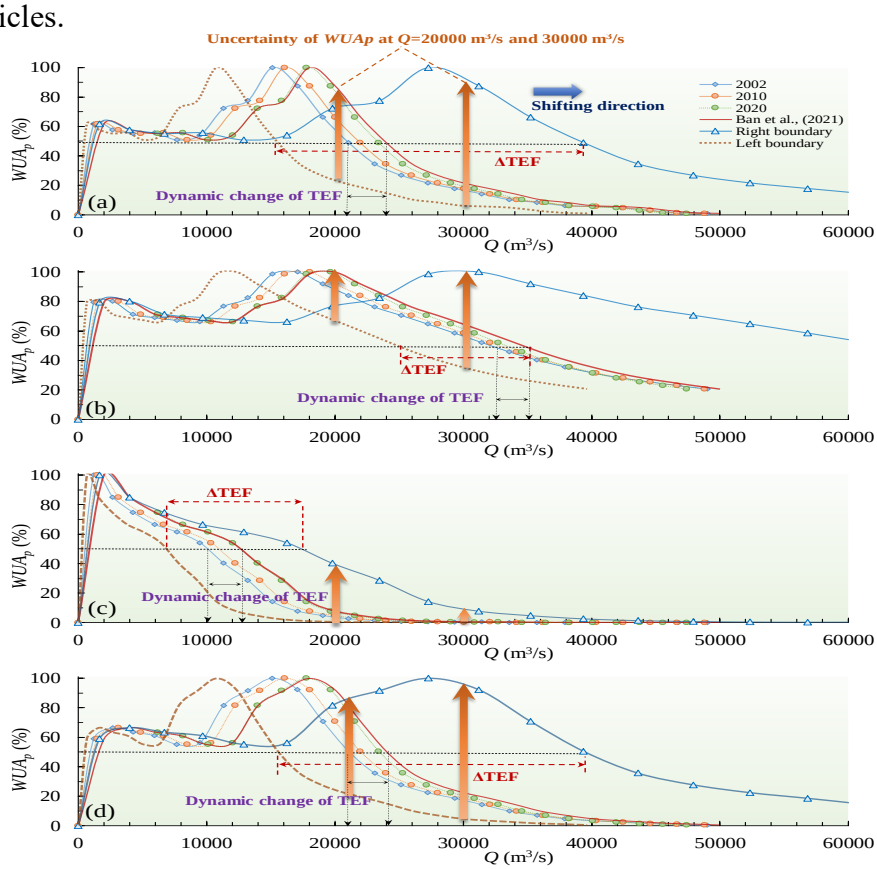

Figure 2. WUA_p-Q curves for different guilds in different years in the Jianli sub-reach of the MYR: (a) Larval fish; (b) Macro-inverbrates; (c) Hygrophytes; (d) Juvenile fish.

Keywords: Environmental flow, dynamic change, channel evolution, Middle Yangtze River.

Acknowledgment

This work was supported by the National Natural Science Foundation of China (Grant Nos. U2040215, 52009095, 51725902), and Natural Science Foundation of Hubei Province (2021CFA029).

References

[1] Arthington A.H., Kennen J.G., Stein E.D., Webb J.A. (2018). Recent advances in environmental flows science and water management—Innovation in the Anthropocene. Freshwater Biology, 63: 1022– 1034. https://doi.org/10.1111/fwb.13108

[2] Ban X., Qi T., Wang H. Z., Du H., Diplas P., Xiao, F., Du Y., Gao W. J., Guo W. X., Shi X., and Huang W. (2022). Comprehensive environmental flows assessment for multi-guilds in the riparian habitats of the Yangtze River. Water Resources Research, 58, e2021WR030408. https://doi.org/10.1029/2021WR030408

[3] Wang H.Z., Liu X.Q., and Wan H.J. (2016). The Yangtze River Floodplain: Threats and Rehabilitation. American Fisheries Society Symposium 84:263–291. https://www.academia.edu/61817151/The_Yangtze_River_Floodplain_Threats_and_Rehabilitation.

Numerical analysis of protected bank instability under the combined impacts of river flow and groundwater flow

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Abstract

Bank erosion in alluvial river is a soil-water interaction problem, and affected by different processes of hydraulic erosion, groundwater flow, and soil property variation etc. (Rinaldi & Nardi, 2013). Many researches were conducted to investigate the mechanisms of bank erosion process (Fox et al., 2007; Rinaldi et al., 2004; Simon & Collison, 2002; Zhang et al., 2021), and groundwater flow inside the river bank have long been recognized as one of the major controlling factors. However, seldom field measurements have been conducted on the large river system. Besides, the construction of revetment work (Gregory, 2006; Hagerty & Parola, 2001) further complicated this process and the mechanism underlying the failure of protected river bank remains unclear.

In order to monitor the variation of groundwater level, a 20 m deep well (Figure 1) was constructed at a typical bank erosion site in the MYR, with the groundwater level and river stage being continuously recorded in two years of 2021 and 2022. Besides, the groundwater flow and stress inside the protected riverbank was simulated by using SEEP/W and SIGMA/W software, with the key parameters being calibrated by the measurements. Numerical tests were then conducted to analyze the impacts of the river stage variation and groundwater flow on bank stability.

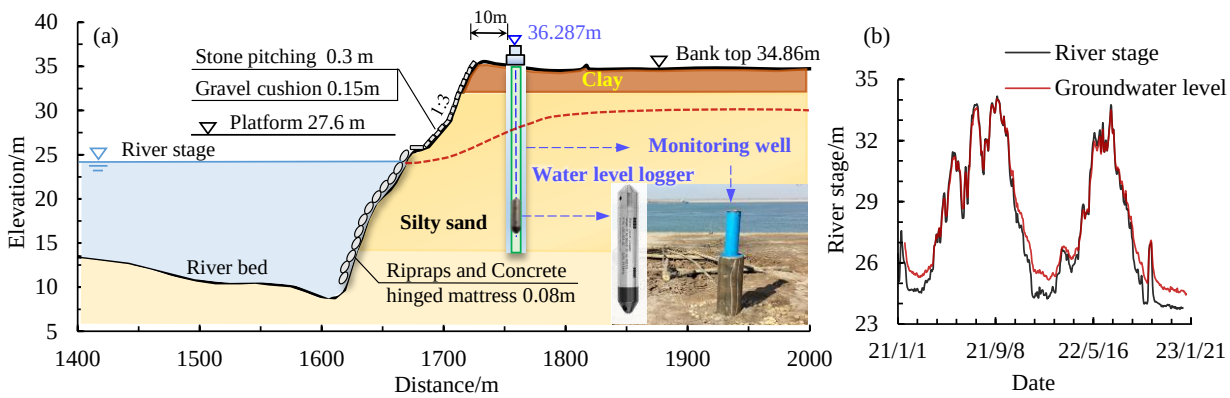

Figure.1 Monitoring well at a typical bank erosion site in the Middle Yangtze River: (a) well setup and; (b) measured groundwater level and river stage in 2021 and 2022.

Results (Figure 1b) has confirmed the delayed response of groundwater level to river stage change, which is especially obvious in the recession period. Moreover, the simulation explored the behavior of the tensile stress under different flow conditions and results (Figure 2) indicated that the tensile failure (during the rising period) leads to the initial damage for the protected riverbank, and this initial damage will be followed by more serious bank erosion events. Tensile failure may occur on the revetment surface due to local stress concentration mainly affected by water level change rate and soil composition.

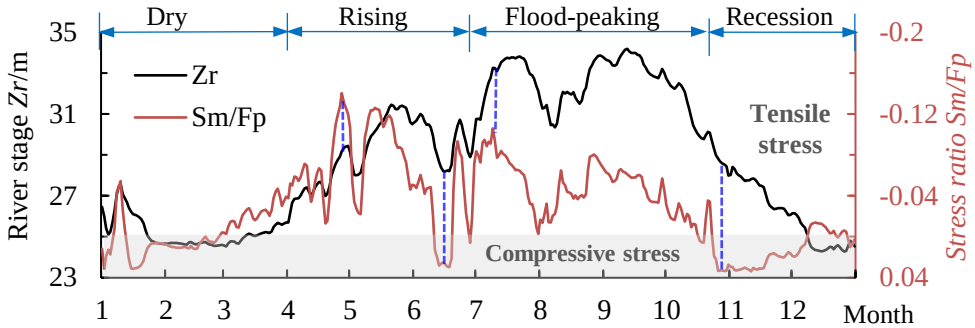

Figure.2 Temporal changes of the in-channel water level (*Zr*) and the ratio of the maximum tensile stress *Sm* (negative value) to the bank-toe hydrostatic pressure *Fp* in 2021.

Keywords: River stage; Groundwater level; Protected bank; Tensile stress; Middle Yangtze River.

Acknowledgment

This work was supported mainly by the National Natural Science Foundation of China (Grant Nos. U2040215, 51725902, 52009095), and it was also supported partly by Natural Science Foundation of Hubei Province (2021CFA029).

References

[1] Fox, G. A., Chu-Agor, M. L. M., & Wilson, G. V. (2007). "Erosion of noncohesive sediment by ground water seepage: Lysimeter experiments and stability modeling". Soil Science Society of America Journal, 71(6), 1822–1830.
[2] Gregory K J. (2006) "The human role in changing river channels". Geomorphology. 79(3/4):17 2-191. https://doi.org/10.1016/j.geomorph.2006.06.018.
[3] Hagerty D J, Parola A C. (2001) "Seepage effects in some riprap revetments". Journal of Hydra ulic Engineering, 127(7), 556-566. https://doi.org/10.1061/(ASCE)0733-9429(2001)127:7(556)
[4] Rinaldi, M., Casagli, N., Dapporto, S., & Gargini, A. (2004). "Monitoring and modelling of por e water pressure changes and riverbank stability during flow events". Earth Surface Process and Landforms, 29(2), 237-254.
[5] Rinaldi, M., & Nardi, L. (2013). "Modeling Interactions between Riverbank Hydrology and Ma ss Failures". Journal of Hydrologic Engineering, 18 (10), 1231–1240. https://doi.org/10.1061/(A SCE)HE.1943-5584.0000716.
[6] Simon A, & Collison A J.C. (2002). "Quantifying the mechanical and hydrologic effects of ripar ian vegetation on streambank stability". Earth Surface Processes and Landforms. 27, 527-546. h ttps://doi.org/10.1002/esp.325.
[7] Zhang, K., Gong, Z., Zhao, K., Wang, K., Pan, S., & Coco, G. (2021). "Experimental and Nume rical Modeling of Overhanging Riverbank Stability". Journal of Geophysical Research: Earth S urface, 126(10), e2021JF006109. https://doi.org/10.1029/2021JF006109.

The Channel Pattern Classification of Upper and Middle Reaches of Heilongjiang River

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Abstract

As the longest international boundary river, the fluvial processes of the Heilongjiang River has always been concerning, and the features of the River pattern need to be deeply elaborated. The length of the China Russia boundary segment of the Heilongjiang River is 1850km, includes the upper reaches from the juncture of the Shilka and Argun to the Zeya confluence (at the city Blagoveshchensk) about 900 km, and the middle reaches from the Zeya extending south-east to the Wusuli confluence (near the city Khabarovsk) about 950 km. The sketch drainage map of the Heilongjiang basin is shown in Figure 1.

Figure 1. Sketch drainage map of the Heilongjiang River

To further probe the channel patterns, in this paper, the upper and middle reaches of the main stream of Heilongjiang River are divided into 108 segments, including 17 bend segments, 38 straight transition segments, and 53 bifurcated segments, through the remote sensing interpretation of the collected satellite map images. And the parameters reflecting the plane morphology of each segment, such as the sinuosity or bifurcated coefficient and widening rate etc. are calculated. In order to divide and classify the different patterns along Heilongjiang River, the discrimination variable is defined as the sinuosity/bifurcated coefficient multiplied by the length of corresponding segment, and the cumulative curve method is applied. According to the cumulative curve method, the turning points of the curves indicate the different of next segment. The result under identifying of the cumulative curve method shows that, the upper and middle reaches of Heilongjiang main stream could be divided into 6 segments, each of them is classified to one channel pattern different from upper and down reaches (as shown in Figure 2).

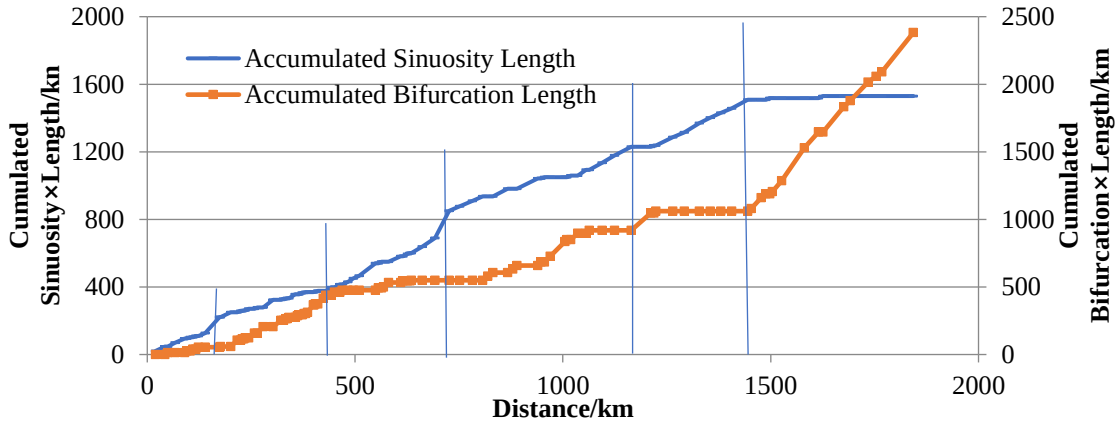

Figure2. Accumulated discrimination variable curves of channel patterns along the Heilongjiang River (the accumulated sinuosity length represents the single channel bending degree, while the accumulated bifurcation length represents the multiple channel branching degree)

The first segment in 0-201km classified as straight pattern, due to the single channel length account to 86% with the sinuosity of 1.28[1]; the second segment in 201-469km classified as braided pattern, due to the multiple channel length account to 55% with the bifurcation coefficient of 2.63; the third segment in 469-807km classified as meandering pattern, due to the single channel length account to 90% with the sinuosity of 1.52; the fourth segment in 807-1224km also classified as braided pattern, owing to the multiple channel length account to 45% with the bifurcation coefficient of 2.71; the fifth segment in 1224-1445km definitely classified as straight pattern, owing to the whole segment is single channel with the sinuosity of 1.18; the sixth segment in 1445-1850km obviously classified as braided channel owing to the multiple channel length account to 95% with the bifurcation coefficient up to 3.11.

Keywords: Channel pattern; Discrimination variable; Cumulative curve method; Heilongjiang River

Acknowledgment

The authors would like to express appreciation for the support of the National Natural Science Foundation of China [U22A20237] and National key research and development program [2018YFC0407301].

References

[1] Qian Ning. On the Classification and Causes of Formation of Different Channel Patterns [J]. Journal of Geographical Sciences, 1985.03, 40(1):1-10

Experimental study of roughness distribution effect on flow resistance in gravel-bed channels with structured block ramps

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Abstract

Previous bed roughness measures (e.g. characteristic particle size D_{84}) for reach-average flow resistance only describe overall river bed fluctuation, how the distribution of bed roughness influences reach-averaged flow resistance remains unclear [1-2]. To study the influence of roughness distribution on flow resistance and find a measure that characterizes not only the fluctuation but also the distribution of bed roughness, we conducted flume experiments on reach-averaged resistance in which the bed roughness is characterized with structured block ramps with four different distributions: transverse, random, cluster and longitudinal (Figure 1).

The results show that channels with different distributions of roughness exhibit distinct flow resistance under the same water discharge, even when the bed has the same amount of block ramps. Channels with transverse block ramps exhibit the highest flow resistance, while channels with longitudinally-distributed block ramps show the lowest flow resistance. Random and cluster block ramp distributions demonstrate comparable and moderate levels of flow resistance. To better characterize bed roughness, we proposed a roughness measure $\sigma_{\text{average2d}}$, which is calculated based on bed topography. We compared $\sigma_{\text{average2d}}$ with other three existing roughness measures: D_{84}, the standard deviation of longitudinal center bed profile (σ_{2d}) and the standard deviation of three-dimensional bed elevations (σ_{3d}). The results show that $\sigma_{\text{average2d}}$ outperforms other roughness measures in describing bed roughness. $\sigma_{\text{average2d}}$ is capable of describing not only fluctuation but also distribution of bed roughness.

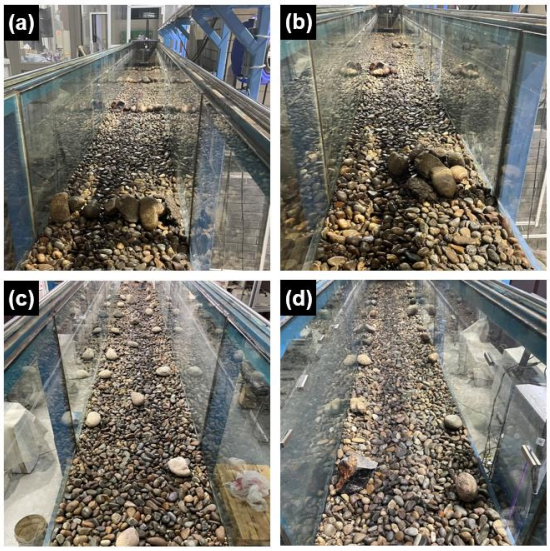

Figure.1 Gravel bed with the same amount of block ramps and different roughness distribution: (a) transverse; (b) cluster; (c) random and (d) longitudinal.

Keywords: Flow resistance; Roughness distribution; Roughness measure; Structured block ramps

Acknowledgment

The authors would like to express appreciation for the support of the National Natural Science Foundation of China [Grant Number: 91747207 and 51525901].

References

[1] Ferguson R. (2007). "Flow resistance equations for gravel- and boulder-bed streams." Water Resources Research 43, 2006wr005422.
[2] Chen X., Hassan, M. A., An, C., & Fu, X. (2020). "Rough Correlations: Meta-Analysis of Roughness Measures in Gravel Bed Rivers." Water Resources Research, 56, e2020WR027079.

Influence of beach erosion during wave action in designed artificial sandy beach-take Haikou Bay in China as example

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Abstract

Beach width is an important factor for tourist comfort, while the back shore is a swash zone where sediment moves quickly[1].Lots of efforts have been given to reveal the erosion and restoration process of beach profiles before and after the storm due to measurement data, physical model and numerical model[2~4]. Reveling the coastal variation differences[5,6] and constructed a theoretical system for assessing the risk of coastal evolution[7]. Artificial sandy beaches focus on beach width stability and evolution. This paper is based on an artificial beach project in Haikou Bay, where, in view of the existing conditions, a new type of beach profile that can protect beach berm and width without being eroded by offshore extremely high waves was put forward. This example may assist those institutions that want to establish artificial beaches or island coastal zones. The anti-erosion sandy beach system we designed maintained balance during wave action. We used the XBeach numerical model to predict erosion spots and characteristics under storm and normal wave events, and we discussed the sediment transport rate along and across the shoreline, which corresponds to profile width and back shore slope. We found that normal waves with lower height and shorter periods can induce stronger erosion than storm waves due to the inner-bay landform in Haikou Bay. Alongshore and offshore are the two main sediment transport routes, but the beach system we designed maintained dynamic equilibrium. We also discussed engineering and biological methods to reduce erosion during wave action. Offshore construction and sandbars are a double-edged sword for beach protection, and biological methods such as green plant root systems retain berm surface sediment without allowing it to be transported offshore by wave action.

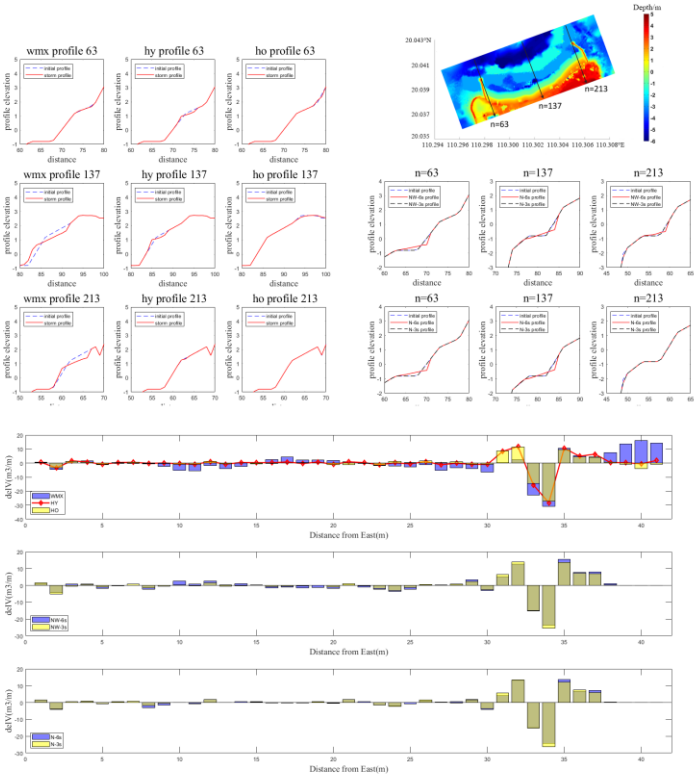

Figure 1. Beach volume change in each profiles during storm and normal wave tests

Keywords: Artificial beach; erosion; wave; numerical simulation

References

[1] ZHOU Yingtao, FENG Xi, GUAN Weibing, et al. Characteristics of beach erosion in headland bays due to wave actiont: Taking the Narrabeen beach in Australia as an example (in Chinese)[J]. Chinese Science Bulletin, 2019, 64: 223‑233.

[2] ZHENG J, ZHANG C, DEMIRBILEK Z, et al. Numerical study of sandbar migration under wave-undertow interaction. Journal of Waterway Port Coastal and Ocean Engineer, 2013, 140(2): 146-159.

[3] ZHANG C, ZHANG Q, ZHENG J, et al. Parameterization of nearshore wave front slope. Coastal Engineering, 2017, 127: 80-87.

[4] JIANG Chenhui, CAO Haijin, FENG Jung, et al. Quasi-static balance profile Test of rigid vegetation coast under regular wave action [J]. Port & Waterway Engineering, 2019, (4): 7-14, 30.

[5] ZHOU Yingtao, FENG Xi, GUAN Weibing, et al. Study on the erosion and silting process of cape shaped curved beach under storm wave action [J]. Sediment Research, 2019, 4:73-80.

[6] FENG X, ZHOU Y T, LU Y, et al. Characteristics of Beach Erosion in Headland Bays due to Storm-Waves[C]. Proceedings of the 29th International Ocean and Polar Engineering Conference, 2019, 3821-3829.

[7] LUO Shilong, CAI Feng, LIU Jianhui, et al. A study on coastal erosion risk assessment in Fujian province [J]. Journal of oceanography (Chinese version), 2014, 36 (09): 132-141.

Utilizing 2D simulation data to enhance 1D morphological modeling of the Hungarian Danube River

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Abstract

The more than 400 km long Hungarian Danube River has been subject to significant bed incision for a long time. The main driving factors behind the erosion processes are: (i) the conventional river regulation measures, such as channelization, which took place in the late 19th century, (ii) intensive dredging activities for construction purposes during the 1960s and 70s, and (iii) the construction of hydropower plants upstream of the Hungarian section. On average, the riverbed of the entire section has deepened by 2 meters over the last 60 years. However, the pace of the bed incision processes decreases as the river morphology approaches a new equilibrium state. The erosion processes of the riverbed have a negative impact on navigability conditions, the quality of riverine habitats, flood conveyance, and different groundwater utilization modes, such as drinking water supply. Therefore, it is crucial to understand the current status of the bed morphology and whether further bed erosion can be expected.

The goal of this study is to analyze past and future morphological changes of the Danube riverbed for the entire Hungarian section, i.e., on a relatively large spatial scale and over temporal scales of decades. To simulate riverbed morphodynamics on this spatio-temporal scale, we developed a procedure in which we parameterize a self-developed 1D model with boundary conditions provided by 2D flow model results. The 1D simulation tool solves hydrodynamics (HD), sediment transport (ST), and consequent morphological changes in a reasonably simple and cost-efficient manner. The methodology applied is not new, it solves the gradually varied flow equations, following by e.g. Parker (2004). The novelty of this work, however, lies in the parameterization of the 1D model.

The most relevant features of the developed method are the followings:

- For setting up the hydrodynamic model, we utilize information from a recently built and validated 2D hydrodynamic model for the entire Hungarian Danube section. To accurately describe the flow conveyance in the 1D model, we introduce an effective width based on the map of specific flow discharge simulated by a 2D HD model (Figure 1). In this way, the influence of e.g., groyne fields can be accounted for.
- To parameterize the sediment transport model, we use bed shear stress information from the 2D model, based on which an effective width for bedload transport is also introduced. Furthermore, field data from recent bed material and bedload measurement campaigns were also utilized, the latter conducted at a hydrographical monitoring station. This information is used to calibrate the well-known Meyer-Peter and Müller (1948) bedload transport formula.
- To validate the morphodynamic model, we compare the simulated morphological changes with calculated bed level differences obtained from recent bed elevation maps (Figure 2).

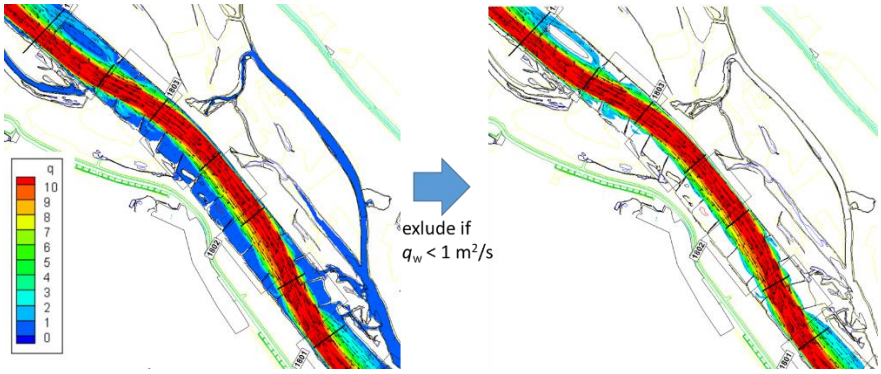

Figure 1. The simulated 2D maps of specific flow discharge are used to provide data on effective flow width for the 1D HD model.

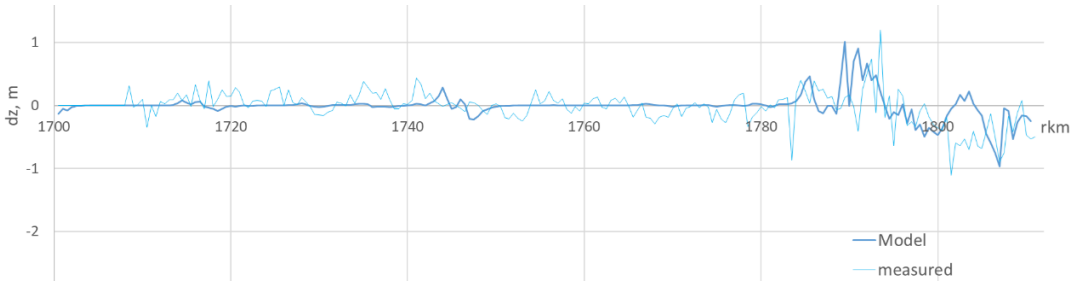

Figure 2. Measured vs. modeled bed elevation changes for a 100 km long section of the Danube River for a time period of 13 years.

Keywords: River morphodynamics; Numerical modeling; 1D model; 2D model; Danube River

Acknowledgment

The research was partly funded by the Sustainable Development and Technologies National Programme of the Hungarian Academy of Sciences (FFT NP FTA). The second author acknowledges the support of the János Bolyai fellowship of the Hungarian Academy of Sciences and the financing support of the postdoctoral project PD 135037 funded by the National Research, Development and Innovation Office.

References

[1] Meyer-Peter, E.; Müller, R. Formulas for bed-load transport. In Proceedings of the 2nd IAHR Congress, Stockholm, Sweden, 7–9 June 1948; IAHR: Delft, The Netherlands, 1948; Volume A2, pp. 1–26.
[2] Parker G. 1D Sediment Transport Morphodynamics with applications To Rivers and Turbidity Currents. e-book. http://hydrolab.illinois.edu/people/parkerg/morphodynamics_e-book.htm, 2004

Temporal Variations in Boulder Mobility and Bed Mobility Controlled by Episodic Sediment Supply in a Step-pool Channel

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Abstract

The adjustment of bed surface in steep gravel-bed channels typically involves matching the local sediment transport to the episodically supplied from upstream and adjacent hillslopes. Previous experimental and field studies have demonstrated that episodic sediment supply has significant influences on the overall channel morphology, bedload transport, and channel stability (Elgueta-Astaburuaga et al., 2018; Hassan et al., 2020; Wang et al., 2021, 2022; Hassan et al., 2023). Further investigation is necessary to examine the role of boulders on channel stability.

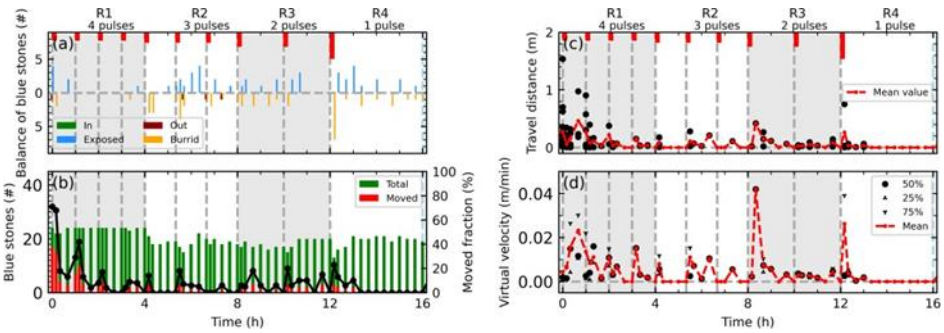

Figure 1. Time series of boulder mobility: (a) boulder exchange, (b) number and fraction of mobile boulders, (c) travel distance, (d) virtual velocity.

In this work, we explore the temporal variations in boulder/bed mobility in response to episodic sediment supply based on the high-resolution data of bedload and bed surface on reach scale from the episodic sediment supply experiments under constant flow discharge by Wang et al. (2021). Our analysis focuses on the largest boulders, identified as blue stones with a diameter of 45 mm, which we tracked using image processing and identification techniques, coupled with Digital Elevation Models (DEMs). Additionally, we measured the grain size distribution of both bedload and bed surface in order to calculate the scaled fractional transport ratio P_i/F_i (P_i is the proportion of each size in the bedload transported mixtures and F_i is the proportion of each size fraction in the bed surface).

Fig. 1 shows the temporal variations in boulder mobility in response to episodic sediment supply. Episodic sediment supply not only adds new boulders but also induces the burial of existing boulders. However, during no-feed intervals, the buried boulders were gradually exposed, and only a few boulders exited the flume (Fig. 1a). Boulders were more mobile due to sediment pulses, as evidenced by much larger numbers and ratios of moved boulders (Fig. 1b), higher travel distances (Fig. 1c), and higher virtual velocities (Fig. 1d). However, after sediment pulses, boulders became more stable with near-zero travel distance and virtual velocity (Fig. 1b-1d). As for bed mobility, the transport ratio in Fig. 2 shows that the fine fractions (< 4 mm) were over-estimated ($P_i/F_i > 1$), the coarser particles (5.6 - 22 mm) are fully mobile with the values of Pi/Fi close to one. The boulders (>22 mm) were

fully mobile ($P_i/F_i \approx 1$) during the first 20 minutes since pulses (Fig. 2a, 2b), while showing partial mobility ($P_i/F_i < 1$) at 40 to 60 minutes (Fig. 2c, 2d).

Our results indicate that episodic sediment supply is the primary control on the boulder and bed mobility, regardless of the magnitude of sediment pulse. For future work, the relationships between bed mobility and boundary shear stress should be quantitatively studied, to in-depth reveal the mechanisms of bed stability in response to episodic sediment supply.

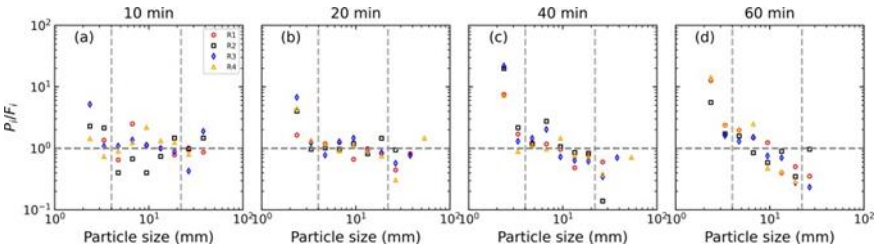

Figure 2. Transport ratio P_i/F_i as a function of grain size since sediment pulses for each run.

Keywords: Steep channel; Episodic Sediment supply; Boulder mobility; Bed mobility; Virtual velocity; Partial transport

Acknowledgment

The authors would like to express appreciation for the support of the National Natural Science Foundation of China [Grant Number: 41941019, 91747207, and 51525901].

References

[1] Elgueta-Astaburuaga, M. A., Hassan, M. A., Saletti, M., & Clarke, G. K. C. (2018). "The effect of episodic sediment supply on bedload variability and sediment mobility." Water Resources Research, 54, 6319– 6335.

[2] Hassan, M. A., Saletti, M., Johnson, J. P. L., Ferrer-Boix, C., Venditti, J. G., & Church, M. (2020). "Experimental insights into the threshold of motion in alluvial channels: Sediment supply and streambed state." Journal of Geophysical Research: Earth Surface, 125, e2020JF005736.

[3] Hassan, M. A., Saletti, M., McDowell, C., & Li, W. (2023). "Sediment dynamics and bed stability in step-pool streams: Insights from 18 years of field observations." Water Resources Research, 59, e2022WR032864.

[4] Wang, J., Hassan, M. A., Saletti, M., Chen, X., Fu, X., Zhou, H., & Yang, X. (2021). "On how episodic sediment supply influences the evolution of channel morphology, bedload transport and channel stability in an experimental step-pool channel." Water Resources Research, 57, e2020WR029133.

[5] Wang, J., Hassan, M. A., Saletti, M., Chen, X., Fu, X., Zhou, H., & Yang, X. (2022). "Experimental insights into the effect of event sequencing and sediment input texture on step-pool channel evolution." Earth Surface Processes and Landforms, 47(2), 569-581.

2D Sediment Modelling to Simulate Short Term Geomorphic Flood Response for River Restoration

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Abstract

2D modelling has become incredibly useful for river restoration and is used as a metric of estimating changes to flood extents as a result of modification (USACE Hydraulic Engineering Center, 2021). However, despite the developments in modelling, a gap remains in the usage and accuracy of sediment modelling to identify an important metric of river restoration: geomorphic change (Bizzi & Lerner, 2015; Lisenby, Croke, & Fryirs, 2017). With the level of development seen on UK rivers historically understanding the potential physical changes that a river may undertake is important for the assurances of both landowners and stakeholders before undertaking any form of restorative work (Entwistle et al, 2021).

Therefore, this paper investigates the accuracy of high-resolution sediment modelling to identify geomorphic change on Blaze Beck in Cumbria, a high energy wandering river system that has recently been restored. Comparisons have been made between the impacts of a simulated flood event created using HEC-RAS 6.3 modelling software and a real-life flood event on October the 27th 2021, to compare changes to geomorphology and identify the degree of accuracy of the 2D change modelling compared to change measured using drone-based photogrammetry.

The results appear generally accurate, predicting locations of head cutting and more general low-level erosion and deposition. Bar formation, splay deposition and general bed raising are all predicted. The model is, however, sensitive to the gradation of sediment it has been trained with and unsensitive to vegetation induced stability and this can skew the ratio and pattern of deposition and erosion depending on the sample data used to simulate conditions (Wu, Shields Jr, Bennett, & Wang, 2005). The model, once refined and iterated to best simulate potential change, is functional even in a high energy hydraulically diverse environment and will have significant value in predicting the degree to which geomorphic change will occur because of restorative or other changes to a river reach (USACE Hydraulic Engineering Center, 2021).

Table 1. Comparison of modelled and real values of sediment budget for Blaze Beck

	Volume Deposited m^3	Volume Eroded m^3	Volume Balance m^3	Areal Equivalent m
1 in 2yr Flood	537.00	153.09	383.92	0.13
1 in 5yr Flood	1660.16	173.37	1486.79	0.27
Real Flood (DEM Differencing)	819.05	104.32	714.73	0.11

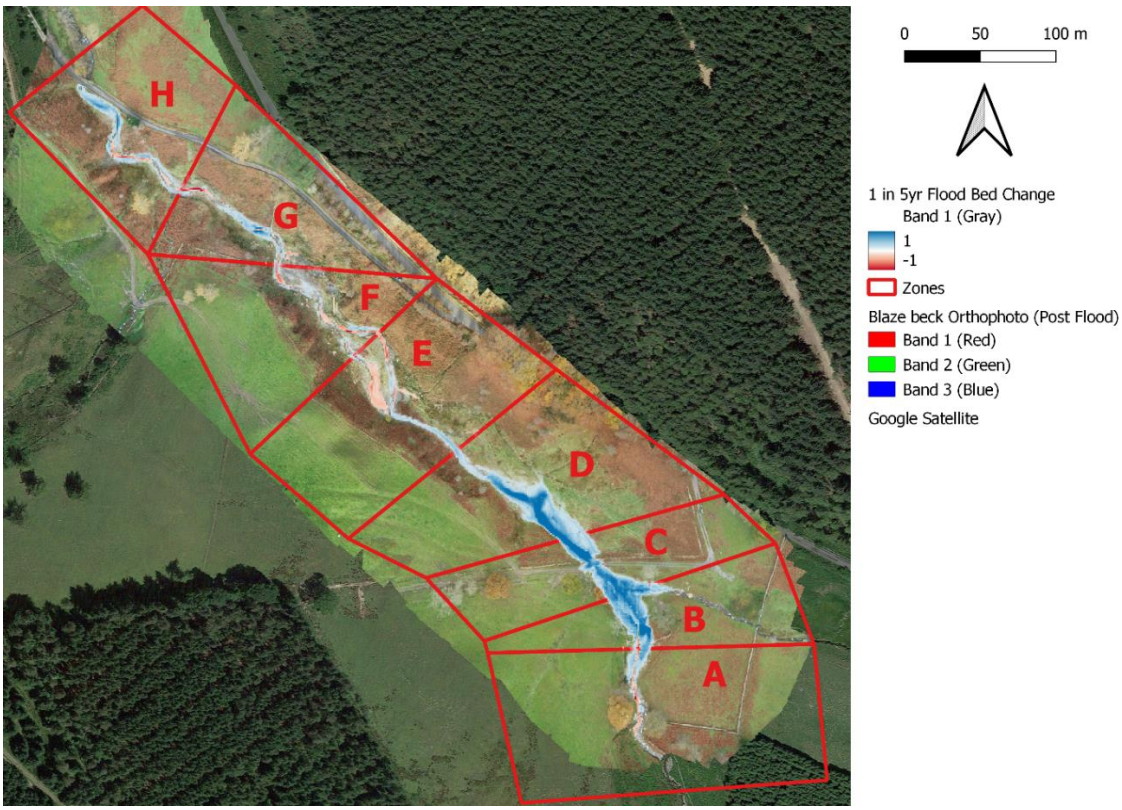

Figure 1. Modelled Erosion and Deposition response pattern at Blaze Beck for a 1 in 5yr flood.

Keywords: Sediment Transport, Geomorphology, Bed Change, River Restoration, 2D Modelling

Acknowledgment

Thanks to Dynamic Rivers and The Alpine Glacier Project for support in this research.

References

[1] Bizzi, S. and Lerner, D. N. (2015), The Use of Stream Power as an Indicator of Channel Sensitivity to Erosion and Deposition Processes, *River Research and Applications.*, 31, pages 16– 27, doi: 10.1002/rra.2717

[2] Entwistle, N. S., Heritage, G. L., Schofield, L. A., & Williamson, R. J. (2019). Recent changes to floodplain character and functionality in England. CATENA, 174, 490–498. https://doi.org/10.1016/j.catena.2018.11.018

[3] Heritage, G. L., Large, A. R., & Milan, D. (2021). A field guide to British rivers. Chichester: Wiley Blackwell.

[4] Lisenby, P. E., Croke, J., & Fryirs, K. A. (2017). Geomorphic effectiveness: A linear concept in a non-linear world. Earth Surface Processes and Landforms, 43(1), 4–20. https://doi.org/10.1002/esp.4096

[5] USACE Hydraulic Engineering Center. (2021, September 1). HEC-RAS 2D Sediment Technical Reference Manual. Retrieved from HEC-RAS Documentation: https://www.hec.usace.army.mil/confluence/rasdocs/d2sd/ras2dsedtr

[6] Wu, W., Shields, F. D., Bennett, S. J., & Wang, S. S. (2005). A depth-averaged two-dimensional model for flow, sediment transport, and bed topography in curved channels with riparian vegetation. Water Resources Research, 41(3). https://doi.org/10.1029/2004wr003730

Causes and trend prediction of water level diverse variation in the Middle Yangtze River following the operation of Three Gorges Dam

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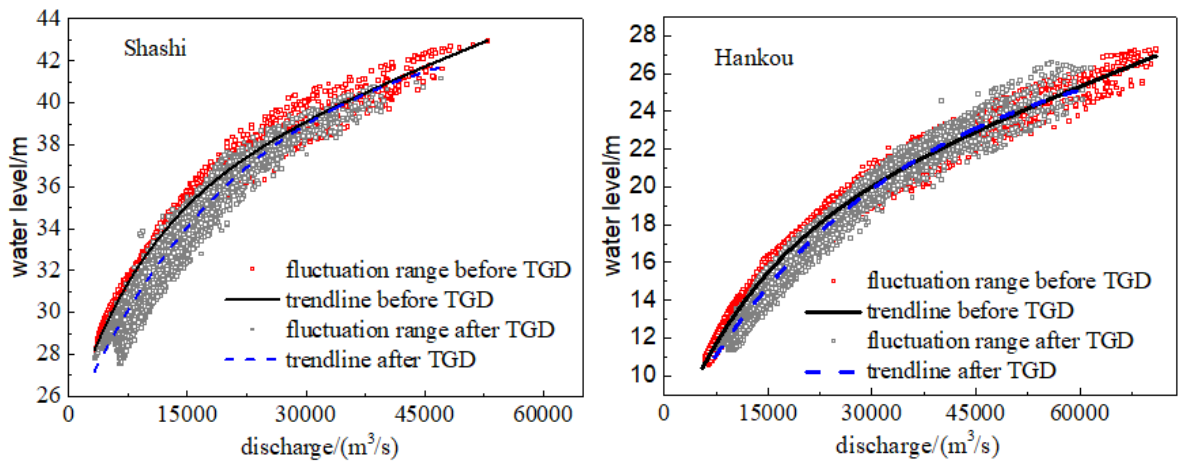
Abstract

The construction of large reservoirs causes the water level adjustment downstream of the dam, which has a significant impact on river regime, navigation, flood control and ecology[1].

In order to research water level variation characteristics, causes and predict the future trend in the Middle Yangtze River following the operation of Three Gorges Dam(TGD), the water level change trend at 7 hydrologic stations from 1986 to 2022 is analyzed by the Mann-Kendall analysis method[2]. The water level at small discharges shows significant decrease compared to that before the operation of Three Gorges Dam for all hydrologic stations, but the water level at medium discharges and flood discharges shows different variation characteristics, Figure.1.



a) At Shashi station, the water level at different discharge shows significant decrease compared to that before the operation of TGD.

b) At Hankou station, the water level at small discharge shows significant decrease compared to that before the operation of TGD, but the water level at medium discharge shows no significant change and the water level at large discharge shows slightly increase.

Figure1. Examples of relationship between water level and discharge at two stations.

Using the analysis method of influencing factors of water level change and the analysis method of water level amplitude based on the abnormal residual[3], this paper estimates the contributions of river erosion, downstream control water level change and resistance change to water level variation at different discharges. The result shows that: the significant decrease of low water level (at given small discharges) is mainly the result of the combined action of river erosion and the control water level decrease in the lower reaches, and river scour plays a leading role. For the middle water level (at given medium discharges). The different variation characteristics are mainly caused by the combined effect of river erosion and the increased resistance. The different variation characteristics

of high water level (at given flood discharges) are mainly due to the combined effect of river erosion, increased resistance and the control water level change in the lower reaches. Table1 shows channel roughness n under different discharge in 2004 and 2020 near Hankou hydrologic station.

Table 1. Channel roughness n under different discharges in 2004 and 2020

discharge/（m^3/s）	12000	20000	30000	45000
2004	0.033	0.023	0.023	0.020
2020	0.034	0.028	0.03	0.025
Proportion of roughness increase	6%	22%	30%	25%

The causes of resistance variation are also discussed. Bed sand coarsening increases the resistance of the river bed for more than25% near the dam, but only 3%~7% from Shashi to Jiujiang. The construction of numerous hydraulic projects plays an important role in resistance increase of the river bed. Bar and marshland vegetation growth promotes flood water level increasing.

Considering the impact of rising flood water level at some hydrologic stations, weakened capacity of rivers and lakes and future climate change, the flood control situation of Middle Yangtze River is still severe.

Keywords: water level change; M-K analysis; stage-discharge rating; channel resistance; Middle Yangtze River

Acknowledgment

The project “Superimposed influence and countermeasures of major fording projects along the Yangtze River under scour condition in the middle and lower reaches of the Yangtze River” (126302001000200002) are gratefully acknowledged for its financial fund.

References

[1] Hu, Y., Li, D., Deng, J., Yue, Y., Zhou, J., Chai, Y., & Li, Y. (2022). Mechanisms controlling water-level variations in the Middle Yangtze River following the operation of the Three Gorges Dam. Water Resources Research, 58, e2022WR032338.

[2] HAMED K H. Trend detection in hydrologic data: The Mann–Kendall trend test under the scaling hypothesis[J]. Journal of Hydrology, 2008, 349(3-4): 350-363.

[3] Chai Y, Yang Y, Deng J, et al. Evolution characteristics and drivers of the water level at an identical discharge in the Jingjiang reaches of the Yangtze River[J]. Journal of Geographical Sciences, 2020.

Exploring the impact of river restoration on morphodynamics in a mountain catchment in Scotland, UK

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Abstract

In recent years there has been a growing interest in developing sustainable solutions for managing rivers and water resources that focus on improving biodiversity while minimizing flood risks. Scotland has exemplified this by moving away from traditional hard engineering approaches to river and flood management, such as embankments, towards more holistic approaches which support river and floodplain connectivity and habitat protection [1]. In this paper, we test the capabilities of HEC-RAS 2D to predict and replicate sediment transport patterns and river morphology post river restoration measures in a 1 km stretch of the Allt Lorgy river, UK.

The Allt Lorgy is located in the Cairngorms National Park, Scotland, and is a tributary of the River Spey. It has a mean daily flow of 0.48 m^3/s with a bankful discharge of ~8 m^3/s. Located in an agricultural region, this river was historically managed by straightening the river using embankments, resulting in a straight, deep channel with little sediment diversity and poor water quality. In the early 2010's restoration of the river began; artificial embankments were removed, woody leaky barriers were placed in the channel, and over 500 native trees were planted on the floodplain [2]. Repeat topographic surveys (LiDAR) have been carried out in 2014, 2016, and 2019 to produce 1 m resolution Digital Elevation Models (DEMs) to assess the impact of the restoration measures and subsequent morphology of the channel.

A numerical model was set up with bathymetry based on the 2016 DEM. Three peak annual floods from the winters of 2016-17, 2017-18, and 2018-19 were run using HEC-RAS 2D combined with the sediment transport formulae of Wilcock and Crowe [3] and Wu et al. [4]. DEMs of difference (DoD) were created by subtracting the final bathymetry (post-simulation) from the original 2016 DEM. These DoDs, which produce maps of erosion and deposition, were compared to the DoD between the 2016 and 2019 DEMs.

Table 1. Erosion and deposition volumes for simulated and observed DEM of Difference

Model	Erosion (m^3)	Deposition (m^3)
Wilcock and Crowe	2615.88	1828.35
Wu et al.	1507.61	1345.66
2016-2019 DoD	1641.34	4298.19

Results (Figure 1) show that HEC-RAS 2D (v6) was able to replicate the erosion and deposition patterns broadly, with erosion occurring in the channel thalweg and deposition on the near floodplains. However, it is clear that HEC-RAS overestimated erosion and underestimated deposition (Table 1). This is likely caused by to two main limitations of the model: only the three largest flood events were simulated, and due to a lack of sediment flux data at the upstream boundary, the sediment recirculation mode was selected which assumes an equilibrium sediment transport. Peak floods in the catchment are driven by heavy rainfall, which can trigger high sediment flux from upstream landslides and runoff. Higher sediment input would result in more channel and floodplain deposition and less erosion. Over-erosion of the river thalweg in the model runs caused an increase in the flood-carrying

capacity of the river, resulting in reduced overbank flow and less extensive deposition. To refine the model and improve the understand of long term restoration induced morphological change, future studies will aim to quantify the sediment flux during peak flows and run longer simulations, for example, during the full wet winter season.

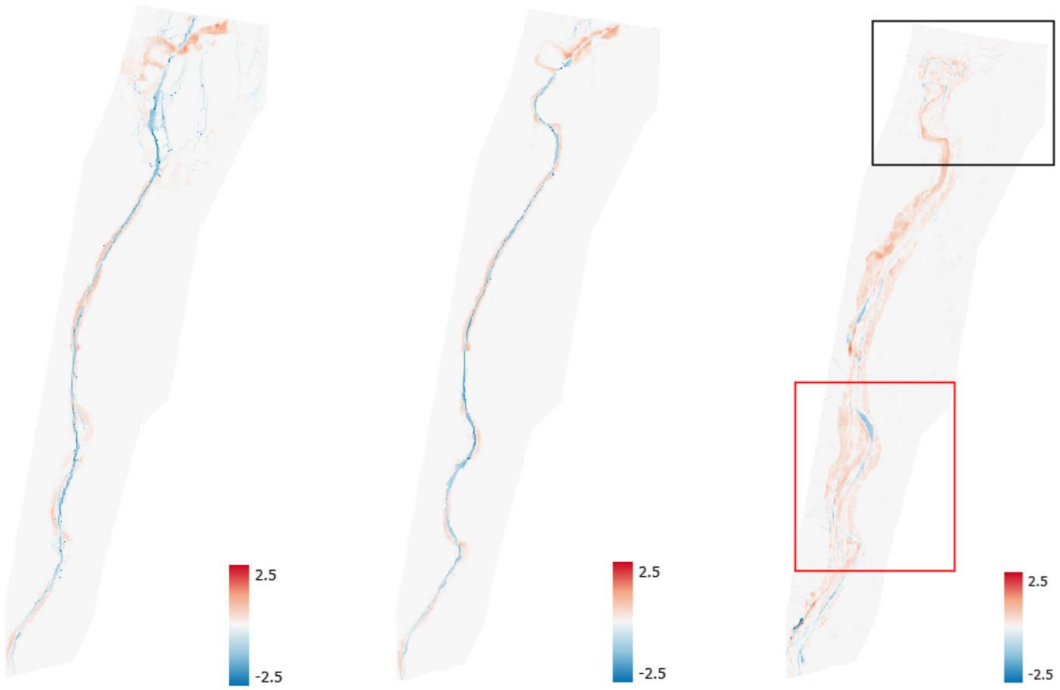

Figure 1. Erosion (blue) and deposition (red) maps (in m) of Allt Lorgy, after numerical simulation of three successive peak annual flood events using: a) WC formula, b) Wu formula, and c) observed DoD (2016 to 2019).

Keywords: River restoration, morphology, sediment transport, numerical modelling

References

[1] Scottish Environment Protection Agency. (2021) *The River Basin Management Plan for Scotland 2021 – 2027*. (https://www.sepa.org.uk/media/594088/211222-final-rbmp3-scotland.pdf)
[2] NFM Scotland. (2016) Allt Lorgy, River Dulnain, Spey Catchment. (https://www.nfm. scot/case-studies/allt-lorgy-river-dulnain-spey-catchment)
[3] Wilcock, P. R. and Crowe, J. C. (2003). Surface-based Transport Model for Mixed-Size Sediment. *Journal of Hydraulic Engineering*, 129(2):120–128, 2. doi: 10.1061/(asce)0733-9429(2003)129:2(120)
[4] Wu, W., Wang, S. S. Y., and Jia, Y. (2000). Non-uniform sediment transport in alluvial rivers. *Journal of Hydraulic Research*, IAHR 38(6): 427434.

Coastal systems under climate change and increasing human pressure: the case of the Venice Lagoon

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Abstract

Coastal systems are among the most economically valuable and highly threatened ecosystems on Earth [1]: they host important socio-economic activities worldwide and provide a wide range of valuable ecosystem services, but are severely threatened by climate changes and increasing human pressure, whose impacts are strongly intertwined. Indeed, the impact of climate change on coastal ecosystems is strongly exacerbated by increasing human-induced pressures [2]. The dramatic increase in the utilization of the coast occurred during the 20th century will likely continue through the 21st century, further boosting the number of people and assets at risk. Storm-surge barriers are increasingly being adopted to protect highly vulnerable and precious coastal urban and infrastructure areas where storm surges and sea flooding could have major impacts. Relevant examples are the barriers built to protect The Netherlands, the cities of London and Hull in the United Kingdom, St. Petersburg in Russia, New Orleans in Louisiana, and Venice in Italy [3].

Figure 1. Top panel: The Venice Lagoon, with an area of 550 km^2, is the largest brackish water body in the Mediterranean sea. Bottom panels, the three inlets of the Venice lagoon (Chioggia, Malamocco and Lido) where the location of the mobile barriers is shown (in yellow).

Surge barriers are also being proposed for flood risk reduction in Coastal Storm Risk Management studies by the United States Army Corps of Engineers (USACE) for 11 estuaries in the USA [4]. Although existing gates and barriers have provided effectiveness against storm surges studies on the environmental impacts of such measures are still in their infancy [3,4,5]. If on the one hand, direct

impacts of the barriers (e.g., tide propagation, wind wave generation and propagation) can be predicted and observed relatively easily, their use, that will likely become more and more frequent in view of the predicted rise in sea levels, might have more complex consequences with longer time scales leading to modifications of the natural environment and to environmental that need to be properly assessed. Here we consider and analyze the Venice Lagoon as a paradigmatic case representative of the coevolution of man and landscape, of natural processes and human agency. The history and fate of Venice Lagoon are tightly intertwined with those of the City of Venice. We show, through an interdisciplinary approach combining field observations, remote sensing, laboratory analyses, and mathematical modeling, that increasing anthropogenic pressure, coupled with the effects of natural processes exacerbated by climate changes, has led to an accelerated morphological deterioration of the lagoon and of the related ecosystem services. We also provide new insights on the short- and long-term consequences of coastal flooding prevention measures, such as storm-surge barriers, which are being widely adopted globally because of the accelerating rise in sea levels. From this point of view, the Venice and Venice Lagoon issues are becoming the new paradigm of the conflicts arising from the interactions among economy, society, and the environment, the three main pillars of sustainable development, furthermore providing an indication of what fate has in store for coastal cities and ecosystems of the future.

Keywords: Venice Lagoon; Storm surge gates; Storm surge barriers.

Acknowledgment

The BIRD2021 project “Unraveling Carbon Sequestration Potential by Salt Marsh Ecosystems” (PI A.D.) and the Research Programme Venezia2021, with the contribution of the Provveditorato for the Public Works of Veneto, Trentino Alto Adige, and Friuli Venezia Giulia, provided through the concessionary of State Consorzio Venezia Nuova and coordinated by CORILA (Research Line 3.2, PI A.D.) are gratefully acknowledged.

References

[1] Barbier, E.B., Hacker, S.D., Kennedy, C., Koch, E.W., Stier, A.C., Silliman, B.R. (2011). “The value of estuarine and coastal ecosystem services”. Ecological Monographs, 8, 169–193.
[2] Nicholls, R.J. et al. (2007). “Coastal systems and low-lying areas”. Climate Change 2007: Impacts, Adaptation and Vulnerability. Contribution of Working Group II to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change, M.L. Parry, O.F. Canziani, J.P. Palutikof, P.J. van der Linden and C.E. Hanson, Eds., Cambridge University Press, Cambridge, UK, 315-356.
[3] Tognin, D., D’Alpaos, A., Marani, M., & Carniello, L. (2021). Marsh resilience to sea-level rise reduced by storm-surge barriers in the Venice Lagoon. Nature Geoscience, 14(12), 906- 911.
[4] Orton, P., Ralston, D., van Prooijen, B., Secor, D., Ganju, N., Chen, Z., et al. (2023). “Increased utilization of storm surge barriers: A research agenda on estuary impacts”. Earth's Future, 11, e2022EF002991. https://doi.org/10.1029/2022EF002991
[5] Tognin, D., Finotello, A., D’Alpaos, A., Viero, D. P., Pivato, M., Mel, R. A., et al. (2022). “Loss of geomorphic diversity in shallow tidal embayments promoted by storm-surge barriers”. Science Advances, 8(13).

The Severaisse observatory: a collaborative site dedicated to the study of sediment transport and its interactions with morphology

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Abstract

1. Introduction

Understanding how sediment transport interacts with the morphology is of first importance and remains a challenging task. These processes have often been studied in flume experiments, but because of scaling uncertainties, field observations are necessary. Field surveys are however difficult, because unlike in the laboratory where one simply turns on the water tap to begin an experiment, in the field the processes depend on the actual hydrology. A second difficulty is developing a sampling strategy that is consistent with the variability of hydrological events. Most of these difficulties have been overcome in the Séveraisse Observatory, which is equipped with modern measurement techniques, allowing a continuous study of sediment flows and bed morphology. With this contribution, we propose to present the Séveraisse observatory and results of the 2023 monitoring season.

2. The Severaisse River

2.1 The site

The Severaisse is a French alpine river located in the Ecrin massif, near Gap, less than 1.5 hours from Grenoble. Sediment transport is very active and allows the development of successive braided morphologies, alternating with plane beds in the valley contractions. Its hydrology is controlled by the melting of snow and glaciers, which guarantees a competent flow for the transport of sediments, each spring.

Figure 1. View of the study site (downstream and upstream Timelapse cameras)

Moreover, the river is very accessible thanks to several bridges located along its course, and is not impacted by human constructions. For all these reasons, the Severaisse river has been monitored by Inrae since 2016, and a new campaign is organized every year. We survey more specifically a braiding reach located at Villar Louvbiere (44.824842401465176, 6.149104982745754).

2.2 Equipments

Water discharge is monitored at a gauging station built in a fixed section located at the reach outlet, and managed by the French Electricity company EDF (they regularly control discharge by ADCP). Bedload is monitored continuously with 3 seismometers (one at the reach entrance, one downstream

at the reach outlet, and one intermediate), and with an hydrophone, calibrated each year by direct sampling (Elwha sampler monitored by hand from a bridge). A continuous measurement of the turbidity, calibrated with direct sampling with an Isco sampler, permits to survey suspension. Two timelapse cameras controled by water level track the morphological changes, while the bed topography is measured at least twice per season from UVA and photogrammetry (structure from motion) surveys. We also regularly sample the bed size distribution with the Wolman protocol.

Figure 2. Bedload measurement

3 Why this presentation?

The Severaisse observatory produces high quality data, which gives us access to a wide range of processes such as relation between bedload transport and morphology [*Misset et al.*, 2020], bedload transport and suspension [*Misset et al.*, 2021], bedload transport and seismology [*Bakker et al.*, 2020], partial transport [*Recking et al.*, 2022]… The goal of this presentation is to arouse your curiosity. The Severaisse river is collaborative site where several labs already collaborate. Anyone willing to participate to this research is welcome.

References

[1] Bakker, M., F. Gimbert, T. Geay, C. Misset, S. Zanker, and A. Recking (2020), Field Application and Validation of a Seismic Bedload Transport Model, Journal of Geophysical Research: Earth Surface, doi:doi: 10.1029/2019JF005416.

[2] Misset, C., et al. (2020), Combining multi-physical measurements to quantify bedload transport and morphodynamic interactions in an Alpine braiding river reach, Geomorphology, doi:https://doi.org/10.1016/j.geomorph.2019.106877.

[3] Misset, C., A. Recking, C. Legout, M. Bakker, F. Gimbert, T. Geay, and S. Zanker (2021), Unraveling sediment sources and transport interactions by using continuous turbidity and seismic measurements in an Alpine catchment., Geophysical Research Letters.

[4] Recking, A., N. Mohamad, A. JOHANNOT, and J. P. TRAVERT (2022), Grain mobility in gravel bed rivers: insight from field measurements, in IAHR, edited, Grenada.

Bed Material Load Controls Active Channel Width in Sedimentation Zones: Data from Western North America

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Abstract

Bed material transport is a first-order control over channel morphology and geomorphic processes in alluvial rivers, but reliable estimation of bed material transport rates in natural rivers remains one of the most intractable problems in fluvial geomorphology. This limitation hampers efforts both to understand the fundamental relation between bed material transport and channel morphodynamics and to sustainably manage rivers.

Channel classification schemes (e.g. Schumm, 1985) have revealed a qualitative link between active channel width and the magnitude of bed material transport, but relatively few quantitative datasets are available to test this relation. One dataset encompassing a suite of smaller gravel-bed channels in Idaho was analyzed by Métivier and Barrier (2012), who found that the bankfull width (W) to depth (H) ratio (aspect ratio) increased by a factor of about four as bankfull bedload transport rate increased by three orders of magnitude and a few other quantitative observations have been gathered.

Parker's (1978, 1979) work showed that gravel-bed streams with banks composed of similar non-cohesive sediments would experience bank erosion and channel widening – the consequence of the advantage gained by bank erosion due to the gravitational assist – until the critical shear stress was very near threshold and the channel sufficiently wide to inhibit further lateral erosion. Parker suggested that, in such channels, τ^*, the effective Shields Number, ~0.04. To the extent that this value is near constant, as he suggested (but cf. Pfeiffer et al., 2017), then channel width would directly set the magnitude of the bed material load. Recent work by Popovic et al (2021) has further strengthened this case showing agreement between Parker's predictions and model results and concluding that "If this theory holds for natural rivers, the aspect ratio of a river could become a proxy for sediment discharge — a quantity notoriously difficult to measure in the field."

We present data from approximately 150 distinct river reaches across five physiographic regions of Western North America that confirm the conceptual framework of Parker and Popov et al. To relate rivers of widely varying sizes, we develop an elementary normalization scheme relating relative width to relative bed material load transport intensity. We define relative width as the ratio of the observed active channel width to the expected bankfull width of a geomorphically 'inert' channel defined using Kellerhals' (1967) regime relations for lake outlet channels ($W=1.8Q^{0.5}$) where W is the active channel width and Q is the channel forming discharge, which we assume to be the 2-year recurrence interval flow. Relative bed material load transport intensity is defined as the ratio of the average annual bed material bedload transport volume to the 2-year recurrence interval discharge. This second normalization implicitly assumes roughly equivalent durations of sediment transporting flows in the various reaches considered. The results show that normalized reach width allows prediction of sediment transport rate to within an order of magnitude (Figure 1A), strikingly suggesting reasonable estimates of bed material transport rate may be produced with only knowledge of the 2-year discharge and active channel width. Further the results show expected patterns relative to channel morphology. relative bed material transport intensity rising from very low values (near zero) at a normalized width ratio of 1, increasing very rapidly up to a normalized width ratio of about 2.5, and increasing more

slowly above this value, which corresponds to the peak observed bed material sediment transport efficiency (Figure 2B).

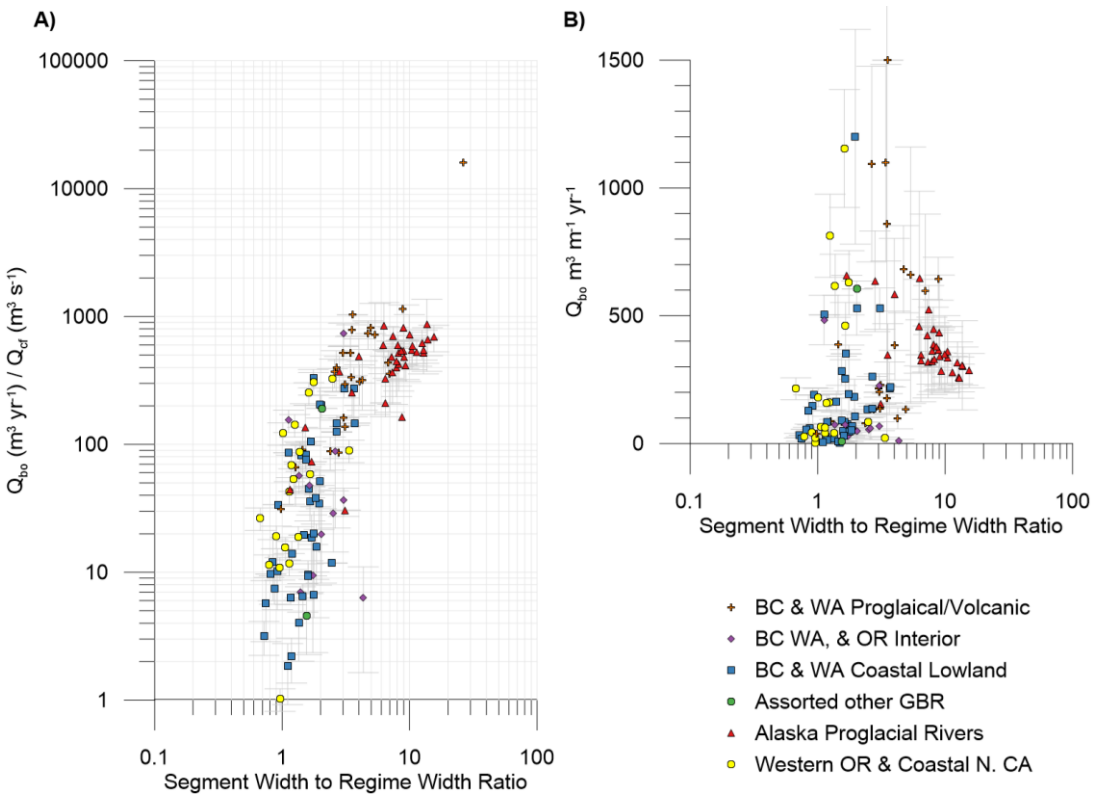

Figure 1. A) Normalized width-normalized sediment transport intensity relation and B) Normalized width to sediment transport efficiency.

Keywords: Bedload Transport, Rational Regime, Gravel Bed River, Channel Width

References

[1] Kellerhals, R. (1967). "Stable channels with gravel-paved beds". J. of the Waterways and Harbors Division, 93(1), 63–84.
[2] Parker, G. (1978). "Self-formed straight rivers with equilibrium banks and mobile bed. Part 2. The gravel river". J. of Fluid Mechanics, 89(1), 127–146.
[3] Parker, G. (1979). "Hydraulic Geometry of Active Gravel Rivers." J. of the Hydraulics Division, 105(9), 1185–1201.
[4] Pfeiffer, A. M., Finnegan, N. J., and Willenbring, J. K. (2017). "Sediment supply controls equilibrium channel geometry in gravel rivers." Proc. of the National Academy of Sciences, 114(13), 3346–3351.
[5] Popović, P., Devauchelle, O., Abramian, A., and Lajeunesse, E. (2021). "Sediment load determines the shape of rivers." Proc. of the National Academy of Sciences, 118(49),
[6] Schumm, S. A. (1985). "Patterns of Alluvial Rivers." Ann. Rev. of Earth and Planetary Sciences, 13(1), 5–27.

Gravel-bed characterization and flow velocity profile

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Abstract

The evaluation of flow velocity and turbulence characteristics in natural rough beds is a complex subject. The characterization of the gravel bed is important to identify the resistance of flow and riverbed evolution mechanism. In particular, the presence of gravels determines a significant effect on flow velocity distribution, especially affecting it in the near-bed flow zone and determining the formation of coherent turbulence structures. The point is that the identification of the gravel bed surface is very complex, depending on many factors such as the gravels' shape, morphology and spatial distribution. How to reasonably quantify gravel bed surface roughness is still an open question and different methods have been proposed in literature [among others 1, 2]. This work reports on a laboratory flume study conducted to explore the effect of gravels and of their non-uniform distribution on the velocity profile shape. Two different non-uniform rough beds have been examined. The image-based technique is used to identify the gravel bed structure and thus the spatial distribution and the concentration of different size of grains. Statistical analysis is then applied to evaluate the gravel surface and the variogram is determined to quantify the bed roughness proprieties [3]. Figure 1 reports the grain size distribution determined for the two examined gravel bed configuration.

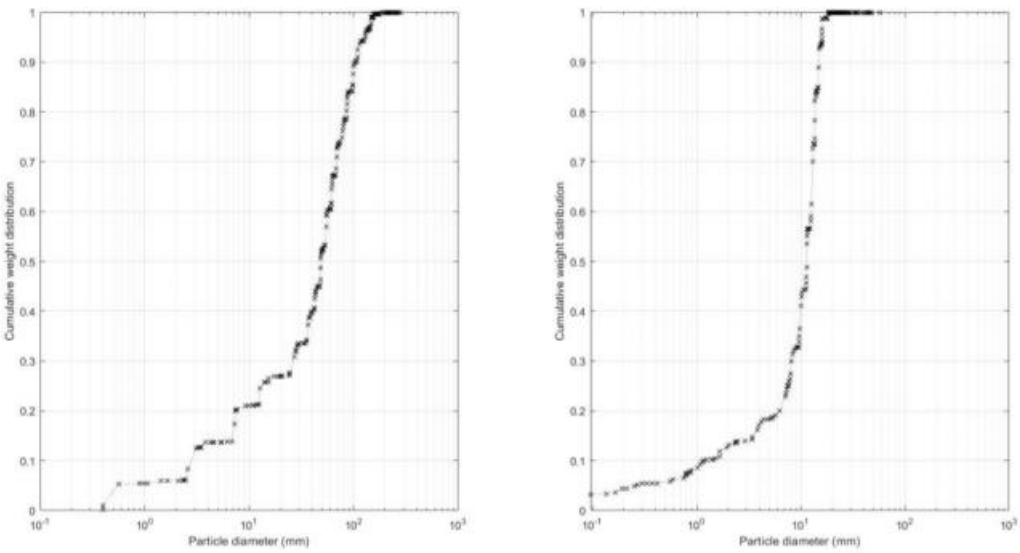

Figure 1. Grain size distribution determined for the two gravel bed configurations

Then, experiments have been conducted with the same flow rate over the two gravel bed configurations. The instantaneous velocities have been measured on a fine grid by using a velocity profiler (DOP2000). The analysis of the stream-wise velocity profiles has been operated by taking into account that, because of the heterogeneity of the bed roughness, the time-averaged approach must be supplemented by the spatial averaged-approach. The study, by considering the determined grains size distributions for the two examined bed configurations, analyzes the effect on the velocity profiles and of the mixing layer thickness.

Keywords: Rivers, gravel bed, velocity profile, experiments

References

[1] Aberle J. & NikoraV., 2006. Statistical properties of armored gravel bed surfaces. Water Resour. Res. 42, W11414.
[2] Nikora, V.I., Goring, D.G., Biggs, B.J.F., 1998. On gravel-bed roughness characterization. Water Resour. Res. 34 (3).
[3] Nikora, V., Walsh, J., 2004. Water-worked gravel surfaces: High-order structure functions at the particle scale. Water Resour. Res. 40, W12601.

Influence of riparian vegetation on streambank stability: evidence from both field observations and laboratory experiments

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Abstract:

Natural floodplains are usually colonized with various plant species that has different abilities in stabilizing streambanks [1]. In the past few decades, a proliferation of reaches has developed at the crucial roles riparian vegetation plays in fluvial processes. However, bridging the two disparate disciplines is a fundamental challenge. Many experiments attempted to reproduce natural highly-curved meandering channels by planting plant sprouts such as alfalfa, although the results are far from satisfactoriness [2-3]. To address the issue, we compile observations of meander migration from both field and laboratorial experiments. We categorize meandering channels in North and South America based on the riparian vegetation as cropland, forest, grassland, and rainforest [4]. Field analyses reveal that the most stable meanders are those developed in rainforests due to their established root systems and clay-rich soils. The most unstable meanders are in cropland areas due to frequent land disturbances associated with cultivation. Rivers in grassland and forests of North America have intermediate migration rates (Fig.1). Besides, we designed a small braided channel in a laboratory and let it freely develop into a highly sinuous single-thread channel after planting vegetation on the floodplains, first Alfalfa sprouts and later *funeria hygrometrica* (Fig. 2). In addition to the soil-reinforcing capacity of plant roots, we found that the two-layer bank structure also facilities high channel sinuosity which extends the channel length and attenuates the energy slope, therefore indirectly increasing streambank stability.

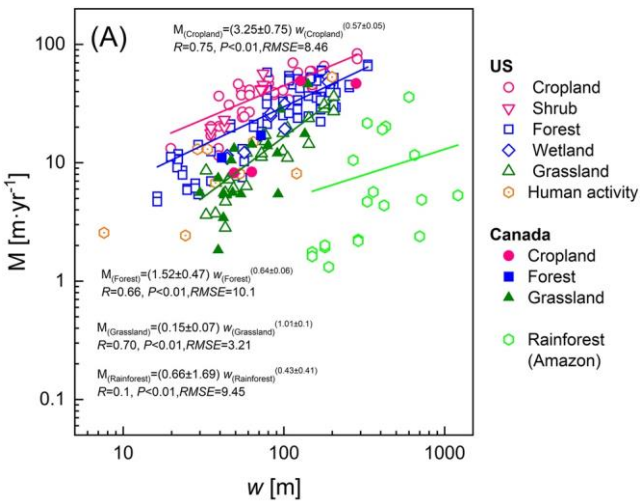

Figure. 1 Meander migration rates *M* as a function of channel width *w* (after Zhu et al., 2022).

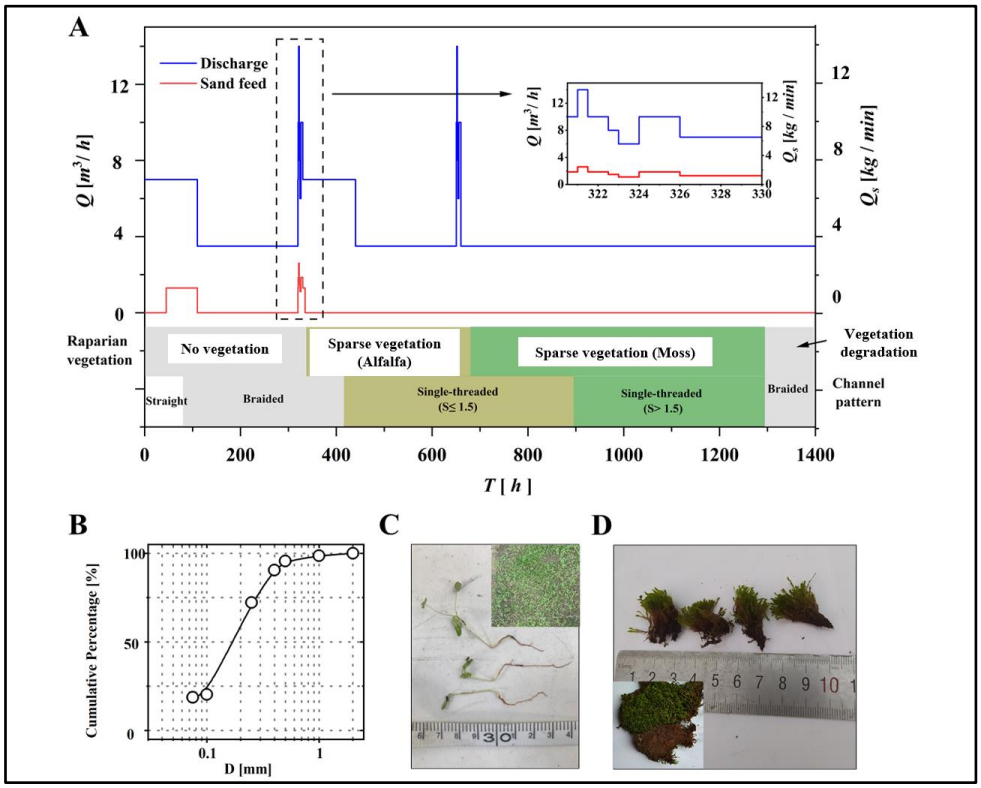

Figure. 2 Overview of experiment setting (A: Q=3.5-7 L/s), riparian vegetation used (C: alfalfa, D: *funeria hygrometrica*), and sediment feed (red line in A and B: D_{50}=0.14 mm).

Keywords: Riparian vegetation; Meandering rivers; River pattern; Bank stability; Laboratory experiments

Acknowledgment

The authors would like to express appreciation for the support of the sponsors [Grant Number: XDA28060300; 2022YFC3203903; 52279077].

References

[1] Harvey, G. L. , & Bertoldi, W. (2015). "Dynamic riverine landscapes: the role of ecosystem engineers." Earth Surf. Process. Landforms 40(12), 1701-1704.
[2] Braudrick, C.A., Dietrich, W.E., Leverich, G. T., & Sklar, L. S. (2009), "Experimental evidence for the conditions necessary to sustain meandering in coarse-bedded rivers." Proceedings of the National Academy of Sciences 106(40), 16936-16941.
[3] Tal, M, Paola, C. (2010), "Effects of vegetation on channel morphodynamics: results and insights from laboratory experiments." Earth Surf. Process. Landforms 35, 1014-1028.
[4] Zhu, L., Chen, D., Hassan M.A., & Venditti, J.G. (2022), "The influence of riparian vegetation on the sinuosity and lateral stability of meandering channels." Geophysical Research Letters 49(2), e2021GL096346.

Modeling the morphodynamic equilibrium of an intermediate reach of the Po River (Italy)

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Abstract

The Po River, located in northern Italy, is the main Italian river. In the last century it has suffered significant altimetric and planimetric changes, mostly due to anthropic works. These changes were initially fast and caused huge alterations of the river morphology. In the last few decades, however, the anthropic pressure on the river has decreased significantly and the topographic surveys, that span a period of about twenty years, suggest the re-establishment of the dynamic equilibrium condition of the active channel bed along most of the reaches.

The present contribution investigates the river bed equilibrium conditions by means of a one-dimensional movable bed model (Lanzoni et al., 2014.), in two morphologically homogeneous reaches of the Po river. The first, called HI, is located between the confluence with the Oglio river and the gauging station of Pontelagoscuro. The second reach, named FG, is located between Serafini Island and the gauging station of Borgoforte.

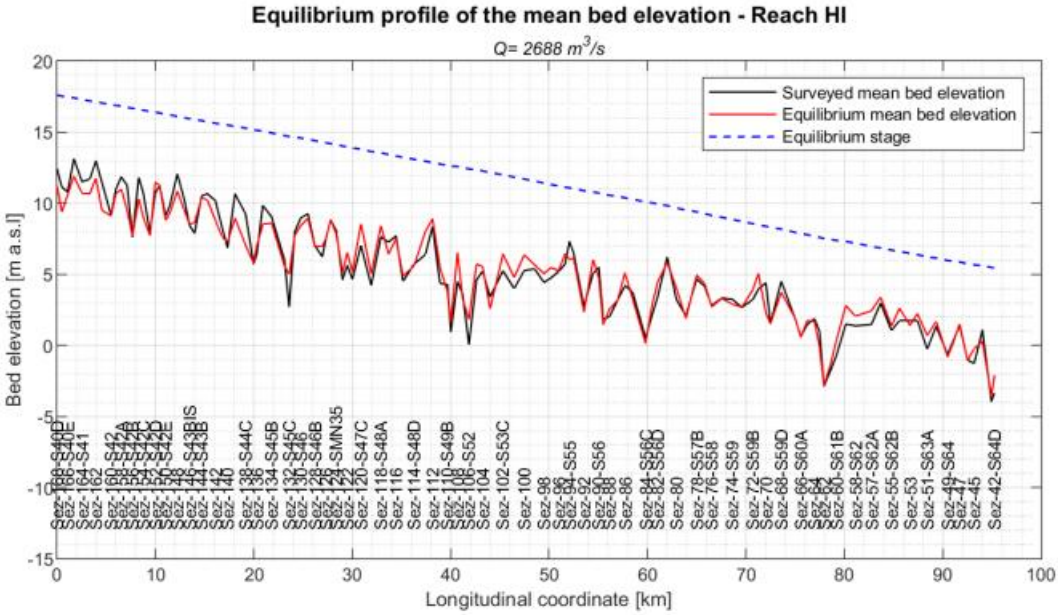
The topographic field surveys used to investigate the possible existence of an equilibrium morphology span the period 1982–2005. Considering steady forcing conditions, we estimated the formative discharge, i.e., the discharge that produces the observed river topography, and the corresponding sediment transport capacity in the investigated river reaches.

We computed the formative discharge as the water discharge that best fits the mean surveyed river bed and we found 2688 m^3/s for reach HI and 2476 m^3/s for reach FG.

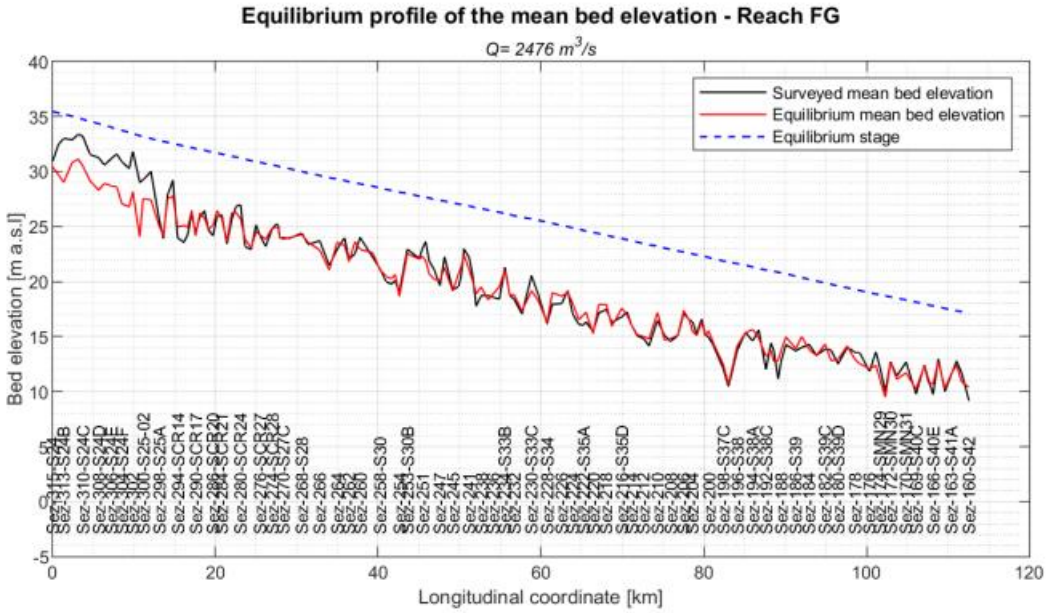
The comparison between the surveyed rived mean bed profile and the computed one in the two analyzed reaches are shown in Figure 1.

In both cases the equilibrium bed profile is quite close to the surveyed one, except for some parts characterized by peculiar river cross section not interpretable by a 1D approach.

Numerical results have been validated comparing them with the ones obtained by applying the Half-Load discharge method (Vogel et al., 2003). This approach, that requires long series of historical daily mean water discharge, gives discharge values that have the same order of magnitude of the formative discharge computed by the one-dimensional movable bed model.



a)



b)

Figure 1. Computed equilibrium mean river bed elevation (red solid line) compared with the surveyed topography (black solid line) for HI reach a) and FG reach b).

References

[1] Lanzoni, S., Luchi, R., Bolla Pittaluga, M. (2014). "Modeling the morphodynamic equilibrium of an intermediate reach of the Po River (Italy)." Advances in Water Resources, Elsevier.

[2] Vogel R.M., Stedinger J.R., Hooper R.P. (2003). "Discharge indices for water quality loads." Water Resources Research, Vol. 39, NO. 10.

Role of sediment supply in the recovery of mudflats in the Yangtze River Delta during the storm events

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Abstract

Tidal flats are located at the border between land and sea, maintaining a unique ecosystem. The global tidal flats are under the pressure from the decreased sediment flux, frequent typhoon events, and sea level rise[1]. The morphodynamic process on tidal flats is determined by many factors[2-3]. Storms and reduction in riverine sediment supply are two important factors affecting the progradation of tidal flats. However, the impacts of different sediment availability and storms on the morphodynamics of tidal flats still need further studies.

This study aims to unravel the influence of storms on the morphodynamic process of unvegetated mudflats, which are the most sensitive section of tidal flats. Field measurements were conducted on the Eastern Chongming tidal flat in 2022. Water depths, current velocities, waves, sediment concentration, and the elevation profile of mudflat were measured before, during and after a storm event. Results showed that the bed shear stress during the storm event (average 1.40 N/m^2) was much higher than that during the fair weather (average 0.21 N/m^2). During this storm, erosion occurred on the mudflat with an averaged elevation change of -17.1 cm (Figure 1). Compared with previous studies [4], we found that after the storm in 2013, the mudflat maintained vertical acceleration at a rate of 0.36 cm/ day, in contrast to a recovery rate of 0.11cm/ day after the storm in 2022. Different sediment availability was found to be the reason for the variation in the recovery rates. More data suggested that the sediment availability of the studied mudflat in 2013 was richer than that in 2022.

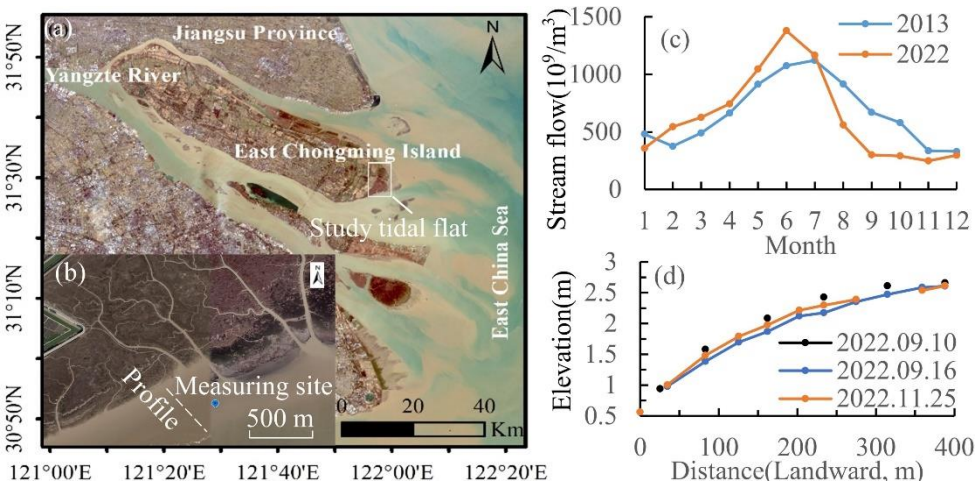


Figure 1. (a) Map of the Yangtze River Delta, (b) location of the measuring site, and (c) monthly stream flow in Yangtze River (d) tidal flat profile on Sep 10, 2022 (5 days before the storm), Sep 16, 2022 (1 day after the storm) and Nov 25, 2022 (70 days after the storm), respectively.

Due to the extremely low water discharge into the Yangtze estuary in 2022, sediment supply to tidal flats decreased substantially compared to 2013. Based on the results, a conceptual model was proposed, showing the different recovery processes under different conditions (Figure 2). This study

highlights the role of the interactions between high-energic storm events and sediment availability in mudflat evolution. The results indicated that rich sediment availability, which was influenced by fluvial sediment supply, could buffer the storm-induced erosion and accelerate the recovery process after the storm, and vice versa.

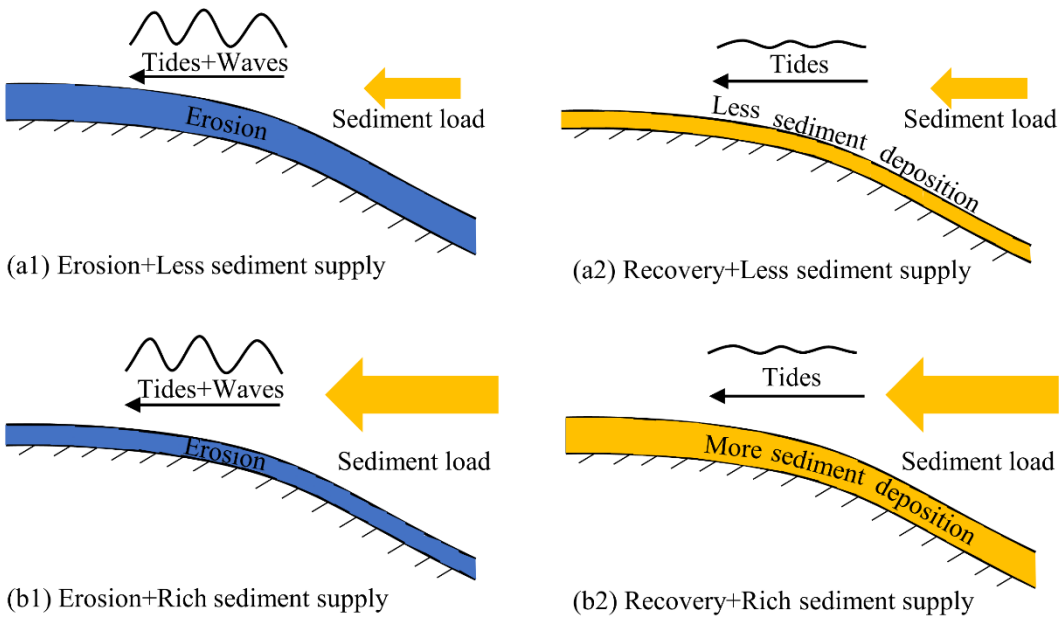


Figure 2. Conceptual models for the sedimentary process on mudflats under (a1) erosion process (a2) recovery process in less sediment supply conditions and (b1) erosion process (b2) recovery process in rich sediment supply conditions.

Keywords: Tidal flat; Storm; Morphodynamics; Recovery; River discharge

Acknowledgment

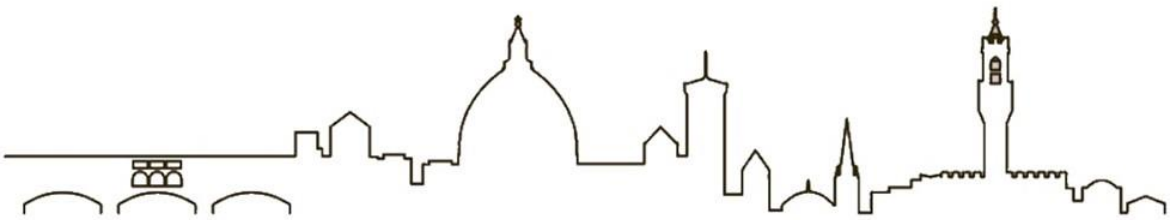
This study is mainly supported by the National Natural Science Foundation of China (NSFC) (No. 42276217). We would like to thank Biaobiao Peng, Zhishang Li, and Penghua Qiao for their assistance in the field work.

References

[1] Murray, N. J., Phinn, S. R., DeWitt, M., Ferrari, R., Johnston, R., Lyons, M. B., & Fuller, R. A. (2019). The global distribution and trajectory of tidal flats. *Nature, 565(7738),* 222-225.
[2] D'Alpaos, A., & Marani, M. (2016). Reading the signatures of biologic–geomorphic feedbacks in salt-marsh landscapes. *Advances in water resources, 93,* 265-275.
[3] Zhou, Z., Wu, Y., Fan, D., Wu, G., Luo, F., Yao, P., & Coco, G. (2022). Sediment sorting and bedding dynamics of tidal flat wetlands: Modeling the signature of storms. *Journal of Hydrology, 610,* 127913.
[4] Xie, W., He, Q., Zhang, K., Guo, L., Wang, X., Shen, J., & Cui, Z. (2017). Application of terrestrial laser scanner on tidal flat morphology at a typhoon event timescale. *Geomorphology, 292,* 47-58.

Topic 3:

Ecohydraulics



Experimental study and simplified analysis method on river flood discharge evaluation for various bank vegetation

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Abstract

River bank is usually planted with grass, shrub and other vegetation due to soil and water conservation, landscaping or ecological factors. The plant coverage has changed the flow surface of the river bank, as well as the flood discharge capacity [1, 2].

In order to study the effect of bank vegetation on river flood discharge, physical model experiments were carried out in laboratory. An experimental platform was built with the length of 40 m, the width of 8~12 m, the water depth of 4~8 cm and the width depth ratio of 100~300. The water levels of no vegetation, sparse vegetation, sparse vegetation + shrub and dense vegetation, were tested under typical flow. Mathematical analysis was further conducted on basis of the classical composite roughness calculation formulas, including Pavlovskij formula and Einstein-Banks formula [3, 4]. A simplified analysis method was proposed to determine the increase of composite roughness while the river bank changed from no vegetation state to planted vegetation state. A practical procedure was also given to analyze the influence of bank vegetation on river flood discharge.

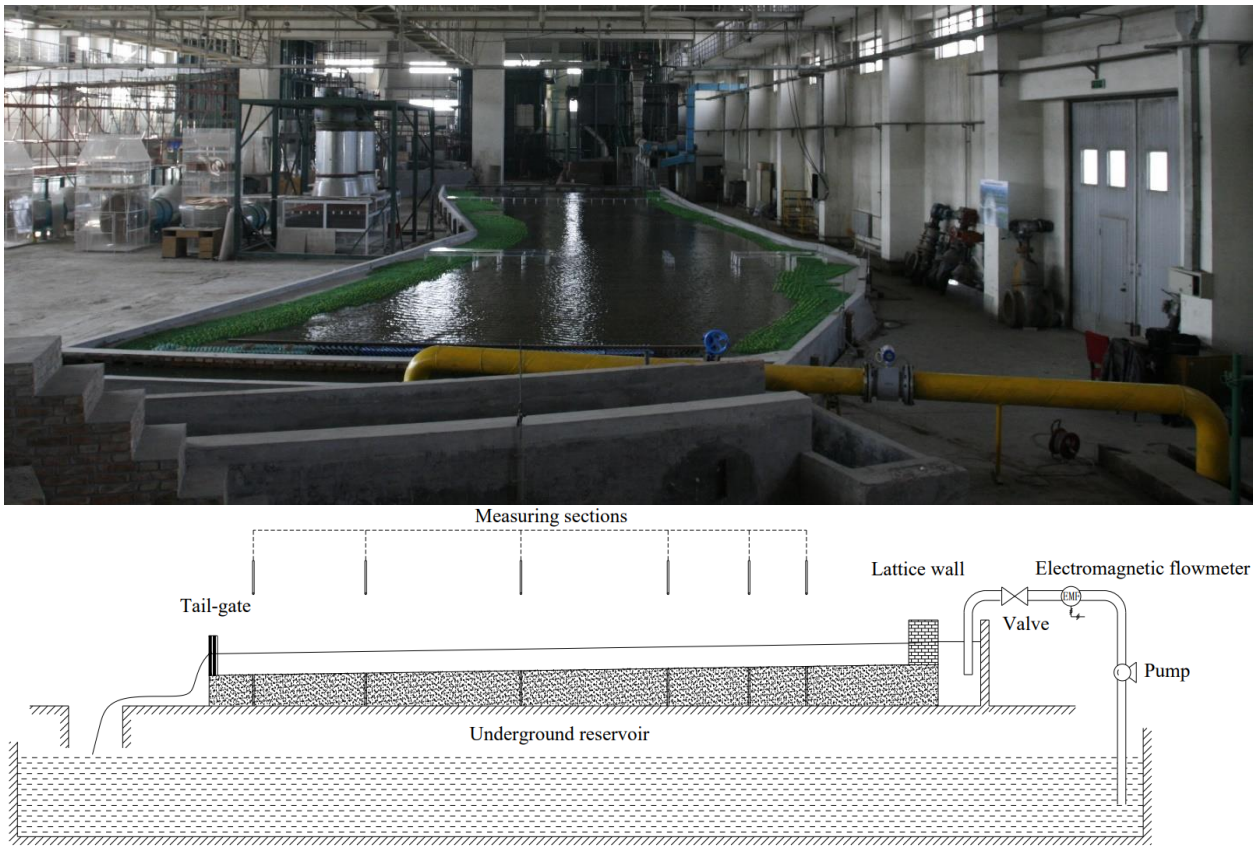

Figure.1 Figure and schematic diagram for the experimental platform

The results showed that, the water level of the tested channel increased by 0.3~1.3 mm due to the dense vegetation, while it increased by 0.1~0.4 mm due to the sparse vegetation and sparse vegetation + shrub. The denser the bank vegetation, the higher the water level. When the river bank planted vegetation, the increase of composite roughness was related to two factors, namely, the ratio of the covered wetted perimeter to the total wetted perimeter and the roughness of the covered area. It increased with the growth of the roughness of the vegetation covered area, and decreased with the increase of width-depth ratio. While the width-depth ratio was larger than 60 and 100, the growth of composite roughness due to planted vegetation was no more than 10% and 7%, respectively.

Keywords: Bank vegetation; River flood discharge; Model experiment; Simplified analysis method; Composite roughness

Acknowledgment

The authors would like to express appreciation for the support of the National Key Research & Development Plan of China [Grant Number: 2022YFC3202500] and the National Natural Science Foundation of China [Grant Number: 52179082].

References

[1] Naoki, K., Shoji, H. & Takashi, A. (2020). "Dynamic modeling of the interaction of riparian vegetation with floods and application to vegetation management" Journal of Hydro-environment Research, 30, 14-24.
[2] Ping, L., Mingyang, S., Dawen, Y., et al. (2019). "Evaluating flood regulation ecosystem services under climate, vegetation and reservoir influences" Ecological Indicators, 107, 105642.
[3] Zhang, J., Zhang, S., Chen, S., et al. (2021). "Effects of sparse rigid stem vegetation coverage on hydrodynamic characteristics of overland flow in a gentle slope area.", Arabian Journal of Geosciences, 14, 1445.
[4] Kejun, Y., Shuyou, C. & Xingnian, L. (2005). "Analysis on methods for predicting composite roughness of river channel with compound cross section.", Journal of Hydraulic Engineering (in Chinese), 36, 1-9.

Interactions between flow and submerged flexible vegetation: from the plant scale to the canopy scale

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Abstract

Aquatic vegetation provides essential ecological services for the ecosystem, and its interaction with the flow alters the transport of mass and momentum [1]. Though the vegetated flows have been a heated topic in the past two decades, gaps in the hydrodynamics of the flow with highly flexible submerged vegetation remains to be filled. Complexity arises from the fact that the motions of flexible vegetation are in full degree of freedom and that the dynamics of flow and vegetation are highly coupled [2].

Herein, interactions between submerged highly flexible vegetation and flow are investigated through physical and numerical studies at different scales. Studies were carried out on three scales: individual, patch and canopy scale, and were focused on two aspects: the motions of the plant and the turbulent structure of the flow. In terms of the dynamics of the vegetation, the swaying modes and characteristics of a single plant and the characteristics of the coherent waving motion of the vegetation canopy were studied. As for the flow structure, the influence of flexible vegetation finite patch and long canopy on turbulence in open-channel flow were investigated.

In the physical study, an effective three-dimensional plant model was developed with a good representativeness, mimicking a class of submerged flexible plants which possesses clumped dissected leaves connected by a thin stem and involves a large deformation. Meanwhile, numerical model was established with a same form of vegetation, based on the Large Eddy Simulation (LES) and the Immersed Boundary Method (IBM). The prototype of the typical vegetation in this study, *Cabomba caroliniana*, is shown in figure 1a, and figure 1b shows the model applied in flume study, while figure 1c illustrates the force analysis in the numerical studies.

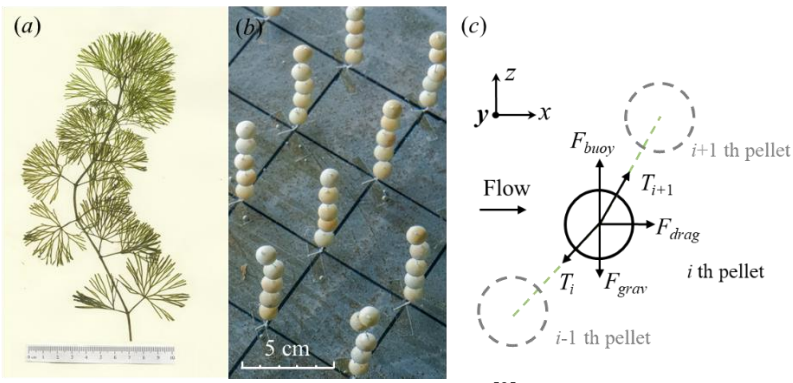

Figure.1 (*a*) Prototype vegetation *Cabomba caroliniana* [3]. (*b*) Photos of the physical model in the flume. (*c*) Force analysis of the pellet in the numerical study.

Flume experiments show that two swaying modes can be found of the plant both alone in the flume and within the vegetation patch. A 'rigid-like' synchronous swaying mode and a 'whip-like' asynchronous flapping mode are found to appear alternately for the individual plants. Compared to the plant in isolation with the same flow Reynold number, the swaying motions of a plant within the vegetation patch are less frequent but more prone to the synchronous mode. The eigen frequency of

the motions increases linearly with the flow Reynolds number in the range of 2×10^4–5×10^4, but the normalized amplitude reaches a saturation at a high flow Reynolds number.

Comparison of physical and numerical results shows that the numerical model can effectively simulate the velocity profiles and the vegetation movement due to interaction with the flow. For the finite patch of flexible vegetation, the increase of flow velocity can increase both the offset angle and the swaying amplitude of vegetation. Compared with the vegetation tilt, the random swaying of the flexible vegetation increases the velocity difference between inside and outside the canopy much more. This further forms Kelvin-Helmholtz-hairpin (K-H-H-P) vortex structure at the interface, and thus intensifies the generation and dissipation of turbulent kinetic energy, enhances the disturbance to flow and increases the resistance to water flow [2].

Further simulation concerned about the coherent waving motions of the long vegetation meadow and the coherent vortexes among the interface of flow-canopy. Alternate vortices with opposite sense of rotations were found to appear at the flow-vegetation interface, which prompt the vegetation canopy to form wave-like coherent waving motion (also termed 'monami'). Moreover, the spatial scale and the streamwise spreading velocity of these vortices determine the wavelength, frequency and amplitude of the monami. As the flow velocity increases, the wavelength of the coherent waving motion decreases, while the frequency and amplitude increase. Besides, as the vegetation spacing increases, the wavelength and amplitude of the coherent waving motion increase, but the frequency decreases [4].

Keywords: Submerged flexible vegetation; Turbulence simulation; Flow-structure interaction; Plant swaying

Acknowledgment

This investigation was supported by the National Natural Science Foundation of China (Nos. 12172196, U2040214), the National Key Research and Development Program of China (2022YFC3201803).

References

[1] Nepf, H. M. (2012). Flow and transport in regions with aquatic vegetation. Annual review of fluid mechanics, 44, 123-142.
[2] Wang, J., He, G., Dey, S., & Fang, H. (2022). Influence of submerged flexible vegetation on turbulence in an open-channel flow. Journal of Fluid Mechanics, 947, A31.
[3] Bugbee, G., Barton, M., Gibbons, J., Stebbins, S. (2018) Connecticut's invasive aquatic plant, clam, and mussel identification guide. Bulletin number 1056. Department of Environmental Sciences, The Connecticut Agricultural Experimental Station, New Haven, CT.
[4] Wang, J., He, G., Dey, S., & Fang, H. (2022). Fluid–structure interaction in a flexible vegetation canopy in an open channel. Journal of Fluid Mechanics, 951, A41.

Hydro-morphological and ecological effects of a sediment pulse in a regulated Alpine river developed for hydropower

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Abstract

In this study, we aimed to assess the hydro-morphological effect of a sediment pulse on a section of the Mera River (central Italian Alps). Additionally, we monitored the related response of the benthic macroinvertebrate community in the same section. To this purpose, we surveyed two contiguous reaches (R1 and R2, Figure 1). Though the distance between the mentioned reaches is relatively short (3.5 km), they are characterized by significantly different streamflow patterns. In fact, the Mera catchment is massively developed for hydropower (Quadroni et al., 2017), and R2 is located a short distance below the tailrace of the most downstream power station of the hydropower cascade of the catchment. Therefore, streamflow at R2 is significantly larger than at R1, and it is subjected to rapid variations (hydropeaking). In contrast, R1 is a residual-flow reach, characterized by generally low and poorly variable discharge (i.e., the sum of minimum flows released by the upstream intake structures plus the contribution of the unexploited catchment).

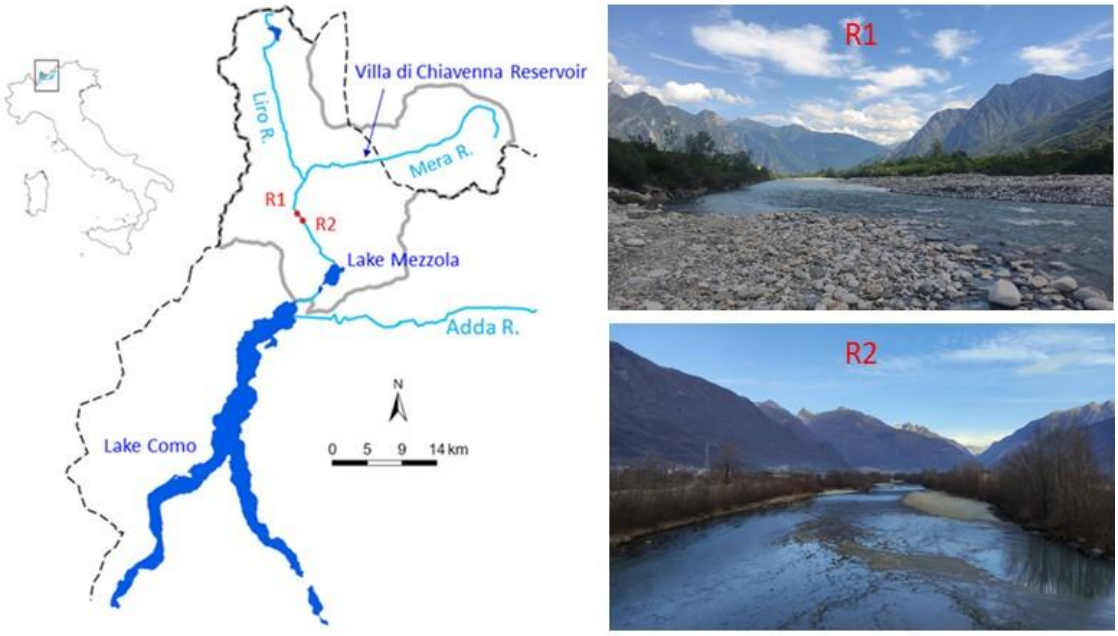

Figure 1. Location map of the Mera River in northern Italy. Catchment of the river and study reaches R1 and R2. Pictures of the investigated reaches.

In terms of sediment supply, the Mera River was recently affected by an extreme sedimentation event (August 2017 - Salmaso et al., 2020). In the subsequent years, changes to flow and sediment management practices adopted by the local river stakeholders, associated to high-intensity rainfall events, further affected the streambed morphology and the river ecosystem (Salmaso et al., 2021). Moreover, an increase in sediment loading during the next decades was recently predicted in the Mera catchment as a consequence of the climate change (Maruffi et al., 2022). Here, we investigated the

effects of a sediment pulse event occurred in summer 2021 by a pre-post comparison of the riverbed topography and of substrate grain-size in R1 and R2, with specific focus on fine sediment (i.e., d < 2 mm). Moreover, we assessed differences between the two reaches in the benthic macroinvertebrate community, collected seasonally from 2020 to 2022.

The sediment pulse event determined evident riverbed fining at both reaches, but recovery to pre-event standard was faster at R2, according to larger and rapidly varying streamflow. However, the average composition of the benthic macroinvertebrate community at R2 was significantly different from that at R1, with total density and family richness significantly lower (Table 1).

Table 1. Mean ± standard deviation and (minimum-maximum) range of total density and family richness of the benthic macroinvertebrate community sampled at R1 and R2.

	Density	**N families**
R1	1823±1445 (182-4416)	13±2 (10-16)
R2	531±618 (73-1540)	10±3 (5-16)

In our opinion, increasing the knowledge on the interaction between multiple anthropogenic pressures (in our case, sediment pulses combined with streamflow alteration due to hydropower) is fundamental to improve the management of the hydro-sedimentary regime of regulated rivers and for their conservation.

Keywords: Sediment pulse; Fine-sediment deposition; Hydropeaking; Regulated river; Hydropower; Biomonitoring.

References

[1] Maruffi, L., Stucchi, L., Casale, F., & Bocchiola, D. (2022). Soil erosion and sediment transport under climate change for Mera River, in Italian Alps of Valchiavenna. Science of The Total Environment, 806, 150651.

[2] Quadroni, S., Crosa, G., Gentili, G., & Espa, P. (2017). Response of stream benthic macroinvertebrates to current water management in Alpine catchments massively developed for hydropower. Science of the Total Environment, 609, 484-496.

[3] Salmaso, F., Crosa, G., Espa, P., Gentili, G., & Quadroni, S. (2020). The year after an extraordinary sedimentation event in a regulated Alpine river: The impact on benthic macroinvertebrate communities. River Research and Applications, 36(8), 1656-1667.

[4] Salmaso, F., Espa, P., Crosa, G., & Quadroni, S. (2021). Impacts of fine sediment input on river macroinvertebrates: the role of the abiotic characteristics at mesohabitat scale. Hydrobiologia, 848(18), 4189-4209.

Estimation of the plant-induced turbulent kinetic energy from the perspective of vortex dynamics

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Abstract

Aquatic vegetation, common in freshwater and saltwater wetlands, is essential in maintaining healthy ecosystem. The presence of vegetation alters the flow structure and affects the sediment transport process. According to the knowledge that 'turbulence plays the central role in initiating sediment motion' [1], researchers adopt the turbulent kinetic energy (TKE) to describe the sediment transport process within the canopy, where the production of turbulence in stem wakes exceeds that associated with bed shear stress, and the τ-based sediment transport model doesn't work [2]. Then, an important question arises, i.e., how to solve the vegetation-generated turbulence that determines TKE-based sediment transport model for vegetated cases.

This study describes the plant-induced turbulence within the emergent canopy from the perspective of vortex dynamics (i.e., how the plant-induced eddies drain the kinetic energy from mean flow and feed it into turbulence), instead of the TKE budget balance generally in use [3]. And some theoretical hypotheses on the stem wake turbulence (including **the volume, turbulence density and turbulent energy of coherent eddies**) are proposed. Based on this theory, a model for the space-averaged vegetation-generated TKE is developed, of which the form is similar to that of [4]. Overall, the new model could reasonably predict the TKE in vegetated regions, reflecting the feasibility of theoretical hypotheses. Note that the composite factor, η, closely related to the flow structure, should be a function of the flow condition, the vegetation volume fraction and the vegetation distribution (random/regular) upon the preliminary analysis, and further study is needed.

Results: From the view of vortex dynamics, the vegetation-generated turbulence within an emergent canopy is predicted by $K_{veg} = \eta \cdot C_D^{form} \frac{l}{d} \frac{\varphi}{(1-\varphi)\pi/2} U_p^2$ (where K_{veg} is the plant-induced *TKE*, C_D^{form} is the form drag coefficient of stems, *l* is the eddy scale, *d* is the stem diameter, φ is the canopy solid volume fraction, and U_p is the pore velocity in the canopy). As the eddy scale $l = \min\{d, s_n\}$, the above formula is written into a piece-wise function,

$$K_{veg} = \begin{cases} \eta_1 \cdot C_D^{form} \dfrac{\varphi}{(1-\varphi)\pi/2} U_p^2 & ,(d/s_n < 1.0) \\ \eta_2 \cdot C_D^{form} \dfrac{s_n}{d} \dfrac{\varphi}{(1-\varphi)\pi/2} U_p^2 & ,(d/s_n \geq 1.0) \end{cases}$$

where η_1 and η_2 are 3.20±1.30 for the sparse case and 1.38±0.17 for the dense case, separately, which are obtained through regression analysis of research data [2, 4-6]. In order to save the paper space, only the regression analysis on research data of Etminan et al. [6] is presented.

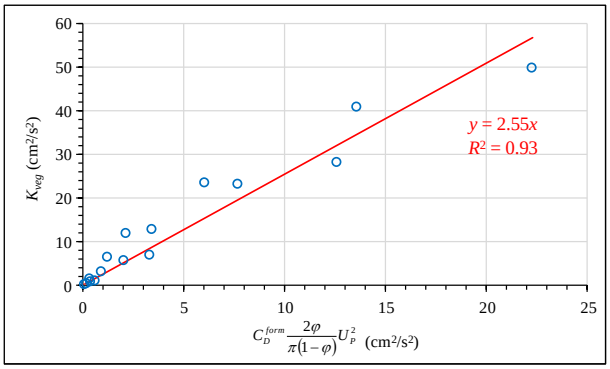

Figure 1. Linear regression between the spatially-averaged *TKE*, K_{veg}, and $C_D^{form}\frac{\varphi}{(1-\varphi)\pi/2}U_p^2$

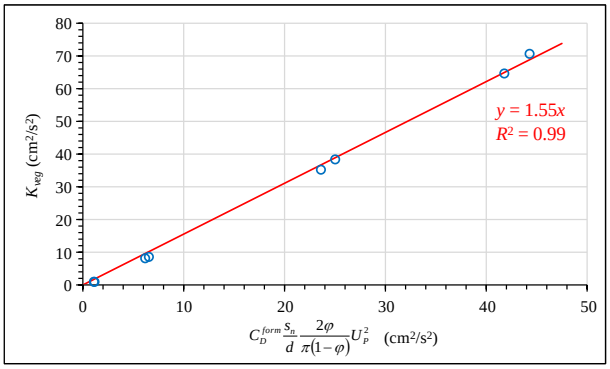

Figure 2. Linear regression between the spatially-averaged *TKE*, K_{veg}, and $C_D^{form}\frac{s_n}{d}\frac{\varphi}{(1-\varphi)\pi/2}U_p^2$

Keywords: Turbulence; Vegetation; Vortex dynamics; Theoretical hypothesis

References

[1] Diplas, P., Dancey, C. L., Celik, A. O. et al. (2008) The Role of Impulse on the Initiation of Particle Movement Under Turbulent Flow Conditions. Science, 322 (5902), 717-720.
[2] Yang, Q. J., Nepf, H. M. (2019) Impact of vegetation on bed load transport rate and bedform characteristics. Water Resources Research, 55, 6109-6124.
[3] Nepf, H. M. (1999) Drag, turbulence, and diffusion in flow through emergent vegetation. Water Resources Research, 35(2):479-489.
[4] Tanino, Y., Nepf, H. M. (2008) Lateral dispersion in random cylinder arrays at high Reynolds number. Journal of Fluid Mechanics, 600, 339-371.
[5] Liu, C., Shan, Y., Nepf, H. M. (2021) Impact of stem size on turbulence and sediment resuspension under unidirectional flow. Water Resources Research, 57, e2020WR028620.
[6] Etminan, V., Ghisalberti, M., Lowe, R. J. (2018) Predicting bed shear stresses in vegetated channels. Water Resources Research, 54, 9187-9206.

Modeling hydraulic habitat suitability of the Ganga River

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Abstract

We have selected a small reach (7.5 km) about 4 km upstream from the Narora barrage. We created a detailed topography of the river using the LiDAR point clouds generated from drone surveys in the field. Since the flow is not recorded in the study reach, we have performed several field campaigns to measure the channel bathymetry, along stream water surface elevation from an Acoustic Doppler Current Profiler (ADCP) and a differential GPS (DGPS), respectively. We have developed a methodology to extrapolate the water level recorded at a gauge station (Anupshahar) located far from the location at which such records are not available. This enables us to define the boundary conditions of the model domain in HEC-RAS. Finally, we have generated the distribution of flow depth and velocity in the study reach at varying discharges.

This study enables us to monitor the minimum flow depth in the river in different seasons. Further, we have shown in data-scarce regions, satellite measurements are an important source of information for habitat modelling. The use of altimeter datasets is quite effective when the availability of the dataset is a limitation. This study presents a methodological framework that analyses the hydraulic habitat suitability of the Ganga River near structural interventions, which can be replicated if the minimum data required are available.

Keywords: Hydraulic Habitat; HEC-RAS; Ganga River; LiDAR; Satellite altimeter

Application of artificial step-pools in natural hazard mitigation

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Abstract

A step-pool is a representative riverbed structure that is highly effective in increasing flow resistance and dissipating flow energy. Well-designed artificial step-pools can control channel incision, improve riverbed stability, and further mitigate natural hazards. In this study, step-pools with characteristics of natural step-pools in terms of their geomorphology and energy dissipation are designed and applied to mitigate channel incision and debris flow in a small watershed where riverbed structures are poorly developed and landslides and massive debris flow have occurred frequently as a result of channel incision (Figure 1).

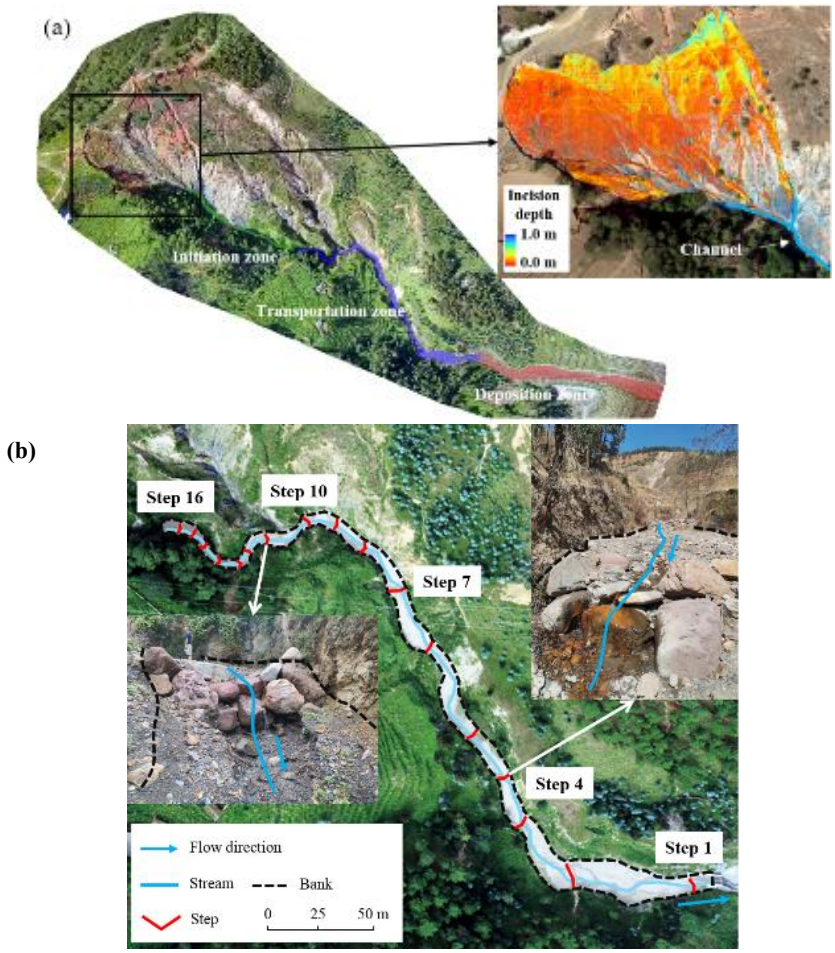

Figure 1. (a) Initiation, transportation, and deposition zones of the channel, and an erosion map of the water erosion zone after the flood season in Fencha Gully, Sichuan; (b) Layout of the 16 constructed step-pools in the gully.

Field investigation indicated that the artificial step-pools experienced little adjustment and generally remained stable during the flood season. The constructed steps caused a decreasing trend in the deposition downstream and achieved the expected natural hazard mitigation effects by reducing

and transferring the debris flow to a hyper-concentrated flow and eventually to a normal flood flow. Therefore, the stable step-pools effectively suppressed massive sediment movements, with 69.3% of the loose sediment eroded from the water erosion zone being trapped in the step-pool reach, which promoted the uplift of the channel bed. Numerical debris flow simulations reveal that, compared with the pre-construction condition, the artificial step-pools reduced the maximum debris flow kinetic energy by approximately 27%. As a result, the channel bed is stabilized and the river ecology has been improved to the level comparable to the naturally stable rivers. These scientific findings and practical applications concerning the use of artificial step-pools could provide guidance for natural hazard mitigation in mountainous areas at the small watershed scale.

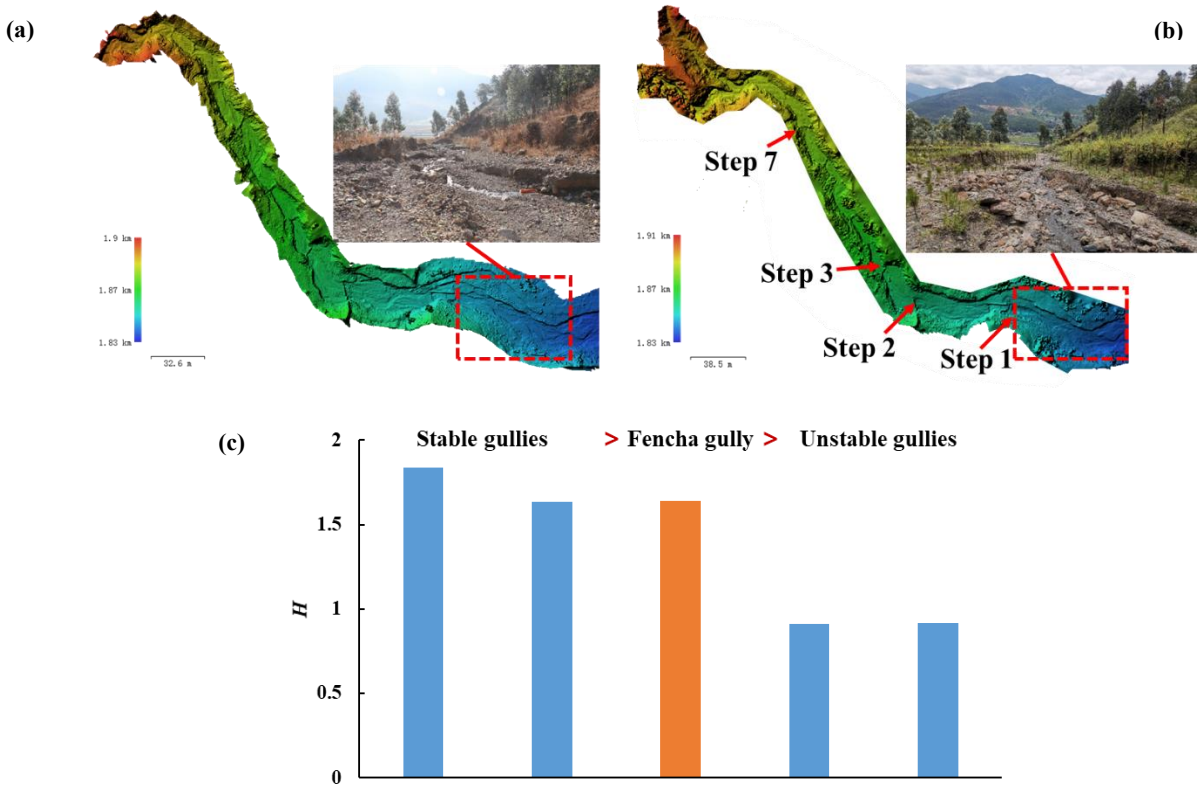

Figure 2. (a) Unstable channel and intensive sediment transport pre-construction of step-pools; (b) Stable channel and low sediment transport post-construction of step-pools; (c) River ecology improvement indicated by Shannon-index of macroinvertebrate communities.

Keywords: Step-pools; Channel incision; Debris flow; Hazard mitigation; River restoration

Acknowledgment

The authors would like to express appreciation for the support of the Strategic Priority Research Program of the Chinese Academy of Sciences (no. XDA23090401), and the Second Tibetan Plateau Scientific Expedition and Research Program (STEP) (no. 2019QZKK0903).

Variation of river habitat diversity in the middle Yangtze River during erosional process after dam impoundment

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Abstract

Diversity of river morphology is of critical importance to river habitat diversity, which is related to the abundance of aquatic organisms [1]. Homogenized and channelized river morphology is assumed to be a threat to river biodiversity, while complex and diversified river channel can benefit riverine species [2][3]. However, most current researches have not focused on the influence of human activities on channel diversity, especially on large-scale rivers.

This article targets at evaluating the river habitat diversity of the Yichang-Chenglingji reach, Yangtze River, which is a typical river reach experiencing severe erosion caused by human activity of dam construction (Three Gorges Dam). Morphological data of 216 cross sections distributed along the 372-km reach from the year 2003 to 2018 are collected, the kurtosis coefficient of elevation frequency distribution in each cross section under bankful water level is calculated to reflect diversity in terms of river depth, with a larger kurtosis coefficient indicating less diversity. Results show that: (1) The averaged kurtosis coefficient of the whole reach increased gradually after dam impoundment, indicating a generally decreasing channel diversity under human influence. (2) The three sections within the study reach witnessed different variation of kurtosis coefficient. The upper section (Yichang-Zhicheng reach) which is a gravel-bed reach immediately downstream the dam witnessed much less change of kurtosis coefficient due to less erosion happening there, the middle section, Zhicheng-Ouchikou, mainly experienced an obvious increase in kurtosis coefficient and the lower section, Ouchikou-Chenglingji, witnessed a decrease in kurtosis coefficient (Fig.1). (3) The Zhicheng-Ouchikou reach is mainly composed of U-shaped cross sections, while the V-shaped cross sections (meandering reaches) dominate in Ouchikou- Chenglingji reach. During post-dam erosion process, U-shaped cross sections mainly experienced downcut in the main channel (Fig.2a), resulting in uniform distribution of water depth, while V- shaped cross sections in meandering reaches witnessed both erosion on the convex bar and deposition of concave channel (Fig.2b), leading to a more complex cross section morphology with lower kurtosis coefficient. This different pattern of morphological adjustment resulted in spatial

differences in variation of channel diversity in the study reach.

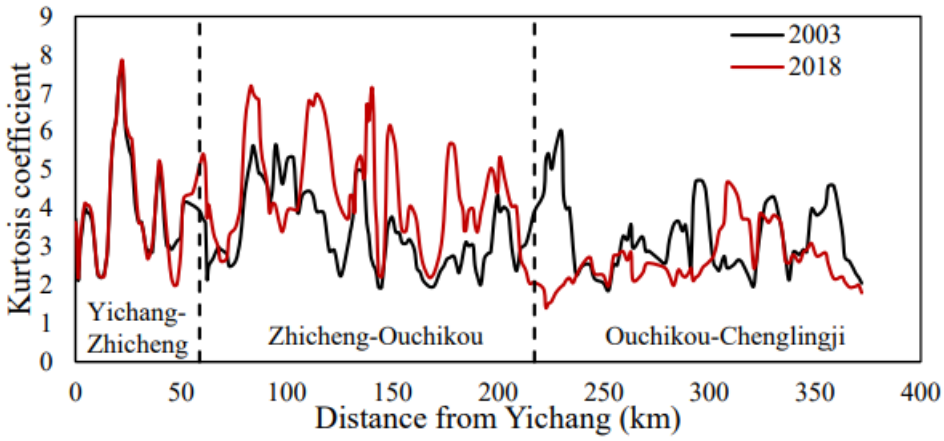
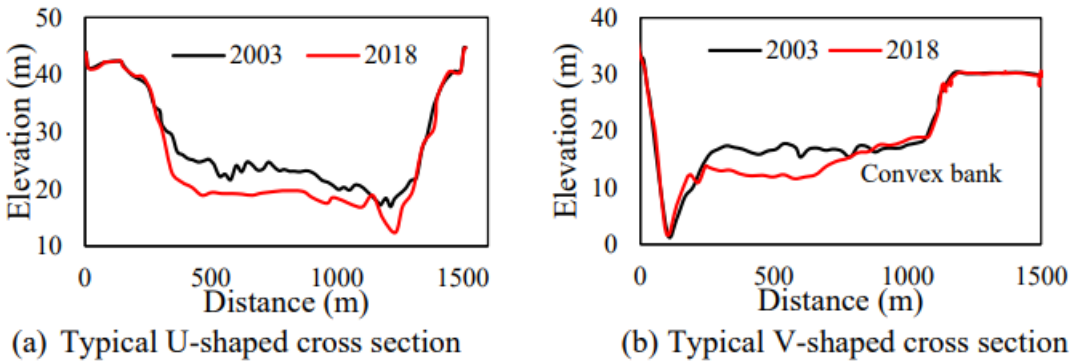


Figure 1. Variation of kurtosis coefficient in the study reach after dam impoundment (Kurtosis coefficient is the mean value of 5 consecutive cross sections).



(a) Typical U-shaped cross section (b) Typical V-shaped cross section

Figure 2. Variation of typical U-shaped and V-shaped cross sections in the study reach.

Keywords: River habitat; channel diversity; kurtosis coefficient; morphological adjustment; dam Impoundment

Acknowledgment

The authors would like to express appreciation for the support of the sponsors: National Key Research and Development Program of China [Grant Number: 2016YFC0402101]; Ministry of Water Resources of the People's Republic of China [Grant Number: 12610100000018J129-03].

References

[1] Cianfrani, C. M. and S. M. P. Sullivan, et al. (2009). "Mixed stream channel morphologies: implications for fish community diversity." Aquatic Conservation: Marine and Freshwater Ecosystems 19 (2), 147-156.
[2] Gostner, W. and M. Alp, et al. (2013). "The hydro-morphological index of diversity: a tool for describing habitat heterogeneity in river engineering projects." Hydrobiologia 712 (1), 43-60.
[3] Liu, J. and X. Zhang, et al. (2021). "Evaluation of the impact of urban river bends on the enhancement of aquatic habitats using a two-dimensional habitat suitability model." Ecological Informatics 65, 101428.

The Research of the Influence of Hydrodynamic Variation in Tidal Reach on Mangrove

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Abstract

The bay is located at the junction of land and sea. As a sea area deep into land and forming obvious water curve, it is affected by both land and sea all year round and is an important part of the coastal zone (Wu, 2017). Shenzhen Bay (Figure 1) is located at the core of the Guangdong-Hong Kong-Macao Greater Bay Area, and its hinterland is backed by Shenzhen and Hong Kong (Lei, 2020). As one of the most typical wetland ecosystems in the Greater Bay Area, mangrove wetland is of great significance in the construction of ecological security barrier in the Greater Bay Area. When human activities affect tidal dynamics and material transport in Shenzhen Bay, mangrove growth is also faced with uncertainty. Zhong (2019) concluded that pollution from the rise of electronics industry in Hong Kong reduced the stability of mangrove ecosystem along Shenzhen Bay. Zhang (2010) believed that the change of land use pattern in the rapid urbanization process of Shenzhen City leads to the increase of runoff of Shenzhen River and more and faster sedimentation, and the sedimentation of Shenzhen Bay under the influence of the project provides additional development space for the mangrove, which contributes to the seaway expansion of mangrove (Wang, 2022). Among the studies on the impacts of hydrodynamic changes on mangrove habitats, there are more studies on the impacts of pollutant transport and sediment erosion and silting on mangrove survival, but few studies on the impacts of salinity changes. Taking the expansion of a drainage outlet of Shenzhen River as an example, this paper simulated the salinity transport process of Shenzhen Bay under different runoff conditions through a numerical model, calculated the salinity change of mangrove area in Futian, and analyzed the impact on mangrove growth. The results of this study can provide a basis for the assessment of the impact of engineering involving rivers on mangrove in Shenzhen River Basin, providing a reference for mangrove protection in other areas.

The water area of this analysis includes Shenzhen River and Shenzhen Bay, among which Shenzhen River is about 13.7km from the estuary to the upper reaches of the three forks, both of which are tidal river sections. Shenzhen Bay covers about 15.6km from the estuary to the mouth of the bay. The model includes the front coast of the Futian mangrove, which is about 5km long.

The shallow water equation for hydrodynamic calculation is based on the Navier-Stokes equation. The salinity was simulated by convection diffusion equation.

Combined with the measured underwater terrain data of Shenzhen River in 2020, the study area is meshed and generalized. Triangulation irregular grid is used to divide the grid. The minimum grid side length is about 10m, and the maximum grid side length is about 120m, forming 20,610 nodes, and a total of 15,169 computing grids. The tidal level is controlled in the downstream and the flow is controlled upstream at the boundary of Shenzhen River. The upstream boundary salinity is 0; The downstream boundary salinity is given according to the actual situation.

When calculating the scheme, the dry season scheme is from January 12, 2020 to February 10, 2020, and the wet season scheme is from September 1, 2020 to September 30, 2020.. Before the expansion, the drain displacement of the scheme is 200 thousand m^3/d, and after the expansion, it is 400 thousand m^3/d.

According to the simulation, the salinity of spring tides is higher than that of neaps. At the same time, the salinity in wet season is obviously lower than that in dry season due to the influence of runoff change. The planar distribution of salinity in Shenzhen Bay shows that the salinity decreases as the distance from the estuary becomes closer.

According to the calculation results of the model, the salinity of the front coast of mangrove in Futian decreased by 4~5ppt in dry season and 1~2ppt in wet season. According to the change of salinity, the expansion of the drain has a great influence on the dry season. However, due to the high salinity in the dry season, the salinity after the expansion is close to that in the wet period before the expansion. Therefore, in general, the impact of salinity changes caused by the project on the mangrove is within a controllable range.

Figure.1 Shenzhen Bay and its mangrove

Keywords: Shenzhen Bay; Numerical Model; Salinity; Mangrove

References

[1] Lei Y D, Yan H Y, Zhong C Y, Feng P J, Jiang S J. (2020). "Regime Shift Recorded by Sediments from the Futian mangrove ecosystem in the Shenzhen Bay". J. Acta Ecologica Sinica, 40(23):8539-8548.

[2] Wang Z S, Feng Z Y, Chen P, Yi R, Tan G M. (2022). "Evolution Process of Mangrove Forests in Shenzhen Bay and lts Response to Human Activities". J. China Rural Water and Hydropower, (12):24-30.

[3] Wu T, Hou X Y. (2017). "Tendency of Coastline Variations on Mainland China Since 1940s". J. Ecological Science, 36(1):80-88.

[4] Zhang J, Sun S L, Lin J G, Chen C L. (2010). "Study on environmental capacity and pollution total quantity control of Shenzhen Bay I.Numerical simulation of tide and tidal current". J. Marine Science Bulletin, 29(01):22-28.

[5] Zhong C Y, Su H, Yan H Y, Jiang S J. (2019). "Industrial development of Hong Kong and its environmental impacts as recorded by sediment Pb variation in Shenzhen Bay, South China". J. Advances in Oceanography & Marine Biology, 1(3):1-6.

Influence of mineral compositions of sediment particles on dissolved oxygen consumption in the sediment-laden flow

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Abstract

The dissolved oxygen content is critical to the self-purification capacity of water and the survival of aquatic organisms in natural water flow (Ben, 2009). The dissolved oxygen consumption caused by biochemical reaction is one of the important indicators in river ecological environment assessment frequently (Wang, 2021). In the analysis of BOD degradation capacity of natural sediment-laden flow, the influence of sediment mineral compositions was often ignored, which would cause the underestimation of river degradation capacity.

In order to clarify the quantitative relationship between the BOD degradation process and the content of cohesive and non-cohesive minerals in the sediment particles, a series of laboratory experiments (Table 1) and theoretical analysis were carried out in the sediment-laden flow. The experimental results show that the BOD temporal hydrographs of the coarse and fine sediment composed of non-cohesive minerals present the convex-shape curves during the degradation process. Meanwhile, the hydrographs of cohesive minerals present the concave-shape curves.

Table 1. Physical characteristics and suspended sediment concentration of each sample.

Sediment type	Sources	Mineral composition	SSC (kg/m^3)	Diameter (mm)
Loess	Middle reach of the yellow river	A	3, 5, 8	0.025
Loess			1, 3, 5, 8, 16	0.050
Pisha sandstone		B	3, 5, 8	0.025
Beach soil	Lower reaches of the Yellow River	C	3, 5, 8	0.278
Montmorillonite powder	Purification	Viscosity mineral	1, 3, 5, 8, 16	0.033

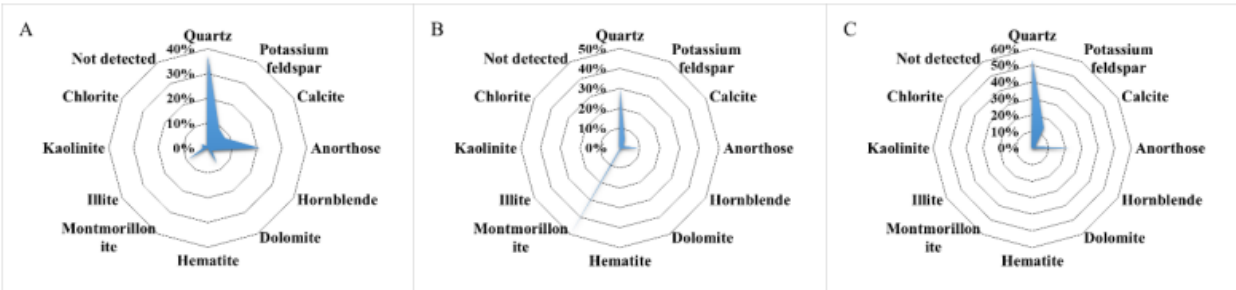

Figure 1. Mineral composition of each sample measured with X-Ray.

The reasons for the different trends of the curves were studied from the perspectives of the turbulence characteristics of the sediment-laden flow and the microstructures of the sediment mineral composition. According to the physical graphs of dissolved oxygen consumption rates,

the dynamic equations of BOD reaction applicable to the sediment-laden flow of non-cohesive mineral composition and cohesive mineral composition were proposed, respectively. The experimental data were used to verify the proposed formulas (Figure 2), and the comparisons indicated that the proposed formulas could reasonably reflect the influences of sediment mineral composition content on BOD degradation process. Based on the experimental study and theoretical analysis, the cohesive mineral composition, especially the montmorillonite, would reduce the degradation rate of BOD, which was due to the binding effect of smaller particle size with larger specific surface area and the hysteresis effect of special layered structure.

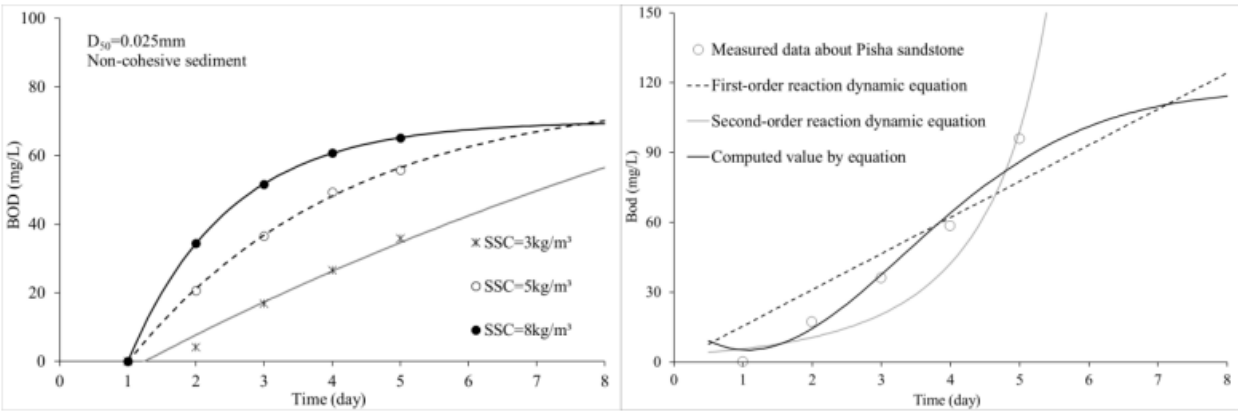

Figure 2. Comparison between calculated values and experimental data for non-cohesive sediment from Loess (Left), and cohesive sediment from Pisha sandstone (Right).

Keywords: Dissolved oxygen; Cohesive mineral; Fine sediment; Montmorillonite

References

[1] Ben L. O'Connor1, Miki Hondzo, Judson W. Harvey. Incorporating Both Physical and Kinetic Limitations in Quantifying Dissolved Oxygen Flux to Aquatic Sediments[J]. Journal of Environmental Engineering, 2009, Vol. 135, No. 12: 1304-1314..

[2] Diaz, R. J., & Rosenberg, R.. Spreading dead zones and consequences for marine ecosystems[J]. Science, 2008, Vol. 321(5891): 926-929.

[3] Wang Kunpeng, Li Qingxiang, Quan Zhou, Dong Yuhong. The Influence of Anisotropic Sediment Layer on Dissolved Oxygen Transfer in Turbulent Flows[J]. Water Resource Research, 2021, Vol. 57: 1-15.

[4] Tian, H. J., Li, Q. X., Pan, M., Zhou, Q., & Dong, Y. H.. High-schmidt-number dissolved oxygen transfer from turbulent flows to permeable microbial sediment bed[J]. Advances in Water Resources, 2019, Vol. 125, 1-12.

Establishment and evaluation of water ecosystem model: A case study of the Lower reaches of Jinsha River

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Abstract

Hydropower development has an important impact on river ecosystems. Identifying and assessing the impact of engineering factors on aquatic biology dynamics is crucial for sustainable management of basin ecosystems. Based on the ecological environment sampling data of the upstream and downstream of XiangJiaBa reservoir, the ecological system model of the lower reaches of the Jinsha River was constructed by using Ecopath ecosystem model to divide functional groups such as organic detrital, phytoplankton, zooplankton, benthic algae, benthic animals and fish. We studied the structural characteristics, energy flow process and energy conversion efficiency, interpreted the material circulation and energy flow characteristics, and evaluated the development and stability of the water ecosystem in the lower reaches of the Jinsha River. On this basis, NMDS (non-metric multidimensional scaling) was used to identify the main hydrological factors affecting the aquatic community. The GAM (generalized additive models) was used to establish quantitative/semi-quantitative relationships between ecosystem indicators and key hydrological factors such as water depth, velocity, and sediment. In addition, the corresponding food web dynamics model was established according to the water ecosystem model, and the model parameters were determined by investigation and ecological metabolism theory. The biomass and stability of each species under different conditions were analyzed by numerical simulation, so as to predict the evolution trend of the ecosystem in the lower reaches of Jinsha River. This work provides important theoretical and technical support for ecological impact assessment and sustainable management of hydropower development.

Keywords: Water ecosystem model; Food web model; Jinsha River; Hydrologic factor

River type-specific approach to quantify clogging based on multiple parameters

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Abstract

Infiltration and accumulation of fine particles in gravel river beds, also known as clogging, is widely known to have severe impacts on the vertical connectivity between surface flow and groundwater [1]. The phenomenon 'clogging' is frequently named as one reason why many rivers fail to achieve the demanded 'good ecological status' for surface water bodies by the Water Framework Directive. Despite the importance of clogging for river health no quantitative and physical- or biologically based criteria are available to evaluate clogging. Currently available abiotic methods are usually of qualitative nature (e.g. mapping) or based on single parameters that are not sufficient to describe the complex and interactive processes of clogging [2]. To overcome these limitations, the presented results include an abiotic dataset of a multiparameter approach (MultiPAC, [3] consisting of measurements and analyses of particle size distributions, porosity values, hydraulic conductivities and dissolved oxygen contents. Additionally, biological sampling including macro invertebrates and the interstitial fauna with subsequent DNA-analyses are performed to complete the interdisciplinary monitoring concept. The following figure represents exemplary the measuring setup to obtain vertical profiles of hydraulic conductivities and dissolved oxygen values using the so-called VertiCO-method (Vertical profiles of hydraulic Conductivity and dissolved Oxygen).

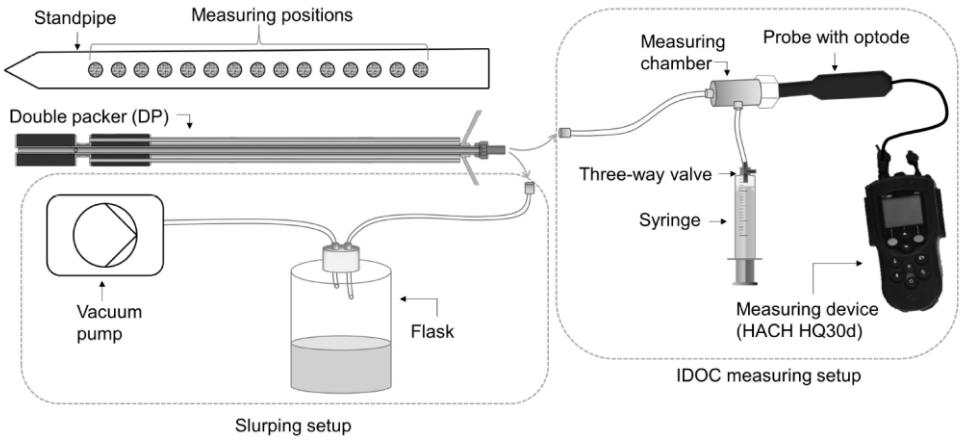

Figure.1 Exemplary measuring setup to obtain vertical profiles of hydraulic conductivities and dissolved oxygen using the so-called VertiCO-method [Bea].

The monitoring was conducted at seven rivers in Germany. All rivers belong to the same river type and all sampling sites represent regular WFD-monitoring stations. The monitoring sites were selected to cover a wide range of different clogging intensities based on different criteria from WFD-sampling (e.g. ecological status, degradation), based on different catchment characteristics (e.g. land use, hillslope) and based on the absence of any sewage water inlets.

As an example Figure 2 shows the fine sediment contents in three categories as well as the vertical profiles of interstitial dissolved oxygen saturation (IDOS) for two rivers have an ecological status of '1' (WFD_1) and '4) (WFD_4) according to the Water Framework Directive.

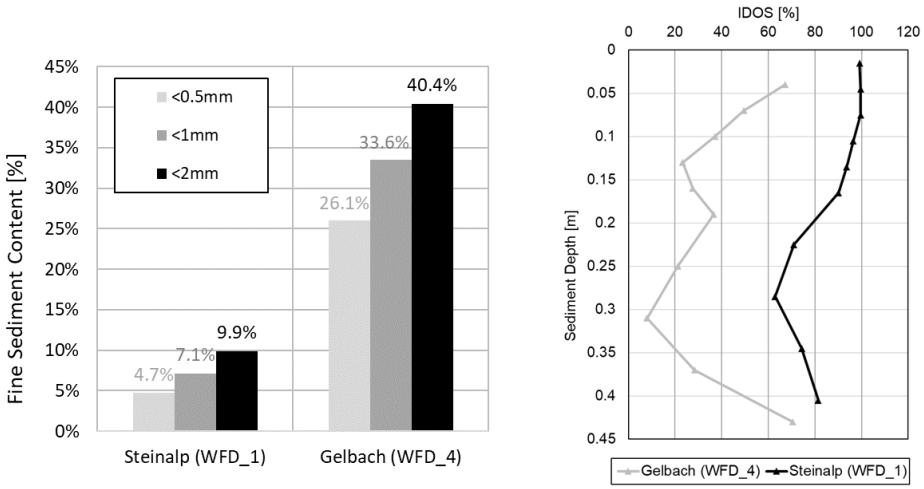

Figure.2 Exemplary results showing the fine sediment contents and vertical profiles of interstitial dissolved oxygen saturations for two rivers with different ecological status according the WFD.

In total, the interdisciplinary monitoring concepts resulted in a data set that is unique so far and offers on the one hand the possibility to compare the measured data with each other but also to relate them to WFD results and to catchment characteristics that could be a basis for a quantitatively-based reliable and comprehensive evaluation method of riverbed clogging.

First analyses of the collected data show exciting findings regarding the degree of clogging and its abiotic and biological descriptions.

Acknowledgment

The authors would like to express appreciation for the support of the sponsors German Federal Environmental Foundation (DBU), Grant Number: AZ 37315.

References

[1] Dubuis, R. & De Cesare, G. (2023). The clogging of riverbeds: A review of the physical processes. Earth-Science Reviews, 239, 104374.

[2] Seitz, L., Lenz, I., Noack, M., Wieprecht, S., & Haas, C. (2019). Kolmation—Eine unterschätzte Größe in der Gewässerbewertung? Wasserwirtschaft, 109(2–3), 41–46.

[3] Negreiros, B., Aybar Galdos, A., Seitz, L., Noack, M., Schwindt, S., Wieprecht, S. & Haun S. (2023). “MultiPAC: a multi-parameter approach for assessing riverbed clogging and vertical hyporheic connectivity, River Research and Application, submitted.

Transient dispersion of active swimmers in an open-channel flow

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Abstract

The rich and complex phenomena of the transport of active swimmers like microorganisms in shear flows are of great significance to various biological and environmental applications. Recent studies have shown that the motility and gyrotaxis of algae could greatly influence their transport in waters. However, little attention has been paid to the initial and transient transport regime when the classical Taylor dispersion model is not applicable. To tackle this problem, we resort to Gill's generalized dispersion model for passive particles like solute, which has the potential for accurately describing the entire transport process. For the first time, we extend Gill's model to the active particles, and the effects of swimming, gyrotaxis, and flow shear on the microorganism dispersion in an open-channel flow have been thoroughly investigated. We first theoretically solve the transient drift and dispersion coefficients, based on which we obtain analytical solutions for concentration distributions of microorganisms, and further validate these results by numerically solving the governing equation (Figure 1). We find that when there is no flow, the longitudinal dispersion of microorganisms can be weakened by the gravitactic accumulation in the vicinity of water surface, while enhanced by a stronger swimming ability of the microorganisms. The effect of the flow shear does not affect the form of the asymptotic concentration distribution, but can greatly enhance the transient drift velocity and the dispersivity. We further analyze the effect of turbulence on microorganisms' dispersion by combing the direct numerical simulation (DNS) and the random walk simulation (Figure 2). The increase of turbulence is shown to decrease the vertical non-uniformity of the concentration distribution, as well as the relative contribution of active behavior to both the drift and Taylor dispersivity during transport.

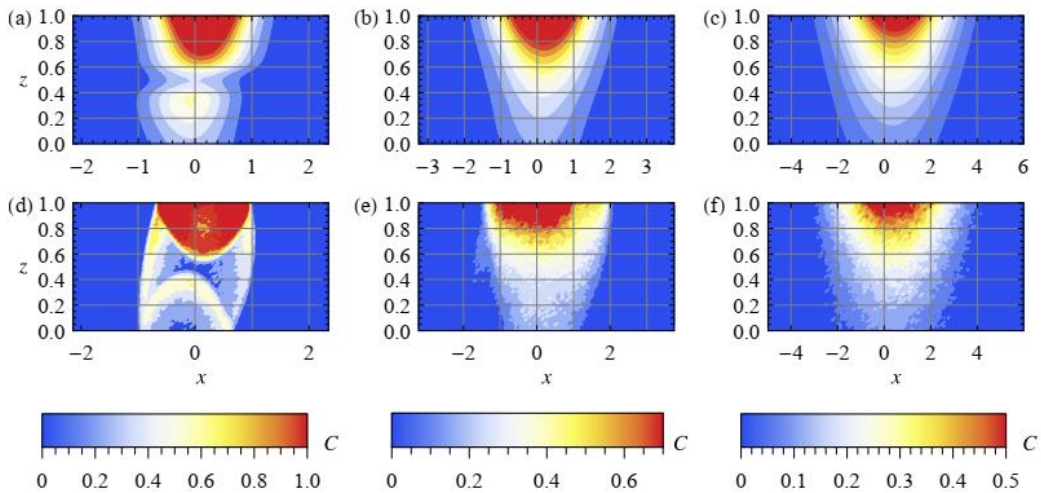

Figure 1. Comparison of the analytical solution with numerical results for the two-dimensional concentration distribution: (a and d) $t = 2$, (b and e) $t = 4$, (c and f) $t = 10$. (a–c) Analytical results and (d,e,f) numerical results. $\lambda = 1$, $\mathrm{Pe}_f = 0.2$, and $\mathrm{Pe}_s = 0.5$ in all cases.

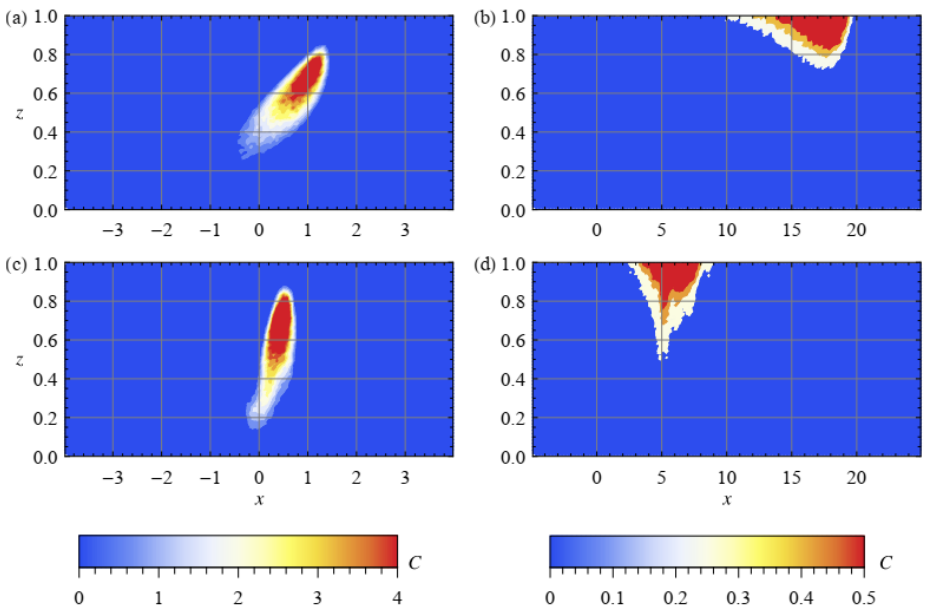

Figure 2. Evolution of the concentration distribution in (a,b) laminar and (c,d) turbulent flows. (a,c) $t = 2$ and (b,d) $t = 20$. In all cases, $\lambda = 1$, $Pe_s = 0.5$ and $Pe_f = 2.0$.

Key results presented in this abstract have been published [1] by Li et al. (2023).

Keywords: Active particle; Open channel flow; Transient transport; Taylor dispersion; Turbulent effects.

Acknowledgment

This work is partially supported by the National Key Research and Development Programme of China (2021YFC3200402), the National Natural Science Foundation of China (U2243222, 52179067, and 52109093), and the Fund Program of State Key Laboratory of Hydroscience and Engineering (2022-KY-04).

References

[1] Li, G., Gong, Z., Jiang, W., Zhan, J., Wang, B., Fu, X., Xu, M., & Wu, Z. (2023). "Environmental transport of gyrotactic microorganisms in an open-channel flow". *Water Resour Res.*, doi: 10.1029/2022WR033229.

Effect of vegetation on the lateral dispersion at the apex section of a meandering channel

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Abstract

Vegetation influences the functioning of the whole river system either altering flow velocities and flow conveyance or affecting the distribution of nutrients and oxygen and thus affecting the water quality conditions.

The major part of studies conducted to investigate flow turbulence structure and lateral dispersion processes in the presence of vegetation [among others 1, 2] consider straight flumes, especially with rigid either submerged or emergent vegetated stems on the bed. In the present study attention is focused on the apex section of a high-curved channel in the presence of flexible submerged vegetation on the bed, and with different spatial distributions. This is motivated by the fact that, because of the significant non-linear feedback between the stream-wise velocity and cross-circulation, in a high-curvature bend the hydrodynamic processes are more complex than those developing in a straight channel, or in a moderate-curvature bend. In particular, the present study analyses how the vegetation and its distribution on the bed could affect the lateral dispersion processes. To this aim, flow velocity data collected in a laboratory meandering flume both in the absence of vegetation and in the presence of flexible vegetation on the bed are used. In this last case both the case of uniformly distributed vegetation (real herbaceous with porosity of 0.952) on the bed and the case of the bed partially covered by vegetation have been examined. The partially covered condition was determined by using two squared (10x10 cm2) artificial flexible vegetation, aligned at a distance of 10 cm from the banks, in sections distant each other of around 50 cm along the channel axis.

To eliminate the spatial heterogeneities due to the vegetation characteristics, both the temporal and the spatial averaging of the measured velocity components have been operated. Thus, the normalized dispersion coefficient in the transversal direction, K_t, has been determined as $\frac{K_t}{Ud} \approx \langle\frac{\sqrt{k'}d}{Ud}\rangle = \langle\frac{\sqrt{k'}}{U}\rangle$, where U is the mean velocity, k' is the turbulent kinetic energy per unit mass, d is the vegetation stem dimension and the brackets represent the spatial average. The vertical profiles of the values of the ratio $\frac{\sqrt{k'}}{U}$ and of the spatial average $\langle\frac{\sqrt{k'}}{U}\rangle$ have been determined at the selected locations along the vertical profiles of the normalized lateral dispersion coefficient $\frac{\sqrt{k'}}{U}$ obtained at two distances from the outer bank in the absence of vegetation on the bed (Figure 1a) with the vertical profiles of the spatial average $\langle\frac{\sqrt{k'}}{U}\rangle$ obtained in the case of partially vegetated bed both in the no-vegetated areas and the in the vegetated area (Figure 1b) and with those obtained in the case of uniformly distributed vegetated bed (Figure 1c).

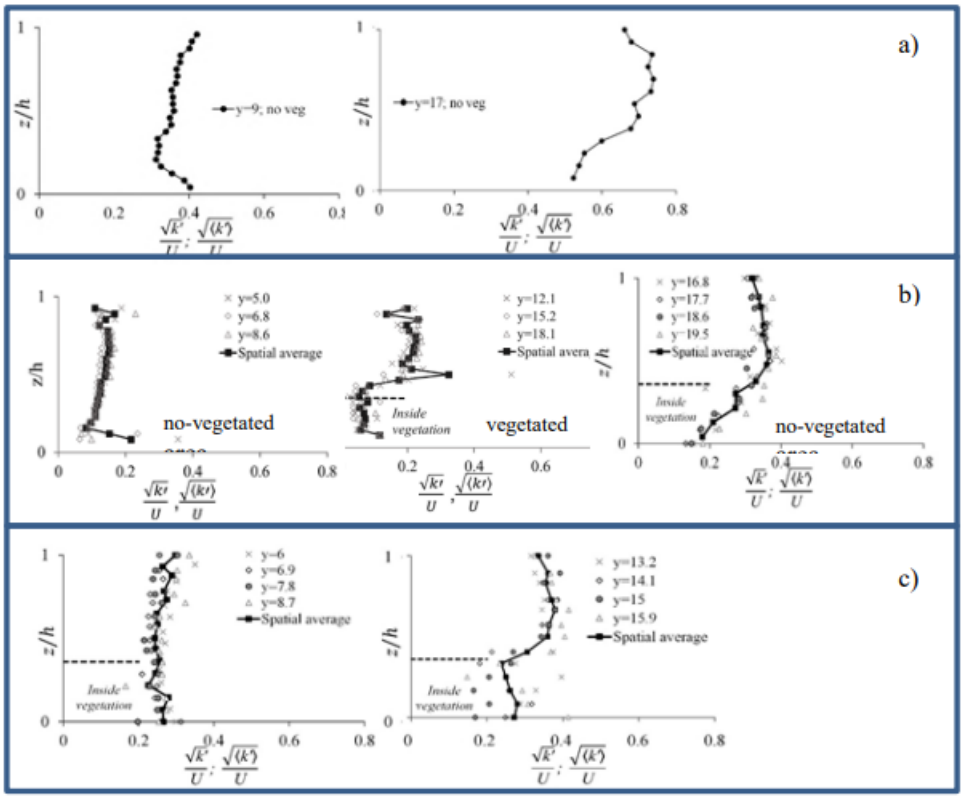


Figure.1 Vertical profiles of normalized lateral dispersion coefficient: a) absence of vegetation at two distances from the outer bank; b) partially vegetated bed: no-vegetated and in vegetated areas; c) uniformly vegetated bed at two distances from the outer bank

Results have shown that the lateral dispersion coefficient assumes, in the absence of vegetation, values greater than those obtained in the presence of vegetation. While in the absence of vegetation the highest values of the lateral dispersion occur in the central part of the cross-section, in the presence of uniformly distributed vegetation the lateral dispersion varies depending on the value of the relative submergence assuming a maximum close to the top of the vegetated layer. In the presence of partially distributed vegetation, a different behaviour inside and outside of the vegetated areas has been observed. In particular, in the central region of the examined section, within each vegetated patch the distribution of the lateral dispersion is similar to that observed in the same region in the case of uniformly distributed vegetation.

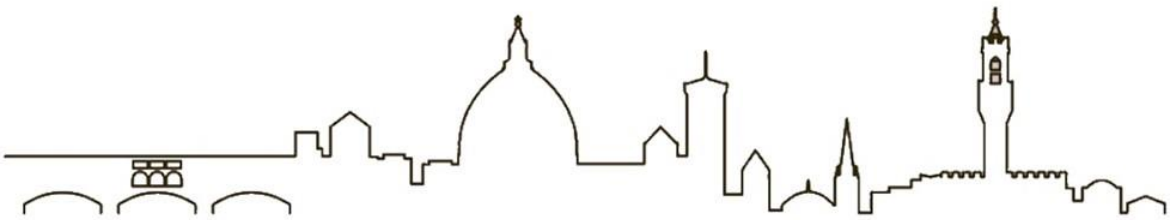
Keywords: Rivers, substances, dispersion, vegetation, experiments

References

[1] Tanino Y. & Nepf H. (2008). Lateral dispersion in random cylinder arrays at high Reynods number. J. Fluid Mech., 600, 339-371.
[2] De Serio F., Ben Meftah M., Mossa M. & Termini D. (2018) Experimental investigation on dispersion mechanisms in rigid and flexible vegetated beds. ADWR vol. 120, 98-113

Topic 4:

Sediment related disasters and climate change



Field Experiment on Landslide Dams Failure

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Abstract

Landslide dam failure can be classified as overflow erosion, large-scale failure, or progressive failure (Takahashi *et al.,* 1988). In many cases, the processes leading to dam failure are not obvious, and further investigation is required (Mizuyama *et al.,* 1988). In this study, we conducted landslide dam failure experiments using a real mountain stream and observed landslide dam failure processes and flood runoff associated with dam failure.

To elucidate the mechanism of landslide dam failure and its associated flood runoff processes, we conducted a dam failure experiment in a real mountain stream (width, 5–6 m) in Gifu Prefecture, Japan. First, a temporary weir was installed upstream of the dam construction site, and a temporary drainage facility was created to divert flowing water away from the site to ensure that the dam would remain dry during construction. Then, sediment was removed from the riverbed, which exposed the underlying rocks. Finally, we created a landslide dam using sediment with a relatively uniform grain size (**Figure 1**). Flood runoff processes associated with dam failure are influenced by dam height, impoundment upstream of the dam, and the downstream slope (Takahashi et al. 1988). Therefore, in addition to varying the dam height and associated amount of impounded water, we also varied the downstream slope and evaluated the resulting runoff processes for seven experimental cases (**Table 1**).

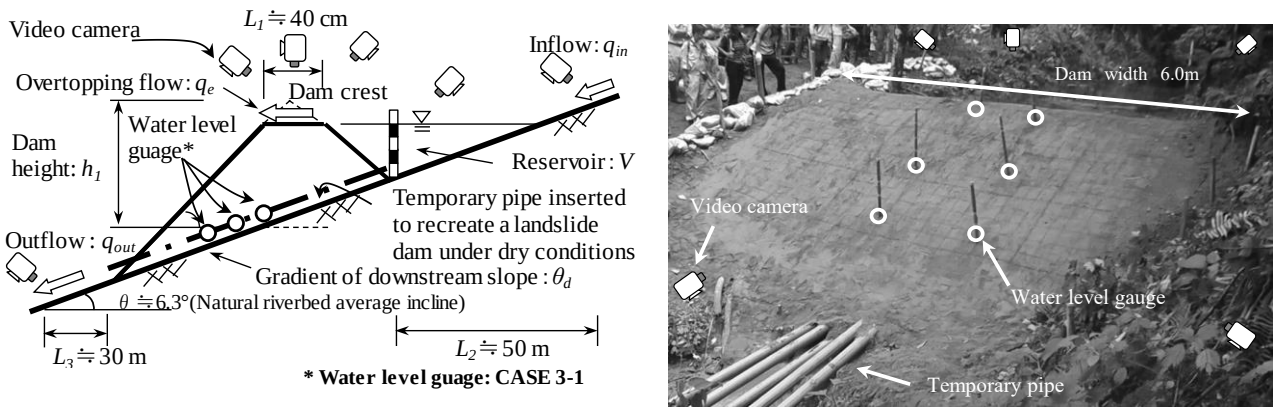

Figure 1. Experimental setup for case 3-1 and photograph of landslide dam construction.

Table 1. Experimental conditions and results.

CASE	Downstream slope (θ_d)	Dam height (h_1)	Dam failure process	Non-dimensional maximum flow-discharge: q_e / q_{in}
1-1	~27°; 1/2	100 cm	Progressive failure	8.62
1-2	~18°; 1/3		Erosion due to overtopping	6.50
1-3	~27°;1/2			10.75
2-1	~25°	120cm		7.81
2-2	~35°			6.88
2-3	~25°	140 cm		14.06
3-1	~35°	200 cm		28.13

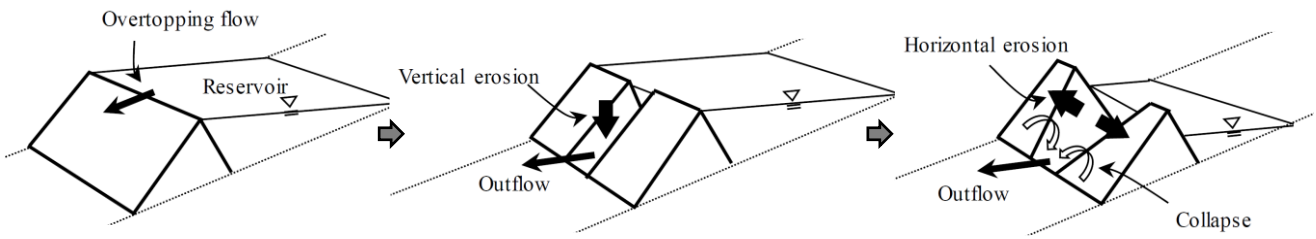

Figure 2. Conceptual diagram of overflow erosion of a landslide dam.

The results of the experiments are shown in **Table 1**. Two types of failure processes were observed: progressive failure due to collapse associated with piping (case 1-1) and erosion failure due to overflow (all other cases). Overflow started at a notch created at the top of the landslide dam, which was designed to stabilize the collapse point, and significant vertical erosion was observed in the initial stage. **Table 1** also shows the non-dimensional outflow for each case, calculated by dividing the maximum dam outflow after dam failure (q_e) by the inflow (q_{in}).

Our experimental results support past observations of real landslide dam failures, with overflow erosion being the predominant failure process. **Figure 2** shows a conceptual diagram of the progression of overflow erosion, in which longitudinal erosion is dominant at the top of the landslide dam during the initial stage of overflow. Then, the side bank of the overflowed dam collapsed gradually, accompanied by the transverse expansion of accumulated sediment as it was slowly entrained by the flow.

Keywords: Field experiment, Landslide dam, Overtopping

Acknowledgment

We thank staff members of the Disaster Prevention Research Institute of Kyoto University and Ritsumeikan University.

References

[1] Takahashi, T. & Kuang, S. F. (1988). “Hydrograph prediction of debris flow due to failure of landslide dam.”, Disaster Prevention Research Institute Annuals of Kyoto University, No.31/ B-2: 601-615.

[2] Mizuyama, T. Ishikawa, Y. & Fukumoto, A. (1989). “Report on the failure of a landslide dam and countermeasures. ", Memorandum of PWRI, No.2744.

Influence of a windstorm-affected area on the transmission of a mountain basin's sediment fluxes

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Abstract

Climate change in Alpine areas is altering the rainfall regimes, increasing the magnitude/frequencies of extreme events, and affecting the sediment dynamics at the scale of both the basin and the river network. However, understanding the responses of sediment transport processes to climate change is still a challenging task as all disturbances are intertwined and each has a different reaction time [1]. This work was carried out in the Rio Cordon basin (Dolomites, Italy) and aimed at monitoring and analyzing the suspended and bedload transport processes (Figure 1A) during five flood events (July 2021-June 2022) in two cross-sections, upstream (CSA) and downstream (CSB) a windstorm-affected area, respectively. In October a windstorm produced changes in the channel morphological configuration such as channel widening, avulsions and lateral erosions. Water discharge (*Q*), water maximum discharge (Q_{peak}) and suspended sediment load (*SSL*) were retrieved from two multiparameter sonde (OTT Hydrolab MS5 and Hydrolab HL4) (Figure 1B). To do so, specific rating curves relating water level - Q and NTU - g l^{-1} were established (more details in [2]). As far as the bedload (*BL*) is concerned, two Bunte bedload traps [3] were installed to determine the transport rate during each event, using the critical *Q* for initiation of *BL* motion equal to 0.44 m^3 s^{-1} [4] (Figure 1C). Then, the total load (*TL*) was computed combining *SSL* and *BL*.

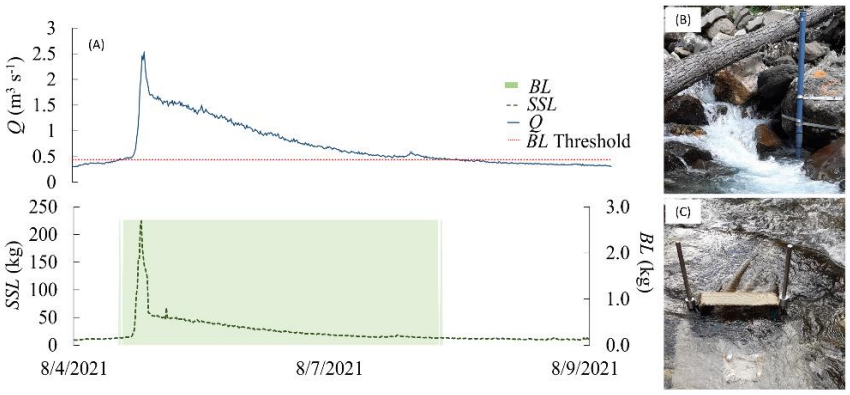

Figure.1 (A) *Q* (blue line), *SSL* (green dotted line) and *BL (*green area) experienced by the Rio Cordon during the Event 4 (EV_4) at CSB, as way of example. The red dotted line indicates the *Q* for initiation of *BL* motion. (B) Multiparameter sonde and (C) Bunte trap used to measure the *SSL* and *BL*, respectively.

Results show different behaviors between *SSL* and *BL* processes (Table 1). On the one hand, *SSL* was consistently higher in CSB compared to CSA, except for the event 1. On the other hand, *BL* was always higher in CSA rather than in CSB. Also, for both cross-sections, the *SSL* fractions (SSL_f) ranging between 0.85 and 1.00 always exceeded those of *BL* (BL_f) that ranged between 0.15 and 0.02. Overall, this suggests that the windstorm-affected area may still be (i) an active source of suspended sediment due to the ready-available fine sediment and bare soil of the eroded banks but also (ii) a spot that promotes bedload deposition due to the ongoing process of morphological stabilization and the

post-event wider active channel. Further monitoring and analysis are needed to better understand and compare the data with the pre-windstorm condition.

Table 1. Summary of the parameter measured during the five flood events recorded between July 2021 and June 2022

Cross-section	Event	Q_{peak}	*SSL (t)*	*BL (t)*	*TL*	SSL_f	BL_f
CSA	EV_1	0.62	86.10	5.07	91.17	0.94	0.06
CSB		0.80	78.26	2.20	80.45	0.97	0.03
CSA	EV_2	0.63	73.07	7.52	80.59	0.91	0.09
CSB		0.76	89.28	3.24	92.52	0.96	0.04
CSA	EV_3	0.76	6.70	0.30	7.00	0.96	0.04
CSB		1.04	8.35	0.16	8.51	0.98	0.02
CSA	EV_4	1.8	93.72	16.14	109.86	0.85	0.15
CSB		2.54	123.02	8.67	131.69	0.93	0.06
CSA	EV_5	1.02	168.41	2.24	170.65	0.99	0.10
CSB		1.71	353.58	0.77	354.35	1.00	1.00

Keywords: Mountain basin; Flood events; Sediment transport; Suspended sediment load; Bedload

Acknowledgment

This study was carried out within the "CAM.SI.FLU.AL" project and the PNRR research activities of the consortium iNEST (Interconnected North-Est Innovation Ecosystem) funded by the European Union Next-GenerationEU (Piano Nazionale di Ripresa e Resilienza (PNRR) – Missione 4 Componente 2, Investimento 1.5 – D.D. 1058 23/06/2022, ECS_00000043). This manuscript reflects only the Authors' views and opinions, neither the European Union nor the European Commission can be considered responsible for them.

References

[1] Hirschberg, J., Fatichi, S., Bennett, G. L., McArdell, B. W., Peleg, N., Lane, S. N., et al., 2021. "Climate change impacts on sediment yield and debris-flow activity in an Alpine catchment." Journal of Geophysical Research: Earth Surface, 126, e2020JF005739.

[2] Pellegrini, G., Mao, L., Rainato, R., Picco, L., 2023. "Surprising suspended sediment dynamics of an alpine basin affected by a large infrequent disturbance." Journal of Hydrology, 617, A, 128933.

[3] Bunte, K., Swingle, K., Abt. S, 2007. "Guidelines for Using Bedload Traps in Coarse-Bedded Mountain Streams: Construction, Installation, Operation, and Sample Processing."

[4] Rainato, R., Mao, L., Picco L., 2020. "The effects of low-magnitude flow conditions on bedload mobility in a steep mountain stream." Geomorphology 367, 107345.

Mainstream Swing Rule in the Sanguanmiao to Weitan Reach of the Lower Yellow River

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Abstract

The Sanguanmiao-Weitan reach of the Lower Yellow River is a typical wandering reach, which has several characteristics of broad-shallow river bed, scattered river regime, swing main channel and frequent abnormal river. In recent years, the special water and sediment conditions have caused changes of the river regime from Sanguanmiao to Weitan, resulting in a large number of beach collapse and endangering the safety of villages and embankments on both sides. In order to clarify the mainstream swing rule in the sanguanmiao to Weitan reach, this paper adopted data analysis and theoretical research to describe the water-sediment process and the characteristics of the channel scouring and siltation. At the same time, according to the adjustment characteristics of the river regime in different periods, the evolution trend of the river regime under different discharge processes was estimated. Studies have shown that, if the incoming water is not abundant, and the reservoirs of the upper and middle reaches are filled with more water, less water will enter the lower reaches of the Yellow River, and the mainstream can swing to the old channel formed in 2018. If the incoming water is abundant, the river will probably continue to recede at the tail of Weitan control project, and the river will follow the governing line. Exploring the characteristics of river regime adjustment from Sanguanmiao to Weitan is of great significance for improving the flood control engineering system and ensuring flood control security.

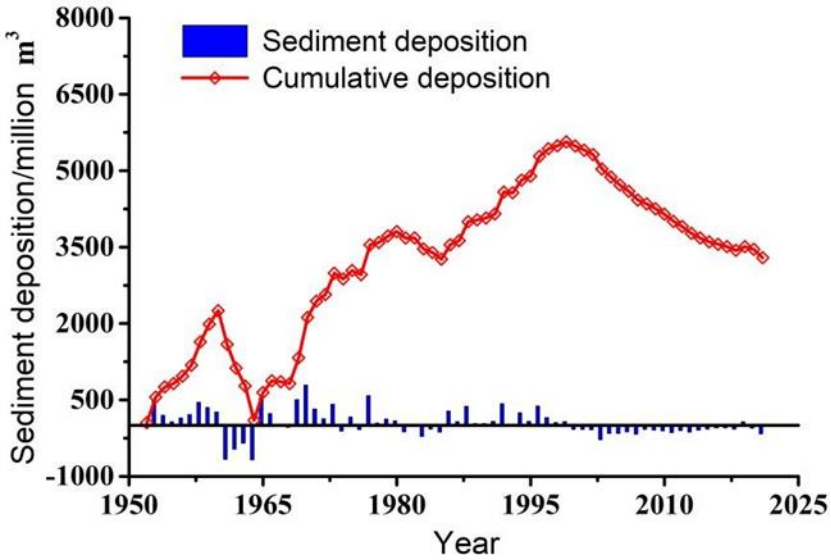

Figure 1. Variation of scouring and siltation in the Lower Yellow River

Table 1. Mainstream features of Sanguanmiao to Weitan

Period	Bending coefficient	Swinging scope/m	Swing strength
1960~1973	1.21	2597	1.96
1974~1999	1.28	2280	1.75
2000~2020	1.37	1392	0.82

Keywords: Mainstream swing; Governing line; River regime adjustment; Change of water and sediment; Scouring and siltation characteristic

Acknowledgment

The authors would like to express appreciation for the support of the sponsors [Yellow River Water Science Research Joint Foundation, Grant Number: U2243220].

References

[1] Wang Yingzhen, Xia Junqiang, Zhou Meirong, et al. (2019). "Characteristics of main channel migration in the braided reach of the lower Yellow River after the Xiaolangdi Reservoir operation". Advances in Water Science. 30(2): 198-209.
[2] Jiang Qingrong, Xia Junqiang, Zhou Meirong, et al. (2020). "Evolution process of different abnormal river bends in the braided reach of the lower Yellow River". Journal of Lake Sciences. 32(6): 1837-1847.
[3] Liu Wei, Wang Suiji, Wang Yanjun. (2020). "Variation of morphological parameters of channel cross-sections and their response to water-sediment processes in the lower Yellow River". Scientia Geographica Sinica. 40(9): 1563-1572.
[4] Xu Linjuan, Wang Yuanjian, Li Junhua, et al. (2021). "River regime evolution of the wandering channel in the lower Yellow River based on long sequence". South-to-North Water Transfers and Water Science & Technology. 19(1): 151-157.
[5] Wang Yingzhen, Xia Junqiang, Zhou Meirong, et al. (2020). "Variations in bankfull area and discharge in the braided reach of the Lower Yelow River over the past 30 years". Journal of Basic Science and Engineering. 28(3): 666-679.
[6] Xia Junqiang, Wang Zenghui, Wang Yingzhen, et al. (2020). "Development and application of a reservoir-channel-floodflain coupling model system for flow and sediment transport in the middle and Lower Yelow River". Journal of Basic Science and Engineering. 28(3): 652-665.
[7] Li Jie, Xia Junqiang, Zhu Chenghao. (2022). "Characteristics and influencing factors of thalweg migration in the Xiaobeiganliu reach of the Yellow River during the period of continuous channel aggradation". Journal of Basic Science and Engineering. 30(4): 883-892.

Research Review on the Secondary Suspended River in the Lower Yellow River

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Abstract

The sediment-laden nature of the Yellow River has created a unique channel shape in the lower reaches, making the lower reaches of the Yellow River a world-famous "suspended river on the ground". Since the middle and late 1980s, due to the adverse combination of water and sediment relations and the impact of human activities, the lower reaches of the Yellow River had formed a "secondary suspended river" with "high channel, low beach and low dike root" (Fig.1). The "secondary suspended river" poses a great threat to the flood control of the lower Yellow River. The formation reason, development process and governance measures of the secondary suspended river were systematically combed in this paper, and providing a theoretical basis for the governance of the secondary suspended river in the new period.

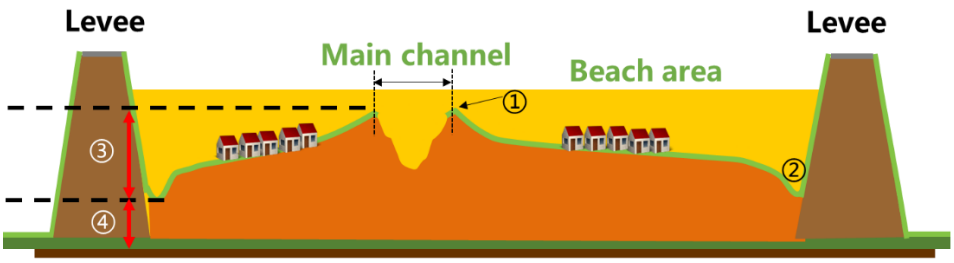

Figure 1. Schematic diagram of secondary suspended river in the lower Yellow River: ①The highest elevation of the main channel edge; ②Channel at the root of the levee

The study shows that the occurrence and development of the secondary suspended river are closely related to the changes of the incoming water and sediment conditions of the river [1-5] and the channel boundary conditions [2, 6-7], especially the hyper concentrated flood has played a certain role in promoting the development of the secondary suspended river [2]. The construction of the production dyke has intensified the siltation of the river channel to a certain extent, and promoted the development of the secondary suspended river. At present, the engineering measures to control the secondary suspended river mainly include water and sediment regulation, dredging of river channels, silting and blocking of ditches, silting and filling of embankments and so on [8-12]. After treatment, the situation of the secondary suspended river has been alleviated, which can relatively reduce the threat of flood control safety.

Keywords: Secondary suspended river; Cause; Governance measures; Lower Yellow River

Acknowledgment

We thank Yellow River Institute of Hydraulic Research for financial support.

References

[1] Jiang E.H, Cao Y.T, Zhang L.Z., et al. (2006). "Study on the law and mechanism of river regime evolution in the wandering reach of the lower Yellow River". Beijing: China Water Resources and Hydropower Press.
[2] Hu Y.S, Zhang X.H. (2006). "Brief discussion on the secondary perched river". Journal of Sediment Research, (5): 1-9.
[3] Hu Y.S. (2001). "On perched streams". Journal of North China Institute of Water Conservancy and Hydroelectric Power, 22 (3): 12-18.
[4] Gao J.Z, Hu C.H, Chen X.J. (2004). "A preliminary study on alteration of watercourse and improvement of the "secondary perched river" in the lower Yellow River". Journal of China Institute of Water Resources and Hydropower Research, (10): 8-18.
[5] Jiang E.H, Han Q.W, Li J.H. (2010). "Overview of typical phenomena and related research on the evolution of the Yellow River bed". Yellow River, 32 (8): 5-7.
[6] Duanmu M.L, Zhang S.Q. (2003). "The formation and control measures of the secondary suspended river of the Yellow River in Henan Province". China Water Resources, (12): 58-59.
[7] Zhang R. (2005). "Several views on the construction of the Yellow River water and sediment regulation system". Yellow River,27 (9): 3-4, 14.
[8] Zhao Y, Bian P, Zhang S.Q. (2002). "The situation and control measures of the secondary suspended river in Puyang section of the Yellow River". Yellow River,12:14-15.
[9] Chen M.P, Zhao Y.Y, Liu J, Chen X.J. (2003). "Study on the recent treatment of the secondary suspended river in the Henan section of the Yellow River". Yellow River, (7): 12-13.
[10] Wan Q, Zhang J.Y, Li J.H. (2019). "Validation of the Secondary Suspended River Management Effect in LYR by the Physical Model Examination". Yellow River, 41 (6): 26-28.
[11] Liu Y, Li J.H, Zhang X. (2022). "Experimental study on Low Land Area Control in the secondary suspended River Reach of the Lower River" section of the lower Yellow River". Yellow River, 44 (2): 41-44.
[12] Liu Y, Xia X.J, Zhang X. (2019). "Experimental study on the influence of dyke river regulation on the Yellow River embankment". Yellow River, (S2): 18-20.

The optimization of cascade check dam system for mitigating debris flow

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Abstract

Debris flow can pose a significant hazard in mountainous areas, as it can cause loss of life, property damage, and disruption to infrastructure and transportation (Iverson, 1997). Check dams have been proven to be an effective structural measure for mitigating debris flow in mountainous areas, as they can effectively trap sediment and reduce the impact speed of debris flow. If the location and number of check dams are not reasonable, it can lead to an ineffective disaster mitigation performance and financial waste.

In previous study, the layout of check dams is determined based on empirical formulas (CGS, 2004), lacking a quantitative scientific design methdology. The objective of this study is to optimize the layout of check dams, increasing debris flow mitigation efficiency and ensuring the most cost-effective investments.

To achieve this objective, a combination of numerical models and optimization models are employed (Figure 1). The simulation model Kanako which can assess the effectiveness of check dams in debris flow mitigation is established and calibrated(Nakatani et al., 2008) . The multiobjective evolutionary algorithm NSGA2 is used to generate and evaluate the layout of dams based on three objective functions: sediment transport volume, debris flow peak discharge, and check dam construction costs (Deb et al., 2002).

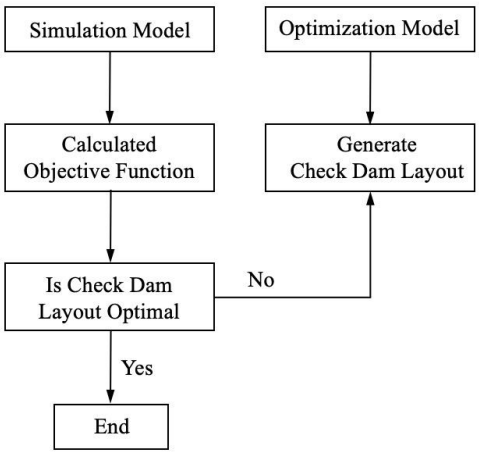

Figure 1. Main stages of checkdam layout determination

This method is applied to Caijia gully in Sichuan Province, a debris flow prone channel. Results show that, compared with the original dam layout scheme of the channel, under the same dam construction cost, as shown in the table below, the optimization layout method significantly improved the engineering protection efficiency and reduced disaster risk. In the debris flow event of the hundred-year return period, the sediment transport volume reduction rate increased by 7.7% and the peak discharge reduction rate increased by 2.2%; similarly, in the debris flow event of the fifty-one return period, the sediment transport volume reduction rate increased by 10.1% and the peak flow

reduction rate increased by 10.6%.

Table 1. Comparison of check dam layout plan

	P=1% Peak discharge reduction rate	P=1% Sediment transport volume reduction rate	P=2% Peak discharge reduction rate	P=2% Sediment transport volume reduction rate
Original check dam layout	61.3%	45.8%	50.4%	62.3%
Optimized check dam layout	63.5%	53.5%	61.0%	72.4%

Keywords: Debris flow mitigation; Check dam layout; Optimization; Debris flow simulation

Acknowledgment

This study is funded by the National Natural Science Foundation of China (41941019).

References

[1] Iverson, R. M. (1997). The physics of debris flows. Reviews of geophysics, 35(3), 245-296.
[2] CGS (China Geological Survey). (2004). Design code for debris flow disaster mitigation measures (DZ/T0239-2004).
[3] Nakatani, K., Wada, T., Satofuka, Y., & Mizuyama, T. (2008). Development Of\"Kanako", A Wide Use 1-D And 2-D Debris Flow Simulator Equipped With GUI. WIT Transactions on Engineering Sciences, 60, 49-58.
[4] Deb, K., Pratap, A., Agarwal, S., & Meyarivan, T. A. M. T. (2002). A fast and elitist multiobjective genetic algorithm: NSGA-II. IEEE transactions on evolutionary computation, 6(2), 182-197.

Seismic monitoring of bedload transport at the Rutor proglacial stream

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Abstract

The sediment supply from glacierized areas to the channel network is increasing due to the ongoing climate change. Quantitative estimations of sediment transport are challenging in Alpine environments. To overcome the practical limitations of direct measurements in such hash environments, seismic techniques have been applied to acquire indirect and continuous measurements of bedload transport (Bakker et al., 2020; Coviello et al., 2022; Lagarde et al., 2021).

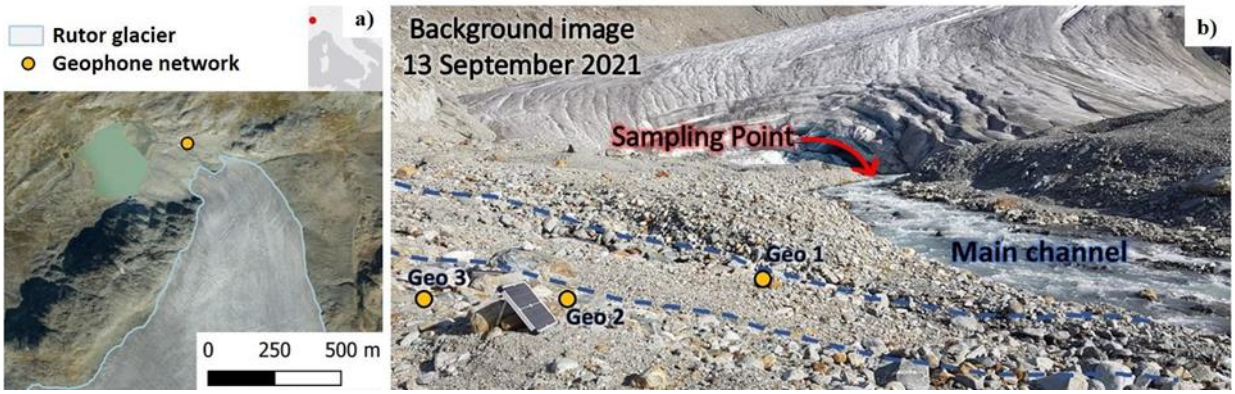

Figure 1. a) Orthophoto of a portion of the Rutor glacier and its proglacial area; the geophones network and the glacier boundary are indicated. b) View on the monitored reach of the proglacial stream draining the eastern tongue of the Rutor glacier. Orange dots indicate the location of the geophones, the dashed blue line is the limits of the ephemeral stream flowing into the main channel

In this work, we present an analysis of the temporal variability of hydro-sedimentary export from the eastern snout of the Rutor Glacier (La Thuille, Western Alps) (Figure 1.a)). Bedload transport has been monitored with a geophone network in the ablation seasons since 2021. The monitoring network is composed by three single-component geophones (4.5 Hz) installed along the proglacial stream draining the eastern tongue of the glacier. The geophones were installed about 200 m downstream of the glacier snout at different distances from the right bank of the channel (3 m, 6 m and 8 m) (Figure 1.b)).

During the 2022 season, direct measurements of bedload transport were performed by placing bedload traps (4 mm mesh size, 20 × 30 cm opening, (Bunte et al., 2004)) at the glacier mouth (Table 1). These measurements are necessary to quantify the transported bedload mass.

Table 1. Direct bedload measurements carried out at the glacier snout in 2022. For each measurement, the duration, the unit bedload rate and the power register by Geo3 is reported.

Date	Hour (UTC +2)	Duration (min)	Qb (kg/m/min)	Power (V^2/min)
14/07/2022	10:43	20	0.02	4.87E+09
14/07/2022	10:59	20	0.02	4.88E+09
14/07/2022	11:09	30	0.06	5.08E+09
14/07/2022	11:32	30	0.89	5.75E+09
14/07/2022	12:12	8	0.92	6.31E+09
14/07/2022	13:00	5	4.46	6.29E+09
14/07/2022	14:06	3	16.21	6.68E+09
14/07/2022	14:45	3	16.1	6.33E+09
14/07/2022	15:26	2	9.66	6.57E+09
16/09/2022	17:13	30	0.03	6.61E+09

Preliminary results show a remarkable variability of bedload rate in time. The geophone network can detect both daily and longer-period fluctuations in bedload and water flow, making it possible to identify time intervals characterized by intense bedload transport.

The dataset of direct measurements will be expanded in 2023 and used to better calibrate the seismic data in order to quantify the bedload export from the glacier.

Keywords: Bedload; Geophone network; Glacier; Proglacial; Sediment

Acknowledgment
The glacier-lab members are gratefully acknowledged for their help during the field campaigns.

References

[1] Bakker, M., Gimbert, F., Geay, T., Misset, C., Zanker, S., & Recking, A. (2020). Field Application and Validation of a Seismic Bedload Transport Model. Journal of Geophysical Research: Earth Surface, 125(5), e2019JF005416. https://doi.org/10.1029/2019JF005416

[2] Bunte, K., Abt, S. R., Potyondy, J. P., & Ryan, S. E. (2004). Measurement of Coarse Gravel and Cobble Transport Using Portable Bedload Traps. Journal of Hydraulic Engineering, 130(9), 879–893. https://doi.org/10.1061/(ASCE)0733-9429(2004)130:9(879)

[3] Coviello, V., Vignoli, G., Simoni, S., Bertoldi, W., Engel, M., Buter, A., Marchetti, G., Andreoli, A., Savi, S., & Comiti, F. (2022). Bedload Fluxes in a Glacier‐Fed River at Multiple Temporal Scales. Water Resources Research, 58(10), e2021WR031873. https://doi.org/10.1029/2021WR031873

[4] Lagarde, S., Dietze, M., Gimbert, F., Laronne, J. B., Turowski, J. M., & Halfi, E. (2021). Grain‐Size Distribution and Propagation Effects on Seismic Signals Generated by Bedload Transport. Water Resources Research, 57(4), e2020WR028700. https://doi.org/10.1029/2020WR028700

Influence of debris flows on river sedimentation

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Abstract

Debris flow which often occurs in tributaries or ditches of mountain rivers, is a kind of special fluid between sediment-laden flow and landslide. Outbreak of debris flows on both sides of mountain rivers may lead to the increase of sediment concentration in the river flow and the elevation of riverbed near the ditch mouth, and even cause river damming, which may affect the river sedimentation processes. Based on field investigation, data analysis and numerical simulation, this paper analyzes the influence of debris flows on river sedimentation.

After the 2008 Wenchuan earthquake, debris flows constantly occurred in the Yongjia gully, which caused serious incidents of road blocked and river damming. The largest scale event was on August 18, 2012 which simultaneously caused the Mianyuan River totally blocked. After analysis and comparison of the rainfall processes for two debris flow events on August 13, 2010 and August 18, 2012, it is concluded that the accumulated precipitation triggered the debris flows increased but the critical rainfall decreased. After the 2008 Wenchuan earthquake, an abundance of loose co-seismic material sources were present in the main channel and branch channel of Yongjia gully. According to detailed site investigations, the active paths of different debris flows were not consistent. The debris flow on August 18, 2012 was mainly occurred in the No.1 branch, which shows that erosion width of the channel is getting narrower and the accumulation thickness is first increased and then decreased with the increase of distance from the main channel outlet. Moreover, the particle size distribution of the debris is random in the channel. In addition, it also analyzed the river-blocked probability of Yongjiagou debris flows under the different rainfall frequency. The results indicate that Yongjiagou debris flow event could cause river damming when rainfall frequency greater than 20% of its return period, even cause the river completely blocked.

Taking a mountain river segment as an example, the influence of debris flows on the river sedimentation processes was simulated, and the short-term response of sediment concentration and riverbed elevation in the reach was studied. After the outbreak of debris flows, the sediment concentration of the reach near the ditch mouth increases significantly, and directly causes the change of the sediment concentration of the downstream (Figure 1). Moreover, there is obvious sedimentation in the reach near the ditch mouth (Figure 2).

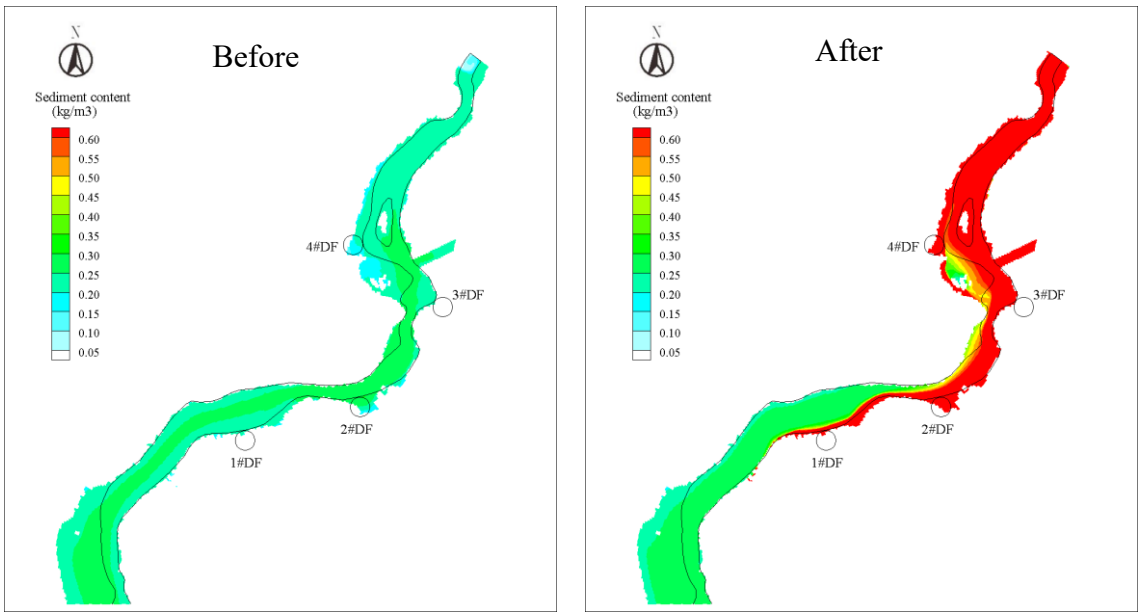

Figure 1. Distribution of sediment concentration in the reach before and after the outbreak of debris flows.

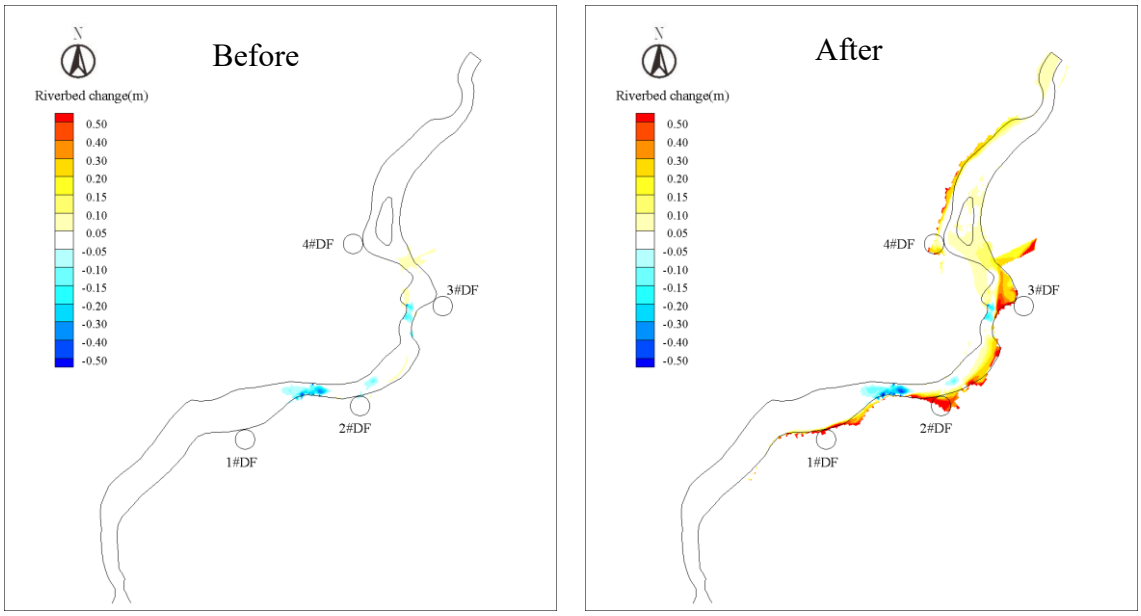

Figure 2. Distribution of erosion and deposition in the reach before and after the outbreak of debris flows.

Keywords: Debris flow; River damming; Mountain river; Simulation

Acknowledgment

The authors would like to express appreciation for the support of the funds: (1) the National Key Research and Development Program of China (Grant Number: 2022YFC3205000), (2) the science and technology project of Huaneng Group headquarters 'HNKJ20-H26 key technology of Y River controlled reservoir operation for ecological protection of ML-YS reach'.

Climate change and sediment transport: risk mitigation for shallow water offshore foundations

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Abstract

Sediment transport and climate change are complex issues that pose significant challenges to communities and ecosystems. Sedimentation processes affect water quality and quantity, reduce the capacity of water storage reservoirs, and damage infrastructure in fluvial and marine environments [1].

Climate change alters the timing and intensity of rainfall, snowmelt, and other forms of precipitation in fluvial environments. These changes can lead to more frequent and severe floods, which can increase the volume of sediments transported downstream. The increased sediment load can lead to erosion of riverbanks and damage infrastructure, as well as change the composition and quality of the water. In maritime environments, climate change causes changes in ocean currents, sea level rise, and increased storm activity, all of which can affect sediment movement. Sea level rise can cause coastal erosion, leading to increased sediment loads in adjacent marine ecosystems. Changes on ocean currents can also alter sediment transport patterns, affecting the distribution of sediments, habitats, and species that depend on them.

In this study, the focus is on issues related to sediments in the marine environment, i.e., offshore structures and foundations. Offshore wind farms belong to a marine renewable energy sector with high commercial development. However, optimization of offshore wind foundations is still of great importance. The focus is on scour protection, which prevents scour phenomena that can lead to failure of bearing capacity and operational limit [2]. Scour protection is an important part of the foundation in marine environments that prevents the occurrence of scour phenomena, one of the most common causes of ultimate and service limits. Optimization of scour protection usually results in significant cost savings while ensuring the structural stability of the system [3].

This research focuses on sediment-induced disasters in marine environments and is part of the ongoing project POSEIDON, which aims to extend and validate dynamic scour protection for complex marine renewable energy foundations. The research involves combined physical and numerical modeling of three types of foundations: a monopile, a jacket structure, and a gravity- based foundation (GBF). Modeling activities focus on 3D characterization of scour effects and deposition zones around a 1:50 geometric scale model (Froude similitude) of offshore foundations for various hydrodynamic conditions, based on the prototype Horns Rev 3 offshore wind farm in the North Sea. The laboratory experiments are being conducted on the wave-current flume of the Hydraulics Laboratory of the Faculty of Engineering of the University of Porto (FEUP), 29 m long and 1 m wide (see Figure 1). The project will optimize these mechanisms by considering the complex interactions between the energy converters, the scour around the foundation, and the foundation itself [3], with efforts to determine the extent of scour and damage, and to ensure the serviceability and functionality of the offshore foundations. By identifying potential issues and addressing them, the project can lead to improved performance, reduced risk, cost saving and environmental benefits for offshore structures and their associated foundations.

Figure 1. Scour effects around a monopile co-located with an oscillating wave surge converter at FEUP.

Keywords: Climate change, Offshore foundation, Scour protection, Sedimentation

Acknowledgment
This work was financially supported by the project PTDC-ECI-EGC-5177-2020 (POSEIDON project), funded by national funds through FCT – Portuguese Foundation for Science and Technology.

References

[1] Wu, M., De vos,L.,Chavez, C, A., Stratigaki, V., Ferradosa, T., Rosa Santos, P., Taveira Pinto, F., & Troch, P. (2020). "Large Scale Experimental Study of the Scour Protection Damage Around a Monopile Foundation Under Combined Wave and Current Conditions." Marine Science and Engineering. 8, 1-417. doi:10.3390/jmse8060417.
[2] Nielsen, A. W., Sumer, B, Mutlu., Fredsoe, J., Christensen, E. D. (2010). "Scour Protection Around Offshore Wind Turbines. Monopiles." Proceedings 5th International Conference on Scour and Erosion. 2010 Oct S. 440-449.
[3] Ferradosa,T., Taveira Pinto, F., Rosa Santos, P., & Chambel, j. (2019). "Probabilistic Comparison of Static and Dynamic Failure Criteria of Scour Protections." Marine Science and Engineering. 7 (2), 1-16. doi:10.3390/jmse7110400.

Bedload sediment transport on the continental slope under internal waves

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Abstract

In recent years, the influence of internal waves on the seabed has attracted more attention from researchers. On the continental slope of the northern South China Sea (SCS), there are a large number of sand waves on the sea bottom with water depths of 100 m ~ 400 m (Reeder et al., 2011). Meanwhile, strong currents near the sea bottom have also been observed in these areas (Xie et al., 2018). Zhang et al. (2019) believed that the strong bottom current is induced by internal waves, which is also the main cause of the generation and formation of sand waves. Therefore, the study of internal wave propagation on continental slopes and its effect on sediment transport is of importance to the design and maintenance of offshore oil and gas engineering projects.

In this paper, the nonhydrostatic ocean model SUNTANS is used to simulate the propagation of internal waves and the bedload sediment transport on the continental slope of the northern SCS. According to the value and direction of the bottom current, the propagation of internal waves along the continental slope from deep to shallow water can be categorized into six modes: a depression mode, a depression dominant mode, an equivalent mode, an elevation dominant mode, an elevation mode and a tidal mode. The bottom shear stresses induced by internal waves on the continental slope of the northern SCS are calculated based on the obtained bottom current velocity. Then, the general characteristics of sediment transport on the slope are analyzed by the bedload transport. Generally, there is no sediment transport on the sea bottom induced by internal waves when the water depth is deeper than 650 m or shallower than 80 m. Downslope sediment transport dominates on the slope in the water depth range of 200 ~ 650 m, which corresponds to the depression dominant mode of internal waves. The upslope sediment transport dominates on the slope at water depths ranging from 80 ~ 200 m, which corresponds to the elevation dominant mode of internal waves, i.e., the direction of the bottom current is the same as the propagation of internal waves. The predicted directions of the bedload transport coincide well with the field observations of the migration of sand waves on the continental slope (Zhang et al., 2019), which further confirms that the main cause of generation and formation of sand waves on the continental slope of the northern SCS is the strong bottom current induced by the shoaling process of internal waves. Based on the present model, the long-term variation of bottom currents can be obtained for the simulation of sand wave evolution on the continental slopes. It is also noted that for the accurate prediction of sand wave movement, especially polarity conversion areas, high-resolution scanned topography data and parameters of seabed properties are required.

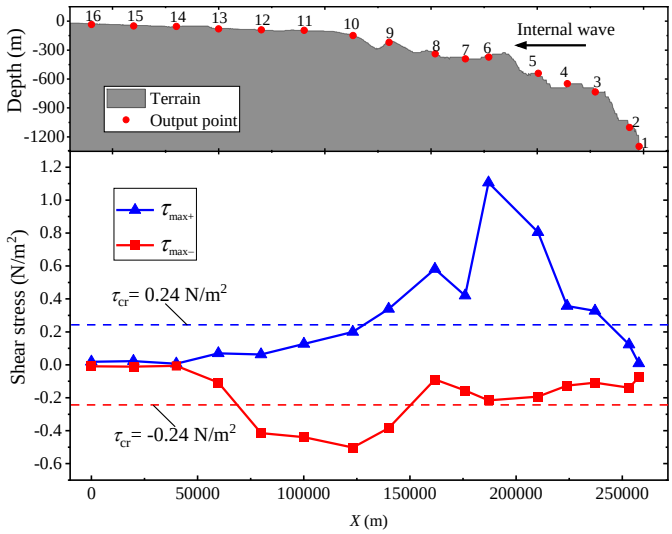

Figure 1. Maximum shear stress on cross-section P1 during the propagation of internal waves on the continental slope of the northern SCS.

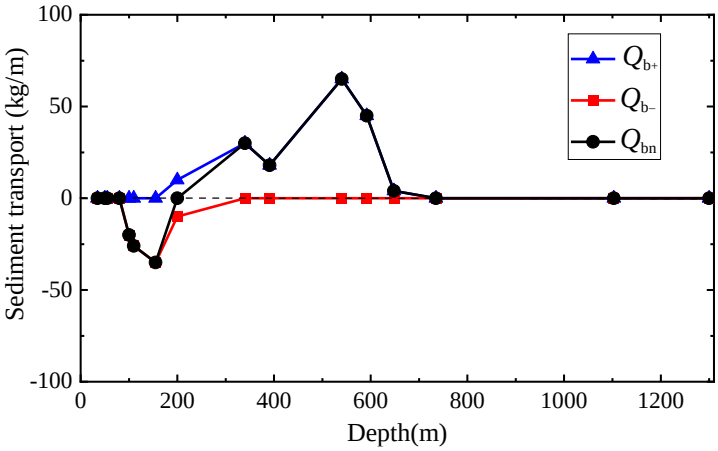

Figure 2. Net mass transport per unit width in one week vs. water depth.

Keywords: internal wave; continental slope; South China Sea; bed shear stress; bedload transport

Acknowledgment

This research was funded by the National Natural Science Foundation of China (Grant Nos. 51579232, 51979192, 51890913).

References

[1] Xie, B., Li, J., Ren, X., Lei, F.H. (2018). "The characteristic analysis of internal solitons in the Liuhua area of the South China Sea". Proceedings of the Twenty-eighth International Ocean and Polar Engineering Conference Sapporo, Japan, June 10-15, 1056-1061.

[2] Zhang, H., Ma, X., Zhuang, L., Yan J. (2019). "Sand waves near the shelf break of the northern South China Sea: morphology and re-cent mobility". Geo-Mar. Lett., 39, 19–36.

[3] Reeder, D.B., Ma, B.B., Yang, Y.J. (2011). "Very large subaqueous sand dunes on the upper continental slope in the South China Sea generated by episodic, shoaling deep-water internal solitary waves". Marine Geology, 2011, 279(1–4), 12–18.

Two Catastrophic Debris Flood Hazards Due to the Shift from Drought to Extreme Rainfall in Post-earthquake Mountain Areas

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Abstract

Debris floods, a kind of mineral and organic sediment-rich floods in steep mountain channels [1], can endanger human lives and cause infrastructure damage. It is generally believed that extreme rainfall events due to climate change will increase the magnitude and frequency of debris floods. It is rarely known that a shift from drought to extreme rainfall even drives more catastrophic debris flood hazards in post-earthquake areas. In this work, we analyze the example of two events in Southwest China in 2022 to improve our understanding of the disaster factors and mechanisms in response to the undergoing climate shifts.

Figure 1. Debris flood hazards. (a-b) Event scene in HS Gully on 12 July 2022; (c-d) Change of the QJ Gully caused by the event on 19 August 2022. Photos (a-b): P. Liang

Historic droughts occurred in Sichuan Province in Southwest China in the summer of 2022 since 1961, including two periods of extremely high-temperature events (4 -16 July and 28 July - 22 August 2022). Compared with the same period of the year, the average temperature was 2.3 ℃ higher, and the total rainfall was 43% lower. However, local extreme rainstorm events in July and August triggered debris floods and debris flows hazards, resulting in more than 40 losses of human life and emergency relocation of 14000 people, nearly 400 houses destroyed and 2200 houses damaged, and a large economic loss of nearly 2.5 billion yuan.

In this work, we focus on two debris flood events respectively occurred in Heishui Gully (HS Gully, on 12 July) and Qingjia Gully (QJ Gully, on 19 August) in Pingwu county, Sichuan Province, China (Figure 1). Based on the field work using UAV aerial photography, interview survey, and information

collection, we collected the general data on small watersheds, historic earthquakes, rainstorms and flood events in recent years, and extreme climate and debris flood hazards in 2022. Results (Table 1) show that either the large long stream (HS Gully) or the small short stream (QJ Gully) has a very large relative elevation, resulting in a steep channel slope (with an average slope much larger than 10%). Earthquakes increased the loose material in the drainage areas, especially in the upstream hillslopes. Although extreme rainstorm events occurred frequently in the last 10 years before 2022, no debris flood hazards occurred in HS Gully and only small events occurred in QJ Gully. It was because of the climate shift from historic drought to record rainfall that drove stable landslides to catastrophic failure [2]. Associated with outbreak floods from landslide dams, the catastrophic debris floods even mobilized the sediments from the channel bank and the bed subsurface, causing hydrogeomorphic hazards on fans and elsewhere.

Table 1. General information on the two field sites and the debris flood hazard events

Content	HS Gully	QJ Gully
Site latitude and longitude	N32.61°, E104.53°	N32.50°, E104.18°
Drainage area and length	102.54 km^2, 18.73 km	3.5 km^2, 3 km
Relative elevation	2545 m (1770 m - 4315 m)	550 m (1200 m - 1750 m)
Violent earthquakes	One M7.0 (2017), one M8.0 (2008), and two M7.2 (1976) in the nearby areas	
Small earthquakes	188 M2.5 - M5.4 in the last 10 years in the nearby areas	
Rainstorms in the county	In the summer of 2009, 2010, 2011, 2013, 2017, 2018, 2019, and 2020	
Hazard events in history	No flood hazards in the last 90 years	Debris floods (1976, 2013, 2016)
Drought before the events [Data during 2022 events]	Rare rainfall during 30 days [> 100 mm within one day] Average soil humidity (0 - 40 cm) < 0.3 during 20 days [>0.44] Average soil relative humidity (0 - 50 cm) < 60% during 20 days [~100%]	
High temperature (2022)	Higher than the average maximum values (29 - 30°C) in 29 out of 31 days	
Date of the debris flood events	12 July 2022	19 August 2022
Extreme rainfall [Monthly total]	151 mm (within 3 hours) [187 mm]	173 mm (within 24 hours) [177 mm]
Human population loss	18 people died or were missing	Zero (79 people transferred)
House loss	49 destroyed, 58 damaged	Six destroyed, four damaged

Keywords: Debris floods; Climate change; Drought; Rainstorm; Hazards; Southwest China

Acknowledgment

The authors would like to express appreciation for the support of the National Natural Science Foundation of China [Grant Number: 41941019, 91747207, and 51525901].

References

[1] Church, M. & Jakob, M. (2020), "What Is a Debris Flood?" Water Resources Research, 56, e2020WR027144.
[2] Handwerger, A.L., Huang, M.H., Fielding, E.J., et al. (2019), "A shift from drought to extreme rainfall drives a stable landslide to catastrophic failure". Scientific Reports, 9, 1569.

Predicting Landslide Dam Outburst Flood Peak Discharge

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Abstract

The downward and outward movement of earth-slope materials, including rock, soil, artificial fill, or a combination of these, is known as a "landslide" [1]. The materials move by falling, toppling, sliding, spreading, or flowing owing to various slope-destabilizing processes. A consequence of some large-scale slope failures, occasionally more disastrous than the collapse and rapid motion of the mass of rock and soil itself, is the blockage of a river resulting in upstream valley inundation and, possibly, a subsequent sudden release of a large quantity of impounded water known as an outburst flood.

A rapid method for estimating the peak discharge from a breached landslide dam is developed in this study by analyzing the maximum outflow rates from 42 outburst floods. Systematic classification of the blockages based on their material composition, sedimentological features, and travel distances is used to assess the erodibility of a dam, which controls the size (height and width) of a breach and its speed forms. Next, three categories or types of obstructions are defined. The blockage type, the dam's height, and the water volume impounded by the barrier inform a regression equation that gives the expected outburst flood peak discharge. Additionally, the prediction interval of peak discharge is calculated based on sound statistical reasoning, which provides a margin of error helpful in assessing the potential downstream flood hazards.

From the onsite investigations of more than 30 large landslide dams, Fan et al. [2] organize them into the following three categories or types – the order of which reflects the breach formation potential from most to least erodible:

- Type 1 Landslide Dams: These blockages are composed primarily of small-sized unconsolidated material usually formed by debris flows, avalanches, and slides with long runout (that is, the travel distance) and substantial entrainment along their traveling path. As a result, these dams show low stability and are eroded comparatively easily by flows overtopping the blockage.
- Type 2 Landslide Dams: These dams are composed chiefly of large boulders and blocks formed by rock avalanches or rockfalls from densely jointed rock slopes. Rock avalanche deposits could also have a dual structure with comminuted debris inside that is overlain by a blocky carapace.
- Type 3 Landslide Dams: These barriers are typically formed by deep-seated rockslides or avalanches that fail as an intact mass, followed by short runouts into narrow valleys. Because of the topographic constraints on the landslide movement, the sliding rock mass cannot disintegrate completely, which keeps the original geological structure that is highly resistant to erosion partly intact.

Type 3 blockages are more consolidated than Types 1 and 2 and are less likely to be breached for their entire height. The almost intact rock mass in the dam body can be impenetrable, although the fine sediment on the top or middle layer may erode from overtopping flows. Dams formed from Type 2 blockages are composed of boulders and blocks more resistant to erosion than Type 1 dams containing unconsolidated or highly permeable debris.

The following equation predicts the expected peak discharge well:

$$\hat{Q}_p = k_Q \times \left(\frac{V_{take}^{1/3}}{H_d}\right)^2 \times \sqrt{gH_d^5} \quad (1)$$

where Q_p (m^3/s) = the outburst flood peak discharge, V_{take} (m^3) = the impounded water volume at the time of breaching, H_d (m) = the blockage height measured from the original river bed to the lowest elevation on the crest in meters, g (m/s/s) = gravitational acceleration, and the dam type factor k_Q is

$$k_Q = \begin{cases} 0.0034, for\ type\ 1\ blockages \\ 0.0017, for\ type\ 2\ blockages \\ 0.0010, for\ type\ 3\ blockages \end{cases}$$

Measured values of Q_p are plotted against values predicted by Eq. (1). The fit is high quality, with the logarithmic errors uniformly distributed about the 1:1 line.

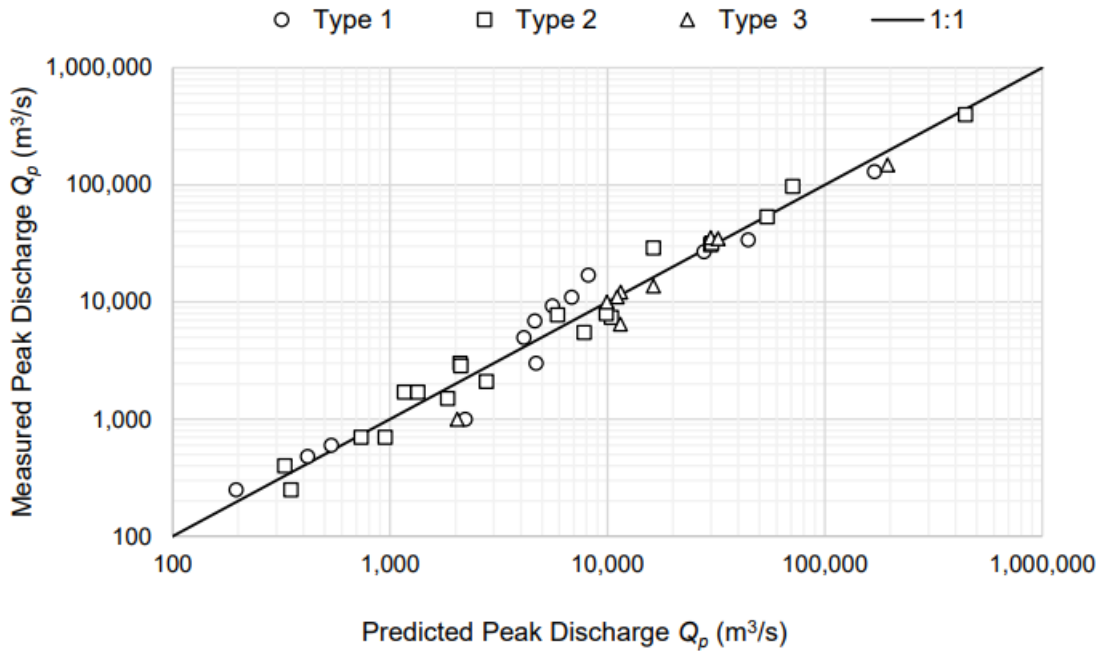

Figure 1. Measured versus predicted (expected value) outburst flood peak discharge for the three categories of landslide dams.

Keywords: Landslide, Dam, Breach, Outburst, Peak Discharge

References

[1] Cruden, D.M. & Varnes, D.J. (1996). "Landslide types and processes." In Turner, A.K. and Schuster, R.L. Landslides, Investigation, and Mitigation: Special Report. Transportation Research Board, National Research Council, vol. 247, 36-75.

[2] Fan, X. & 13 others (2021). "Recent technological and methodological advances for the investigation of landslide dams." Earth-Science Reviews, 218 (7) https://doi.org/10.1016/j.earscirev.2020.103116

Analysis on the Variation of Water and Sediment and Its Cause of Formation at Zhimenda Station at the Source of the Yangtze River in More than 60 Years

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Abstract

Under the influence of global climate change, the precipitation and temperature in the source of the Yangtze River increased, and the water and sediment fluxes responded accordingly. Due to the high topography of the source region, the lack of data, and the interweaving of hydrosphere and cryosphere, the variation law and mechanism of water and sediment fluxes are still unclear. Based on a series of observations, the temperature, precipitation and fluxes of water and sediment in the source region of the Yangtze River were systematically studied. The results show that the temperature growth rate in the source region is 0.0321℃/a. The precipitation growth rate in the source region of the Yangtze River was 1.27mm/a. The runoff rising rate is 86 million m^3/a, and the sediment discharge rising rate is 31,700 t/a. The abrupt change years of Zhimenta in the source region of the Yangtze River were 2005 and 2017. Taking 1957-2004 as the base period, the contribution rates of precipitation and temperature to the increase of runoff from 2005 to 2016 were 56.13% and 43.87%, respectively, and the contribution rates of precipitation and temperature to the increase of sediment discharge were 93.59% and 6.41%, respectively. From 2017 to 2021, the contribution rate of precipitation and air temperature to the runoff growth was 48.28% and 51.72%, and the contribution rate to the sediment transport growth was 44.49% and 55.51%, respectively. The role weight of air temperature gradually increased. The change of the flux of water and sediment in the source of the Yangtze River may also bring adverse effects on flood control, project silting prevention, bank stability and aquatic habitat, which should be given full attention.

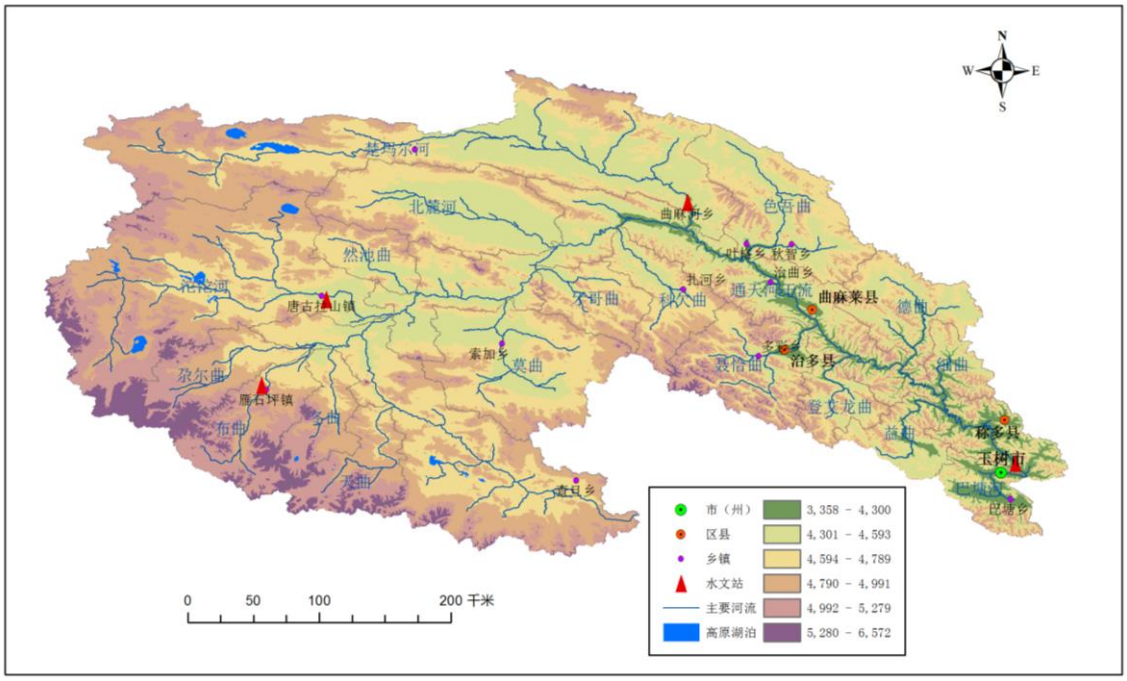

Figure.1 Water system map of the source area of the Yangtze River

Table 1. Attribution analysis table of runoff change at Zhimenda Station

Q($10^8 m^3$)	Measured	Extrapolated	Total change	Percent	P	Percent	T	Percent
1957-2004	123.02							
2005-2016	157.76	142.52	34.74	28.24%	19.50	56.13%	15.24	43.87%
2017-2021	196.16	158.33	73.14	46.36%	35.32	48.28%	37.83	51.72%

Keywords: The Tibetan Plateau; The Yangtze river source; Water and sediment flux; Climate change

Experiments of natural hazard mitigation and ecological restoration in an artificial step-pool channel

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Abstract

Step-pools are quite common in high-gradient mountain rivers, where the steps are composed of large pebbles and boulders, and the pools are filled with finer grain materials. The step-pool structure can effectively dissipate flow energy, thereby inhibiting bedload movement and maintaining channel stability. Restoration project involving artificial step-pools is attracting more and more attention by researchers and managers (Chin et al., 2021).

Most artificial step-pools are designed following the maximum resistance hypothesis (Abrahams et al., 1995) or the dimensionless geomorphic parameters, e.g., the jamming ratio. Previous research has proved that the step-pools to be relatively stable, ecologically friendly (Zimmermann et al., 2020). However, the effectiveness of step-pool systems for natural hazard mitigation and ecological restoration, still needs to be quantified.

In this study, a total of 16 artificial step-pool is embedded in an incised debris flow gully (Huang et al., 2021; 2023), and then the geomorphic features of the step-pool channel are measured and interpreted. To investigate the effectiveness on influencing the debris flow movement, numerical simulations of debris flows under pre- and post-construction conditions of the step-pools were performed. Meanwhile, benthic macroinvertebrates are sampled from the step-pool channel and five surrounding channels, so as to analyze the effects of the artificial step-pools on ecological restoration.

Results (Figure 1) show that, the jamming ratio of the step-pools is mostly less than 6.0, and the S_P values, i.e., the development degree of riverbed are over 0.1, and these values are increased significantly compared with the original values, guaranteeing the stability of the constructed steps. The stable step-pools effectively suppressed massive sediment movements, with 69.3% of the loose sediment eroded from the water erosion zone being trapped in the step-pool reach, which promoted uplift of the channel bed. Numerical simulation of debris flows reveals that the maximum kinetic energy of debris flow was reduced by about 27 % with the artificial step-pools compared to the pre-construction condition. Moreover, a total of 549 macroinvertebrate specimens were collected from the study area, belonging to 23 families, and 27 genera. As shown in Figure 2, the species richness was similar at the five sites. But the Shannon index and Simpson index were higher at the sites with step-pools, which provided stable habitats for macroinvertebrate and resulted in more diverse ecosystems. Both natural and artificial step-pools maintain eco-systems with good health, indicating the ability on ecological restoration of artificial step-pools.

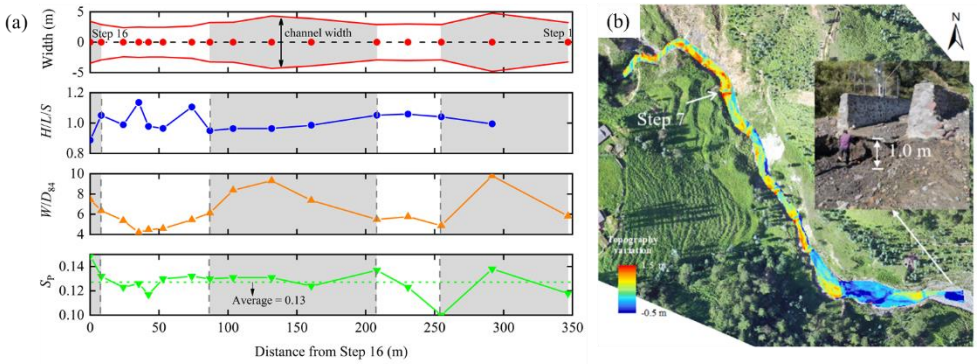


Figure 1. (a) Geomorphic features of the step-pools including channel width, *H*/*L*/*S*, Jamming ratio W/D_{84}, and S_P value; (b) Map of the topography variation of part of the transportation zone.

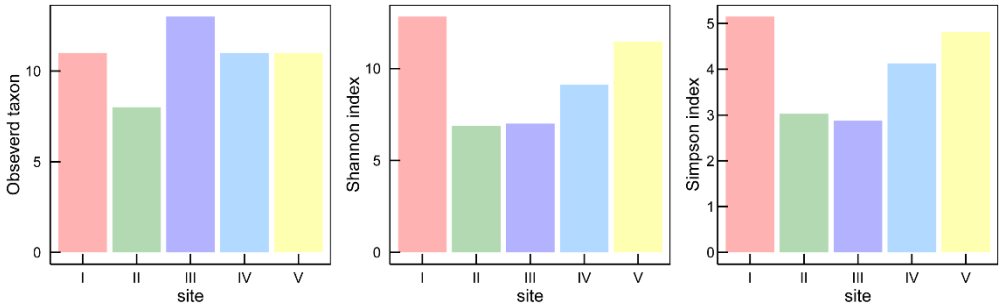


Figure 2. Alpha diversity at the five sites: (a) number of observed taxon; (b) Shannon index; (c) Simpson index. I represents the artificial step-pool channel, II and III represent the debris flow gully nearby, IV and V represent the stable channel with artificial structures and natural step-pools.

Keywords: Step-pool; Debris flow; Benthic macroinvertebrates; Channel stability

Acknowledgment

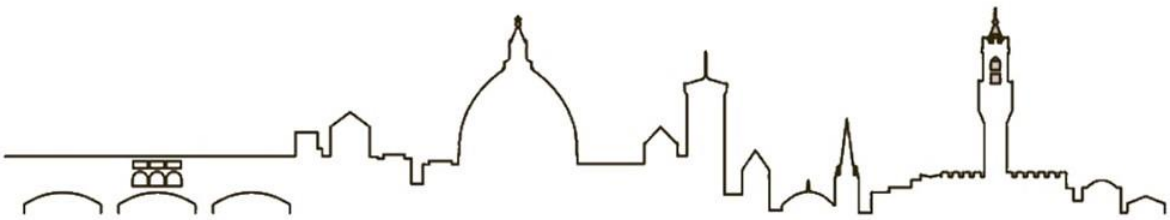
The authors would like to express appreciation for the support of the Strategic Priority Research Program of the Chinese Academy of Sciences [Grant Number: XDA23090401].

References

[1] Chin, A., O'Dowd, A. P., Mendez, P., Velasco, K., Florsheim, J. L., Laurencio, L. R., Leventhal, R. D. (2021). "Toward natural approaches in restoration: Experiments of co‐evolving physical and biological structures in a self‐organizing step‐pool channel". River Research and Applications. 37(10), 1480-1493. https://doi.org/ 10.1002/rra.3851.
[2] Abrahams, A.D., Li, G., Atkinson, J.F., 1995. Step-pool streams: adjustment to maximumflow resistance. Water Resour. Res. 31 (10), 2593–2602.
[3] Zimmermann, A.E., Saletti, M., Zhang, C., Hassan, M.A., 2020. Step-pool channel features, in: Reference Module in Earth Systems and Environmental Sciences. Elsevier. URL.
[4] Huang, K., Xu, M., Wang, Z., 2021. Experimental Study on Landslides of Loose Sediment Slope Induced by Stream Bed Incision. Front. Earth Sci. 9, 468.
[5] Huang K, Liu W, Xu M, et al. Application of artificial step-pools in natural hazard mitigation[J]. Catena, 2023, 220: 106658.

Topic 5:

Reservoir sedimentation, interactions between sediment and hydraulic structures



An integrated set of measures for sustainable sediment management at the Le Grazie artificial reservoir, Central Italy

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Abstract

The sedimentation taking place in artificial reservoirs due to watercourse damming determines the progressive loss of storage capacity, also affecting the operational safety. Mean annual loss rates around 1% have been observed worldwide and losses around 26% at global scale and 30% in Italy are estimated until 2050 [1].

The problem of reservoir sedimentation is addressed at the Le Grazie reservoir (Fig. 1), located in Marche Region (Italy) and built in the '60s on the Chienti river mainly for hydro-electricity. The reservoir is impounded by a 20 m high barrage (with a gated spillway and a bottom outlet) and an up to 9 m high embankment along its left bank. Since the construction, its water storage volume, originally 1.77·106 m^3, has drastically reduced by 82% (Fig. 1b), with an average loss rate of about 16 000 m^3/year. In 2019, 60 000 m^3 of sediment have been removed mechanically to ensure the bottom outlet operation. Since this intervention, an integrated set of measures has been planned to pursue a sustainable sediment management as follows:

1. At the San Rocco-Entogge torrent, which flows laterally into the reservoir, forming a delta, a system of three retention basins with a total volume of about 13 000 m^3 has been designed to reduce the sediment input. The mainly sandy sediments shall be excavated regularly from the retention basins during dry periods.
2. Regular flushing of sediment from the reservoir [2] is planned, by opening the bottom outlet during normal operation, and additionally with drawdown of the water level during the recession stage of flood events.
3. As an innovative approach, fine sediment venting via the power waterway of the connected hydropower plant [3] is foreseen. The Ributino hydropower plant with a head of 28 m is equipped with two Kaplan turbines (of 2.8 MW each). On the basis of the average annual turbine water volume during 2015-2020 (179.4 106 m^3), the achievable annual sediment output through the power waterway has been assessed for various percentages of volume utilization and suspended sediment concentrations (SSC) in the turbine discharge (Tab. 1). It was found that this option has the potential to considerably improve the sediment balance of the reservoir. In addition, sediment samples from the reservoir have been analyzed and monitoring of the water quality up- and downstream the reservoir and of the turbine erosion have been planned.

This combined set of well-known and innovative sediment management actions is expected to considerably improve the sediment balance of the case study reservoir and serve as a demonstrator project for the sustainable operation of further artificial reservoirs.

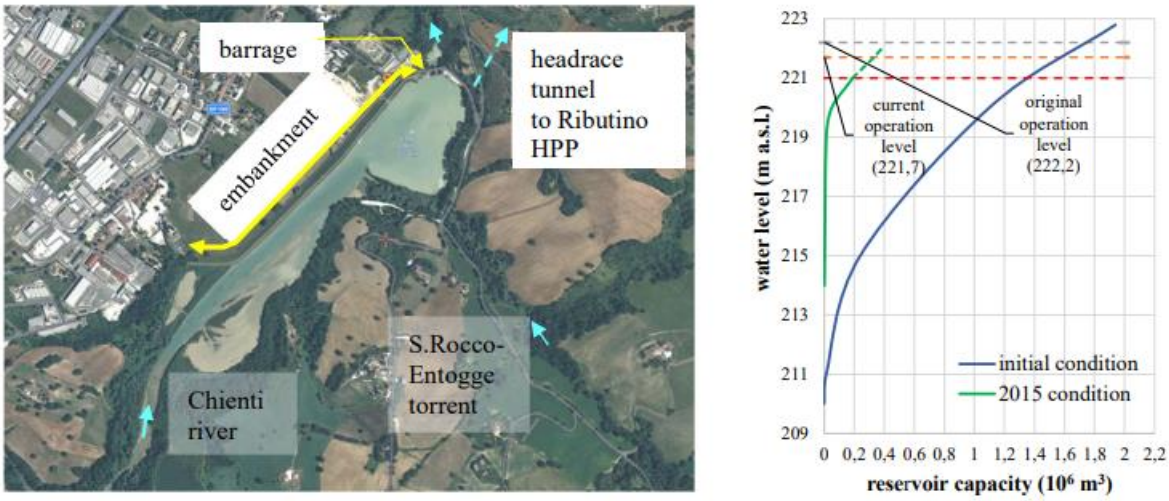

Figure 1. (a) Overview of the Le Grazie reservoir on the Chienti river in central Italy and (b) the pronounced reduction of its reservoir capacity due to sedimentation.

Table 1. Sediment reduction by conveyance via power waterway at Le Grazie reservoir for different values of suspended solid concentration, SSC, in turbined flow and percentage of turbined volumes.

Turbined water volume with sediment injection / annual total (%)	Turbined volume with sediment injection (10^6 m^3/year)	SSC (g/l)	Expected sediment output (ton/year)	Expected avoided reservoir loss (10^2 m^3/year)
33.3	59.8	1.0	59 800	443.0
33.3	59.8	0.5	29 900	221.5
50	89.7	1.0	89 700	664.4
50	89.7	0.5	44 850	332.2

Keywords: artificial reservoir; sediment management; sediment venting via turbines, flushing

Acknowledgment

The authors thank Le Grazie dam manager, “Azienda Specializzata Settore Multiservizi” spa.

References

[1] Perera, D., Williams, S., Smakhtin, V. (2023). “Present and Future Losses of Storage in Large Reservoirs Due to Sedimentation: A Country-Wise Global Assessment.” Sustainability 15(1), 219.
[2] Boes, R.M., Baumer, A., Pfeifer, S., Albayrak, I., Felix, D. (2022). “Techniques to reduce sedimentation in bed load and suspended load dominated reservoirs”. Proc. 27th Intl. Congress on Large Dams (ICOLD 2022), Marseille, France; Q. 107 - R23: 348–366.
[3] Felix, D., Albayrak, I., Boes, R.M., Abgottspon, A. (2017). “Sediment transport through the power waterway and hydro-abrasive erosion on turbines,” Proc. of Hydro Conference, Seville, Spain: paper no. 27.07.

Tool for sediment management in the Marmolejo reservoir. Calibration of the sedimentation model with Machine Learning.

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Abstract

The meadow of the Guadalquivir River in the urban area of Andújar suffers floods on a recurring basis, existing historical records of many flood episodes. The area has undergone profound transformations such as the construction of the Marmolejo dam in 1962. At the exploitation water level the sheet of water of the reservoir reaches up to the Roman bridge of the town.

In 2013, the CHG entrusted CEDEX with the "Hydraulic modelling of the Guadalquivir and Jándula Rivers in the urban area of Andújar". In the first place, a review of the available previous technical information was carried out, providing the bathymetry of the riverbed in 1962, 1997 and 2001. Besides, another bathymetry was carried out in May 2014. Then, a hydraulic model was developed with the software Iber, verifying the great sedimentation of the Marmolejo reservoir. Based on this study, a series of actions were designed, such as the heightening of some sections of the barrier on the right bank and a dredging in the area of the Roman bridge. These measurements were designed with the support of a physical model in the Cedex Installations. To guarantee the effectiveness of such measures, it was necessary to maintain the sedimentation level of the reservoir to the date of May 2014, when the sedimentation volume was less than 7.5 hm3.

Since then, a collaboration has been established between the CHG, ENDESA (owner of the dam) and CEDEX to study the best operation rules of the reservoir. Several complementary bathymetries have been carried out between the years 2018 and 2022.

An experimental numerical campaign has been addressed with the R-Iber model, an adaptation of the code of the Iber software for supercomputing on graphics cards. Considering the depth of the reservoir, the shallow water equations are applicable. The main phenomenon that determines the sedimentological evolution of the reservoir is the transport in suspension. The characteristic diameter of the sediment in suspension is 35 microns and it is of a cohesive nature, which is why the Arathurai-Arulanandan transport model has been selected. This model allows to define the critical stresses of beginning of erosion and sedimentation, as well as the erosion rate. In addition, the advection-diffusion equation is solved to determine the evolution of the suspended sediment concentration, and the Exner equation to study the bathymetric evolution of the bed.

A first experimental phase was carried out, reproducing the bathymetric evolution of the reservoir in four inter-bathymetric periods, which were selected as test cases. The first two periods include a managed flood with full gate opening, and the third is a period without flooding and without any full gate opening, maintaining continuously the exploitation water level. The fourth corresponds to a period of repairing of the power plant when the gates were kept fully open for two months and later a small flood arrived during which it was not possible to operate the gates.

The calibration has been very complex. An improvement in representativeness was achieved by modifying the Arathurai Arulanandan model by making variable the erosion rate and stablishing a linear relation with the bed stress. Besides, the analysis of test case three of net sedimentation, showed the need to consider the variation in the porosity of the sediment at the bottom of the reservoir (Miller, 1953), due to compaction. At the beginning of the sedimentation process the porosity can be 70%,

later it can be reduced due to the compaction process. Both improvements made it possible to define the most appropriate ranges of the transport parameters.

However, obtaining a detailed calibration with this methodology is unapproachable. Therefore, a machine learning technique has been used. For this, a battery of simple tests is carried out, in a steady-state regime of both liquid flow and solid flow, in two operating scenarios, depending on the disposition of the gates. With full gate opening, the outlet contour condition of spillway is used and with partial gate opening the outlet contour condition is defined to maintain the exploitation water level. As a result, comparing the volume of sediment introduced in each test and the sedimented and/or eroded, a volume variation rate is obtained. To obtain this rate, the swelling of the reservoir sediment is considered. Finally, a function defined by sections is obtained that provides the variation in sedimentation of the reservoir as a function of the circulating flow, for each gate operation scenario.

To verify the goodness of these sedimentation functions, it has been prepared a computer application programmed in FORTRAN language that reads from the file the date, the flow rate and the water level of the reservoir. The complete record of flows and daily water levels of the Marmolejo station are available since October 1, 1999. Based on a first sedimentation volume data, which may coincide with a bathymetric data, the application provides the evolution of the volume of sediment stored in the reservoir. The application also reads the reservoir bathymetric information from the file so that it can self-calibrate. Figure 1 shows the sedimentological evolution of the reservoir since October 1999. It also indicates the flow regime, the gate operation and the bathymetric records. A great representativeness can be observed.

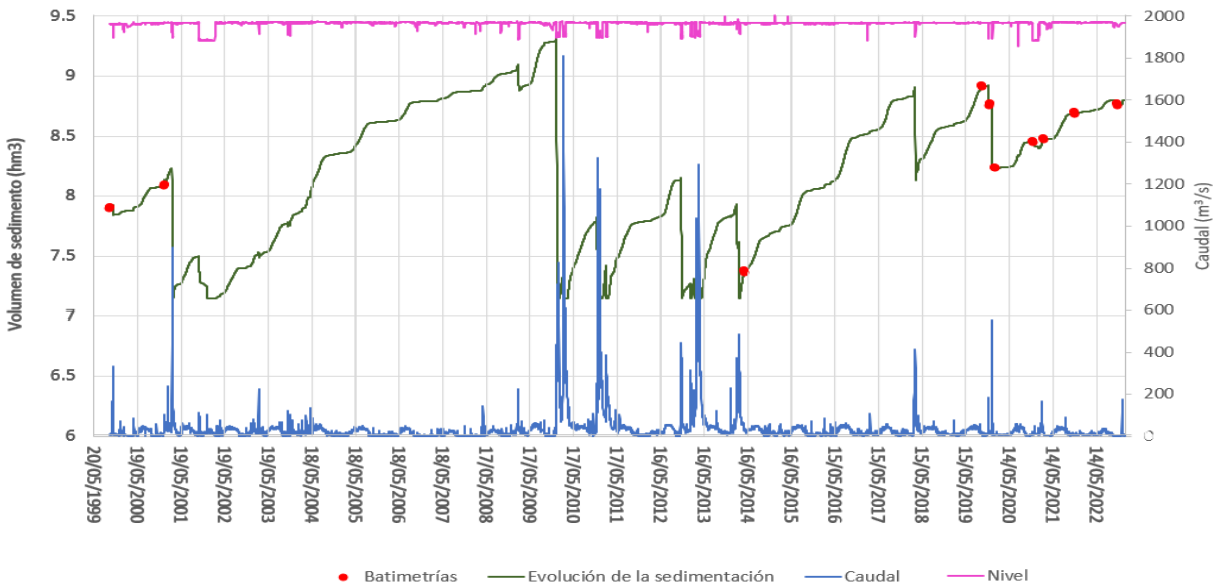

Figure 1. Evolution of the Marmolejo Dam Evolution.

As a support tool, a web application has been programmed that allows to simulate the influence of these instructions in different periods of time, reading the flow and water level from the SAIH of the CHG and calculating the sedimentation temporal evolution with the new data. In addition, it allows to simulate any given periods with different operating instructions.

Keywords: Reservoir Sedimentation, Sediment transport and Numerical simulation. Sediment management.

References

[1] Ariathurai, R. and Arulanandan, K. (1978). Erosion rate of cohesive soils. ASCE Journal of the

Hydraulics Division, 104(HY2): 279–283.

[2] Bladé, e., Cea, l., Corestein, g., Escolano, e., Puertas, j., Vázquez-Cendón, e., Dolz, j., Coll, a. (2014). Iber: herramienta de simulación numérica del flujo en ríos. Revista Internacional de Métodos Numéricos para Cálculo y Diseño en Ingeniería, Volume 30, Issue 1, 2014, Pages 1-10, ISSN 0213-1315, DOI: 10.1016/j.rimni.2012.07.004

[3] Miller, Carl R. (1953), "Determination of the Unit Weight of Sediment for Use in Sediment Volume Computations" Bureau of Reclamation, Denver, Colorado.

[4] Sanz, M., López. D, Bladé, E. Dehghan (2022) A CUDA Fortran GPU-parallelised hydrodynamic tool for high-resolution and long-term eco-hydraulic modelling. Environmental Modelling & Software. Volume 161, March 2023, 105628.

[5] López. D. et al. 2019. Problemas de sedimentación en embalse de Marmolejo. El reto de una explotación sostenible. JIA 2019 – VI Jornadas de Ingeniería del Agua. 22-25 octubre. Toledo. España.Camenen, B. (2007). “Simple and General Formula for the Settling Velocity of Particles”. J. Hydraulic Engineering, 133(2), 229–233.

Suppression of Scour around Circular Cylinder by Jet Flow

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Abstract

The problem of local scour around bridge piers has been the subject of extensive experimental and computational study due to its relevance to bridge safety. In contrast, relatively little has been done with regards to advancing practical methods for slowing down the process of erosion or for preventing it from occurring in the first place. In this paper, we present the results of a computational and experimental study of such a method that does not seem to have been studied before, and that offers a practical and cost-effective way to mitigate excessive pier scour.

Briefly, the method entails the placement of a tube much smaller in diameter relative to the pier diameter along the stagnation line through which water is introduced in the form of discrete jets into the incident flow. The experimental parameters are listed in Table 1. The experiments, involving moving bed scour, were carried out in water the flume shown in Fig. 1. The jet flow is supplied by water pump that can yield jet velocities in the range 1 - 8 m/s. The scour holes were measured by 3D scanner for full view (as shown in Fig. 2 (a, b)), and by laser displacement techniques at selected points.

Table 1. Experimental parameters.

Flume width	Water depth	d50	Current velocity	Diameter of cylinder
160 cm	15 cm	1.19 mm	0.345 m/s	10 cm
Jet flow velocity	Diameter of jet holes	Interval of jet holes	Lowest hole to bed	Amount of jet holes
1 – 8 m/s	4 mm	10 mm	5 cm	3

Tests were performed to determine the optimal height above the sand bed of the jet closest to it. This was found to be at distance of 5 cm which was adopted for the remaining tests. Thereafter, tests were performed to investigate the effects of the jets' velocity on the size of the scour hole. This turns out to be an important parameter in determining the reduction in the size of the scour hole relative to the baseline case of no jets. As shown in Fig.2 (c), when the velocity of jet flow increases, the depth of the front part of scour decreases, especially at the higher values of the jets' velocity. Indeed, at the highest velocity of 8 m/s, the deepest point of scour hole was found to decrease from 89.8 mm to 40.8 mm. Furthermore, the scour hole behind the cylinder disappears and even slightly rises above the initial elevation. On the other hand, the high jets' velocities appear to have adverse effect on the size of the scour holes on either side of the pier as shown by the bold line in Fig. 2 (c). The observation that the depth of the scour hole around cylinder for the baseline case without jets is significantly reduced by the introduction of the jets suggests that the method proposed in this study is potentially used in the restore work of existing scour problems.

Figure 1. Experimental setting of scour with jet flow: left: water flume arrangement; right: picture of jet flow before merged into rising incoming flow

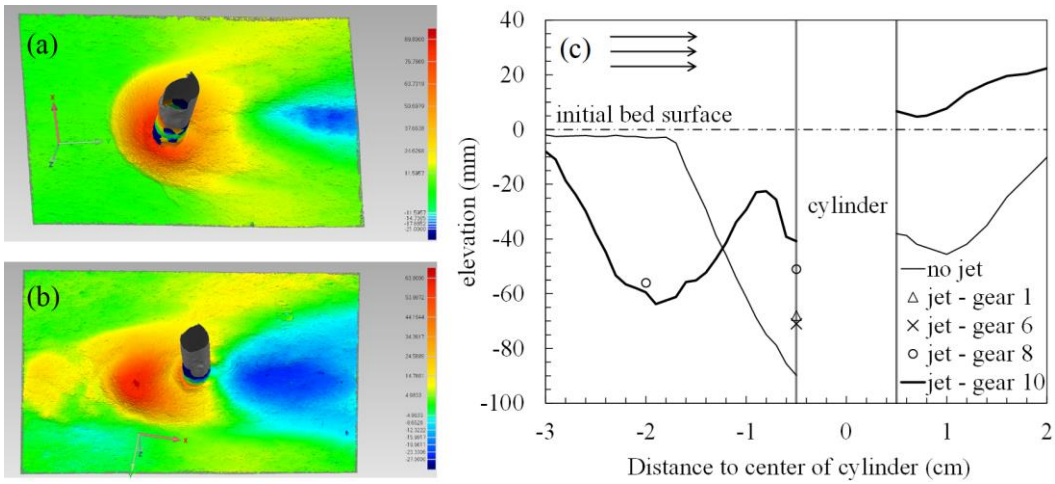

Figure 2. Measured results of elevation around scour hole: (a) (b) contour of circular cylinder without and with jet flow (gear 10) by 3D scanning; (c) elevation along central line

Computations were performed using the OpenFOAM simulations software both in order to guide the experimental program and, also, to understand the physical processes involved. The effects of turbulence were accounted for by performing well-resolved Large Eddy Simulations. While the results are still being analyzed at the time of writing, they suggest that the effect of the jets is in significantly reducing the strength of the downward flow along the cylinder stagnation line.

Keywords: Scour; cylinder; jet flow; CFD

Acknowledgments

The financial support provided by the Natural Science Basic Research Program of Shaanxi Province (2023-JC-YB-292) and the Fundamental Research Funds for the Central Universities, CHD (300102212909). Postgraduate students Xiaoyan Kuang, Wanghui Dang and Chaoqun Feng are gratefully acknowledged for their help during the laboratory experiments.

Experimental Study on Bed Erosion by Clear Water Downstream of the Dam

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Abstract

The nature of flow, sediment transport and bed erosion were studied in a laboratory flume using mixed-size sediment under clear water conditions. During each experiment, water depth, bed and water surface elevation, bedload transport and bed state were continuously monitored. Steady inflows were established with an unit discharge of about 0.01 m^2/s to 0.03 m^2/s^{-1}. Well sorted gravel and sand were employed to compose four kinds of sediment beds with different gravel/sand contents, i.e., uniform 100% gravel bed, uniform 100% sand bed, and two graded sediment beds respectively with 53% gravel and 47% sand as well as 22% gravel and 78% sand. For different sediment beds, the experiments were conducted under the same discharges, thereby allowing for the role of sediment composition in dictating the bed erosion to be identified. The measured bed elevation for all the twenty runs show that significant degradation is spotted, yet the scour is mainly confined to the upstream part. For a specific sediment sample, the degradation enhanced with the increase of the inlet flow discharge. Under a specific unit-width flow discharge, the degradation for the four sediment samples generally follows the rule that the scour process increases with the increase of sand content in the sediment bed. However, it also exhibits an interesting phenomenon that the maximum scour depth with pure sand is not the largest, instead the case with 78% sand content features the deepest scour. In line with this observation, the scour with pure sand extended considerably farther downstream along the channel than other beds. In fact, bed forms like small dunes were present in cases with pure sand, which were not discerned in other sediment beds. This has important implications for the evaluation of the scour hole evolution, echoing that the sediment bed composition has significant and complicated effects on the scour dimensions below sills, as identified in previous studies.

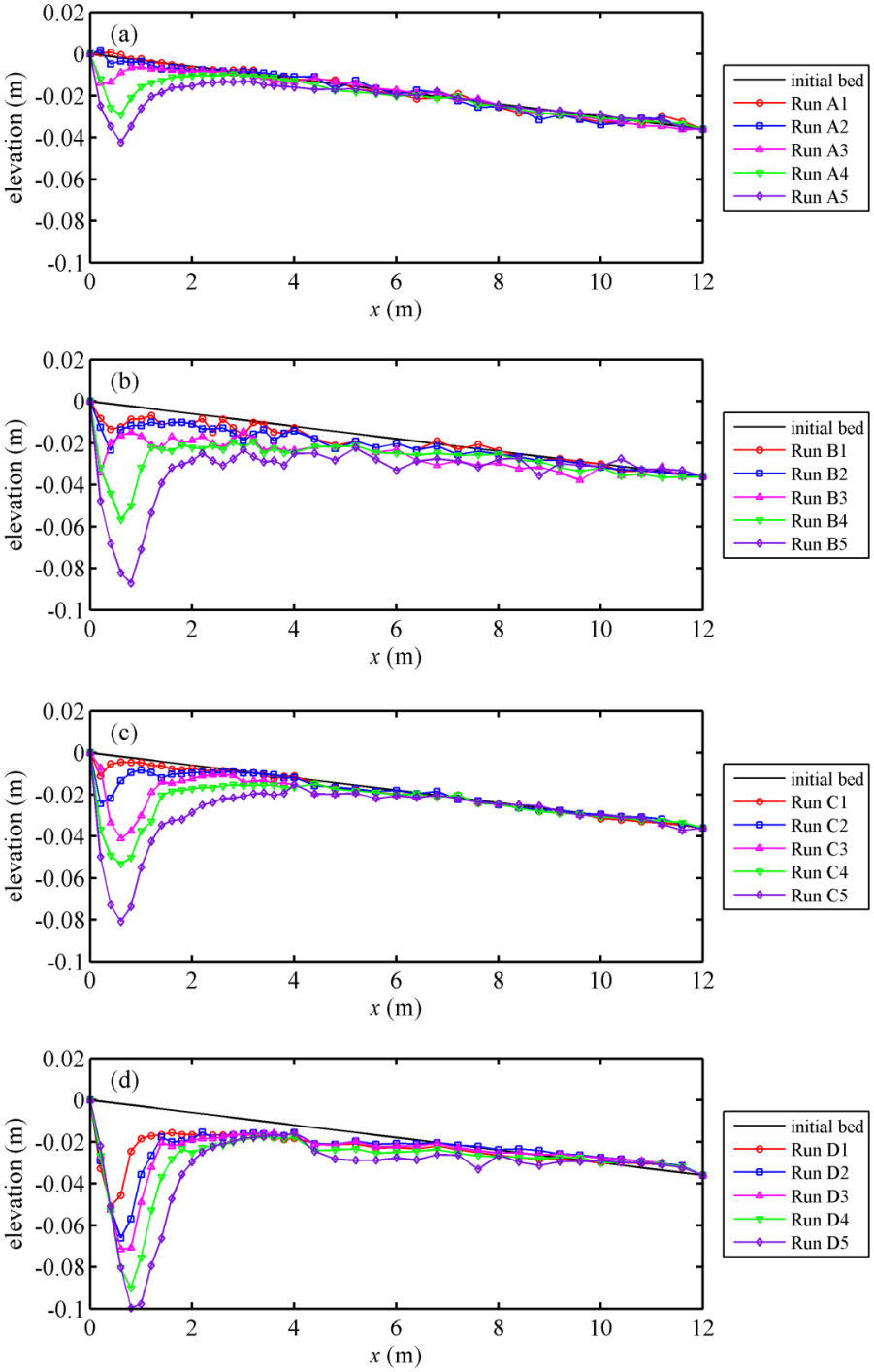

Figure.1 Cross section averaged final bed elevation in relation to different inflow discharges for (a) uniform 100% gravel bed, (b) uniform 100% sand bed, (c) 53% gravel and 47% sand bed, and (d) 22% gravel and 78% sand bed.

Keywords: Sediment transport; Clear Water; Bed erosion; Dams

Modeling the effect of land cover change on sediment accumulation in small agricultural reservoirs in Tuscany region

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Abstract

Among the problems that hilly agriculture must face, water management has always been of primary importance. In hilly regions, the water regime is an important constraint on entrepreneurial choices as it reduces the crops' applicability and technical alternatives [1]. The use of small reservoirs for irrigation purposes and for the mitigation of drought effects in agriculture is historically widespread within the Italian territory. However, the presence of an artificial barrier, necessary for water resource storage in the reservoir, modifies the natural equilibrium of water streams, creating an area characterized by low water speeds and, consequently, by a high capacity of sedimentation of the solid material transported by the streamflow, resulting in an increasingly careful phenomenon which is the sediment accumulation in the reservoirs.

Sediment accumulation is one of the most critical problems in reservoir management and affects the functionality and lifetime of the storage: over time, in fact, the reservoirs may lose partially or totally their storage capacity, due to soil erosion within the watershed. In non-anthropized contexts, the rate of sediment removal is sufficiently slow, so the processes of soil formation, by rock disintegration and alteration, compensate for the losses, and the thickness of the soil remains almost unchanged [2]. With some types of crops, the erosive processes can be particularly accelerated, causing, in addition to the loss of fertility of the soil itself, a faster sediment accumulation in the reservoirs that are downstream and a significant reduction of their useful capacity in a short time. One of these is certainly the vineyard, which, due to its surface morphology and the mechanical operations of soil leveling necessary for crop implementation, is responsible for the high production of sediments within the watershed of which it is part [3].

The present work aims at estimating the effects of the application of this crop on sediment accumulation in hilly reservoirs, with the use of HEC-HMS. We have estimated the production of sediments at a basin scale and the consequent accumulation of sediments in a reservoir that is located within the Suvignano farm, which is currently free of significant sediment accumulation issues. The Suvignano estate is in the hilly area of Crete Senesi, is about 15 km from Siena, and is property of Ente Terre Regionali Toscane, after the seizure of this property confiscated from organized crime on 16/11/2018. In this area of Tuscany, wine production is particularly developed, but not within the farm of Suvignano, where the cultivation of cereals, renewal crops, and forage is practiced and there is a large grazing area.

The analysis aimed at estimating how much the rate of sediment accumulation in the reservoir would vary with the replacement of currently arable land with vineyards. We evaluated 3 scenarios: in the first scenario, we estimated the amount of sediment accumulated in the reservoir with crops currently practiced within the basin, without variations of land cover; in the second scenario we estimated the sedimentation with the replacement of currently arable land with vineyard within the perimeter of the estate of Suvignano; in the third, we evaluated the change in sedimentation with the replacement of arable land with vineyards in the entire catchment area upstream of the reservoir.

The results, represented in Figure 1, show that this change would lead to a high increase in annual sediment accumulation in the reservoir, which should be considered at least at the agronomic design stage, as well as in the estimation phase of the costs of water supply, which must include the cost of the reservoir volume restoring, lost by sediment accumulation.

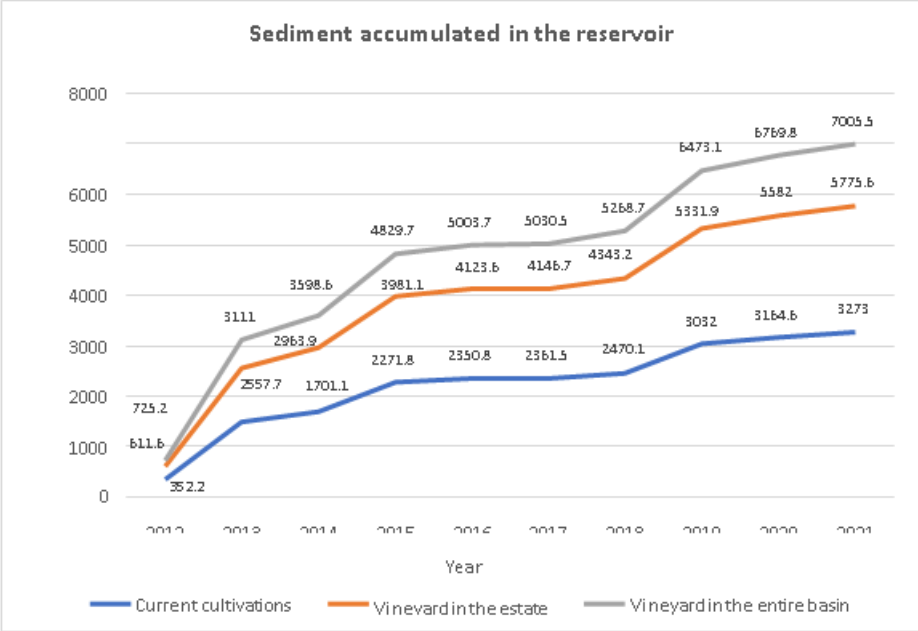

Figure 1. Comparison of the tons of sediment accumulated in the reservoir in the various soil cover scenarios analysed

Keywords: Reservoirs, Sedimentation, Erosion, Vineyards, HEC-HMS, Watershed

References

[1] Corinto, G. L. (1990). Gli invasi collinari ed i loro usi plurimi. Gli invasi collinari ed i loro usi plurimi, 1000-1009.
[2] Julien, P. Y. (2010). Erosion and sedimentation. Cambridge university press.
[3] Borselli, L., Pellegrini, S., Torri, D., & Bazzoffi, P. (2002). Tillage erosion and land levelling: evidences in Tuscany (Italy). Man and soil at the third millenium. Rubio JL; Morgan RPC; Asins S.

Regime Change of Sediment Suspension in the sub-saturated Jingjiang reach of the Yangtze River, China

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Abstract

The impoundment of cascade mega-reservoirs in the upper Yangtze River has exerted dramatic and accumulative impacts on its lower reaches—not only the decline in sediment load but also the change of suspension regimes (Fig. 1). Based on a 1990–2021 dataset, we examined fundamental flow-sediment relationships in the Jingjiang reach, approximately 100 km below the Three Gorges Dam (TGD). We find, after TGD impoundment in 2003, the threshold distinguishing wash-load and bed-material-load increased from ~0.063 mm to >0.125 mm. The wash-load concentrations in the reach in the post-TGD period illustrate strong relationships with the flow capacity index, they, however, were determined by upstream impoundment. In addition, the flow capacity coefficients, i.e., m and k, in the "starving" reach became significantly lower than their equilibrium counterparts (Guo et al., 2023). To characterize the non-Fickian dynamics of suspended sediment (Chen et al., 2013) and the non-equilibrium regime (Ma et al., 2022) in the reach, we propose a novel formula for the concentration profile of sub-saturated sediment based on Hausdorff fractal derivative advection-dispersion equation (HADE) (Liu et al., 2023). The HADE performs better than Han's (Ma et al., 2022) and Rouse's formulae in describing the sediment concentration profiles in the Jingjiang reach (Fig. 2). The study aims to facilitate effective management of the heavily-dammed river and the experience could be drawn on for other large rivers in the world that are facing hydropower development.

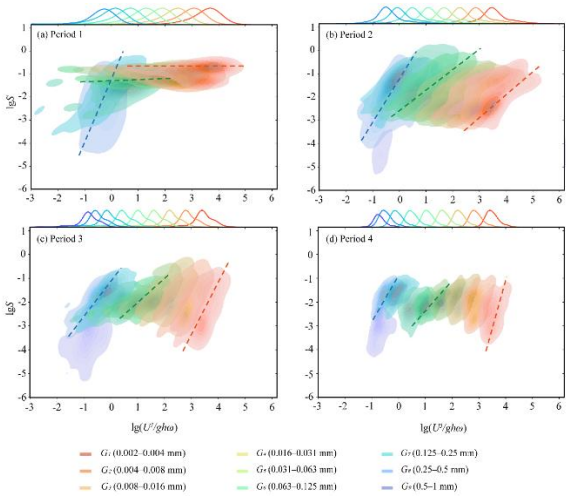

Figure.1 Intensity scatter plots of fractional concentration (S_k) and suspension index ($U^3/gh\omega$) at the JL gauge during the four periods (i.e., before 2003, 2003-2008, 2009-2012, after 2013).

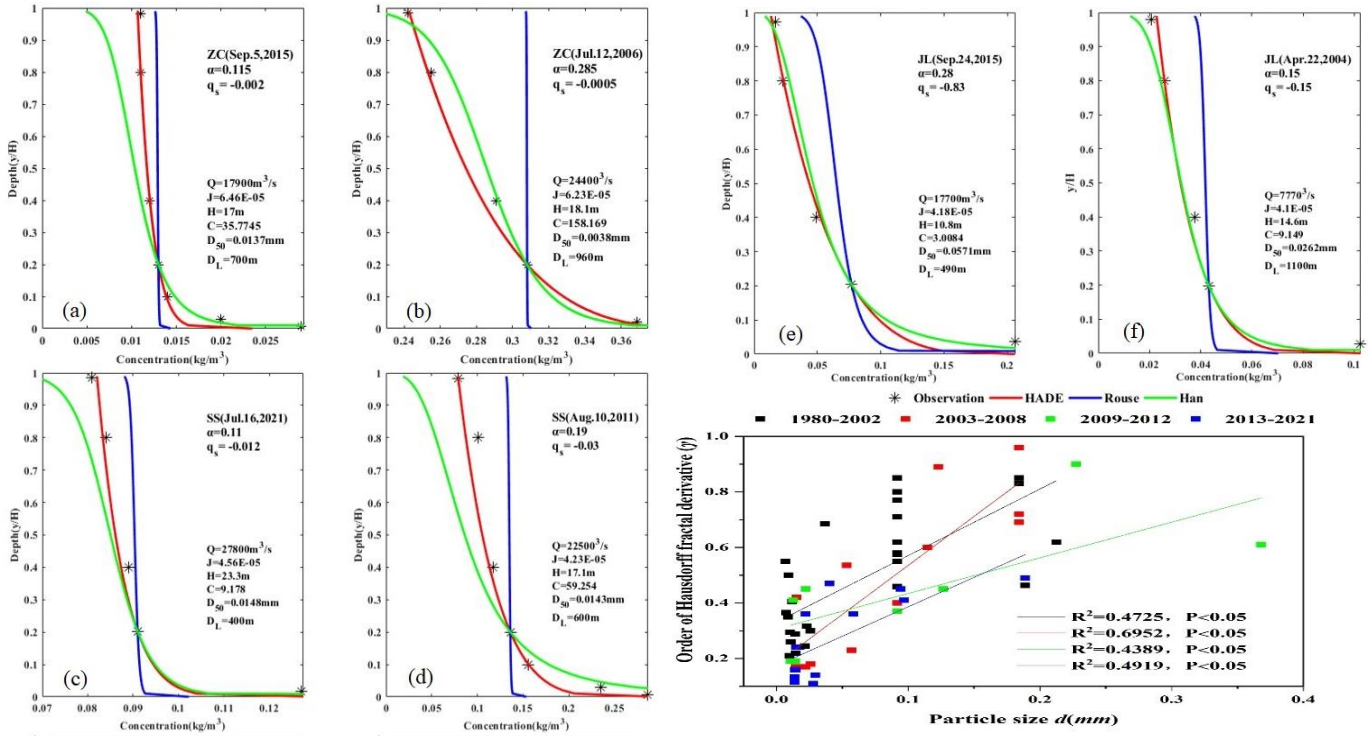

Figure.2 Compare three formulae in describing the vertical distribution of sediment suspension; relationship between the order of the Hausdorff fractal derivative γ and the particle size d. The Von Karman constant κ=0.4, and the reference height a=0.2 h.

Keywords: sediment suspension; Jingjiang reach; regime change; non-equilibrium; sub-saturated; Three Gorges Dam

Acknowledgment

This study was supported by the National Key Research and Development Program of China (2022YFC3203903), the National Natural Science Foundation of China (No. 52279077).

References

[1] Chen, D., Sun, H.G., & Zhang, Y. (2013). "Fractional dispersion equation for sediment suspension." Journal of Hydrology 491, 13-22.
[2] Ma, Z., Guo, Q., Guan, J., and Le, M. (2022). "Non-equilibrium concentration profile formulas of suspended sediment and their preliminary applications." International Journal of Sediment Research 37(4), 505-513.
[3] Guo, A., Chen, D., He, L., Peng, Y., & Duan, G. (2023). "Reshuffling of the sediment suspension regime in the starving middle Yangtze River downstream from cascade maga-reservoirs." Journal of Hydrology (under review).
[4] Liu, M., Chen, D., Sun, H., & Zhang, F. (2023). "Vertical distribution of suspended sediment concentration in the unsaturated Jingjiang reach, Yangtze River, China." Fractal and Fractional (under review).

Water and sediment simulation of shoal-trough evolution and regulation line optimization in Maozhou Estuary of Lingding Bay

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Abstract

Maozhou River, the largest river in Shenzhen, China, is the boundary between Shenzhen and Dongguan. Under the influence of a large range of tidal flat reclamation, the movement characteristics of water and sediment and the evolution of scour and silt have changed greatly in the estuary area, and the estuarine shoreline needs to extend outwards, which greatly changes the hydrodynamic environment of the estuary, affects saltwater intrusion, changes the original aquatic habitat, and forces the tidal current to decrease significantly. In order to adapt to the development conditions of Maozhou Estuary, Lingding Bay, and ensure smooth flood discharge as the primary principle, and to comply with the law of water and sediment movement and river regime development, the regulation line of estuary is selected and optimized. The regulation line scheme is divided into single and double channels. There are two schemes of enclosure filling and enclosure filling and excavation under different broadening rates of the two types of channels. Mathematical simulation and physical model experiment of hydrodynamic sediment are carried out. The results show that the effects of various schemes of estuary regulation line on the rising and falling currents of Lingding Bay are mainly concentrated in Jiaoyi Bay and its adjacent waters, and that after the implementation of the scheme, the erosion and deposition in the surrounding waters have little change and have no adverse impact on the river regime. With the increase of the widening rate, the influence of scheme on the flood discharge in the estuary decreases gradually. According to comprehensive analysis of the impact on hydrodynamics, estuary flood discharge and river regime stability, compared with single-channel and double-channel, the impact on flood level, tidal volume, high and low tide level, flow velocity and riverbed erosion and deposition has good consistency. Under the same broadening rate, the impact of each scheme is of the same magnitude. In addition, the layout scheme of the Maozhou estuary regulation line proposed in this study has no adverse effect on the dynamic conditions of the flow field in the area near the Hong Kong-Zhuhai-Macao Bridge, and to a certain extent, it plays a guarantee role for the successful implementation of the bridge project. In view of the complexity of the hydrodynamic sediment movement in estuarine, there are some limitations in the determination of the regulation line control scheme in this paper. It is suggested to further strengthen the monitoring of human activities such as beach utilization and sand mining in this area, and timely promote the implementation of estuarine system control project.

Keywords: shoal and trough evolution; flood-carrying and tide-receiving; regulation line; water and sediment simulation; single and double channels; Lingding Bay.

Impacts of Changes in Runoff and Sediment Loads of the Yellow River on its Lower Reaches and Countermeasures Proposed

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Abstract

The Yellow River, with the largest amount of sediment load and the complex runoff-sediment relationship, is one of the most difficult rivers to manage in the world. The sediment concentrations of the middle Yellow River have been decreased thanks to the measures of soil and water conservation and ecological construction in the river basin. Together in the effects of joint multi-reservoir operation in the upper and middle reaches, especially the Xiaolangdi Reservoir put into operation in 1999, the annual sediment load of the river has been reduced from 1.6 billion tons to about 250 million tons in the recent decade (Liu et al., 2021). Shown in Figure 1 and Table 1 the annual runoffs of Gaocun and Lijin Gauging Stations on the Lower Yellow River (LYR) present decline trends during 1951 and 1999, while the values has been kept low but quite stable during 2000 and 2019. The sediment loads of these 2 stations show significant decline trends during 1951 and 2019.

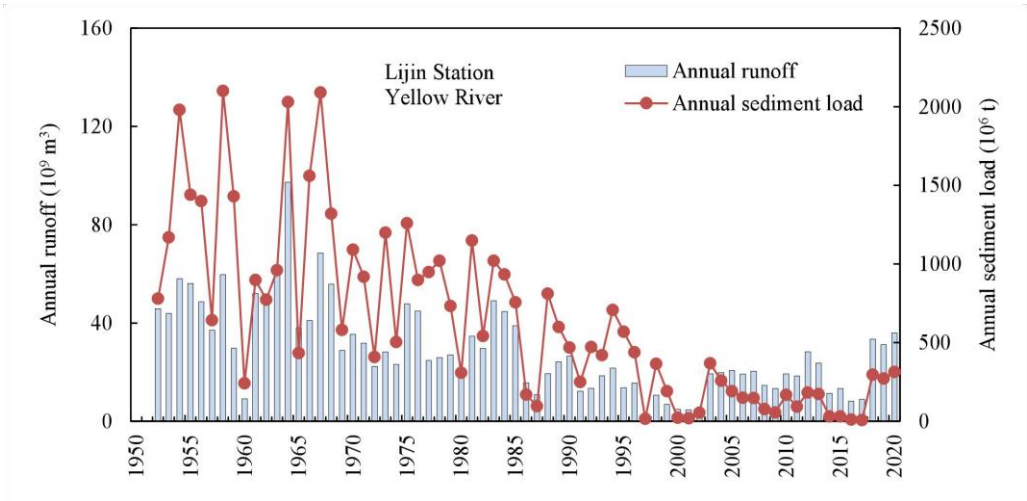

Figure 1. Changes in annual runoff and sediment loads at Lijin Gauging Station

The changes in runoff and sediment loads and the regular operation of water-sediment regulation since 2002 present a significant impact on the LYR. The river flow discharge capacity of the LYR increases from 1800 to 4300 m^3/s due to the main river channel was scoured deep. The coastline of the Yellow River Delta has been changed from silting-up to retreat caused by the declining runoff and sediment loads discharged into the sea (Wang and Liu, 2019; Hou et al., 2021; Fu et al., 2023). For a better implementation of the major national strategy for ecological protection and high-quality development of the Yellow River basin, the impacts of the changes in runoff and sediment loads and the operation of water-sediment regulation on the LYR are analyzed, and strategies and measures for the protection and management of the LYR are proposed in this paper.

Table 1. Changes in annual runoff and sediment loads at Gaocun and Lijin Gauging Stations.

Period	Gaocun Station		Lijin Station	
	Annual Runoff (billion m^3)	Annual sediment load (million tons)	Annual Runoff (billion m^3)	Annual sediment load (million tons)
1951-1973	46.00	1230	45.56	1150
1974-1986	39.52	890	32.71	788
1987-1999	23.77	525	15.01	416
2000-2019	24.39	140	16.86	130

Following further in-depth studies are suggested based on the analysis: 1) the impacts and countermeasures of the long term flow with relatively low sediment concentration of the Yellow River on the LYR, in which the main river channel form of the LYR which suits current flow and sediment conditions will be proposed; 2) the integrated management of the Dongping Lake that to increase its flood storage and detention capacity; 3) the impacts of changes of runoff and sediment loads of the river on the Yellow River Delta evolution that to explore the possibility of discharging river flow through Qingshui Channel and Diaokou Channel combined; and 4) the construction of the Taohuayu Reservoir that to further reduce the peak flood, decrease the probability of flooding, and reduce the utilization rate of Dongping Lake's flood storage area

Keywords: Runoff and sediment loads; Soil and water conservation; Dongping Lake; Yellow River

Acknowledgment

Qun Li and Xiaolin Sun are gratefully acknowledged for their help during the research.

References

[1] Fu, J., Lu, J., Wu, M.X., Ma, L.M., An, C.H. (2023). “Medium-sized channel shaping in the lower Yellow River due to water–sediment regulation.” Water Supply, 23(1).
[2] Hou, C.Y., Yi, Y.J., Song, J., Zhou, Y.(2021). “Effect of water-sediment regulation operation on sediment grain size and nutrient content in the lower Yellow River.” Journal of Cleaner Production, 279. https://doi.org/10.1016/j.jclepro.2020.123533.
[3] Liu, C., He, Y., Li, Z.W., Chen, J., & Li, Z.J. (2021). “Key drivers of changes in the sediment loads of Chinese rivers discharging to the oceans.” International Journal of Sediment Research, 36(6), 747-755.
[4] Wang, Z.Y., Liu, C. (2019). “Two-thousand years of debates and practices of Yellow River training strategies.” International Journal of Sediment Research. 34(1), 73–83.

Excavation problems in mechanical drainage reclamation of the Pisan plain

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Abstract

The Consorzio di Bonifica 4 Basso Valdarno, within the scope of its institutional competences, has for years now been approaching the problems deriving from the activities of maintaining the efficiency of the reclamation channels present in the Pisan plain.

The canals covered by this contribution, consisting of artificial canals, dug decades ago for the reclamation of areas having an average position lower than sea level and forming part of a system of canals served by mechanical drainage reclamation necessary for the removal of water, require continuous excavation activities to guarantee sufficient tie rods for the functioning of the water pumping plants.

The excavation activities of these channels are preceded, as per current Italian legislation (D.Lgs. 152/2006 and subsequent amendments), by the chemical-physical characterization of the material present within the outflow sections. In the case of the Pisan plain, it has often been found that, in addition to the presence of high concentrations of hydrocarbons, generally found in all watercourses, the values of various metals are higher than the contamination thresholds; in particular, a significant percentage of cobalt, nickel and zinc is often found.

By way of example, some values recorded during various analysis campaigns are reported:

Table 1. Recorded values (measured value/threshold value Tab.A of Table 1 of Annex V to part IV of Legislative Decree 152/2006 and subsequent amendments)

Sample collection point	Cobalt (mg/kg)	Nickel (mg/kg)	Zinc (mg/kg)
Colatore A (Coltano)	28.1/20.0	210.0/120.0	163.0/150.0
Collettore Secondario dei Paduli Settentrionali (Coltano)	24.6/20.0	106.0/120.0	120.0/150.0
Testalfosso (Coltano)	27.2/20.0	132.0/120.0	145.0/150.0
Colatore C (Coltano)	30.7/20.0	128.0/120.0	145.0/150.0
Soil sample n.1 (Coltano)	41.0/20.0	119.0/120.0	188.0/150.0
Soil sample n.2 (Coltano)	21.4/20.0	93.0/120.0	99.0/150.0

The table also shows the values of the samples taken in a neighboring land, from which it can be deduced that the concentrations of these metals are widespread and typical of the whole plain.

Solutions have been studied, and are still being studied, which allow for sustainable management of the resulting material deriving from excavation activities.

In 2015 an experimental intervention was carried out which consisted in the removal of sediments in the loading tank of a drainage system. The excavated material was treated with dewatering technology, i.e. dehydrated inside special draining big bags and with the addition of flocculant substances; with a subsequent batch, the resulting material was managed and the equipment used for dewatering (big bags, waterproofing, ...) was disposed of.

This intervention was very expansive.

Figure.1 Dewatering technology for the management of the excavated material

The possible alternatives provided by current regulations were then evaluated (D.Lgs. 152/2006 and subsequent amendments, D.P.R. 120/2017 and subsequent amendments) and in particular, the management of the material as a by-product, the handling of sediments moved within waters surface or in the field of hydraulic appliances, or as an extrema ratio, the removal, for its use for environmental recovery purposes for the filling, for example of former quarries, or for its management as real waste. To date, even these attempts have extremely high costs.

The possibility of defining the background values in the Pisan plain was investigated, correlating the exceeding of the thresholds with the geomorphological nature of the basin.
This study is still ongoing but also in this case there are regulatory, timing and operational problems.

In conclusion, we hope for a decisive and targeted regulatory intervention that will simplify the procedures where the planned interventions have the purpose of maintaining the efficiency of the channels and the safety of people and things, otherwise the high costs and lengthy procedures will not allow us to give adequate answers to a territory in constant evolution and increasingly subjected to anthropic stress.

Keywords: Excavation, reclamation, contamination, pollutants, waste

Acknowledgment

The author thanks ANBI for their continued efforts to find a solution.

References

[1] D.L.gs.152/2006 “Codice dell’Ambiente”
[2] D.P.R. 120/2017 “Regolamento recante la disciplina semplificata della gestione delle terre e rocce da scavo, ai sensi dell'articolo 8 del decreto-legge 12 settembre 2014, n. 133, convertito, con modificazioni, dalla legge 11 novembre 2014, n. 164”

Research on Riverbed Sediment Grain Size Change of the Lower Yellow River after the Operation of Xiaolangdi Reservoir

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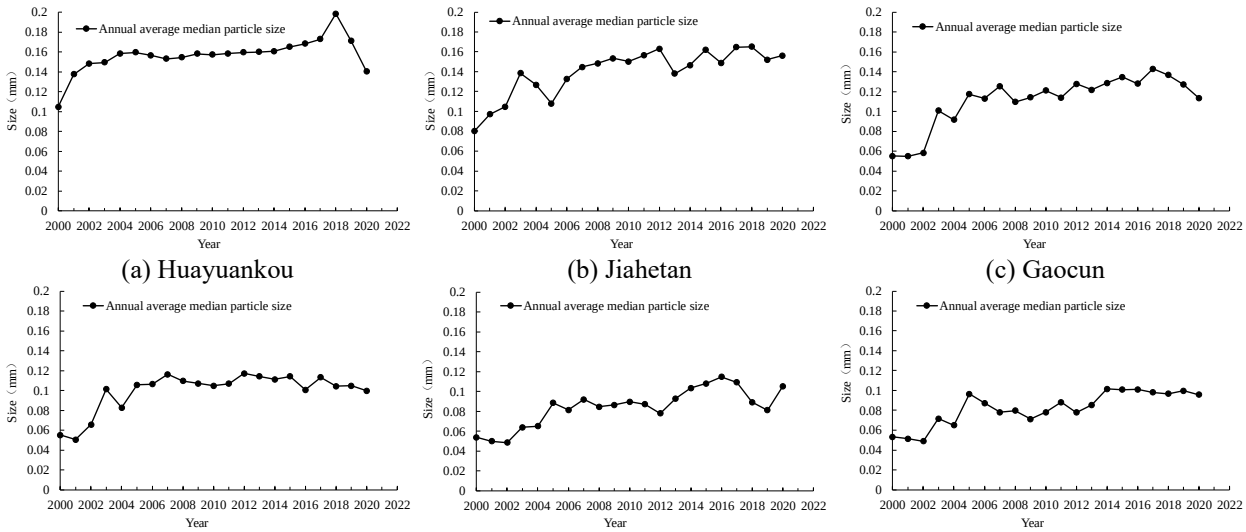
Abstract

The riverbed sediment change of downstream channel is a hot problem since construction of the large dams and reservoirs in the world(Ma, 2012; Gierszewski, 2020; Zhou, 2020). The Yellow River is the second longest river in China. Xiaolangdi reservoir, located at the mouth of the final gorge in the middle reach of the Yellow River is a key controlling project of releasing water and sediment to the Lower Yellow River. The Xiaolangdi dam was finished and began storing water in October 1999. And it was used to implement a water-sediment regulation scheme annually since 2002 to alleviate the rising riverbeds of the Lower Yellow River. Most previous studies related to riverbed response to large reservoirs have focused mainly on average annual sediment load, sediment transport efficiency, channel cross-section change and morphological response (Chen, 2009,2012; Ma, 2011; Xue,2020; Kong et al.,2020, 2022). Few studies have examined the riverbed sediment grain size response of the operation of Xiaolangdi reservoir and water-sediment regulation scheme because it is difficult to obtain long-term data of riverbed sediment grain size. In this research, long-term multi-temporal riverbed sediment grain size of the Lower Yellow River has been analyzed. The analysis of bed sand grain-size space distribution is also implemented.



(a) Huayuankou (b) Jiahetan (c) Gaocun

(a) Sunkou (b) Luokou (c) Lijin

Figure 1 Riverbed Sediment Grain Size Change of the Lower Yellow River from 2000 to 2020

The results present that the riverbed became coarser gradually. The riverbed is coarser on the whole river according to six hydrology stations observation results. The riverbed sediment grain size during water-sediment regulation scheme period is larger than that of the flood season in the reach above Sunkou Hydology Station, while the result reverse in the reach below it. The coarsening process show that its rate is fast first, then slow and keep stable for a long time. The coarsening degree is close double. After several years, a coarsening layer may formed on riverbed of downstream channel. The

coarsening can cause riverbed resistance increasing, and then scouring efficiency reducing. This study is helpful for the calculation of the resistance changes of downstream channel in sandy river since reservoir construction and research on effect of aquatic habitats.

Keywords: Riverbed; Sediment Grain Size; Lower Yellow River; Xiaolangdi Reservoir

Acknowledgment

This work was partially funded and supported by the National Natural Science Foundation of China (Grant No. 42041006, U2243222, U2243219) and the Natural Science Foundation of Henan Province(212300410372, 222300420013), the Excellent Young Talents Project of Yellow River Conservancy Commission (HQK-202313).

References

[1] Chen, J.G., Zhou, W.H., Sun, P. (2009). "Effects of water-sediment regulation by Xiaolangdi Reservoir on channel erosion in the Lower Yellow River." Journal of Sediment Research 3, 1–7.
[2] Chen, J.G., Zhou, W.H., Chen, Q. (2012). "Channel re-establishment of the Lower Yellow River in ten years operation of Xiaolangdi Reservoir." Journal of Hydraulic Engineering 2, 127–135.
[3] Gierszewski, P. J, Habel, M., Szmańda, J., et al. (2020). "Evaluating effects of dam operation on flow regimes and riverbed adaptation to those changes." The Science of the total environment 710, 136202.
[4] Kong, D.X., Latrubesse, E. M., Miao, C. Y. et al. (2020). "Morphological response of the Lower Yellow River to the operation of Xiaolangdi Dam, China." Geomorphology 350, 106931.
[5] Ma, Y.X., Huang, H.Q., Nanson, G.C., Li, Y., Yao, W.Y. (2012). "Channel adjustments in response to the operation of large dams: the upper reach of the lower Yellow River." Geomorphology 147-148, 35–48.
[6] Xue, B.W., Zhang, X.P., Xu, L.J. (2020). "Response Law of Sediment Diameter Change in the Lower Yellow River to Water and Sediment Regulation in Xiaolangdi Reservoir." Journal of North China university of water reaources and electric power(natural science edition) 41(2), 55-62.
[7] Zhou, Y.J., Lu, J.Y., Jin, Z.W. (2021). "Experimental Study on the Riverbed Coarsening Process and Changes in the Flow Structure and Resistance in the Gravel Riverbed Downstream of Dams." Frontiers in Environmental Science 9, 611668.
[8] Zhou, Y., Li, D., Lu, J., et al. (2020). "Distinguishing the Multiple Controls on the Decreased Sediment Flux in the Jialing River Basin of the Yangtze River, Southwestern China." Catena 193, 104593.

Study on the event-scale hysteresis characteristics of cascade reservoirs in the upper Yangtze River--a new method was proposed

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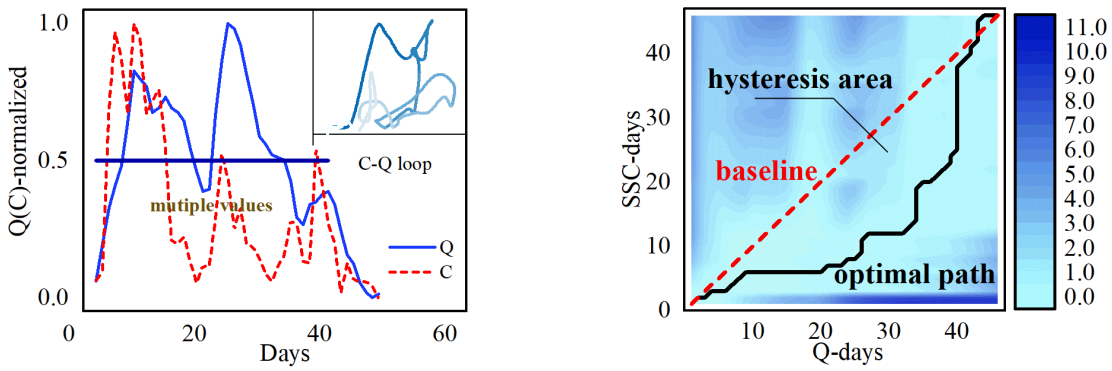
Abstract

For large natural rivers, water-sediment transport occurs at different time scales. Sediment peak transport during flood events is very important to river channel evolution, sediment disaster prevention and the sustainability of reservoir. The discharge peak and sediment peak in rivers and reservoirs usually move downstream asynchronously. and thus, in-depth research on sediment peak transport and hysteresis between discharge-sediment must be performed for the refined regulation of rivers and reservoirs[1].

The upper reaches of the Yangtze River exhibit significant spatial and temporal variations in sediment yield and transport, with prominent issue of heterogenous sediment sources. In the past 20 years, under the impact of factors such as the construction of cascade reservoirs, soil and water conservation projects, and changes in climate and rainfall, phenomenon of hysteresis has become more prominent. Current research is mainly focused on the Three Gorges Reservoir[2], and there is still a lack of research on the upstream cascade reservoirs.

The two main methods for measuring the hysteresis pattern are the loop analysis and the hysteresis indexes[3]. But both of these methods have certain drawbacks, Figure.1 (a). So this document proposes a new idea for hysteresis pattern distinction based on the dynamic time wrapping algorithm. DTW algorithm is a method that can measure the similarity of two independent time series. It has been widely used for word audio matching. The method will be applied to twist the two time series based on the principle of the shortest cumulative path to get the correspondence between the two. We calculate the hysteresis index based on the optimal path after twisting, Figure.1 (b). The calculation results show that the hysteresis area is below the baseline, which is 2.21, so the hysteresis pattern is sediment peak ahead, and the hysteresis time is 2.21 days.



a) Sediment-discharge loop, For a complex flood event, it is difficult to correspond C-Q loops to existing hysteresis patterns. A single interval discharge correspond to multiple sediment values, which makes it difficult to explicitly calculate HI.

b) The purposed method is to calculate the hysteresis area between the optimal path and the baseline (depending on the length of the two series, typically the line 'y=x'), and to define the hysteresis type and time by the value of this area and the up-down relationship with the baseline.

Figure.1 Example of a single flood event and the new method introduction.

Subsequently, we applied the method to the judgment of flood peak sand peak asynchrony in the incoming field floods of the upper Yangtze River cascade reservoirs, and developed an understanding of the hysteresis characteristics of the upper Yangtze River, Figure.2.

Hysteresis pattern of flood events in the PZH station to WDD reservoir of the upper Yangtze River are dominated by sediment peak ahead, which account for 52% to 63%. As floods propagate to the downstream XLD reservoir and XJB reservoir, the percent of sediment peak delay increases and gradually dominates, with delay accounting for 55% to 61%.

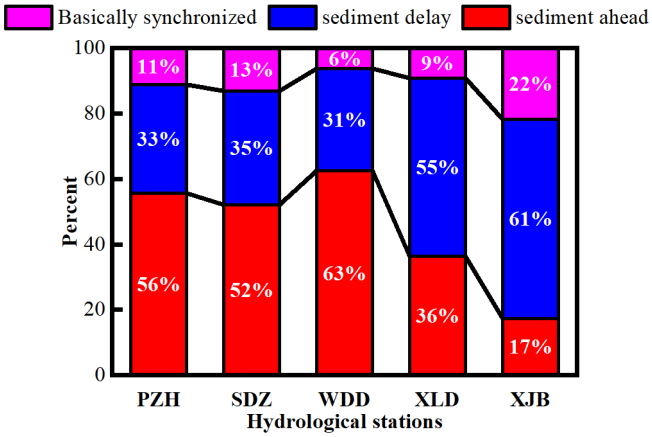


Figure.2 hysteresis pattern characteristics of cascade reservoir in the upper Yangtze River, the hydrological stations from left to right corresponds to upstream to downstream.

Keywords: hysteresis pattern; dynamic time wrapping algorithm; cascade reservoirs in upper Yangtze River

Acknowledgment

The project "Study on asynchronous transport mechanism of discharge and sediment concentration peaks and model for water and sediment yield and transport in the upper Yangtze River" (U2040218) are gratefully acknowledged for its financial fund.

References

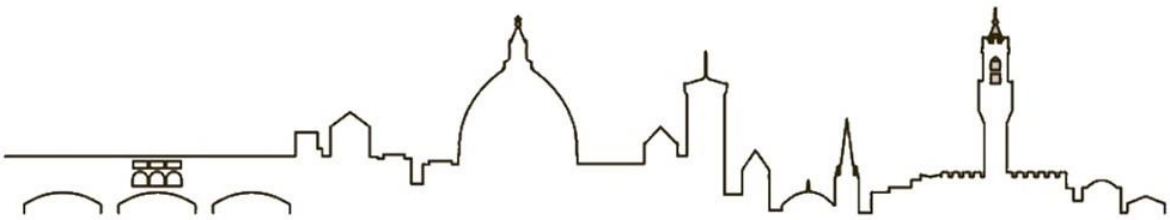
[1] Kondolf GM., Gao Y., & Annandale GW. (2014). "Sustainable sediment management in reservoirs and regulated rivers: Experiences from five continents." Earth's Future 2(5), 256-280.

[2] Ren J., Zhao M., & Zhang W. (2020). "Impact of the construction of cascade reservoirs on suspended sediment peak transport variation during flood events in the Three Gorges Reservoir." Catena (Amst) 188, 104409

[3] Malutta S., Kobiyama M., & Chaffe PLB. (2020). "Hysteresis analysis to quantify and qualify the sediment dynamics: state of the art." Water Sci Technol 81(12), 2471-2487.

Topic 6:

Sustainable sediment management at the basin scale



Sedimentation basin in the Massaciuccoli lake area, EU Phusicos project "According to nature"

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Abstract

In mountain areas, natural hazards, flooding, snow avalanches, droughts, and landslides are triggered by climate change, anthropization, and economic development. Nature-Based Solutions (NBSs) are attracting increasing interest as they are able to couple technical solutions against natural hazards with ecological and socio-economic resilience. On this matter, the five-year H2020 Innovation Action "PHUSICOS—According to Nature" (Grant Agreement nr. 776681) project aims to assess the effectiveness of NBSs and hybrid solutions to hinder hydro-meteorological events in rural and mountainous areas in Europe.

In the Serchio case one of the main problems to solve with the proposed and implemented NBS measures is the runoff of soil and pollutants from the farmland to irrigation canals and from there to the nearby Lake Massaciuccoli on the Tuscan coast. In addition, the measures will have flood reduction potential.

Buffer strips

The design of the implemented buffer strips and the selection of plants has been made in close cooperation with the University of Pisa, Italy. The width of the strips was a matter of discussion, and the resulting 3 m was a compromise between the scientific experience and the farmers' willingness to provide land. The agreement was reached through an active Living Lab process. In addition to preventing runoff of pollutants from the farmland, the strips will also prevent runoff of sediments and thereby clog the channels, which also serve as a flood mitigation measure. The authority has collaborated with stakeholders (local farmers and other organizations) to implement these NBSs, including the maintenance and monitoring plans, and explore planning strategies with the overall goal of developing an ecosystem-based management approach for hydrogeological risk reduction in the whole area of the Massaciuccoli Lake. All proposed measures are implemented, and a number of monitoring activities have been initiated. Several chemical indicators are monitored with installed probes in addition to the water level and turbidity of the surface water in the canals.

Sedimentation Basin

The implemented sedimentation basin forms an essential third element in the NBS measures to reduce the runoff of sediments and pollutants from the Studiati and Gioia fields. The Basin is vegetated with water plants selected for optimal uptake of pollutants (nutrients and pesticides). It has access to machinery for maintenance, including the outtake of trapped sediments after flooding events. The sedimentation basin project was modified and updated based on input from the stakeholders during the Living Lab process, to better integrate into the environmental and landscape context. Based on this, additional vegetated areas and a zone designed for nesting birds were established.

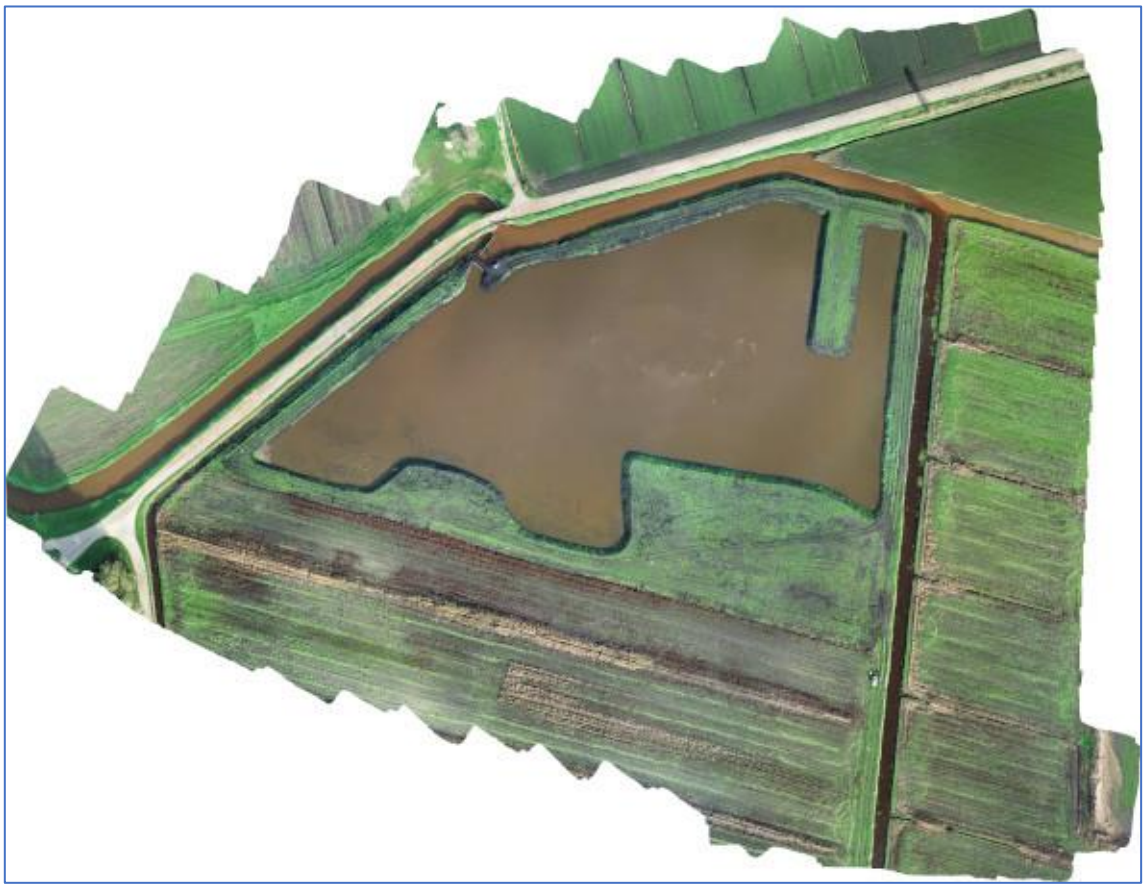

Figure 1. Sedimentation basin

Canal modification

A final implemented NBS intervention for the area around Lake Massaciuccoli has been to modify the shape (cross-profile) of two important canals to increase their hydraulic capacity and thereby increase their flood-mitigating capacity. The modifications also included planting bank vegetation, which will slow down the water flow, reduce bank erosion, and can absorb pollutants. The canals have been modified by enlarging the original trapezoidal cross section by constructing small 'floodplains' along the banks, increasing the practical section of the canals during flooding events. Furthermore, the modified cross-section provides a better environment for the bank vegetation, with carefully selected species.

In addition to the main goal of reducing flood risk and runoff of sediments and pollutants, the measures have a range of co-benefits, such as:

- a cleaner lake
- well-being for inhabitants and for tourists, as this is an important tourist area
- enhancing biodiversity by avoiding agriculture all the way up to channels
- carbon storage with increased vegetation, which is not harvested
- boosting the local green economy
- 6. creating increased cooperation, enthusiasm, and sense of 'ownership' among stakeholders (farmers).

Contrasting fluvial responses to large dam removals with and without sediment management

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Abstract

Removing dams is an increasingly common means to restore rivers and remove liability or hazards associated with aging dams [1], and more information is becoming available on fluvial sedimentary and geomorphic responses to large dam removal. We compare long-term responses of two western-U.S. rivers with different sediment-management strategies after large dam removal: the Elwha River, Washington, where two dams (32 m and 64 m high) were removed over 2011–2014, and the Carmel River, California, where one 32-m-high dam was removed in 2015. Sedimentary effects of these dam removals were monitored using before-after/control-impact studies that measured bed elevations on channel cross-sections and bed-sediment grain size in selected reaches upstream and downstream of the dam sites.

After the Elwha River dam removals sediment was exported from the reservoirs by natural river erosion, causing substantial aggradation downstream (widespread deposition 1–3 m thick in the lower river), temporary conversion of the channel morphology from pool-riffle to braided and plane-bedded, and major growth of the river-mouth delta [2, 3]. As of 2022, almost a decade after the peak of the sediment pulse, the lowermost Elwha River still had bed elevations >1 m higher than before dam removal. These changes occurred in response to a 20-million-ton sediment pulse, equivalent to decades of background sediment output from the Elwha watershed.

In contrast, dam removal on the Carmel River was managed deliberately to limit reservoir-sediment export, to prevent major aggradation downstream that would have increased flood risk. This was achieved with an engineering design that sequestered two-thirds of the reservoir sediment and re-routed the river over a newly constructed bedrock-based channel that limited the base-level drop relative to the original channel configuration. This strategy successfully prevented major sediment export, and geomorphic changes downstream of the dam site were relatively minor: pools filled, but aggradation was generally limited to 0.5–1 m or less and no major planform changes occurred downstream [4]; the dam-removal sediment pulse was equivalent to less than one year of annualized long-term sediment export [5]. Most geomorphic change on the Carmel River was attributable to effects of high flows one and four years after dam removal, not to increased sediment supply. In contrast, on the Elwha River most geomorphic change was driven by new sediment supply (most sediment export occurred in the first two years after dam removal despite a lack of floods then).

Both dam removals successfully achieved the desired outcomes for river management. The Elwha River dam removals were intended to facilitate full-watershed restoration as they allowed anadromous fish passage past the dam sites; the new sediment on the riverbed was finer-grained (improving fish-spawning habitat) and reversed decades of coastal erosion. The Carmel River dam removal was not intended as a full-watershed restoration (another dam remains upstream) but achieved the desired management outcomes of removing an unsafe dam while improving fish passage and avoiding major aggradation downstream. The Elwha River example demonstrates that when large dam removals are managed using natural river erosion in a steep watershed with high sediment supply,

a large sediment pulse will result, with some sediment effects lasting more than a decade: rivers in steep terrain can efficiently export a large sediment pulse (many years' worth of watershed sediment supply), although the signal in the low-gradient lowermost river and coastal areas can persist >10 years. The Carmel River example shows that it is possible for a large dam removal to have relatively little impact downstream if the sediment release is limited intentionally, e.g., in watersheds where sediment deposition (bed aggradation) would be undesirable or hazardous.

Figure 1. A–C: Lake Mills reservoir formed by Glines Canyon Dam on the Elwha River, Washington, USA, before (A) and after (B, C) dam removal and natural erosion of reservoir sediment. D–F: San Clemente reservoir formed by San Clemente Dam on the Carmel River, California, USA, before (D) and after (E, F) dam removal and deliberate sequestration of two-thirds of the reservoir sediment deposit in place.

Keywords: Dam removal; reservoir sedimentation; fluvial sediment

Acknowledgement:

These studies were supported by the U.S. Geological Survey, National Oceanic and Atmospheric Administration, and Bureau of Reclamation.

References

[1] O'Connor, J., Duda, J., & Grant, G. (2015). "1000 dams down and counting." Science 348, 96–497.

[2] Ritchie, A.C., Warrick, J.A., East, A.E., Magirl, C.S., et al. (2018). "Morphodynamic evolution following sediment release from the world's largest dam removal." Scientific Reports 8, 13279.

[3] East, A.E., Logan, J.B., Mastin, M.C., et al. (2018). "Geomorphic evolution of a gravel-bed river under sediment-starved versus sediment-rich conditions: river response to the world's largest dam removal." J. Geophys. Res., Earth Surf., 123, 3338–3369.

[4] Harrison, L.R., East, A.E., Smith, D.P., Logan, J.B., Bond, R.M., et al. (2018). "River response to large-dam removal in a Mediterranean hydroclimatic setting: Carmel River, California, USA." Earth Surf. Proc. Landforms 43, 3009–3021.

[5] East, A.E., Harrison, L.R., Smith, D.P., Logan, J.B., & Bond, R.M. Six years of fluvial response to a large dam removal on the Carmel River, California, USA. Earth Surf. Proc. Landforms, in press.

The spatiotemporal variations of land use and soil erosion in rocky mountainous areas of northern China

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Abstract

The rocky mountainous areas of northern China is one of the key regions for prevention of soil erosion in China. At present, most studies in this area focused on specific soil and water conservation measures and their ecologic effect or soil erosion of small watersheds, but few studies focused on the spatiotemporal variations of land use/cover change and soil erosion condition in recent decades for the whole region. Since the 1980s, with the development of economy and society, the land use and vegetation cover caused by human activities changed a lot in this area. This study is aimed at providing data support for regional soil erosion control strategy.

Based on the data of Haihe and Huaihe River Basin, this paper quantitatively analyzed the trends and characteristics of land use from 2009-2016, NDVI from 2000 to 2015, soil loss area of different intensities from three national soil erosion surveys, and the runoff and sediment discharge of two hydrologic stations on Haihe and Huaihe River.

The results showed that: (1) The area of towns, villages, industrial and mining land, and transportation land in the two basins increased by approximately 7% - 10%, while the area of cultivated land, woodland, grassland and other types of land decreased by approximately 0.5% - 6%. The socioeconomic development and urbanization progress leads to the transformation of land use in this region. (2) Vegetation coverage increased gradually, and the high coverage area where NDVI > 0.7 was expanded. The percentage of high coverage area increased from 12.88% to 25.26% for Haihe River Basin, and from 13.42% to 19.14% for Huaihe River Basin, respectively. (3) The soil loss area decreased from 169,200 km^2 in the late 1980s to 116,200 km^2 in 2011, of which the area of severe and moderate erosion decreased the most, reaching 51.2% and 42.3%, respectively. (4) The average annual sediment discharge of Haihezha station decreased from 191,000 tons during last century to 300 tons during this century, while the average annual sediment discharge of Bengbu station decreased from 8.9040 to 3.8183 million tons at the same time (Figure 1).

In general, through the implementation of ecological restoration and soil and water conservation projects such as small watershed comprehensive management, shelter forests construction in the northern part of China and sloping farmlands reformed to terrace, the vegetation coverage in rocky mountainous area has increased steadily in the past two decades. The effect of ecological restoration was also reflected from the decreased soil loss area, and the intensity of soil loss has generally shown a downward trend.

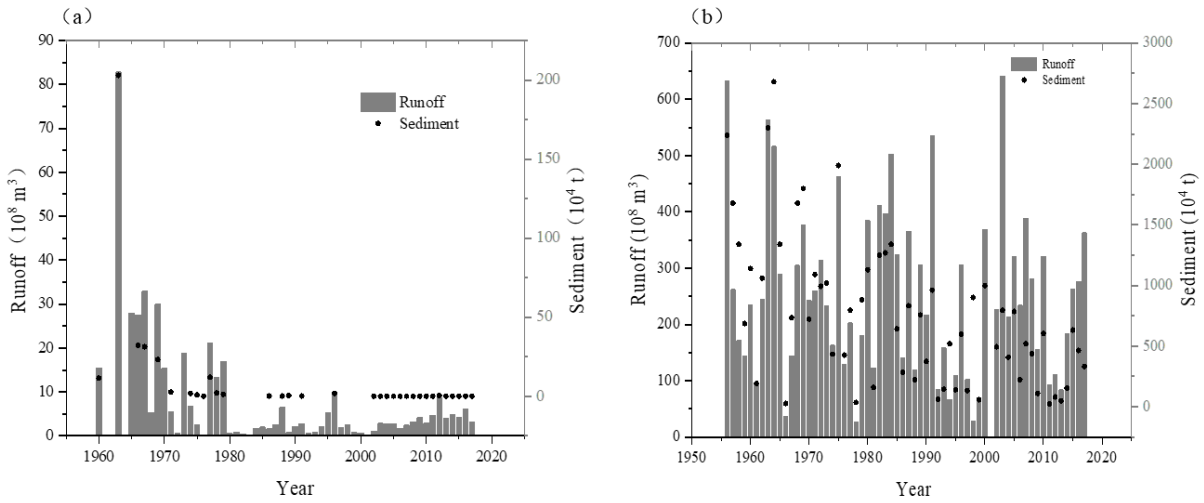

Figure 1. Inter-annual variation of runoff and sediment in Haihe and Huaihe River Basin: (a) Haihezha station, (b) Bengbu station.

Keywords: land use; NDVI; soil erosion; spatiotemporal variation; rocky mountainous areas of northern China

Acknowledgment

The authors would like to express appreciation for the support of the sponsors [The National key research and development program of China (Grant Number 2021YFE0113800), The National Natural Science Foundation of China (Grant Number U2243213), and The National Natural Science Foundation of China (Grant Number U2243212)].

References

[1] Li, X., Ma, Z., Yao, X., Jing K., Zhu, H. (2008). Current status and comprehensive control strategies of soil erosion for rocky mountain areas in the Northern China. Science of Soil and Water Conservation, 6(1): 9-15.

[2] Wang, Z., Cao, J. (2019). Research advances in vegetation restoration and its ecological effects in earth-rock mountain areas of North China. Chinese Journal of Eco-Agriculture, 27(09): 1319-1331.

[3] Wei, S., Guo Y., Hou K. (2015). Technical standard and demonstration of slope land to terrace in rocky mountainous area of northern China. Soil and Water Conservation in China, (4): 28-30.

[4] Wang N, Jiao J, Bai L, et al. (2020). Magnitude of soil erosion in small catchments with different land use patterns under an extreme rainstorm event over the Northern Loess Plateau, China. Catena, 195: 104780.

[5] Fang H. (2020). Impact of land use changes on catchment soil erosion and sediment yield in the northeastern China: A panel data model application. International Journal of Sediment Research, 35: 540-549.

Erosion and Sedimentation Processes in a Semi-Arid Basin of the Brazilian Savanna under Different Land-Use, Climate-Change, and Conservation Scenarios

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Abstract

Estimating the on-site and off-site impacts of soil erosion as a function of land-use and climate conditions in semi-arid basins are key for soil and water conservation strategies. However, a large research gap exists in the topic, requiring further investigation using local hydrological data. To accomplish it, the calibrated SDR-InVEST model was applied to the Pardo-FB basin, in Brazil, in different land-use, soil conservation, and climate conditions. Mean annual soil loss and sediment yield in the basin varied from $7x10^{-3}$ to $36\ x10^{-3}$ $Gg.ha^{-1}.yr^{-1}$ and 1.2 to 52.2 $Gg.yr^{-1}$, respectively. The basin areas where on-site and off-site erosion tolerances were exceeded ranged from 20% to 50% and from 0% to 1%, respectively, depending on the scenario. The results indicate that anthropic areas and rainfall erosivity increase landscape connectivity, generating higher erosion and sedimentation rates. Restoration of native vegetation and soil conservation practices reduce these impacts, but had their effectiveness is reduced in very humid scenario. The study results could be utilized for the establishment of soil conservation strategies in the basin, as well as in similar savannic semi-arid river basin of the world.

Methods

The Pardo-FB basin, situated in eastern Brazil, has an area of 5,508 km2, a mean altitude of 926 m, and a mean slope of 13%. The basin is a relatively circular in shape, with compactness coefficient, shape factor, and circularity index of 1.43, 0.27, 0.47 respectively. The drainage density is 1.23 km^{-1}, which provides a relatively fast hydrological response to precipitation. The predominant soils in the basin are Oxisols (55%), followed by Leptsols (20%).

The basin climate is semi-arid, with a mean annual precipitation of 748 mm (Figure 2). The basin's relatively low rainfall and high temperature make it basin susceptible to desertification. The InVEST-SDR model was used to calculate the soil loss on the basin slopes and the sediment yield at the basin outlet, under different land-use and conservation scenarios, and distinct climate settings (dry, normal, wet years.

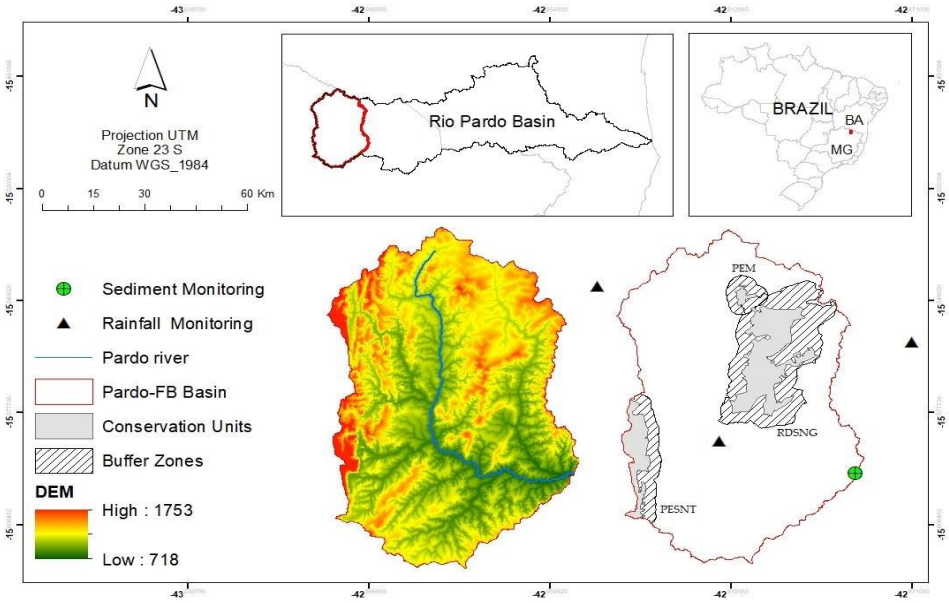

Figure1. Rio Pardo Basin, in eastern Brazil.

Main Results

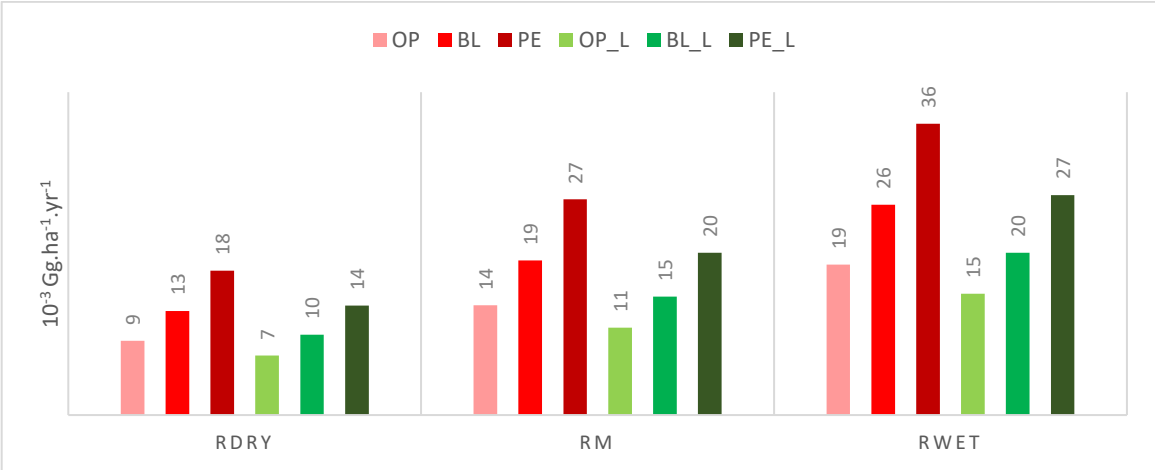

Figure 2. Mean soil loss in the Pardo basin, under different climates & management.

Keywords: Erosion, sedimentation, semiarid savanna, Brazil.

References

[1] Croke, J.; Nethery, M. Modelling Runoff and Soil Erosion in Logged Forests: Scope and Application of Some Existing Models. 'Catena' 2006, *67*, 35–49

[2] Silva, C.R. da; Chaves, H.M.L.; Camelo, A.P. Calibração e Validação Da Equação Universal de Perda de Solos Modificada (MUSLE) Utilizando Dados Hidrossedimentológicos Locais. 1Rev Bras Cienc Solo' 2011, *35*, 1431–1439, doi:10.1590/S0100-06832011000400037.

[3] Verheijen, F.G.A.; Jones, R.J.A.; Rickson, R.J.; Smith, C.J. Tolerable versus Actual Soil Erosion Rates in Europe. 'Earth Sci Rev' 2009, *94*, 23–38, doi:10.1016/j.earscirev.2009.02.003

Revisiting the relationships between channel geometry and sediment grain size in mountain rivers

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Abstract

Empirical equations relating the river geometry with discharge and sediment grain size have been proposed since the 1950s, by considering various spatial scales (i.e., reach and catchment scales). For instance, at the cross-sectional scale, Parker et al. (2007) and Wilkerson & Parker (2011) found dimensionless relationships between flow discharge, water depth, the river width, and channel slope in bankfull conditions for gravel-bed and sand-bed rivers, respectively. At the catchment scale, many authors found empirical correlations between drainage area and local morphological properties, in terms of bed slope and grain size distribution (Gasparini et al., 2004; Golden & Springer, 2006; Eaton, 2013, among others). One of the pioneer works proposing such empirical equations was Hack (1957), who found a power law relationship between the local bed slope, s, and the catchment-area-to-mean-grain-size ratio (A / D_{50}) for various rivers in the US (Figure 1a). To our knowledge, a theory explaining the empirical formulation has not been proposed yet in literature. In this work, we derive a physically-based relationship relating local bed slope to the mean grain size and the upstream drainage area, which helps clarifying the origin of the early proposed empirical relationships and the reasons for further extensions.

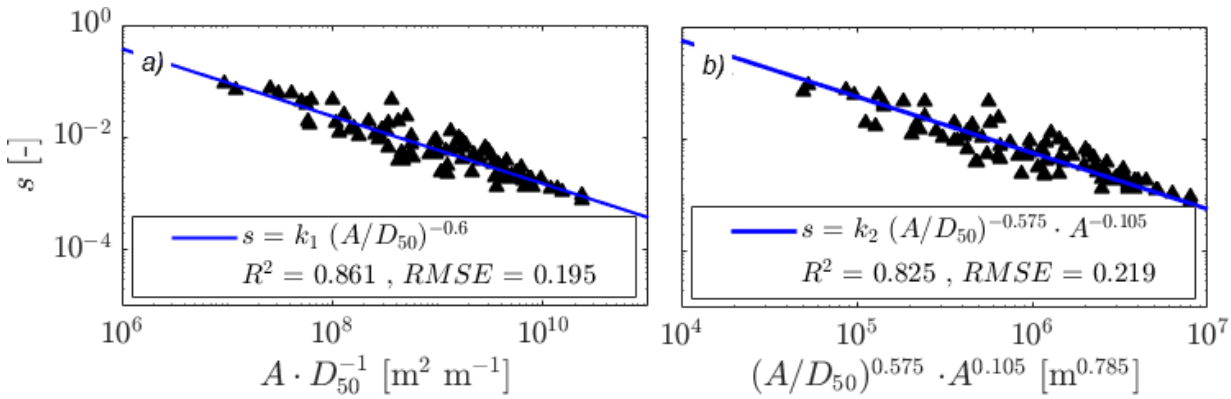

Figure 1. The dataset of Hack (1957) is shown in both panels by black triangles. Blue lines identify the regression relationships found by Hack (1957) and derived in this work, in panels a and b, respectively.

The procedure relies on the hypotheses of long-term morphological equilibrium of the channel, normal flow conditions, and rectangular cross section. By considering a Meyer-Peter-Muller type of equation for the sediment transport, the scaling relationship between drainage area and flow discharge in bankfull conditions, and the presence of additional macroroughness due to, for instance, instream large wood (Rickenmann, & Recking, 2011), we derived the following formulation:

$$s \propto \left(\frac{A}{D_{50}}\right)^{-0.575} A^{-0.105}$$

This relationship shows an exponent for the A-to-D_{50} ratio very close to the value of -0.6 found by Hack (1957). However, the inclusion of macroroughness brings in an additional term proportional to the drainage area only. Results of the comparison against the dataset of Hack (1957) are highlighted in Figure 1b. The proposed relationship shows quite good agreement, with a slightly lower correlation coefficient (R^2 = 0.825) in comparison to the empirical equation (R^2 = 0.861). Due to the implied formulations for the sediment transport and the presence of macroroughness, the proposed scaling relationship is mainly suitable for mountain river catchments. Currently, the comparison against different datasets (e.g., Golden & Springer, 2006) is under investigation, together with the possibility to include terms related to geometric features of a cross-section (e.g., river width, flow area) in the formulation. This will lead to a more reliable characterization of fluvial properties at the catchment scale based on simple and quick measurements at the local scale.

Keywords: Rivers; Scaling relationship; Catchment area; Grain size, Bankfull equilibrium

References

[1] Parker, G., Wilcock, P. R., Paola, C., Dietrich, W. E., & Pitlick, J. (2007). Physical basis for quasi‐universal relations describing bankfull hydraulic geometry of single‐thread gravel bed rivers. Journal of Geophysical Research: Earth Surface, 112(F4).

[2] Wilkerson, G. V., & Parker, G. (2011). Physical basis for quasi-universal relationships describing bankfull hydraulic geometry of sand-bed rivers. Journal of Hydraulic Engineering, 137(7), 739-753.

[3] Gasparini, N. M., Tucker, G. E., & Bras, R. L. (2004). Network‐scale dynamics of grain‐size sorting: Implications for downstream fining, stream‐profile concavity, and drainage basin morphology. Earth Surface Processes and Landforms, 29(4), 401-421.

[4] Golden, L. A., & Springer, G. S. (2006). Channel geometry, median grain size, and stream power in small mountain streams. Geomorphology, 78(1-2), 64-76.

[5] Eaton, B.C., 2013. Hydraulic geometry: empirical investigations and theoretical approaches. In Shroder, J.F. (Ed.), Treatise on Geomorphology. Academic Press, San Diego, pp. 313–329.

[6] Hack, J. T. (1957). Studies of longitudinal stream profiles in Virginia and Maryland (Vol. 294). US Government Printing Office.

[7] Rickenmann, D., & Recking, A. (2011). Evaluation of flow resistance in gravel‐bed rivers through a large field data set. Water Resources Research, 47(7).

River management practices in the Middle Valdarno sub-basin

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Abstract

The "Consorzio di Bonifica 3 Medio Valdarno" (CBMV), the public authority in charge of rivers maintenance and flood management, operates on 5600 Km of river reaches in the middle Valdarno sub-basin, including the Florence plain.

The main activities of every "Consorzio di Bonifica" are the maintaining and management of the draining network, the maintaining and management of water bonification, the maintaining of irrigation facilities and the land consolidation in accordance with the relevant regional plans.

Over the last years, in addition to the priority activities listed above, the Consorzio di Bonifica 3 Medio Valdarno (CB3) has also focused on river sediment management.

River floodplain systems were no longer not only impacted by climate, vegetation and geology, but also by social, political, economic and technical impact factors. Anthropogenic activity affected soils and resulted in different erosion and deposition processes [1].

The recently published *"Water Framework Directive (2000/60/EC). Integrated sediment management. Guidelines and good practices in the context of the Water Framework" (2022)* [2], aims to establish a common understanding on the role of sediment in achieving the objectives of the Water Framework Directive in order to develop an integrated sediment management plan (ISMP) in the context of the River Basin Management Plan (RBMP). According to the Italian legislation, Legislative Decree 152/06, article 117, 2-quater (National Environmental Act), sediment management plans (SMP) are an obligatory and integral part of (RBMPs).

The activity of the CBMV aims at implementing these guidelines by providing an action program on the river floodplain in the Middle Valdarno sub-basin.

Examples of possible measures are: the optimisation of engineering structures (e.g. sediment basins) to modify flow characteristics to reduce shear stress, flow velocity, transport capacity and promote deposition; the sediment bypassing to facilitate the movement of sediment from upstream of a retaining structure and return it to the system downstream.

In some cases, the sediments dredged were used to construct bank levees with the objective of protecting arable lands from flooding. Sediment reintroduction is conducted following a pre- designed planning.

The aim of the present work is to illustrate the main field activities carried out by the CBMV to manage the sediment transport dynamics in rivers.

Figure 1. A sediment basin designed to trap and store sediment on a tributary reach managed by the Consorzio di Bonifica 3 Medio Valdarno.

Keywords: Integrated Sediment Management Plan; River Basin Management Plan; Sediment management

References

[1] Maaß, AL., Schüttrumpf, H. & Lehmkuhl, F. Human impact on fluvial systems in Europe with special regard to today's river restorations. Environmental Science Europe 33, 119 (2021).

[2] Ausili, Antonella & Borowiec, Piotr & Boughaba, Jeanne & Branche, Emmanuel & Brils, Jos & Brinke, Marvin & Brooke, Jan & Bussettini, Martina & Carere, Mario & Carls, Ilka & Casado Martinez, M. Carmen & Clayton, Helen & Cleveringa, Jelmer & Comiti, Francesco & David, Szilvia & Dokkum, Ronald & Dudas, Katalin & Ferrer, Carles & Goltara, Andrea & Winterscheid, Axel. Integrated sediment management. Guidelines and good practices in the context of the Water Framework Directive (2022).

A New Multi-Criteria Methodology for Sustainable Management of River Sediment

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Abstract

Rivers are critical ecosystems that provide a wide range of ecological, social, and economic benefits to human society. However, they are dynamic systems that are constantly changing due to both natural and human-induced factors [1]. Among these factors, sediment dynamics are particularly important because they influence various ecological and societal functions, such as water quality, habitat availability, navigation, and flood control [2]. Effective sediment management strategies are needed to maintain sediment balance and support river ecosystems [3]. Following a multi-disciplinary approach, the primary objective of this study is to develop a comprehensive understanding of the river hydraulic, morphological and ecological conditions and provide recommendations for effective and sustainable sediment management practices. In this work, we propose a multi-criteria approach to develop an overall design strategy for medium-term (i.e., some decades) bed sediment management. A sequence of steps will be considered: (i) hydro-geomorphic, sedimentological and ecological characterization for each sub-reach composing the investigated river, (ii) definition of an integrated, multi-disciplinary, approach to identify the river 'health conditions' and therefore, the related critical aspects, (iii) definition of a strategy for sediment management based on the hydro-geomorphic and ecological health and recovery potential of each sub-reach [4, 5]. The above-mentioned steps are based on several approaches. The geomorphological assessment and monitoring include three tools: the Morphological Quality Index (MQI), the Morphological Quality Index for monitoring (MQIm), and the Geomorphic Units survey and classification System (GUS). The ecological health is defined with the habitat and microhabitat integrated analysis (e. g. SUM, STAR_ICM index, etc.). These tools constitute the assessment phase of an overall multi-scale, process-based hydromorphological framework developed in the context of the REFORM (REstoring rivers FOR effective catchment Management) EU project [6]. The hydraulic and morphodynamic analysis is based on the investigation of both the river bed evolution and its equilibrium profile [7]. In particular, sediment budget will provide indications about the tendency of a sub-reach towards incision or aggradation. The equilibrium bed profile will be investigated by implementing a hydro-morphodynamic numerical model capable of handling complex natural geometry and movable bed [8].

The proposed methodology will be implemented to assess the hydro-geomorphic, sedimentological and ecological conditions of selected reaches of the four major rivers in the Tuscany region (central Italy). These rivers include the Ombrone River, Magra River, Arno River, and Serchio River (Figure 1). In each of them, scenario analyses will be conducted to determine the appropriate level of sediment management intervention required.

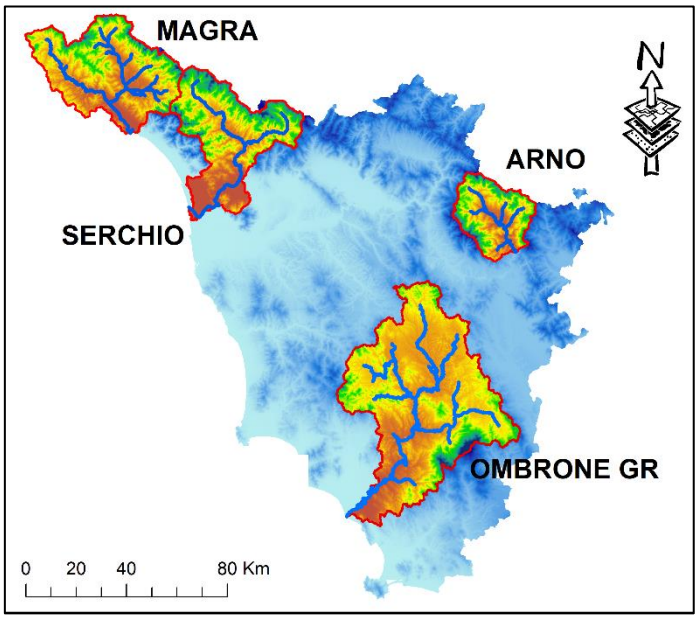

Figure.1 River Basins of the Ombrone, Magra, Arno and Serchio in Tuscany (Italy).

Keywords: River; Hydro-geomorphic and Ecological analyses; Morphodynamic modelling; Sediment management

References

[1] D. Dudgeon et al., "Freshwater biodiversity: Importance, threats, status and conservation challenges," Biol. Rev. Camb. Philos. Soc., vol. 81, no. 2, 163–182, 2006.
[2] C. J. Vorosmarty et al., "Global threats to human water security and river biodiversity," Nature, vol. 467, no. 7315, 555–561, 2010, doi: 10.1038/nature09440.
[3] G. J. Brierley and K. A. Fryirs, "Geomorphology and River Management: Applications of the River Styles Framework," Geomorphol. River Manag. Appl. River Styles Framew., no. March 2007, pp. 1–398, 2008, doi: 10.1002/9780470751367.
[4] Rinaldi, M., Simoncini, C. and Piégay, H., Scientific design strategy for promoting sustainable sediment management: the case of the Magra River (Central-Northern Italy). River Res. Applic., 25: 607-625. 2009. https://doi.org/10.1002/rra.1243
[5] Erba, S., Cazzola, M., Belfiore, C. et al. Macroinvertebrate metrics responses to morphological alteration in Italian rivers. Hydrobiologia 847, 2169–2191, 2020.
[6] M. Rinaldi, B. Belletti, M. Bussettini, F. Comiti, B. Golfieri, B. Lastoria, E. Marchese, L. Nardi, N. Surian, New tools for the hydromorphological assessment and monitoring of European streams, Journal of Environmental Management, 202, Part 2, 363-378, 2017.
[7] M. Bolla Pittaluga, R. Luchi, and G. Seminara, "On the equilibrium profile of river beds," J. Geophys. Res. Earth Surf., vol. 119, no. 2, pp. 317–332, 2014, doi: 10.1002/2013JF002806.
[8] L. Minatti, "A well-balanced FV scheme for compound channels with complex geometry and movable bed," Water Resour. Res., 51, 8, 6564–6585, 2015.

The influence of urban drainage system on fluvial sediments - case study: the Reglia dei Mulini in Camucia

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Abstract

Flooding is the most common, widely experienced, and deadliest form of natural disaster (UNISDR, 2015). Efforts to mitigate flooding have centered on engineered solutions such a dredging river. Dredging sediments from river channels increases flow capacity. As such, dredging is often seen as the most appropriate flood-reduction measure by both stakeholders and policy makers (e.g., Chaudhary, 2012). The goal of the study doesn't intends evaluating the effectiveness of river dredging but rather than how this operation is influenced by the site-specific conditions, in which the catchment area of the river is located, in particular the interaction with the urban drainage system.

Normally urban drainage systems have outlets into rivers. This condition could be caused the presence of high concentration of pollutants (Garnero et al., 2018).

It is necessary to characterize the dredging sediment chemically (Boutouil et al., 1997) in order to characterized the concentration of the pollutants respect to the concentration limits indicated in the Italian Law n.152/2006 and in order to manage the dredged sediments in relation to their reuse or recovery in apposite sites or landfill.

In this paper, we focus the attention on the dredging operation of the Reglia dei Mulini, an artificial channel that drains water from the entire urban area of Camucia, in the municipality of Cortona (Arezzo, Italy), which is characterized by the presence of productive, tertiary and commercial activities and is densely populated (Fig. 1). The channel is in Valdichiana area (Tuscany, Italy). The channel has a slope of 0.001%. These physical aspects induced a progressive accumulation of sediments that needing a management program, in order to avoid the reduction of the original hydraulic sections compromising the flow capacity.

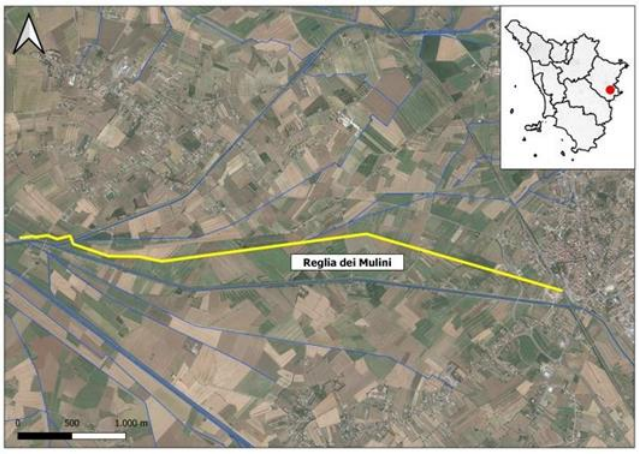

Figure 1. Case study area

In the Reglia dei Mulini, there are numerous sewage outlets of combined urban drainage system that influencing the concentration of the pollutants in the channel. Therefore, a part of the sediments overlaps the legislative concentration limits of the pollutants for reusing. In the area, the cost to

manage contaminated sediment is 160 €/t while the one for reusing is zero. Indeed, the concentration of the pollutants in the water outfalling from sewage influences the total costs of the dredging operation in not negligible way. This case study demonstrates that future studies will have to improve the design of the sewage outlet sin order to assess better the effect of the outlet discharge respect to the quality of the river, thus the pollutants concentration of the sediment. Now the design of an outlet is based on a discharge that is a multiple (5-8 times) of the grey water, but future studies have to be improved with an integrated approach assessing hydrological, hydraulic and pollutants analysis at catchment scale.

Figure 2. Reglia dei Mulini after dredging operation

References

[1] UNISDR (United Nations International Strategy for Disaster Reduction). 2015. Sendai framework for disaster risk reduction 2015–2030. Geneva: UNISDR.
[2] Chaudhary, F., 2012. River Dredging Could Reduce Impact of Flood, Fiji Times
[3] Garnero, P.L., Monferran, M. V., González, G.A., Griboff, J., de los Ángeles, B.M. (2018). "Assessment of exposure to metals, As and Se in water and sediment of a freshwater reservoir and their bioaccumulation in fish species of different feeding and habitat preferences.", Ecotoxicol. Environ. Saf. 163, 492–501. https://doi.org/10.1016/J.ECOENV.2018.07.023.
[4] M Boutouil, D Levacher, F Marot, P Conil, P Sanson. Engineering Geology and the Environment, Marinos, Koukis, Tsiambaos & Stournaras (eds)© 1997 Balkema, Rotterdam, ISBN 90 5410 877 0 Devenir des vases et boues de dragage: solidification et stabilization

Sustainable sediments and water management in the lower Cornia valley through river restoration and recharge aquifer

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Abstract

The middle section of the Cornia River underwent severe anthropogenic pressure due to sediments extraction, which took place after World War II and continued at least until the 80s. In a few decades, such an alteration has caused the narrowing and incision of the active bed of the main watercourse and, thereby, a reduction of the floodplain, ecological impoverishment, and a decrease in the natural recharging of the aquifer.

Figure 6. Width of riverbed between years (left side) and riverbed incision (right side).

The river restoration intervention in the scope of the REWAT LIFE project aims at representing an example of river management that could restore, as much as possible, the ecological and morphological equilibrium of the watercourse.

The action focused on three different sections of the Cornia River, amounting to 1.150 linear meters in the so-called "meander zone" in the Suvereto Municipality, where the riverbed is in direct contact with the aquifer. In total, about 3.500 cubic meters of gravel material have been moved from accumulation sites to riverbed incision sites, restoring transversal and longitudinal connections. The active riverbed of the river was widened and equipped with counter banks to increase the surface area in contact with water and benefit natural recharging in the event of a rise in the level of the river. Invasive vegetation was removed, and autochthonous tree species were planted.

Figure 7. Site of interventions through riverbed widening and aquifer recharge.

Expected results were as follows: 20% widening of the active riverbed; 10% enhancement of natural aquifer-recharging; restoration of natural river processes, enhancement of habitat and biological diversity. After 2 years the results reported an increase in natural recharging of the aquifer (approximately 1,3/1,5 million cubic meters per year), a widening of the "active" riverbed, removal of invasive vegetation, planting of native essences, improvement of ecological river water quality.

Keywords: Morphological restoration; aquifer recharge; riverbed widening; biological diversity restoration; river quality improvement.

Acknowledgment

The author would like to express appreciation for the support of Scuola Superiore Sant'Anna in Pisa, and Genio Civile Valdarno Inferiore e Costa of Tuscany Region for the monitoring of discharges before and after the morphological restoration.

References

[1] Barazzuoli, P., Bouzelboudjen, M., Cucini, S., Kiraly, L., Menicori, P., Salleolini, M., (2008). "Olocenic alluvial aquifer of the river Cornia coastal plain: database design for groundwater management." Environmental Geology, 39, 123–143.
[2] Regione Toscana (2003). "Studio conoscitivo del contesto idrogeologico della Val di Cornia di supporto alla pianificazione in materia di risorsa idrica e di tutela delle acque" Dipartimento delle Politiche Territoriali e Ambientali, Relazione finale, a cura di GetasPetrogeo.
[3] Regione Toscana, Direzione generale delle politiche territoriali e ambientali (2009). "Caratterizzazione geologica, idrogeologica e idrochimica dei Corpi IdriciSotterranei Significativi della Regione Toscana (CISS9 32CT020 "Acquifero della Pianura del Cornia".
[4] Sanchez-Villa, X., Fernàndez-Garcia, D., Folch, A., Rodriguez-Escales, P., Siirila, E., Henri, C., Barba, C., (2015). "MARSOL Demostrating Managed Aquifer Reharge as a Solution to Water Scarsity and Drought. Methodology for Probabilistic Risk Evaluation Linked to MAR Activities. Deliverable 16.1, 16.4.

Works for the restoration of the Bruna river's sections

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Abstract:

The Consorzio di Bonifica 6 Toscana Sud (CB6, by its Italian acronym) is a public authority which deals with planning and carrying out the structural actions necessary to guarantee the best water management in the territory, with a wide functional experience such as soil protection, water supply, defence and environmental protection. The CB6 is one of the few land reclamation consortia in Tuscany, one of its tasks is to keep the maintenance of river banks and a correct management of watercourses that belongs to its district. Yearly the Consorzio schedules the maintenance needed along watercourses (so called Piano delle Attività di Bonifica). These actions consist mainly in mowing bushes along river banks, or remove declining trees above the channel, in order to check the condition of embankments or guarantee a correct water flowing in to channels and prevent flood damages.When a flood or a hazardous event occurs, extraordinary maintenance activities are requested. Extraordinary maintenance activities may be different, depending on the hydraulic structures that have been damaged. In this work we focus on how CB6 manages transport sedimentation along Bruna river, in Grosseto province. Bruna river is approximately 70 km long and has its rise on top of Colline Metallifere, from Accesa lake. Originally, Bruna river was a small stream with torrential regime. Starting from the beginning of the 1835, it has been decided to reclaim the territory from swamp and maintain the consolidated land for agricultural use. So, several rivers have been excavated to take advantage of their flooding rich in sediment transportation and fill up those lands. According to "Lotto 1 - Lavori di sistemazione del fiume Bruna ed opere complementari" 1929 project, Bruna's riverbed river had been enlarged and embankments have been added. The aim of the present work, ended up in October 2022, was to ensure the restoration of the original hydraulic cross sections of the outflow by grading the embankments, handling and removal of the sediments from the riverbed, according to validated original sections of 1929's project. In order to re-estabilish the original sections it has been excavated approximately 61.500 mc in less than 3.2km.

Figure 1: Bruna's active channel

Figure 2: sediment excavation

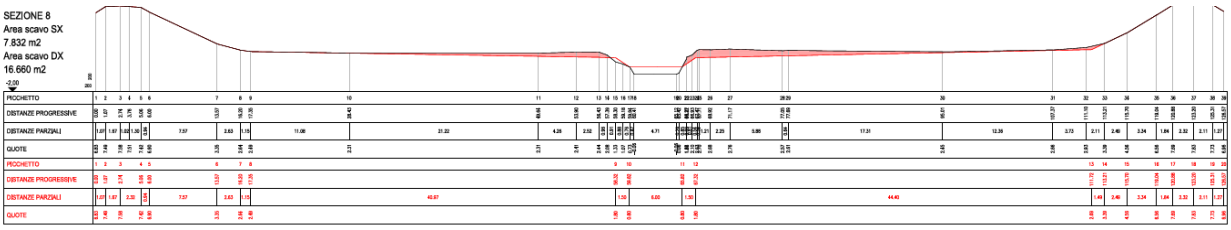

Figure 3: validated section type (sezione di progetto) 2022

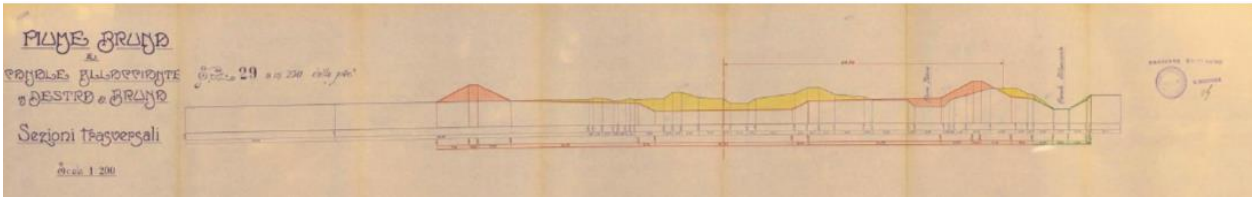

Figure 4: validated section type (sezione di progetto) 1929

Figure 5: excavation of Bruna channel 1931-37

Keywords: Flood damage; rivers, river section; hazard; active channel; originary section; maintenance work; sediment transportation management; flood deposit

Acknowledgment

Volunteers and workers are gratefully acknowledged for their support and constant work during extreme hazardous meteorological events, in order to guarantee a correct surveillance and government of channels system in southern Tuscany.

References

[1] Consorzio di Bonifica Grossetana “Lotto 1 - Lavori di sistemazione del fiume Bruna ed opere complementari” 1927

[2] Consorzio di Bonifica 6 Toscana Sud “Perizia n° 142 - Lavori di ripristino delle aree golenali e regolarizzazione della canaletta di magra del fiume Bruna dal ponte di Macchiascandona verso valle per circa 3100,00 m e opere di ricalibratura sull’argine destro dalla confluenza del torrente La Valle fino a ponte Giorgini - comuni di Castiglione della pescaia e Grosseto

Sediment transport influenced by spatial distribution of terraces

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Abstract

It is an important issue of concern to all parties that what is reason of the sediment transport reduction of the Yellow River, which be once the river with the highest sediment discharge in the world, from 16×10^8 tons in the first half of the last century to the current 2×10^8 tons. For reducing sediment and high-quality development, more than 4×10^4 km^2 of terraced fields have been constructed and a large number of terraced fields still will be built on the Loess Plateau. It was of great practical significance to study the influence of the spatial-pattern optimization of terraced fields on sediment transport in the basin.

This study conducted experiments by constructing a watershed entity scale model based on the 3D scenario representation of surface rainfall-runoff erosion dynamics and similarity theory. The objectives were for investigating sediment transportation processes as influenced by spatial distribution of terraces and giving their relations and serving the terraced field planning on Highly Managed Small Watersheds (HMSW).

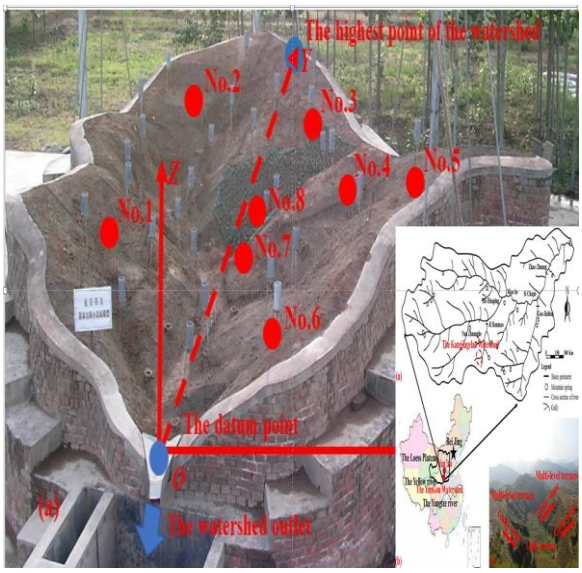


Figure 1. Location and watershed

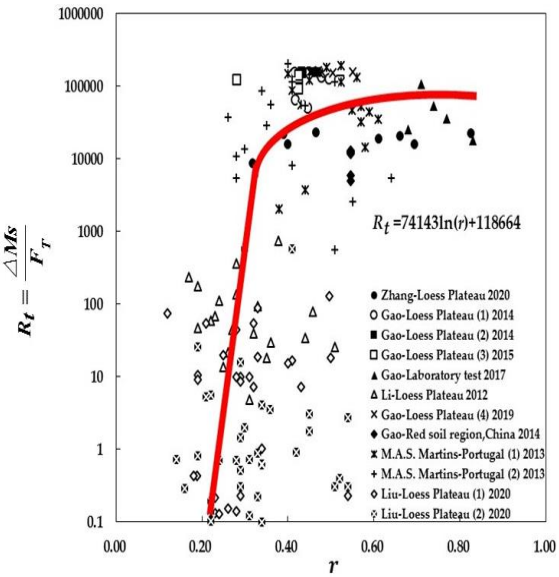


Figure 2. Relationship Rt and r

The results showed that the change of the spatial pattern of terraced fields in the basin had an important impact on the production of runoff and sediment. There were approximate quadratic function relationship between the spatial location and parameters of runoff and confluence. If Rt was terrace reduction sediment transport benefit, it could be defined as the reduction in watershed sediment transport modulus per unit terrace area. The longitudinal distribution of Rt was upper and middle > lower and the vertical distribution of Rt was high > low place. The 77.67% was erosion

reduction of the terraces of middle and upper occupying 33% of the watershed area. The change of the Rt was around logarithmically related to the relative distance（r） from the center of the terrace. When r was around 0.35, there was an inflection point in Rt growth. The results of this study have important practical significance for the planning and construction of terraced in the watershed.

Keywords: Sediment transport; Terraced fields; Spatial Distribution; Loess Hilly-gully Region

Acknowledgment

Anbin Li, Lin Ma, Boyan Feng, Yuanhao Yu, Ruolin Meng, Xinghua Li, Xingcheng Zhang, Saiqi Han, Shaobo Long, Fanfan Zhou, Sixuan Liu, Lu Wang, and ZhaorunWang are gratefully acknowledged for their help during the laboratory experiments.

References

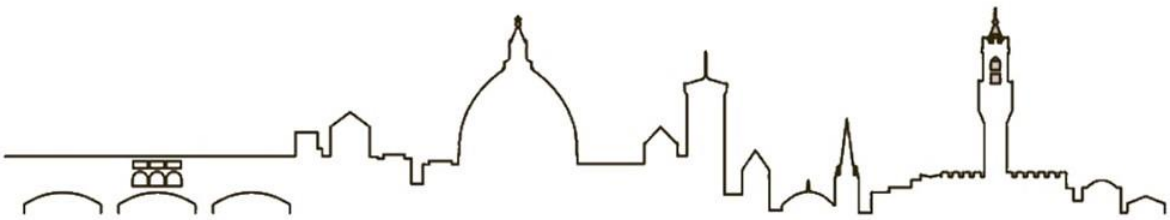
[1] Liu, X.Y.;Wang, F.G.; Yang, S.T.; Li, X.Y.; Ma, H.B.; He, X.Z. (2014). Sediment reduction effect of level terrace in the hilly-gully region in the Loess Plateau. J. Hydraul. Eng. 45, 793–800..

[2] Dorren, L.; Rey, F. A Review of the Effect of Terracing on Erosion; Boix Fayos, C., van Asselen, S., Imeson, A.C., Eds.(2004). Briefing Papers of the Second SCAPEWorkshop; Amsterdam: Scape, Italy, 2004; pp. 97–108.

[3] Zhe G., Genguang Z.*, Henghui F., Qianqian J., Anbin L., Yuanyuan Z., Boyan F.,Yuanhao Y., Lin M. and Jianen G.*.（2022）Erosion-Transportation Processes Influenced by Spatial Distribution of Terraces in Watershed in the Loess Hilly–Gully Region (LHGR), China. Water,14,1875.https://doi.org/10.3390/w14121875

Topic 7:

Social, economic & political issues to sediment and water management



WASER and its Establishment

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Abstract

Problems of soil erosion and sedimentation are a matter of global concern (Sundborg and Rapp, 1986). With the intensification of global changes and the impacts of human activities, many countries are facing severe challenges of sediment problems in river management, flood prevention and disaster reduction, water resources development and utilization, and ecological environment protection. The prevention and control of sediment disasters and the rational use of sediment resources are directly related to the rational use of water and soil resources in the river basin, flood control and the protection of the ecological environment. It is an important part of the sustainable development strategy for all countries (Lin, 2003). Although sediment problems have resulted from natural events, they are closely related to social, economic and other human activities. Therefore, the sound solution of sediment problems must come from the concerted efforts of experts in various fields concerned and is thus always interdisciplinary. Many international organizations also direct attention to sediment problems. However, the scope of these organizations is often limited to the specific topics of interest in the individual organizations. It is necessary to establish a truly comprehensive organization for promotion of sediment research.

In view of the increasing recognition of sediment as a topic of global significance, the World Association for Sedimentation and Erosion Research (WASER) was inaugurated on October 19, 2004 during the 9th International Symposium on River Sedimentation (9th ISRS) in Yichang, China. About 400 scientists, hydraulic and civil engineers and river managers attended the inauguration ceremony (WASER, 2004).

The 1st ISRS held in Beijing in March, 1980 can be seen as having sown the seed for WASER, indicated by Prof. Des. Walling, the first President of WASER (WASER, 2005). Initiated and promoted by Prof. Bingnan Lin, the then-Chairman of the Advisory Council of International Research and Training Center on Erosion and Sedimentation (IRTCES), the proposal for the new Association was first put forward in the 4th Advisory Council meeting of the IRTCES in October, 1998. The proposal was discussed in meetings organized by Prof. Zhaoyin Wang during the 7th ISRS in Hong Kong, China in December, 1998 and during the 28th IAHR Congress in Graz, Austria in August, 1999. Afterward comments and opinions were sought internationally and domestically by making use of opportunities such as meetings, conferences and visits, and most responses were positive with many good suggestions.

IRTCES had consulted widely with eminent scientists and engineers in the field of erosion and sedimentation studies on the proposal by sending letters and emails during 2002 and 2003. About 220 scientists and engineers had replied in response to the proposal and expressed their supports for the new Association and willingness to be members of the Association. Several organizations, including UNESCO and IAHS, were clearly supportive in the proposal.

With the strong support of the Chinese government, especially the Ministry of Water Resources, the first council meeting of the WASER was held in Beijing on Oct. 16, 2004. The meeting approved the statutes of WASER, confirmed the logo and elected the President, Vice Presidents, council members and Secretary General. The then-Minister Shucheng Wang and then-Vice Minister Lisheng Suo of Water Resources of China had a meeting with the council members in Yichang on October 18, 2004.

WASER is an independent non-governmental, non-political, non-profit organization, at all times free of racial, gender or national prejudice. The objectives of WASER are to promote the study and development of the science of erosion and sedimentation and to foster the application and dissemination of the knowledge. The mission of WASER is to further understanding and its application in the field of erosion and sedimentation, through international contacts among scientists, engineers, organizations, institutions, and governments (WASER, 2005).

Under the excellent leadership of the 1st & 2nd terms of President Prof. Des. Walling (UK), the 3rd & 4th terms of President Prof. Giampaolo Di Silvio (Italy), and the 5th & 6th terms of President Prof. Zhaoyin Wang, WASER has developed and becomes an international hydro-science organization of world influences. Main activities of the Association includes: 1) Sponsoring the ISRSs, which has been served as the official Symposium of the WASER since 2004: the 10th – 14th ISRSs were held in Russia in 2007, South Africa in 2010, Japan in 2013, Germany in 2016, and China in 2019; 2) Sponsoring and co-sponsoring other international conferences: the 3rd - 7th ICECs sponsored by WASER and IRTCES were held in Japan in 2009, Vietnam in 2012, Omen in 2015, France in 2018, and China in 2021; and over 30 other international conferences such as the 1st – 5th World Large Rivers Conferences co-sponsored by WASER were held; 3) Publishing the *International Journal of Sediment Research* (IJSR), which has become the official journal of WASER since 2004: it has changed from being a quarterly journal to a bimonthly one in 2019 and the Journal Impact Factor (JIF) has increased to 3.259 for 2021 from 0.718 for 2013; 4) Organizing international training workshops: several international training workshops on sediment transport, reservoir sedimentation, and integrated sediment management were organized. The Online Training Workshop on Sediment Transport Measurement and Monitoring which held in 2021 attracted more than 870 participants from 61 countries and regions; 5) Prizes awarding: 7 distinguished experts have been awarded as the Honorary Members of WASER, 8 eminent scientists have been awarded as the International Qian Ning Prizes, and 15 papers have been awarded as the IJSR best papers since 2007.

WASER has its website as http://www.waser.cn/, and the Secretariat is located in IRTCES, Beijing, China. All of the scientists and engineers interested in the sedimentation and erosion management and studies are welcome to become a member of the Association.

Keywords: Erosion and sedimentation; association; symposia; journal

References

[1] Lin, B.N. (2003). "Proposal to Organize a World Association for Sediment Research by the International Research and Training Center on Erosion and Sedimentation (IRTCES)". http://www.waser.cn/waser/AW/webinfo/2015/05/1431074893250364.htm.
[2] Sundborg, A., Rapp, A. (1986). "Erosion and Sedimentation by Water: Problems and Prospects". Ambio, 15(4), 215–225.
[3] WASER (2005). "Statutes of the World Association for Sedimentation and Erosion Research". International Journal of Sediment Research, 20(1), 78-80.
[4] WASER (2004). "Inauguration of the World Association for Sedimentation and Erosion Research (WASER)". International Journal of Sediment Research, 19(4), 321-326.