

Past, present and future suspended sediment transport in large German rivers

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Introduction: Suspended sediment transport is an integral part of river systems and provides important services for ecological functioning and human use of river channels.

Suspended sediment transport has been strongly altered by human activity in many parts of the world. While deforestation and agricultural land use strongly increased soil erosion and sediment supply, dam construction for hydropower production, waterlevel control, and irrigation purposes disconnects downstream sediment transport with often negative effects for downstream river ecology and human wellbeing. Restoring disturbed sediment balances of river systems requires detailed knowledge of past, present and future trajectories of sediment transport. This study aims to present the state of the art of suspended sediment monitoring in large German river systems, which represent an important logistics transport routes for the German economy.

Methods: Suspended sediment in German waterways is monitored at ~ 62 monitoring stations by the Waterways and Shipping Authorities starting in the 1960s. The dataset provides valuable information on the long-term development of suspended sediment transport in Germanys major rivers. We use suspended sediment rating [1] analysis to understand event-based and seasonal suspended sediment dynamics and to infer sources of suspended sediments. Past trends were derived for suspended sediment concentrations [2]. Climate change impacts were evaluated using convection permitting climate simulations [3], which allow for a better representation of rainfall induced soil erosion events for the calculation of future rainfall erosivity scenarios. Finally, we compared recent loads with long-term rates derived from stratigraphical evidences.

Results: The results indicate that river systems in Germany have witnessed strong increases of suspended sediment transport in response of large-scale deforestation during the Bronze age. After reaching maximum suspended sediment loads during the last 200 years, suspended sediment concentrations have strongly declined between 1990 and 2010. Since 2010, the decreasing trend of suspended sediment

concentration has stopped. Global warming leads to higher atmospheric moisture fluxes causing an increase in the intensity and frequency of heavy rain events, globally as well as in Central Europe [e.g. 4]. Especially in summer, convective, high-intensity precipitation is increasing. The observed past and expected future increase in extreme precipitation suggests an increase in soil erosion and suspended sediment supply in the near and far future. This expected trend is supported by increasing rainfall erosivity in Central Europe for the near and far future, of up to 80%.

Discussion: The presented trajectory of suspended sediment transport in German river systems provides valuable insights for sustainable sediment management in these systems. The results are discussed in light of past (natural) reference conditions for suspended sediment in German rivers and expected future developments, which require climate-resilient sediment management solutions.

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Tracing gravel in the German Upper Rhine using radio acoustic transmitters – findings from a preliminary study

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Introduction: The Rhine is Germany's most important inland waterway. Downstream of its last barrage near Iffezheim it is free-flowing. Construction of this barrage resulted in the retention of all sediment fractions larger than sand, which in turn requires ongoing bed load nourishment since 1978, in order to prevent river bed incision.

The effectiveness of these nourishment measures can only be assessed through a thorough monitoring which in turn enables appropriate adjustments to be made, if necessary, to counteract undesirable developments of the river bed morphology. Regularly conducted echo-soundings, along with bed load transport measurements and river bed samplings help to inform about the development of the river bed. However, open questions remain regarding the conditions required for bed load transport to occur and its extent during various discharge conditions. Apart from an improved assessment of the effectiveness of the nourishment measures and a generally better system understanding, answering these questions would provide valuable input parameters for the validation and calibration of bed load transport models.

With the aim of obtaining better insights into the bed load dynamics of the Upper Rhine in the future, we tested an elsewhere proven method for this river reach in this preliminary study.

Methods: We used artificial tracer stones consisting of a distinctive radio acoustic transmitter incorporated into resin material and added lead balls to obtain the density of natural gravel (Liedermann et al., 2013). Production of the tracers using a mold of a representative stone ensured the identical shape of all tracers in a size group. A total of 22 tracers, ranging in size from 24.5 to 67.3 mm, was added to the river within one cross-section, just downstream of the nourishment reach. The size of the tracers covered the range from median grain size up to the 99th percentile for this river reach. Additionally, 4 tracers (d_{90} -size: 49.7 mm) were positioned at different depths of a depth profile.

Individual positions were determined from a boat using a directional antenna, with searches taking place

every 3 weeks, on average, for the first 15 months, and after 21 months.

With the aim of reducing the work effort, we are also working on ways to automate the detection process.

Results: Overall detection rates of the tracers were at 73%, significantly dropping at water levels ≥ 5 m, especially for the two smaller tracer sizes, while the larger tracers could be reliably detected during most conditions. Additionally, increasing dispersion over time made searches more time-consuming.

Average tracer velocities over the 21-month period were between 9 m/day (d_{99}) and 20 m/day (d_m), with the fastest tracers moving at 13 m/day (d_{99}) and 27 m/day (d_m). During high discharge conditions, average velocities ranged up to 38 m/day (d_{99}) and 102 m/day (d_m), respectively, while during low-flow conditions only very little to no transport occurred.

Similar to transport velocity, transport probability generally increased with increasing discharge conditions throughout the tracer size range, while it decreased with increasing tracer size. However, even during low-flow conditions, transport probability was at least 40%, even for the larger tracers. Once tracers moved, they often showed laterally alternating patterns within the fairway between point bars.

Discussion: Using radio acoustic tracer stones proves to be feasible to investigate bed load dynamics in the Upper Rhine, especially for larger grain sizes in the coarse gravel range – due to stronger signals – and for flow condition even above mean flow. However, large efforts to detect most of the small number of tracers at adverse conditions reveal the need for further improving the method, e.g. through automation.

Size- and discharge-specific transport probabilities hint towards conditions for incipient motion. Together with transport velocities and pathways, these insights provide valuable data for the improved validation and calibration of bed load transport models, which in turn help to better inform sediment management measures.

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Landscape Reading of River Systems: Exploring the Geological History of Alpine Rivers

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Introduction: Understanding a river's morphology requires examining its geological history: Fluvial development is controlled by changes in climate as well as tectonic processes and sediment dynamics [1, 2]. Glaciation processes, for example, are majorly responsible for reshaping landscapes by eroding older sediments and reorganizing river pathways [3, 4, 5]. The relationship between the geological history and morphological characteristics of selected Alpine rivers is analyzed, incorporating the findings of [6]. We illustrate how river morphology reflects the evolutionary history of different stretches along selected rivers [6].

Methods: We applied a hybrid approach [7] to the 'landscape reading' concept [8] to differentiate between the selected rivers' sections. This method uses three parameters: Active Channel (AC), Active Floodplain (AF), and Morphological Floodplain (MF). These were determined through a GIS survey (ASTER GDEM v3; AC, MF) and a hydraulic 1D step-backwater model (HEC-RAS) of a five-year-recurrence interval flood scenario (HQ5; AF), based on [7]. Channel sinuosity, including hydraulic and topographic sinuosity [9], was also evaluated.

Results: Analyses of landscape reading elements, hydraulic vs. topographic sinuosity, and longitudinal profile, confirm how the upper Biya (Siberia), formed in the late middle Pleistocene, contrasts with the older, well-developed valley downstream [10] (Fig. 1). The upper Biya has a linear longitudinal profile (associated with sediment equilibrium [11]), while the rest of the river follows a concave shape (indicating downstream fining and channel aggradation [11]).

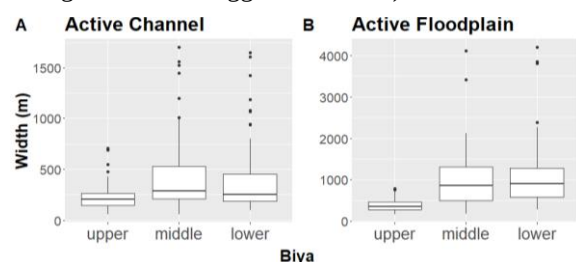


Fig. 1: Biya: Selected landscape reading elements.

Discussion: The shape of natural rivers is mainly a result of geological factors as well as climatic and hydrological controls. If these boundary conditions change at any point in space or time along a river, it is likely to exhibit changes in its morphology.

The example from the Biya precisely demonstrates this: Its upper valley shows evidence of a past glacial lake outburst flood. Moraine dam failure caused the catastrophic Biya debris flow (BDF) which initiated major valley incision processes that led to the development of the upper Biya about 37.5 ka before present [10, 12].

The relatively simple landscape reading approach, [7] effectively accounts for such differences in the evolutionary history between river sections. This method already yielded similar findings at the Vjosa [7].

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Sediment Dynamics in an Alpine River: A Case Study from the Ötztal, Austrian Alps

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Introduction: By the end of the 21st century, the Alps are predicted to be largely ice-free [1]. This reduction in glacier area raises many critical questions about the impact on high alpine (glacio-)fluvial processes and associated sediment dynamics [2, 3]. Particularly in formerly glaciated catchments, there is a considerable need for research to understand how glacier loss affects sediment fluxes and storage. This study addresses this issue by analyzing the long-term effects on sediment transport in an alpine river system. The focus is on the Vent/Rofenache monitoring station in the Austrian Ötztal, a representative example of a high alpine, formerly heavily glaciated catchment.

Methods: Sediment transport has been systematically analyzed at the Vent/Rofenache monitoring station since 2007. Both direct and indirect measurement methods are used (Figure 1). An indirect system, the plate geophone system (Figure 1 a, b), is used, which is based on the recording of seismic signals induced by the movement of bedload particles over the steel plates [4]. The direct methods include the use of a mobile basket sampler (Figure 1 c), which allows bedload material to be collected and quantified during specific discharge conditions [5]. The calculation of bedload transport can be achieved through an integrative approach, which involves a combination of direct and indirect measurements [6].

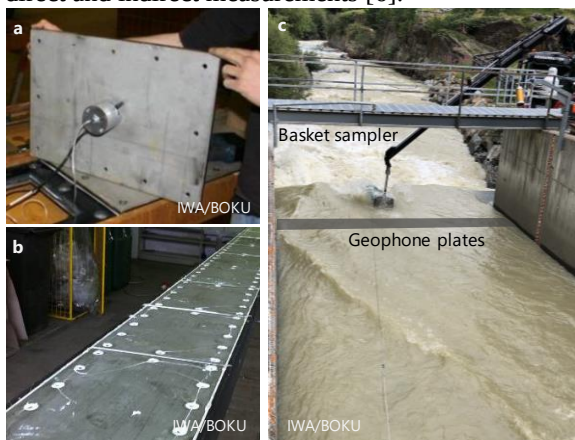


Fig. 1: (a) Steel plate with geophone sensor underneath; (b) geophones plates [6]; (c) direct bedload measurement with mobile basket sampler downstream of the geophone plates.

Results: The results so far show a clear dependence of sediment transport on hydrological conditions, which in turn are strongly influenced by glacier retreat. As glaciers retreat, the sources and amounts of sediment change. While in other catchments increased sediment release from formerly glaciated areas was observed in the early years after deglaciation, there are now signs that sediment flows are stabilizing [7]. This is still under investigation for the Rofenache catchment area. The measurements also show that extreme weather events, such as heavy rainfall or intense snowmelt, play a crucial role in sediment transport and strongly characterize interannual variability.

Discussion: The results highlight the complex relationships between glacier retreat, hydrological changes and sediment dynamics in high alpine catchments. Glacier retreat not only changes the availability of sediment sources, but also influences transport pathways and processes [3]. These changes have far-reaching consequences for the management of alpine water resources, the ecological stability of rivers and the infrastructure in the affected regions. Future studies should focus on modelling long-term developments in order to develop scenarios for the sediment budget under different climate projections.

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Glacio-fluvial sediment connectivity: A catchment-scale perspective in a rapidly retreating glaciated area in the Austrian Alps.

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Introduction: What will be the consequences to high alpine rivers if glaciers disappear and the Alps become almost ice-free? The scientific community widely acknowledges that the ice-free Alps are a likely scenario by the end of the century [1,2]. This ongoing transformation prompts the question: How formerly glaciated catchments will influence high-alpine glacio-fluvial processes, downstream sediment yields, and sedimentological conditions?

Sediment is transported through a catchment via various processes, passing through different compartments of the sediment cascade in a glaciated catchment. Each subsystem of the sediment cascade can act as a (temporal) sediment sink or sediment source [3,4]. The catchment (dis)connectivity between subsystems is highly dynamic and crucial whether sediment reaches the glacio-fluvial system [3] and is thus one decisive parameter for transport-limited or supply-limited conditions at reach scale [4]. Controlling factors for the subsystem connectivity are, e.g., geology, slope angle, confinement, sediment texture, grain size, vegetation, or magnitude-frequency flows [5].

The study aims to outline, from the glacio-fluvial perspective, the (i) sediment connectivity and sediment supply throughout the catchment of the *Rofenache River* and (ii) longitudinal, lateral, and vertical (dis)connection at the reach scale. The study site is located in the Austrian Alps (Fig. 1), characterized by a high relief (1889 – 3763 m a.s.l.) and continuous glacier retreat since the end of the Little Ice Age (LIA) around 1850 – totaling $\Delta A_G = 34.5 \text{ km}^2$ [6] – with yearly ablation records in the recent decade [7].

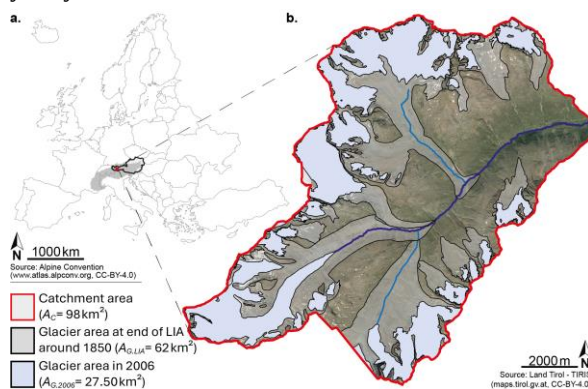


Fig. 1: (a.) Location of the study area in Europe and the eastern Alps in Austria; (b.) catchment area illustrating the glacier loss since LIA around 1850 [6].

Methods: The study area is defined by (i) LIA glacier margins and (ii) active bedload-bearing tributaries. The data used to detect (dis)connections within this spatial boundary were obtained by (i) multitemporal, multispectral aerial surveys using a UAV (DJI Mavic 3M) at different flight levels and (ii) documentation of granulometric data on the sediment along the proglacial rivers. High-resolution digital terrain models and orthomosaics were generated from the survey data. The characterization of the catchment area was done by (i) geodata analysis and (ii) hydraulic modeling. This combined approach allows a detailed connectivity analysis, mapping the (partly disconnected) sediment supply chain within the catchment, and identifying erosion and deposition zones in the reach scale.

Results: Within the studied catchment, hierarchical levels of subsystems were identified. The primary sediment load of the main proglacial river *Rofenache* is supplied by various tributaries. Each tributary subsystem is further divided into several proglacial sub-subsystems, predominantly characterized by a large quantity of glacially deposited sediment. The detailed sediment connectivity analysis revealed (temporal) sediment storages across different landform types in all spatial directions (lateral, longitudinal, and vertical).

Discussion: The study findings indicate that glacio-fluvial sediment connectivity and reworking is highly affected by time-varying controlling parameters, driving the recurring shifts between supply-limited and transport-limited conditions at the reach scale. Glacier retreat enhances sediment connectivity within a catchment in several ways [8]. However, the downstream sediment yield is primarily determined by the (subsystem) connection to the proglacial river system.

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Urslau case study: A comparison of transport equations with long-term monitored bedload data

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Introduction:

The need for natural measurement data on bedload transport is crucial for implementing sustainable engineering measures and improving process understanding. Measured data are indispensable for the validation and calibration of transport formulas. This study is based on a long-term bedload data set from an alpine stream and offers valuable insights for analyzing bedload transport process and comparing it with commonly used transport equations.

Study Site:

The Urslau stream is situated in the province of Salzburg, within the alpine region of Austria. In 2011, an integrative bedload monitoring station was installed. The upstream catchment area covers 56 km², stream width is 8m and bed slope is 0.021.

Methods:

The integrative bedload monitoring station combines direct and surrogate measuring devices and therefore compensates for shortcomings and limitations of individual methods [1]. It enables a continuous and holistic monitoring of the process. Direct measurements are performed at the measuring site using a slot sampler (Birkbeck type) and an adapted mobile net sampler. Seven plate geophones are distributed across the stream cross-section, which have been continuously recording the transport process since 2011. The geophones are calibrated by correlating the results of the direct measurements and the geophone impulses [2, 3]. Fig.1 shows a basket sampler measurement at the measuring site.

Results:

In contrast to single-point measurements, a long-term, continuous, and integrative bedload dataset captures a broad spectrum of bedload transport characteristics (e.g., temporal variability, sediment availability, bedforms, the influence of previous flow events, fluctuations in sediment availability) in gravel-bed streams. This article deals with the comparison of this integrative measured data with commonly used transport equations. A key aspect of this evaluation is the classification of bedload transport events into

different event types, which are linked to sediment availability [2, 3].

Fig 1 b presents exemplary for the results of this study measured versus calculated (using the Meyer-Peter Müller formula) bedload volume of events. The volumes of large, extraordinary events, which are associated with high sediment availability, are better described than those of ordinary events.

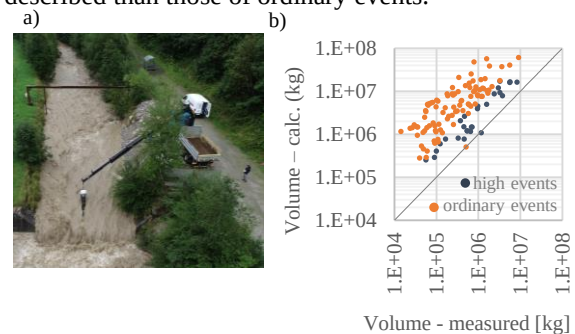


Fig. 1: a) basket sampler measurement at the study site, b) Calculated vs. measured volumes

Discussion:

The use of bedload transport formulas is crucial in practice, but recent research has raised questions about their reliability, given the highly variable and complex nature of the bedload transport process. The benefit of the current study is the availability of a long-term integrative bedload data set at a steep downstream section of a mountain stream. The study suggests that, depending on the specific question and the choice of the appropriate formula, improved calculation results for practical applications can be achieved.

Acknowledgments:

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Exploring the role of sediment availability in the morphological response during floods: the case of the Tenetra stream (Marche, Italy)

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Introduction and goal: Predicting geomorphic changes in rivers after floods remains a significant scientific challenge due to the complex interplay of hydrodynamic forces, sediment supply, and sediment availability. These factors play a crucial role in determining how rivers respond to extreme events, including channel morphology, sediment transport, and deposition patterns. Exploring these aspects is the primary objective of this study. Effective sediment control and management are increasingly recognized as critical to promoting the sustainable use of natural resources and mitigating environmental impacts.

Study site:

On 15-16 September 2022, the Marche region experienced an exceptional meteorological event, with localized rainfall reaching 419 mm in twelve hours—a record intensity over the past decades. This huge amount of rain water was derived by a self-regenerating storm system and led to the overflow of watercourses and widespread flooding, with peak rainfall intensities of up to 90 mm/h [1]. In the municipal territory of Cantiano, one of the most severely affected areas, intense soil erosion led to the mobilization of substantial amounts of mud and debris, exacerbating damage to built-up areas. The research focuses on a sub-basin of the Burano River, which experienced profound morphological changes due to the mobilization of coarse sediments during the event. This study seeks to advance understanding of these processes to improve predictive models and inform sustainable river management practices.

Methods: The Iber model [2], a two-dimensional numerical tool designed for simulating free surface flow in rivers, is employed to investigate erosion and deposition processes in Tenetra Creek. Iber solves the full depth-averaged shallow water equations to compute water depth and velocity. These equations are resolved using an unstructured finite volume solver explicit in time. The sediment transport module within Iber is used to model bedload transport, applying the Meyer-Peter and Müller equation [3]. Rainfall and topographic data were incorporated to refine the simulations, capturing critical aspects such

as flow velocity, depth, critical shear stress, and erosion potential. Peak flow conditions were defined based on hydrodynamic modelling scenarios, with maximum discharge values derived from rainfall data during the considered event.

The model used a sediment inlet with bedload capacity, to dynamically calculate sediment inflow, ensuring sediment transport was based on the flow's capacity to mobilize material rather than imposing arbitrary quantities. The transport capacity was determined using hydraulic parameters such as velocity, shear stress, and sediment grain size, employing a combination of theoretical models and empirical equations. Multiple scenarios were developed to analyse the river's response to erosion and sedimentation processes responsible for morphological changes in the riverbed. The modelling incorporated various (d_{50}) values to explore the dynamics governing the coarse sediments' transport and better understand the underlying mechanisms driving these changes.

Results: The results of the above-mentioned applied methods are expected to provide critical insights into the role of sediment availability and its influence on morphological changes during flood events, not only in the studied river but also in analogous fluvial systems. This enhanced understanding will contribute to developing more effective flood management and river restoration strategies, aiding in designing of sustainable measures to mitigate flood impacts and improving sediment management practices across similar geomorphic contexts.

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Analysis of sediment transport in Ebro Delta channels to optimise the irrigation network efficiency in diverting sediment to vulnerable areas.

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Conference theme: Healthy Sediments

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Introduction: The Ebro Delta is one of the most valuable delta systems in the Mediterranean, where a Ramsar protected wetland coexists with an extensive rice production area supported by a complex network of irrigation canals. Sediment supply to the delta has drastically declined in recent decades due to sediment trapping within the upstream reservoirs system of Mequinensa, Riba-Roja, and Flix. The sediment deficit, combined with natural land subsidence and accelerated coastal erosion driven by climate change, poses a significant threat to the delta's land availability. In response, the Confederación Hidrográfica del Ebro is exploring a pilot project in the Riba-Roja reservoir to develop a bypass system that would release trapped sediments and restore their transport to the delta. However, this approach may lead to increased sediment loads in the irrigation network, potentially causing sediments to accumulate in the channels rather than being effectively distributed across the delta. This project aims to analyse the sediment transport capacity of the irrigation canals and optimize the network's operation to direct sediment toward areas most vulnerable to land subsidence and coastal impacts.

Methods: Using a numerical model of the irrigation network, the Consortium will analyse the transport of fine sediment under different hydraulic conditions, sediment concentrations and particle sizes to estimate the sediment volumes reaching vulnerable areas. By simulating the scenario of the Riba-Roja bypass system, the project aims to evaluate its potential to mitigate land loss in the Delta. Finally, the study will assess the operational feasibility of the irrigation network under these conditions and propose management strategies to direct sediment to the most vulnerable areas.

The methodology uses a coupled 1D hydraulic and sediment transport model applied to various irrigation channel scales with different section geometries and discharge ranges, all within a unified simulation domain. The IBER tool's 1D urban drainage module is adapted for open channel flow with variable hydraulic conditions and depth-averaged convection-diffusion sediment transport. Calibration involves a

field campaign measuring hydraulic variables (flow velocity and depth) and conducting sediment injection tests with different particle sizes.

Calibration of the model will be carried out through a field campaign where hydraulic variables (flow velocity and depth) and suspension matter, including suspended sediment, will be measured. These experiments determine the appropriate sediment transport formula for the model (between Ariathurai, Ariathurai-López, Smith-McClean, or van Rijn), calibrate the channel roughness coefficient, and validate model performance in various flow and concentration scenarios, which are also field-tested.

Results: After model validation, scenarios of channel discharge, sediment concentration, and particle size are simulated to generate transport efficiency curves (relationship between flow conditions and sediment particle diameter) for each channel typology. The expected results include defining particle size thresholds for transport and deposition, estimating sediment volumes reaching vulnerable areas, and identifying sediment-prone locations within the irrigation network.

Discussion: In collaboration with the Ebro Delta farmer-irrigation communities, this project will provide a user-friendly modelling tool to optimize channels operations and reduce sediment-related maintenance costs. Using numerical methods validated by field experiments, the study will evaluate whether the irrigation network can enhance resilience by directing sediment to areas vulnerable to land subsidence and climate-driven sea impacts.

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Sediment Transport and Metal Dynamics in an Acid Mine Drainage-Affected Estuary: Insights from the Ria of Huelva

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Introduction: The Ria of Huelva estuary is a severely Acid mine drainage (AMD)-affected system, which receives the inputs of two strongly metal polluted rivers, the Odiel and Tinto, which drain the Iberian Pyrite Belt (SW Spain). Consequently, enormous concentrations of potentially toxic elements (PTE) are transported to the estuary and through it to the Atlantic Ocean. Although the mixing of waters in estuaries results in the presence of a salt wedge and a progressive decrease in salinity inland, the Ria of Huelva also experiences a water pH gradient, ranging from acidic values (2.5 to 3.5) to alkaline values typical of the seawater. As a result, the sediment of the estuary of Huelva, which reflect the polluted river discharges, have been classified as one of the most metal polluted estuaries worldwide [1].

Methods: Water and sediment samplings have been conducted under different hydrological conditions (e.g., during rainfall-induced flooding event, before and after the summer period) and along the estuary to reflect the sharp hydrochemical gradients. Filtered and unfiltered water samples has been collected for the study of dissolved and total contaminants concentrations. Whereas surface sediments have been sampled at tidally influenced sites using PVC tubes, separated in different aliquots, frozen at -80 °C in sterile plastic bags and freeze-dried (Telstar LyoQuest, -40 °C and 0.2 mbar of pressure) before acid digestion. Trace elements concentrations have been determined by iCAP TQ ICP-MS (Thermo Scientific ®) at the AETE-ISO Platform (OSU OREME, Université de Montpellier).

Table 1. Metals and metalloid concentrations of reference for water and sediments and measured concentrations.

(*) Surface Water		Tinto-Odiel Rivers Water average		Sediments (mg/kg)		Tinto-Odiel estuary
Element	(µg/L)			ERL ^a	ERM ^b	(**)Nature concentration
As	25	> 70	8.2	70	10	2900
Cd	0.2	30	1.2	9.6	0.18	5
Cr	5 (Cr(VI))	5	81	370	30	106
Cu	25	> 5 000	34	270	14	2400
Ni	20	> 200	20.9	51.6	19	56
Pb	7.2	> 75	46.7	218	23	1800
Zn	60	> 2 000	150	410	60	3500
Fe	-	1 000 -15 000	-	-	66 300	144 000
Al	-	> 10 000	-	-	170 000	70 000

^{*}Environmental Quality Standards expressed as an annual average value (NCA-MA)

^(**)Concentration ranges of heavy metals in coastal marine sediments free of anthropogenic influence (CEDEX 2021)

^aERL (effects range-low): represents values below which biological effects are

^bERM (effects range-median): represents values above which biological effects are

Results: Contaminants transported from mining areas exhibit different behaviors in the estuary: non-conservative elements, mainly Fe, Al, and Cu, are removed from the water through mineral precipitation during the neutralization of AMD. In other words, they tend to become part of the particulate matter that deposits in the bottom sediments. On the other hand, conservative elements like Zn, Mn, Ni, and Co remain in solution throughout the estuary, reaching the Atlantic Ocean. Finally, elements with an ON-OFF behavior, mainly arsenic, are initially retained through processes of adsorption or mineral coprecipitation (OFF) and later released back to the water column (ON), also reaching the ocean along with conservative elements. Sediments from the study site turn out to be highly polluted with PTE concentrations surpassing Spanish guidelines and international sediment quality guidelines, especially for As (300 – 1300 mg/kg), Cu (300 – 3500 mg/kg) and to a lesser extent Zn (100 – 1400 mg/kg) and Cd (0.2 – 5.8 mg/kg) (Table 1).

Discussion: Environmental impact associated with mining-affected water discharges as well as industrial activities are the major threats for the degradation of the high ecological value of the estuarine/coastal system of the Ria of Huelva, which include several environmental protected areas (e.g., Biosphere Reserve and RAMSAR site Paraje Natural Marismas del Odiel, Natural Reserves Marismas El Burro and Isla de Enmedio and Special Areas of Conservation (SACs) Marismas y Riberas del Río Tinto and Estuario del Río Tinto.

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Wet season sediment plume distribution across northern Australia; primary productivity and climate change.

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Introduction: Northern Australia is home to some of the world's most expansive and ecologically significant river systems. These river catchments, which drain into the Gulf of Carpentaria and the Timor Sea, deliver sediments and nutrients that are vital to both the health of the region's coastal ecosystems and its commercial fisheries¹. This study investigates the relationship between wet season river flows, sediment plume extent, and primary productivity in adjacent coastal seas, with a focus on understanding potential impacts from climate change and water extraction on these dynamics.

Methods: Hydrological data from 2003 to 2023 was analysed for the Flinders, Gilbert, and Daly Rivers to determine peak wet season flow events and the corresponding sediment plume extent using MODIS satellite imagery. Primary productivity following each event was determined using ocean colour algorithms. Future plume extent under climate change anomalies was determined from ensemble climate projections.

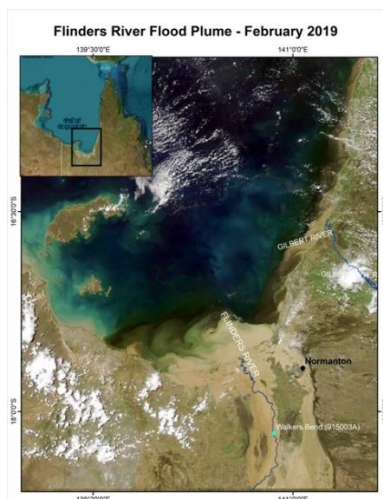


Fig. 1: Sediment plume in the Gulf of Carpentaria, northern Australia, following a peak wet season flood event.

Results: The study found that flood plumes were highly variable across the 20-year period, with significant events recorded in 2019 and 2023 and strong relationships between 7-day river flows and plume extents for all rivers.

Primary productivity, measured through chlorophyll-a concentration, was significantly associated with plume size in the southern Gulf of Carpentaria and Anson Bay, specifically for tertiary plumes from the Flinders, Gilbert, and Daly Rivers. Future climate projections indicate potential reductions in rainfall by 2070-2099, which could lead to decreases in flood plume extent and associated primary productivity.

Discussion: This research highlights the critical connection between river flows, coastal flood plumes, and marine productivity in northern Australia. The findings underscore the importance of maintaining environmental water flows to sustain coastal ecosystems and fisheries, particularly in the context of increasing water allocation pressures and the potential impacts of climate change on regional rainfall patterns.

References: [1] Burford, M. A., & Faggotter, S. J. (2021). Comparing the importance of freshwater flows driving primary production in three tropical estuaries. *Marine Pollution Bulletin*, 169, 112565.

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