EDITORIAL

LARGE RIVERS HYDROLOGY AND SEDIMENT TRANSPORT

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ABSTRACT. This paper provides a short overview of the large river research topics discussed during the 4th World's Large Rivers Conference and submitted to the Geography Environment Sustainability special issue. The various aspects of hydrology, sediment transport and river morphology issues are presented based on case studies from Eurasia and Africa.

KEYWORDS: sediment transport, river morphology, river pollution, river geochemistry, Arctic, fluvial processes, flood

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INTRODUCTION

Large rivers are particularly vulnerable to conflicting uses and pressures that have risen in recent years. In addition to the lack of an overall assessment of the current status of the World's Large Rivers, the conflicting demands on such rivers, the likely future impacts of anthropogenic activities, and any restoration potential. There is also a lack of an overview assessment of the problems associated with their restoration. This special issue, «Large rivers hydrology and hydrogeochemistry», follows-up the 4th World's Large Rivers Conference, which was held as a hybrid event from the 3rd – the 6th of August 2021 in Moscow and covers two of four thematic focus areas of the conference: Hydrology, Hydraulics and Hydroclimatic Impact (TOPIC I), Sediment transport and river morphology (TOPIC II).

The current issue's Hydrology, Hydraulics and Hydroclimatic Impact section begin with studies by Nasonova et al. (2022) and Vasilenko et al. (2022) exploring the influence of climate change on water and heat flux of Arctic rivers. In contrast to Arctic environments, Houteta et al. (2022) give insights into altering water balance components in sub-tropics due to global warming. Yaitskaya et al. (2022) further describe the necessity of high-quality digital elevation models (DEM) for hydrodynamic modelling, while the study by V. Bondarev (2022) reveals the social consequences of flooding at the beginning of the XXI century. The second part of the issue is devoted to Sediment transport and river morphology studies. It starts with a paper by Schmalfuss et al. (2022) tackling the problem of hydromorphological analysis in hydrology, followed by research focused on bedload sediment measurements (Petrovskaya et al. 2022). The last two papers examine water quality issues associated with sediment load in the Selenga River delta (Zaharova and Belyaev 2022) and Tarbela reservoir (Mazhar et al. 2022). Key aspects addressed by the manuscripts in this volume are visualized in Fig. 1.

Fig. 1. Word cloud showing the most frequently used expressions in this thematic issue (based on manuscript titles and abstracts)

HYDROLOGY, HYDRAULICS AND HYDROCLIMATIC IMPACT

Global warming is expected to majorly impact the pan-Arctic basins, primarily in the north, resulting in changes to air temperature, precipitation, and snowmelt. **Nasonova et al. (2022)** investigate the effects of climate change on five Russian Arctic river basins. The researchers used a SWAP model and data from five global climate models (GCMs) with four different climate change scenarios to come up with projections of how the water balance components (river runoff, evapotranspiration, and precipitation) could be altered. The study found that these components generally increased for all the rivers and varied depending on the natural conditions and scenarios used. The researchers also looked at the uncertainties in the projections, which are caused by using different GCMs and scenarios, and found that the contribution of the GCMs was nearly double that of the scenarios in the 2006-2036 period and then decreased over time.

The water and heat flux changes in the 1930–2018 period from more than 30 gauging stations located in the Russian Arctic are analyzed by **Vasilenko et al. (2022)**. Their analysis revealed that the heat flux from the rivers had not significantly increased in the past three decades, except for the Yenisei and Yana rivers. However, the water temperature of the rivers had increased since 1960, particularly in May and June, but not to a statistically significant extent. It was also determined that dams built along the rivers affected the water temperature in their lower reaches but not further downstream. Finally, the heat flux had decreased by 25% in the Yenisei river's lowlands and estuaries.

The Intergovernmental Panel on Climate Change (IPCC) has determined that sub-tropical areas are particularly vulnerable to the negative repercussions of climate change. The research by **Houteta et al. (2022)** look into water balance components alteration, such as streamflow, evapotranspiration, and land use and land cover (LULC) changes in the Mono River Basin (Togo-Benin) before and after the construction of the Nangbéto dam. The authors noted that a decreased natural vegetation correlated to decreased evapotranspiration and lateral flow. As a result, the paper concluded that sustaining and conserving natural vegetation is crucial for proper water resource management in Mono River Basin.

The following paper discusses digital elevation models creation for the needs of hydrodynamic modelling of the Don and Volga rivers. **Yaitskaya et al. (2002)** used topographical maps, bathymetric surveys, hydrographic maps, and Landsat-8 and Sentinel-2 satellite images to construct DEMs. To assess the accuracy, the article tested various roughness coefficients to see which most accurately represented the fluctuating water stages during events such as flooding from surges. The authors found that the DEMs created enabled them to reproduce the observed dynamics of river discharges and water level fluctuations during high water events, and this was the first time such detailed DEMs had been created for these river deltas.

Scientists have noticed that when it comes to an understanding the social consequences of natural disasters like floods, there is no clear consensus in scientific publications about which consequences should be focused on for proper analysis and management decisions. To see what matters to people in this context, **Bondarev (2022)** looked at over 100 scientific articles on the five biggest flooding disasters of the early 2000s. The results showed that usually, there is a six or seven-year cycle of interest in floods, reaching a peak in the second or third years, though some exceptions occur. As for what matters to us, death losses got the most attention, followed by social solidarity and management problems. Additionally, the study revealed that the level of interest in floods in any given country was linked to its Human Development Index (HDI), meaning that countries with higher HDI rankings were more interested in things like death losses, social solidarity and management than those with lower rankings.

SEDIMENT TRANSPORT AND RIVER MORPHOLOGY

The Biya river, located in the Russian Altai mountains, is an example of a hydromorphological reference system - an area of water relatively undisturbed by humans and thus well preserved. **Schmalfuss et al. (2022)** used aerial imagery, satellite maps, and data on landforms to analyze the Biya in three sections - upper, middle, and lower - and look for differences in topography and hydromorphology. The study showed that the differences in river shape related to the terrain around the river, which supports the idea that understanding a river should include its surroundings. Implementing easily obtainable parameters - like the width of the river channel - can help detect differences in river morphology and improve our understanding of fluvial processes.

Based on the mode of transport, sediment transport in rivers can be divided into suspended, bedload, and suspended bedload material transport (Rhoads 2020). Various methods exist to measure bedload sediment discharge in large rivers, but the empirical equation is the most popular and cost-effective one. **Petrovskaya et al. (2022)** investigated filling a ditch across the Amur River using an echo-sounder measuring device in the summer of 2018. This resulted in 108 measurements used to compare 80 bed load formulas. Researchers used four methods for this comparison: bed form, critical velocity, critical water discharge, and regression approaches. The bed form approach was the most accurate, with 17 out of the 26 formulas showing an error rate of less than 60%. The other 56 formulas had only 5 with an error of less than 60%; these five corresponded to the critical velocity approach.

Suspended sediment is primarily fine inorganic particles of clay and silt and can substantially affect water quality in rivers (Loperfido 2014). Therefore the knowledge of sediment origin can be crucial for sustainable management planning (Walling 2005). The research by **Zaharova and Belyaev (2022)** was conducted using the geochemical fingerprinting method, which uses a quantitative approach to determine sediment origin and associated pollution. Using this method, they found that the majority of sediment on the floodplains of the delta was sourced from floodplains and terraces slopes, and only a small amount originated from remote areas. Additionally, analysis of suspended sediment showed that material from floodplain banks was the dominant source of accumulation. Finally, heavy metals and pollutants were found to accumulate in the lower reaches of the delta during large floods, which could lead to pollutants entering Lake Baikal when the streamflow is lower.

Human activities, such as building dams and other structures, can have a significant influence on lakes and the life in them. This includes changing the sedimentation rate, the availability of light and nutrients, and how often the lake is disturbed. **Mazhar et al. (2022)** collected satellite images from 1990 to 2020 and studied how human activities had changed land use and water quality in the Tarbela reservoir, the biggest rock-filled dam in the world. They discovered that the amount of built-up areas increased by 630 km^2, reservoir turbidity decreased by 4%, chlorophyll and water increased, and overall water quality improved by 2020. The study suggests that more steps should be taken to decrease sediment and turbidity levels so that the reservoir's life can be extended.

CONCLUSION

In addition to providing economic vitality and habitat diversity, the world's large rivers and floodplains play an essential role in building civilization. Despite the effort to understand large river hydrology over the last few decades, very few hydrological, sediment, and nutrient data are available on large rivers worldwide. (Best 2019). Hopefully, the papers in this special Geography, Environment, Sustainability issue will narrow this gap and allow readers to study the latest developments and advances in World's Large Rivers.

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