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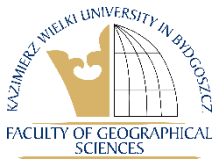

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Session 1

Sediment quantity - cascades, budgets, yields

USING CS-137 MEASUREMENTS AND RUSLE TO EXPLORE THE EFFECT OF LAND USE CHANGES ON SOIL EROSION RATES IN SOUTHERN ITALY

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Soil erosion by water is a serious environmental problem in upland areas of Southern Italy. In these areas, the change in land use over the last 4-5 decades has increased pressure on land and water resources, resulting in different forms of soil degradation. Quantifying the amount of soil loss from these areas is difficult in absence of direct measurements.
In this context, the radionuclide Cs-137 offers a good alternative to the classic experimental sites (plot, catchments) that, on the contrary, require long term measurements to produce reliable estimates of soil loss. In this contribution, measurements of Cs-137 in floodplain areas are firstly described for a representative Calabrian catchment as an example to reconstruct the variation of soil deposition during the last six decades. These measurements have been combined with land use maps of different periods to derive an estimate of the cover and management factor C for each land use class and to obtain an estimate of soil loss using the RUSLE model at a catchment scale. The final comparison between maps of soil erosion related to different periods and Cs-137 measurements on depositional areas allowed to obtain interesting information on soil erosion variation in these areas.

Keywords: Cs-137, soil erosion, sediment yield, land use change

APPLICATION OF SENTINEL 1 AND SENTINEL 2 SATELLITE IMAGES TO STUDY SAND BARS DYNAMICS OF THE LOWER VISTULA RIVER, POLAND

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The Vistula River was regulated at the end of the 19-th century design did not considered large bedload transport. Excess of bedload material is stored in numerous alternate-diagonal sandbars continuously moving downstream and creating navigation obstacles. The movement of the sandbars can be traced on the optical satellite images of Sentinel-2 and the pattern of thalweg can be detected on SAR images of Sentinel-1 satellite. To study the shift of the sandbars a sequence of Sentinel 2 Images recorded 2015 08 20, 2016 09 04, 2017 07 30 was used.

The intensity of sandbar movement depends on the hydrological conditions. In a wet year in 2017 the sandbars were shifted by 1.4 m per day, in the dry year 2015 by only 0.7 m per day. Patterns of thalweg can be traced on Sentinel-1 radar image (2016 01 11) showing the phase of frazile ice flow. Location of the sandbars is cyclic and the period of repeated location is 3 years.

Keywords: Vistula River, sand bars, sediment transport, satellite

ASSESSING THE DOMINANT PROCESSES AFFECTING SEDIMENT GENERATION AND TRANSPORT ACROSS EUROPE

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Large scale hydrological models have emerged as valuable tools to increase our understanding of how hydrological and hydromorphological processes impact fluxes of water quality constituents. The Hydrological Predictions for the Environment (HYPE) model is a semi-distributed, catchment-based hydrology and water quality model which has been applied across the catchment to global scales. In HYPE, hydrological and water quality processes are tied to hydrological response units with parameters partly tied to soil and landcover (SLC) classes. This facilitates the use of HYPE for large scale modeling and prediction in ungauged basins. At the European scale, a HYPE model setup (E-HYPE) has been used to simulate nitrogen, phosphorus, and suspended sediment fluxes. A fourth version of the E-HYPE model was recently released with updates to input and forcing data, new SLC class definitions, a higher-resolution catchment delineation, and improved calibration and sediment process descriptions.

Here, we use the revised E-HYPE model to study the dynamics of catchment processes and the spatial variation of their impacts on sediment generation and sediment transport across Europe. During the E-HYPE sediment calibration, model subbasins were clustered based on simulation performance and analyzed to identify the dominant processes affecting biases in sediment fluxes. Specifically, we assessed how simulation performance varied across: areas representative of distinct soil and landuse characteristics, various flow regimes, and different seasons. Clusters with large biases could indicate a lack of understanding of the processes affecting sediment transport in these types of catchments and need for improved monitoring. Results from the study will be used to assess sediment delivery to coastal areas and the loss of reservoir storage capacity due to sedimentation.

Keywords: hydrological modeling, sediment modeling, sediment yields, HYPE

WHERE IS THE SOURCE AND HOW MUCH IS CONTAMINATED? TWO STRONG QUESTIONS ABOUT SEDIMENT

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Intensive sediment yield and sediment pollution are two important environmental issues especially in developing country due to lack of proper management in agricultural and industrial development accompanied unsustainable urbanization. During the last three decades, sediment and pollutant source identification has been considered in the watersheds. Sediment source identification is carried out using natural tracer, field data, laboratory analysis and statistical modeling methods. Since sediment and pollutant source identification is among the essential tools for soil and water management of the watersheds, the present study aims to determine the sediment sources and heavy metals pollution in the Talar watershed, Mazandaran province. Soil samples for different land uses and bed sediment in main stream were collected as different sources and sink, respectively. Using FingerPro package and R software, the optimum sent of tracers were selected and relative contribution of different sources was determined using unmixing model. Also, the level of heavy metal pollution calculated using sediment quality indices. The results indicate that river bank shows the highest percentage of relative contribution among different land uses. Also, muli-element sediment quality indices show the level of heavy metal pollution is higher than allowable limit. Due to the importance of the Talar River in the agricultural water supply in north of Iran, the results of this study are applicable to land management and decision makers to maintain river health.

Keywords: FingerPro, sediment fingerprinting, sediment quality indices, soil erosion, Talar

TWO-DIMENSIONAL NUMERICAL SIMULATION OF SUSPENDED SEDIMENT TRANSPORT IN LOBO RIVER RESERVOIR (WESTERN-CENTRAL OF CÔTE D'IVOIRE)

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Built to improve the water supply of the populations of the city of Daloa, the water reservoir of the Lobo River is no longer functioning properly due to sedimentation phenomena. This study aims to understand the hydro-sedimentary functioning of the reservoir for better management. Based on the river flows, bathymetric surveys, suspended solids concentrations, settling velocity, a two-dimensional modelling of the flows and sedimentation of the Lobo River reservoir was carried out using the MIKE 21FM/MT software. The simulation results indicate that the hydrodynamic model could reproduce the variation of water levels at the free surface of the reservoir. The results are very sensitive to the boundary conditions of the model but also to the initial conditions. A strong influence of the initial conditions on the long-term stability of the models was observed. It could be seen that in all cases the deposition rate tends towards a final value which only depends on the river flow. The 2.3.5. Trapping efficiency of the reservoir is between 26.7% and 80.4%. The different simulation scenarios indicate that the deposition thicknesses are between 0.02 and 48 mm and that the deposition occurs when the flow is loaded, during the rise and fall phase of the hydrograph. The old intake, the new intake and the weir are the preferred areas for sediment deposition in the Lobo River reservoir.

Keywords: sediment transport, trapping efficiencies, modeling

MEASUREMENTS AND NUMERICAL ESTIMATION OF THE BEDLOAD TRANSPORT RATE OF THE DNIEPER RIVER BELOW KANIV DAM

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This work focuses on studying the understanding of bedload transport on the large lowland river with a sandy bed, in conditions of dam reservoir operation. The research was conducted in the section below the Kaniv dam of the Dnieper River (Ukraine). Own measured and archival morphological data were used for calculations of the cubic volumes of displaced sediments. Performing channel stability calculations based on the following indicators allowed to determine threshold parameters for numerical models of hydrodynamics and bedload transport developed in MIKE 21C.
As a result, we found that the balance of bedload sediments was negative from the very beginning of the dam in Kaniv. In the period 1962–2015, about 19.08 million m^3 of sandy sediment was eroded (0.44 million $m^3 \cdot year^{-1}$). Calculated per bed area unit, this indicates a loss of the bottom layer of the main channel, 1.56 m thick throughout the entire period of the dam's operation. There is a constant trend of deep erosion of the riverbed in the section up to 13 km from the dam at the rate of 5.3 $cm \cdot year^{-1}$ (the average depth of the bed increased by 2.26 m on average). Based on the developed 2D MIKE 21C model and the simulated hydropeaking operation scenario of the dam, the temporary bedload transport was determined. Maximum loads were as high as 130 m^3 per hour with a flow >7,000 m^3. The results of the research confirm the intensification of sediment transport in the conditions of fluctuating flows caused by the operation of hydroelectric power plants.

Keywords: bedload transport, Dnieper River, MIKE 21C, dam impact

RELATIONS BETWEEN SUSPENDED LOAD AND BEDLOAD RATES IN LONGITUDINAL PROFILE OF THE VISTULA RIVER AND ITS CARPATHIAN TRIBUTARIES

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The average amount of suspended load in the Vistula River before the construction of dam reservoirs in the drainage basin had shown rapid increase with the river course from the source as far as the confluence of the last Carpathian tributary, whereas in the further river course, the amount of suspended load had been at the same level as far as the river mouth to the Baltic Sea. The construction of dams resulted in decrease of suspended load in the tributaries, especially Carpathian ones, and in the Vistula River, which was the consequence of material deposition upstream the dams. Similar large changes occurred in the case of the bedload in the longitudinal profile of the Vistula River and its tributaries. Insofar the differentiation of average values of suspended load along the Vistula River and the Carpathian tributaries in both time variants was recognized, in the case of bedload the situation is not known. The rates of losses in transport of suspended load and bedload are pointed out by the cubic area of deposited sediments upstream the dams, with an attempt to separate amounts of load supplied by both types of mechanical transport. Such calculations were carried out in the case of dam reservoirs and in miniature reservoirs upstream the anti-debris dams on mountain rivers, and in landslide depressions in the source zones of the Carpathian water courses.

The share of suspended load and bedload [%] in mechanical transport in the lower, middle and foremountain sections of the Vistula is accepted among fluvial geomorphologists. They agree that it changes up the river course (in favour of suspended material) and amounts to 25% and 75%; 50% and 50%; 70% and 30% respectively. In the lower and middle courses of the Carpathian tributaries of the Vistula River, the share amounts to 90% and 10%, and in their upper courses (without source sections) it amounts to 95% and 5%. In the source sections of the Carpathian watercourses, especially on flysch slopes with landslide depressions, the suspended load represents almost 100% of material in mechanical transport. The results of the investigations

indicate domination of suspended load in fluvial transport of debris in the Carpathian part of the Vistula drainage basin and in the mountain course of the river. On the other hand, in the lower course of the Vistula bedload predominates, i.e. sand fraction, which is transported in suspension during high water stages in the Carpathian watercourses and foremountain section of the Vistula River.
In the source sections of the Carpathian watercourses, in the case of sediments deposited upstream of dams and in natural depressions, sediments transported in suspension and as bed load were determined. Changes in shares of cubic area of these sediments during filling up the reservoir basins were determined, as well as effects in material transport downstream the dams. The investigation results shown in this paper represent novelty in Polish fluvial research literature.

Keywords: Vistula River, suspended load, bed load, sediment transport

Session 2

Sediment quality – geochemistry, nutrients, contaminants, emerging issues

FEATURES OF 137CS ACCUMULATION ON THE FLOODPLAIN OF THE ABUKUMA RIVER AS AN INDICATOR OF EROSION AND SEDIMENTATION PROCESSES IN THE RIVER VALLEY BOTTOM

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A portion of sediment-borne 137Cs in river water accumulates on floodplains during high-flow events and becomes a source of secondary contaminations in subsequent events. This study aims to elucidate processes of 137Cs accumulation / redistribution on floodplains and presents the 137Cs inventory and depth distribution in deposited sediments. The sediment cores were taken in 2018 and 2019 at six floodplain cross-sections, located along the Abukuma River in Nihonmatsu (NIH), Kuroiwa in Fukushima (KUR), Fushiguro in Date (FUS), Marumori (MAR), Kakuda (KAK), and river mouth section in Iwanuma (Mouth). The mean 137Cs inventory obtained by sampling campaigns in October 2018 at NIH, KUR, FUS, MAR, KAK, and Mouth were 150 kBq m^{-2} (n = 2), 600 kBq m^{-2} (n = 3), 490 kBq m^{-2} (n = 2), 270 kBq m^{-2} (n = 2), 90 kBq m^{-2} (n = 2), and 40 kBq m^{-2} (n = 1), respectively. These values were 1.2-9.1 times higher than those estimated by 6th airborne survey at each point, suggesting secondary accumulation of 137Cs. The 137Cs inventory and maximum 137Cs concentrations in sediment depth profile tended to be high at the sampling points, located on the highest floodplain level above the river channel within each floodplain cross-section. The mean 137Cs inventory obtained by sampling campaigns in October and November 2019 at NIH, KUR, FUS, MAR, KAK, and Mouth were 180 kBq m^{-2} (n = 2), 540 kBq m^{-2} (n =2), 410 kBq m^{-2} (n = 1), 120 kBq m^{-2} (n = 2), 420 kBq m^{-2} (n = 3), and 46 kBq m^{-2} (n = 1), respectively. Although 137Cs inventory on the floodplains are not so different, depth distributions of 137Cs in the deposited sediment changed from those of 2018. These results suggest that an extreme flood triggered by Typhoon Hagibis in middle of October 2019 resulted in a substantial redistribution of 137Cs at Abukuma fluvial system.

Keywords: Cesium-137, floodplain, sediment dynamics

PARTICLE SIZE AND GEOCHEMISTRY OF SUSPENDED MATERIAL OF ALPINE RIVERS IN THE SOUTHERN ALPS, NEW ZEALAND

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Hillslopes are transient stores of organic and inorganic material that are ripe for mobilisation into river networks during storm events. Material entrained in rivers as suspended material, should reflect the catchment lithology, but, mineral composition is supply-controlled from rock types that might preferentially fail, and transport-controlled, where some mineral fractions may be more prone to erosion into larger rock clasts (bedload), and others winnowed into finer fractions, like silt and clay. The aim of this study is to explore whether the mineral composition of suspended sediment is uniform across different size fractions, and whether distinct element compositional changes occur as grain size transitions from coarse sand (2 mm) to silt (< 63 μm). Secondly, we consider whether the particle size distribution of bulk suspended sediment differs between catchments of different geomorphological attributes, and over flow events. The geochemical composition of river sand deposits was determined by collecting sand-sized samples close to the waters edge from lag deposits. These samples were oven dried and sieved into 0.5 phi sized increments. Each sub-sample was analysed using a portable XRF, and normalised into a percentage weight total. Bulk suspended sediment samples were collected from 6 rivers draining the Southern Alps, and settled for 7 days to partition sediment > 1 μm in size. The bulk suspended sediment was dried at 30°C and its geochemistry determined using a portable XRF (as above), and measured for particle size distribution using a Malvern 3000 particle size analyser fitted with a Hydro 2000 wet sampler. Comparison of the bed sand and the suspended sediment geochemistry showed notable differences in the composition of major oxides with marked decreases in the proportion of SiO2 in suspension (52–55 wt %) compared to bed sand (64–80 wt %). All other major oxides were relatively enriched in the suspended sediment. Enrichment was observed in all of the trace metals in suspension, with some elements being detected that were previously absent from bed sand analyses, e.g., As and Cr. SiO2 was preferentially transported in the coarser clastic grain sizes, and over-represented in the sand grains compared to silt and clays. An apparent size differential may govern rock and mineral break down, where the minor elements are relatively enriched in the smaller clastic sizes due to differences in mineral hardness, i.e., SiO_2 was relatively resistant to comminution and abrasion processes compared to feldspathic-derived minerals like CaO and MnO.

Keywords: geochemistry, alpine rivers, New Zealand

TEMPORAL VARIATIONS IN PARTICULATE AND DISSOLVED ^{137}CS ACTIVITY CONCENTRATION IN THE ABUKUMA RIVER DURING TWO HIGH-FLOW EVENTS IN 2018

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Although previous authors attempted to elucidate 137Cs wash-off processes in different river catchments during high-flow events, investigations on large scale river catchments are still rare. This chapter presents observations of riverine 137Cs dynamics during two high-flow events in 2018 on the Abukuma river. River waters were collected at Kuroiwa site, locating at midstream of Abukuma river, during two high-flow events on 5th to 8th July 2018 (JUL18) and 30th Sep to 3rd Oct 2018 (OCT 18). River water samples of 20-40 L in JUL18 and OCT18 were collected for 5 times and 7 times, respectively. The samples water was subjected to measurements of 137Cs activity concentration in suspended sediment (Bq kg^{-1}) and dissolved 137Cs activity concentration (mBq L^{-1}). Mean 137Cs activity concentration in suspended sediment during JUL18 and OCT18 were 1570 and 1200 Bq kg^{-1}, respectively. Mean dissolved 137Cs activity concentrations during JUL18 and OCT18 were 5.5 and 2.2 mBq L^{-1}, respectively. Total 137Cs wash-off during JUL18 and OCT18 were estimated as 8.6 × 109 and 5.5 × 1010 Bq, respectively. Dissolved 137Cs activity concentrations decreased with time during both of JUL18 and OCT18 and the temporal trends were similar to those of concentrations of major cations (Na+, K+, Ca_{2+}, Mg_{2+}). Maximum 137Cs activity concentration in suspended sediment was observed in peak discharge phases during both of JUL18 and OCT18. Total carbon contents, specific surface area and speciation of suspended sediments appeared not to explain variations in 137Cs activity concentration in suspended sediments during the events. In future, comparative studies in various catchments should improve our understanding of riverine 137Cs dynamics and predictability.

Keywords: Cesium-137, distribution coefficient, particle size distribution, speciation, suspended sediment

COMPARATIVE STUDY ON SEDIMENT QUALITY ASSESSMENT OF TROPICAL RIVERS IN KLANG VALLEY, MALAYSIA

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In contrast to the old shield areas of West Africa and the Amazon Basin, the geological landform of SE Asia is characterized by high relief, active tectonism and volcanism. These features, together with heavy tropical rains, result in the major rivers having some of the highest sediment yields in the world. The frequent tropical rain storms mobilize these sediments and rapidly flush very fine sand, silt and clay from the stream bed in suspension especially in Malaysia where convectional rain storms have been shown to exceed 200 mm/hr. Land use change especially from formerly tropical rain forests into agricultural greatly increases rates of soil erosion. As a result, most rivers on the west coast of the Peninsular Malaysia show heavy sediment loads, especially those that pass through rapidly developing areas like the Klang Valley, Malaysia. In order to explore the difference of geochemistry and mineral characteristics in Klang Valley rivers sediment, the major and trace elements were compared. Thus, this article reviews current trends in the levels of contaminants in sediments since the year 2000 for an overall assessment regarding the heavy metals' concentrations, spatial distribution and their potential sources. A review on sources of sediments, sampling techniques among others aimed at providing critical analysis of current and emerging capabilities of analytical methods employed for sediment analysis is conducted. Practical aspects relevant to tropical conditions, including methods variability, modeling advances and sample preparation and extraction methods and speciation techniques are discussed. The usege of a range of pollution indicators ecological risk analysis based on single pollution indices such as Contamination Factor, Contamination Degree, Pollution Load Index and Geoaccumulation Index are discussed.
The differences in the geochemistry and mineral contents in the sediments of these rivers could be potential indicators to distinguish the sediment sources of the rivers from each other and need to be monitored for a better understanding of the tropical river water-sediment interaction.

Keywords: sediment quality, assessment, tropical river, Malaysia, comparative study

SEDIMENT QUALITY, EMISSION DYNAMICS AND STREAM IMPACT OF URBAN DRAINAGE DISCHARGES - THE CASE STUDY OF LOCKWITZBACH IN DRESDEN, GERMANY

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Fine particles are a main carrier of particle bound pollutants like heavy metals and adsorbed organic pollutants. Furthermore, they are highly mobile in the urban water system and emitted from combined and separate sewer networks during storm events. Therefore, the concentration of fine suspended solids with a particle size smaller than 63 µm is introduced as a reference parameter for urban drainage impact assessment in Germany. This study aims at characterising the impacts of a stormwater discharge on the stream bed of an urban catchment in Dresden, Germany. Hence, particle size distribution and particle bound pollution were analysed in samples from a separate sewer system outlet. In addition to the stormwater samples, presence of fine sediments and the concentration of heavy metals in the receiving stream bed were measured.
Data was gained from a monitoring station, located at the outlet of the urban catchment (23.6 ha, 43% impervious surfaces), equipped with online sensors for turbidity and flow rate as well as automatic sampling during rain events. In total, 190 samples from 55 storm events were analysed for their fine fraction (63 µm) of total and organic solids. Logarithmic transformed turbidity and suspended solids concentrations were related by linear regression. The regression equation was transferred to the high-resolution sensor readings for peak concentration, mean event concentration and event load determination. Additionally, between March 2021 and June 2022, 26 sediment samples were collected along the stream bed 5m and 1000m downstream of the outlet. Heavy metals were analysed from total suspended solids (TSS) and stream bed sediment samples for the particle size.

Keywords: fine sediment export, heavy metals, sewer overflow, urban sediments

ORGANIC PETROLOGY AS A PROXY METHOD FOR IDENTIFYING THE SOURCES OF SEDIMENTS. A SHOWCASE FOR THE JIU RIVER BASIN (ROMANIA)

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Considered one of the most polluting industries, coal mining has been and continues to be seen as an activity generating contaminant particles in the air, water and soil, though nowadays in many countries, this activity has been reduced or even stopped. From the perspective of sediment sources in a mining river basin, however, it may be worthwhile to look at the other side of the coin, and take advantage of this sedimentary "heritage" in the river environment. Thereby, from a scientific point of view, coal exploitation can be of particular value for the recognition of source areas with no specific geological and geochemical characteristics, comparatively to other possible sediment sources.

The paper aims to investigate the link between upstream sediment source areas on the one hand, and downstream transfer and accumulation zones of fine sediments on the other hand, by using the organic petrology, based on the analysis of coal particles trapped in fine sediments. The study focuses on the Jiu River Basin (an important tributary of the Danube River in SW Romania) renowned for the coal mining: bituminous coal in the upper (mountainous) area and lignite, in the middle (hilly) sector. Coal exploitation has led to mixed geochemical composition of riverbed sediments and alluvial deposits in the downstream sector of the main river, further down the coal extraction basins.

The research relies on the petrographic analysis of 11 sediment layers forming a bank deposit of Jiu River in its lower sector, where a variable amount of coal (between 6 - 16%) was found. The relationship with the potential sediment sources was investigated by also sampling upstream riverbed alluvia. The analyses include the determination

of maceral composition and random reflectance (Rr) measurements to establish the content of lignite, bituminous coal, chars and minerals. The presence of both bituminous coal and lignite particles in the analysed sediment samples demonstrated the contribution of different upstream source areas to the sediment supply in the lower sector of the Jiu River. In turn, chars were encountered in larger quantities in the samples from the upstream sector due to increasing contributions from anthropogenic coal sources (releases from thermal Power Plants).
The results encourage further analysis of the coaly matter in the fluvial sediments, the coal proving its suitability as a hydro-sedimentary tracer of anthropogenic origin in the fine sediments of the Jiu River. In the context of integrated basin management, the analysis of the coal content of the alluvial material may be a novel approach allowing to identify the origin of the fine sediments in river channels. Furthermore, investigating the origin of the organic component of the Jiu River's fine sediments would contribute to providing management solutions for the stabilization of waste dumps and the enforcement of legal actions for controlling post-mining erosion processes to minimize downstream impacts on river sediments.

Keywords: alluvial deposits, coaly particles, coal mining, Jiu River Basin, organic petrology, sediments sources

SEDIMENT-ASSOCIATED METALS AND NUTRIENTS ALONG THE MOLOPO RIVER IN MAHIKENG, SOUTH AFRICA

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Metal and nutrient contamination along rivers affected by urbanization remains a global threat to biodiversity and society due to the abundance, persistence and environmental toxicity of some of these metals. The use of sediment to assess the severity and potential ecological risk posed by water pollution is well-recognised internationally. However, until recently the use of sediment in water pollution studies was limited in South Africa. Some studies in the South have demonstrated variable trends in metal contamination in water and sediments along the same study areas. This exploratory study investigated sediment-associated metal and nutrient concentration along a reach of the Molopo River in Mahikeng, the capital of the North West province, South Africa, with the aim of assessing the pollution load and potential ecological risk posed by the sediment. Heavy metal (Cr, Mn, Co, Ni, Cu, Zn, As, Cd, Hg and Pb) concentration, nutrient (NO_3 and PO_4) content and magnetic susceptibility of bed sediment samples collected from the river and various small dams along the Molopo River were characterised. The highest levels of heavy metals in the sediment were found upstream and were lower in the dams. The enrichment factors (Ef) generally showed moderate enrichment of the investigated metals at all sites for most metals. Similarly, the geo-accumulation indices of most of the metals showed moderate to heavy pollution throughout the course of the investigated sections. The contamination factors (CF) of Mn, Cu, and Ni in the study area were low (1) indicating the influence of external discrete sources of pollution. The overall Pollution Load Index (PLI) and Potential Ecological Risk were high throughout the study area. The nutrient content associated with sediment was high along most of the investigated sites. The present work did not show any significant correlation between magnetic susceptibility and heavy metal contents in surface sediments as is commonly the case.

Keywords: water quality, pollution load index, sediment, heavy metal

ENCAPSULATION OF CONTAMINANTS IN SEDIMENTS OF MOUNTAIN RIVERS, TRANSPORTATION AND DEPOSITION IN RESERVOIRS

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One of the most characteristic basins of the Central Asian runoff formation zone (CA) is the Vakhsh River basin, the solid flow of which is formed by riverbed erosion, leaching of banks and the bottom of riverbeds. Analysis of the research results shows that before the construction of the Nurek reservoir by volume of 10.5 km3, the Vakhsh River (containing up to 10 kg of sediment per cubic metre) annually delivered more than 100 t of sediment rich by various minerals.

According to the Hydrometeorology Agency of the Republic of Tajikistan the average annual value of sediments of the Vakhsh river at the Hydrological post Sariguzar -17 km below the Nurek Hydropower Station (Nurek HPS) since 1972 (the beginning of filling the Nurek reservoir) decreased from 1000 g/s to 82 g/s in 1980. The Nurek reservoir almost completely precipitates suspended sediments of the Vakhsh River. The results of the measurement of the amount of suspended sediment of the Vakhsh River at Sariguzar station for the period 1975-1980 show that the curve of the average monthly values of suspended sediment clearly shows two peaks corresponding to the months of May and August. It can be assumed that they correspond to heavy rainfall in the river basin in May and the melting of seasonal snows and glaciers of the Vakhsh river basin in the month of August.

Morphometric analyses have shown that clay substances encapsulate chemical elements (anions, cations) of sediment composition. The main components of sediments are calcium, magnesium, Na+K and anions SO_4^{2-}, Cl^-, PO_4^{-3}

Keywords: mountain river, reservoir, chemical composition, weathering

Session 3

Sediment impacts on river channel hydromorphology and management

IN SITU MEASUREMENTS OF SUSPENDED SEDIMENT DYNAMICS USING A LISST-25X: A CASE STUDY IN THE OLTREPO PAVESE, NORTHERN APENNINES (ITALY)

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The aim of this work is to assess the sediment dynamics of a small watershed in the Northern Apennines dominated by suspended sediment transport. Therefore, we analysed and correlated the sediment volume concentration and grain size distribution of the suspended sediments with the precipitation pattern. The study area is sited in the Varzi Municipality, Northern Apennines, Italy and is represented by a small watershed that is dominated by intensive soil erosion processes and related forms and features. The basin is East-West oriented with South facing slopes characterised by a Badlands processes, and a cultivated North facing slope with prevailing rill-interrill phenomena. Initially, a morphometrical characterisation of the basin was performed based DEM with a 15 cm resolution DEM. Subsequently, the physical characteristics of the topsoil were investigated by grain size analysis and through NDVI analysis. Finally, the eroded sediments were directly assessed at the outlet of the basin thought a laser diffraction technique utilising a LISST-25X device (Sequoia Ltd.). The instrument measures the Suspended Sediment volume Concentration (SSC) as well as the Sauter Mean Diameter (SMD) of the eroded sediments, allowing insights into the morphogenetic processes and the sediment dynamics of the basin. The measurements conducted from the 30/10/2018 to 11/11/2018 under 'humid condition' after an intense precipitation period and from the 02/4/2019 to 08/4/2019 after a 'dry period'. The results show a direct correlation between precipitation and SSC with a concentration delay estimated in 2-4 hours after the most intense precipitation event. Moreover, we reveal that the SMD values are

inversely related to the precipitation due to turbidity effects. The study highlights the importance of land use as well as the geopedological conditions in the sediment mobilization. Furthermore, the morphological and physical characteristics of the basin act on the sediment dynamics. Thin entisols, as well as the clay-rich bedrock, cause the initial infiltration of water and a delay in the runoff and the consecutive sediment transport. The SSC and SMD measurements conducted in an intensively eroding catchment reveal for the first time a correlation between precipitation and suspended sediments discharge in Badlands.

Keywords: badlands, rill-interrill, suspended sediments, LISST-25X, Northern Apennines

WATER EROSION POTENTIAL OF THE CONGO RIVER IN STANLEY-POOL BAY

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This work focuses on the study of the understanding of erosions and transfer processes of suspended or sedimentary matter from the Congo River in Stanley-Pool Bay. To do this, a processing of rainfall data over three decades (1990-2020), which are parameters influencing the process of erosion dynamics, allowed the production of a map of water erosion using the universal equation of losses in floors, i.e. the USLE model. Based on free access spatial data and GIS, this model has made it possible to quantify the rate of matter transported during these three decades. The results show the spatialization of erosion risks on the right bank of the Congo River, particularly in Stanley-Pool Bay, suggesting a topography dominated by steep slopes up to 10%, strong erosivity and erodibility, then weak soil protection. Finally, this study shows that about 40% of the study area suffers soil loss. The risk of erosion is very severe despite the vegetation cover.

Keywords: solid transport, sediments, modelling, Stanley Pool, Congo River

COUPLING OF SWAT AND DSAS MODELS TO ASSESS SEDIMENT DYNAMICS IN THE SUBARNAREKHA RIVER ESTUARY

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One of the world's critical environmental issues is the ongoing deterioration and depletion of estuarine habitats such as mangroves, tidal mudflats, marshlands, lagoons, and inlets. The apparent reasons for this depletion include visible eustatic shifts, tidal surges, climatic instability, and frequent cyclonic storms. However, anthropogenic activities like agriculture, coastal aquaculture, urbanization, and forest resource misuse induce habitat alteration and fragmentation. This study focuses on the Subarnarekha River estuary, situated at the junction of the Indian states of West Bengal and Odisha, stretching over 4.10 km along the East coast of India. This river's estuarine environment has been found to have endured severe forest degradation over nearly 40 years, which resulted in coastal degradation and shoreline recession. So, the current study aims to analyze the long-term shoreline configuration affected by climatic instabilities and anthropogenic interventions by assessing runoff and sediment dynamics of the estuarine section of the Subarnarekha river basin. Thus, a coupled modelling approach has been adopted for this investigation, involving the semi-distributed catchment scale hydrological model SWAT ("Soil and Water Assessment Tool") and the statistical model DSAS ("Digital Shoreline Analysis System"). Firstly, SWAT has been applied to divide the river basin's estuarine section into sub-basins and Hydrological Response Units (HRU) by integrating inputs of catchment topography (SRTM DEM), soil data (FAO DSMW), daily weather data (rainfall, solar radiation, relative humidity, wind speed from NASA Power), and land use change data ("Object-Oriented" classification using Gey Level Co-occurrence Matrix on Landsat and Sentinel 2 satellite data). Then based on this integration, the SWAT model has estimated Water Yield (incorporating cumulative runoff, rainfall excess, lateral flow, groundwater and stream-flow contributions to the water table, and transmission losses from tributaries) and sediment yield (incorporating sediment yield, peak runoff rates, erodibility, and cover management factors for each HRU) using MUSLE ("Modified Universal Soil Loss Equation") of different time steps (daily, monthly, yearly) from 2000-2021.

Furthermore, the model simulation results of daily water yield and sediment yield from 2000 to 2021 were calibrated and validated using statistical metrics such as NSE (Nash-Sutcliffe efficiency), R2 (Coefficient of determination), and RMSE (Root Mean Square Error) and yielded satisfactory values greater than 0.7 for both the periods of calibration (2000-2018) and validation (2019-2021). This study emphasizes the SWAT model's efficacy in estimating water and sediment yield, and their influencing elements in the estuarine section of the Subarnarekha River, highlighting an unavoidable scenario of climate change risk.
Secondly, the DSAS model has been applied to the estuary to calculate rate-of-change statistics using multiple significant shoreline positions extracted from multispectral satellite images, by performing radiometric on each band of satellite images by converting DN values to radiance values and radiance values to reflectance values. Then statistical methods such as EPR ("End Point Rate"), SCE ("shoreline change envelope"), LRR ("Linear Regression Rate"), and NSM ("Net Shoreline Movement"), to assess erosion/accretion scenarios affecting the study area's sediment dynamics between 2000-2021.
Finally, a future projection scenario for the estuary has been generated, implying a dire situation for local residents, who should immediately implement sustainable management procedures to avoid becoming environmental refugees. Therefore, it is necessary to assert adequate zonal plantations with respective assemblage and efficiency of the species, bio-stabilize coastal dunes, monitor grazing, and strong community resilience via cooperation, and dispute resolution, to ensure the long-term ecological stability of the Subarnarekha estuary.

Keywords: SWAT, DSAS, Subarnarekha River, sediment yield, estuary and coastal degradation

REMOTE SENSING OF FLOOD PLAIN AND RIVER CHANNEL MORPHO-DYNAMICS IN THE MENCHUM-MUGOM BASIN, WESTERN HIGHLANDS OF CAMEROON

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Times floodplains and river basins are amongst the most human transformed and dynamic wetlands in the world. The study probes into a space-based mapping of flood plain and river channel morphodynamics using high resolution Copernicus Sentinel-2 (10m) optical data in the Menchum – Mugom River foodplain, North West Region of Cameroon.
We extracted floodplain morphology for two time periods (2016 and 2022) based on high precision multi-resolution segmentation object-based image classification (OBIA). Mapped floodplain morphology include; sediment deposits, ox-bow lakes, and meanders. The studied river channel showed significant migration between 2016 and 2022 with far reaching implications on flow direction and speed. The floodplain showed significant human transformations via settlement expansion, paddy cultivation and seasonal cropping of wetland swamps. The study concluded that the use of high resolution optical remote sensing data and mixed methods can enhance rapid mapping and change detection of flood plains and river basins for sustainable planning initiatives.

Keywords: change detection, river bank erosion, channel migration, sediment yields, Paddy, ox-bow lakes

NUMERICAL MODELING OF SEDIMENT TRANSPORT IN THE AREA OF THE VISTULA RIVER OUTLET

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The specific nature of sediment movement under the influence of combined marine and fluvial hydrodynamic forces has been discerned on the example of the Vistula River outlet. For this purpose a river current was incorporated into a package of deterministic models of marine coastal zone developed in the IBW PAN. The dispersion relation in the form applicable for the wave motion superimposed on the stationary current was introduced into the models of wave transformation and wave-generated currents. The river current was included at the upper limit of the wave-current bottom boundary layer. The intensity of sediment transport involved by interaction of waves, wave-generated currents and river flow was calculated by a three-layer model of sediment motion developed in the IBW PAN in the past years. Such a modeling package has been applied for the study of specific short-term behavior of sandy sediment motion in the distributary channel on the prograded delta of the Vistula River for a wide range of river and marine hydrodynamic conditions. Moreover, the theoretical deposition zone for individual fractions of river sediments was evaluated for different Vistula discharges and sea level conditions.

Keywords: hydrodynamic modeling, Vistula River

APPLICATION OF HEC-RAS MODEL TO ANALYZE DYNAMIC SEDIMENT TRANSPORT IMPACT PRE AND POST CONSTRUCTION OF FALL STRUCTURES AT LOWER NARA CANAL OFF-TAKING FROM UPPER NARA CANAL, SUKKUR BARRAGE, INDUS RIVER, SINDH, PAKISTAN

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Indus River is seventh among the largest Rivers in the World such as Amazon, Huanghe (Yellow), Ganga-Brahmaputra, Changjiang (Yangtze), Changjiang (Yangtze), Mississippi, and Irrawaddy which receives an average suspended load of 259 Million Tons (MT) annually and covered area 29524 km2. The annual sediment load transports in the Indus River varies from 270 to 600 MT before the construction of barrages and dams. Hence 0.725 million tons/day approximately 260 MT/year after the building of hydraulic structures. The average particle size D50 of the bed load is observed at about 0.125 mm at the Sukkur barrage. Indus River changes its behavior, channel dimension, pattern, and flooding frequency with respect to temporal and spatial and morphology of Indus braided with high to low meanders. This paper presents the research study using the HEC-RAS Model to evaluate sediment dynamic problems in lower Nara canal pre and post-construction of fall structures at RD-77 and 101 respectively which is a major tributary of upper Nara canal that off-takes from Sukkur barrage on the left bank of Indus River. Three types of datasets were provided to the HEC-RAS model i) geometry data ie design parameters of hydraulic structures, Digital Surface Model (DEM) for developing longitudinal and cross-section of canal profiles, ii) Boundary conditions i.e. U/S condition (Flow series, 6,043 cusecs) D/s Condition (Normal depth, 0.002) and iii) Initial condition and transport parameters i.e. size distribution, boundary conditions i.e. Rating Curve for computing the sediment dynamic in the canal. As a result, the Model has computed longitudinal and cross-section, velocity, water surface profiles, and sedimentation dynamics. Further Model results show the sedimentation dynamic computation in Invert Change (Ft) Sediment transportation without fall structure is aggradation (5.75 ft and degradation (4.50 ft) and with fall structure aggradation (4.25 ft) and degradation (2.75 ft) respectively. Mass Bed Change Cum (Tons) Sediment transportation without fall structure is

aggradation 500,000 tons and degradation 225,000 tons and with fall structure aggradation 155,000 tons and degradation 125,000 tons. Long Cum Mass Change (Tons) Sediment transportation without fall structure is degradation 600,000 tons and with fall structure is aggradation 110,000 Tons and degradation 165,000 Tons. Mass in Cum (Ton) Sediment transportation without fall structure is aggradation 1,750,000 Tons and with fall structure is aggradation 1,300,000 Tons. Hence the results of the Model revealed that aggradation at u/s and degradation at d/s of fall structures that is a true representation of the behavior of fall structures. Whereas, the section is wider than aggradation occurred and degradation is experienced in narrow sections in both scenarios (with and without fall structures). The positive impact of constructed fall structures was analyzed on the morphology of the canal. Hence, the construction of fall structures are essential at the change of country/steeper slope to avoid unnecessary erosion.

Keywords: HEC-RAS MODEL, Sediment transport, GIS & RS, Hydraulic structures, Digital surface model, Nara Canal

ASSESSMENT OF HUMAN IMPACT IN THE BRDA RIVER CATCHMENT (POLAND) USING THE EROSIVE STABILITY CHANNEL FACTOR

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It is commonly believed that changes in the land use of the catchment area have a direct impact on the fluvial processes. The channel processes are related to erosion, transport, and accumulation of sediments in the catchment. The stability of river channels results from the natural characteristics of the catchment, intensified by human activity. The main aim of the research was the assessment of the Brda riverbed stability in the two periods 1980–1989 and 1991–2018. The Brda River is 245 km long, and its catchment amounts to 4,661 km^2. A significant component of underground outflow and a large retention capacity of the river-lake system in the upper part of the Brda River catchment results in high discharge regularity. On the other hand, the presence of hydrotechnical structures in the middle (Mylof Reservoir), and in the lower (Koronowo, Tryszczyn, and Smukała reservoirs) parts of the catchment showed strong human pressure on the fluvial system. Our research was based on hydrological, sedimentological, and spatial data (QGIS software) investigations on the Brda River catchment. Field measurements were used to define the river channel characteristics. Finally, the Erosive Stability Channel Factor was proposed. Factor describing the degree of human pressure on the fluvial system. To verify the assessment of the Brda riverbed stability, hydrological (rating curves) and spatial (land cover changes) examinations were used. The results showed that in 1980–1989 riverbed was instability – there was a trend to accumulate sediments in the riverbed. However, from 1991–2018 the river channel was stable – erosion and accumulation processes dominated. The long-term trends in the riverbed stability resulting from human activity were determined. The used method made it possible to indicate the directions of sustainable sediment management on the Brda River catchment.

Keywords: channel stability, erosive stability channel factor, catchment degradation, sediment transport, human impact

Session 4

Introduction of the strategic activities for the development of waterways

ASSESSMENT OF THE IMPACT OF THE RIS SYSTEM ON IMPROVING THE SAFETY OF INLAND WATERWAYS BASED ON THE EXAMPLE OF THE LOWER ODER RIVER

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In recent years, shipping traffic in the German-Polish border area has increased every year and mainly involves tourist and sporting vessels. This results in new safety risks. The increased number of waterway users, especially those using the waterways incidentally, contributes to an increased risk of emergencies such as accidents and an increased risk of environmental pollution and damage to property.

The Polish and German public administrations take care of safety on the border section of the Oder Waterway, despite competence differences between individual institutions. Competence, legal and organisational differences significantly limit cross-border cooperation. They also make it difficult to carry out joint tasks in the field of navigational safety supervision, such as Polish-German police patrols or actions promoting navigational safety. A major problem for the administrations of both countries is also the insufficient flow of information and data between the various institutions. This problem can be partly solved by the use of RIS, through which information and data can be exchanged between all IWT stakeholders. The ongoing exchange of information and data between the administrations of both countries and their presentation in (at least) two languages, Polish and German, will significantly improve communication and contribute to better safety monitoring. Thanks to cross-border cooperation, it would be possible to improve law enforcement, for example where a Polish RIS operator seeing abnormal behaviour by a waterway user (e.g. excessive wave action) could inform the German services when they are closer to the scene and can take action more quickly. RIS could also be used for joint coordination of disaster mitigation or icebreaking operations..

Keywords: Inland shipping, RIS system (River Information Services), the Odra Waterway, safety of navigation

Session 5

Limitations for inland navigation

APPLICABILITY OF PHYSICAL MODELS IN HYDRAULIC ENGINEERING

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Hydro-engineering facilities, due to their complexity, very often require adaptation to local conditions. Design of new or modernization of existing ones can be supported by numerical models and physical models. The best approach is to apply both methods in a complementary way. Institute of Hydro-Engineering PAS is experienced in conducting such studies. Some examples of physical modelling carried out in the modernized open air Hydraulic Laboratory of IHE PAS, will be presented.

Keywords: numerical and physical modeling, hydraulic engineering

PROBABILISTIC UKC MODEL AS A PRACTICAL TOOL FOR SAFETY DEPTH DETERMINATION ON LOWER VISTULA RIVER

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The hydrological conditions in the Vistula basin are characterized by high seasonal variation, with a tendency to occur in extreme high water stages and long periods of low water levels. A ship's safe manoeuvrability depends on the available water depth of the navigation area concerning the vessel's draft. For safe navigation on restricted area which are rivers is to keep safety distance to the river bottom which is connected with their sedimentation. The research presents probabilistic model of under-keel clearance (UKC) evaluation for inland ships. The model enables to determine the distribution of UKC in several ships passages and in further step to assess the probability of ships grounding accident during the inland waterway. Results of this research could be helpful for inland transport management, risk assessment of ships entering river, and analysis for a new waterways project.

Keywords: Vistula river, inland navigation, oversized cargo, under-keel clearance (UKC) analysis

AN OVERVIEW OF METHODS FOR SAFE DESIGN AND EXPLOITATION OF INLAND WATERWAYS

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Inland waterways play an important role in the transportation system, so they must be designed and used efficiently and safely. For this purpose, numerous methods from the field of engineering and safety and risk assessment can be used. However, these are based on different premises, have a different scope and focus, and thus different areas of application.
Therefore, this paper discusses selected methods that are suitable for inland waterway planning considering risk and safety, including the goal-oriented safety case approach, system-theoretical process analysis, and risk assessment.
Challenges and opportunities of these approaches are highlighted and discussed together with recommendations for the application of the methods.

Keywords: Risk-based design, STPA, inland waterways, safety of navigation

Poster session

FLUVIO-GEOMORPHOLOGICAL DYNAMICS AND HYDROGEOLOGICAL RISK ASSESSMENT OF THE LAMBRO RIVER: A CASE STUDY OF THE COLOGNO MONZESE SECTION (LOMBARDY, ITALY)

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The present work has two main objectives: i) the hydro-geomorphological analysis of the variations of the Lambro River and ii) the assessment of the potential hydrogeological risks in the district of Cologno Monzese, San Maurizio al Lambro, in Central-West Lombardy, Italy. The study area is sited in the Po Plain and is characterised by fluvial and alluvial sediments mainly deposited by the Lambro River. In addition, the study area presents anthropogenic deposits accumulated as landfill of a steel mill. Today these areas have been reclaimed and used as a public park. In recent decades, the Lambro river flooded several times, particularly the centre of San Maurizio al Lambro causing damages and inconveniences to the population. In order to overcome this problem, several hydraulic works were established on the river system, including a bypass created in early 2019 in the North of the study area. This bypass should safeguard a road bridge. In order to understand the morphological evolution of the river we analysed the plan view changes of the Lambro River using the QGIS environment.
The morphological variation was assessed through a set of orthophotos (of years 2015, 2007, 2003, 1998, 1975, 1954), freely available on 'Geoportale della Lombardia', and two maps (of years 1950 and 1888) acquired by the Military Geographical Institute (IGM). Subsequently, through detailed terrain analysis performed on 0.5m and 5m DTM, respectively provided by 'Geoportale Nazionale' and 'Geoportale della Lombardia', we created a simple hydrogeological model considering the riverbank high, the water level and the pluviometric data. Furthermore, the bypass functionality was assessed comparing the precipitations of the most important river flooding in 2002 and those of two exceptional rain events in June and October 2019. The rainfall data were acquired from 'Arpa Lombardia' website. The results highlighted how fluvio-morphological

changes influenced the river dynamics. In the northern part of the study area the Lambro River course was deviated by more than 80 m with a consequent decrease in length. The morphometrical analysis also showed that the entire inhabited centre of San Maurizio al Lambro is at a high potential flooding risk, being at the same level as the riverbed. Furthermore, if the Lambro River overflows the riverbanks in the northern part of the study area, exceeding the minimum height of 2.9 m of the embankments, it would flood the whole town as it was the case in 2002. Up to now the bypass was fundamental in protecting San Maurizio al Lambro, avoiding flooding in both of the 2019 events analysed. However, it was only partially functional in safeguarding the bridge, which was exposed to phenomena like the pressure of the flowing water hitting the bridge and accumulation of large debris in front of the bridge.

Keywords: river dynamics, geomorphological mapping, hydrogeological risk, historical cartography, Lambro River

IMPACT OF DEFLECTORS ON HYDROMORPHOLOGICAL PROCESSES IN LOWLAND RIVERS ON THE CASE OF THE FLINT RIVER

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River restoration is one of the measures taken to improve the characteristics of land-water ecosystems. One of the hydraulic structures used in river channels for this purpose are river channel deflectors. They are environmentally friendly low head hydraulic structures built up with wood wicker and stones. The reason for them is to protect river banks against erosion, to change the direction of river flow making river course naturally meandrous instead of artificially straight, to make the natural refugia's for fish and invertebrates and finally to improve hydraulic discharge conditions. Since most of that kind of channel deflectors are low head, they are very likely to be used by river managers and designers in lowland creeks and small lowland rivers. However, the extent and magnitude of hydromorphological changes including accumulation, erosion and sediment transport features is so important that a thorough understanding is required. To do that, firstly three channel flow deflectors were constructed and installed in the lower section of the Flinta river. Secondly, hydrometric measurements were continued systematically over three years. Next, based on field studies and field data, analyses were carried out and the locations and timing of accumulation and composition of sediment deposited in the riverbed were determined. Sites of bed and bank erosion were also identified and the average volume of sediment carried in the river was determined. The novelty of the research is that the obtained results are showing that river channel deflectors have a significant influence on the processes of morphological changes of the riverbed and as a consequence of it also on changes of hydromorphological parameters

of river flow. It was also found that an effect of deflectors on the roughness at high water levels was non-significant and did not increase the risk of flooding. The greatest impact of the channel deflectors is seen at low water levels and low flows that do not exceed average flow values. The obtained results can be considered universal in relation to typical transformed small lowland watercourses that have been straightened and regulated and are about to the process of river restoration.

Keywords: hydromorphology, river restoration, river channel deflector, Flinta river, lowland river

SPATIAL DYNAMICS OF SUSPENDED SEDIMENT IN THE SIKKIM-DARJEELING HIMALAYAN RIVER

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Himalayan rivers are known to carry large quantity of sediment and therefore its management is important for hydro projects located in Himalayan region. The aim of this research is to characterise the magnitude of suspended sediment transfer at a number of points distributed through the Teesta catchment (~8150 km2 in Himalaya) using existing databases and published literature. The Teesta River originates from the glaciers in the northern Sikkim. Cutting schists and gneisses through the Darjeeling Himalayas the river flows into the Brahmaputra. The catchment is characterized by direct contact of steep slopes with the river channels and frequent extreme rainfall leading to mass movement. Between 1999 and 2016 four high dams were constructed in the Teesta catchment. . The planned construction of further dams means that the catchment would have one of the highest average dam densities in the world. The results indicate that before the construction of the dams, average annual discharges increased from a few m3/s in glacierized catchment (19.8 km2) to 400 m3/s in the middle part of the Teesta catchment (4800 km2) in the Sikkim Himalaya. In the Darjeeling Himalaya, the discharge was about 580 m3/s and did not rise with the increase in the Teesta catchment (from 7700 to 8150 km2). The average annual suspended sediment concentration (SSC) increased from 0.09 mg/l in glacierized catchment to 1 mg/l in the middle part of the Teesta catchment in the Sikkim Himalaya and 3.2 mg/l in the outlet of the Teesta from the Darjeeling Himalaya. The average annual suspended sediment yield (SSY) increased from 281 t/km^{-2} in glacierized catchment to 3300 t/km^2 in the middle part of the Teesta catchment in the Sikkim Himalaya. A sharp increase in SSY from 3600 to 12160 t/km^2 was observed in the Darjeeling Himalayas. After the dams were built, a large decrease in average SSY was observed from 3400 to 1300 t/km^2 in the foothills of the Sikkim-Darjeeling Himalaya.

Keywords: suspended sediment, sediment cascades, sediment yield, Himalaya, India

THE ROLE OF SMALL RESERVOIRS IN SHAPING THE TRACE METALS CONTENT OF EPHEMERAL RIVER SEDIMENTS (NEGEV DESERT)

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In this study, the trace metal contents of sediments of rivers of the Negev Desert (Nahal Sansana, Nahal Revivim and Nahal Pura) influenced by small water bodies were compared. Among all 19 metals analysed (Pb, Cd, Cr, Co, Cu, Mn, Ni, Zn, Sr, As, Mg, Al, Ba, Cs, Fe, Ga, Rb, U, V), Al, Fe, Mg are the dominant metals, accounting for 99%. Statistical analysis (Principal Component Analysis and Hierarchical Cluster Analysis) showed that sediments in rivers above the reservoirs in the Negev Desert show similar metal concentrations. An increase in metal concentrations was observed in the bottom sediments of the reservoirs compared to the rivers above and below them. A comparison of metal concentrations in rivers above and below the reservoirs does not show a clear trend of changes, as metal concentrations below the reservoir are not always lower than those above the reservoir. The lowest enrichment factor (EF) values were recorded below the analysed reservoirs and the highest in the reservoirs. The lack of enrichment of ions after passing through the reservoir indicates that their source is the areas upstream of the reservoir, and the reservoir itself has little influence on metal ion concentrations downstream. At the same time, the lower EF values recorded in the river below the dam are due to the self-purification process in the reservoir. The concentrations of most metals in the analysed sediments in rivers and reservoirs in the Negev desert do not show a potential ecological risk.

Keywords: metal content, sediments, ephemeral river, reservoir, arid zone, Negev Desert, Israel

APPLICATION OF SATELLITE IMAGES FOR WATER RETENTION ANALYSIS (THE TRESNA RESERVOIR CASE STUDY)

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In research in the field of water management, analyses based on satellite data are very popular. Examples from the literature show that on their basis, it is possible, among other things, to an assessment of flood detection, obtain data on river processes and ice phenomena, or mapping of irrigation systems. However, this paper focuses on the possibility of using satellite images in research on water retention in the context of counteracting the effects of drought and presents the results of the actions taken. For this purpose, satellite images provided by the Sentinel Hub were used. On their basis, the range of the shoreline of the Tresna reservoir on the Soła River (southern part of Poland) was determined under various operating conditions (during normal conditions of use and drought) in the hydrological year 2021. The conducted analyzes showed that satellite images could also be helpful in water retention analysis and monitoring hydrological drought.

Keywords: water retention, drought prevention, satellite images, Sentinel

SEASONAL VARIABILITY AND ORIGINS OF MAJORS MINERALS ELEMENTS TRANSPORTED BY THE CONGO RIVER IN BRAZZAVILLE STATION

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In context of climate change, population groth and anthropogenic pressures, we have reassessed the dissolved load of the Congo River, in order to detect possibles changes in the chemical composition of these water at Brazzaville station. This present study focuses on the analysis of the interannual variability of majors minerals elements fluxes of the Congo River during the hydrological cycle. It ils based on a analysis of geochemical data collected on the Congo River at Brazzaville station during the period 2005-2019. The results obtained during this study show that chemical composition of the Congo River remains stable and varies very little from one year to another. The average annual flow of dissolved load transported by the Congo River are 38×10^6 t/yr, dominated by the carbonate with the of 14×10^6 and the silica flow of 13×10^6 t/yr. The other majors minerals elements (calcium, potassium, sodium, chlorine, sulphates and nitrates) account for 11×10^6 t/yr. The Congo River are "magnesium calcium bicarbonates" type, little mineralised with the pH of 6.8. the rock alteration is the main sources of majors minerals elements input into the Congo River. Anthropogenic inputs are not yet significant throughout the station of Brazzaville despite their visible impacts in some parts of Congo River basin. The total chemical specific transport is 10.8 t/km^2/yr, with atmospheric inputs included at Brazzaville station.

Keywords: seasonal variability, origins, major minérales éléments, Congo River

EROSIVE SHORE AS A SOURCE OF SEDIMENTS SUPPLY TO A WATER RESERVOIR - 30 YEARS DEVELOPMENT OF JEZIORSKO RESERVOIR SHORE ZONE (CENTRAL POLAND)

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Erosive sections of the shore of an artificial water reservoir manifested by the presence of active, recessing cliffs, is one of the areas of sediments alimentation to the reservoir. The morphological changes occurring in this area are initiated by wind waves on the reservoir, which triggers the cliff retreat and activation of geodynamic processes within the slopes being transformed, and then sorting, transport and accumulation of activated sediments within the coastal platform forming at the toe of the cliff. The shore platform and the cliff create one coherent morphodynamic system known as the shore zone. The changes taking place in this area hinder human economic activity, but what is extremely important, due to the hindered development of littoral and the supply of sediments to the reservoir, they also affect the physical and chemical parameters of the water in the reservoir and its capacity.

The results of the research conducted on the Jeziorsko reservoir, operating since 1991 in conditions of large fluctuations in water levels, up to 5 m during the year, confirm the relationship indicated in the literature between the temporal and spatial variability of the processes taking place within the shore zone of the water reservoir and the features of the natural environment as well as triggering the processes taking place in this area. These include the geological structure, slope morphology, climatic conditions, and the range and variability of water level fluctuations. The highest rate of shore transformation occurred during the reservoir filling period and its first years of operation, followed by its distinct two- or threefold decrease, the course of which over time is characterized by periodic pulsation-like variability. However, the development of the shore zone of this reservoir continues to this day.

Keywords: erosion, shore, sediments, water reservoir, cliff

EROSION RESISTANCE OF THE CATCHMENT AS AN INDICATOR OF ANTHROPOPRESSURE ON EXAMPLE OF THE LOWER VISTULA RIVER

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Erosion in temperate zones is one of the main processes that shape the landscape. Currently, it is mentioned as among the most relevant environmental problems that occur in the world. Contemporary economic development leads to increasing landscape changes under the influence of human activity. The factors of anthropopressure include various forms of human activity aimed at using the resources of the landscape. These include buildings, industry, agriculture, and forestry.

The study aimed to determine the areas of the Lower Vistula catchment exposed to the denudation process. The uniqueness of the research is the use of a model dedicated to biological processes in the qualitative assessment of erosion.

The research area covered 17 experimental sub-catchments, i.e. 10 direct catchments of the Vistula River and 7 partial catchments of its second-order tributaries.

The Open-Source GIS software was used to process spatial data: System for Automated Geoscientific Analyzes (SAGA GIS) and Quantum GIS (QGIS). Digital terrain model (DTM) and Corine Land Cover data were used. Ten geoenvironmental dependent and independent variables were used for the maximum entropy model (MaxEnt).

The model results revealed areas predisposed to denudation, indirectly determining the degree of anthropogenic transformations in these catchments. Moreover, to verify the results of this study, the USLE model was used to calculate soil loss in the catchment.

The research outcome shows the usefulness of the applied method of maximum entropy in research on the determination of the spatial distribution of the predictive power of environmental features in terms of the possible occurrence of the denudation process.

Keywords: erosion prediction, maximum entropy model, Vistula River

EFFECT OF EMERGENCY WATER DISCHARGES FROM THE DAM IN WŁOCŁAWEK ON THE SEDIMENTARY STRUCTURES OF CHANNEL BARS IN THE LOWER FLOW REGIME OF THE RIVER VISTULA

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Changes in the flow of the watercourse transform the river bed as a result of erosion and accumulation processes. Channel bars move as a result of the water flow. The results of tests carried out on two riverbeds formed in the Vistula River, which were transformed during emergency water discharges from the Włocławek reservoir, are presented. In order to present the changes in structure and texture, outcrops were dug in channel sections and samples were taken for grain size analysis. The rate of migration of channel bars caused by emergency discharges was determined. Sedimentary structures were recorded as groups of layers indicating the variability of flow conditions (2D and 3D dunes, parasitic ripplemarks, reactivation surfaces). It has been observed that changes in water level and flow are reflected in sedimentary structures. The emerging channel bars are affected by aeolian processes that destroy the traces of flow.

Keywords: discharge, sedimentary structures, channel bar, dam, Włocławek reservoir

THE IMPACT OF HYDROMORPHOLOGICAL TRANSFORMATIONS OF THE LOWLAND RIVER BED ON THE POPULATION OF *EPHEMERA DANICA* (EPHEMEROPTERA)

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Relationships between various techniques of stream restoration and selected characteristics of larvae of *Ephemera danica* (Müller 1764), were investigated along a small lowland watercourse. Effects of stream restoration were assessed on the basis of abundance, biomass, and body length of mayfly larvae as well as their biological condition (i.e. relation of mean body weight and length) within a decade (2007–2017) at each of 10 various hydrotechnical constructions along a 2.5-km stretch of the watercourse. Our results show that hydromorphological changes in the stream bed were strong stress factors for the mayfly population, especially in the first year of monitoring. In the following years, the applied restoration techniques created windows of opportunity for the population of *E. danica* which were successfully used by this species, as it increased in abundance and body length and colonized the whole restored stretch of the stream. Finally, 10 years after the river bed transformation, mayfly density increased 4-fold, while larval body length and biomass increased about 40-fold, as compared with the pre-restoration period. The improved habitat conditions of *E. danica* were observed in the sections where stream banks were strengthened with tree trunks, double groynes, and double semi-palisades to protect the banks against erosion. Surprisingly, the highest increase in larval abundance was recorded in a by-pass zone, an isolated part of the stream bed, which played the role of a refuge. Using redundancy analysis (RDA), we found that the mayfly population development after the stream restoration was primarily due to modified water velocities in the transformed sections and changes in water quality. We inferred that the modification of the stream bed has contributed to favourable changes in the studied mayfly population, which constitutes an important food base for the fish fauna.

Keywords: Ephemeroptera, stream restoration, bioindicator, hydroecology, ecological conditions

USING MIKE 21C TO MODELING OF BEDLOAD TRANSPORT AND HYDRODYNAMIC ON LARGE RIVERS WITH SAND-BED

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This research presents two-dimensional modeling the MIKE 21C by DHI software which is based on a curvilinear computational grid. Using this type of tool we can receive velocity and depth of water, the amount of sediment transport and morphological changes of the riverbed. The result is a matrix showing the dynamics of riverbed changes under given hydrological and morphological conditions, which can be easily presented as a map or animation. The main aim of research was to create a model of sediment bedload transport in the lower Vistula river. Moreover, the sub aim was to test the effectiveness of the curvilinear grid of MIKE 21C and two theories of bedload transport for modeling the morphology of a regulated channel with sandy riverbed. Modeling work based on own bathymetry maps with sandbar and two hypothetical hydrological scenarios: bank-full discharge (2350 m^3s^{-1}) and maximal observed discharge 6100 m^3s^{-1}. Presented research proved that the most accurate transport theory equation for large lowland regulated rivers (slope of riverbed est. 0,2‰) is Engelund & Fredsoe (1976). Based on morphology modeling, it was confirmed that the Vistula's river forms dynamics are very high (1-8 meters per day).

Keywords: bedload transport, Vistula River, MIKE 21C, sandbars dynamics

ASSESSMENT OF THE ECOLOGICAL CONDITION OF THE KRZYNIA DAM RESERVOIR IN THE SŁUPA RIVER VALLEY BASED ON THE STRUCTURE OF THE BOTTOM FAUNA

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The history of the creation of a complex of dam reservoirs (Konradowo-Krzynia) in the basin of the Slupia River was associated with the regulation of the shape of the riverbed, carried out at the beginning of the 20th century. Cutting through the Slupia River valley, an earth dam 220m long has created the Krzynia dam reservoir, with an area of 75ha, a usable capacity of 1.38 million m3, a maximum depth of 6.1m, an energy capacity of 0.64 million m^3, and a backwater reach of 6470m. Water to the reservoir is supplied by a 150m-long canal. The final stage of work was the completion of the hydropower plant on August 27, 1926.
The study of the macrozoobenthos of the Krzynia reservoir was carried out in three zones: the influence of the waters of the river Slupia, the middle (stagnant water) and the outflow from the reservoir (the vicinity of the hydroelectric power plant). Benthic invertebrates were represented by 30 taxa from 6 groups: Oligochaeta, Hirudinea, Crustacea, Inecta, Gastropoda, Bivalvia.
The major role of these was played by Oligochaeta and larvae of Chironomidae, groups that are highly resistant to high trophic waters. The total density of invertebrates was 880 osobn. m^{-2} and reached maximum values in the middle zone of the reservoir (1060 osobn. m^{-2}). Significant biomass was characterized by populations of Dreissena polymorpha and larvae of Chironomidae, but only at the site of the inflow of Slupia River waters.
The total biomass of organisms was only 58.25 gmm m^{-2}. The groupings of benthic fauna preferred the shallow water zones of the basin. The Shannon biodiversity index determined indicated a low value in all zones of the reservoir. Only in two littoral areas near the inflow and outflow the value of this index obtained average values (1.5-2.0).
The general analysis of the ecological status of the Krzynia reservoir based on the structure of the macrozobenthos indicates a very simplified biocenotic structure. The density, biomass and diversity of the studied ecological formation are low. One can conclude, then, that the construction of the Krzynia reservoir has resulted in the interruption of the river continuum of the Slupia River and negative natural ecological effects.

Keywords: Krzynia Reservoir, Slupia River, biomonitoring, benthic zoocenoses

EFFECTS OF AN EMERGENCY SEWAGE DISCHARGE INTO A LARGE EUROPEAN RIVER ON THE STRUCTURE OF CHIRONOMIDAE LARVAE

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The study was conducted on the Vistula River in the urban section (Warsaw) between December 2019 and May 2021. This period included an analysis of the effects of the 2019 and 2020 accidents, during which 3 m^3/s of untreated sewage was discharged directly into the Vistula River. During the accident, more than 10 million m^3 of wastewater entered the river. Insect larvae of the family Chironomidae, considered as indicators of the state of purity of flowing waters, were selected for monitoring the effects of the accident. Four study areas were delimited, including one in front of the urbanised area (reference point) and others corresponding to the impact of the sewage discharge at distances of 0.5, 2.5 and 4.5 km from the collector. Due to the high heterogeneity of the habitats (flow variability), sites were established at both banks and in the middle of the river channel in each study section. This resulted in the collection of 60 samples in which the presence of individual taxa of Chironomidae larvae was identified. As a result of the taxonomic study, the presence of 24 taxa of Chironomid larvae was identified, whose density reached 3347 individuals m^{-2}. At the site closest to the discharge collector, extreme taxonomic diversity was observed: the lowest 4 months after the first failure (2 taxa) and the highest (7 taxa) ten months after the first failure. A total of 14 taxa of chironomid larvae were identified on this section of the watercourse, compared to only 10 within 2.5km of the collector. *Chironomus f.l plumosus* (D=37.2), *Cryptochironomus borysthenicus* and *Polypedilum dff. deletum Goetghebuer* (both 10.2%) constituting the dominant group. They were accompanied in the subdominant rank by *Cryptochironomus zabolotzkyi* and *Paratendipes intermedius* (both 5.3%). The maximum larval density values observed throughout the study period were recorded at the site closest to the collector ($\bar{x}$=1067 indv. m^{-2}), the lowest at a distance of 2.5km from it ($\bar{x}$=622 indv. m^{-2}). The biodiversity of Chironomidae larvae in the study stretch changed over the successive periods studied. However, there is a noticeable increase in both the Shannon index values with distance

from the river discharge site. The response of fly larvae groupings to subsequent discharges is also different. The second failure that took place in August 2020 caused a clear decrease in the number of species much stronger than after the failure in 2019. The insect β-diversity of the studied fragment of the Vistula River was 4.73 (Whitteker index).

Keywords: river, biodiversity, Chironomidae