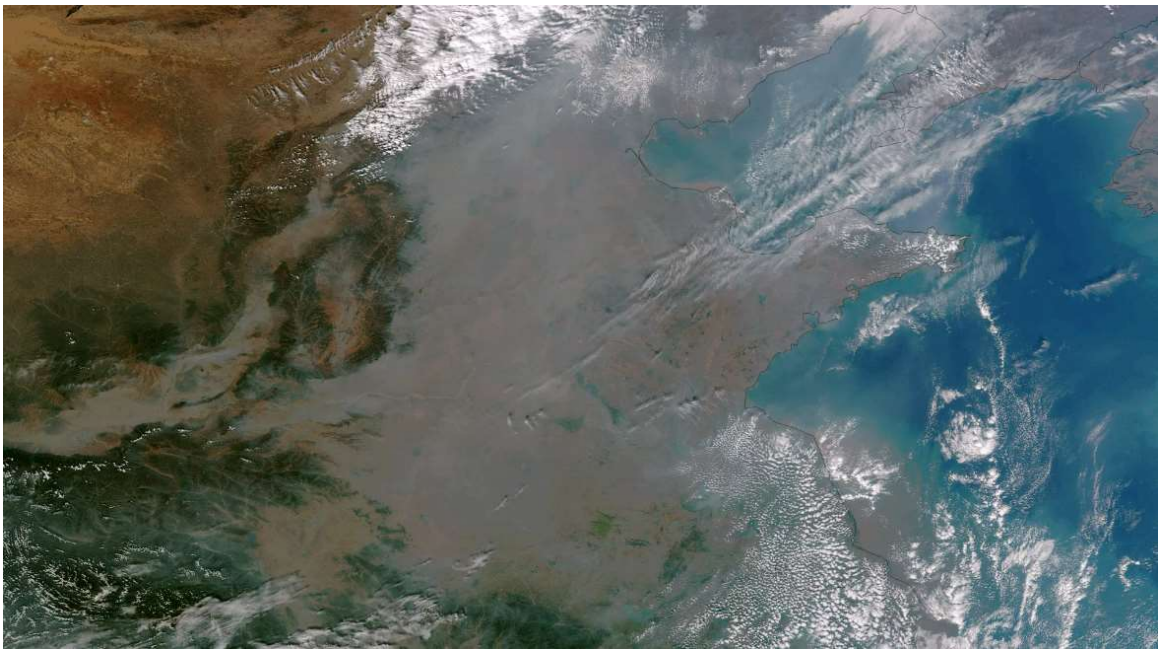

BOOK OF ABSTRACTS

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PLENARY SESSION

ANTHROPOGENIC ALTERATIONS OF LOWLAND RIVER SYSTEMS AND UNEXPECTED RESPONSES AS MEASURED AND MODELED FOR TWO CASE STUDIES: THE MISSISSIPPI RIVER (U.S.A.) AND THE YELLOW RIVER (CHINA)

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Keywords: river deltas, hydrological impacts

Abstract

Lowland rivers have been manipulated by humans for millennia, with built structures resulting in significant impacts to water flow, sediment transport, and channel stability. Some engineering projects carry the potential for unintended consequences, including endangering human lives and infrastructure, and disrupting the commercial and ecological viability of river channels, floodplains, and deltas. In this seminar, I will present case studies of engineering projects on two of the world's largest river systems, including the Mississippi River (USA) and the Yellow River (China). I will detail the histories and impacts of built water diversions (latter) and dams (former), and how these structures affect the morphology of the systems, resulting in unexpected morphodynamic responses. First, we will consider the Old River Control Complex (ORCC) from the Mississippi River, which is the largest water diversion of any river in the world. This structure partitions water as an approximately one-third, two-third split between the Atchafalaya and lowermost Mississippi rivers (respectively). Using numerical modeling, bolstered by extensive data analyses covering the last six decades since its construction, it is demonstrated that the ORCC significantly diminishes sediment transport capacity in the main channel, which results in unabated sediment deposition and produces ever-increasing river stages and flooding conditions. This situation presents a serious problem for the long-term safety of the ORCC structure. Second, I will detail how the recent construction of the Xiaolangdi Dam on the Yellow River, and operation of the annual "sediment and water regulation" scheme, has resulted in lowering of the channel bed elevation downstream of the dam by using sediment-depleted water to erode the bed. However, this has resulted in sediment coarsening and enhanced channel roughness, which in turn generates increasing stage for a given discharge. Hence, counterintuitively, lowering of the channel bed through sediment erosion has resulted in a system potentially more prone to flooding. Both the Mississippi and Yellow river studies share a key lesson: diversions and dams must consider proper ratios of water-to-sediment discharge to maximize efficiency and prevent unintended consequences, including enhancing channel aggradation and roughness, which results in greater river flooding potential and could compromise the safety of the designed (engineered) infrastructure.

METALS AND METALLOIDS BACKGROUND VALUES, PARTITIONING AND FLUX IN LARGE RIVERS OF NORTHERN EURASIA

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Keywords: hydrogeochemestry, Arctic rivers, trace elements, suspended load, dissolved load

Abstract

Northern rivers transport vast quantities of water and constituents from the continents to the Arctic Ocean. Snow and ice melt in Polar regions are associated with dramatic changes in the hydrological regime and significantly enhance erosional processes. Such changes are the most important driver of the hydrological cycle of Polar rivers and dominate the fluxes of dissolved and particulate substances from land to the Arctic Ocean.

This study aims at understanding interbasinal and seasonal variations of metals and metalloids (B, V, Cr, Mn, Fe, Co, Ni, Cu, Zn, As, Mo, Cd, Sb, Sn, W, Pb, U) at the lower Ob, Yenisey, Lena, and Kolyma rivers, as well as Selenga River catchment which represents the upper part of Yenisey river basin – the region most subjected to anthropogenic impact (most agriculture, mining, and urbanization). The dataset on elements in river water and suspended solids for the Ob, Yenisey, Lena, and Kolyma rivers was collected during 2018-2021 regularly at the stations located upstream from deltaic areas and includes 435 suspended matter grain sizes estimates, chemical results from 449 water and suspended matter samples. The dataset on the Selenga River was collected during 2011-2017 at around 76–110 monitoring locations distributed over the catchment area (477,000 km^2) during different hydrological seasons. The approach enables differentiation of background, baseline, and anthropogenic levels of dissolved and suspended metal(loid)s. The study emphasizes average regional concentration levels of metal(loid)s for each river and reveals elevated relative pollution of Ob and Lena compared to Yenisey and Kolyma, as well as seasonal and cross-sectional variations. The results were used to calculate the particulate flux of studied metal(loid)s, which constitute over 13% of the total annual sediment load for the Ob River, 31% for the Yenisey River, 19% for the Lena River, and 20% for Kolyma River.

TORRENTIAL FLOODS PREVENTION

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Keywords: torrential floods, nature based solutions, land degradation neutrality, erosion and torrent control.

Abstract

Torrential floods are the most frequent phenomenon in the arsenal of "natural hazards" in Europe and globe, being the first when it comes to losses, causing huge damage and the loss of human lives. Torrential events are characteristic both in urban and rural landscapes. Appearance of torrential floods is consequence of factors which are partly or completely out of man control. Climate, specific characteristics of relief, distinctions of soil and vegetation cover, social-economic conditions have resulted in the occurrence of erosion processes and torrential floods. Anthropogenic influence could be increased by irresponsible activities concerning land use or decreased with preventive activities: spatial planning in endangered watersheds; afforestation of bare lands, amelioration of degraded forests, meadows and pastures; appropriate agricultural techniques; application of agroforestry; erosion control measures and torrent training works. Soil bioengineering works in the headwaters lead to improvement of interception effects and infiltration-retention capacity of soil. Performing of erosion and torrent control works in line to Nature Based Solution (NBS) and Land Degradation Neutrality (LDN) could be the way for decreasing of natural and man-made hazard.

IMPORTANCE OF SUSTAINABLE LAND MANAGEMENT ON THE SURVIVAL OF PRECIOUS LAND AND WATER RESOURCES

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Keywords: degradation, sustainability, management, environmental effects, economic effects

Abstract

According to the natural characteristics, Balkan peninsula, and especially Western Balkan countries (WB) are predisposed to erosion processes. However, both worldwide and in WB, a large percentage of erosion processes are contributed by anthropogenic factors, as well as natural. The activity of man can be both negative and positive, depending on the degree of awareness of the importance of using natural resources on the principles of sustainability. Sustainably managed land resources are imposed as a necessity to preserve humanity and the planet. As a contribution to sustainable land management (SLM), the paper presents three directions in this sense: Disaster risk reduction (DRR), Community based natural resources management (CBNRM) and the Sustainable land management model (SLM).

Current nature-based DRR solutions practiced in the region are varied, building on a long tradition of erosion and torrent control in Yugoslavia, but to a lesser degree in Albania. While the expertise to implement nature-based DRR solutions is present in the region, many of the specialised enterprises that historically implemented hazard management works no longer exist. Mainstreaming of DRR into sectoral policy is generally limited. Nature-based DRR is also generally framed as part of the climate change agenda (adaption and mitigation) and within the EU accession framework (Waters Directive, Habitats Directive, etc).

Preventing the degradation of torrential floods and erosion processes contained in the sustainable management of land resources, which includes the use of participatory methods. The paper presents the participation of the community in the management of natural resources (CBNRM), according to which the community becomes the primary implementer, with the assistance and under the supervision of professional services. In the case of public participation in the sustainable management of land resources of the part of South Morava river Basin shows the socio-economic and ecological approach of the local population.

This paper also presents a model of sustainable management of land resources, adapted to the conditions of hilly-mountainous areas of Serbia, which includes the planning of production on sloping terrain from the aspect of land resources, then the needs of the population for certain localities particular production, and profitability of planned production. Regarding ecological effects of the model of SLM, soil loss is reduced under the level of tolerance in the researched area. Economic effects of the established model of SLM, proved by Benefit-Cost Analysis, are on the satisfactory to significant level. These reasons are enabling people to stay and survive in these regions.

IMPACTS OF CLIMATE CHANGE ON THE MOBILIZATION OF METALS FROM CONTAMINATED SOIL TO GROUNDWATER - RIVER SYSTEMS

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Keywords: Climate change, Metal contamination, Pollutant transport, Catchment-scale

Abstract

Surficial layers of soil are subject to high pollution pressures from various anthropogenic activities, including industry, agriculture and urban development. Over the past century, the soil cover in many parts of the world is therefore severely impacted by multiple substances, not least by metal(loid) contamination. This work aims at investigating how climate-driven hydrological changes can impact, and possibly aggravate, catchment scale mobilization of metals, including the related transport of metals through groundwater-river systems.

In addition to climate-driven changes in erosion of contaminated soil, we here show that climate-driven changes in groundwater levels can considerably impact the mobility and transport of metals on the scale of entire catchments. For instance, metal contaminants in upper soil layers may become submerged into the groundwater system, as a direct consequence of climate-driven increases in groundwater levels. This will increase the risk of metal mobilization and transport to downstream river systems. Furthermore, in regions where groundwater levels show a decreasing trend, metals may mobilize as a consequence of increased oxygen availability in the soil-water system. Additionally, the occurrence of groundwater level (high/low) extremes, which are expected to become more frequent in a future climate, may also significantly impact freshwater quality. Through field-data driven numerical model simulations, considering actual groundwater level changes representative of Northern Eurasia and North America, we specifically show that mass flows of As and Pb may increase by factors between 2 and 10 in groundwater-river systems, even in regions that are subject to relatively modest groundwater level increases of 1-2 decimeters. Hence, for the successful protection and sustainable management of freshwater resources, such risks would need specific attention.

UNRAVELING THE HYDROGEOMORPHOLOGICAL IMPACT ON TERRESTRIAL SEDIMENT FLUXES ALONG ESTUARIES OF LAKE BAIKAL TRIBUTARIES

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Keywords: Selenga River; Upper Angara River; delta; buffers; sediment conveyance; heavy metals

Abstract

Sediments fluxes and particulate matter composition abruptly change along the lower reaches of large rivers where a decrease of sediment and metals spreading is observed due to channel gradient decline towards the receiving water body related to buffer effects in the delta. Here we investigate estuaries of the largest tributaries of the Lake Baikal. Based on hydrogeomorphological classification we separate transient and depositional estuaries (buffers). Based on in-situ monitoring, field sampling, and satellite datasets the suspended sediment budget for the largest depositional estuaries of the Selenga and Upper Angara rivers was estimated. Both rivers experience sediment deficit which is observed during recent decades are characterized by the reduction of the sediment deposition rates. Under low-flow conditions we observed a longitudinal increase of the sediment transport rates along the Selenga River delta. Sediment transport rates in the Upper Angara river are constantly reduced under various hydrological conditions.

Our results highlight that intense winds induce fine sediment (≤ 100 μm) export to the lake, whereas increased river discharges induce pronounced sediment deposition across delta wetlands. Extreme waves and streamflow events were less intense since 1995 reducing fine sediment export to the Lake Baikal. Additionally, based on Rouse number (Ro) analyses for the 28 transects along lower Selenga River where vertical geochemical sampling was done both with the simultaneous discharge measurements, we demonstrated the significance of the hydraulic control for sediment-associated metal partitioning along the rivercourse. Due to interaction between the transient flow and channel bed (near-bottom sediments (bed load) and bottom deposits), pronounced increase of coarse mineral fractions (50-2000 mm) in the near-bottom layer in the depositional delta pattern was revealed. Along the hydraulic gradient from the main river course to the estuary, the increase of the metals in the near-bottom layers is observed at the low values of Ro.

TERRITORY OF SERBIA AS INDICATOR OF TRANSBOUNDARY AND DOMESTIC WATERS OF SOUTHEASTERN EUROPE

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Keywords: Serbia, Southeast Europe, transboundary waters, water management, flood, drought

Abstract

Water is an essential determinant of natural, social and landscape characteristics. It generates opportunities and limitations, chances and threats, negative and positive phenomena and processes including environmental, economic, political, social as well technical aspects. Problems relating to water security, water protection, equitable access to water as well as upstream and downstream interests are increasingly present from micro to macro level. Such trends are recognized in Southeastern Europe, with regional and local specificities conditioned by natural, social, geopolitical and other characteristics. Although relatively rich in water resources, the region shows a high degree of sensitivity and vulnerability. The causes are numerous, and most often they are recognized in the unfavorable natural regime of waters, poor ecological status, geopolitical and interest driven fragmentation of space, climate changes, and lack of development of water management infrastructure. Unfortunately, floods (May-June) and droughts (July-August) are almost regular seasonal occurrences in Serbia, often with catastrophic consequences. Floods are frequent, from overflowing rivers with predominantly transboundary waters (Tamiš – 2005, Danube 2006 and 2013) as well as domestic ones (Velika Morava – 2005, Nišava, Vlasina and Jablanica – 2007, Zapadna Morava and Veliki Rzav – 2009, Timok – 2010 etc.). The floods in 2014 were particularly disastrous, with estimated economic damage of 1.7 billion euros, and also in 2023. Floods, as a rule, cause landslides that threaten population, settlements, infrastructure, agricultural areas and crops. Droughts are a frequent phenomenon during summers (2000, 2003, 2009, 2011, 2015, 2021, 2022), causing serious disruption of agricultural and manufacturing industries, drinking water supply, energy and, in extreme cases, inland waterway transportion system. As for Serbia, the state and assessment of water resources are a basic segment of quality and capacity of environment, but also the perspective of existence and overall development of society. The territory of Serbia offers a good field for research of trends of change in the quality and quantity of transboundery and domestic waters in Southeast Europe.

SESSION 1: TRANSBOUNDARY WATER AND SEDIMENT POLLUTION

TRANSBOUNDARY WATER AND SEDIMENT POLLUTION – ANALYSIS OF MONITORING RESULTS IN SERBIA

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Keywords: Danube river basin, transboundary profiles, sediment

Abstract

The paper presents results of sediment and surface water quality as part of the monitoring carried out by the Environmental Protection Agency based on the annual program adopted by the Government of the Republic of Serbia. An analysis of sediment quality for the period 2012-2017 and water quality for the year 2021 was presented for transboundary profiles on rivers Danube (Bezdan – entrance profile, Radujevac – exit profile), Sava (Jamena – entrance profile) and Tisa (Martonos – entrance profile). Selection of the profile was made according to the representativeness criterion of obtaining an insight into possible impact of cross-border pollution in the Danube river basin. Aim of the analysis is to present a "historical record" of sediment quality, which with current water quality results on same profiles, indicates possible cause-and-effect relationships. International criteria based on an empirical approach were used for sediment quality assessment, regarding laboratory data like the responses of benthic organisms to exposure to polluted sediment. The following criteria indicating the mean and extreme value of the negative effect on active invertebrates were used: severe effect level (SEL), probable effects level (PEL), effect range median (ERM), toxic effect threshold (TET). For assessment of sediment pollution in terms of the content of heavy metals, recommended values "Quality target" by the International Commission for the Protection of the Danube River (ICPDR) were used, and in terms of the content of organic micro pollutants maximum permissible values according to Serbian regulations. In the final considerations, a recommendation was made to innovate the sediment quality study for a new period 2018-2022, initiating the definition of quality standards for treated sediments, which will expand existing regulations governing the area of landfills and waste, taking into account specific properties of material dredged from the river bottom.

THE INVESTIGATION OF MORPHODYNAMIC PROCESSES OF A HUNGARIAN DANUBE SECTION

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Keywords: sediment transport, 3D, 1D, Hungarian Danube

Abstract

The Upper Danube in Hungary is formed in a bed with gravel-sand mixture. In its natural state, it took on a braided pattern, but due to the river regulation works made at the end of the 19th century, a main channel was formed. Since then, several further significant artificial interventions have taken place on the section, e.g., wing dam fields were installed and a water dam was also built. All these significantly upset the sediment balance of the river section and the induced morphodynamic processes also changed the bed geometry.

Our goal with field measurements was to collect data that made it possible to reveal the current morphodynamic processes. Based on these, we realized that the current state is already close to a new dynamic equilibrium state. The measured data, on the other hand, provided the opportunity for numerical modeling to the examinees. We also used 3D and 1D morphodynamic models to investigate processes at different scales. Basis of these, we were able to calculate and predict the expected changes of gravel bars, and we discovered the large spatial and temporal processes induced by the installation of wing dam fields.

This research was supported by Hungarian Academy of Science – National Program for Sustainable Development and Technologies. The authors acknowledge the funding of the OTKA (Hungarian Scientific Research Fund) Grant No. OTKA_PD 135037. The first author acknowledges the funding from the János Bolyai fellowship of the Hungarian Academy of Sciences.

MINING AND WATER POLLUTION IN THE HYDROGRAPHIC BASINS OF THE APUSENI MOUNTAINS, ROMANIA

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Keywords: Apuseni Mountains, mining, Romania, contaminants' transfer, water pollution

Abstract

Mining, in its various forms, is an economic activity with multiple implications on the environment, and thus, it can subject it to long-term pressures, some of them irreversible. The main mining-associated impacts on river systems, besides the morphological changes, concern the water quality issues: acid mining drainage, a long-term environmental issue associated to mining.

The Apuseni Mountains, representing the northwestern branch of the Romanian Carpathians, have a rich and ancient history in the exploitation of precious metals and complex ores. The underground resources mining constituted a major source of income for the population, but is also the main cause of water pollution and land degradation in the region. Due to mining processes, a series of river basins of the Mureș and Criș rivers' systems, both tributaries, through Tisa River, of the middle Danube River, were affected.

In this context, our work aims to evaluate the potential exposure of water bodies to pollution sources generated by the mining industry, by performing a spatial analysis of explanatory variables that might influence pollutants' transfer within a river catchment (e.g. slope, soil and lithological porosity and permeability, terrain rugosity, land use, sediments' mobility within the slopes – river system, disposal of landfills, etc).

The research documents the mine history in the Apuseni Mountains, main sources and their potential input into the river systems. Using physical in GIS environment, it was possible to estimate the potential flow path from source to sink. This study represents the support of some follow-up investigations on the hydrological and topographical components necessary to perform a hydro-sedimentary connectivity analysis between mining perimeters, tailing ponds and the emissary hydrographic network, in order to determine the level of risk for the transport of pollutants of mining origin (by water and sediments) from the Apuseni Mountains to the cross-border area between Romania with Hungary.

POINT OR NONPOINT POLLUTION – WHAT IS THE DOMINANT SOURCE OF MACRONUTRIENTS IN THE SEDIMENTS OF DRAINAGE CANALS?

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Keywords: Drainage canals, Sediments, Nutrients; Pollution

Abstract

In the lowland, predominantly agricultural area of Vojvodina, 2.15 million ha, (northern part of Serbia), the water-air regime of the soil is maintained by means of a network of drainage canals with a total length of over 22000 km. Most of the catchment areas of these canals are located on arable land and under the influence of Non Point Source Pollution (NPSP) from agriculture, while certain canal are exposed to Point Source Pollution (PSP) from settlements or industrial zones. Low water flow velocities and other impacts favor the deposition of sediments in the canals. Accumulation and increase in the concentration of nutrients and other dangerous and harmful substances occurs in deposited sediments, with negative environmental consequences.

About 100 sediment samples were collected and analyzed, an equal number from canals under the influence of NPSP from agricultural areas and from canals into which untreated wastewater from settlements and industry (PSP) is discharged.

The following concentrations were found in the sediment samples. NPSP canals from agriculture: nitrogen, N in the range 0.03-1.14% (average 0.27%); phosphorus, P_2O_5: 5.2-183.0 (29.4) mg/100g; potassium, K_2O: 3.5-107.0 (24.2) mg/100g. These concentrations are on average 1.1-1.6 times higher than values characteristic of the surrounding arable soil (chernozem). Significantly higher concentrations of parameters were found in sediment samples from PSP canals, N: 0.08-1.22 (0.53)%; P_2O_5: 4.3-265.0 (58.1) mg/100g; K_2O: 7.7-382.0 (48.8) mg/100g. These values are 2.1-3.1 times higher than the corresponding values in arable soil. That is, nutrient concentrations in PSP canal sediments were 1.5-3.5 times higher than concentrations in NPSP canals.

The impact of agriculture as a NPSP on elevated concentrations of nutrients in canal sediments is evident. However, in Vojvodina, the processes of accumulation and increase nutrient concentration in sediments are much more pronounced in PSP drainage canals that are under the influence of urban areas (PSP).

Acknowledgments: Provincial Secretariat for Higher Education and Scientific Research, AP Vojvodina, Republic of Serbia (Grant No. 142-451-3114/2022-01/2).

GEOQUALIMETRIC AND CARTOGRAPHIC MODELS OF THE LEVEL OF EROSION-ENVIRONMENTAL HAZARD OF WATERSHEDS

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Keywords: river basin, territory, erosion and environmental hazard

Abstract

A system-geoclimetric approach to a non-additive aggregated criterion of erosion-ecological hazard of river basin lands is proposed. The properties of constructed non-linear partial and integral assessments of degradation (poor quality) of anthropogenically modified watershed areas are considered, which have a probabilistic interpretation and allow creating correct synthetic assessment and forecast maps-schemes of the level of environmental hazard of the accelerated development of erosion processes in the region under study.

This article was prepared on the topic of the State Assignment No. FMGE-2019-0007 AAAA-A19-119021990093-8 "Assessment of physical-geographical, hydrological and biotic changes in the environment and their consequences for creating the foundations for sustainable nature management."

SPATIAL AND TEMPORAL VARIABILITY OF SEDIMENT AND DISSOLVED LOADS IN THE NIŠAVA RIVER (EASTERN SERBIA)

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Keywords: dissolved load**,** suspended sediment load, seasonal variability, extreme meteorological–hydrological events, Nišava River, Serbia

Abstract

During the period of 2009-2010, the sediment load and dissolved load were analysed in the Nišava river. Water samples were collected every day over a two-year period at four hydrological stations: Dimitrovgrad, Pirot, Bela Palanka and Niš. The specific dissolved load ranged from 68.8-92.4 t/km^2/yr for the measuring stations and the specific suspended sediment load from 20.7-121.5 t/km^2/yr. The analysis revealed that 70.6-87% of the total load was transferred during the spring and winter seasons. In general, the dissolved load dominates the total load. The dominance of the suspended sediment load is related only to extreme precipitation and hydrological events and was recorded at the upstream (Dimitrovgrad) and downstream (Niš) measuring stations. The transport of the load of suspended sediment shows three specificities: exponential pattern of transport, pronounced temporal variations in different seasons and spatial variations within the same season. Lower values of the load of suspended sediment in the middle stations (Pirot and Bela Palanka) are the result of the influence of the anthropogenic factor.

SESSION 2: BALKAN REGION WATER AND EROSION PROBLEMS

EVALUATION OF RAINFALL EROSIVITY IN THE SE EUROPE

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Keywords: rainfall erosivity, soil erosion, hydro-meteorological hazard, indices, overview, SE Europe.

Abstract

Understanding the impact of water erosion in specific regions is crucial for implementing effective measures to mitigate its adverse effects. Long-term analysis of rainfall erosivity (*RE*) plays a significant role in flood prevention, hydro-meteorological hazard mitigation, enhancement of ecosystem services, sustainable land use, and agricultural production. Extensive research has demonstrated that climate change directly affects the potential of atmospheric precipitation to induce soil erosion, primarily through variations in rainfall intensity and the occurrence of extreme precipitation events. Various approaches have been developed for estimating soil erosion, including indices based on precipitation data such as the Precipitation Concentration Index (*PCI*), Fournier index and its modification (*FI*/*MFI*), and Angot pluvial index (*K*). Additionally, there are rainfall erosivity and erosivity density estimators based on kinetic energy and precipitation intensity, such as models based on power functions using event or daily rainfall measurements for the calculation of erosivity at all temporal scales (*RE*/*ED*), and models based on the universal soil loss equation (*USLE*) methodology and its modifications (*RUSLE* and *RUSLE2*). In this work, we present an overview of the most used approaches for the evaluation of *RE* in SE Europe over the past decade. These approaches are essential for understanding the complex relationships between hydro-meteorological factors and soil erosion processes. By objectively selecting appropriate methods and techniques, valuable information can be obtained for conducting detailed and dynamic soil erosion assessments. Furthermore, these approaches facilitate the analysis of extreme erosive events at a regional scale, leading to sustainable soil erosion evaluation and effective control measures.

METHODOLOGY FOR MONITORING THE RISKS OF COLLAPSE OF ROADS, BUILDINGS AND STRUCTURES DUE TO SOIL EROSION

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Keywords: soil erosion, dynamic geophysical monitoring, emergency risk management.

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Abstract

Proposed technology for automated monitoring of the possible soil erosion designated to reduce the risk of collapses of roads, buildings and structures.

GIS-BASED MODELLING OF EXCESS EROSION AND LANDSLIDE SUSCEPTIBILITY AREAS ON THE NATIONAL LEVEL: EXAMPLE OF NORTH MACEDONIA

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Keywords: multi-hazard modeling, natural hazard assessment, geo-hazards, excess erosion, landslides, GIS, North Macedonia

Abstract.

In the last few decades, worldwide studies show that the number of natural hazards has steadily increased, generally due to climate change, causing significant damage. Analyses of the meteorological data for the area of North Macedonia show evident climate change, especially regarding the frequency and intensity of heavy rains. Therefore, identifying potential natural hazard areas is increasingly important for better prevention and protection of the landscape and the population.

Due to the favorable natural conditions and anthropogenic factors, Republic North Macedonia (in further text North Macedonia) is under a high risk to natural hazards, especially excess erosion and landslide occurrences. Steep slopes of the terrain combined with soft rocks (schists on the mountains; sands and sandstones in depressions), erodible soils, semiarid continental climate and sparse vegetation cover give a high potential for soil erosion. For this reason, the paper presents an approach to modelling of above-mentioned geohazards in North Macedonia. Utilizing Geographic Information Systems (GIS), relevant data pertaining to the entire research area were employed to analyze and assess the extent of excessive erosion, and susceptibility to landslides, and identify areas prone to multi-hazards. By leveraging the capabilities of GIS, a holistic understanding of the interaction between the geohazard and landscape was achieved. Using the Gavrilović EPM - Erosion Potential Method, an average value of 0.43 was obtained for the erosion coefficient Z, indicating areas prone to high erosion risk. Furthermore, because of the weak landslide inventory, the national scale and for better accuracy, Analytical Hierarchy Process (AHP) approach is used in combination with the statistical method (frequency ratio). The results show 78% landslide susceptibility model accuracy. According to the combined multi-hazard model, 5.15% of the total area of North Macedonia is both at high risk of landslides, and excess erosion. The primary objective of a multi-hazard modeling is to identify and delineate hazardous areas, thereby aiding in activities aimed at reducing the hazards and mitigating future damage. This becomes particularly significant when considering the impact of climate change, which is associated with increased landslide activity and excessive erosion. The approach based on a national level presented in the paper has the potential to provide valuable information for regional planning and decision-making processes.

MEASURING AND MODELLING RESERVOIR SEDIMENTATION IN NORTH MACEDONIA

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Key words: erosion, reservoir sedimentation

Abstract

The construction of dams with reservoirs in the Republic of North Macedonia dates from 1938, and until now 27 large dams have been constructed which enclose impounding reservoirs with total volume of more than 0.5 x $10^9 m^3$. Additionally there are more than small 200 reservoirs mostly for irrigation purposes. All these reservoirs are multipurpose but mainly for irrigation and hydro energy production. The largest reservoirs are: "Kozjak" (550 x $10^6 m^3$), "Shpilje" (520 x $10^6 m^3$) and "Tikvesh" (470 x $10^6 m^3$). Although smaller, reservoir "Kalimanci" (127 x $10^6 m^3$) is interesting because of huge erosion processes in the watershed, mass erosion control activities and several measurements done in the past. Erosion and filling of reservoirs with sediment is one of the main problems leading to reduced lifespan of the reservoirs with large environmental and economic implications. Reservoir sedimentation also provides valuable information on erosion intensity and sediment transport within a catchment.

In some big reservoirs there are few measurements, but in the most of the reservoirs there very few measurements or none performed. For all of the reservoirs was performed modelling of the sediment yield. Focus of this study is modelling and monitoring of three reservoirs: "Shplilje", Tikvesh" and "Kalimanci". Measuring the sedimentation in the reservoirs started in 1970 using classical surveying methods on stabilized cross profiles. Current measuring is done using echosounder with GNSS, while further calculation are in GIS environment. Modelling of erosion intensity as well as mean annual sediment yield was carried out using EPM (Erosion Potential Method) by Gavrilovic.

Within the "Tikvesh" reservoir eleven measurements were done. According to the latest measuring (2016) there are 39.7x10^6 m^3 or mean annual intensity is 830 000 m^3/y. There can be distinguished two different periods. In the period 1968-1991 the mean annual intensity was 1 270 000 m^3/y while in the period 1991-2016 it decreased to 430 000 m^3/y. Similar situation is in the reservoir "Kalimanci" where twelve measurements were done. According to the latest measurement (2013) there were 13,9 x10^6 m^3 or mean annual intensity for the whole period is 315 682 m^3/y. In the period 1969–1985, the average annual deposition in the reservoir is 493 055 m^3/y and in the period 1986–2013 the average annual deposition in the reservoir is 214 325 m^3/year. Modelling erosion intensity was done two times in the 80's and again few years ago. Erosion intensity expressed through erosion coefficient show significant decrease. This decrease is a result of mass erosion control works (especially in "Kalimanci" watershed), migration, decrease number of livestock, land abandonment and land cover change (forest growth on former agricultural land), consolidation etc. Sedimentation in the reservoir "Shpilje" was measured only once in 2014, showing 36.7 x10^6 m^3 or mean annual intensity of sedimentation is 815 555 m^3/y. While for the "Tikvesh" and "Kalimanci" reservoirs results of modelling are not so much different from the results of the measuring, in the case of "Shpilje" reservoir result from the modelling using EPM are 20% lower but modeling was done using the current situation that differs form situation in the past where there were more population in the region, more agricultural activities, especially livestock husbandry while mass erosion and torrent control activities were constructed later. According to the modelling, in all big reservoirs annual sediment yield is at least 3 500 000 m^3.

SHOREZONE FUNCTIONALITY INDEX – AN APPROACH TO SUPPORT WATER FRAMEWORK DIRECTIVE – CASE STUDY LAKE PRESPA

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Key words: Lake shorezone, SFI, Lake Prespa, hydro-morphological quality elements

Abstract

The shorezone is a transition zone (ecotone) between a lake and its surrounding territory that can perform important ecosystem services, such as regulating nutrient inputs and protecting against nonpoint source pollution, ensuring the maintenance of ecological processes, providing food and habitat for organisms, and protecting the shoreline from erosion. The Shorezone Functionality Index (SFI) was developed in Italy in 2004. When using the SFI, geo-morphological (topography, morphology, geology), hydrological (climate, temperature, rainfalls, drainage network), ecological (Vegetation type, size, continuity, interruption) and socioeconomic (land use, infrastructure, agriculture and forestry) parameters are evaluated in the field from an ecological perspective: biotic and abiotic factors are used to evaluate the buffering capacity of riparian vegetation, the complexity and artificiality of the shoreline, anthropogenic uses of the surrounding territory, and the way inputs from the watershed enter the water body. The data collected in the field is processed using the Shorezone Functionality Index software package (SFINX02) which determines the functionality value for each homogeneous stretch. SHOREZONE is delineated on HOMOGENOUS STRETCHES with various length depend on a changes of characteristics on the shorezone.

Lake Prespa consist of 2 lakes Micro and Macro Prespa that is subject of this study and is shared between North Macedonia, Greece and Albania. Macro Prespa is natural; tectonic lake, on altitude 844-853 m asl (because of fluctuation), through the karstic mountain Galitsica is connected to Ohrid Lake (cca 695 asl). Maximal depth is 54 m, lake volume 27-49 km^3, lake area is 261 km^2 and the watershed area is 566 km^2. Average residence time is 83.6 years, Tributary effluent capacity is cca 5 m^3/s, there are significant water level fluctuation, summer transparency – sechi disc is 3-5 m, trophic classification is mesotrophic to eutrophic.

The total length of shorezone is 106 km. Greece part (cca 22, km) of the Macro Prespa shorezone was not studied. According to the shorezone typology were identified 5 types of stretches: Type 1 – Trees and Reeds (Reeds and functional tree belt with a high level of functionality in eastern side of Ezerani wetland MKD), Type 2 – Reeds natural and provide a higher functionality (Ezerani wetland – MKD), Type 3 – Cliff with Reeds (provide higher complexity, and has functionality), Type 4 – Cliff without Reeds (a typical example of a stretch that is natural, although not functional), Type 5 – Bare soil/beach with high artificiality, no functionality. In total, 45 stretches with various lengths were delineated.

Final results from subjective on-filed assessment of the status of the shorezone and status using software were compared and were noticed few differences especially on category poor. Shorezone length North Macedonia and Albania is 84.3 km. Following the WFD classification out of them 36.4% are assigned as high, 19.6% as good, 39.8% as moderate, 1.8% as poor and 2.4% as bad. The first two categories area acceptable while other 3 are unacceptable and need measures. Situation in North Macedonia is much better and 79.8% of the shore zone is with acceptable status. On the other hand, situation in Albania is bed and only 25.4% of the shorezone has acceptable status.

WHAT IS HAPPENING WITH DANUBE RIVER DISCHARGE?

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Keywords: Danube, Discharge, Trends, Serbia, Hungary, Romania

Abstract: This study presents an analysis of the changes in summer Danube River discharge, focusing on extreme events, using daily discharge data from eight stations across four countries spanning the 1961-2020 period. The study employs the Mann-Kendall (MK) and Pettitt tests (PT) to examine temporal patterns and change points (CP) in extreme events across different locations. CP indicates significant change in observed patterns or trends. The results reveal diverse patterns among the studied locations. At Bratislava, a significant increasing trend in extreme events was observed, while the PT identified a CP associated with a notable decrease in their occurrence. Nagymaros exhibited no significant trend, although a CP suggested a shift in the occurrence of extreme events. Conversely, no significant trend or CP were found in Mohach. Bezdan and Bogojevo displayed no significant trend in extreme events but exhibited CP in April, 2002 and June 2002 for Bezdan and Bogojevo respectively, indicating shifts in occurrence patterns. In Orsava and Zimnicea, a decreasing trend in extreme events was observed, accompanied by significant CP in September 1976 and April 2004 for Orsava and Zimnicea respectively, implying substantial shifts in their occurrence. Ceatal Ismail, on the other hand, showed neither a significant trend nor CPs. The results underscore the importance of further research and the implementation of appropriate mitigation strategies to address the changing patterns of extreme events in these locations. By understanding these changes, stakeholders can develop effective measures to adapt and respond to potential risks associated with extreme river discharge.

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LONG-TERM CHANGE IN HYDROCLIMATIC REGIMES IN CATCHMENTS ACROSS SERBIA

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Keywords: catchment hydrology; climate change; hydroclimatic indicators; hydrological signatures; Mann-Kendall test; trends.

Abstract

This study presents trend analyses in several catchments across Serbia. The trend analyses are preformed over series of precipitation, temperature and streamflows. These variables are represented by different indicators, such as the total annual precipitation, or maximum daily precipitation depth, temperature, and streamflow rate. The indicators are selected to represent different features of the catchment hydroclimatical regimes, such as mean or extreme conditions, or seasonality, and are all computed at the annual level. The Mann-Kendall test for trend is applied over these annual series of indicators, and the series that result in the test null hypothesis rejection at 5% are considered to exhibit a statistically significant trend. The results of the Mann-Kendall test are complemented by the Sens' slope estimator values, which indicate a sign of a trend. The trend analyses are further extended to joint considerations of concurrent occurrence of trends in climatical and hydrological indicators in the same catchment by conducting a correlation analysis. The objective of these analyses is to examine if the trends in climatical variables inevitably translate to trends in streamflow-related indicators, i.e., hydrological signatures, which is important in context of climate change and effective water resources management.

KEY ROLE OF FLOOD EXPOSURE IN FLOOD RISK MANAGEMENT IN SERBIA

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Keywords: flood exposure, flood risk management, drivers, local communities, Serbia

Abstract

Growing exposure and vulnerability of the population and their goods influence the increase of natural disaster and flood risk, which further implies necessity for rational flood risk management activities. Trend of larger damages, injuries and deaths caused by natural hazards point out that the exposure and vulnerability are risk components which have a key role as a distinctive factor between the natural hazards and disasters, as well as those on which activities should be directed in order to reduce risks and damages. Flood risk management in Serbia is managed by 1) the three Public Water Authorities which are in charge for large rivers in Serbia (watercourses of the I order) and 2) local authorities (municipalities and towns) which are responsible for the watercourses of the II order. Such duties division turned out not to be fully functional since local authorities have limited operational capacities (human and financial resources) to cope during the floods. Therefore the aim of this paper is to present the flood exposure distribution of 1% probability of occurrence flood-prone areas in Serbia, considering administrative spatial units responsible for flood risk management. Selected indicators are total population, built-up areas, protected areas and mineral resources. Presented analyses and results could be used by management authorities to make and revise flood risk management plans. This paper contributes to the definition of problems and barriers related to "how to decrease high exposure?" and proposal of order of their solving. The main selected drivers are social (scientific researches, education and raising flood risk awareness), followed by those from political, legal and institutional sphere. This order of activities would lead to necessary changes in laws (for example the division of watercourses defined in *Law on water*), and subsequently to revision of management capacities, such as redistribution of duties. All mentioned activities imply cooperation with local communities.

DISCHARGE VARIABILITY OF THE RIVERS IN THE ŠUMADIJA REGION (SERBIA)

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Keywords: discharge, t-test, variability, river, Šumadija Region.

Abstract

Discharge, as one of the most important parameters in water quantity assessment, is often analyzed in terms of its dependence on recent climate change and variability. This study analyses the discharge variability of the selected rivers in the Šumadija Region (8,569 km^2) in the central part of Serbia. Most rivers in this region are shorter watercourses, between 50 and 80 km long, characterized by an uneven regime and occurrences of droughts and flash floods. Generally, these rivers have a low amount of water, especially in summer, when discharges in some rivers are below 1 m^3/s. In this regard, the analysis of discharge changes in 8 rivers from this territory in the sixty-year period was done. Using the t-test, a comparison of two thirty-year periods (1961-1990 and 1991-2020) was made to estimate if there were significant changes in the discharges on annual and monthly levels. The obtained results showed that in all rivers, on the annual level, a decrease in discharge was observed in the later period compared to the earlier one. This decrease in the Lepenica and Lugomir rivers is statistically very significant ($p \leq 0.01$). According to the inter-annual distribution of discharges, in all rivers, discharge generally decreased from January to June and mainly a slight increase from July to December in 1991-2020 compared to 1961-1990. Applying the t-test, it was determined that these changes in monthly discharges between two 30-year periods generally are not statistically significant, but there are some exceptions. A very significant ($p \leq 0.01$) decrease in discharge was observed at Lepenica in February and May, at Jasenica in June, and at Lugomir in June and September, while a significant decrease ($p \leq 0.05$) was registered at Lepenica in January and March. These changes can be correlated with a statistically significant increase in air temperatures in this region, especially in the summer period, which has been presented in several studies. A significant increase ($p \leq 0.05$) in discharge was observed at Peštan in October and at Kubršnica in September and October, which can be related to significant precipitation. The obtained results can serve as a first step for decision-makers in water management planning in this densely populated region.

HYDROGRAPHIC CHARACTERISTICS OF POLIMLJE

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Keywords: basin, relief, erosion, Lim, river, springs

Abstract

The hydrographic characteristics of the Lim River system are formed as a consequence of the climate, geological composition of the terrain and the relief. This complex area is mostly drained by the River Lim with its tributaries. Springs and hot springs emerge at the foot of hills and mountains, while lakes are frequently located on mountains and represent glacial remains.

The Lim Basin is hydrologically quite different from other parts of Montenegro and Serbia, primarily due to its geological composition. In its lower parts in particular, clastic rocks which retain water are present, while river erosion and denudation create flatter forms of relief, surfaces and basins. In order to obtain the basic morphometric parameters of the Lim River basin, in addition to the data from VO "Zeta" (Hrvavčević, 2004), GIS technologies (Quantum GIS Lisboa 1.8.0) were used as one of the basic tools. A topographic map with a scale of 1:50000 (TK 50), published by the Military Geographical Institute, supplemented in 1970 and printed in 1980, was chosen as the basic source of data on the basin; the map is georeferenced in the state coordinate system of the Gauss-Kruger projection (GK 6).

FREQUENCY ANALYSIS OF TORRENTIAL FLOODS OF TOPČIDERSKA REKA AND LEPENICA

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Keywords: Torrential floods, FFA, Serbia, GEV, Natural Hazards

Abstract

Days of torrential precipitation in June 2023 caused flooding in many parts of Serbia, forcing authorities to declare a state of emergency in 56 municipalities. That is why, the understanding the dynamics of torrential floods is crucial for scientific advancement and societal well-being. With increasing social and economic pressures on land use and the intensification of the hydrological cycle due to global warming, the potential for torrential floods is on the rise worldwide. In Serbia, torrential floods are the most common natural hazards, causing significant loss of life and property damage in both urban and rural areas. This research focuses on flood frequency analysis (FFA) using the L-moments method and annual maximum discharge data for two rivers (Topčiderska reka and Lepenica) in the Šumadija region of Serbia. Through L-moments ratio diagrams and Cramer von-Mises and Kolmogorov-Smirnov tests, the Generalized Extreme Value distribution is identified as the best-fit distribution for both rivers. Finally, the quantile estimates for the return periods of 10, 50, 100, 500 and 1000 years were calculated for each watershed. The findings of this study can serve as a reference for future research aiming to establish an official FFA distribution for the entire Šumadija region. The results of this study could provide additional information for engineers in terms of designing the dimension of different hydraulic structures (levees, bridges, spillways, etc.) and policy makers as a decision support tool for urbanization, floodplain regulation and management along rivers in Šumadija.

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MONITORING OF SURFACE WATER QUALITY ALONG THE COAST OF GREAT WAR ISLAND

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Keywords: Great War Island, water quality monitoring, pollution impact on water, polluted waters, drinking water.

Abstract

The Island was formed by fluvial sand deposition, so it could be assumed that wastewater has a significant impact on the island itself. The water of the Danube river is classified as Class III in terms of quality, but due to the presence of nitrites, according to the classification table, it belongs to Class V[1]. Using GIS software, maps were obtained showing the influence of the tested ions on the island. Based on these characteristics, it can be concluded that the wastewater discharged into the Danube and Sava rivers has an impact on Great War Island. By comparing the models of the authors mentioned in the study regarding the lateral influx of surface water into the alluvial aquifer and their interaction with groundwater, it can be concluded that pollutants and chemical compounds from the surface flow of the Danube and Sava rivers have a significant impact on the quality of groundwater. The study provides graphical representations of the impact and distribution of specific tested compounds and ions. The research is based on the analysis of water samples taken from the shores surrounding Great War Island, and the data was processed using GIS tools. Water samples were taken at six stationary points, and on-site determination of physical characteristics such as pH value, color, turbidity, and odor was conducted. The determination of NO_3^-, NO_2^-, and NH_4^+ ions was carried out colorimetrically. The concentration of carbonate ions was determined based on pH values. HCO_3^-, Cl^-, Ca_2^+, and Mg_2^+ ions were determined volumetrically.

[1] The category outside the quality class according to the Regulation on Surface Water Quality consists of total of 4 categories (I, IIa-IIb, III, IV).

ASSESSMENT OF WATER QUALITY PLAVSKO LAKE (MONTENEGRO)

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Keywords: WQI, Plavsko Lake, Montenegro

Abstract

Plavsko Lake is the largest mountain lake in Montenegro. It belongs to glacial accumulation lakes. It is located in the terminal basin of the former Pleistocene Plavsko Glacier, which descended from the Prokletije Mountains. The lake is a flowing lake, with the main tributary the Ljuča River, and the distributary the Lim River. With an altitude of 906 meters, a maximum depth of up to 9 meters, and an average surface area of 1.99 square kilometers, Plavsko Lake is one of the most beautiful natural gems of Montenegro and a center of ecotourism in Plav municipality in the northeastern part of the country. The aim of this study is to assess the water quality of Plavsko Lake using the Water Quality Index (WQI) model i.e. the SWQI method. Data from the period 2010-2018 from the State Hydrometeorological and Seismological Institute were used, and the WQI was calculated based on 10 parameters of physicochemical and microbiological water quality, determined through water sampling from the middle of Plavsko Lake. These parameters include oxygen saturation, biochemical oxygen consumption for 5 days, ammonium ion concentration, pH value, total nitrogen oxides, orthophosphates, suspended solids, temperature, electrical conductivity, and coliform bacteria count. The average annual values of the WQI indicate that the water of Plavsko Lake belonged to the category of excellent quality (WQI = 90-96). An exception was the year 2014 when the water quality was of very good quality (WQI = 87). In order to keep the water of Plavsko Lake clean, it is necessary to protect the environment from pollution and uncontrolled anthropogenic pressures, not only the water body itself but also its watershed area.

THE INFLUENCE OF POLLUTANTS ON THE FORMATION OF THE CHEMICAL COMPOSITION OF THE RIVER SUŠICA, REPUBLIC OF SRPSKA, BOSNIA AND HERZEGOVINA

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Keywords: hydrogeochemical processes, chemical composition, water quality, factor analysis, the Sušica river catchment, Bosnia and Herzegovina

Abstract

The Sušica is a left side tributary of the Trebišnjica river. Due to the dominant presence of Triassic dolomites in the catchment, it is characterized by normally developed river system. From the Zaslapnica spring to the Gorica Reservoir, the Sušica river is 12 km long. It is a mudflow with a large variation of flow. The Sušica river catchment is inhabited by population engaged in agriculture and tourism. There is no systemic wastewater treatment in this area.

The prevailing water types in the Sušica river catchment are Ca-Mg-HCO_3 and Mg-Ca-HCO_3. These water types are a reflection of the predominant carbonate material, especially dolomites. Water samples for physicochemical analysis have been mainly collected four times a year by the Hydro Power Plant on the Trebišnjica river (HET), in the period 2004 and 2020. They were taken at five locations along the river. Physicochemical analysis of water included up to 56 parameters, but only 10 were taken for statistical data processing: pH, Ca2+, Mg2+, HCO_3-, $SO_4$2-, Cl-, P, NH_4+, electrical conductivity and TDS.

The parameters of the physicochemical analysis were subjected to factor analysis, where three factors were singled out. They explain 69.42% of the variance of the original data set. The first factor (F1), which explains 41.22% of the total variance, represents the dissolution of dolomite. The second factor (F2) explains 16.6% of the total variance and indicates the dissolution of calcite, gypsum and chlorides. The third factor (F3) explains an additional 11.6% of the variance and includes a strongly positive loading for NH_4+ (0,9). Therefore, F3 represents the influence of anthropogenic activities in the Sušica river. Apart from NH_4+, within the third factor, $SO_4$2- is also characterized by significant and positive loading (0.6). This shows that sulfates are not only created by the dissolution of gypsum, but they may be a product of pollution.

GEOGRAPHY OF DISEASES CAUSED BY BIOLOGICAL AGENTS FROM WATER – AP VOJVODINA

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Keywords: Population health, AP Vojvodina, Biological pollutants, Water, Disease

Abstract

The aim of this article is to investigate the health effects of biological agents originating from the waters of the AP Vojvodina (northern Serbia). Microbiological defects in untreated drinking water were analysed for coliform microorganisms, *Escherichia coli, Enterococcus (genus Streptococcus), Pseudomonas aeruginosa*, aerobic mesophilic and thermotolerant microorganisms of faecal origin, and the possible effects on public health are discussed. Characteristic diseases caused by biological pathogens (acute bacillary dysentery, giardiasis, infectious jaundice, leptospirosis, tularemia, amoebic dysentery) are also shown with an illustration of the changes in disease patterns and their tendencies. These analyses can influence the improvement of population and public health status, the adaptation of prevention programs in vulnerable areas, and the reduction of waterborne disease prevalence among the local population.

ASSESSMENT OF SOIL EROSION IN THREE SUB-BASINS IN KOPAONIK NATIONAL PARK (SERBIA), EMPLOYING SWAT AND REMOTE SENSING

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Keywords: Environmental Impact; Ski Resorts; Deforestation; Surface Runoff; Landsat; LCLU change

Abstract

Soil erosion is one of the main environmental problems nowadays, mainly related to land-use changes, such as agricultural intensification and deforestation. In Serbia, despite the estimation that 86% of the total country's territory is potentially at soil erosion risk, during the last decades the rate of soil erosion has been in decline. This is related to demographic and economic processes: depopulation, population migrations from rural to urban areas, demographic ageing, and decrease in agricultural activities. Despite this tendency, several mountain areas are being exposed to continuous land degradation, mainly caused by winter tourism development. The largest and most developed ski resort in Serbia is located within the area of Kopaonik National Park, situated on Kopaonik Mountain, where major threats to landscape and natural ecosystems are deforestation, increasing soil erosion, construction of ski slopes and urbanisation accompanied by illegal construction, etc. In this research, we employed remote sensing techniques for data collection and utilized the Soil and Water Assessment Tool (SWAT) to assess sedimentation and surface runoff. The focus was on three sub-basins situated in the Kopaonik ski resort region, with data spanning the years 1984 and 2018. The obtained results show a decrease in surface runoff and sediment yield in sub-basin 2, and an increase in sub-basins 1 and 3. Additional analysis of land-cover changes in the given area indicates an enlargement of evergreen forest cover, reduction of pastures and mixed forest cover, and appearance of deciduous forests, barren soil, and urban areas. Results indicate that the main processes affecting soil erosion are the development of winter tourism and recovery of vegetation due to a decrease in agricultural activities.

FUTURE AGRICULTURAL PRODUCTION STRUCTURE MODEL (FAPSMS) IMPACT ON SOIL EROSION

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Keywords: sustainable management; soil erosion; soil conservation; RUSLE model; model of future production

Abstract

Various models of sustainable soil management are being applied in the world. They are aimed to prevent the erosion destruction of the soil through adequate processing methods, with appropriate yields and positive economic effects of such production. Conservation of soil on sloped terrains is of great importance, especially having in mind that mountain soils are home to 25% of all terrestrial biodiversity, including agrobiodiversity. Sustainable agricultural management needs to account for site specific characteristics, including topographic factors and coexisting biotopes. In Serbia the trend of people leaving rural households and moving to cities became increased during the second half of the twentieth century that led to a change in soil use so that the areas under meadows, orchards and vineyards were increased at the expense of areas under arable soils and pastures so the intensity of erosion processes have decreased. However, soil erosion is still very widespread in Serbia. More than 86% of Serbia's surface is affected by erosion of different intensity. According to Gavrilović's erosion potential method, soil erosion endangerment of research area of Barička river basin is in the category of medium erosion endangerment. The aim of this study is to determine existing soil erosion risk and risk after application of Future Agricultural Production Structure Model from the Aspect of Preserving Land Resources for Mountain Catchment Areas of Serbia (FAPSMS), in the suburban area of the morphological unit of the Barička river watershed, in Serbia. An analysis of soil erosion risk was carried out, using the Revised Universal Soil Loss Equation (RUSLE) method, with the existing and projected structure of agricultural production according to the FAPSMS. The results show that soil erosion losses are already below tolerance values with the existing production structure and that they could be reduced even more by applying the projected structure.

ECONOMIC EFFECTS OF APPLYING FUTURE AGRICULTURAL PRODUCTION STRUCTURE MODEL (FAPSMS)

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***Corresponding author:** sustainable management; economic analysis; soil conservation; model of future production; soil erosion

Abstract

It is necessary to harmonize the needs of society in terms of agricultural production and land protection from various forms of degradation throughout sustainable land management. Various models of sustainable soil management are being applied with an aime to prevent the erosion destruction of the soil through adequate processing methods, with appropriate yields and positive economic effects of such production. Assessing the justification of investment in sustainable management of land resources is an important step in this process. Analysis of soil erosion risk was carried out in the suburban area of the morphological unit of the Barička river watershed, using the Revised Universal Soil Loss Equation (RUSLE) method, with the existing and projected structure of agricultural production according to the Future Agricultural Production Structure Model from the Aspect of Preserving Land Resources for Mountain Catchment Areas of Serbia (FAPSMS). The value of the existing and projected production structure from an economic aspect was also examined using dynamic economic methods such as Internal Rate of Return (IRR), Repayment of the Invested Funds (RIF), Cost-Benefit Ratio (CBR) and Net Present Value (NPV). In order to assess the risk and uncertainty of investments, a sensitive analysis of dynamic methods IRR and RIF was carried out. Economic indicators show that the investment is justified and that it is more sensitive to changes in income.

ASSESSMENT OF PLASTIC POLLUTION OF THE SOIL ENVIRONMENT

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Keywords: microplastics, soil quality, soil parameters, soil respiration, pollution

Abstract

Plastic pollution is fast becoming a serious global environmental problem with the increase in plastic waste over recent decades. One of the first investigations of plastic and microplastic (MP) in the soil on the territory of Serbia is currently underway and is being carried out within the project "Evaluation of the Microplastic in the Soils of Serbia – EMIPLAST – SoS" funded by the Science Fund of the Republic of Serbia. The aim of the research is to reveal the impact of the presence of plastic materials on soil's main chemical, physical and biological properties. The examination of the impact of MP on the soil is being carried out through a comparative analysis of samples from localities that are and are not exposed to MP pollution. Sampling was done in three seasonal repetitions in the 2022 and will be done in the same way in 2023 in all selected plots. Microbial respiration is measured from all samples using the alkaline trap method as an indicator of microbial activity. The parameters related to the soil structure are not variable in such a short time frame, which is why they were determined at the beginning and will be determined at the end of the experimental period: mechanical composition, volumetric mass, specific mass, porosity, aggregate stability and organic matter content. Soil parameters that may affect aggregate stability such as pH, electrical conductivity and total carbon content, as well as soil nutritional status (N, P_2O_5, K_2O, Cu, Zn, Mn and $CaCO_3$) were determined. These parameters are used to characterize the soil at the research sites. Preliminary results showed that some soil properties are significantly affected by the presence of plastic materials. In order to establish the level of the negative impact of microplastics on soil properties and microbial activity in the longer term, the study is ongoing.

Acknowledgment

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IMPACTS OF MINING ON SOIL AND WATER – ECOSYSTEM SERVICES APPROACH

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Keywords: soil and water resources; mining; ecosystem services.

Abstract

Soil and water resources are fundamental to our survival and well-being. Degradation and depletion of these resources can be associated with mining activities. Mining is essential part of modern society as it provides a wide range of minerals and valuable resources that are used for energy production, building and construction, transportation etc. Exploration, drilling, blasting, excavation, transporting, and processing are all stages in the life cycle of a mine which can have significant impact on both, soil and water resources, as well as biodiversity, air qualty and cultural heritage. At the end of a mine's useful life, the closure stage begins rehabiliting the site to minimize its impact on the environment.

This work analyse how the ecosystem services provided by soil and water resource are impacted by mining activities during the useful life of the mine and after the closure of the mine. Identification of both, negative impacts on the ecosystem services, as well as positive impacts due to post-mining land restoration (through reforestation, revegetation, and erosion control) is performed. This research is critical for planning mitigation efforts to improve ecosystem services provided by soil and water resources, as well as to identify pathways for sustainable mining.

RAINFALL SIMULATORS FOR SOIL RESEARCH – CONSTRUCTION AND DEVELOPMENT

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Keywords: rainfall simulators, rainfall simulator construction, rainfall simulator development, soil research, dripping and spraying rainfall simulators.

Abstract

Rainfall simulators are important instruments in soil research. In 2019 we have constructed and calibrated portable field spraying rainfall simulator for a research of effects of changes in soil moisture content on changes in mechanical parameters of soil and formation of surface runoff and soil erosion. Also, we have constructed a dripping rainfall simulator with one dripper for the research of splash erosion and calibration of hypodermic needles for a further development of dripping rainfall simulator with a more than one dripper for research of rainfall impact and runoff on soil erosion. Beside that we are in a process of modifying portable field spraying rainfall simulator in term of drops falling height and size, giving us a greater possibility in the application and analysis of soil erosion. In the paper we will represent our results and experience gained through the literature analyses and the process of construction and calibration of rainfall simulators for our research. We have analyzed process of development rainfall simulators, conducted an analysis of the design and performance of the current dripping rainfall simulators, while collecting data and creating a database related to the design and performance of spraying rainfall simulators improving our understanding of research needs and simulator abilities to simulate natural rainfalls. Such approach is pushing us toward to harmonization of some future rainfall simulators improving and facilitating data analysis of soil research all around the world. Scientific research in which rain simulators are used, and which can be applied in the fields of hydrology, agriculture, forestry, as well as in other industrial branches, are becoming increasingly necessary and frequent.

ILLEGAL, UNREPORTED AND UNREGULATED FISHING AS A THREAT TO ENVIRONMENTAL SECURITY FOR THE DANUBE

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Keywords: crimes against environment, IUU (illegal, unreported, and unregulated) fishing, transboundary water, Danube

Abstract

Illegal, unreported and unregulated (IUU) fishing is a broad term often associated with organized crime. Low risk with high profit is what drives IUU fishing. Illegal fishing on the Danube has significant, multiple effects and ramifications on the economy, population and sustainable development of the subject region. Current laws, prosecution of culprits and conviction rates do not provide sufficient and acceptable results in confronting crimes against wildlife. Furthermore, such crimes are difficult to sanction because law enforcement in Southeastern Europe is still inadequate. State authorities do not have sufficient resources and personnel to deal with crimes against protected species, often taking place accross wide territory of land, rivers or seas. Illegal fishing and trade of sturgeon is particularly important for the lower Danube basin region. Sturgeons face regional extinction and whilst there is a complete ban on sturgeon fishing, selling and buying, the number of illegalities is still present along the Danube. The paper analyzes IUU fishing on the example of sturgeon in Serbia, Romania and Bulgaria. There is no doubt that states need increased capacities of enforcement authorities, modern patrolling equipment and new technologies in order to successfully confront and suppress illegal fishing and trade of endangered species.

SESSION 3: BAIKAL LAKE AS A WORLD HERITAGE TRANSBOUNDARY CATCHMENT UNDER THREAT

APPLICATION OF ^{137}CS FOR EVALUATION FOR SPATIAL-TEMPORAL REDISTRIBUTION OF SEDIMENT AND SEDIMENT-ASSOCIATED POLLUTANTS

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Key words: floodplain sedimentation, fingerprinting technique, ^{137}Cs fallout, Selenga River,

Abstract

Cesium-137 is an isotope of technogenic origin, which is widely used as a chromomarker and tracer to assess the sedimentation rate at deposion sites and to identify the proportional contribution of various sediment sources to the river sediment yield. ^{137}Cs fallout in the Selenga River basin occurred from 1953 to the 1980s, with a maximum in 1963. It was associated with testing of nuclear explosions in the open atmosphere. The levels of initial ^{137}Cs fallout generally depended on the layer of precipitation during the warm season. The trend of decreasing ^{137}Cs initial fallout from 2380 Bq/m^2 to 1600 in south-east of the Selenga River basin is established based on our own and published data. Estimates of ^{137}Cs vertical distribution in deposits were obtained for different parts of the Selenga River delta and some floodplain sections in the Mongolian part of the basin. This made it possible to determine the sedimentation rates and changes in the levels of pollution of suspended sediments over two time windows. Plots of the ^{137}Cs vertical distribution floodplain sediments can also be used for identifying the contribution of various sediment sources to river sediment yield. However it is necessary to take into account the mechanical composition of floodplain deposits. The data obtained by us and published by other researchers on the use of ^{137}Cs and other fallout radionuclides for assessing the intensity of erosion-accumulation processes, identifying the proportional contribution of various sediment sources to the river sediment yield, and assessing spatial-temporal changes in the transport of pollutants in various chains of the fluvial network in the Selenga River basin allows to state that the more widespread use of these tracers will allow us to reliably reconstruct the transboundary migration of heavy metals and other sediment-associated pollutants for at least two time windows.

UNDERSTANDING WATER AND SEDIMENT DISPERSAL AT THE SELENGA DELTA ACROSS SCALES

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Keywords: River Delta, Channel Network, Geomorphology, Avulsions, Bifurcations, Sediment

Abstract

River deltas are an important landform that provides critical ecosystem service and nourishes populated coastal landscapes. Mitigating climate change-induced deltaic land loss thus requires understanding how water and sediment are dispersed in deltas across spatial and temporal scales. Herein, this talk presents research that employs a graph theoretic model combined with field and remote sensing surveys to examine the partitioning of water discharge in the channel network of the Selenga Delta (~10^0–10^2 years). Over a geological timescale (>10^3 years), river deltas distribute sediment and build land in coastal regions by abruptly shifting course through channel avulsion. Our understanding of how deltas build such morphology assumes that the size of the downstream basin, such as a lake or ocean, is constant over time. However, geological activities like earthquakes and tectonic subsidence alter the size and shape of the delta. The second part of the talk analyzes 150 years of delta and basin morphology data from the Selenga Delta and Lake Baikal to understand how earthquakes and subsidence impact channel avulsions and delta landforms. We determined two distinct avulsion styles for the Selenga Delta: a regional-scale avulsion driven by earthquakes and a local-scale avulsion caused by sediment deposition. The two distinct scales of avulsions blend over time to shape the delta system. Our work highlights the importance of understanding the variety of downstream basin processes that impact delta morphology.

THE BAIKAL LAKE TRIBUTARIES: MODELLING CURRENT STREAMFLOW TO PROJECT FOR FUTURE AND REVEAL THE PAST

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Keywords: hydrological model, transboundary catchment, future climate, paleohydrology

Abstract

Hydrological models by nearly 50 years of their development have proven to be an effective tool for simulating runoff generation in river systems and eventually streamflow discharge in the river networks. Under current climatic conditions creating a model for the transboundary Baikal Lake catchment (>60% of the Selenga River basin is located on the territory of Mongolia) which allows for assessments of changes in the water regime is especially relevant. Given this, the ECOMAG (ECOlogical Model for Applied Geophysics) was created at the Institute of Water Problems of the Russian Academy of Sciences and was successfully tested for streamflow simulation of the largest Baikal tributaries. The model calculates daily streamflow with high accuracy, reproducing annual runoff trends during the last decades. The model was used to assess the impact of current and future long-term climate changes on the water regime. The current research discusses the adverse impacts of future climate change on the runoff of the Baikal tributaries. Possibilities for paleohydrological assessment are presented using the hydrological model combined with stochastic weather generator in an attempt to describe the hydromorphological conditions of the past.

The study was carried out under Governmental Order to Water Problems Institute, Russian Academy of Sciences, subject no. № FMWZ-2022-0003 and № FMWZ-2022-0001.

ASSESSMENT OF THE GOLOUSTNAYA RIVER ESTUARY IN WESTERN BAIKAL FROM A HYDROLOGICAL AND HYDROMORPHOLOGICAL PERSPECTIVE

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Keywords: river delta, Lake Baikal, channel morphology, hydromorphological assessment

Abstract

The Goloustnaya River is a tributary to the Lake Baikal, flowing into the lake at the southwestern shoreline and forming a delta that covers the area of about 13 sq. km. Positioned exactly across the lake from the largest lake Baikal tributary – the Selenga River, the Goloustnaya River shows contrasting hydrological and hydromorphological conditions, which determine the nature of streamflow discharge and sediment distribution in the deltaic channels. The distributary network, consisting only of 3 active channels, and linear size of this delta allows for easy access and rapid flow measurements over each of them, thus serving as a great natural lacustrine hydrology laboratory. In the 2022 we conducted a field campaign to research the discharge and sediment distribution in the deltaic channels. For this we installed a network of automatic water level loggers accompanied by streamflow discharge measurements. The Onset Hobo U20L loggers were installed in the deltaic channels and the streamflow discharges were measured under three conditions: spring freshet rise, early summer freshet ebb and late summer low flows. This setup allowed for characterization of deltaic channel distribution along with water turbidity and dissolved solids measurement. Water balance computation between the distributary channels and the main stream reveals that during higher flows the channels distribute less stream flow than is measured in the delta apex, and in the low-flow conditions the opposite effect is observed. This effect is explained by saturated flow conditions in coarse highly permeable deltaic deposits during different streamflow conditions. This shows that unlike other river deltas on the Lake Baikal, the Goloustnaya River estuary can be characterized as an alluvial fan rather than a delta. This is further confirmed by channel morphology measurements also carried out during the field campaign.

IMPACT OF THE LAKE BAIKAL WATER LEVEL FLUCTUATIONS ON THE ECONOMY AND THE NATURAL ENVIRONMENT

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Keywords: Lake Baikal, extremely high level, digital elevation model, flood zones, unique natural objects, infrastructure facilities.

Abstract

Analysis of data on the whole range of problems related to Lake Baikal made it possible to conclude that the Irkutsk hydropower plant has a negative impact on the lake ecosystem, as well as on the nature and economy of its coastline, precisely due to the adjustment of the lake's level regime. It should also be noted that the Baikal region is going through a period of extreme climatic changes.

Digital elevation models of shallow water areas (22 model sites) and coastal areas of the Republic of Buryatia within the boundaries of 22 settlements, recreation zones and areas of importance for ecosystems (25 sites) were created. GIS modeling of flooding/desiccation zones for 47 sites was carried out. Damage to the economy (transport, energy facilities, shore protection structures, social facilities, households, etc.) and ecosystems (forest resources, red-listed animals and plants, soils, hunting and fishing resources, etc.) as a result of the impact of the Lake Baikal water level increase/decrease was assessed.

The objects of fauna and flora affected by flooding were determined at the key sites. The number of endemics, their density and the area they occupy have been determined. It was determined that 250 km of the shoreline on the eastern shore of Lake Baikal may be exposed to potential abrasion. The width of the strip of destruction deep into the shoreline can be up to 8-9 m.

Damage due to flooding and abrasion was calculated for water levels of 457.20 m (hereinafter Pacific elevation system), which was observed in 2021, and 457.85 m. In the zone of negative impact at the level of 457.85 m, 460 households and 31 social facilities fall into the zone of negative impact. Maximum damage is caused to forest land, shore protection structures, transport and industrial facilities.

Conclusions:

1. The ecosystems of the Republic of Buryatia are significantly damaged (soils as a result of abrasion, forest resources, red-listed plants, hunting and fishing resources, etc.).

2. Temporary decree No. 379 of the Government of the Russian Federation of 16.03.2022 sets the following limits for the water level of Lake Baikal: 455.54-457.85 meters. Our position (with consideration of the experience of reaching a water level of 457.23 meters in 2021 and analysis of damage to the economy and ecosystem of the lake) is to insist on keeping the range of 456.00-457.00 meters. In case of force majeure circumstances (extremely high or extremely low inflow to Lake Baikal) minimum and maximum water levels are allowed within the range of 455.80-457.20 meters.