TRANSPORT OF WATER, CHEMICALS AND ENERGY IN THE SOIL – PLANT – ATMOSPHERE SYSTEM

in conditions of the climate variability

Book of Abstracts

Edited by
L. Toková
P. Rončák

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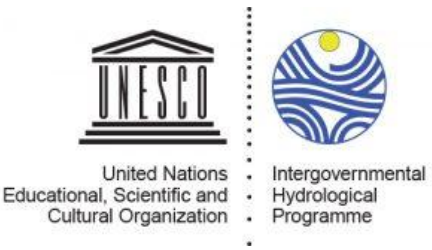
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L. Toková, P. Rončák
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COMPARATIVE ASSESSMENT OF LONGITUDINAL DISPERSION COEFFICIENT FORMULATIONS UNDER DIFFERENT HYDRAULIC AND GEOMETRIC CONDITIONS

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ABSTRACT

The longitudinal dispersion coefficient (D_L) is an important parameter in one-dimensional modelling of pollutant transport in rivers and streams. Longitudinal dispersion results from flow velocity and mass concentration gradients combined with turbulent mixing, causing a pollutant cloud to spread along the flow direction. Since these processes are not explicitly resolved in a one-dimensional model, their overall effect on longitudinal spreading is represented by the effective coefficient D_L. Numerous empirical and semi-empirical formulations have been proposed to estimate D_L from flow hydraulics and channel geometry. However, these formulations differ in their mathematical structure, required input variables, and dependence on channel and flow conditions. As a result, estimates of D_L may vary under the same conditions depending on the selected formulation. This study presents a comparative assessment of selected commonly used formulations for estimating the longitudinal dispersion coefficient in open-channel flows. The formulations are compared in terms of their mathematical structure, required hydraulic and geometric parameters, and their dependence on variables such as mean flow velocity, flow depth, channel width, aspect ratio, and shear velocity. A Python-based sensitivity analysis is used to examine how changes in these variables affect the estimated D_L within representative hydraulic and geometric ranges. The aim is to better understand how the selected formulations respond to changes in channel and flow characteristics and to identify the variables that have the greatest influence on their estimates. The results will provide a basis for a subsequent study focused on selecting suitable D_L formulations for streams with specific hydraulic and geometric characteristics and their potential application in pollutant-transport modelling.

Keywords: longitudinal dispersion coefficient, pollutant transport, open-channel flows, hydraulic and geometric parameters, sensitivity analysis

AI-ASSISTED DIGITIZATION AND QUALITY CONTROL OF MINI DISK INFILTROMETER DATA IN STRIP-CROPPING FIELD CAMPAIGNS

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ABSTRACT

Strip-cropping and conservation tillage are key soil management strategies for mitigating climate change impacts on soil water dynamics, yet field monitoring campaigns often generate large volumes of handwritten records that are laborious to process. Using Mini Disk infiltrometer (METER Group) measurements from an experimental strip-cropping site in Kolíňany (Slovakia), this study evaluates a large language model (LLM) workflow (Gemini 4 Hydrogen, Google AI Studio) against standard spreadsheet processing (MS Excel). The LLM digitized raw field logs, performed automated quality assurance/quality control (QA/QC), fitted physical infiltration models ($I=C_1 \cdot \sqrt{t}+C_2 \cdot t$ and power-law rate decay) and generated an interactive web dashboard with vector graphics export. Results matched Excel calculations while substantially reducing formula setup time and improving physical model selection. However, human verification remained essential for resolving ambiguous handwriting (0:51), irregular volume steps, and physically meaningful trendlines—highlighting both the potential and pedagogical boundaries of LLMs in landscape engineering.

Keywords: large language models, instant data evaluation, field measurements, infiltration, Mini Disk infiltrometer

Acknowledgement: This work was supported by the by the Slovak Research and Development Agency under contract number APVV- 23-0530 and the Cultural and Educational Grant Agency, grant number KEGA 006SPU-4/2024.

THE IMPACT OF SILTING UP OF DRAINAGE CANALS ON THE GROUNDWATER LEVEL

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ABSTRACT

Natural water resources are dynamically interconnected, with interactions between groundwater (GW) and surface water (SW) influenced by topography, climate, hydrogeology and river morphology. Riverbed sedimentation can alter these interactions by reducing or preventing the exchange of water between the river and the aquifer. This study investigated how bed sediments influence GW-SW interactions in a lowland area drained by a canal network. Sediment thickness was measured in the canals, and the saturated hydraulic conductivity of sediment samples was determined by laboratory methods. The collected data were incorporated into a numerical model to simulate GW–SW interactions under different sediment thickness scenarios. The study confirmed the impact of bed sediments on GW–SW exchange in the area. It was demonstrated that sediment deposits exceeding 0.5 m significantly impact hydraulic exchange and could potentially disrupt the connectivity between groundwater and surface water.

Keywords: silting, thickness of bed sediments, GW – SW interaction

Acknowledgements: This work was supported by the Research Grant Agency VEGA under contract No. VEGA 2/0028/23.

SOIL WILTING POINT RESPONSES TO BIODEGRADABLE MULCH FILM MICROPLASTICS

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ABSTRACT

The increasing use of biodegradable mulch films in agriculture has raised concerns about their potential impacts on soil properties following their fragmentation into microplastics. Although biodegradable plastics are designed to degrade under specific environmental conditions, their incorporation into soil may alter its physical and hydraulic properties, with potential implications for plant water availability. This study aimed to investigate the effects of polylactic acid (PLA) microplastics derived from biodegradable mulch films on the permanent wilting point (PWP) of an Umbrisol collected from the Borský Mikuláš area in Slovakia. Soil samples were amended with PLA microplastics at a concentration of 5%, and the resulting mixtures were analysed in three replicates. The results showed that the addition of PLA microplastics increased the volumetric water content at the permanent wilting point from 0.040 $m^3.m^{-3}$ in the control soil to 0.080 $m^3.m^{-3}$ in the PLA-amended soil, representing a 100% increase. This increase suggests that PLA microplastics may alter soil water retention characteristics, potentially affecting the amount of water retained in the soil at the permanent wilting point. These findings highlight the importance of considering the effects of biodegradable microplastic residues on soil hydraulic properties and plant water availability.

Keywords: biodegradable, microplastics, wilting point, water retention

Acknowledgements: This study was supported by Scientific Grant Agency No. VEGA 2/0037/24 and project PostdokGrant No. APD0199.

THE IMPORTANCE OF TECHNICAL SUPERVISION DURING WELL DRILLING

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ABSTRACT

Technical supervision during well construction is essential for protecting groundwater resources and ensuring the long-term reliability of wells. Since 2015, the Middle Tisza District Water Directorate has supervised groundwater exploration works as part of water-rights permitting procedures. The supervision process includes reviewing geophysical logging, checking casing and filter pipes, filter gravel and cement, and observing well development and pumping. Approximately 20 groundwater-related technical inspections are carried out annually, covering about 90–95% of wells included in newly issued water-rights permits. Experience shows that on-site recommendations can improve well design and construction, including material selection and filter placement. Inadequate sealing of the annular space may allow contaminated shallow water to enter deeper protected aquifers. Technical supervision therefore supports groundwater protection and helps deliver wells that operate safely and effectively over the long term.

Keywords: technical supervision, well drilling, groundwater protection, water management, well construction

BIOCHAR EFFECTS ON SOIL WETTABILITY AND WATER TRANSPORT IN SANDY SOILS UNDER CONTRASTING LAND-USE SYSTEMS

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ABSTRACT

Sandy soils are highly vulnerable to water stress because of their high permeability and low water-holding capacity, while soil water repellency can further modify infiltration and water movement. This study evaluated the effects of two hydrophilic biochars applied at 2, 6 and 10% (w/w) on soil wettability and saturated hydraulic conductivity (K_{sat}) of sandy soils under contrasting land-use systems in the Záhorská nížina lowland, western Slovakia. Laboratory experiments were conducted using soils from arable land, grassland, coniferous forest and deciduous forest. Initial contact angle varied substantially among land uses, with the highest value observed for coniferous forest soil (104.46°). Biochar generally increased contact angle compared with the arable control, without a clear concentration-dependent response. K_{sat} generally decreased with increasing biochar application rate, although the response depended on biochar type. These results indicate that biochar modifies soil wettability and water transport through changes in soil pore pathways and hydraulic behaviour.

Keywords: biochar, sandy soil, soil water repellency, saturated hydraulic conductivity, water transport

ASSESSMENT OF SOIL EROSION AND PROPOSAL OF EROSION-CONTROL MEASURES IN THE ŠURIANKY AREA

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ABSTRACT

Soil erosion and the associated transport of sediment represent significant problems in intensively cultivated agricultural landscapes. This study focuses on a selected erosion-prone site in the cadastral area of Šurianky, where concentrated surface runoff during heavy rainfall events leads to substantial sediment accumulation at a critical point. The aim is to assess the causes and spatial characteristics of the erosion process and to propose suitable landscape measures for reducing runoff and sediment transport. The assessment is based on digital terrain model analysis, slope characteristics and drainage patterns, including Strahler stream order analysis. The spatial distribution of erosion risk and the main runoff pathways were evaluated in relation to the current agricultural land structure. The study also considers historical changes in land parcel structure, particularly the consolidation of formerly fragmented agricultural land into large continuous fields. Based on the identified critical areas, appropriate erosion-control measures are proposed and their effect on surface runoff and sediment transport is evaluated. The results provide a basis for improving the spatial structure and ecological stability of the agricultural landscape at the selected site.

Keywords: soil erosion, surface runoff, GIS, sediment transport, erosion-control measures

HOW DATA CHOICES SHAPE LOCAL CLIMATE ADAPTATION PRIORITIES: AGRICULTURAL DROUGHT AND URBAN HEAT IN TRNAVA, SLOVAKIA

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ABSTRACT

Climate risk assessments supporting local adaptation planning are sensitive to the choice of climate datasets, spatial resolution and observation periods. This study evaluates how refined data inputs affect agricultural drought and urban heat assessments in Trnava, Slovakia, using CLIMAAX methodologies. Agricultural drought estimates based on CMIP5-driven EURO-CORDEX scenarios (12 km) were compared with locally downscaled, bias-corrected CMIP6 scenarios (500 m) for 2021–2050. Projected yield losses decreased from 10.56% to 1.09% for wheat and from 19.52% to 0% for rapeseed, while maize losses remained high (44.04% and 41.60%). Urban heat assessments compared Landsat-derived land surface temperatures from summer observations (2013–2024) with tropical-day observations (2021–2025). The estimated area of high and very high heat risk increased from 177.1 to 439.5 ha, with 17 of 34 vulnerable facilities located in zones exceeding 40°C. These differences reflect combined changes in datasets, scenarios, observation periods and spatial coverage rather than climate trends alone. The findings highlight the importance of locally relevant data and transparent methodological choices for targeted agricultural and urban heat adaptation.

Keywords: climate risk assessment, agricultural drought, urban heat, climate scenarios, CLIMAAX, adaptation strategies

Acknowledgements: This work was supported by the CLIMAAX project (Grant Agreement No. 101093864), funded by the European Union's Horizon Europe programme; the Slovak Research and Development Agency (contract No. VV-MVP-24-0208); the VEGA Grant Agency (grant No. VEGA 2/0115/25); and the COMPLANT project, funded under the Young Researchers Support Programme of the Slovak University of Technology in Bratislava.

CALCULATION OF SOIL WATER STORAGE AND CRACK POROSITY BASED ON VERTICAL SOIL MOVEMENTS

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ABSTRACT

Moisture-induced volume changes in heavy soils are manifested as vertical surface movements and crack formation. This study presents a method for calculating soil water storage and crack porosity in the unsaturated zone using pedotransfer functions. The method uses data on surface movements, water-table position and particle-size distribution, assuming isotropic and reversible volume changes. Validation at the Senné site in the East Slovak Lowland in 2019 showed good agreement between measured and calculated soil water storage. The calculated crack volume represented a potential capacity to accommodate approximately 120 mm of water from rainfall or surface inflow. The method enables estimation of soil water storage and crack porosity, which are difficult to measure directly, from readily measurable properties and provides inputs for modelling the water regime of heavy soils. Its applicability is limited by the validity range of the pedotransfer functions used.

Keywords: clayey soils, pedotransfer functions, soil volume changes, soil texture, East Slovak Lowland

EVALUATION OF THE IMPACT OF WEATHER CONDITIONS ON THE SURVIVAL OF ROE DEER

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ABSTRACT

The aim of our study was to analyze the impact of meteorological conditions on the survival of roe deer (*Capreolus capreolus*) in the Jalovecký Creek catchment area. Meteorological conditions were evaluated using the Winter Severity Index (WSI). To determine the WSI, it is necessary to record the minimum daily air temperature and the average daily snow depth. Our WSI calculations were based on data from three locations within the Jalovecký Creek catchment: Červenec (C1420) at an elevation of 1,420 m a.s.l., Hlboká dolina (H1400) at 1,400 m a.s.l., and Lysec (L1000) at 1,000 m a.s.l. The Winter Severity Index was determined for three winter periods, from 2022/2023 to 2024/2025. The resulting daily WSI value represented the sum of points assigned for minimum air temperature and snow depth. Based on the results, we can conclude that at higher elevations (sites at 1,400 and 1,420 m a.s.l.), conditions during the assessed winter periods proved to be very severe, and thus unsuitable for roe deer survival.

Keywords: meteorological conditions, winter season, Jalovecký creek catchment

Acknowledgements: The study was supported by project Water4All/2023/1128.C/REACTION and the VEGA Grant Agency No. 2/0019/23.

CURRENT CHANGES IN THE WATER REGIME OF THE IRTYSH RIVER IN THE CONTEXT OF ANTHROPOGENIC LOAD

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ABSTRACT

The paper presents a comprehensive analysis of the time series of runoff Irtysh River for the period 1938-2021 using independent statistical criteria and graph-analytical methods. It was found that at most sites of the study basin hydrological series retain statistical homogeneity, indicating the stability of the mean value, dispersion and distribution of runoff within the selected intervals. At the same time, local inhomogeneities detected at some sites confirm the presence of changes in the hydrological regime Special attention is paid to comparison of natural and observed (anthropogenic-induced) runoff. The analysis of total integral curves has shown that since 1960, under the influence of water management activities, the water regime has been transforming from conditionally natural to controlled, with steadily high values of observed runoff. This indicates the increasing role of hydraulic structures - primarily reservoirs - in regulation and redistribution of water resources of the Irtysh River both in temporal and spatial aspects of this problem. The results of the study confirm high consistency between the applied methods and reliability of the obtained conclusions. It is concluded that the impact of reservoirs and other water infrastructure elements should be taken into account in planning and shaping long-term water management strategies. Insufficient attention to the potential of 'nature-based solutions' in the context of sustainable water resources management is also noted.

Keywords: Irtysh River, water regime, statistical criteria, reservoirs, flow transformation

HISTORICAL INFLUENCES ON THE FLOW REGIME OF THE KLATOVKY BRANCH

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ABSTRACT

The project 'Status improvement ofwetland of Klátov branch National Nature Reserve (NNR)', was in years 2020 -2024 financed from the Norwegian financial mechanism, The project focused on the possibilities for revitalizing a protected area—one of the cleanest natural side channels of the Danube River. The Klátovsky branch was in the beginning of the 20th century dammed for the purpose of protecting nearby municipalities from floods. Thuscut off from the surface water source – the Little Danube. It happened after disastrous floods in1897, and especially in 1899. Since then, the only source for the Klátov branch has become groundwater. This resulted in the disconnection from the original surface water source—the Little Danube (Malý Dunaj)—and a fundamental change in the flow regime. This occurred following major, recurring floods in 1897 and 1899. Consequently, groundwater temporarily became the sole water source for the Klátovsky branch (Klátovské rameno). This led to a significant reduction in flow and massive sediment accumulation. Later, newly constructed canals and local surface runoff (stormwater) began contributing to the flow. Between 1961 and 1964, the modernization of bridges in the region—specifically those with narrow spans—had the most significant impact on the flow. This paper analyzes the chronological progression of flow changes in the Klátovsky branch and their subsequent impact on water quality.

Keywords: Klatovsky Branch, Danube river, Flow regime, Floods, River restoration

Acknowledgements: This publication is the result of the project implementation: „Status improvement of wetland of Klátovské rameno NNR located in SKUEV0075" (ACC04/08) funded by the NORWAY GRANTS.

HYDROLOGICAL DROUGHT OF SURFACE WATER IN SUMMER 2026

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ABSTRACT

The summer of 2026 (June, July, and August) was the warmest summer globally on record, tied with the summer of 2024. August was the warmest August ever recorded worldwide. Monthly precipitation totals in Slovakia reached 73% of the 1991-2020 normal in June, 64% in July, and only 44% in August. This paper presents an analysis of the hydrological situation of surface waters in Slovakia during the summer of 2026. Discharges declined below the long-term mean monthly values. Mean daily discharge values at the monitored water-gauging stations were at low-flow levels, corresponding to the 355-day and 364-day discharges. Several rivers and streams across Slovakia experienced complete drying up. June 2026 was classified as a well-below-normal month, July 2026 as a dry month, and August 2026 as an extremely dry month.

Keywords: drought monitoring, mean daily discharge, 2026

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SURFACE WATER HYDROLOGICAL DROUGHT IN THE CALENDAR YEAR 2025

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ABSTRACT

The calendar year 2025, based on a comparison of annual precipitation totals with the 1991-2020 reference period, was classified as precipitation-normal. Regarding air temperature, 2025 ranked as the eighth warmest year in Slovakia since 1931, while the warmest year on record remains 2024. This paper presents an analysis of annual minimum mean daily discharges observed at selected water gauging stations. The onset of hydrological drought is identified by mean daily discharges falling below the threshold value $Q_{330d,1961-2000}$, defined from the reference period 1961-2000. Among the assessed water gauging stations, mean daily discharge values fell below the $Q_{330d,1961-2000}$ threshold for at least one day during 2025 at 93% of the stations. Furthermore, several gauging stations located within the Váh, Hron, Ipeľ, and Bodrog River Basins recorded the lowest annual minimum mean daily discharge, establishing new historical minima since the beginning of observations.

Keywords: drought monitoring, mean daily discharge, 2025, historical minima

Acknowledgements: This work was supported by the Slovak Research and Development Agency under the Contract No. APVV-23-0332.

DETECTION OF NON-PERENNIAL NATURAL WATER BODIES AS A BENEFIT OF HYDROMORPHOLOGICAL MONITORING

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ABSTRACT

The monitoring of hydromorphological quality elements at the Slovak Hydrometeorological Institute (SHMÚ) has been ongoing since 2010 with focus on natural water bodies. According to the currently used methodology, the surveys should be conducted during low flow periods, which in Slovakia are usually between August and October. According to the „Framework Water Monitoring Programme of Slovakia" for the observation periods (2010 – 2015; 2016 – 2021; 2022 – 2027) and in accordance with additaments for different years, the monitoring of the hydromorphological elements was annually done. Between 2010 and 2025 over 500 monitoring sites were evaluated, of which 18 were identified as dry. A water body was considered dry, when no flowing water was present, although isolated puddles or small amounts of residual water could still be visible. Although the primary purpose of the surveys during low-flow periods was not the identification of non-perennial streams, the existing hydromorphological monitoring program provides an opportunity to identify water bodies or river reaches that have dried out. This information can complement data collected from the standard monitoring network of water gauging stations operated by SHMÚ and therefore contribute towards more comprehensive assessment of the spatial extend of hydrological drought.

Keywords: non-perennial natural water bodies, hydromorphology, monitoring sites

Acknowledgements: This work was supported by the Slovak Research and Development Agency under the contract No. VV-MVP-24-0208.

NOT HOW MUCH, BUT WHEN: THE DANUBE IN 2026, CHANGING FLOW SEASONALITY AND THE FUTURE OF WATER RESOURCES IN SLOVAKIA

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ABSTRACT

Summer 2026 brought exceptionally low flows to the Danube as early as July, at a time when the demand for water is highest. Extremely low precipitation across the basin, high air temperatures and a thin snow cover in the Alps in winter 2025/2026 reduced the discharge at the Bratislava/Devín profile to less than half of the usual July and August values (about 2,100 $m^3 \cdot s^{-1}$). July 2026 set a record for a summer month, with a return period of approximately 126 years. According to operational data as of 5 October 2026, however, the 7-day minimum discharge of 2026 (621 $m^3 \cdot s^{-1}$) has not yet fallen below the historical minimum of October 1947 (612 $m^3 \cdot s^{-1}$). The year 2026 resembles the dry year 1947 in the course of discharges, but differs in timing: both the spring snowmelt and the onset of the low summer flows came about a month earlier. The Danube collects water from a large part of Europe, so a lack of precipitation in the Alps, Austria or Germany is immediately felt in Slovakia as well. The annual volume of water in the Danube has not changed significantly in the long term, but its distribution within the year has. A comparison of the 1991–2020 periods show higher flows in winter and early spring and lower flows in July and August. Similar shifts in seasonality are shown by 26 Slovak rivers over the period 1930–2020. The changes differ between regions, however: 7-day minimum flows in the mountains increased by 12.8%, whereas in lowland basins they decreased by 15.7% to 23%, with the mean annual discharge falling by up to 27%. The future of water resources will therefore be determined less by the total amount of water and more by its uneven distribution in time. Adaptation requires retaining the winter surplus in the landscape, protecting wetlands, Danube side arms and strategic drinking-water sources, and making use of long observation series.

Keywords: Danube River, summer 2026, minimum flow, seasonality, regional differences

RAINFALL FLOODS IN THE UKRAINIAN CARPATHIANS: MODERN TRANSFORMATIONS ON THE PRUT AND CHEREMOSH RIVERS

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ABSTRACT

The issue of river hydrological regime transformation under the influence of climate change remains a subject of active scientific debate. This study examines changes in the rainfall flood regime of rivers in the Ukrainian part of the Prut River basin (using the examples of the Prut River near Yaremche and the Cheremosh River near Usteriky). The relevance of this research is driven by the increasing risk of catastrophic rainfall floods in the Carpathian region. Based on observation data from 1958–2023 for the warm period (May–October), two types of maximum runoff series were formed: annual maxima (the highest flood peak for each year) and partial duration maxima (all peak discharges of rainfall floods exceeding a certain threshold value). Modern trends in flood activity were determined by comparing the indicators of the baseline (1958–1990) and current (1991–2023) periods. The transformation of seasonality, the temporal structure of rainfall flood formation, changes in the statistical parameters of their distribution, as well as the frequency and recurrence of hydrological events of various intensities were analyzed, and the reasons for these changes were substantiated.

Keywords: Prut River basin, Ukrainian Carpathians, rainfall floods, annual maxima, partial duration series, hydrological regime transformation, flood frequency, climate change impacts

PARTICIPATORY MONITORING OF SOIL EROSION BY WATER IN THE TEACHING PROCESS: A WEB MAP AND FIELD SURVEY FORM

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ABSTRACT

Water soil erosion requires accurate spatial data and continuous assessment. To address this, an educational Open Science initiative was developed to engage students in practical monitoring. Data is collected using a participatory methodology integrating ArcGIS Survey123. The standardized field form captures precise location, water erosion forms and effects, crops, tillage technologies, and photo documentation, seamlessly synchronizing to the ISoPÚK web map platform (Information System on Land Consolidation and Landscape). Currently, 268 erosion events have been reported, with 74 successfully verified in the field. The spatial database maps these localized events for further analysis and quality control. Ultimately, this participatory monitoring links academic research with practical field verification, providing vital evidence to identify severe land degradation and propose targeted remedial measures to agricultural land users.

Keywords: land degradation, water erosion, participatory monitoring, GIS, Open Science

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BEYOND MORE RAIN: HOW URBAN GROWTH REWIRES FUTURE STORMWATER HOTSPOTS

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ABSTRACT

This study develops an integrated spatial framework to examine how future rainfall, urban growth, and Low Impact Development (LID) jointly shape stormwater response in Trnava, Slovakia. Historical and future imperviousness were represented using Copernicus datasets and CA-Markov modelling, while projected daily rainfall extremes were transformed into physically plausible minute-scale storms using a multi-criteria historical analogue approach. These inputs were coupled with a detailed SWMM drainage model to separate the effects of climate change, urbanisation and their interaction, and to evaluate the performance of bioretention, infiltration trenches and vegetative swales. The results reveal a striking scale contrast. Climate change primarily controls the increase in total runoff, whereas urbanisation has a disproportionate influence on runoff concentration and local peak flow. When both drivers act together, their catchment-wide volumetric response remains approximately additive, yet strong nonlinear amplification emerges at specific subcatchments and connected drainage nodes. LID measures can substantially attenuate runoff locally, but their relative effectiveness decreases as storm loading increases, leaving several compound-response hotspots insufficiently protected.

Keywords: Compound climate-urbanisation effects, Urban stormwater, SWMM, Low Impact Development, Spatial hotspot analysis

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ASSESSMENT OF THE HYDROLOGICAL SITUATION IN THE SUMMER OF 2026 FROM A GROUNDWATER PERSPECTIVE

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ABSTRACT

The assessment of the hydrological situation in Slovakia during the summer of 2026 was based on operational data measured at selected monitoring sites within the Slovak Hydrometeorological Institute's national groundwater monitoring network. A decline in groundwater reserves at these monitoring sites had been observed since the beginning of 2026. The summer months brought record-high temperatures and minimal precipitation, causing groundwater levels and spring yields to drop significantly below their long-term averages. This adverse situation affected all river basins in Slovakia. Throughout the summer, the most critical conditions persisted in the Bodrog River basin, where groundwater levels and spring yields at several monitoring sites approached or even fell below long-term minimum values. By the end of August, a decline in groundwater levels and spring yields was recorded at 85% of all monitored sites. The average drop in values across the various river basins ranged from 0.3 to 0.8 meters. Current data indicate an increasing sensitivity to changes in groundwater recharge. The groundwater response to precipitation is delayed; consequently, drought conditions within subsurface structures can persist for months until infiltration through soil horizons causes water levels to rise again.

Keywords: hydrological situation, groundwater, long-term average, drought

UPDATING N-YEAR DISCHARGE VALUES IN THE LUŽICKÁ NISA RIVER BASIN

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ABSTRACT

The contribution is focused on updating N-year discharge values at Czech hydrometeorological institute gauging stations. Aim area is using the example of discharge-gaging site Hrádek nad Nisou in the Lužická Nisa river basin as a case study. Discharge values are analyzed using QNStat, an internal application developed through the Python language. The input data consists of a time series of annual peak discharges. Observed significant flood events occurred in the Lužická Nisa basin in 1958 and 2010. An estimate of the historical flood of 1897 was also included in the calculation dataset. Incorporating historical floods provides insights background into estimating their N-year return periods relative to length of the observed data series. Results confirm the current 100-year discharge value for Hrádek nad Nisou gauging station. Changes are significant in the lower quantiles of N-year discharges, specifically within the 1-year to 20-year flow range.

Keywords: N-year discharge, flood, discharge-gaging site, annual peak discharge, Czech hydrometeorological institute

SIMPLE BEATS COMPLEX? BENCHMARKING METEOROLOGICAL GAP-FILLING FOR HYDROLOGICAL MODELLING IN THE MYJAVA RIVER BASIN, SLOVAKIA

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ABSTRACT

Hydrological modelling requires gap-free, physically consistent meteorological forcing. Using daily data (1981–2020) from 4 temperature and 20 precipitation stations in the Myjava River Basin, Slovakia, we tested 31 gap-filling methods ranging from statistical to deep learning. Following missing-data diagnostics, methods were assessed with 20 Monte Carlo cross-validation runs (10% artificial masking; MAE, RMSE, R^2) and checks of variability, extremes, spatial patterns and precipitation–temperature consistency. Performance depended mainly on spatial coherence and network configuration rather than model sophistication. Temperature was reconstructed accurately ($R^2 \approx 0.995$), while intermittent, spatially heterogeneous precipitation was harder to reproduce ($R^2 \approx 0.94$–0.95), especially in intense summer events. Inverse distance weighting and improved k-nearest neighbour performed best, outperforming complex nonlinear models. High aggregate accuracy alone does not ensure hydrologically robust forcing, as reconstruction may smooth extremes or distort spatial variability; simple distance-based methods are therefore strong, transparent benchmarks.

Keywords: meteorological gap filling, precipitation and air temperature records, cross-validation, hydrological forcing, Myjava River Basin

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SOIL MOISTURE RETENTION AND DYNAMICS AS A RESULT OF BIOCHAR APPLICATION TO AGRICULTURAL SOIL

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ABSTRACT

Soil degradation and increased frequency of dry periods caused by climate change pose serious risks to sustainable crop production and agricultural water management. Biochar has emerged as a promising soil additive that can improve soil physical structure and water retention; however, its effectiveness under field conditions requires empirical verification. This study evaluates the impact of biochar application on soil moisture dynamics in agricultural soil. A comparative field experiment was conducted on two adjacent, homogeneous experimental plots with silty loam soil. The experiment compared a control plot (standard agricultural management without biochar) and a plot with applied biochar showing basic composition. Soil moisture levels were continuously monitored throughout the soil profile during the entire growing season to capture temporal fluctuations and drying rates during periods without precipitation. The results of the comparison between the control plot and the biochar-amended plot demonstrated that biochar application significantly improved soil water retention capacity and stabilized moisture levels. Specifically, the plot with applied biochar exhibited a lower rate of soil water depletion compared to the control and was able to maintain higher amounts of plant-available water during prolonged dry periods. These findings confirm the potential of biochar as an effective, sustainable strategy to mitigate water stress in arable soils and enhance agricultural resilience to drought.

Keywords: biochar application, agricultural soil, soil moisture dynamics, soil water retention capacity

GROUNDWATER AS A SOURCE FOR IRRIGATION

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ABSTRACT

The drought experienced this year has highlighted the need to assess water sources for orchard irrigation. Groundwater is currently pumped for irrigation in many orchards, even though it also supplies approximately 38–39% of the drinking water demand. The use of groundwater for irrigation in the Czech Republic is highly restricted and strictly regulated by legislation (Water Act No. 254/2001 Coll.). Consequently, we focused on groundwater level dynamics in shallow boreholes regularly monitored by the Czech Hydrometeorological Institute. Statistical characteristics of groundwater levels were determined for selected boreholes in South Moravia. Monthly water level fluctuations over the assessed period are best represented by their amplitude. The feasibility of groundwater extraction varies throughout the year; indications suggest that unnatural declines in water levels occur during the summer and autumn months.

Keywords: drought, moisture balance, water resources, minimum level

EFFECT OF AQUATIC VEGETATION ON THE MANNING´S COEFFICIENT FOR GABČÍKOVO – TOPOĽNÍKY CHANNEL

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ABSTRACT

The goal of this paper was to investigate the change of flow conditions along the Gabčíkovo – Topoľníky channel (Žitný Island) on the base of Manning´s roughness coefficient value. This coefficient is not easy to determine and its value is varying constantly during the growing season, especially in a lowland stream with aquatic vegetation occurrence. Determining the effect of aquatic vegetation on flow conditions in streams is very important for estimation of hydrodynamics in natural streams. Measurements performed during growing season at the Gabčíkovo – Topoľníky channel stream were used for an evaluation of vegetation impact on flow conditions. The variations of roughness coefficients of Gabčíkovo – Topoľníky channel are presented in Manning's equation. The outcomes of this study can be concluded that the variation of Manning's coefficient value is influenced by the cross-section profile characteristic, flow depth, slope of channel, and especially quantity of submerged vegetations in the channel.

Keywords: Manning´s roughness coefficient, flow conditions, submerged vegetation, River Surveyor

EVALUATING THE EFFECTS OF MICROPLASTICS ON THE SATURATED HYDRAULIC CONDUCTIVITY OF SILT LOAM SOIL

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ABSTRACT

This study investigated the effects of polylactic acid (PLA) and polystyrene (PS) microplastics in three particle-size fractions on the saturated hydraulic conductivity of silt loam soil, measured under laboratory conditions using an automated KSAT system (METER Group GmbH, Munich). The silt loam soil texture influences pore-size distribution and connectivity, which may affect the soil's response to microplastic contamination. For PLA, saturated hydraulic conductivity increased by 288.5% in the fraction smaller than 100 µm, whereas negligible increases were observed in the 100–200 µm and larger than 200 µm fractions compared with the control (85.9 cm d^{-1}). The pronounced increase in the finest fraction may be associated with changes in pore connectivity or soil aggregation, potentially facilitating preferential water flow within the silt loam matrix. For PS, hydraulic conductivity increased by 86.8% in the fraction smaller than 100 µm, whereas decreases of 7.6% and 39.7% occurred in the 100–200 µm and larger than 200 µm fractions, respectively. The reduction in the coarsest PS fraction may reflect disruption of continuous water-conducting pores or increased flow-path tortuosity. These contrasting responses suggest that microplastic particle size and polymer properties interact with the existing pore structure of silt loam soil, resulting in different effects on saturated hydraulic conductivity.

Keywords: silt loam soil, polylactic acid, polystyrene, saturated hydraulic conductivity

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POLYMER-SPECIFIC EFFECTS OF MICROPLASTICS ON SOIL PROPERTIES

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ABSTRACT

This study investigated how three commonly occurring microplastic (MP) polymers — high-density polyethylene (HDPE), polystyrene (PS), and polyvinyl chloride (PVC) — affect the hydro-physical properties of silt loam soil, with particular emphasis on soil water repellency and hydraulic properties. The results revealed polymer-specific effects that varied considerably among the investigated materials. The addition of HDPE and PVC significantly decreased soil bulk density (ρ_d) while tending to increase soil water repellency, as indicated by changes in the contact angle (CA) and water drop penetration time (WDPT). However, these changes were minor and did not result in a shift in the soil water repellency classification. In contrast, PS exhibited a distinct response, significantly increasing unsaturated hydraulic conductivity at a pressure head of −2 cm (k(−2 cm)). Overall, these findings demonstrate that the effects of microplastic contamination on soil hydro-physical properties depend on polymer type, with potential implications for soil water dynamics.

Keywords: silt loam soil, microplastics, water repellency, unsaturated hydraulic conductivity

Acknowledgements: This study was supported by the Scientific Grant Agency VEGA 2/0037/24.

THE IMPACT OF PRECIPITATION DEFICIT ON THE POPULATION DYNAMICS OF THE EUROPEAN SPRUCE BARK BEETLE IN THE HOREHRONIE REGION

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ABSTRACT

Climate change, manifested by an increasing frequency of drought periods, significantly affects the health status of spruce stands and increases their susceptibility to bark beetle attacks. The aim of this study was to evaluate the relationship between precipitation deficit during the vegetation period and the population dynamics of the European spruce bark beetle (*Ips typographus*) in the Forest District Šaling (Horehronie region). Monitoring of total atmospheric precipitation was conducted from 2008 to 2023. The data were analyzed in relation to a reference 14-year average (2008–2021), whereas the extreme years 2022 and 2023 were excluded from its calculation. The results were also compared with the long-term climate normal (1951–1980). Bark beetle monitoring was carried out using a network of pheromone traps. The results indicate that pronounces outbreak of *Ips typographus*, tended to occurs with a one-year time lag following years with substantial precipitation deficits, as was clearly confirmed for the extremely dry years 2015, 2018, and 2022. The findings highlight the importance of precipitation patterns in assessing the risk of bark beetle outbreaks and may contribute to prediction and management strategies in forestry practice.

Keywords: climate change, drought, total precipitation, spruce stands, European spruce bark beetle

HOW CAN HYDROGEL INFLUENCE THE SATURATED HYDRAULIC CONDUCTIVITY IN SOILS WITH DIFFERENT TEXTURES

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ABSTRACT

Hydrogels are a promising material for improving soil water management due to their ability to retain water. Our study focused on assessing the effect of hydrogel application on saturated hydraulic conductivity (Ks) in three soils with different textures (sandy, silt loam, and silty clay) and determining whether this effect varies by soil type. The results showed that hydrogel application was associated with a decrease in the average Ks value in all studied soils, although this decrease was not statistically significant in sandy soil. More pronounced changes in Ks were observed in finer-grained soils, indicating that soils with different grain-size distributions respond differently to hydrogel application. A reduction in Ks may affect water movement and drainage in the soil. Therefore, to comprehensively assess the practical benefits of the hydrogel, the results must be supplemented, in particular, with measurements of soil retention properties.

Keywords: hydrogel, saturated hydraulic conductivity, sandy soil, silt loam soil, silty clay soil

IMPACT OF CLIMATE CHANGE ON THE OPERATIONAL RELIABILITY OF DRINKING WATER SUPPLY RESERVOIRS

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ABSTRACT

Climate change is altering the hydrological regime in Central Europe, increasing the risk of prolonged droughts and challenging the reliability of drinking-water reservoirs. The ClimRes project aims to develop a methodological framework for assessing reservoir system reliability under changing climatic conditions. The project focuses on the interconnected Hriňová–Klenovec–Málinec pilot reservoir system in Slovakia. It integrates multi-model climate projections, hydrological modelling, projected water demand and reservoir operation simulations within an ensemble-based assessment framework. The project will evaluate water-supply reliability and compliance with required ecological flows under future climate scenarios, with particular attention to prolonged droughts and operational constraints, including the temporary unavailability of individual reservoirs. The proposed framework aims to quantify reliability, assess uncertainties, identify potential vulnerabilities and develop adaptation measures. The expected outcomes will support climate-resilient reservoir operation and long-term drinking-water security.

Keywords: adaptation measures, reservoir system modelling, decision-support framework, climate change scenarios, drinking-water reservoirs, ensemble-based assessment

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HYDRAULIC CONDUCTIVITY OF FOREST SOIL AFTER HEATING TO DIFFERENT TEMPERATURES

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ABSTRACT

Natural fires cause different soil heating temperatures. Saturated hydraulic conductivity (Ks) is defined as the ability of water-saturated soil to conduct water. Measuring and determining Ks is important because it quantitatively characterises the soil's permeability. Soil samples were heated under laboratory conditions. We measured Ks using the variable hydraulic gradient method. The Ks values of forest soils change after heating, with the range of these changes depending on soil texture. In addition, vegetation cover on forest soil affects Ks. The effect of texture on Ks is noticeable at higher temperatures, while the effect of vegetation is significant at lower heating temperatures. We found an increase in Ks at 200°C to $1.06\pm0.08x10^{-4}$ $m\cdot s^{-1}$ and a decrease at 300°C to 1.03±0.01x10-6 $m\cdot s^{-1}$, compared with the value for unheated forest soil $4.88\pm0.14x10^{-5}$ $m\cdot s^{-1}$. Changes in Ks of forest soil after heating lead to altered water infiltration, increased surface runoff, and intensified soil erosion.

Keywords: heating, forest soil, saturated hydraulic conductivity, variable hydraulic gradient method

SOIL DROUGHT 2026 IN THE CZECH REPUBLIC - HISTORICAL TRENDS AND FUTURE CLIMATE PROJECTIONS

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ABSTRACT

In 2026, the territory of the Czech Republic was affected by an extreme soil (agricultural) drought, which peaked in mid-August. During this period, very low soil moisture (up to 10% relative soil water saturation) was recorded in the 0–100 cm profile on 77 % of the republic area. This can be attributed to several contributing factors. Very warm winter of 2025/2026 with the lack of snow cover, early onset of spring and rapid water withdrawal by vegetation, significantly higher spring and summer temperatures resulting in higher real evapotranspiration and, above all, a lack of spring precipitation. All these factors were analyzed in the context of long-term development, indicating that the 2026 drought was not merely a random fluctuation but part of a broader pattern of warming and accelerated soil drying. The analyses also include an outline of climate development and soil drought till 2090 using an average climate change scenario. To prepare this article, data from the Czech Hydrometeorological Institute and the Slovak Meteorological Institute were analyzed, using methods, algorithms and models implemented on the portals intersucho.cz, intersucho.sk, klimatickazmena.cz and fenofaze.cz.

Keywords: climate change, snow, precipitation distribution, water balance

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