UNIVERSITY of SOPRON

HydroCarpath 2022

Hydrology of the Carpathian Basin: Synthesis of Data, Driving Factors and Processes across Scales

Edited by Péter Kalicz, Kamila Hlavčová, Silvia Kohnová, Borbála Széles, Viera Rattayová, Zoltán Gribovszki

HydroCarpath International Conference

Hydrology of the Carpathian Basin: Synthesis of Data, Driving Factors and Processes across Scales

Abstracts and Posters of the Conference

Edited by
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Silvia Kohnová, Borbála Széles, Viera Rattayová, Zoltán Gribovszki

Vienna, Austria,
Bratislava, Slovakia,
Sopron, Hungary
24 November 2022

Working Committee of Environmental Sciences and
Working Committee of Forestry,
Regional Centre of the Hungarian Academy of Sciences,

Veszprém (VEAB)

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Contents

COUPLING OF A HIGH-RESOLUTION WEATHER GENERATOR AND A RAINFALL-RUNOFF MODEL IN THE DANUBE BASIN

PETER VALENT[1], JÜRGEN KOMMA[1], GÜNTER BLÖSCHL[1]

[1] Institute of Hydraulic and Water Resources Engineering, Vienna University of Technology, Karlsplatz 13/222, A-1040 Wien, Vienna, Austria

The major flood events of recent years require a further understanding of their climatological and hydrological causes to carry out risk adjustments as efficiently as possible. The WETRAX project (Weather Patterns, Cyclone-Tracks and related precipitation Extremes), which was carried out from 2012–2015, investigated the changes in flood-relevant train paths and large-scale weather situations due to climate change in southern Germany and Austria. As a follow-up project, WETRAX+ was conceived with the aim of translating these findings into hydrological statements that can be directly used for flood risk management and climate change adaptation strategies. In the project, a series of data sets (precipitation, temperature) in daily resolution (observed) and in hourly resolution (generated) were to be created and made available. The study area covers the Bavarian/Austrian river basins (primarily Danube and Drau). In addition, a distributed rainfall-runoff model was built to simulate 10,000 years of hourly river discharges for the current and future climate scenarios at a large number of river profiles located all over the whole catchments. The generated river discharges were analysed and the sources of the changes in runoff characteristics tracked to the changes of the frequency of the projected weather patterns.

Comparative analysis of historical flood events in the Danube and Main River catchments between 1845 and 1950

Miriam Bertola[1], Marlene Haas[1], Jürgen Komma[1], Günter Blöschl[1]

[1] Institute of Hydraulic Engineering and Water Resources Management, Vienna University of Technology, Karlsplatz 13, 1040 Vienna, Austria (bertola@hydro.tuwien.ac.at)

Historical flood events that occurred before the beginning of systematic flow records represent valuable information that should be considered in flood frequency analyses. However, in most cases historical data is still stored in printed volumes and therefore not easily accessible and ready-to-use for hydrological analyses. The aim of this study is to show the added value of recovering and including historical data in flood hazard analyses. Here we have collected, digitized, and compiled a dataset of the largest historical flood data in the Danube and Main catchments between 1845 and 1950. The newly-developed dataset contains discharge and water level measurements observed at several locations for 13 and 9 flood events respectively in the two catchments. Using the dataset developed, we performed a comparative analysis of the historical flood events in terms of their spatial, temporal, and causal characteristics. The findings show that these historical flood discharges are among the largest ever measured in the two catchments and are useful for improving our estimates of flood frequency distribution tails. This work reviews the spatial, temporal and causal characteristics of these very large historical events in comparison with recent events and discusses the implications for flood hazard assessments.

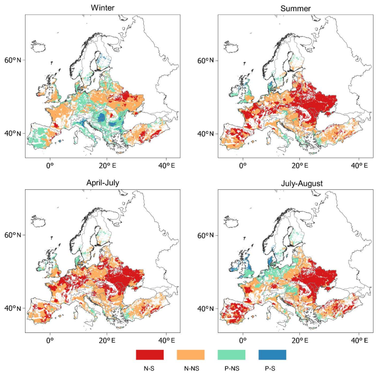
Developing a climate-smart land use system on reclaimed wetlands in the Carpathian-Balkan Region

Zsolt Pinke[1], **Tamás Ács**[2], **Péter Kalicz**[3], **Zoltán Kern**[4], **Zsolt Kozma**[2], **László Pásztor**[1]

[1] Eötvös Loránd University, Department of Physical Geography, Hungary
[2] Budapest University of Technology and Economics, Department of Sanitary and Environmental Engineering, Hungary
[3] University of Sopron, Institute of Geomatics and Civil Engineering, Hungary
[4] Research Centre For Astronomy and Earth Sciences, Hungary

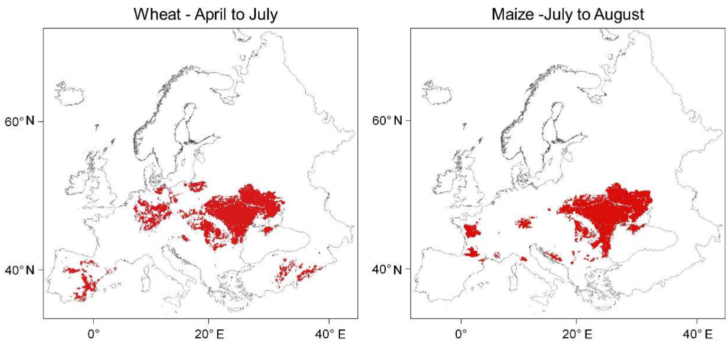
Charting the long-term (1961–2017) relations of wheat and maize yields to climatic drivers, the Carpathian-Balkan Region appears as one of the most sensitive hotspots of the recent warming of the climate in Europe (R^2wheat = 0.38–0.63; R^2maize = 0.23–0.67). Analysing these associations by landscape types in the Middle Central Danube Basin, which is situated within that region, the statistical and GIS-based methods used show that the Hungarian Plain became most vulnerable to increasing temperatures in from 1921–2010 (R^2wheat = 0.48; R^2maize = 0.59). Focusing on the Hungarian Plain, there is a sharp discrepancy between the environmental conditions, and the recent land use practice, and water management. Endless monocultures of cropland farming dominate the weak soils of former wetlands, which covered approximately 25% of the landscape before their massive reclamation in the late 19th century. Therefore, considering the soil conditions, environmental vulnerability, the various categories of environmental vulnerability and nature nature protection in each grid cells (100 m · 100 m) of the Hungarian Plain, we defined two target zones of a massive wetland restoration covering an estimated 9400 km^2. On a micro-regional scale, we simulated different water retention scenarios on the former wetlands and via changing groundwater levels on the yields of the surrounding croplands and forests, quantified the impacts, as well as the effects of vegetation changechanges in vegetation of the different land use scenarios on the hydrological fluxes.

This research was supported by NKFIH (FK 134547).

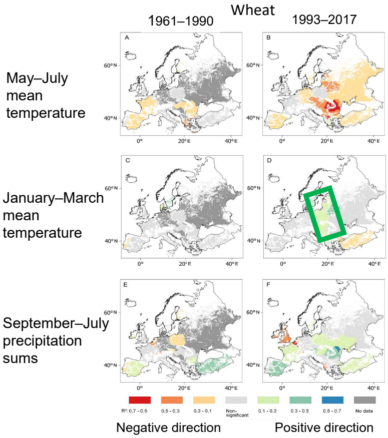


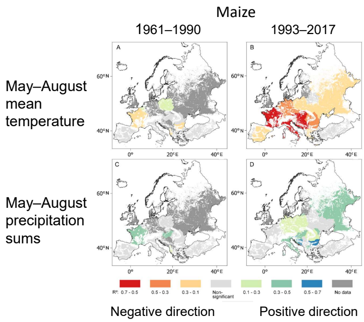
Pinke et al., 2022.
European Journal of Agronomy

Seasonal trends of available water content change in the 0–28 cm soil layer in European croplands between 1981 and 2017 (ERA5 Land 0.1° × 0.1°)
N: negative slope; P: positive slope; S: significant; NS: non-significant



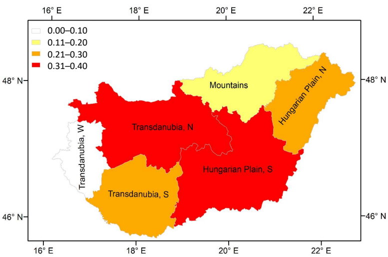
Overlap of (i) significant 0–28 cm layer available soil water content decrease and (ii) significant relationship with a positive regression slope between soil water content and wheat and maize yields in Europe 1993–2017





Pinke et al., 2022. Scientific Reports

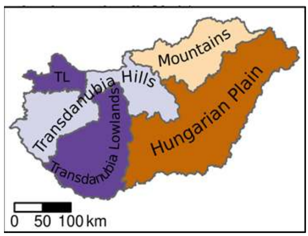
Landscape-based selection



Regional sensitivity map of maize yield to groundwater for Hungary (1986–2010).
Legend: coefficients of determination between August–October groundwater depth and annual maize yields.

Pinke et al., 2020. Science of Total Environment

Landform-based selection



Wheat

	Western Transdanubia		Northern Transdanubia		Mountains		Northern Hungarian Plain		Southern Hungarian Plain		Northern Hungarian Plain		Northern Hungarian Plain	
	R^2	CI	R^2	CI	R^2	CI	R^2	CI	R^2	CI	R^2	CI	R^2	CI
1921-1950														
Prec	0,01	0,00–0,14	0,15	0,00–0,41	0,03	0,00–0,24	0,09	0,00–0,50	0,18	0,00–0,49	0,00	0,00–0,00	0,18	0,00–0,45
Temp	0,55*	0,25–0,78	0,53*	0,12–0,80	0,41*	0,00–0,79	0,21*	0,00–0,62	0,09	0,00–0,48	0,60*	0,06–0,89	0,12	0,00–0,52
1951-1980														
Prec	0,01	0,00–0,09	0,15*	0,01–0,34	0,00	0,00–0,00	0,14	0,01-0,46	0,03	0,00-0,24	0,04	0,00–0,17	0,01	0,00–0,11
Temp	0,17*	0,00–0,45	0,13	0,00–0,44	0,42*	0,05–0,73	0,11	0,00-0,40	0,16*	0,02-0,64	0,39*	0,02–0,67	0,16*	0,00–0,50
1981-2010														
Prec	0,27*	0,04–0,56	0,11	0,00–0,41	0,10	0,00–0,34	0,04	0,00–0,26	0,21*	0,02–0,55	0,04	0,00–0,17	0,19*	0,01–0,49
Temp	0,32*	0,05–0,70	0,38*	0,06–0,74	0,37*	0,07–0,71	0,40*	0,12–0,70	0,48*	0,14–0,79	0,35*	0,04–0,73	0,49*	0,16–0,79
Gw	0,03	0,00–0,27	0,14*	0,00–0,45	0,23*	0,03–0,42	0,08	0,00–0,28	0,11	0,00–0,34	0,13	0,00–0,37	0,11	0,00–0,34

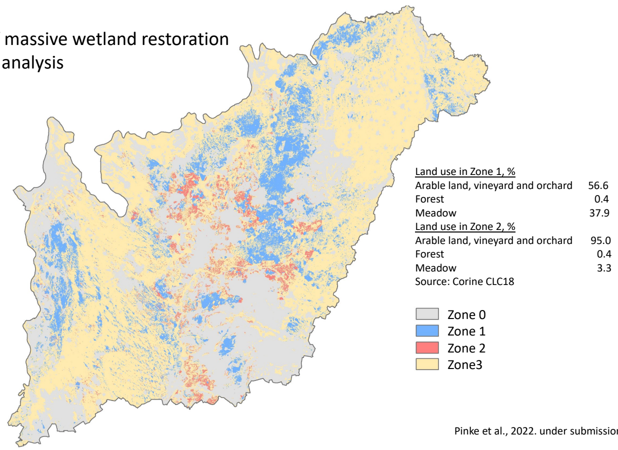
Maize

	Western Trandanubia		Northern Trandanubia		Mountains		Northern Hungarian Plain		Southern Hungarian Plain		Northern Hungarian Plain		Hungarian Plain	
	R^2	CI	R^2	CI	R^2	CI	R^2	CI	R^2	CI	R^2	CI	R^2	CI
1921-1950														
Prec	0,21*	0,01–0,46	0,23*	0,01–0,53	0,42*	0,04–0,71	0,29*	0,03–0,60	0,20*	0,00–0,49	0,32*	0,10–0,58	0,29*	0,02–0,57
Temp	0,01	0,00–0,07	0,00	0,00–0,01	0,01	0,00–0,17	0,02	0,00–0,15	0,00	0,00–0,00	0,01	0,00–0,11	0,00	0,00–0,04
1951-1980														
Prec	0,09	0,00–0,32	0,07	0,00–0,39	0,22*	0,01–0,57	0,04	0,00–0,36	0,46*	0,17–0,71	0,11	0,00–0,40	0,28*	0,01–0,65
Temp	0,04	0,00–0,21	0,01	0,00–0,12	0,00	0,00–0,07	0,02	0,00–0,22	0,05	0,00–0,26	0,02	0,00–0,21	0,01	0,00–0,10
1981-2010														
Prec	0,63*	0,39–0,81	0,50*	0,17–0,73	0,39*	0,09–0,64	0,36*	0,07–0,64	0,55*	0,23–0,75	0,30*	0,08–0,55	0,52*	0,22–0,75
Temp	0,44*	0,20–0,61	0,46*	0,18–0,67	0,41*	0,12–0,65	0,41*	0,11–0,66	0,51*	0,15–0,75	0,38*	0,15–0,62	0,49*	0,17–0,73
Gw	0,25*	0,02–0,52	0,24*	0,00–0,54	0,20*	0,00–0,49	0,24*	0,02–0,54	0,41*	0,11–0,65	0,16*	0,00–0,43	0,34*	0,06–0,64

Results of linear regression and bootstrap resampling tests. * = significant association, CI = confidence interval, Gw = groundwater table, Prec = precipitation sums, Temp = mean temperature

Pinke et al., 2022. under submission

Target areas of massive wetland restoration
Zonal land use analysis



Pinke et al., 2022. under submission

THE EFFECTS OF DRAINAGE ON THE HYDROLOGY OF A HUNGARIAN LOWLAND CATCHMENT

ZSOLT KOZMA[1], BENCE DECSI[1], TAMÁS ÁCS[1], MÁTÉ KRISZTIÁN KARDOS[1], PÉTER KALICZ[2], ZSOLT PINKE[3]

[1] Budapest University of Technology and Economics, Department of Sanitary and Environmental Engineering, Hungary (kozma.zsolt@emk.bme.hu)
[2] University of Sopron, Faculty of Forestry, Institute of Geomatics and Civil Engineering, Hungary
[3] Eötvös Loránd University, Department of Physical Geography, Hungary

The severely modified lowland catchments of the Great Hungarian Plain have a characteristic hydrological behavior within the Carpathian basin. The restoration of former wetlands could increase the hydrological buffering capacitiy of the landscape; thus, it could foster its adaptation to contemporary climatic, ecological and agricultural challenges.

We analysed the hydrological consequences of a theoretical restoration attempt by using physically-based simulations. The 200 km^2 study site is located next to the River Tisza and encompasses a deep floodplain area. Here, the local elevation range is only 6 metres, but the morphology of the heterogeneous terrain offers a remarkable semi-natural storage capacity. An integrated hydrological model was set up with the MIKE SHE software to describe the spatio-temporal variations of the water resources under present conditions (with an operational drainage system) and for an alternative case (without a drainage system). Simulated variations of the surface and subsurface waters were compared to satellite imagery and groundwater monitoring data. The results suggest a significant capacity for a nature-based hydrological adaptation.

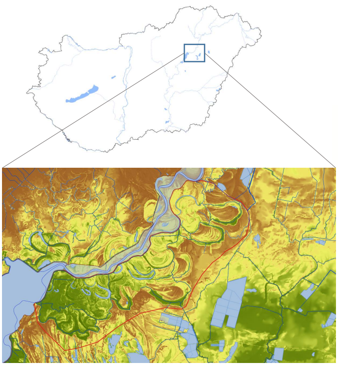
This work is part of the “Developing a climate-smart land use system on reclaimed wetlands of the Hungarian Plain” OTKA FK-134547 research project.

THE EFFECTS OF DRAINAGE ON THE HYDROLOGY OF A HUNGARIAN LOWLAND CATCHMENT

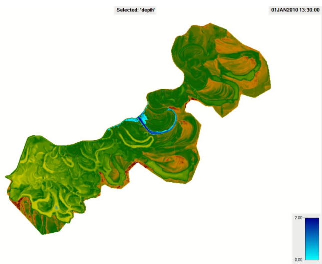
HydroCarpath Conference
Vienna, Austria
24/11/2022

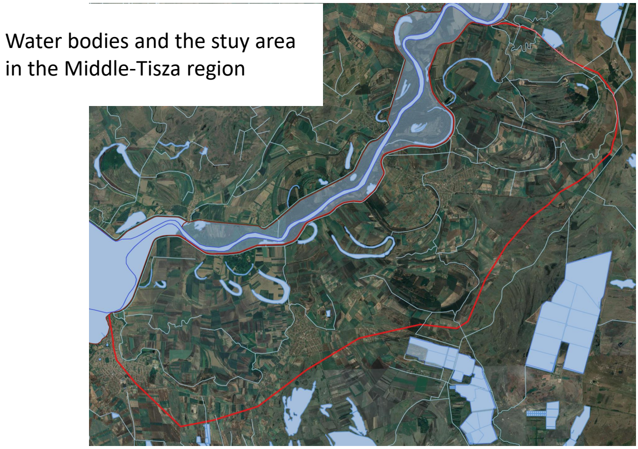
Zsolt Kozma, Bence Decsi, Tamás Ács
Máté Kardos, Péter Kalicz, Zsolt Pinke

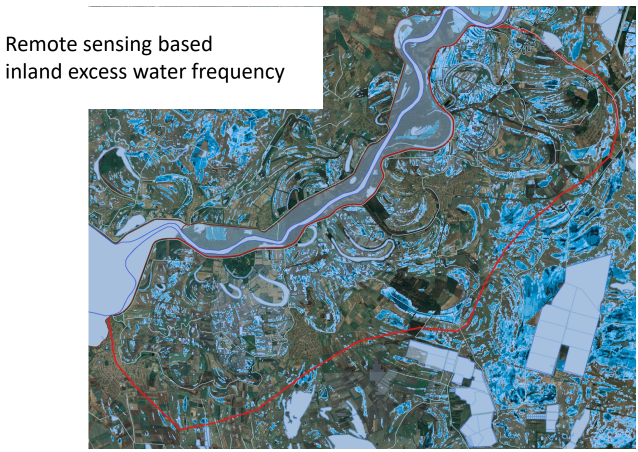
Main goal of the research project

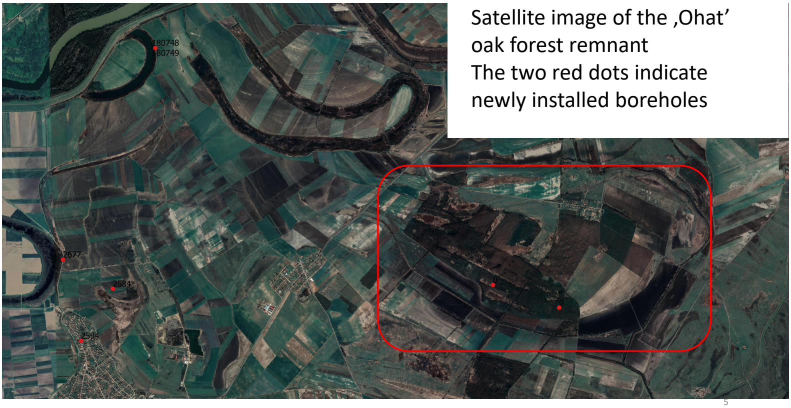


- Floodplain reclamation with regular inundations
- GW recharge
- Altered vadose zone conditions
- Increased crop productivity and tree growth



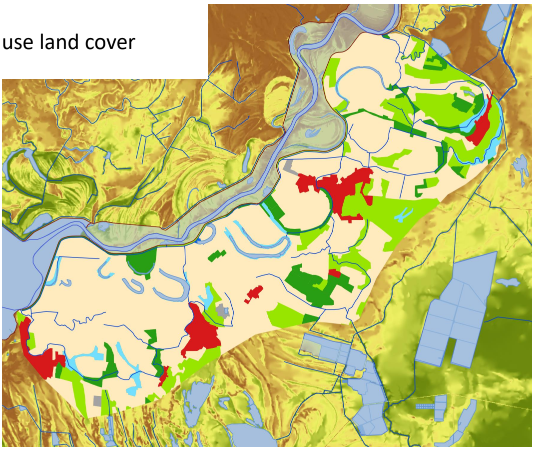

Water bodies and the stuy area
in the Middle-Tisza region


Remote sensing based
inland excess water frequency



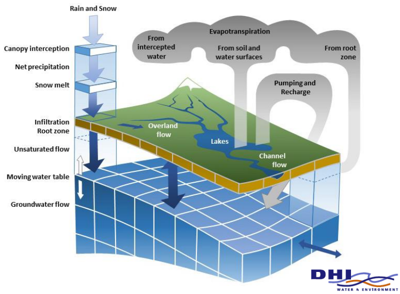
5

Corine land use land cover



6

Applied hydrological model

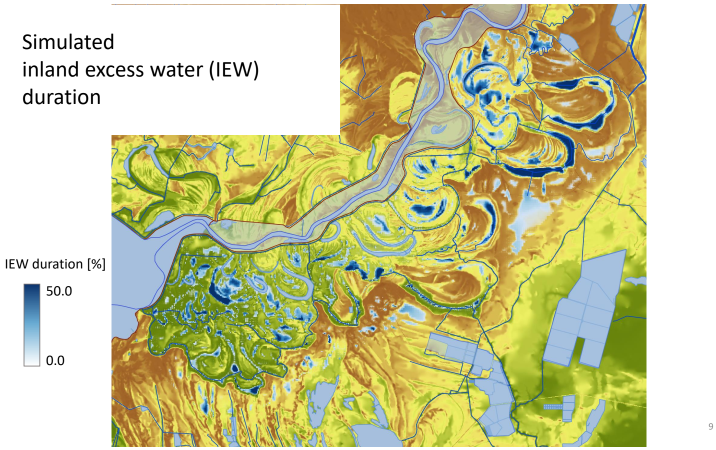


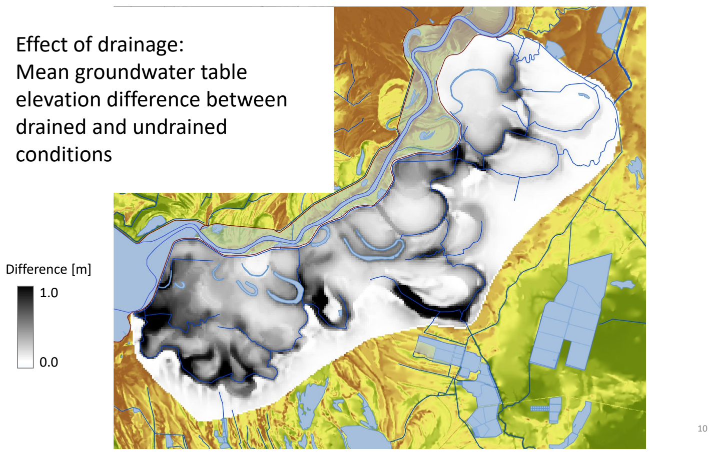
https://manuals.mikepoweredbydhi.help/2017/Water_Resources/MIKE_SHE_Printed_V1.pdf

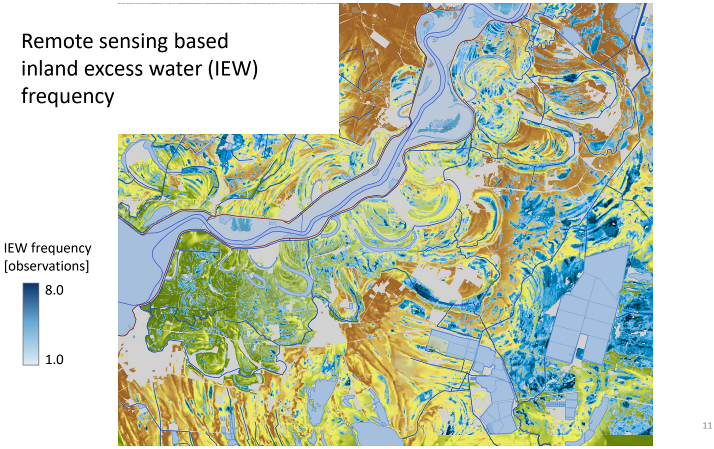
MIKE She
- Snow, interception
- Evapotranspiration
- Surface flow
- Unsaturated zone seepage
- Groundwater flow

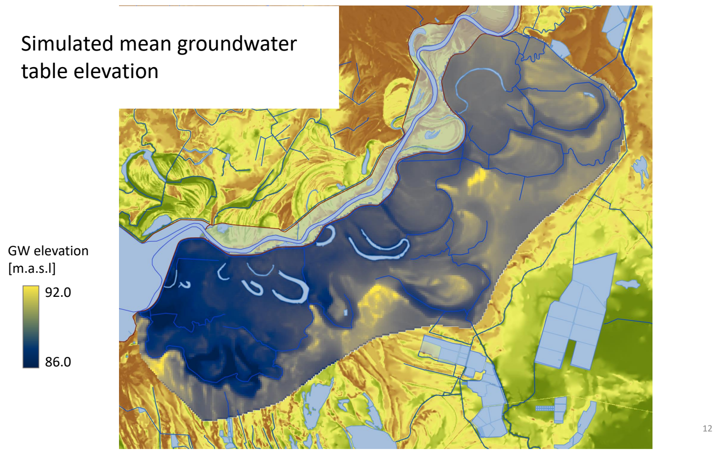
MIKE Hydro River
- Channel flow routing
- Hydraulic structures

Results

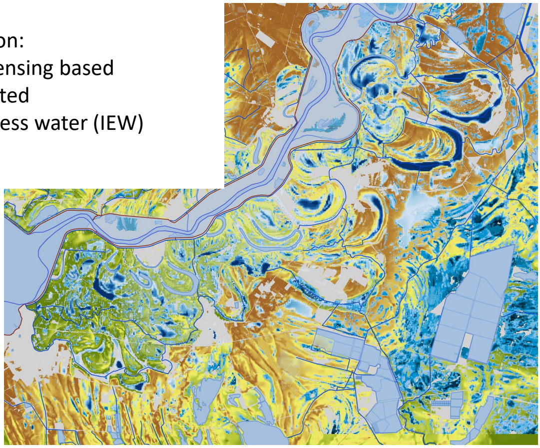

Simulated
inland excess water (IEW)
duration
IEW duration [%]
50.0
0.0
9


Effect of drainage:
Mean groundwater table
elevation difference between
drained and undrained
conditions
Difference [m]
1.0
0.0
10


Remote sensing based inland excess water (IEW) frequency
IEW frequency [observations]
8.0
1.0
11


Simulated mean groundwater table elevation
GW elevation [m.a.s.l]
92.0
86.0
12

Comparison:
Remote sensing based
Vs. simulated
inland excess water (IEW)
frequency



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Thank you!

The project FK20-134547 has been implemented with the support provided
from the National Research, Development and Innovation Fund of Hungary.

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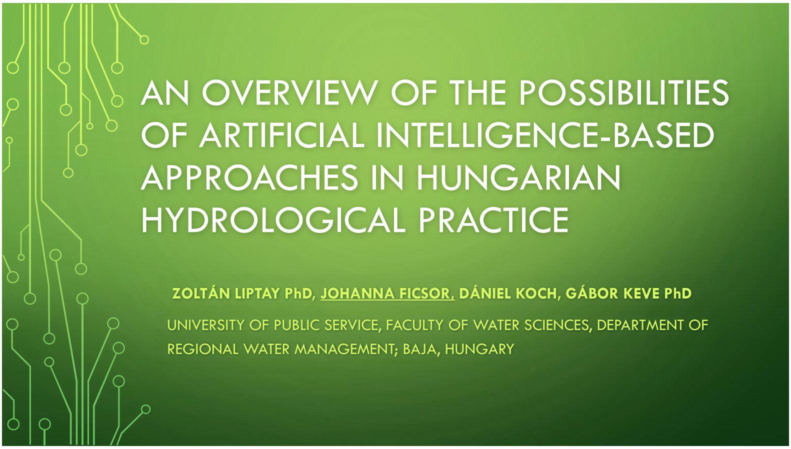
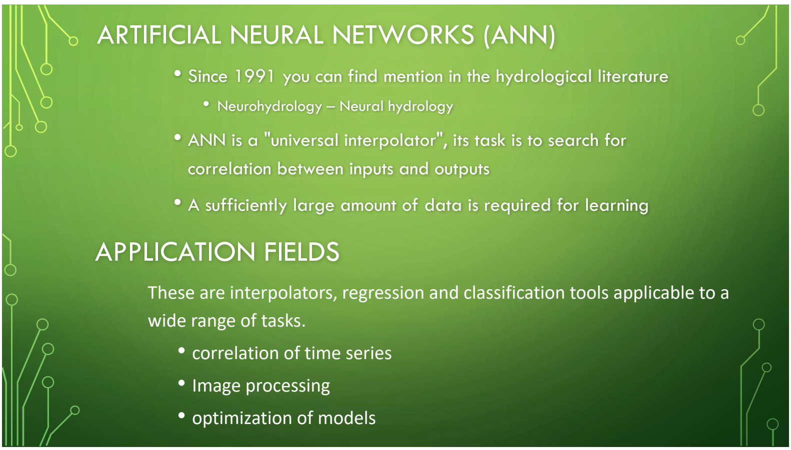
An overview of the possibilities of artificial intelligence-based approaches in Hungarian hydrological practice

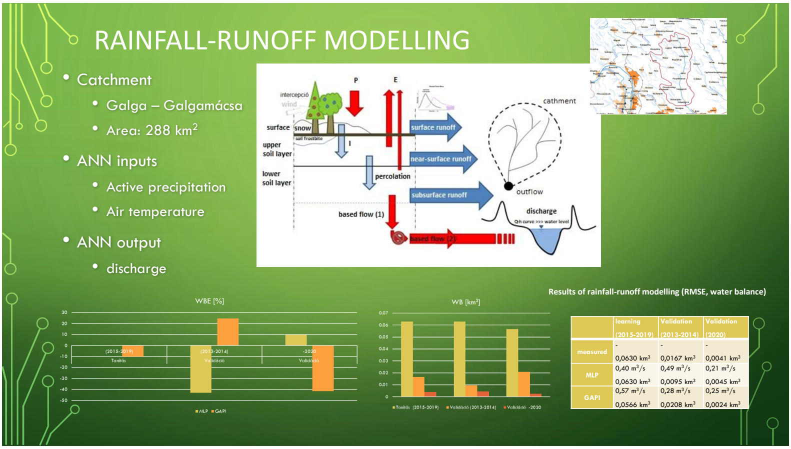
Zoltán Liptay[1], Johanna Ficsor[1], Dániel Koch[1], Gábor Keve[1]

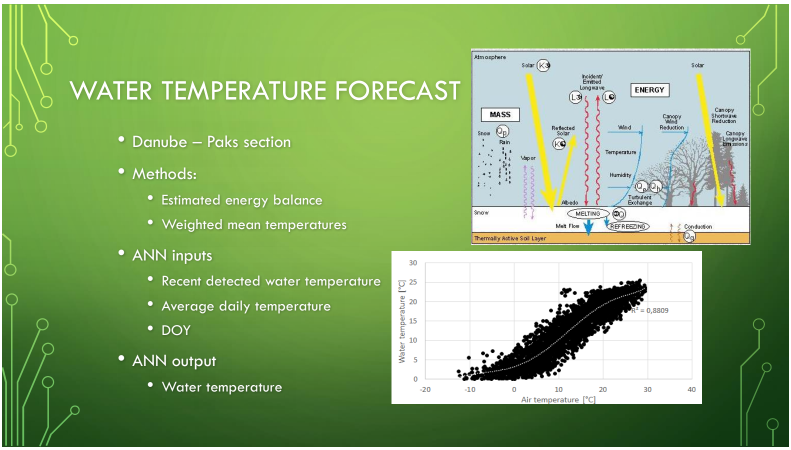
[1] University of Public Service, Faculty of Water Sciences, Department of Regional Water Management; Baja, Hungary (liptay.zoltan.arpad@uni-nke.hu)

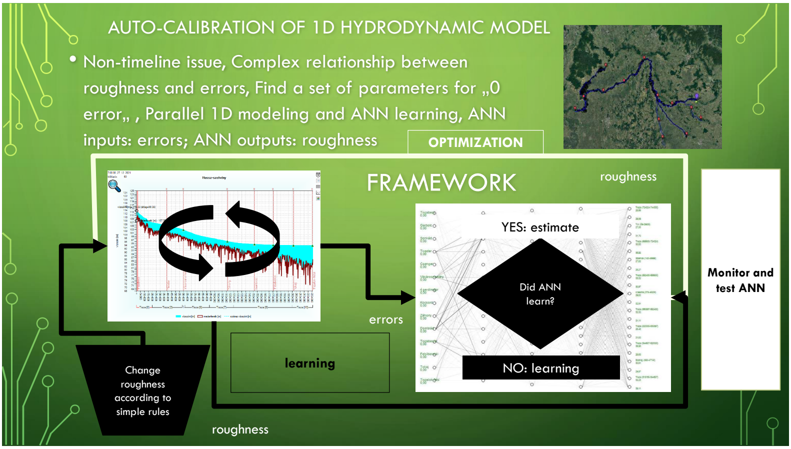
Artificial intelligence has a long history, and its hydrological applications also date back decades. Artificial neural networks (ANN) are interpolators, regression and classification tools applicable to a wide range of tasks. Image processing is one of their main applications, which is also useful in hydrology, e.g., satellite images of inundations and ice formations or pictures of sediment movements and morphology, etc. The second type of ANN is based on the correlation of time series that use artificial neural networks as black box models. In cases where a physical description of the problem is not available, it is able to provide satisfactory results if a sufficient amount of learning data is at hand. Hydrological forecasting could benefit from such tools. However, mixed results are presented in the literature. Another type of application is the optimization of models by identifying the correlation between calibration variables and errors, or even solving problems by a physically-informed neural network. Three areas were selected in our study: rainfall-runoff modelling of a small catchment, water temperature simulations, and the optimization of a 1D hydrodynamic model.

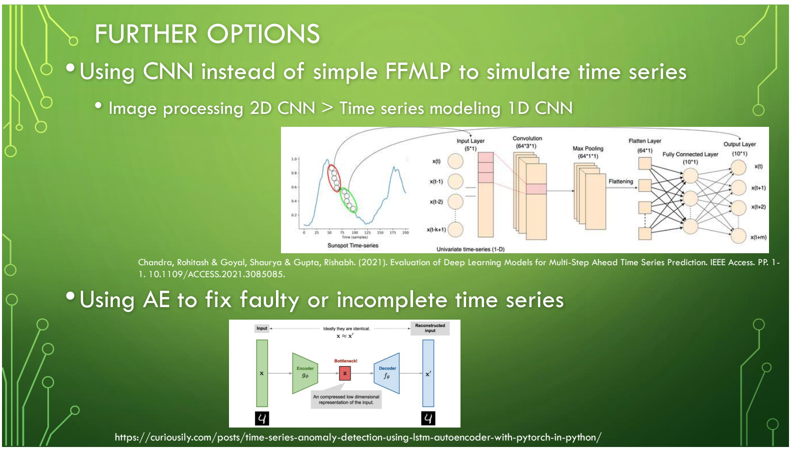

AN OVERVIEW OF THE POSSIBILITIES OF ARTIFICIAL INTELLIGENCE-BASED APPROACHES IN HUNGARIAN HYDROLOGICAL PRACTICE
ZOLTÁN LIPTAY PhD, JOHANNA FICSOR, DÁNIEL KOCH, GÁBOR KEVE PhD
UNIVERSITY OF PUBLIC SERVICE, FACULTY OF WATER SCIENCES, DEPARTMENT OF REGIONAL WATER MANAGEMENT; BAJA, HUNGARY

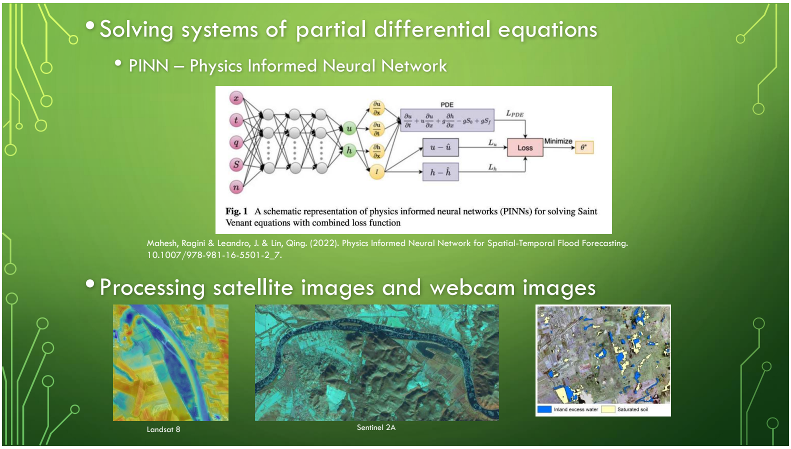

ARTIFICIAL NEURAL NETWORKS (ANN)
Since 1991 you can find mention in the hydrological literature
Neurohydrology – Neural hydrology
ANN is a "universal interpolator", its task is to search for correlation between inputs and outputs
A sufficiently large amount of data is required for learning
APPLICATION FIELDS
These are interpolators, regression and classification tools applicable to a wide range of tasks.
correlation of time series
Image processing
optimization of models

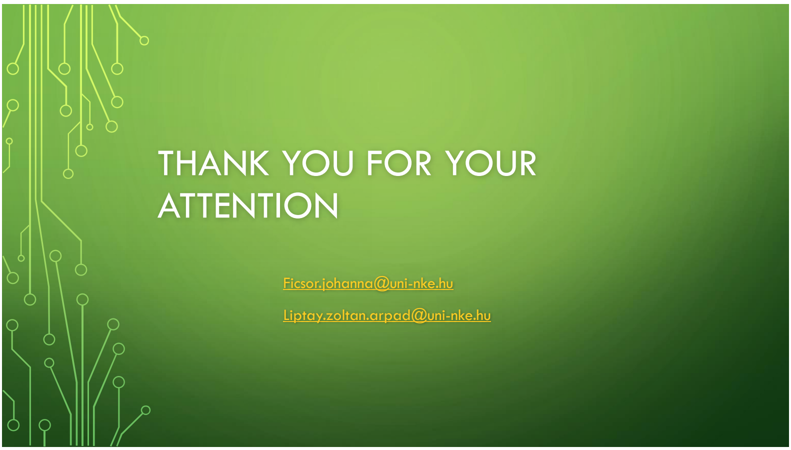

RAINFALL-RUNOFF MODELLING
Catchment
Galga – Galgamácsa
Area: 288 km²
ANN inputs
Active precipitation
Air temperature
ANN output
discharge
intercepció
wind
surface
snow
soil frostbite
upper soil layer
lower soil layer
P
E
surface runoff
near-surface runoff
percolation
subsurface runoff
based flow (1)
based flow (2)
cathment
outflow
discharge
Q-h curve >>> water level
WBE [%]
WB [km³]
Results of rainfall-runoff modelling (RMSE, water balance)
learning (2015-2019) | Validation (2013-2014) | Validation (2020)
measured | - 0,0630 km³ | - 0,0167 km³ | - 0,0041 km³
MLP | 0,40 m³/s 0,0630 km³ | 0,49 m³/s 0,0095 km³ | 0,21 m³/s 0,0045 km³
GAPI | 0,57 m³/s 0,0566 km³ | 0,28 m³/s 0,0208 km³ | 0,25 m³/s 0,0024 km³


WATER TEMPERATURE FORECAST
Danube – Paks section
Methods:
Estimated energy balance
Weighted mean temperatures
ANN inputs
Recent detected water temperature
Average daily temperature
DOY
ANN output
Water temperature
Atmosphere
Solar
ENERGY
MASS
Snow
Rain
Vapor
Reflected Solar
Wind
Temperature
Humidity
Turbulent Exchange
Albedo
MELTING
REFREEZING
Melt Flow
Conduction
Thermally Active Soil Layer
Canopy Wind Reduction
Canopy Shortwave Reduction
Canopy Longwave Emissions
Water temperature [°C]
Air temperature [°C]
R² = 0,8809


AUTO-CALIBRATION OF 1D HYDRODYNAMIC MODEL
• Non-timeline issue, Complex relationship between roughness and errors, Find a set of parameters for „0 error„ , Parallel 1D modeling and ANN learning, ANN inputs: errors; ANN outputs: roughness
OPTIMIZATION
FRAMEWORK
roughness
YES: estimate
Did ANN learn?
NO: learning
Monitor and test ANN
errors
learning
Change roughness according to simple rules
roughness


FURTHER OPTIONS
• Using CNN instead of simple FFMLP to simulate time series
• Image processing 2D CNN > Time series modeling 1D CNN
Chandra, Rohitash & Goyal, Shaurya & Gupta, Rishabh. (2021). Evaluation of Deep Learning Models for Multi-Step Ahead Time Series Prediction. IEEE Access. PP. 1-1. 10.1109/ACCESS.2021.3085085.
• Using AE to fix faulty or incomplete time series
https://curiousily.com/posts/time-series-anomaly-detection-using-lstm-autoencoder-with-pytorch-in-python/


• Solving systems of partial differential equations
• PINN – Physics Informed Neural Network
PDE
Loss
Minimize
Fig. 1 A schematic representation of physics informed neural networks (PINNs) for solving Saint Venant equations with combined loss function
Mahesh, Ragini & Leandro, J. & Lin, Qing. (2022). Physics Informed Neural Network for Spatial-Temporal Flood Forecasting. 10.1007/978-981-16-5501-2_7.
• Processing satellite images and webcam images
Inland excess water
Saturated soil
Landsat 8
Sentinel 2A


THANK YOU FOR YOUR ATTENTION
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The value of ASCAT data for the calibration of a conceptual hydrological model

Martin Kubáň[1], Juraj Parajka[2], Ján Szolgay[1], Kamila Hlavčová[1], Silvia Kohnová[1]

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[2] Centre for Water Resource Systems, TU Wien, Vienna 1040, Austria; parajka@hydro.tuwien.ac.at (J.P.);

In the last decade, the quality of remote sensing data has rapidly improved. With better quality data, the demand for its implementation in scientific research rises. In our paper, we decided to implement the ASCAT SWI direct product of the soil water index to the calibration and validation process of the conceptual HBV-type model. We used the SWI data of the surface and root zone layers for 209 Austrian catchments for the multi-objective calibration and validation of the model. The three multi-calibration strategies with different weights for the runoff and SWI were performed for the period 2007–2014. From the calibration results, we detected how the SWI data influenced the reaction of the soil component of the HBV-type model. The validation results show that, with the use of the SWI data, the multi-objective approach slightly improved the runoff simulation in the catchments with a lower mean elevation and a higher percentage of agricultural lands, mainly in the regions of Upper and Lower Austria and the lowlands of the Carinthia region.

Keywords: SWI direct, efficiencies, Austria

The value of ASCAT data for the calibration of a conceptual hydrological model

Martin Kubáň
Department of Land and Water Resources Management

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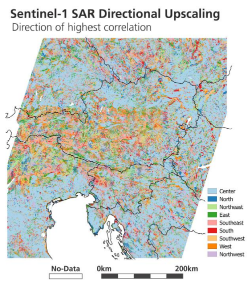
Objectives

- Testing of the ASCAT SWI product of two soil zones by the assimilation to process of calibration of the r-r model
- Setup of the Objective function
- Detection value of the ASCAT SWI for runoff simulation
- Selecting the catchments suitable for the incorporation of the ASCAT SWI
- Effect of the ASCAT SWI product on the Hydrologic balance



HSAF/CDOP3/ATBD/, 2020

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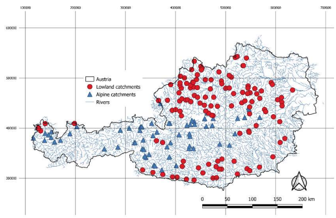
Interested area

- 209 catchments in Austria without significant anthropogenic influence on the runoff (dams, hydropower plants …)
- Catchments with variable geophysical characteristics
- Alpine and lowland catchments
- Input data distributed into elevation zones by 200

  vertical meters in daily timestep



Sleziak et al. 2017

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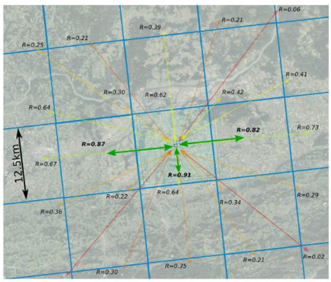
ASCAT SWI product

- Data from the ASCAT sensor on the board of the METOP-A, -B and –C measured from 2015 till now
- Dataset of the SWI was downscaled backwards based on the Sentinel 1 (12.5km) data, to the year 2007 with the nearest neighbour's method
- Product for two soil zones of the SWI – Soil Water Index:
  - root zone represents (28-100cm)
  - surface zone represents (3-5cm)
- 500-500 m grid data
- Product is updated daily by the department of geodesy and cartography at TUW



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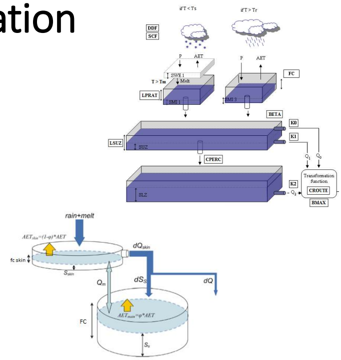
TUW model dual Calibration

- Conceptual rainfall-runoff model
- TUW dual version is more suitable for the incorporation of the SWI data than the original TUW model
- The model contains two soil layers reservoirs (root and surface)



Parajka et al. 2009

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Calibration

- For the years 2007-2014 - 4 calibration variants with different **weights for Runoff and SWI**
- Optimalization for Runoff based on the combination of the NSE and log NSE (NSE+logNSE)/2
- Optimalization for SWI based on the correlation between simulated SWI and measured SWI ASCAT
- Input data - Precipitation, Air temperature (Spartacus), EP Blaney-Criddle

SINGLE OBJECTIVE	**weight Runoff**	weight SWI
RUNOFF	**1**	0

VS

MULTI OBJECTIVE	**weight Runoff**	weight SWI surface	weight SWI root
RUNOFF + SWI surface	**1/2**	1/2	0
RUNOFF + SWI root	**1/2**	0	1/2
RUNOFF + SWI surface +SWI root	**1/3**	1/3	1/3

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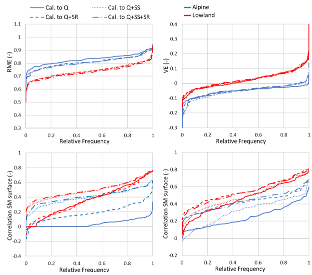
Calibration Results

- Comparison against the single-objective approach
- Slightly decrease in the RME
- VE without changes
- Significant improvement in the correlation between ASCAT SWI and simulated SWI



Calibration variant (2007-2014)	RME		VE (%)		R surface soil moisture		R root soil moisture	
	Alpine	Lowland	Alpine	Lowland	Alpine	Lowland	Alpine	Lowland
Cal. to Q	**0.83**	**0.75**	-0.05	**0.02**	0.02	0.37	0.23	0.49
Cal. to Q+SS	0.81	0.74	-0.05	**0.02**	0.40	**0.49**	0.36	0.49
Cal. to Q+SR	0.81	0.74	-0.05	**0.02**	0.18	0.38	0.43	**0.54**
Ca. to Q+SS+SR	0.81	0.73	**-0.04**	0.03	**0.41**	0.48	**0.44**	**0.54**

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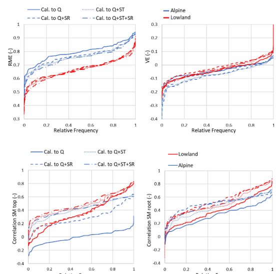
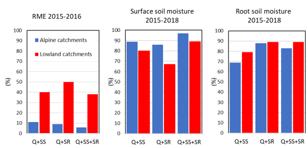
Validation Results

- For years 2015-2018
- Detection of the catchments with the improvement of the RME

  (improvement between 3 - 10 %, median 5 %)
- Difference in the improvement between Alpine and Lowland catchments





Calibration Variant	Median of R of Surface Soil Moisture		Median of R of Root Soil Moisture	
	Alpine	Lowland	Alpine	Lowland
Runoff (Q)	0.01	0.33	0.36	0.40
Q + SS	**0.43**	0.46	0.48	0.46
Q + SR	0.27	0.33	**0.54**	**0.54**
Q + SS + SR	**0.43**	**0.48**	0.53	0.49

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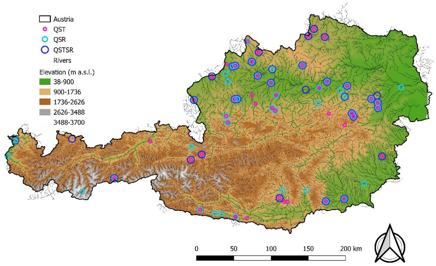
Validation Results

- For the years 1991-2000
- Detection of the improvement in RME in nearly 22% of the catchments, with weight to runoff (w=1/2, 1/3)
- Improvement mainly in Lowland regions
- 4 validation variants



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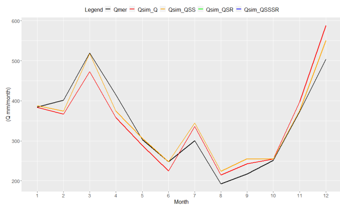
Validation Results

- Characteristics only for the improved catchments (RME)
- All 3 multi-objective variants with the improvement in the catchments with similar characteristics
- Catchments characteristics:
    - Lower Mean Elevation
    - Lower Slope of the terrain
    - Lower Forest percentage
    - Higher Agricultural lands



Medians of the catchment characteristics for 198 catchments

198	[%]	[Num.]	[+/-]	A	MELE	SL	FP	AP	MAP	MTLT0
Q+SR	22%	44	improved	223.2	**761.0**	**13.6**	54.4	**23.7**	1216.2	0.17
Q+ST	22%	44		239.4	**849.7**	**13.2**	57.6	**21.9**	1173.2	0.18
Q+ST+SR	17%	34		183.5	**719.2**	**8.5**	52.1	**39.2**	1077.1	0.17
Q+SR	78%	154	unimproved	170.2	**1178.1**	**22.1**	46.4	**14.4**	1307.4	0.22
Q+ST	78%	154		165.1	**1176.9**	**22.0**	45.5	**14.2**	1307.4	0.22
Q+ST+SR	83%	164		168.1	**1178.1**	**22.7**	46.4	**13.4**	1326.0	0.22
Medians of 198 catchments				178.3	1036	19.48	46.7	16.1	1277.7	0.20

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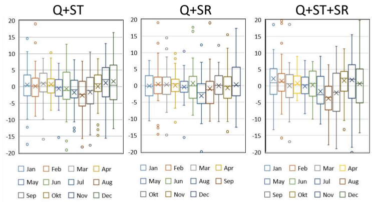
Water Balance

- Hydrologic water balance for the catchments with better RME
- Detection of the improvement in multi vs single objectives for specific months
- We compute the Differences in long-term runoff mean monthly values



Multi-objective approach	Percentage of the improved catchments in long-term mean monthly runoff											
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Q+ST (44 catch.)	**55**	**57**	**57**	**61**	48	43	45	34	39	**59**	**64**	**55**
Q+SR (44 catch.)	50	**55**	**61**	**61**	43	50	39	34	45	**52**	**48**	**52**
Q+ST+SR (34 catch.)	**56**	**65**	**62**	**59**	**59**	**56**	38	26	32	**65**	**62**	**56**
Q+ST FC- (35 catch.)	**60**	**57**	**66**	**63**	43	43	43	37	40	**60**	**66**	**60**
Q+SR FC-(31 catch.)	**61**	**58**	**58**	**58**	39	48	42	39	**52**	**61**	**52**	**55**
Q+ST+SR FC-(34 catch.)	**56**	**65**	**62**	**59**	**59**	**56**	38	26	32	**65**	**62**	**56**
Q+ST FC+ (9 catch.)	33	**56**	22	**56**	**67**	44	**56**	22	33	**56**	**56**	33
Q+SR FC+(13 catch.)	23	46	**62**	**62**	**54**	**54**	31	23	31	31	38	**46**
Q+ST+SR FC+ (0 catch.)	0	0	0	0	0	0	0	0	0	0	0	0

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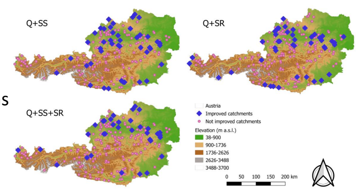
Conclusion

- With the assimilation of the ASCAT SWI into the conceptual r-r model
- We can expect a decrease in the RME in the Alpine catchments
- Catchments where we can expect the improvement of the RME
  - Lowland catchments (Mean elev. Median 800 m a.s.l.)
  - Higher percentage of agricultural lands (>20%)
  - Lower slopes of the terrain (<13%)
- The improvement can be expected in the Spring, winter and autumn months
- The decrease can be expected in summer months



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Thank you for your attention!

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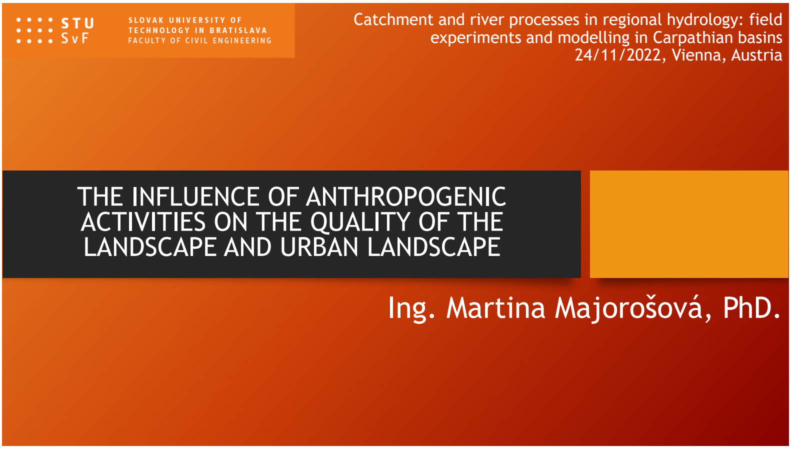
THE INFLUENCE OF ANTHROPOGENIC ACTIVITIES ON THE QUALITY OF THE LANDSCAPE AND URBAN LANDSCAPE

MARTINA MAJOROŠOVÁ[1]

[1] Department of Land and Water Resources Management, Faculty of Civil Engineering, Slovak University of Technology in Bratislava, Bratislava, Slovakia

Many negative changes in the landscape are caused by anthropogenic activities. Unfortunately, anthropogenic factors cause problems in the natural ecosystems, and the natural processes work no longer as they did before; often they do not work at all. Generally, it needs to be paid more attention to this topic. Therefore, this research is focused on the issue from several points of view, namely, improper regulation of water flows, the introduction of invasive species into natural riparian vegetation, loss of biodiversity and the absence of green spaces in the urban areas. The research results focus on various topics related to anthropogenic impacts on the landscape. A large part of the research offers results and methods that could be used directly in practice. The main task of landscape planners is to restore natural processes to the landscape and urban landscape, thus eliminating the negative anthropogenic impact.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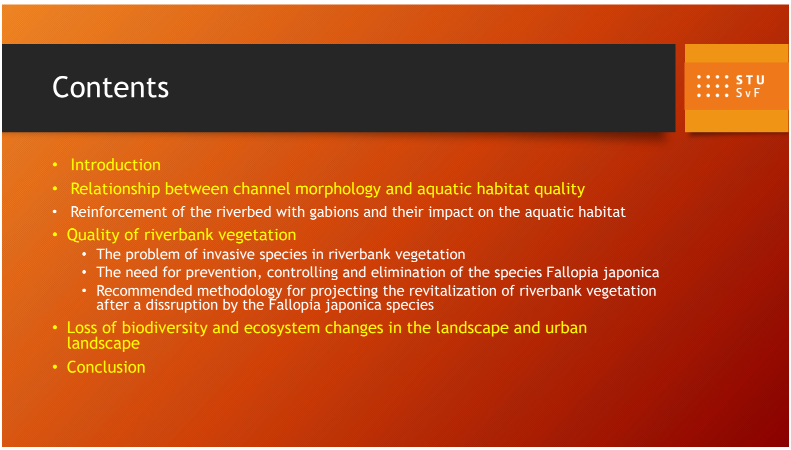
SLOVAK UNIVERSITY OF TECHNOLOGY IN BRATISLAVA
FACULTY OF CIVIL ENGINEERING
Catchment and river processes in regional hydrology: field experiments and modelling in Carpathian basins
24/11/2022, Vienna, Austria
THE INFLUENCE OF ANTHROPOGENIC ACTIVITIES ON THE QUALITY OF THE LANDSCAPE AND URBAN LANDSCAPE
Ing. Martina Majorošová, PhD.


Contents
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• Introduction
• Relationship between channel morphology and aquatic habitat quality
• Reinforcement of the riverbed with gabions and their impact on the aquatic habitat
• Quality of riverbank vegetation
• The problem of invasive species in riverbank vegetation
• The need for prevention, controlling and elimination of the species Fallopia japonica
• Recommended methodology for projecting the revitalization of riverbank vegetation after a dissruption by the Fallopia japonica species
• Loss of biodiversity and ecosystem changes in the landscape and urban landscape
• Conclusion

Introduction

- Many **negative changes** in the landscape are **caused by anthropogenic activities**
- They cause problems in the natural cycles
- Antropogenic activities caused that the natural processes no longer funtion as they used to, often not at all
- It is necessary to solve the negative changes caused by human in the natural ecosystems
- Generally, there is no given enough attention to this issue therefore, this research focuses on the issue **from several perspectives.**

Relationship between channel morphology and aquatic habitat quality

- A serious type of problem caused by anthropogenic activities in the landscape is the **flow regulation**.
- By **changing morphology and the conditions** in the stream, the composition of **the fauna and flora will also change.**
- The **need to assess the quality** of the aquatic habitat of the stream is necessary **for designing the appropriate revitalisation** of the stream.
- The research on the quality of aquatic habitat has been ongoing for many years at STU in a team, where I have been a part since I started my doctoral studies.

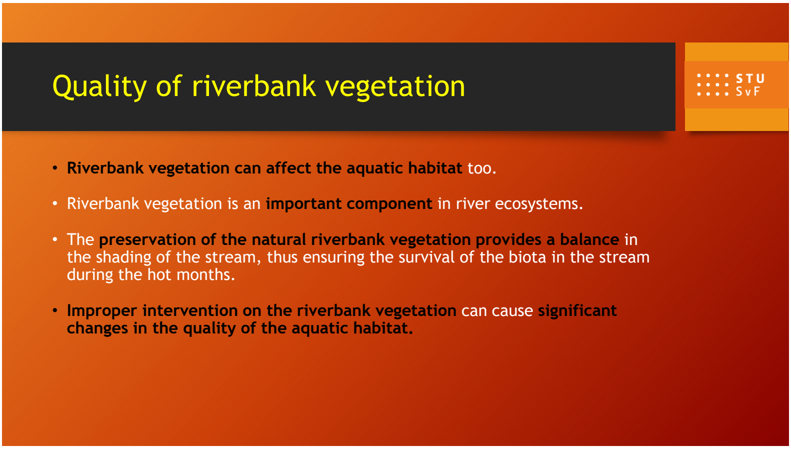
Relationship between channel morphology and aquatic habitat quality

- Many **old stream regulations** caused significant changes in the riverbed, changing its volumetric capacity so that it was sufficient for floods, **but the monotonous regulated shape of the riverbed caused significant changes in the habitats** that were in the stream before the regulation.

- **By knowing the assessment of the quality of the aquatic habitat,** it is possible to **propose an appropriate revitalisation**, which will support biodiversity and **reduce the anthropogenic impact** that was caused by incorrect stream regulations in the past.

Reinforcement of the riverbed with gabions and their impact on the aquatic habitat

- In the further step, **the impact of wire stone mattresses (gabions) on aquatic habitat was assesed.**
- The stream's morphology is also **influenced by the reinforcement of the stream**
- We **compared the aquatic habitat** and the ichthyomass of **natural reference reach and revitalised** reference reach of **Oščadnica River.**
- The fish were caught by an electric aggregate. Subsequently, the **fish were counted, measured, weighed, their species was determined** and they were returned to the stream.
- The result of these measurements was that the **natural section** of the Oščadnica River had a **higher abundance**, but had **minimal differences in biomass values.** On the other hand, there were **fewer fish in the regulated reference reach**, but the **total weight was higher.** The **number of species was the same in both sections.** It can be concluded that the gabions used to reinforced the riverbed are a suitable construction material for this purpose.


Quality of riverbank vegetation
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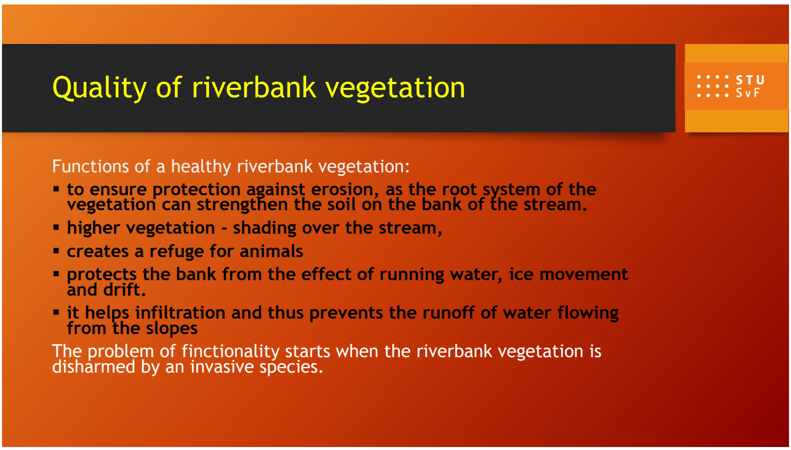
• Riverbank vegetation can affect the aquatic habitat too.
• Riverbank vegetation is an important component in river ecosystems.
• The preservation of the natural riverbank vegetation provides a balance in the shading of the stream, thus ensuring the survival of the biota in the stream during the hot months.
• Improper intervention on the riverbank vegetation can cause significant changes in the quality of the aquatic habitat.


Quality of riverbank vegetation
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Functions of a healthy riverbank vegetation:
▪ to ensure protection against erosion, as the root system of the vegetation can strengthen the soil on the bank of the stream.
▪ higher vegetation - shading over the stream,
▪ creates a refuge for animals
▪ protects the bank from the effect of running water, ice movement and drift.
▪ it helps infiltration and thus prevents the runoff of water flowing from the slopes
The problem of finctionality starts when the riverbank vegetation is disharmed by an invasive species.

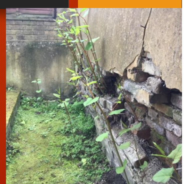
The problem of invasive species in riverbank vegetation

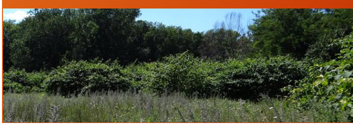
- Aggressive anthropogenic activities include the **removal of riparian vegetation and, indirectly, the introduction of plants.**
- **The escape of introduced species** of plants, imported for decorative purposes, **can result in the unwanted expansion** of aggressive species into our natural habitats **and then invasion occurs**
- The invasive species ***Fallopia japonica*** has been attacking Slovak riverbank vegetation for several years.

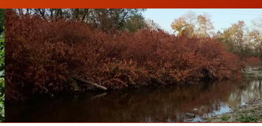
The need for prevention, controlling and elimination of the species *Fallopia japonica*

Fallopia japonica :

- reduces the capacity of the riverbed,
- disrupts the balance of riparian vegetation,
- creates a monoculture riverbank vegetation,
- disrupts building structures,
- causes complications for the maintenance of parks and green spaces



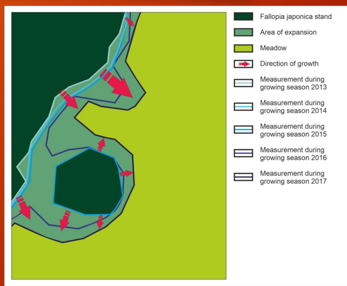




The mapping of Fallopia japonica by inovative approaches

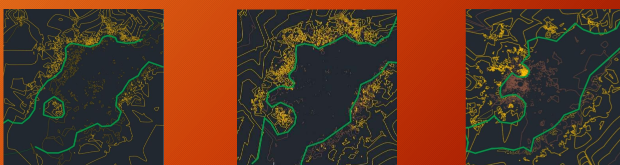
Reference reach on Schwechat River

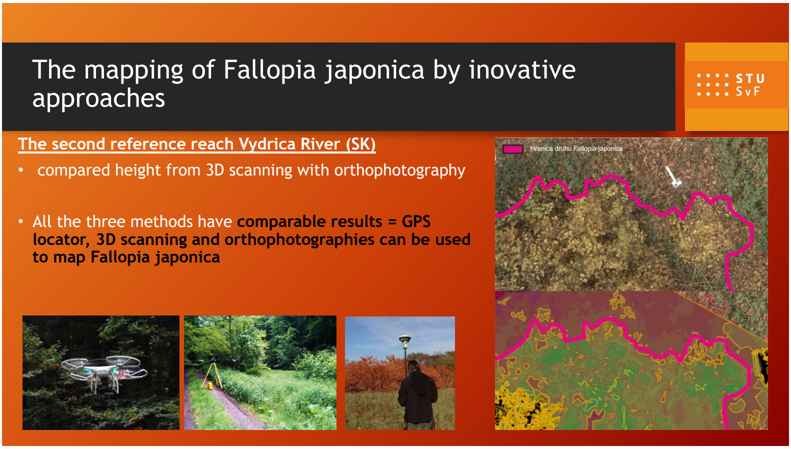
- mapping by using Leica GPS locator and Trimble TX5 3D Laser Scanner
- We confirmed growing dynamics of spread.
- The average annual increase in the Schwechat River between 2013 and 2014 was 0.37m, between 2014 and 2015 0.65m, 2015 and 2016 0.95m and between 2016 and 2017 up to 1.11m.
- The longer Fallopia japonica lives on the stand, the faster it expands.



The mapping of Fallopia japonica by inovative approaches

- Then, GPS line of the Fallopia japonica stand boundary was inserted into hypsometry from a 3D scan during three growing seasons (12.05.2014, 06.11.2015, 19.05.2016)
- Significant match was confirmed - both methods are applicable




The mapping of Fallopia japonica by inovative approaches
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The second reference reach Vydrica River (SK)
• compared height from 3D scanning with orthophotography
• All the three methods have comparable results = GPS locator, 3D scanning and orthophotographies can be used to map Fallopia japonica
Hranica druhu Fallopia japonica


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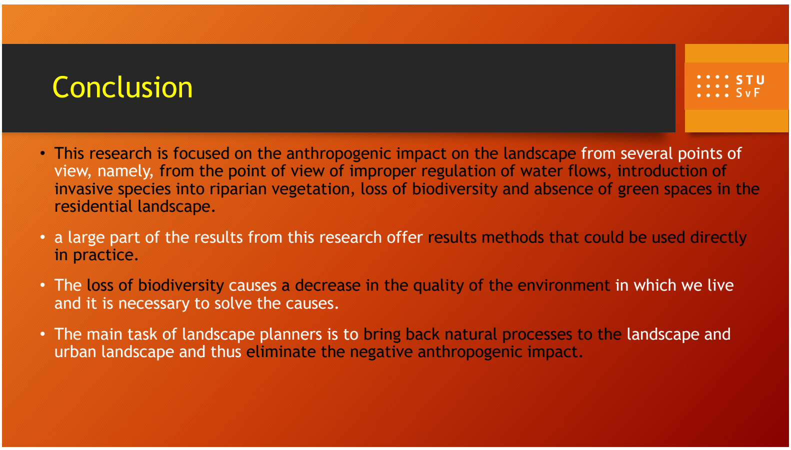
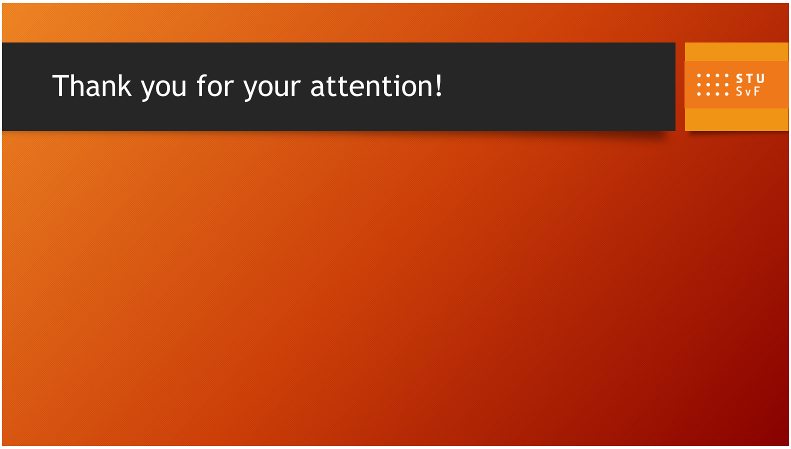
MANUÁL
zaobchádzania
s inváznym druhom
Fallopia japonica
v brehových porastoch
pre miestne územné
samosprávy
Obsah
1 Vymedzenie základných pojmov
3 Charakteristika invázneho druhu Fallopia japonica


Figures: from left pine tree, chestnut, poplar tree, mulberry
Source: authors
NATURE ELEMENTS SCHEME
Tree varietes examples that are in the campus:
- Pinus
- Abies
- Thuja
- Tilia
- Fraxinus
- Acer
- Populus
- Aesculus
- Morus
Buildings and paved surface
Low greenery
High and medium greenery
Water spring
Figure 3. Scheme of basic natural elements (Source: Authors).
HEALING AND THERAPEUTIC LANDSCAPE DESIGN
PROPOSAL SCHEME - LANDSCAPE DESIGN
ADJUSTMENTS OF AREAS
1. Unused atrium - completing with decorative greenery
2. The adjustment of paved atrium surface, completing with greenery
3. The adjustment of paved atrium surface, completing of therapeutic space, adjustment of greenery and existing elements
4. The adjustment of sport facilities and their fences
5. Growing of flowers/herbs/fruits (small wineyard, orchard)/vegetables
6. The adjustment of unused area of a former kindergarden
7. Completing with insulation greenery
8. The adjustment of water stream, river bank
9. Place for a bio waste/composting
10. Completing with decorative greenery near the fountain
COMPLETING THE ENVIRONMENT
- The adjustment of the existing elements
- To add some species
- To add bench of flowers
- Completing the environment in the spirit of sensory garden (greenery with different colour, smell, touch, sight, taste, sound of water from a fountain)
- Completing with elements supporting the therapy
- To support natural biodiversity
- Wheelchair accesibility
- Link between interior / exterior (to enforce vistas from inside to outside, utilising of atriums, vistas into atriums)
- Completing with interior greenery and its maintenance
MANAGEMENT OF EXTERIOR PLACES:
- more focus on continual recultivation, better informing
- safety, utilisation and access to the individual places
- organisation of volunteer works, to take grants possibilities
- to ensure the periodical greenery maintenance: to remove invasive trees, dry branches, mowing, bio waste, river bank maintenance, the control of health condition of trees, planting


Conclusion
STU
SvF
This research is focused on the anthropogenic impact on the landscape from several points of view, namely, from the point of view of improper regulation of water flows, introduction of invasive species into riparian vegetation, loss of biodiversity and absence of green spaces in the residential landscape.
a large part of the results from this research offer results methods that could be used directly in practice.
The loss of biodiversity causes a decrease in the quality of the environment in which we live and it is necessary to solve the causes.
The main task of landscape planners is to bring back natural processes to the landscape and urban landscape and thus eliminate the negative anthropogenic impact.


Thank you for your attention!

Precipitation data processing from various tipping bucket rain gauges in the Hidegvíz Valley experimental catchment

Csenge Nevezi[1], Zoltán Gribovszki[1], András Herceg[1], Blanka Holik[1], Katalin Zagyvai-Kiss[1], Péter Kalicz[1]

[1] University of Sopron, Faculty of Forestry, Institute of Geomatics and Civil Engineering, Hungary

In the early 1990s, meteorological data collection started with data loggers in the Hidegvíz Valley experimental catchment, including the precipitation measurements. These data-collecting instruments are mostly automated; the only manual device is a traditional Hellmann-type ombrometer. Although the measurements have mostly been continuous throughout the years, the collected and stored datasets have not been processed or used, because of technical difficulties or a lack of time. After we realised how crucial these measurements are, even on a micro-scale, to creating future hydrological models, we started focusing equally on the data collection and processing. Regarding the precipitation measurements, we started preparing datasets from three tipping bucket rain gauges and used the Hellmann ombrometer for our calibrations and corrections. Each automated device has a unique resolution: for the 'Boreas' type, 0.1 mm, for the 'Dataqua' type, 0.1, and for the 'HHM' type, 0.5 mm per tip. These collectors have different types of software for transfering the data, but are mostly outdated and are not running on modern operating systems. Our solution for this problem was to use the R program, which allowed each dataset to be able to be converted to Excel files. The data are visualised, and the antecedent precipitation index (API) was calculated.

Key words: data processing, tipping bucket rain gauge, API

Acknowledgements: This article was made in frame of the project TKP2021-NKTA-43 which has been implemented with the support provided by the Ministry of Innovation and Technology of Hungary (successor: Ministry of Culture and Innovation of Hungary) from the National Research, Development and Innovation Fund, financed under the TKP2021-NKTA funding scheme.

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PRECIPITATION DATA PROCESSING FROM VARIOUS TIPPING BUCKET RAIN GAUGES IN THE HIDEGVÍZ VALLEY EXPERIMENTAL CATCHMENT

Csenge Nevezi[1], Zoltán Gribovszki[1], András Herceg[1], Blanka Holik[1], Katalin Anita Zagyvainé Kiss[1], Péter Kalicz[1]

[1] University of Sopron, Faculty of Forestry, Institute of Geomatics and Civil Engineering, Hungary

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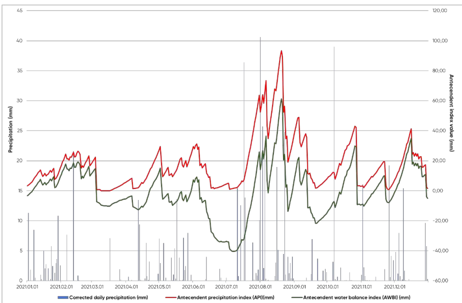

Figure 1: Corrected daily precipitation, API and AWBI in 2021 in the Hidegvíz valley meteorological station.

- Datasets from three various tipping bucket rain gauges and used the Hellmann ombrometer for calibrations and corrections
- Each automated device has a unique resolution: for the ‘Boreas’ type, 0.1 mm, for the ‘Dataqua’ type, 0.1, and for the ‘HHM’ type, 0.5 mm per tip
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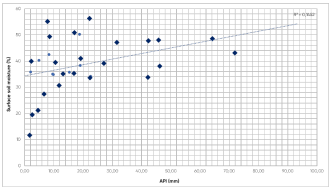

Figure 2: Surface soil moisture and API relation in the meteorological station (open field). Dark blue dots are marking the vegetation period.

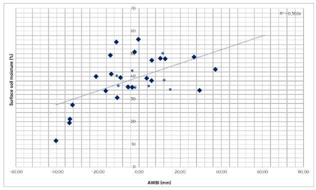

Figure 3: Surface soil moisture and AWBI relation in the meteorological station (open field). Dark blue dots are marking the vegetation period.

- API and AWBI were compared to surface soil moisture data
- Early test to determine, which one is convenient or more accurate for occurrent soil moisture estimation

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PRECIPITATION DATA PROCESSING FROM VARIOUS TIPPING BUCKET RAIN GAUGES IN THE HIDEGVÍZ VALLEY EXPERIMENTAL CATCHMENT

Csenge Nevezí[1], Zoltán Gribovszki[1], András Herceg[1], Blanka Holik[1], Katalin Anita Zagyvainé Kiss[1], Péter Kalicz[1]

[1] University of Sopron, Faculty of Forestry, Institute of Geomatics and Civil Engineering, Hungary

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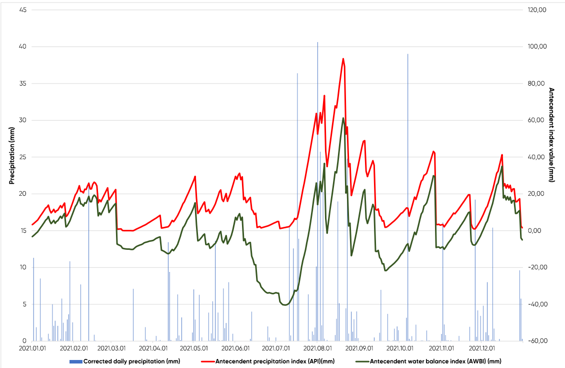


Figure 1: Corrected daily precipitation, API and AWBI in 2021 in the Hidegvíz valley meteorological station.

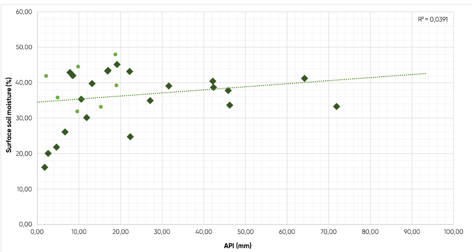


Figure 2: Surface soil moisture and API relation in the alder forest. Dark green dots are marking the vegetation period.

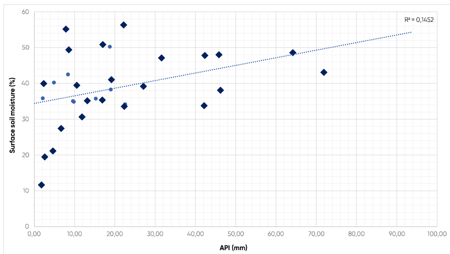


Figure 4: Surface soil moisture and API relation in the meteorological station (open field). Dark blue dots are marking the vegetation period.

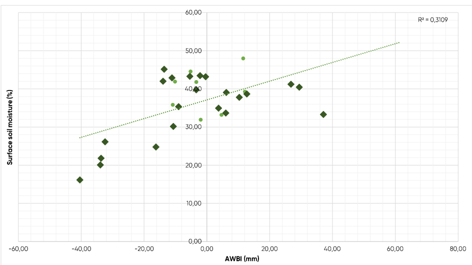


Figure 3: Surface soil moisture and AWBI relation in the alder forest. Dark green dots are marking the vegetation period.

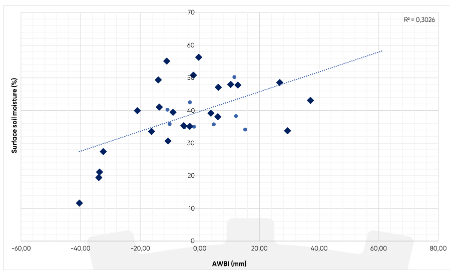


Figure 5: Surface soil moisture and AWBI relation in the meteorological station (open field). Dark blue dots are marking the vegetation period.

ACKNOWLEDGEMENTS: This article was made in frame of the project TKP2021-NKTA-43 which has been implemented with the support provided by the Ministry of Innovation and Technology of Hungary (successor: Ministry of Culture and Innovation of Hungary) from the National Research, Development and Innovation Fund, financed under the TKP2021-NKTA funding scheme.

Analyzing the connection between rainfall intensities and times of concentration using rainfall-runoff modeling

Klaudia Négyesi[1], Eszter Dóra Nagy[1]

[1] Department of Hydraulic and Water Resources Engineering, Faculty of Civil Engineering, Budapest University of Technology and Economics; Department of Hydraulic and Water Resources Engineering, Faculty of Civil Engineering, Budapest University of Technology and Economics (negyesiklaudia@edu.bme.hu)

The study aims to examine the relation between rainfall intensities and the times of concentration based on rainfall-runoff modeling using recently developed features of HEC-HMS. The time of concentration is generally considered to be a constant characteristic of a catchment. However, various publications have shown that the response time is a dynamic property (Szilagyi, 2007). To gain more insight into the mentioned relationship, model simulations were performed. The applicability of the dynamic time of concentration was examined with the help of a recent version of the HEC-HMS software, which has the option of using dynamic values. The models were built for both the characteristic and dynamic cases. As a result, a comparison was made between the effectiveness of the Wisnovszky empirical equation (a characteristic case), which is commonly applied in the Hungarian practice, and the applicability of the rainfall intensity, i.e., the time of concentration function (a dynamic case). Applying the latter improves the model´s performance, especially where the Wisnovszky equation yields an inadequate estimation of the time of concentration. The relation between the time of concentration and rainfall intensity was confirmed; moreover, the applicability of the new HEC-HMS feature was reviewed.

ANALYZING THE CONNECTION BETWEEN RAINFALL INTENSITIES AND TIMES OF CONCENTRATION USING RAINFALL-RUNOFF MODELING

HydroCarpath 2022

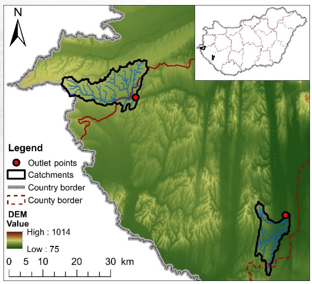
BUDAPEST UNIVERSITY OF TECHNOLOGY AND ECONOMICS
Faculty of Civil Engineering - Since 1782
Department of Hydraulic and Water Resources Engineering

Klaudia Négyesi, PhD Student
Eszter Dóra Nagy, Assistant Lecturer

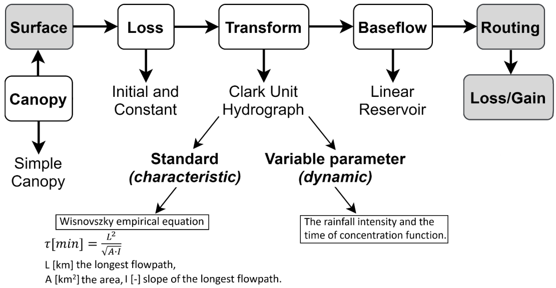
24th November 2022

INTRODUCTION

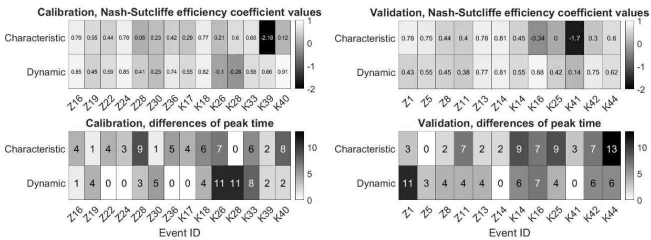
- Focus of the study: **time of concentration.**
- **2 Hungarian catchments:** Zala and Kiskomárom.
- It is generally **considered to be a constant** characteristic of a catchment.
  □ dynamic property (Szilágyi, 2007)
- **Model simulations** using HEC-HMS.
- The models were built for both the **characteristic and dynamic cases.**



MATERIALS AND METHODS



RESULTS AND CONCLUSIONS



The **model performance can be improved using the dynamic approach** of the time of concentration. The variable parameter which is a **new feature of HEC-HMS proved to be applicable.** In addition, the **results confirm the relation between the time of concentration and the rainfall intensity**


THANK YOU FOR YOUR ATTENTION!
Contacts
Klaudia Négyesi, PhD Student, negyesiklaudia@edu.bme.hu, Budapest University of Technology and Economics, Hungary
Eszter D. Nagy, Assistant Lecturer, nagy.eszter@epito.bme.hu, Budapest University of Technology and Economics, Hungary
References
Szilagyi, J. (2007) Analysis of the nonlinearity in the hillslope runoff response to precipitation through numerical modeling. Journal of Hydrology. 337(3-4), pp. 391-401. doi:
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Department of Hydraulic and Water Resources Engineering
HydroCarpath 2022 5

Analyzing the connection between rainfall intensities and times of concentration using rainfall-runoff modeling

BUDAPEST UNIVERSITY OF TECHNOLOGY AND ECONOMICS
Faculty of Civil Engineering - Since 1782
Department of Hydraulic and Water Resources Engineering

Klaudia Négyesi[1], Eszter D. Nagy[2]

1. Introduction

The time of concentration is generally considered to be a constant characteristic of a catchment. However, various publications have shown that the response time is a dynamic property (Szilágyi, 2007). To gain more insight into the relationship, model simulations were performed. The applicability of the dynamic time of concentration was examined with the help of a recent version of the HEC-HMS software that has the option of using dynamic values. The models were built for both the characteristic and dynamic cases. As a result, a comparison was made between the effectiveness of the Wisnovszky empirical equation (a characteristic case) which is commonly applied in Hungarian practice and the applicability of the rainfall intensity and the time of concentration function (a dynamic case).

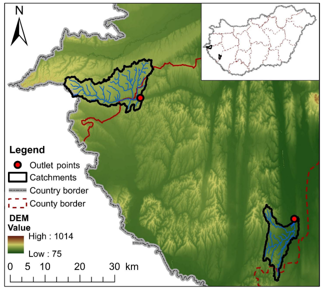

Figure 1. Overview of the study area.

2. Study area

To increase representativeness, two different river catchments (Zala and Kiskomárom) were examined. The catchment of Zala has an area of 188 km^2 while Kiskomárom has an area of 99 km^2. The climate of the two catchments is moderately cool and moderately humid. If we review the land cover of these basins, the ratio of artificial surfaces is very similar between the two catchments, at Kiskomárom it is 4%, while at Zala this value is 5%. Agricultural areas are more significant at Kiskomárom (61%) where the ratio is double the rate at Zala (36%). Kiskomárom is covered mostly with loam but a smaller area of sand and clay loam can also be seen. Zala is almost completely covered with loam or clay loam.

3. Materials and methods

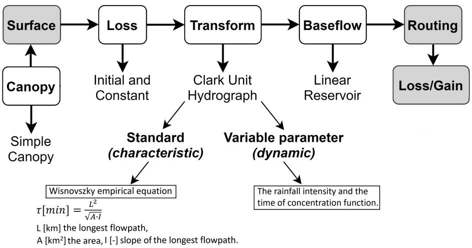

Figure 2. Methodology applied using HEC-HMS.

Data (Nagy et al. 2020):

Discharge data: from staff gauges (5+ min.)

Precipitation data: gauging stations (5+ min.) and ECMWF database (1 hr.)

Model simulations performed in HEC-HMS:

- Seven rainfall events for calibration, six for validation for each basin.
- Model performance reviewed by the Nash-Sutcliffe efficiency coefficient (NSE) and by examining the differences in the peak times.

The study included the analysis of

- the comparison of the characteristic and dynamic cases,
- the relationship between the time of concentration and rainfall intensity,
- the applicability of the new HEC-HMS variable parameter feature.

4. Results and conclusions

The results of the simulations can be seen in Fig. 3. where the lighter the color signify better model performance. On reviewing the results of the calibration, the NSE values of the dynamic case are significantly better at Kiskomárom, but the difference is less significant at Zala. Regarding the differences of peak time, the simulations of the dynamic case have more values below 3 hours at both catchments.

The results of validation show that in the case of Kiskomárom, the dynamic approach also yielded satisfactory results. However, at the Zala catchment, the results are not significantly better than the results of the characteristic case as it was during the calibration.

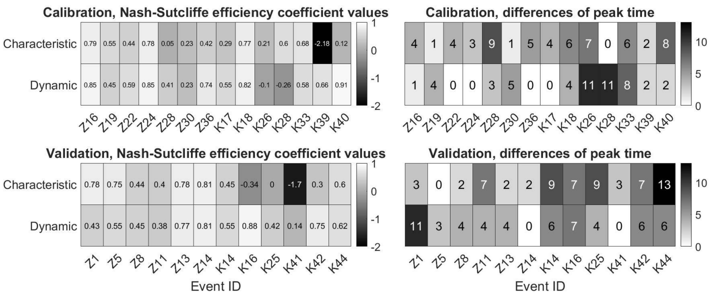

Figure 3. NSE values and differences of peak time for the characteristic and dynamic approaches.

Overall, the model performance according to the NSE and the time of peak discharges can be improved using the dynamic approach of the time of concentration. The calibration itself is more difficult to perform than in the characteristic case but if the proper curves are applied, the simulations can give significantly better results. The variable parameter which is a recent feature of HEC-HMS proved to be applicable. In addition, the results confirm the dynamic relation between the time of concentration and the rainfall intensity.

Contacts

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[2]Assistant lecturer, email: nagy.eszter@emk.bme.hu, Budapest University of Technology and Economics, Department of Hydraulic and Water Resources Engineering.

References

Szilagyi, J. (2007) *Analysis of the nonlinearity in the hillslope runoff response to precipitation through numerical modeling.* Journal of Hydrology. 337(3-4), pp. 391-401. doi: 10.1016/J.HYDROL.2007.02.005.

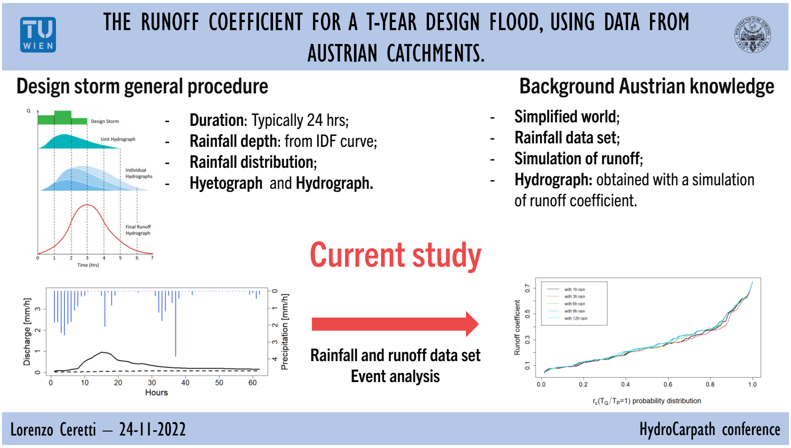
Nagy, E. D., & Szilágyi, J. (2020). *Comparative analysis of catchment response times and their definitions using measured and reanalysis rainfall data.* HydroCarpath International Conference https://doi.org/10.13140/RG.2.2.29763.02089

THE RUNOFF COEFFICIENT FOR A T-YEAR DESIGN FLOOD, USING DATA FROM AUSTRIAN CATCHMENTS.

LORENZO CERETTI[1,2], GÜNTER BLÖSCHL[2], ALBERTO VIGLIONE[1], JURAJ PARAJKA[2], MIRIAM BERTOLA[1,2]

[1] Department of Environment, Land and Infrastructure Engineering (DIATI), Polytechnic University of Turin, Corso Duca degli Abruzzi 24, 10129 Turin, Italy
[2] Institute of Hydraulic Engineering and Water Resources Management, Vienna University of Technology, Karlsplatz 13, 1040 Vienna, Austria (lorenzo.ceretti@studenti.polito.it)

The runoff coefficient is the percentage of rainfall that can be detected as runoff during a storm, and it has a relevant role in design in engineering practice. The aim of this study is to analyse the correlation between the event runoff coefficient and catchment characteristics, with respect to the return period of the storm and the flood peaks. In this study we estimated the runoff coefficient for flood events from hourly rainfall and runoff series for several Austrian catchments. Each event has been separated with an automatic procedure based on three main steps: (1) baseflow separation from direct runoff; (2) identification of each single event, starting from the largest peak flow of each runoff time series; (3) estimation of the event runoff coefficient using a rainfall runoff model that minimize the root mean square between the observed runoff and the modelled runoff. For each event, we then estimated the return period associated with the respective peak flow (TQ) and the maximum precipitation for different durations (TP). Preliminary results indicate that the TQ can be much higher than the corresponding TP and that their relationship is mainly related to the wetness of the system, as represented by the event runoff coefficient. In the next step of this research, we will analyse the presence of seasonal trends of the runoff coefficient for multiple Austrian catchments and its correlation with climatic and physiographic catchment characteristics.


THE RUNOFF COEFFICIENT FOR A T-YEAR DESIGN FLOOD, USING DATA FROM AUSTRIAN CATCHMENTS.
Design storm general procedure
- Duration: Typically 24 hrs;
- Rainfall depth: from IDF curve;
- Rainfall distribution;
- Hyetograph and Hydrograph.
Background Austrian knowledge
- Simplified world;
- Rainfall data set;
- Simulation of runoff;
- Hydrograph: obtained with a simulation of runoff coefficient.
Current study
Rainfall and runoff data set
Event analysis
Discharge [mm/h]
Precipitation [mm/h]
Hours
Runoff coefficient
Lorenzo Ceretti – 24-11-2022
HydroCarpath conference

Isotopic hydrograph separation at the Hydrological Open Air Laboratory

Borbála Széles[1], Juraj Parajka[1], Ladislav Holko[2], Gerhard Rab[1], Stefan Wyhlidal[3], Katarina Schott[4], Christine Stumpp[5], Patrick Hogan[1], Lovrenc Pavlin[1], Peter Strauss[6], Günter Blöschl[1]

[1] Institute of Hydraulic Engineering and Water Resources Management, Faculty of Civil Engineering, Vienna University of Technology, Vienna, Austria (szeles@hydro.tuwien.ac.at)
[2] Institute of Hydrology, Slovak Academy of Sciences, Bratislava, Slovakia (holko@uh.savba.sk)
[3] NES, Nuclear Engineering Seibersdorf GmbH, Seibersdorf, Austria (Stefan.Wyhlidal@nes.at)
[4] BOKU University of Natural Resources and Life Sciences, Institute of Soil Science, Stable Isotope Group, Tulln, Austria (katharina.schott@boku.ac.at)
[5] BOKU University of Natural Resources and Life Sciences, Institute for Soil Physics and Rural Water Management, Vienna, Austria (christine.stumpp@boku.ac.at)
[6] Federal Agency of Water Management, Institute for Land and Water Management Research, Petzenkirchen, Austria

Exploring the isotopic composition of precipitation and streamflow in small catchments and the event and pre-event components of precipitation events using two-component and ensemble isotopic hydrograph separation may better explain overall catchment behaviour, more specifically, the sources of the origin of the water. The aim of this study is to investigate the origin of water for different streamflow gauges in a small agricultural catchment that represent different runoff generation mechanisms. The analysis is performed at the Hydrological Open Air Laboratory (HOAL) in Austria, which is a 66 ha experimental catchment dominated by agricultural land use. One of the main specialities of this research catchment is that several tributaries of the catchment representing different runoff generation mechanisms are gauged. Two-component and ensemble isotopic hydrograph separations (for both ^{18}O and ^{2}H) are conducted for three streamflow gauges (the catchment's inlet and outlet and a tile drainage system) for multiple events in the warm periods of 2013–2018. The results of the two methods are compared and discussed for different runoff generation mechanisms.

Impact of hydrological and hydraulic modelling approaches to a flash flood event in the Hidegvíz watershed in Hungary

Gergely Ámon[1], Katalin Bene[1]

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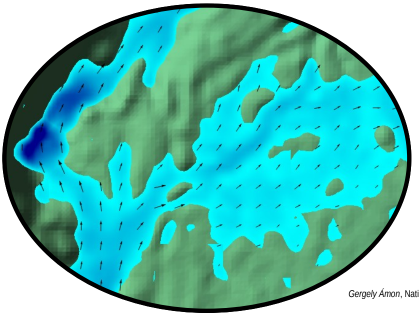
There are numerous modelling techniques to simulate rainfall-based runoff on watersheds. Each modelling approach contains different uncertainties on the parameters that define the behaviour of a watershed. Two numerical models, i.e., hydrological and hydrodynamical, were selected to compare and evaluate the runoff characteristics of a flash flood event. Flash flood events are an increasing risk because of growing rainfall intensities. The watershed discussed is located in a western north area of Hungary called the Hidegvíz valley. It has daily and 10-minute meteorological and hydrological data measurements. The study used simulated and measured 10-minute increment rainfall to investigate high flow and flash flood event characteristics. A lumped method was used for the hydrological simulation with an area-averaged distribution of the soil parameters and a calculated time of concentration. For the hydrodynamical simulation, distributed mesh was used to apply 2D shallow water equations with an additional eddy viscosity model on a mesh. The two models were used to compare a runoff time series and infiltration losses during event-based simulations. Keywords: Numerical modelling, watershed hydrology, hydrodynamics, parameter sensitivity

Impact of hydrological, hydraulic modelling approach to a flash flood event in the Hidegvíz watershed in Hungary



Gergely ÁMON, Katalin BENE

Hydrocarpath Conference

24th November 2022

Gergely Ámon, National Laboratory for Water Science and Water Security, **Széchenyi István University, Győr**

Introduction

Study area:

- Hidegvíz Valley, a study watershed of the University of Sopron

Geomerty:

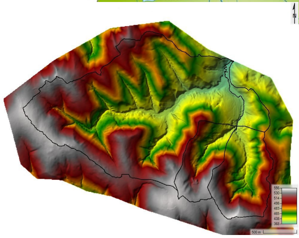
- LiDAR data with 0.5*0.5 m resolution

Hydrological data:

- Hydrometeorological data measuring station owned by the University of Sopron

Problem:

- Measured data, gauged watershed: yes; dynamic numerical overland models: no



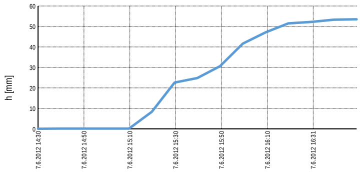
Hydrological data

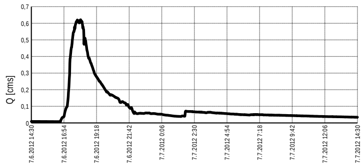
Rainfall time series:

- Rainfall event at 06/07/2012 14:30 – 16:50 Measured at the hydrometeorological station

Runoff time series:

- 06/07/2012 14:30 – 07/07/2012 14:30, measured at the downstream area of the watershed



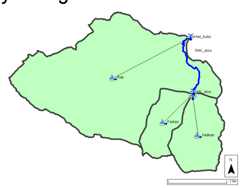


Model structures - hydrological

Hydrological model:

- Semi-distributed parameterization
- Three watersheds: Rák-stream, Farkas valley, Vadkan Valley
- Area averaged unsaturated soil data

Model elements:



SZÉCHENYI EGYETEM UNIVERSITY OF GYŐR

Model structures - hydrodynamical

Overland flow: 2D SWE eq. solver, SWE-LIA (local inertia method) optimized for computation time and model stability with Δt= 0.5 sec

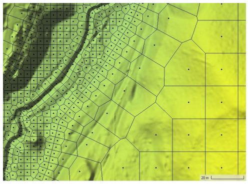
$$\frac{\partial V}{\partial t}+(V\cdot\nabla)V+f_c k\times V=-g\nabla z_s+\frac{1}{h}\nabla\cdot(\nu_t h\nabla V)-\frac{\tau_b}{\rho R}+\frac{\tau_s}{\rho h}$$

Eddy viscosity model (Smagorinsky-Lilly model):

$$\vartheta_t=D u_* h+(C_s\Delta)^2|\overline{S}|$$

Infiltration method: Green and Ampt

Overland flow and infiltration was calcuated on an adaptive mesh



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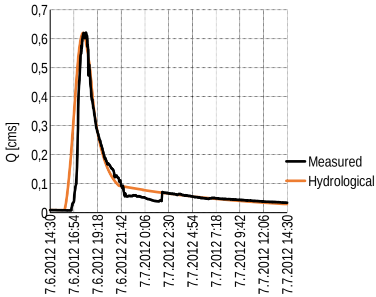
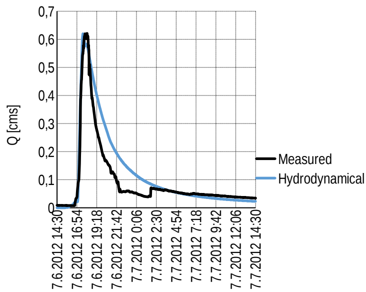
Results - outflow





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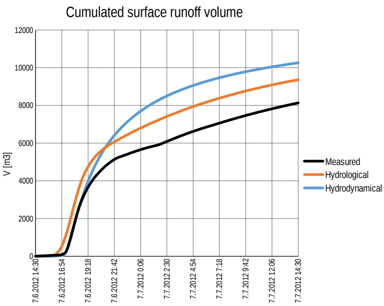
Results - volume



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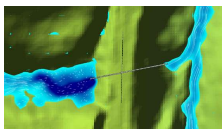
Conclusions and future

Conclusion

- The hydrodynamical model can be applied to simulate surface runoff
- Hydrological model has problems with the rising limb calculation
- Hydrodynamical model has with the recession limb calculation
- Hydrodynamical model is sensitive to inline structures
- Both models needs to be improved



Future

- Further rainfall events will be simulated
- Sensitivity analyses for model parameters
- Fully distributed hydrological models
- Hydrodynamical model with more detailed land use and soil distribution

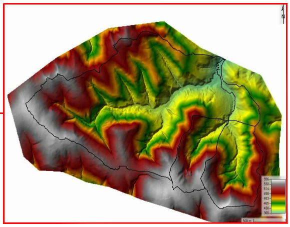
Thank You for Your attention!

The research presented in the article was carried out within the framework of the Széchenyi Plan Plus program with the support of the RRF 2.3.1 21 2022 00008 project.

Gergely Ámon, National Laboratory for Water Science and Water Security, **Széchenyi István University, Győr**

Impact of hydrological, hydraulic modelling approach to a flash flood event in the Hidegvíz watershed in Hungary

G.Ámon[1], K. Bene[2]



Study area:

The watershed is in the north-western side of Hungary, near Sopron. The Hidegvíz Valley's been a long time experimental watershed of the University of Sopron.

The watershed area contains 3 different sub-basins:

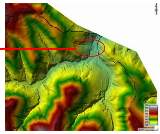
- Rák-stream - 4.41 km^2
- Farkas valley - 0.6 km^2
- Vadkan valley - 0.93 km^2

The model geometry is based on a high detailed LiDAR survey.
The 3D Hydrosoil map was used for unsaturated soil parameters.
Land use: mainly 95% forested area.

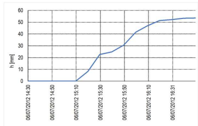
Measured data:

The data was provided by the researchers of the University of Sopron.
Measuring station at Hidegvíz outflow:

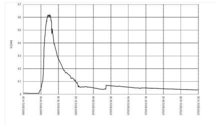
- Precipitation:
  rainfall event between 06/07/2012 14:30 - 16:50
- Runoff:
  runoff time series between 06/07/2012 14:30 - 07/07/2012 14:30



Location of the hydrometeorological station



Cumulative rainfall time series



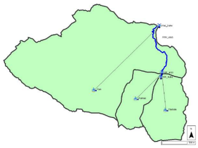
Outflow time series

Runoff model comparation

Hydrological runoff model:

Semi-distributed model with three watersheds (HMS).
Conceptual modules for rainfall-runoff process:

Simple canopy → Clark Unit Hydrograph → Green & Ampt infirltration → Baseflow (recession)



Hydrological model geometry

Calibrated parameters		Subbasin areas		
		Rák-stream	Farkas valley	Vadkan valley
Simple canopy	Initial storage [%]	10	10	10
	Maximum storage [mm]	5	5	5
Clark Unit Hydrograph	Time of concentration, t_c [h]	2.68	1.68	2.02
	Storage coefficient, t_R [h]	1.2	0.9	0.9
Green and Ampt infiltration	Wetting front suction, Sf [mm]	216.55	216.55	216.55
	Hydraulic conductivity, F [mm/h]	27.596	27.596	27.596
	Imperviousness [%]	0	0	0
Baseflow (recession)	Initial flow [cms]	0.0014	0.001	0.0065
	Recession constant	0.2	0.2	0.2
	Ratio to peak	0.32	0.32	0.09

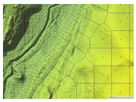
Hydrodynamical runoff model:

2D FVM surface flow model, with solver based on SWE (shallow water equations) (HEC-RAS).
SWE-LIA (local inertia) method was used:
The modified governing equation's goal is to guarantee stabile and faster calculation.

$$\frac{\partial V}{\partial t} + \cancel{(V\cdot\nabla)V} + f_c k \times V = -g\nabla z_s + \cancel{\frac{1}{h}\nabla\cdot(v_t h \nabla V)} - \frac{\tau_b}{\rho R} + \frac{\tau_s}{\rho h}$$

The time step for calculating overland flow is still small, maximum 1 seconds.
Eddy viscosity model was added:

$$\vartheta_t = Du^* h + (C_s\Delta)^2|\bar{S}|$$



Part of the generated mesh

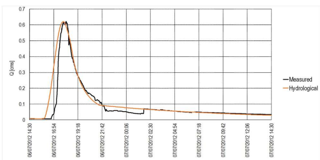
Input data

- Adaptive mesh based on LiDAR
- Manning's n parameter, forested area [0.12-0.16], channel [0.03-0.045]
- Green and Ampt infiltration

Calibrated parameters		
Surface	Manning's n, forest	0.16
	Manning's n, stream	0.04
Green and Ampt infiltration	Wetting front suction, S_f [mm]	219.05
	Hydraulic conductivity, K [mm/h]	26.667
	Initial content	0.179
	Saturated content	0.353
	Resudial content	0.0314
	Pore size distribution	0.395

Results

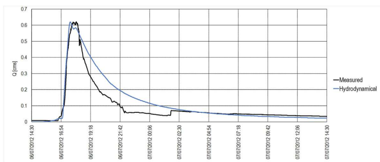
Hydrological runoff model on the measuring station:



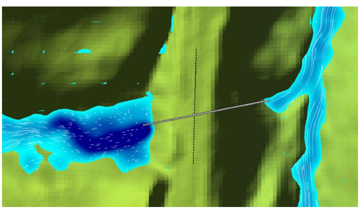
NSME, KGE values and volume error:

Hydrological	NSME	0.81
	KGE	0.81
	Volume error	0.15
Hydrodynamical	NSME	0.82
	KGE	0.69
	Volume error	0.26

Hydrodynamical runoff model on the measuring station:



Culvert in the hydrodynamical model:



Conclusion:

The hydrodynamical model can be applied to simulate surface runoff
Hydrological model has problems with the rising limb calculation
Hydrodynamical model has with the recession limb calculation
Hydrodynamical model is very sensitive to inline structures
Both models needs to be improved

Future research:

Further rainfall events will be simulated
Sensitivity analyses for model parameters
Fully distributed hydrological models
Hydrodynamical model with more detailed land use and soil distribution

Contact:
[1]Gergely Ámon, assistant lecturer, Phd student, amon.gergely@sze.hu, Széchenyi István University, Győr
[2] Katalin Bene, associate professor, benekati@sze.hu, Széchenyi István University, Győr

The research presented in the article was carried out within the framework of the Széchenyi Plan Plus program with the support of the RRF 2.3.1 21 2022 00008 project.

ESTIMATION OF EXTREME FLOOD DISCHARGE VALUES WITH SYNTHETIC WEATHER DATA IN THE AUSTRIAN ALPS

CAROLINE EHRENDORFER[1], MATHEW HERRNEGGER[1]

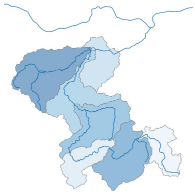
[1] Institute for Hydrology and Water Management, Department of Water, Atmosphere and Environment, University of Natural Resources and Life Sciences, Vienna, Austria (caroline.ehrendorfer@boku.ac.at)

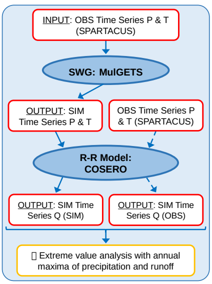
The length and quality of observed runoff data is frequently insufficient to derive robust extreme runoff values, which are crucial for water management planning for the present and future climates. Using synthetic weather data generated by stochastic weather generators (SWGs) as input to rainfall-runoff models to derive extreme runoff peaks could be of value for basins with missing or short observation periods. However, various shortcomings are known regarding the generators' abilities to accurately produce extreme rainfall amounts. This work examines the transfer of synthetic weather data into runoff extremes using the MulGETS stochastic weather generator and the COSERO rainfall-runoff model in several alpine subbasins of the Austrian Ybbs River. A GEV distribution was fit to the timeseries of annual runoff maxima to derive events with return periods of 30, 100 and 300 years. The results of the flood frequency analysis using synthetic data underestimated the results using observed data in all the subbasins and for all return periods by at least 30 %. The findings show that the application of SWGs to estimate runoff extremes may not be applicable and must be critically reviewed.

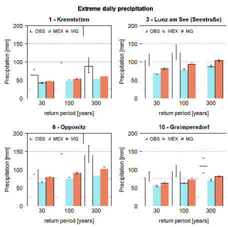
Estimation of extreme flood discharge values with synthetic weather data in the Austrian Alps

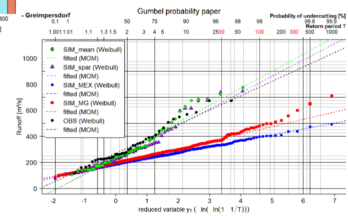
Caroline Ehrendorfer[1], Mathew Herrnegger[1]

[1] Institute of Hydrology and Water Management (HyWa), University of Natural Resources and Life Sciences, Vienna, Austria









Estimation of extreme flood discharge values with synthetic weather data in the Austrian Alps

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www.boku.ac.at/en/wau/hywa

BACKGROUND & MOTIVATION

The length and quality of observed runoff data is frequently insufficient to derive robust extreme runoff values, which are crucial for water management planning under the present and future climate.

The use of synthetic weather data generated by **stochastic weather generators (SWGs)** as input to rainfall-runoff models to extend runoff timeseries and derive extreme runoff peaks could be of value, especially for basins with missing or short observations. However, while SWGs offer attractive possibilities to explore long time series of potential weather and the resulting runoff, shortcomings are known regarding the generators' abilities to accurately produce extreme rainfall amounts[1,2,3,4].

This work examines the transfer of synthetic weather data into runoff extremes using the stochastic weather generator **MulGETS**[5,6,7] and rainfall-runoff model **COSERO**[8] in several alpine subbasins of the Austrian Ybbs River (Fig. 1).

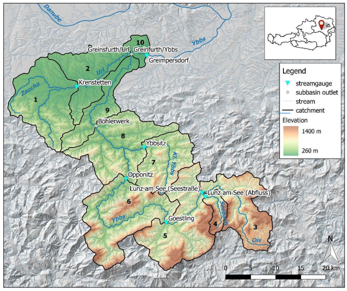


Figure 1. Study region (1120 km²) with 10 subbasins (NB).

MATERIALS & METHODS

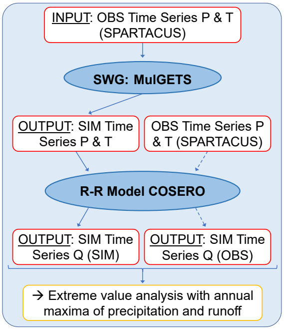
"Observed" Timeseries:
SPARTACUS[9]: 1961 – 2017
Runoff: 8 – 42 yrs.
Length simulation: 1000 yrs.
Temporal resolution: 24 h
Spatial resolution: 1 x 1 km

MulGETS = Multi-site weather Generator of École de Technologie Supérieure

- Generates spatially correlated precipitation and temperature
- Occurrence: two state Markov chain
- Amounts: parametric distribution (Multi-Exponential (MEX) or Multi-Gamma (MG))

COSERO = COntinuous SEmidistributed RunOff model (BOKU, HyWa)

- Based on HBV Model[10]
- Calculation for HRUs (Hydrological Response Units)



RESULTS

Means, seasonality and even 95%-quantiles of daily precipitation (and subsequently, runoff) were well reproduced by the SWG.

However, the extreme value analysis for precipitation showed a clear underestimation of extreme amounts (Fig. 2).

This translated into the flood frequency analysis, where the results using synthetic data underestimate those using observed data in all subbasins and for all return periods by at least 30%.

The Multi-Gamma distribution performed better than the Multi-Exponential (Fig. 3), but overall, they are both unsuitable for generating extreme precipitation and subsequently extreme runoff in this catchment.

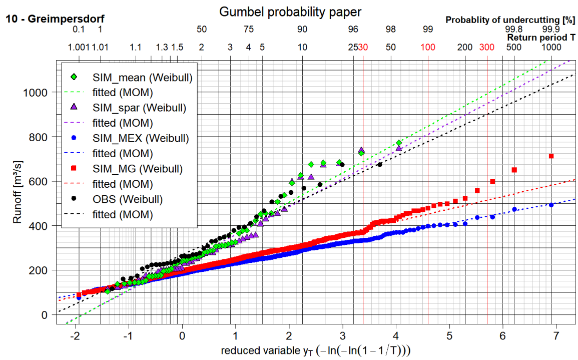


Figure 3. Flood frequency distribution plotted on a logarithmic Gumbel paper for subbasin 10. Each point represents an annual maximum.

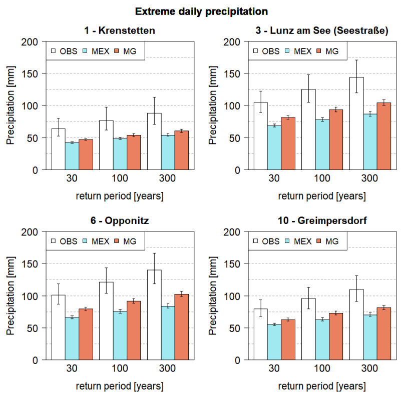


Figure 2. Extreme daily precipitation amounts with return levels of 30, 100 and 300 years derived from the fitted Gumbel distribution using the method of moments, and the corresponding 95%-confidence intervals derived from bootstrapping analysis.

CONCLUSION

The inadequate weight of the tail of the parametric distributions in this SWG leads to an underestimation of extreme precipitation amounts. This translates into the underestimation of extreme runoff. The application of this particular SWG to estimate runoff extremes, also in climate change studies, may not be applicable and must be critically reviewed.

[1] Chen, J., & Brissette, F. P. (2014b). Stochastic generation of daily precipitation amounts: Review and evaluation of different models. Climate Research, 59(3), 189–206. https://doi.org/10.3354/cr01214
[2] Furrer, E. M., & Katz, R. W. (2008). Improving the simulation of extreme precipitation events by stochastic weather generators. Water Resources Research, 44(12). https://doi.org/10.1029/2008WR007316
[3] Li, C., Singh, V. P., & Mishra, A. K. (2012). Simulation of the entire range of daily precipitation using a hybrid probability distribution. Water Resources Research, 48(3). https://doi.org/10.1029/2011WR011446
[4] Semenov, M. A. (2008). Simulation of extreme weather events by a stochastic weather generator. Climate Research, 35(3), 203–212. https://doi.org/10.3354/cr00731
[5] Brissette, F. P., Khalili, M., & Leconte, R. (2007). Efficient stochastic generation of multi-site synthetic precipitation data. Journal of Hydrology, 345(3–4), 121–133. https://doi.org/10.1016/j.jhydrol.2007.06.035
[6] Chen, J., Brissette, F. P., Leconte, R., & Caron, A. (2012). A versatile weather generator for daily precipitation and temperature. American Society of Agricultural and Biological Engineers, 55(3), 895–906.) MulGETS
[7] Chen, J., Brissette, F. P., & Zhang, X. J. (2014). A multi-site stochastic weather generator for daily precipitation and temperature. Transactions of the ASABE, 57(5), 1375–1391. https://doi.org/10.13031/trans.57.10685
[8] Herrnegger, M., Senoner, T., Klotz, D., Wesemann, J., Nachtnebel, H. P., & Schulz, K. (2015). RAINFALL-RUNOFF-MODEL COSERO Handbook 2015.2.
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Attribution of flood changes with a time series in the presence of autocorrelation: Modifications for Spearman´s rho and Kendall´s tau

David Lun[1], Svenja Fischer[2], Alberto Viglione[3], Günter Blöschl[1]

[1] Institute of Hydraulic Engineering and Water Resources Management, Vienna University of Technology, Vienna, Austria
[2] Institute of Hydrology, Water Resources Management and Environmental Engineering, Ruhr-University Bochum, Bochum, Germany
[3] Department of the Environment, Land and Infrastructure Engineering, Politecnico di Torino, Turin, Italy

Statistical dependency measures such as Kendall's tau or Spearman's rho are frequently used to analyse coherences between time series in environmental data analyses. Autocorrelation of the data can however result in spurious cross correlations if they are not accounted for. Here, we present an asymptotic distribution of the estimators of Spearman's rho and Kendall's tau, which can be used for the statistical hypothesis testing of cross-correlations between autocorrelated observations. The results are derived using U-statistics under the assumption of absolutely regular (or β-mixing) processes. These comprise many short-range dependent processes, such as the ARMA, GARCH and some copula-based models relevant to the environmental sciences. We show that while the assumption of absolute regularity is required, the specific type of model does not have to be specified for a hypothesis test. The simulations show the improved performance of a modified hypothesis test for some common stochastic models and small to moderate sample sizes under autocorrelation. The methodology is applied to a time series of flood discharges and temperatures observed in Europe and yields results that are consistent with the literature on changes in flood regimes in Europe.

HydroCarpath 2022

Attribution of flood changes with time series in the presence of autocorrelation: Modifications for Spearman's Rho and Kendall's Tau

Poster Pitch

David Lun[1]

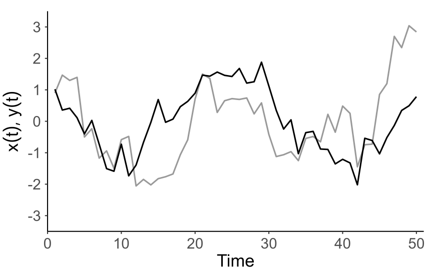
[1]Institute of Hydraulic Engineering and Water Resources Management, Vienna University of Technology, Vienna, Austria

24.11.2022

Vienna Doctoral Programme on Water Resource Systems
www.waterresources.at

Rank correlations in hydrology: Motivation

- Correlation analyses are ubiquitous in empirical hydrological studies investigating dependencies and can attribute flood changes to their respective drivers.
- Rank correlation measures (Spearman's Rho ρ_S and Kendall's Tau τ) are often preferred over Pearson correlation.
- The estimation of rank correlation measures is affected by autocorrelation in the observations, which can result in spurious correlations.



Example: 2 time series represent measurements of hydrological quantitites. Are they related?

→ Statistical hypothesis test for cross-correlation

$\mathcal{H}_0$: X and Y independent

$\mathcal{H}_1$: X and Y are related

Rank correlations in hydrology: Motivation

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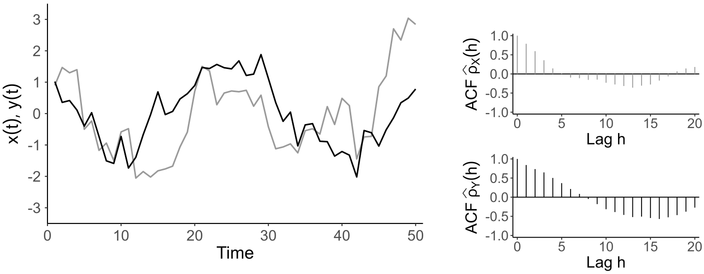

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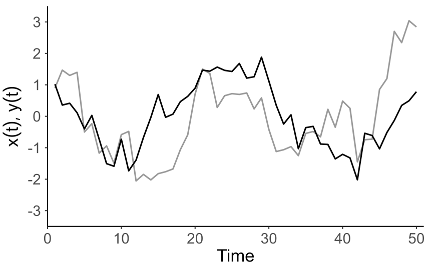

If our time series are autocorrelated 'standard' statistical results no longer hold and can result in incorrect conclusions!

We present a 'modified' testing procedure that accounts for autocorrelation.

Effect of autocorrelation on $\widehat{\rho}_S$: Spurious correlations

Example: Two statistically independent time series, which are individually autocorrelated (Gaussian VAR(1) with $\rho = 0$, $\phi_X = \phi_Y = 0.8$).

The 'classical' significance test for Spearman's Rho indicates a statistically significant relationship, whereas a 'modified' test does not.

'Classical' test

'Modified' test

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Vienna Doctoral Programme on **Water Resource Systems**
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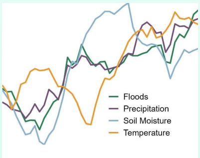
Der Wissenschaftsfonds.

Researcher: **David Lun**
Topic: **Flood Statistics**

Attribution of flood changes with time series in the presence of autocorrelation: Modifications for Spearman‘s Rho and Kendall‘s Tau

MOTIVATION & SCIENCE QUESTION



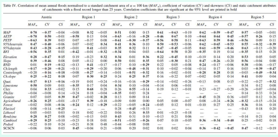
How can we check for statistically significant correlations with auto-correlated observations?

→ Hydrological time series frequently show persistence

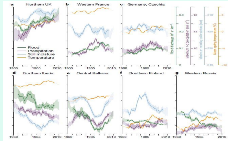
→Statistical estimators are affected by persistence. Result: Spurious correlations

HYDROLOGICAL APPLICATIONS

Exploratory data analysis[1]



Confirmatory data analysis[2]



Statistical Modelling[3]

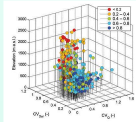


Fig. 6 Spearman rank correlation between flood peaks and volumes (colour coded), as a function of the coefficient of variation of flood peaks (CV_Q), the coefficient of variation of flood durations (CV_{Dur}) and the mean catchment elevation. Duration is defined here as the time difference between beginning and end of the flood event.

[1]Merz, R., & Blöschl, G. (2009). Process controls on the statistical flood moments-a data based analysis. *Hydrological Processes: An International Journal*, *23*(5), 675-696.
[2]Blöschl, G., Hall, J., et al. (2019). Changing climate both increases and decreases European river floods. *Nature*, *573* (7772), 108-111.
[3]Gaál, L., et al. (2015). Dependence between flood peaks and volumes: a case study on climate and hydrological controls. *Hydrological Sciences Journal*, *60*(6), 968-984.

METHODS

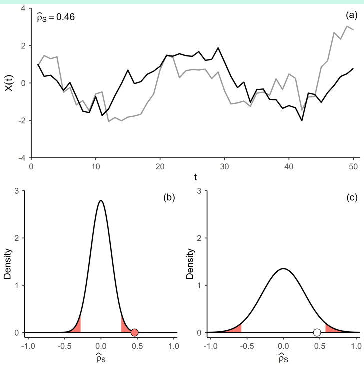
β-mixing processes in hydrology

- ARMA processes
- GARCH processes
- M-dependent processes (finite memory)
- Gaussian processes (including quantile-to-quantile transformations of Gaussian processes) under certain conditions
- $Cov(X_0, X_k) = O(\rho^k)$ for some $0 < \rho < 1 \rightarrow \beta_k = O(\rho^k)$

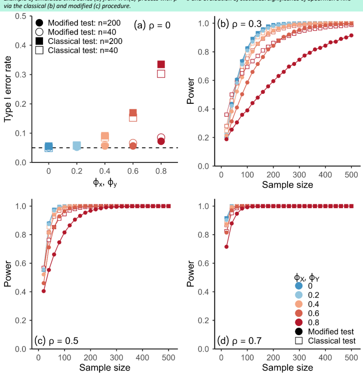
Simulation studies

$$\begin{pmatrix} X_i \\ Y_i \end{pmatrix} = \begin{pmatrix} \phi_X & 0 \\ 0 & \phi_Y \end{pmatrix} \begin{pmatrix} X_{i-1} \\ Y_{i-1} \end{pmatrix} + \begin{pmatrix} \varepsilon_i \\ \delta_i \end{pmatrix}, \quad i \in \mathbb{Z}$$

$$\begin{pmatrix} \varepsilon_i \\ \delta_i \end{pmatrix} \sim \mathcal{N}(0, \Sigma), \qquad \Sigma = VAR \begin{pmatrix} \varepsilon_i \\ \delta_i \end{pmatrix} = \begin{pmatrix} 1 & \rho \\ \rho & 1 \end{pmatrix}$$



Example of simulated time series (a) from VAR(1)-process with ρ = 0 and evaluation of statistical significance of Spearman's Rho via the classical (b) and modified (c) procedure.



Simulated Type I error rate and power of classical (squares) and modified (circles) testing procedure.

RESULTS AND APPLICATIONS

Theoretical results

Let $(X_i, Y_i)_{i \in \mathbb{Z}}$ be a bivariate, strictly stationary, absolutely regular process with absolutely continuous marginal distributions and β-mixing coefficients β_k satisfying

$$\sum_{k=1}^{\infty} k \cdot \beta_k^{\delta/(2+\delta)} < \infty \quad (1)$$

for some $\delta > 0$. Under the assumption of independence between $(X_i)_{i \in \mathbb{Z}}$ and $(Y_i)_{i \in \mathbb{Z}}$, the limiting distributions of the estimators of Spearman's Rho $\hat{\rho}_S$ and Kendall's Tau $\hat{\tau}$ between $(X_i)_{i \in \mathbb{Z}}$ and $(Y_i)_{i \in \mathbb{Z}}$ are given by

$$\sqrt{n}\hat{\rho}_S \xrightarrow{D} N\left(0, 1 + 2\sum_{h>0} \rho_S^X(h)\rho_S^Y(h)\right)$$

$$\sqrt{n}\hat{\tau} \xrightarrow{D} N\left(0, \frac{4}{9}\left(1 + 2\sum_{h>0} \rho_S^X(h)\rho_S^Y(h)\right)\right)$$

where $\rho_S^X(h)$ refers to the Spearman-correlation between X_t and X_{t-h}, and the analogue applies to $\rho_S^Y(h)$.

Let κ be a kernel function satisfying Assumption 1 in de Jong and Davidson (2000)[4] and b_n be a non-decreasing sequence with $b_n \rightarrow \infty$ and $b_n = o(n^{1/2})$. Let κ and b_n also satisfy

$$\sum_{j=1}^{n} \sqrt{j} \cdot \kappa\left(\frac{j}{b_n}\right) = o(n^{1/2}) \qquad (2)$$

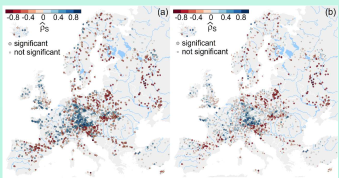
Then

$$\hat{\sigma}^2 = 1 + 2\sum_{h=1}^{n-2} \kappa\left(\frac{h}{b_n}\right) \hat{\rho}_S^X(h)\hat{\rho}_S^Y(h) \xrightarrow{P} 1 + 2\sum_{h>0} \rho_S^X(h)\rho_S^Y(h) = \sigma^2 \qquad (3)$$

Pairwise independence of $(X_i, Y_i)_{i \in \mathbb{Z}}$ is not required for consistency here. Under the assumption of pairwise dependence between $(X_i)_{i \in \mathbb{Z}}$ and $(Y_i)_{i \in \mathbb{Z}}$ with $\rho_S, \tau \neq 0$, the test based on the test statistics $T_{\rho_S} = \frac{\sqrt{n}\hat{\rho}_S}{\hat{\sigma}^2}$ and $T_\tau = \frac{\sqrt{n}\hat{\tau}}{\frac{4}{9}\hat{\sigma}^2}$ with $\hat{\sigma}^2$ from equation (3) is consistent.

[4]R. M. de Jong and J. Davidson, *Consistency of kernel estimators of heteroscedastic and autocorrelated covariance matrices*, Econometrica (2000), 68(2):407-424, 2000.

Application: Smoothed time series of climatological data



Estimated Spearman correlations between smoothed time series of flood peaks and temperature. Evaluation of statistical significance via classical (a) and modified (b) procedure.

Time series in hydrological analyses are frequently smoothed, which introduces autocorrelation

→ Different kinds of smoothing (exponential smoothing, moving averages, …) of iid-processes result in β-mixing processes

→ We smoothed annual flood peaks and catchment-averaged mean annual temperatures (2-sided MA with equal weights)

The classical testing procedure results in spurious correlations, whereas results of the modified procedure are consistent with existing literature on flood regime changes

Take-home message

In hydrology we often check for relationships among observations in data-based studies. These relationships are frequently investigated with correlations and statistical hypothesis tests.

If data is autocorrelated, the assumptions of many statistical hypothesis tests are violated, and the results of such tests can be incorrect. This can, for example, result in ‘statistically significant’ spurious correlations.

The modified testing procedure suggested here is able to filter out this information.

An R-package is available for the presented methodology:

R-package: corTESTsrd

Publication

PUBLICATIONS

Lun, D., Fischer, S., Viglione, A. and Blöschl, G. (2022). Significance testing of rank crosscorrelations between autocorrelated time series with short-range dependence. Accepted in Journal of Applied Statistics.

Lun, D., Viglione, A., Bertola, M., Komma, J., Parajka, J., Valent, P. and Blöschl, G. (2021). Characteristics and process controls of statistical flood moments in Europe - a databased analysis. Hydrology and Earth System Sciences, 25 (10), 5535–5560. https://doi.org/10.5194/HESS-25-5535-2021

Lun, D., Fischer, S., Viglione, A. and Blöschl, G. (2020). Detecting Flood-Rich and Flood-Poor Periods in Annual Peak Discharges Across Europe. Water Resources Research, 56 (7), e2019WR026575. https://doi.org/10.1029/2019WR026575

Merz, B., Basso, S., Fischer, S., Lun, D., Blöschl, G., Merz, R., Guse, B., Viglione, A., Vorogushyn, S., Macdonald, E. et al. (2022). Understanding heavy tails of flood peak distributions. Water Resources Research, 58 (6), e2021WR030506. https://doi.org/10.1029/2021WR030506

ESTIMATION OF DESIGN FLOODS USING THE CN METHOD AND THE CLM CLIMATE MODEL

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Changes and variations in climate conditions, together with human activities, are the main factors that influence hydrological conditions and the erosion of watersheds. Therefore, the main focus of this research was: 1) the effect of land use changes over the period from 1990 – 2018 on design floods; 2) the effect of climate change on design floods.

The design floods with different return periods were calculated using the Curve Number (CN) methodology. The first important input data were the CORINE Land Cover maps for 1990, 2006, 2012, and 2018 representing land use changes over time. The second most valuable input data were two types of design rainfall intensities. The actual measured data of rainfall intensities obtained from the SHMI and the scenario data of rainfall intensities obtained from the CLM model were downscaled using a Simple scaling method. The Deutscher Verband für Wasserwirtschaft und Kulturbau model (DVWK model, German Association for Water Management and Culture) was used to estimate the design maximum rainfall intensities with different return periods. The calculations were applied to three small river basins, i.e., the Rovensk and Brezovský streams, and Svacenícky Creek, located in the Myjava region in Western Slovakia.

ESTIMATION OF DESIGN FLOODS USING THE CN METHOD AND THE CLM CLIMATE MODEL

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AIMS OF THE STUDY

The increase in extreme hydrological events has caused global environmental problems, such as increased floods and droughts, pollution of water resources, soil erosion, and an impact on the economy and the lives of a large part of the population. Changes and variations in climate conditions, together with human activities, are the main factors that influence hydrological conditions and the erosion of watersheds.

Therefore, the main focus of this research was to assess:

1) the effect of land use changes over the period from 1990 – 2018 on design floods;
2) The effect of future climate change on design floods.

The design floods (Q_N) for a return period of 10, 20, 50, and 100 years were calculated using the Curve Number (CN) methodology. The first important input data were the CORINE Land Cover (CLC) maps for 1990 and 2018 representing land use changes over time. Climate change was presented with data from the CLM model.

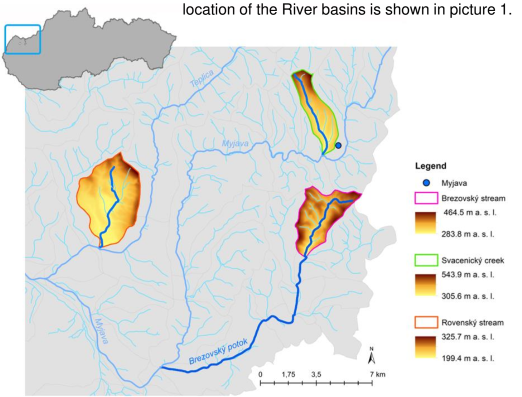
METHODOLOGY

The main methodological basis is the modified SCS - CN method, which was used to calculate design culmination flows (Q_N), through the height and volume of the direct outflow. The calculation was based on the assumption that the basin is affected by the design rain with a constant intensity and duration equal to the time of concentration (T_c) of the runoff from the basin, and that the design rain will cause a flow with the same return period (N). Short-term design rain totals were used as effective precipitation, which was created based on maximum 60-, 120-, 180-, 240-, and 1440-minute rain durations for the warm half-year (April to October). The totals of design rains from the Myjava climatological station were used in the calculations, which were based on: 1) actual data (provided by SHMÚ for the period 1995-2009); 2) and scenario data obtained from the CLM model for the historical (1961-2020) and future periods (2071-2100).

The simple scaling method was used to determine precipitation totals for shorter durations based on observed or simulated data with a duration longer than one day. The DVWK (Deutscher Verband für Wasserwirtschaft und Kulturbau / German Association for Water Management and Culture) methodology was used to estimate design maximum rainfall intensities with different return periods.

STUDY AREA

The territory of three small River basins, Rovenský stream, Brezovský stream, and Svacenický creek, which are located in western Slovakia and are sub-basins of the Myjava River, was chosen for the calculation. The location of the River basins is shown in picture 1.



Pic. 1 Location and elevation of the selected River basins

The basin of Rovenský stream, with its final profile at the mouth of the Teplica River, has an area of 15.42 km^2. The average altitude of the basin is 234.63 m a. s. l. and the average slope is 5.5%. The basin of Svacenický creek, with the final profile at the mouth of the Myjava River, has an area of 6.47 km^2. The average altitude of the basin is 388.29 m a. s. l., and the average slope is 11.0%. The basin of the Brezovský stream, with the final profile above the tributary of the Priepasnianský stream, has an area of 8.94 km^2. The average altitude of the basin is 383.0 m a. s. l., and the average slope is 14.6%.

INPUT DATA AND CALCULATION PROCEDURE

To estimate the design floods, the design rainfall intensities from the Myjava climatological station were used, which were downscaled from actual data (provided by SHMI) for 1995-2009 period, and scenario data (obtained from the CLM climatological model by doc. RNDr. Martin Gera, PhD) for the historical period 1961-2020 (HP) and the future period 2071-2100 (FP). These data were then interpolated using for duration T_c (Table 1).

The following digital maps were used as input data: vector maps of land use (CLC) for 1990 and 2018 year; a Digital Elevation Model (DEM) raster map with a cell size of 20x20m, a vector map of soil types, and a water management map of the Slovak Republic on a scale of 1:50,000, 3. edition.

Table 2 contains the Curve Number (CN) values determined using the land use map, the soil types map, and the SCS-CN methodology.

Tab. 1 Design rainfall totals (P) used in the calculation

N [year]	P [mm]								
	Real data (1995-2009)			CLM data (1961-2020)			CLM data (2071-2100)		
	RS*	SC**	BS***	RS*	SC**	BS***	RS*	SC**	BS***
10	31,38	26,09	26,70	19,86	15,22	15,74	21,16	15,76	16,35
20	35,05	29,13	29,82	22,52	17,27	17,86	24,48	18,23	18,93
50	40,20	33,42	34,21	25,81	19,79	20,46	28,78	21,44	22,25
100	43,13	35,86	36,71	28,18	21,61	22,35	32,01	23,84	24,74

*Rovenský stream, T_C=198,3 min; **Svacenický creek, T_C=101,3 min; ***Brezovský stream, T_C =110,3 min

Tab. 2 Estimation of the weighted average value of the CN

Land use	hyd. category	CN [-]	Rovenský stream		Svacenický creek		Brezovský stream	
			F [km^2]		F [km^2]		F [km^2]	
			1990	2018	1990	2018	1990	2018
Coniferous forest	B	60	-	-	-	-	0,04	0,11
Broad-leaved forest	B	60	-	-	-	-	-	0,01
Pastures	B	69	-	-	0,02	-	-	-
Agricultural land	B	72	12,71	12,64	6,05	6,41	7,19	6,60
	C	81	1,47	1,48	-	-	-	-
	D	85	0,28	0,28	0,04	0,04	-	-
Transitional woodland-shrub	B	67	-	-	-	-	-	0,25
Urban area	B	98	0,65	0,72	0,36	0,02	0,12	0,21
	C	98	0,29	0,28	-	-	-	-
	D	98	0,02	0,02	-	-	-	-
Mixed forest	B	60	-	-	0,01	0,02	1,58	1,76
ΣF [km^2]			15,42	15,42	6,48	6,48	8,94	8,94
CN_v [-]			**74,71**	**74,82**	**73,48**	**72,11**	**70,18**	**69,96**

RESULTS

In the first part of the research, the aim was to assess **the impact of land use change on design floods (Q_N)**. The calculation was divided into two parts: 1) CN_v values for the year 1990 and the design rainfall totals (based on real data) were used as input data; 2) the CN_v values for 2018 and the design rainfall totals (based on real data) were used as input data;

The results of these calculations are compared in Table 3.

Tab.3 Estimated Q_N values based on the real data

N [year]	Q_N [m^3.s^{-1}]					
	Rovenský stream		Svacenický creek		Brezovský stream	
	1990	2018	1990	2018	1990	2018
10	10,87	10,92	6,16	5,83	7,16	7,10
20	13,15	13,21	7,49	7,10	8,73	8,65
50	16,60	16,67	9,52	9,04	11,13	11,04
100	18,68	18,75	10,75	10,22	12,59	12,49

The next step was to assess **the impact of climate change on the design floods (Q_N)**. The calculation was divided into two parts: 1) CN_v values for 2018 and design rainfall totals for the historical period 1961-2020 (HP), and;

2) CN_v values for the year 2018 and the design rainfall totals for the future period 1071-2100 (FP) were used as input data;

The results of the calculations were compared in Table 4.

Tab. 4 Estimated Q_N values based on the CLM data for the historical and future periods

N [year]	Q_N [m^3.s^{-1}]					
	Rovenský stream		Svacenický creek		Brezovský stream	
	HO	BO	HO	BO	HO	BO
10	4,85	5,44	2,18	2,32	2,68	2,88
20	6,09	7,07	2,75	3,04	3,39	3,78
50	7,76	9,40	3,54	4,09	4,37	5,09
100	9,06	11,30	4,15	4,96	5,13	6,18

CONCLUSION

Based on the results in Table 3, the design floods were not significantly affected by the change in land use in the selected basins. The main reason is that the land use changes have not affected the weighted average value of the CN number. Climate changes have had a more significant effect on design floods. The results in Table 4 show that design floods for the period 2071-2100 are higher compared to the period 1961-2020, by 12 to 25% in the case of Q_{10} to Q_{100} for the Rovenský stream basin, by 7 to 20% in the case of Q_{10} to Q_{100} for the Svacenický creek, and Brezovský stream basins.

EFFECTS OF AN EXTREME DROUGHT IN EASTERN BAKONY, HUNGARY.

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In the summer of 2022, an extreme drought occurred in Hungary. Early defoliation occurred in various stands. The area is on the northern side of Keleti-Bakony, which has beech stands. The majority of the forest stands investigated on the border of the village of Tés are beeches, and the economically valuable forests are also made up of these stands. An important issue is the reaction of these stocks to extreme weather events, which can help us gain information for the future. It does not matter whether the early falling of leaves is a defense mechanism, which could even be an adaptation to the lack of water caused by drought or whether it indicates the decline of the tree species. More long-term investigations are needed, which is why we created monitoring points.

Acknowledgement: VERGA Veszprémi Erdőgazdaság Zrt. This article was made in the frame of the project TKP2021-NKTA-43 which has been implemented with support provided by the Ministry of Innovation and Technology of Hungary (successor: Ministry of Culture and Innovation of Hungary) from the National Research, Development and Innovation Fund, financed under the TKP2021-NKTA funding scheme.

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Effects of an extreme drought in Eastern Bakony, Hungary

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Beech (*Fagus sylvatica)*

- **ecological characteristics of beech** (hydrological aspect)
  - shade tolerant,
  - mesophilic, medium heat demand
  - thin crust, foliage giving great shade
  - diffuseporous species
  - spread: East and West Europe, more sporadic in South Europe with a Sub-Atlantic character
  - occurrence in Hungary: Northern- and Transdanubian Midmountains, West- and Southwest-Transdanubia, Zselic, Mecsek (Bartha 1999)
  - habitat: beeches and rock relief forests (Bartha 1999)

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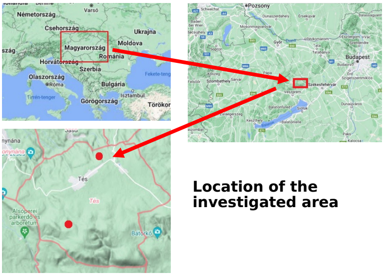
Bakony Mountains



Location of the investigated area

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Drought and effects

Extreme drought in 2022 summer,
Early defoliation occurred in various stands.
Defense mechanism?
Adaptation to the lack of water?
Indicates the decline of beech?
Monitoring necessary

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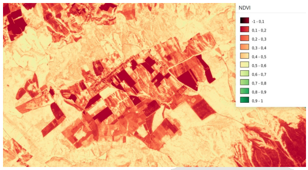
Research material and method

Remote sensed data (Sentinel-2)
Meteorological station already available (2 km)

Drought affected and
Control area (with insignificant leaf loss) selected
Rain gauge
Temperature and humidity sensors installed

Soil moisture measurement and dendrometer installation planned.



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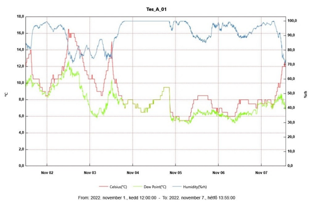
Preliminary results

Sentinel-2 normalized vegetation index time-series
Defoliated individuals identified at field
Precipitation
Humidity and
Temperature data (from 2022-11-01 at the affected area)

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Effects of an extreme drought in Eastern Bakony, Hungary

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In the summer of 2022, an extreme drought occurred in Hungary. Early defoliation occurred in various stands. The area is on the northern side of East-Bakony, which has beech stands. The majority of the forest stands - investigated on the border of the village of Tés - are beeches and the economically valuable forests are also made up of these stands. An important issue is the reaction of these stocks to extreme weather events, to help us gain information for the future. It does not matter whether the early falling of leaves is a defense mechanism, that could even be an adaptation to the lack of water caused by drought or whether it indicates the decline of the tree species. More long-term investigations are needed and this is the reason of creating more monitoring points.

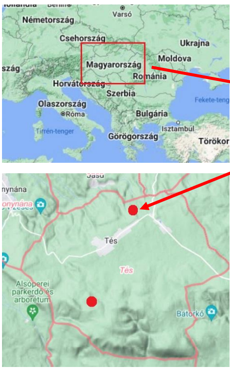
Defoliated tree in the investigated area

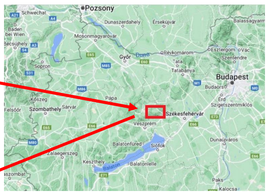
Hydrological interactions

Characteristics of beeches forests in relation to water balance:

- **ecological characteristics of beech** (hydrological aspect)
    - shade tolerant, the shade-tolerant species need less water to produce dry matter (Madas 1980)
    - mesophilic, medium heat demand (Bartha 1999)
    - thin crust, foliage giving great shade
    - diffuseporous species evaporate more intensively and less water is stored (Köcher, P. et al. 2013)
    - spread: East and West Europe, more sporadic in South Europe with a Sub-Atlantic character (Bartha 1999)
    - occurrence in Hungary: Northern- and Transdanubian Midmountains, West- and Southwest-Transdanubia, Zselic, Mecsek (Bartha 1999)
    - habitat: beeches and rock relief forests (Bartha 1999)

Research area measurement layout





Location of the investigated area

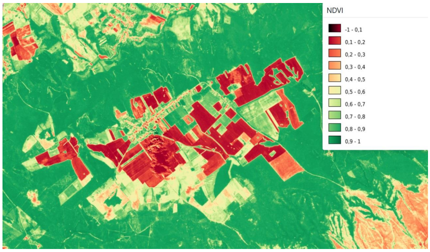
In Tés (Hungary), we selected a plot to be investigated and a control plot after examining early leaf loss in beech stands as a result of the drought. At the control location, no or insignificant leaf loss occurred under similar conditions (tree species, etc.). At the inspection and control points, we measure climate data (temperature, humidity) with a frequency of 5 minutes and the amount of precipitation during the period with a simple precipitation collector. There is also a meteorological station in the immediate vicinity (2 km) of the tested and control points. Later, I would like to complete the study with a soil moisture measurement and a dendrometer to measure the change in the stem cross-section of the individuals.

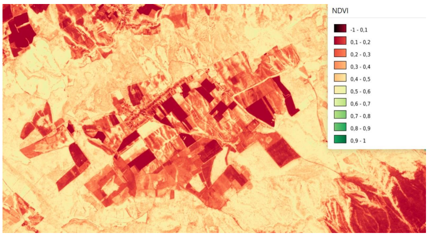
Nearby weather station

The project was supported by Verga forestry, Private Limited Liability Company, Veszprém, Hungary and TKP2021-NKTA-43 project

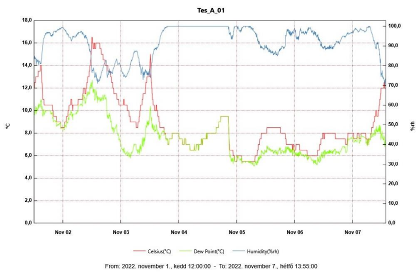
Investigation of past and present climatic conditions and their consequences

The instruments in the examined area and their measured data





Sentinel-2 space images, normalized vegetation index display. In the two images, we can see the decrease in photosynthetic activity, which occurs as a result of a negative effect like drought (Molnár et.al 2022). The two pictures were taken one year apart on 08/07/2021 (top) and 08/05/2022 (bottom) in the morning hours, at the same time).



Data measured in the examined area, using the EasyLog USB Temperature and Humidity meter

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USING SATELLITE DATA PRODUCTS IN THE PROCESS OF CALIBRATING A HYDROLOGICAL MODEL

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Over the years, the need to use additional data in hydrology modeling has been steadily growing. More particularly, in those areas with little or no data, the available satellite data seemed to indicate that additional data was necessary. Satellite data is crucial in offering valuable tools for exploring hydrological processes. Now that there are many sources to choose from, it is only logical to start testing them and comparing them to in-situ data, if there are any. For this brief study, the ASCAT Direx Soil Water Index (SWI) data were used to calibrate the TUWdual hydrological model. These data represent the soil moisture data of particular areas measured by ASCAT sensors on the METOP -A, -B, and -C satellites. They are represented as a grid with a 500·500 m spatial resolution and a temporal resolution of one day; they are expressed in percentages. The soil moisture data were used for selected catchments located in Slovakia. The purpose of using the soil moisture data is to test it on catchments in Slovakia in the process of calibrating the TUWdual model variant. The TUWdual version represents a lumped conceptual rainfall-runoff model with a dual representation of the soil layer, which was developed at the Technical University of Vienna. Following the design of the HBV model, the TUW model was used with a daily time step for all the input data. However, a shorter time step could also be used. All the input and output data and model parameters are spatially constant for the catchments. The model's performance was evaluated through the Nash - Sutcliffe indicator and the logarithmic Nash - Sutcliffe indicator and volume error while using various weights on the discharges. The correlation between the observed and simulated soil moisture values was also calculated in order to reassess the additional input that the soil moisture represents. Our plan for future research is to divide the catchments based on their height zones or land use zones for further rainfall- runoff modelling.

USING SATELLITE DATA PRODUCTS IN THE PROCESS OF CALIBRATING A HYDROLOGICAL MODEL

MILICA ALEKSIĆ, MARTIN KUBÁŇ, KAMILA HLAVČOVÁ, JÁN SZOLGAY, ANNA LIOVÁ

24TH NOVEMBER, TU VIENNA, AUSTRIA

HYDROLOGY OF THE CARPATHIAN BASIN: SYNTHESIS OF DATA, DRIVING FACTORS AND PROCESSES ACROSS SCALES

INTRODUCTION

- The research aims to test provided soil moisture data as a part of hydrological modelling
- The **soil moisture** data represents an additional input parameter in modelling besides discharge, air temperature, precipitation, and potential evapotranspiration values
- Modelling is performed using the TUW model dual in the environment of the R statistical software

INTRODUCTION

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- The satellite product used for this research represents **the soil moisture** data for Slovakia
  - **ASCAT Direx Soil Water Index SWI**
- The spatial resolution is 500 x 500 meters
- The temporal resolution is one day

METHODOLOGY

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- **TUW MODEL dual**
  - lumped conceptual rainfall-runoff model with a dual representation of the soil layer developed at the TUW
- The **INPUT DATA –** from 2007 to 2019, in daily time steps
  - Average daily discharge data Q [m3/s], Daily precipitation totals P [mm], Average daily values of air temperature T [°C], Potential evapotranspiration PET [mm], ASCAT SWI [%] – Upper zone SM_001, and root zone SM_010

METHODOLOGY

- **CALIBRATION (2007-2014)**
  - run the model without soil moisture data (NO_SM)
  - add the soil moisture data for both zones separately SM_001, and then SM_010
  - run the model with both soil moisture data at the same time (SM_001+SM_010)
- During this strategy, for the discharge was assigned different weights, ranging from 0.5 to 0.9
- Model efficiency was evaluated through the Nash-Sutcliffe coefficient (NSE), logarithmic Nash-Sutcliffe coefficient (logNSE), and volume error (VE)

METHODOLOGY

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- **VALIDATION (2015-2019)**
  - Run model with the optimised parameters
  - Model efficiency was evaluated through the Nash-Sutcliffe coefficient (NSE), logarithmic Nash-Sutcliffe coefficient (logNSE), and volume error (VE)

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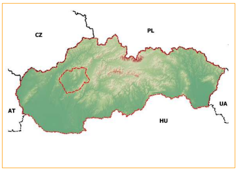
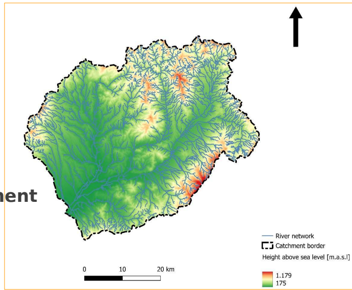
STUDY AREA



Nitra-Nitrianska Streda catchment

- **Area:** cca 2094 km²
- **Min height:** 175 m.a.s.l
- **Max h. :** 1179 m.a.s.l



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RESULTS

	2007-2014			2015-2019		
SM_001	**NSE**	**logNSE**	**VE**	**NSE**	**logNSE**	**VE**
no Qp	0,65	0,76	0,01	0,71	0,78	-0,08
0,9	0,68	0,78	-0,05	0,65	0,67	-0,17
0,8	0,67	0,79	-0,03	0,70	0,75	-0,16
0,7	0,66	0,77	-0,02	0,69	0,66	-0,12
0,6	0,67	0,76	0,00	0,71	0,71	-0,15
0,5	0,66	0,79	0,01	0,71	0,70	-0,12
NO_SM						
	0,67	0,80	-0,0041	0,72	0,78	-0,11

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CONCLUSION

- The first test of provided soil moisture data as a part of hydrological modelling for Slovak cachment
- The plan for future research is to attempt to calibrate the TUW dual model:
  - with the catchments divided by height zones
  - with the catchments divided by land use zones

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THANK YOU FOR YOUR ATTENTION

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HydroCarpath 2022, Hydrology of the Carpathian Basin: synthesis of data, driving factors and processes across scales, 24th November, TU Vienna, Austria

TESTING SATELLITE PRODUCT ASCAT SWI ON SELECTED CATCHMENT IN SLOVAKIA

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1 INTRODUCTION

Satellite products represent an increasingly helpful „tool" for many water-related study areas and water resources management and hydrology modelling. Thanks to satellite imagery, scientists have the opportunity to monitor not only changes in land cover but also changes in soil moisture or air temperature.

The satellite product used for this research represents the soil moisture data for Slovakia. The Department of Geodesy and Cartography provided the soil moisture data (soil water index) used for modeling at the University of Technology in Vienna. This product is named ASCAT Direx Soil Water Index (SWI), and it stands for scatterometer, which is located onboard the Metop satellites. The spatial resolution of the raster satellite images, representing the soil moisture values, is 500 x 500 meters, and the temporal resolution is one day.

This research aims to test provided soil moisture data as a part of hydrological modelling. The soil moisture data represents an additional input parameter in modelling besides discharge, air temperature, precipitation, and potential evapotranspiration values. Modelling is performed using the TUW model dual in the environment of the R statistical software. All the mentioned data were used from 2007 to 2019 on the selected catchment in Slovakia.

2 METHODOLOGY

INPUT DATA

- Input data were prepared in the daily time step.
- Average daily discharge data Q [m^3/s]- obtained from Slovak Hydrometeorological Institute.
- Daily precipitation totals P [mm]- calculated using Inverse Distance Weighting method.
- Average daily values of air temperature T [°C] - obtained using the temperature gradient method in an automated manner. It is a linear interpolation in which the average daily air temperature and the station's altitude correlate
- Potential evapotranspiration PET [mm]- Blaney Criddle method
- ASCAT SWI [%] – Upper zone SM_001, and root zone SM_010

TUW MODEL dual

- TUW dual version represents lumped conceptual rainfall-runoff model with a dual representation of the soil layer developed at the TUW, following the design of the HBV model.
- Soil layers: skin soil layer, representing the layer observed by satellite soil moisture sensors and a root zone soil storage.
- Consists of 18 parameters- For this study, the most interesting ones were FC – Field capacity i.e., max soil moisture storage [mm], and fc_skin – i.e. max soil moisture storage, of the top soil skin layer [mm]
- Three submodels: snow, soil, and runoff.

CALIBRATION

- Chosen period for calibration is from 2007 to 2014.
- The strategy behind calibration was to run the model without soil moisture data (NO_SM), then to add the soil moisture data for both zones separately SM_001, and then SM_010, and run the model, and finally to run the model with both soil moisture data at the same time (SM_001+SM_010).
- During this strategy, for the discarge was assigned different weights, ranging from 0.5 to 0.9.
- Model efficiency was evaluated through the Nash-Sutcliffe coefficient (NSE), logarithmic Nash-Sutcliffe coefficient (logNSE), and volume error (VE).
- Coefficient of correlation for Soil moisture

VALIDATION

- Chosen period for validation is from 2015 to 2019.
- Running model with the optimised parameters.
- Model efficiency was evaluated through Nash-Sutcliffe coefficient (NSE), logarithmic Nash-Sutcliffe coefficient (logNSE), and volume error (VE).

3 STUDY AREA

Nitra-Nitrianska Streda catchment

- **Area:** cca 2094 km^2
- **Min height:** 175 m.a.s.l **Max h. :** 1179 m.a.s.l **Mean h. :** 419.5 m.a.s.l **Median h. :** 363 m.a.s.l
- **Mean slope:** 18.4 % **Median slope:** 15 %

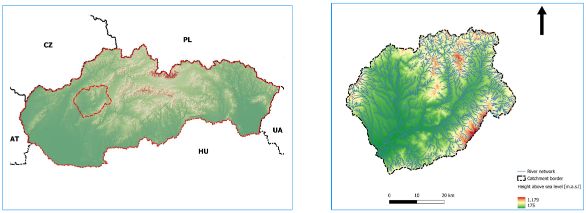
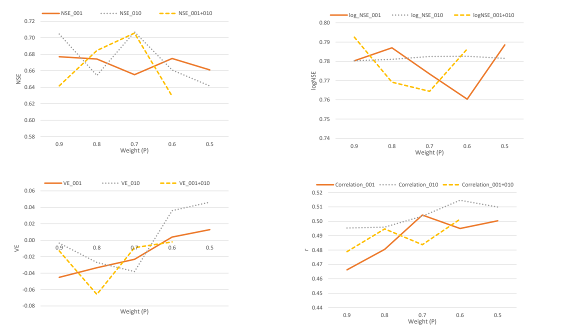


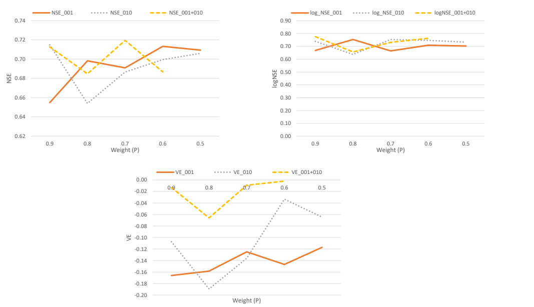
Fig. 1: The location of the catchment in Slovakia (left side), and the digital elevation model of the catchment (right side)

4 RESULTS

MODEL EFFICIENCY RESULTS FOR THE CALIBRATION PERIOD FROM 01.01.2007 TO 31.12.2014



MODEL EFFICIENCY RESULTS FOR THE VAIDATION PERIOD FROM 01.01.2015 TO 31.12.2019



4 DISCUSSION AND CONCLUSION

This brief study aimed to test the ASCAT SWI product of soil moisture on the Nitra-Nitrianská Streda catchment in Slovakia. This catchment seemed suitable as it is classified as a lowland basin with a median height of 363 m.a.s.l. During the modelling, the weights on the discharge values have been gradually changed to monitor the difference between model efficiency indicators. While efficiency was the best in the calibration period NSE= 0.67, logNSE= 0.8, and VE= -0.004, the efficiencies did not worsen in the other attempts with soil moisture data. These median values are ranging 0.66 and 0.7 for the NSE and 0.78 to 0.79 for the logNSE in the calibration period. Regarding the validation period, the median NSE values are 0.7, and logNSE values range between 0.7 and 0.76. The plan for future research is to attempt to calibrate the TUW dual model with the catchments divided by height zones or land use zones. According to studies on the Austrian catchments, the expectations are that model will simulate discharge better in the mostly lowland agricultural areas.

Uncertainties in the calculation of the Lake Velence water budget

Máté Chappon[1], Petra Baják[2], Anita Erőss[2], Katalin Bene[1]

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[2] József and Erzsébet Tóth Endowed Hydrogeology Chair, Department of Geology, Institute of Geography and Earth Sciences, Faculty of Science, Eötvös Loránd University, Pázmány Péter sétány 1/c, 1117, Budapest, Hungary

In recent years the water levels of Lake Velence, which is Hungary's third largest lake, have dropped significantly due to a series of climatic and anthropogenic phenomena. Various engineering solutions have been considered to supplement the lake water from surface and subsurface sources. However, policymakers and professionals argue about the necessity and extent of such interventions.

The lake's water budget has been calculated on a monthly basis by the local water directorate since 1986. The method has several uncertainties resulting in calculation errors for each month. The error has been determined as the difference between the computed and observed lake levels. The water budget calculation methodology will be evaluated in two steps: 1) analysing the time series of calculation errors and 2) investigating the lake and groundwater interactions. The latter is a missing element of the current water budget calculation method, but recent groundwater flow mapping studies have revealed its pronounced contributions.

The research will result in an improved water budget calculation method that will enhance our understanding of the main processes governing lake water levels. The new methodology will give water managers a clearer picture of the effectiveness and necessity of engineering interventions.

UNCERTAINTIES IN THE WATER BUDGET CALCULATION OF LAKE VELENCE

SZÉCHENYI EGYETEM
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Petra Baják, Anita Erőss
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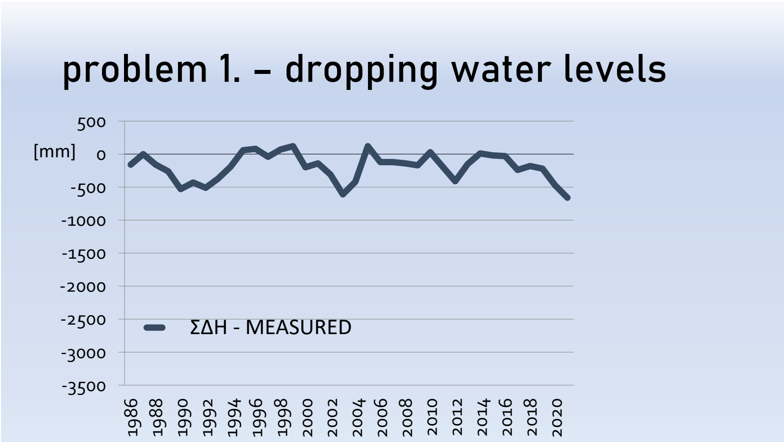
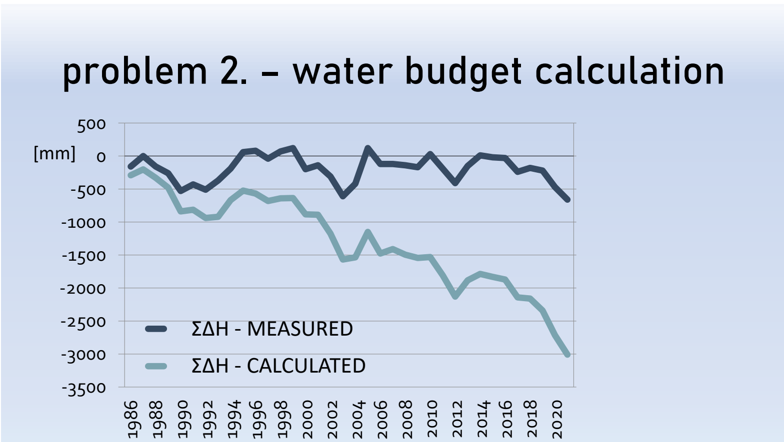
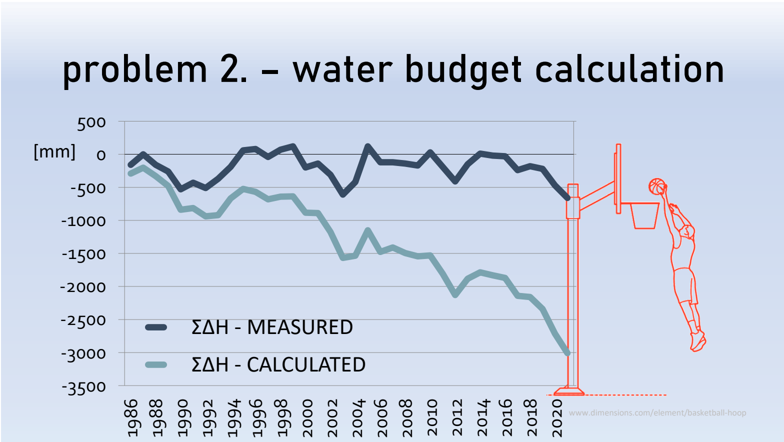
chappon.mate@sze.hu

problem 1. – dropping water levels

Record-low water level in 2022!


problem 1. – dropping water levels
[mm]
500
0
-500
-1000
-1500
-2000
-2500
-3000
-3500
ΣΔH - MEASURED
1986
1988
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
2010
2012
2014
2016
2018
2020


problem 2. – water budget calculation
[mm]
500
0
-500
-1000
-1500
-2000
-2500
-3000
-3500
ΣΔH - MEASURED
ΣΔH - CALCULATED
1986
1988
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
2010
2012
2014
2016
2018
2020


problem 2. – water budget calculation
[mm]
500
0
-500
-1000
-1500
-2000
-2500
-3000
-3500
ΣΔH - MEASURED
ΣΔH - CALCULATED
1986
1988
1990
1992
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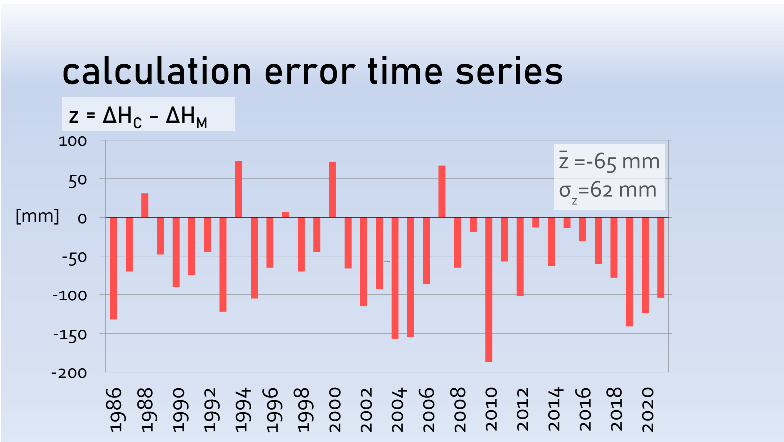
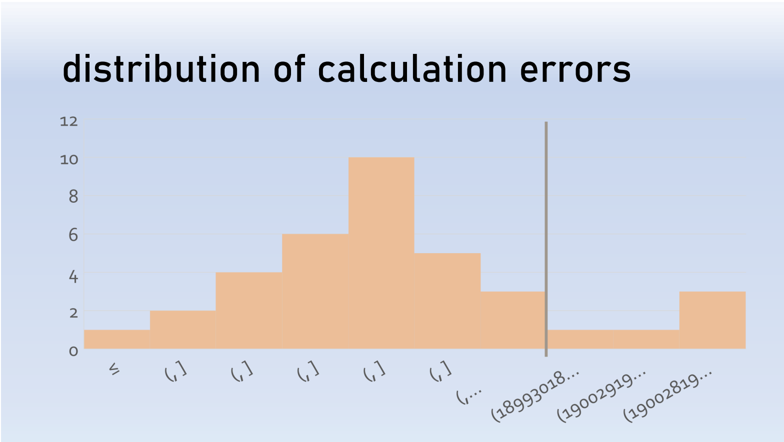
2020
www.dimensions.com/element/basketball-hoop


calculation error time series
$z = \Delta H_C - \Delta H_M$
[mm]
100
50
0
-50
-100
-150
-200
$\bar{z}$ =-65 mm
σ_z=62 mm
1986
1988
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
2010
2012
2014
2016
2018
2020


distribution of calculation errors
12
10
8
6
4
2
0
≤
(,]
(,]
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(,]
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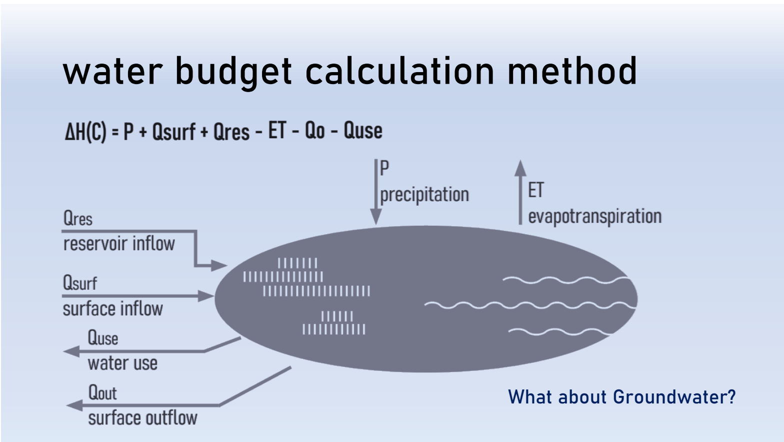
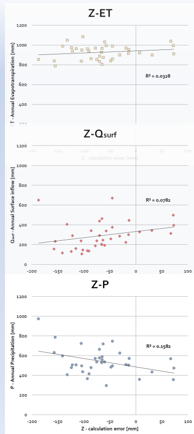
(,...
(18993018...
(19002919...
(19002819...


water budget calculation method
ΔH(C) = P + Qsurf + Qres - ET - Qo - Quse
P
precipitation
ET
evapotranspiration
Qres
reservoir inflow
Qsurf
surface inflow
Quse
water use
Qout
surface outflow
What about Groundwater?

correlations

	(P-Z)	(Qsurf-Z)	(ET-Z)
r -corr. coeff	-0,40	0,28	0,18
p (significance)	4%	20%	60%



future plans

1. Analyzing monthly calculation errors.
2. Modelling groundwater flows.
3. Recalculating lake water budget including groundwater flow components.
4. Re-evaluating calculation errors.
5. Improving calculation methods for evaporation and surface runoff.

Thank you for your attention!

The research presented in this poster presentation was carried out within the framework of the Széchenyi Plan Plus program with the support of the RRF 2.3.1 21 2022 00008 project.

UNCERTAINTIES IN THE WATER BUDGET CALCULATION OF LAKE VELENCE

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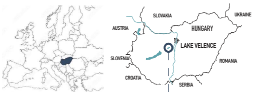
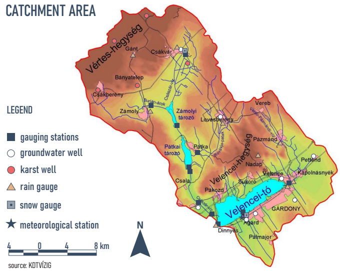
UNIVERSITY OF GYŐR



source: National Geographic

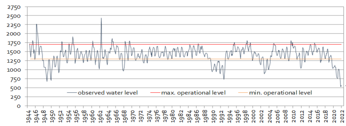


source: KDTVÍZIG

INTRODUCTION

In recent years the water levels of Lake Velence - Hungary's third largest lake - have dropped significantly due to a series of climatic and anthropogenic phenomena. Various engineering solutions are being considered to supplement the lake water from surface and subsurface sources. However, policymakers and professionals argue about the necessity and extent of such interventions.

Understanding the main processes governing lake water levels is key to manage the quality and quantity of the lake.



Record-low water level in 2022!

DATA AND METHOD

1. MEASUREMENT

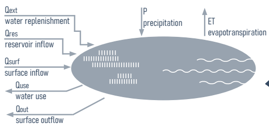
Change in water level measured: ΔH_M

Monthly time series of lake water levels for the 1986 – 2021 period - KDTVÍZIG [2]

2. WATER BUDGET CALCULATION

Change in water level - calculated [1] ΔH_C

ΔH(C) = P + Qsurf + Qres + Qext - ET - Qo - Quse



Monthly time series for each component of the water budget equation for the 1986 – 2021 period - KDTVÍZIG [2]

WHY isn't groundwater part of the equation?

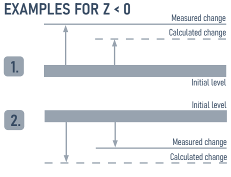
PARAMETER	CALCULATION METHOD
P – [mm] precipitation	Averaging data of 4 meteorological stations placed around the lake
Qin – [mm*] Surface inflow	Measured runoff data; Hydrologic similarity with **constant similarity factor** for ungauged inflows
Qres – [mm*] Reservoir inflow	Reservoir operation data; Discharge calculated using rating curves
Qext – [mm*] Water replenishment	Karst water pumped from outside of the catchment area; Discharge calculated using pump curves
ET [mm] Evapo-transpiration	XI. – III.: modified Meyer equation IV. – X.: pan evaporation modified values using **reed constants**
Qout – [mm*] Surface outflow	Regulated outflow from the lake; discharge calculated using rating curve
Quse – [mm*] Water use	Water use downstream from the lake; discharge calculated using rating curve
Groundwater	Not part of the currently applied calculation method, however recent ground-water flow mapping studies [3] revealed its pronounced contribution

*dimensions of discharges: mm = $[(m^3 \times s^{-1}) \times s] / (m^2 \times 10^3)$

calculation constants for ET, and Q_{surf} determined 47 years ago [4]

CALCULATION ERROR: $Z = \Delta H_C - \Delta H_M$

EXAMPLES FOR Z < 0



1. Measured change ΔH_M = +160 mm; Calculated change ΔH_C = +90 mm; Z = 90-160 = -70 mm; H_0
2. H_0; Measured change ΔH_M = -100 mm; Calculated change ΔH_C = -148 mm; Z = -148 - (-100) = -48 mm

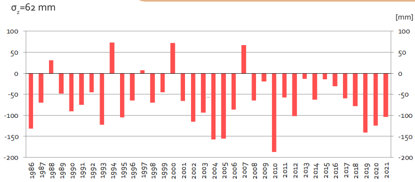
Z MEANING

– Z is negative, if the calculated water level is lower than the measured level. This can be a result of underestimating influxes and, or overestimating outfluxes.

+ Z is positive, if influxes are overestimated and, or outfluxes are underestimated

TIME SERIES FOR Z – ANNUAL DATA:

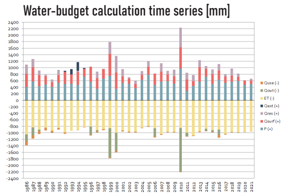
$\bar{z}$ =-65 mm
σ_z=62 mm



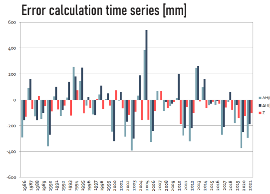
Only 5 of the past 36 years had a positive calculation error!

RESULTS

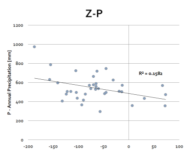
Water-budget calculation time series [mm]

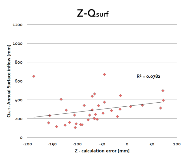


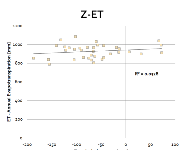
Error calculation time series [mm]

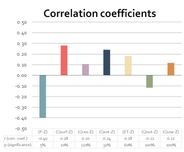


UNCERTAINTIES









Pearson Correlation of precipitation and calculation error :
r_{PZ} = -0,4 (with p < 5%)

DISCUSSION

1. Groundwater flow is not part of the water budget calculation. However groundwater flow mapping[3] and other evidences detailed below suggest its contribution.
2. Calculation errors are predominantly negative, meaning, that the current water budget calculation method underestimates inflows and, or overestimates outflows.
3. A weak negative correlation with p < 5% significance between precipitation and calculation error was found. This means large negative errors (underestimating inflows / overestimating outflows) tend to occur in years with high amounts of rainfall.
4. Annual evapotranspiration and surface inflows are uncorrelated with calculation error. However the calculation method of the former two contain highly uncertain elements.

FUTURE PLANS

1. Analyzing monthly calculation errors.
2. Modelling groundwater flows.
3. Recalculating lake water budget including groundwater flow components.
4. Re-evaluating calculation errors.
5. Improving calculation methods for evaporation and surface runoff.

LET'S DO THIS!

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[b] : József and Erzsébet Tóth Endowed Hydrogeology Chair, Department of Geology, Institute of Geography and Earth Sciences, Faculty of Science, Eötvös Loránd University, Pázmány Péter sétány 1/c, 1117, Budapest, Hungary

Literature:

[1] Water Resources Research Center Hungary (VITUKI), "Hydrological and water quality characteristics of Lake Velence and its reservoirs," Budapest 1985
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[3] P. Baják et. al, "Integration of a Shallow Soda Lake into the Groundwater Flow System by Using Hydraulic Evaluation and Environmental Tracers," Water 14, 2022, 951 doi:10.3390/w14060951
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Acknowledgements
The research presented in this poster was carried out within the framework of the Széchenyi Plan Plus program with the support of the RRF 2.3.1 21 2022 00008 project.

Impact of nature-based solutions on the water balance of Lake Velence

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More frequent extreme weather events have shown that Lake Velence in Hungary is strongly influenced by the effects of climate change. Severe droughts and shallow water levels have had an impact on the quality of life of both the human and water - based population. To reduce the impact of these events, developed countries and, more recently, Hungary have started pilot-scale implementations with nature-based solutions.

There are numerous good nature-based solution practices for small hilly and flatland settlements to reduce the adverse effects of climate change. In the Lake Velence area, steps have been taken towards the implementation of some of these solutions. Currently, the number of solutions implemented in the surrounding catchments is low; as a result, they do not have a noticeable impact on the lake's budget or surface runoff volume. In the future, a broader spread of water retention measures in these catchments could have an impact on the lake's water level. Local water budget calculations and rainfall-runoff (SWMM) models will be applied to determine the impact of nature-based solutions on the water budget and water level of Lake Velence.

keywords: blue-green infrastructure, nature-based solutions, climate change, water retention, sustainability, Pareto-efficiency

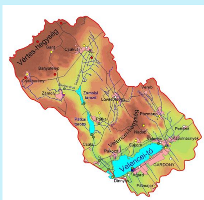
SZÉCHENYI EGYETEM
UNIVERSITY OF GYŐR

Impact of nature-based solutions on the water balance of Lake Velence

Attila Kálmán*, Dr. Katalin Bene
Széchenyi István University of Győr

HydroCarpath International Conference, 24/11/2022, Vienna

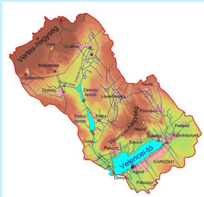
Catchment of Lake Velence



HydroCarpath International Conference, 24/11/2022, Vienna 2.

Catchment of Lake Velence

Problem:
Due to climate change settlements and their outskirts have also **higher water demand**.
The small gardens, fruit trees and vineyards in the area are currently exposed to the unpredictable and uneven rainfalls.



HydroCarpath International Conference, 24/11/2022, Vienna 3.

Catchment of Lake Velence

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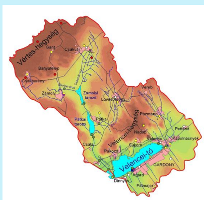


HydroCarpath International Conference, 24/11/2022, Vienna 4.

Nature-based solutions

Solution: water retention (using NbS)

- **Retention pond**
- **Detention pond**
- **Rain garden**

Nature-based solutions

Solution: water retention (using NbS)

- **Retention pond**
- **Detention pond**
- **Rain garden**

Water is present. Task: keep it at site.

At present: low water retention, few NbS

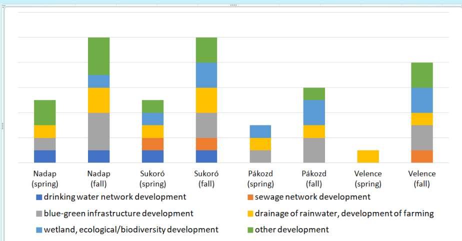
Nature-based solutions

Solution: water retention (using NbS)

- **Retention pond**
- **Detention pond**
- **Rain garden**

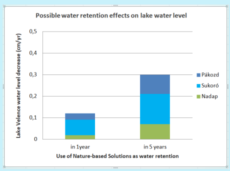
Water is present. Task: keep it at site.

Water retention – Nature-based solutions

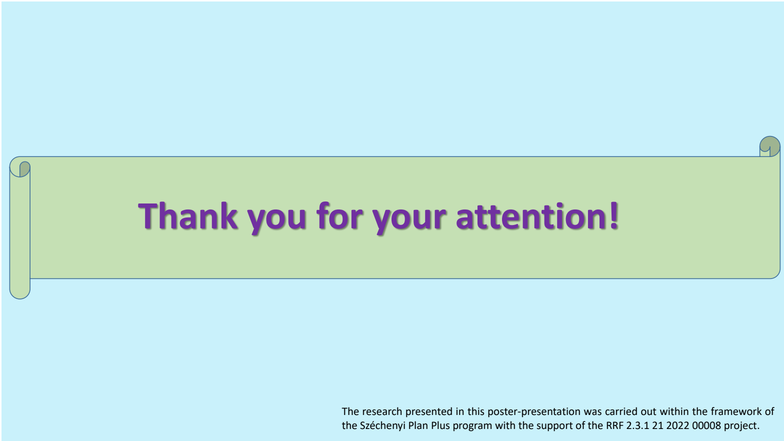


Survey among mayors
(2022 early spring and 2022 fall)

Water related development ideas and plans.
(Extreme drought in 2022 has this „benefit”.)



Future
Extensive water retention may have an impact on the lake budget.
Local benefits far exceed the negative impact on the catchment water budget.

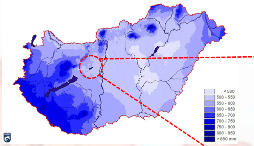

Thank you for your attention!
The research presented in this poster-presentation was carried out within the framework of the Széchenyi Plan Plus program with the support of the RRF 2.3.1 21 2022 00008 project.

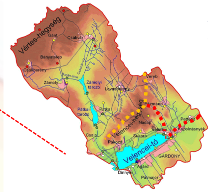
Impact of nature-based solutions on the water balance of Lake Velence

SZÉCHENYI EGYETEM
UNIVERSITY OF GYŐR

Problem statement

Due to climate change settlements and their outskirts have **higher water demand**. The small gardens, fruit trees and vineyards in the area are currently exposed to the unpredictable rainfalls.





Catchment: appr. 600 km²

Surface area: appr. 25 km²

Average depth: 1.5 m

Water volume*: 37.5x10⁶ m³

* when average water depth is 1.5 meters

3 catchments:**

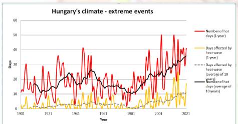
Császár-creek (North/West) ~ 60%

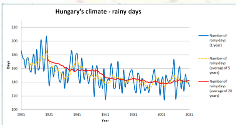
Southern flatland (South) ~ 20%

Vereb-creek (North-East) ~ 20%

** based on rainwater accumulation

Can blue-green infrastructures solve the water demand issues?





Climate change

- ❑ **evaporation**
  (increasing temperature & extreme events)
- ❑ **uncertain precipitation**
  (fluctuating and uncertain precipitation events, decreasing precipitation days)

Nature-based solutions (NbS)

Challenges:

- No water utility network
- Sinking water table
- Longer precipitation-free periods
- Food safety issues (corn, wheat)
- Increased grape production (viticulture)
- Ecologically protected area
- Small private areas, many owners

Area transformation: increasing orchard and vineyard areas

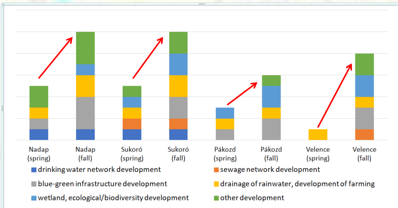
Retention pond
Detention pond
Rain garden

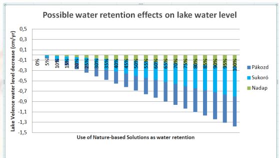
Source: BTL Liners, water retention for wineries

Stakeholder involvement

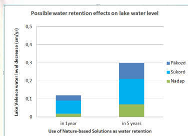
2020
2022

Extreme drought in 2022 had some positive side affects: Development map around Lake Velence has undergone severe changes as a result of extreme drought in 2022
(based on mayors' answers, 2022 early spring – 2022 fall)

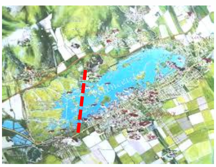




At present: low usage of nature-based solutions and water retention
Future/attitude: this year's extreme drought had a significant impact

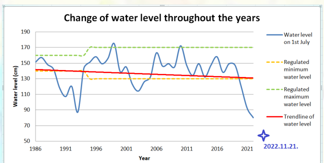


Characteristics of the lake



2 regions:

- **open surface (East) -> $^2/_3$**
  touristic demand:
  high water level
- **reed cover (West) -> $^1/_3$**
  ecology demand:
  high or shallow water level



(36 years avr. water level change) = - 1cm/yr ⁺

⁺ 1986-2022 – decrease of water level

250,000 m³ water ≈ 1 cm of lake water level

Future

Extensive water retention by municipalities and the population may have an impact on the lake budget.

Discussion:

- NbS are effective tools to irrigation challenges in catchment of lake Velence
- Local benefits far exceed the negative impact on the catchment water budget
- In ecologically vulnerable watershed, nature-based solutions need to be applied in an integrated way on an ecologically vulnerable watershed

Future plans:

- Raising social awareness through workshops and education
- Inclusion of all settlements in the integrated water management in the watershed
- Extended water budget and retention calculations based on stakeholder involvement
- Determine location and impact of nature-based solutions using SWMM

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National Laboratory for Water Science and Water Security, Széchenyi István University of Győr, Department of Transport Infrastructure and Water Resources Engineering, Egyetem tér 1, Győr 9026, Hungary

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CHANGES IN THE HYDROLOGICAL BALANCE IN TWO BASINS WITH LONG-TERM OBSERVATIONS

VERONIKA BAČOVÁ MITKOVÁ[1], ZBYNĚK BAJTEK[1], MARCEL GARAJ[2], DANA HALMOVÁ[1], PAVOL MIKLÁNEK[1], PAVLA PEKÁROVÁ[1]

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The reliable determination of the basic components of the water balance of an area (precipitation, runoff, balance evaporation) primarily depends on the accuracy of the direct measurement of the first two components from which it is calculated. In the Ipel' River basin (Sk), we have had three continuous observations of daily flows since 1931, i.e., from Krupinica at Plášťovce, Litava at Plášťovce, and Ipel' at the Holiša station. This study is focused on an evaluation of changes in the hydrological balance of the Krupinica River basin and Litava River basin (both rivers flow to the Plášťovce station) for the entire 90-year period as well as for the three 30-year subperiods of 1931–1960, 1961–1990, and 1991–2020. A comparison of the 30-year periods shows a significant decrease in the runoff of the Krupinica River, i.e., from 231 mm to 144 mm, as well as that of the Litava River, i.e., from 206 mm to 130 mm. This decrease was even more pronounced in the runoff coefficient, i.e., from 0.32 over 0.27 to 0.21 in the last period of 1991–2020 in Krupinica. In Litava it fell from 0.3 over 0.24 to 0.2.

Acknowledgement

This work was supported by the APVV Project No. 20-0374 "Regional detection, attribution and projection of impacts of climate variability and climate change on runoff regimes in Slovakia", and the VEGA Project No. 2/0004/19 "Analysis of changes in surface water balance and harmonization of design discharge calculations for estimation of flood and drought risks in the Carpathian region".

CHANGES IN THE HYDROLOGICAL BALANCE IN TWO BASINS WITH LONG-TERM OBSERVATIONS

ÚSTAV HYDROLÓGIE SAV, v. v. i.
INSTITUTE OF HYDROLOGY SAS

Veronika Bačová Mitková[1], Zbyněk Bajtek[1], Dana Halmová[1], Pavol Miklánek[1], Marcel Garaj[2]
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SHMU

Abstract

The reliable determination of the basic components of the water balance of an area (precipitation, runoff, balance evaporation) primarily depends on the accuracy of the direct measurement of the first two components from which it is calculated. In the Ipeľ River basin (SK), we have three continuous observations of daily flows since 1931, i.e. from Krupinica at Plášťovce, Litava at Plášťovce, and Ipeľ at the Holiša station. This study is focused on an evaluation of changes in the hydrological balance of the Krupinica River basin and Litava River basin (both flows at the Plášťovce station) for the entire 90-year period as well as for the three 30-year subperiods of 1931–1960, 1961–1990, and 1991–2020. A comparison of the 30-year periods shows a significant decrease in the runoff of the Krupinica River, i.e. from 231 mm to 144 mm, as well as that of the Litava River, i.e. from 206 mm to 130 mm. This decrease was even more pronounced in the runoff coefficient, which has changed from 0.32 over 0.27 to 0.21 in the last period of 1991–2020 in Krupinica. In the Litava basin it has fallen from 0.3 over 0.24 to 0.2.

Water balance

We used a balance equation in the form:

$$P = R + ET + \Delta S, \qquad (1)$$

where:

P – average annual precipitation depth [mm],
R – average annual runoff depth [mm],
ET – balance evaporation depth [mm],
ΔS – average total losses Δt.

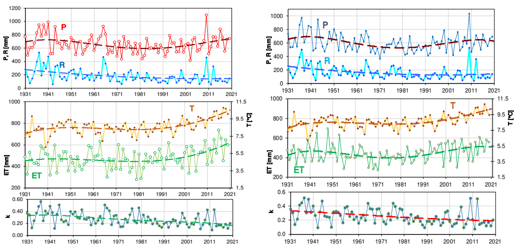


Fig. 2 Annual precipitation depth P and annual basin runoff R, over the Krupinica River (left) and Litava River (right) basin up to Plášťovce, (upper), course of the annual evaporation ET and mean annual basin air temperature T; runoff coefficient k (lower); time period 1931–2020. Polynomial and linear trends.

Dependence of annual runoff on precipitation and air temperature

From the measured annual values over a 90-year period, a regression analysis was used to derive an empirical relationships for estimating the future development of runoff in the Krupinica and Litava basin (between runoff, precipitation and air temperature):

$$R_{sim,Krupinica} = 131 + 0.519\,P - 33.47\,T, \qquad (2)$$

$$R_{sim,Litava} = 23.38 + 0.522\,P - 22.01\,T, \qquad (3)$$

where: R_{mod} – mean annual runoff;
P – annual areal precipitation on the basin;
T - mean annual air temperature in the basin.

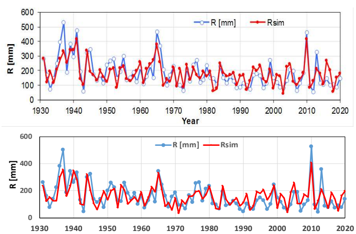
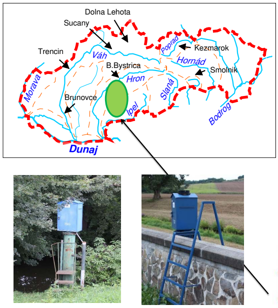


Fig. 3. The course of measured annual outflows R and simulated (Rsim) according to relation (2) and (3) .

Imput data



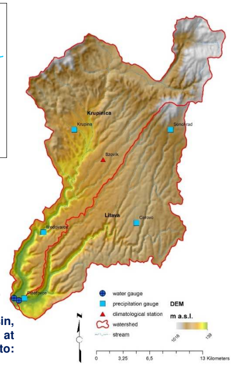


Fig. 1. Scheme of the Krupinica and Litava basin, Slovakia (left); water gauge of the SHMI at Plášťovce on Krupinica and Litava River. (Photo: J. Mészáros, 2021).

Changes of the hydrological balance (model BILAN)

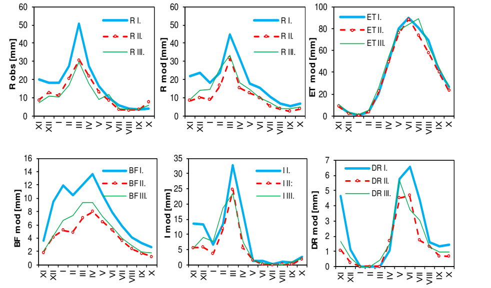


Fig. 4. Comparison of the 30-years mean monthly runoff components during three periods (observed runoff Robs, modelled runoff Rmod, evapotranspiration ET, base flow BF, interflow I, and direct runoff DR). Litava River.

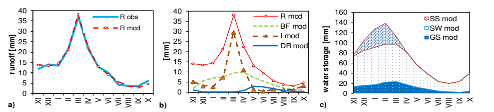


Fig. 5. a) Comparison of the long-term mean monthly runoff R (measured) and Rmod (modelled); (b) Longterm modelled mean monthly runoff Rmod, base flow BF, interflow I, and direct runoff DR; c) snow water storage SS, soil water storage SW, and groundwater storage GS; period 1930/31–2019/20. Litava River.

Conclusion

The modelled results of the components of the hydrological balance for the whole period 1930/31–2019/20 by the BILAN model show:

- Long-term average baseflow accounts for 40.7% of the total runoff, hypodermic runoff accounts for 46.8% and direct runoff accounts for 12.5% of the total runoff of the Litava in Plášťovce.
- Cumulatively, the highest water retention in the basin was in the month of February (138.3 mm), the lowest in the month of August only (20 mm).

In this paper, we focused on the assessment of the long-term balance over a 90-year period with the BILAN model. It should be noted that it is difficult to collect the necessary homogeneous input data for 90 years from the same location and with comparable instruments. In addition, the assessed catchment must not be significantly anthropogenically influenced. There are only a few such catchments left in Slovakia. It is therefore necessary to focus on the assessment of changes in the hydrological balance in these catchments.

Acknowledgements This work was supported by the project WATSIM "Water temperature simulation during summer low flow conditions in the Danube basin", and by the APVV project No. 20-0374 "DETECTIVES", and the VEGA project No. 2/0004/19

Seasonal and spatial changes in mean monthly discharges in selected gauging stations of Slovakia

Zuzana Sabová[1], Silvia Kohnová[1]

According to both climate scenarios, we can observe shifts in the seasonal and spatial behaviour of mean monthly discharges. The results indicated that the most significant decrease in average monthly discharges occurred in eastern Slovakia in the spring period. According to the MPI climate scenario, an increase in average monthly discharges of up to 25

The shift in the highest mean monthly discharges until 2100 is as follows: for western Slovakia, a shift to January and February from March applies; for central Slovakia, it remains in March and April; for northern Slovakia, it is a shift from May to April; for eastern Slovakia, it is a noticeable shift from March and April to the whole period between January and April. The lowest average monthly discharges will mainly appear in August, September, and November by the year 2100. Changes in the occurrence of the highest and lowest average monthly discharges could mean changes in snowmelt, the forms of total precipitation, and the air temperature.

Acknowledgement This work was supported by the Slovak Research and Development Agency under Contract No. APVV-20-0374. The study was also supported by the VEGA Grant Agency under Project No. 1/0632/19. The authors are very grateful for their research support.

Keywords: average monthly discharges, the KNMI and MPI climate scenarios, Slovakia, climate change

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HydroCarpath 2022

SEASONAL AND SPATIAL CHANGES IN MEAN MONTHLY DISCHARGES IN SELECTED GAUGING STATIONS OF SLOVAKIA

Author: Ing. Zuzana Sabová
Supervisor: prof. Ing. Silvia Kohnová, PhD.
24.11.2022

Slovak University of Technology
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Research area, material and methods

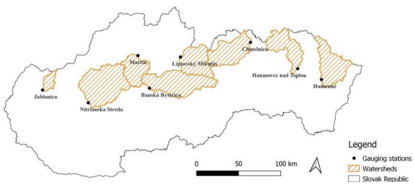

Fig. 1: *Location of the selected catchments in the territory of Slovakia*

The inputs to the analysis were:

- daily discharge series of observed data in 1981-2010 (provided by the Slovak Hydrometeorological Institute),
- modelled discharges using the HBV model (1981-2010),
- and simulated discharges according to the KNMI and MPI scenario inputs (1981-2100).

Pre-processing of data from both climate scenarios goes through the HBV rainfall-runoff model with Technical University of Wien (TUW) implementation.

The results of mean monthly discharges were divided into four groups location in the territory of Slovakia, i.e., the western, central, northern, and eastern Slovakia. The results are processed as a relative deviation of

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Results

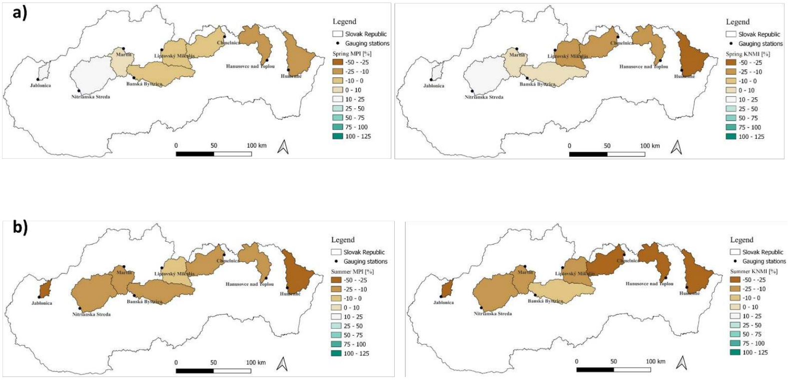

Fig. 2: Results of analyses of mean monthly discharges for selected river basins of Slovakia in the spring and summer, according to simulated data from the MPI and KNMI climate scenarios until

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Results

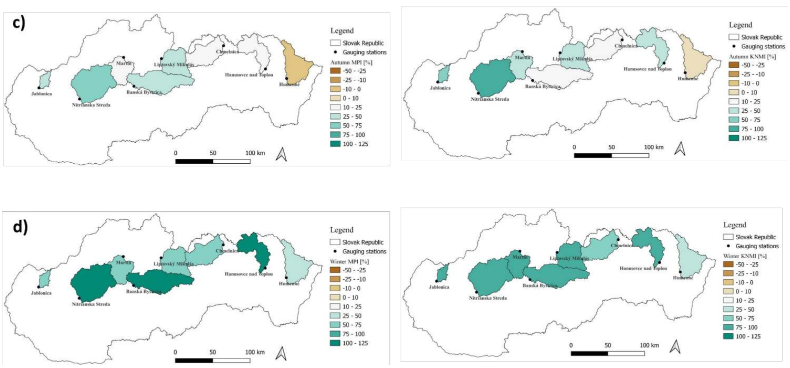

Fig. 3: Results of analyses of mean monthly discharges for selected river basins of Slovakia in the autumn and winter, according to simulated data from the MPI and KNMI climate scenarios until

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Conclusion

The results show more extreme changes in mean monthly discharges for the simulated data according to the KNMI climate scenario for spring, summer, and autumn; for the simulated data according to the MPI climate scenario, more significant changes are visible in winter.

In spring and summer, is expected a decrease in mean monthly discharges until 2100. On the contrary, in autumn and winter, is expected an increase in mean monthly discharges by 2100.

Changes in mean monthly discharges could mean changes in snowmelt, the forms of total precipitation, and the air temperature for the future.

Slovak University of Technology
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Thank you for your attention

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SEASONAL AND SPATIAL CHANGES IN MEAN MONTHLY DISCHARGES IN SELECTED GAUGING STATIONS OF SLOVAKIA

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ABSTRACT

The study analyses future seasonal and spatial changes in mean monthly discharges in eight selected gauging stations of Slovakia covering the western, central, northern, and eastern parts of the territory. The input data in all the gauging stations were the daily discharge series of the data observed from 1981-2010. These data were used to calibrate the TUW rainfall-runoff hydrological model, an HBV-type model developed by the Technical University of Vienna and used in all the catchments. Subsequently, climatological inputs from the KNMI and MPI climate scenarios for the period 1981-2100 were used to simulate daily discharges up to the year 2100. The simulated discharges were then statistically analyzed and compared with the historical period.

According to both climate scenarios, we can observe shifts in the seasonal and spatial behavior of mean monthly discharges. The results indicated that the most significant decrease in average monthly discharges occurred in eastern Slovakia in the spring period. According to the MPI climate scenario, an increase in average monthly discharges of up to 25 % for western Slovakia and a decrease of 10 % for northern Slovakia are expected in the spring. In western Slovakia, the highest increase in average monthly discharges is expected in the autumn. For part of northern Slovakia, an increase in the average monthly discharges of 50 % in the fall is expected. The summer is characterized by a decrease in the average monthly discharges in the entire territory of Slovakia, especially in eastern Slovakia. According to the MPI climate scenario data, the increase in the values of average monthly discharges could be over 100 % in western, central, and eastern Slovakia. Despite this significant increase, the modelled data of the MPI climate scenario predicts milder changes in the average monthly discharges compared to the KNMI climate scenario until 2100.

1 RESEARCH AREA

Research area was divided in eight selected catchments of Slovakia, i.e., Myjava – Jablonica, Váh – Liptovský Mikuláš, Turiec – Martin, Nitra – Nitrianska Streda, Hron – Banská Bystrica, Poprad – Chmeľnica, Laborec – Humenné, and Topľa – Hanušovce nad Topľou, see Fig. 1.

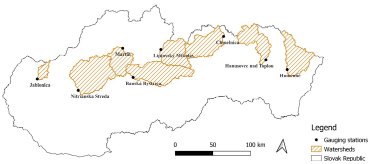

Fig. 1: Location of the selected catchments in the territory of Slovakia

2 MATERIAL AND METHODS

The hypothetical climate scenarios used in this study are the Dutch KNMI (with the A1B emission scenario) and the German MPI (with the A1B emission scenario).

The inputs to the analysis were daily discharge series of observed data in 1981-2010 (provided by the Slovak Hydrometeorological Institute), modelled discharges using the HBV model (1981-2010), and simulated discharges according to the KMNI and MPI scenario inputs (1981-2100). Pre-processing of data from both climate scenarios goes through the HBV rainfall-runoff model with Technical University of Wien (TUW) implementation.

The results of mean monthly discharges were divided into four groups location in the territory of Slovakia, i.e., the western, central, northern, and eastern Slovakia. The results are processed as a relative deviation of modelled and simulated discharges according to MPI and KNMI climate scenarios [%].

3 RESULTS

Eastern and northern Slovakia shows the highest decrease in the values of average monthly discharges until 2100 in the spring season (Fig. 2a). For western Slovakia, an increase of up to 25 % is expected by 2100.

In the summer (Fig. 2b), the highest decreases in mean monthly discharges are expected in the eastern part of Slovakia, according to simulated data from the KNMI climate scenario. The growth of mean monthly discharges is recorded only in the Banská Bystrica (simulated data according to the KNMI climate scenario) and Liptovský Mikuláš (simulated data according to the MPI climate scenario) gauging stations by 2100.

Changes in the autumn period are in all gauging stations characterized eastern part of Slovakia by an increase in mean monthly discharges (Fig. 2c). Simulated data according to the KNMI climate scenario show the most significant changes in mean monthly discharges in the spring, summer, and autumn seasons. In the winter season, there are more expressive changes in mean monthly discharges for the simulated data according to the MPI climate scenarios. For western Slovakia, the highest mean monthly discharges increase in autumn.

In the winter season (Fig. 2d), only the growth in mean monthly discharges in selected river basins in Slovakia is visible until the year 2100. The highest increase in mean monthly discharges (up to 100 %) is expected in the Nitrianska Streda, Banská Bystrica, and Hanušovce nad Topľou gauging stations.

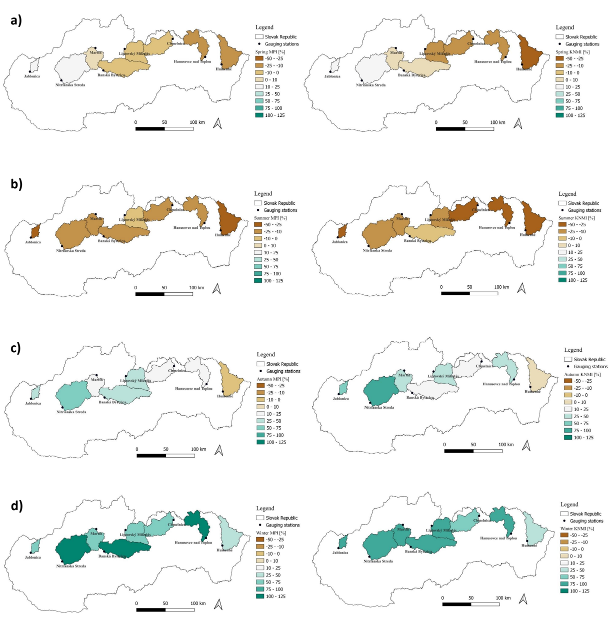

Fig. 2: Results of analyses of mean monthly discharges for selected river basins of Slovakia by seasons according to simulated data from the MPI and KNMI climate scenarios until 2100

4 CONCLUSION

The paper analyses the seasonal changes of mean monthly discharges for selected river basins of Slovakia for the future horizon. Data from two climate scenarios, the KNMI and MPI, were used. The results show more extreme changes in mean monthly discharges for the simulated data according to the KNMI climate scenario for spring, summer and autumn; for the simulated data according to the MPI climate scenario, more significant changes are visible in winter for both scenarios.

The shift in the highest mean monthly discharges until 2100 can be summarized: for western Slovakia, a shift to January and February from March applies; for central Slovakia, it remains in March and April; for northern Slovakia, it is a shift from May to April; for eastern Slovakia, it is a noticeable shift from March and April to the whole period between January and April.

The lowest average monthly discharges will mainly appear in August, September, and November by 2100. Changes in the occurrence of the highest and lowest average monthly discharges could mean changes in snowmelt, the forms of total precipitation, and the air temperature.

Acknowledgement

This work was supported by the Slovak Research and Development Agency under Contract No. APVV-20-0374. The study was also supported by the VEGA Grant Agency under Project No. 1/0632/19. The authors are very grateful for their research support.

The dynamics of the soil moisture content under different forest stands in the Sandridge Region of Hungary

Bence Bolla[1], András Szabó[1], Kitti Balog[2], Péter Kalicz[3], Zoltán Gribovszki[3]

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Every forest plays a significant role in the fight against climate change, but trees need additional water sources to survive during dry periods. Soil moisture and precipitation were measured according to three indicators: grassland as a control point and black locust (42 years) and black pine (84 years) stands near Kecskemét, Hungary. The soil moisture content was lower under the forest stands during the growing season compared to the control site at shallow depths (0-80 cm). Meanwhile, the highest soil moisture content in the deeper soil layers was observed under the black locust most of the year. The maximum difference was still insignificant (5.6%) at a depth of 200 cm between the grassland and the forest stands.

Acknowledgements: This article was made in frame of the project TKP2021-NKTA-43 which has been implemented with the support provided by the Ministry of Innovation and Technology of Hungary (successor: Ministry of Culture and Innovation of Hungary) from the National Research, Development and Innovation Fund, financed under the TKP2021-NKTA funding scheme.

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Hydrocarpath
Vienna
24.11.2022

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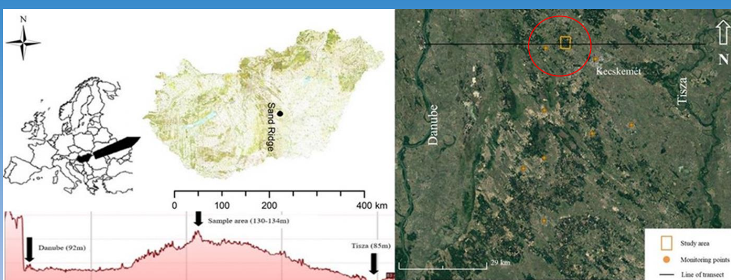
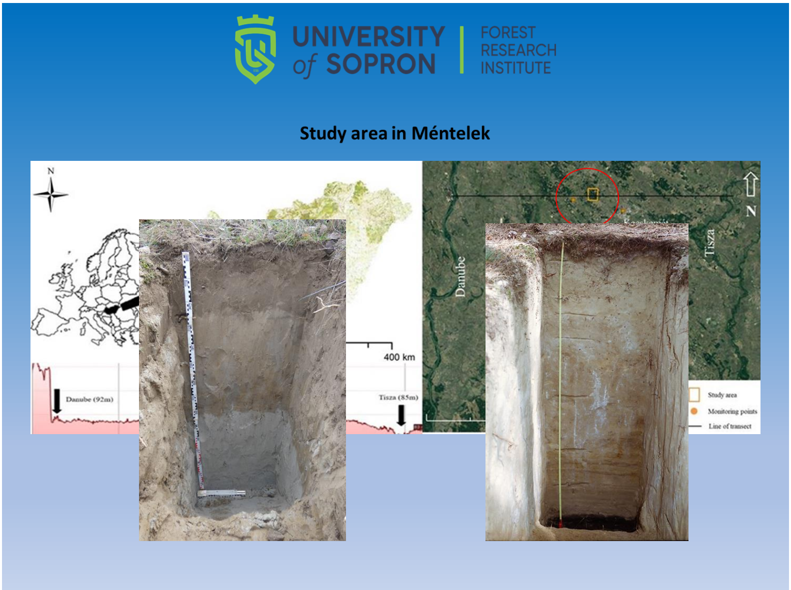
Study area in Méntelek

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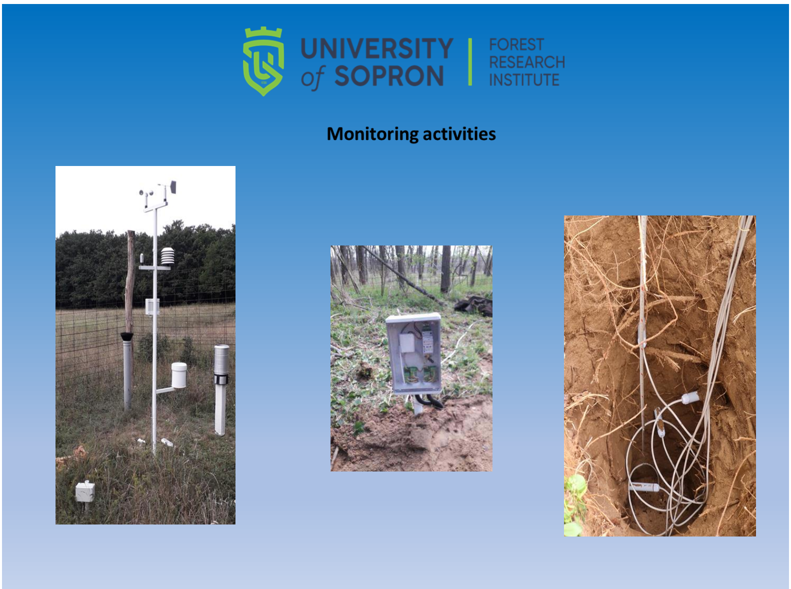
Study area in Méntelek
N
400 km
Danube (92m)
Tisza (85m)
Danube
Tisza
N
Study area
Monitoring points
Line of transect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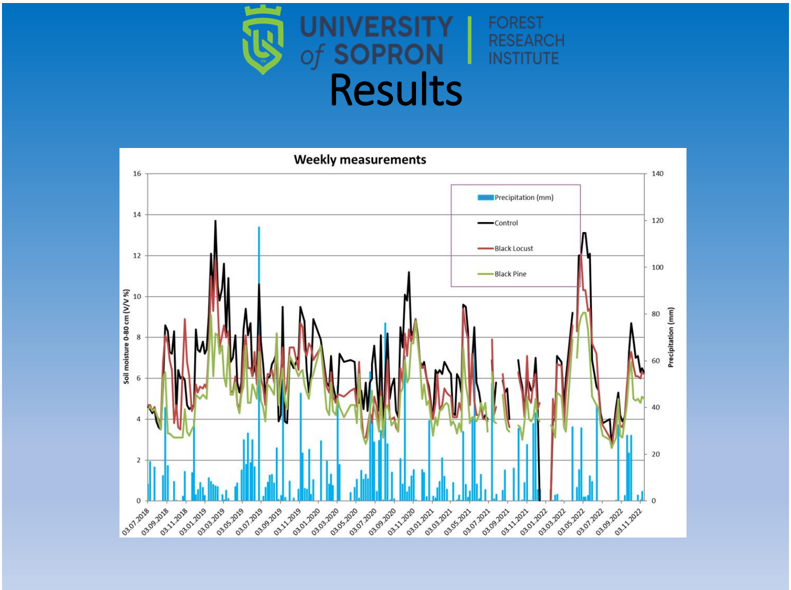
Monitoring activities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Results
Weekly measurements
Precipitation (mm)
Control
Black Locust
Black Pine
Soil moisture 0-80 cm (V/V %)
Precipitation (mm)
0
2
4
6
8
10
12
14
16
20
40
60
80
100
120
140
03.07.2018
03.09.2018
03.11.2018
03.01.2019
03.03.2019
03.05.2019
03.07.2019
03.09.2019
03.11.2019
03.01.2020
03.03.2020
03.05.2020
03.07.2020
03.09.2020
03.11.2020
03.01.2021
03.03.2021
03.05.2021
03.07.2021
03.09.2021
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03.03.2022
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03.07.2022
03.09.2022
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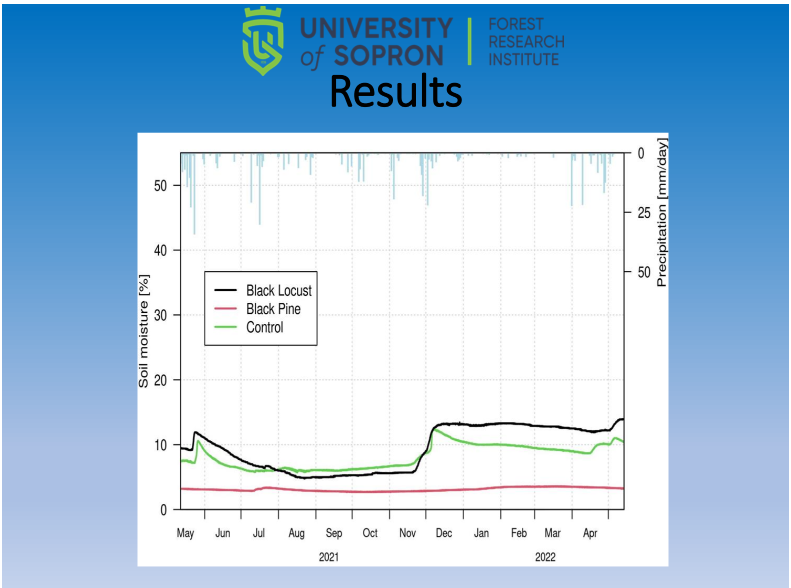
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Results
Black Locust
Black Pine
Control
Soil moisture [%]
Precipitation [mm/day]
0
10
20
30
40
50
0
25
50
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec
Jan
Feb
Mar
Apr
2021
2022


Thank you!

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The dynamics of the soil moisture content under different forest stands in the Sandridge Region of Hungary

BENCE BOLLA[1], ANDRÁS SZABÓ[1], KITTI BALOG[2], PÉTER KALICZ[3], ZOLTÁN GRIBOVSZKI[3]
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The reduction of the available water resources is a global concern. Groundwater depletion in the Hungarian Great Plain has been significant since the mid-1970s, especially at the Kiskunság Sand Ridge.

The regional water balance is a result of the complex interaction of the groundwater-soil-vegetation-atmosphere system. Achieving an adequate investigation necessitates the monitoring of the basic elements of these four sub-systems.

Since 1999, the University of Sopron Forest Research Institute has been performing complex hydrometeorological and soil moisture measurements at a grassland, a black locust (*Robinia pseudoacacia*) stand, and a black pine (*Pinus nigra*) forest stand in Kecskemét.

Our results indicate the soil moisture content is lower below forest stands than on the control site (grassland) during the growing season. In contrast, this difference cannot be an indicator of the "underground deserts" in Kiskunság Sand Ridge, knowing the soil moisture values are 0.7-1.64% higher below the grassland in the upper 80 cm layer of soil.

According to our own measurements: the annual average temperature increase of 1.8 C° occurred between 1999 and 2021. That increase the potential evaporation (PET), which has a negative effect of the overall hydrologic balance of the area as there is no increase in the precipitation. The local forest stands may also have additional positive water balance effects: the interception of temperate forests significantly cools the environment in summer, reducing evaporation, evapotranspiration, and erosion. In the near future, the monitoring will be expanded with satellite imagery based on weather datasets, vegetation and water indices showing the water content of forest stands.

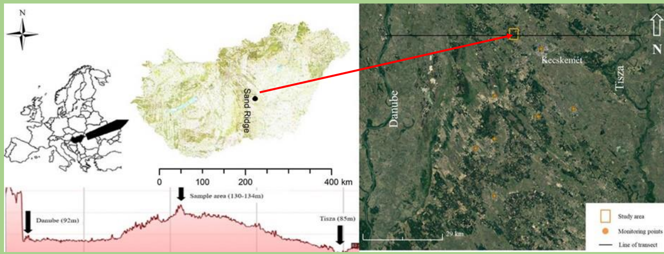

Fig. 1: Location of the study site and auxiliary measurement points.

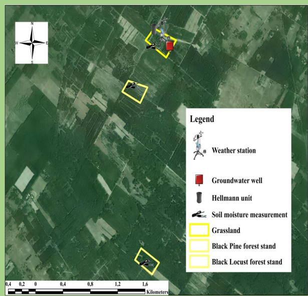

Fig. 2: Location of the monitoring points.

Fig. 3: Soil profile pits black pine and control (grassland) site with the soil moisture sensors.

Fig. 4: The Tsm-06 soil moisture measurement device and the AgroMet weather station.

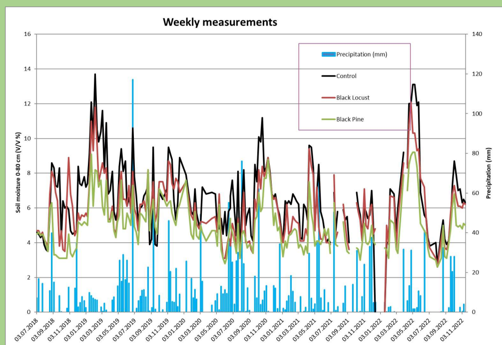

Fig. 5: Total soil moisture based on a grassland and two forest stands in Méntelek (0-80 cm)

The results indicate the soil moisture content is lower below forest stands than on the control site (grassland) during the growing season. In contrast, this difference cannot be an indicator of the "underground deserts" in Kiskunság Sand Ridge, knowing the soil moisture values are 0.7-1.64% higher below the grassland in the upper 80 cm layer of soil.

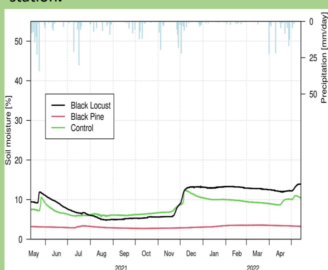

Fig. 6: Short-term soil moisture data at depth of 200 cm

The highest values were measured from August to November under the control point, with the maximum difference of 1,6% to black locust. Meanwhile, in most of the year (May – July, 2021, and December, 2021 – May, 2022), the highest soil moisture content was observed under the black locust. The average difference was 3.5% and the maximum difference was 5.6% compared to the control. The lowest values were measured under black pine with negligible fluctuation (values were between 2.8% and 3.6%).

Acknowledgements

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PROJECT FINANCED FROM THE NRDI FUND

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IMPACT OF THE WATER SUPPLY ON FOREST GROUNDWATER LEVELS: A CASE STUDY IN THE WEST INNER-SOMOGY MICRO-REGION (HUNGARY)

ANDRÁS HERCEG[1], PÉTER KALICZ[1], LÁSZÓ HORVÁTH[2], ZOLTÁN GRIBOVSZKI[1]

[1] University of Sopron, Faculty of Forestry, Institute of Geomatics and Civil Engineering
[2] Kaszó Ltd.

Climate change all over Europe can be characterized by a substantial warming trend, but the most significant effect is its impact on the water cycle through altering precipitation patterns and evapotranspiration processes on multiple scales. The anticipated changes may induce a higher rate of water consumption in plants, which could lower the groundwater table; thus, the regeneration of groundwater-dependent forest communities in these areas is a significant issue. Forests with high water requirements on the plains and wetland areas of Hungary are particularly affected.

As to groundwater-dependent forest ecosystems, a good example of positive water supply interventions is the Kaszó LIFE project, which is aimed at the improvement of the water supply of the forests, small fens, and grasslands in the Szentai forest (West Inner-Somogy micro-region). Lake rehabilitation and log weirs were applied to ensure the restoration of the degraded habitats.

The objective of this study is an analysis of the hydrological impacts of water supply interventions on the groundwater level. The main conclusion is that the construction of the lakes has significantly affected the water levels in the surrounding wells, but the effects of the log weirs are thus far undetectable.

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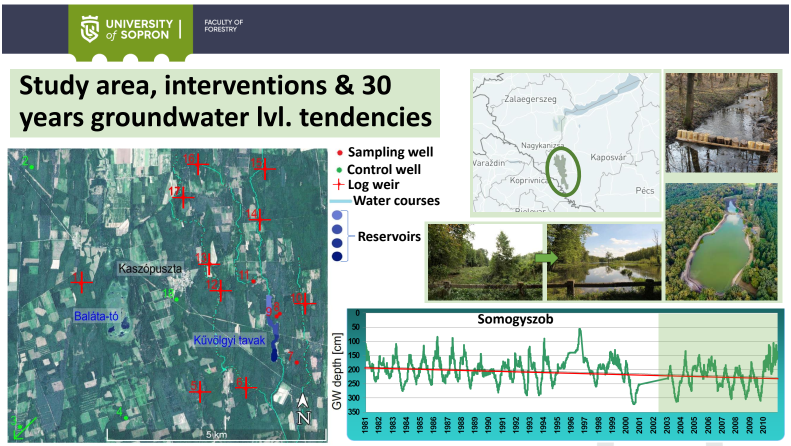
IMPACT OF THE WATER SUPPLY ON FOREST GROUNDWATER LEVELS: A CASE STUDY IN THE WEST INNER-SOMOGY MICRO-REGION (HUNGARY)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Study area, interventions & 30 years groundwater lvl. tendencies
Sampling well
Control well
Log weir
Water courses
Reservoirs
Kaszópuszta
Baláta-tó
Kűvölgyi tavak
5 km
N
Zalaegerszeg
Nagykanizsa
Kaposvár
Varaždin
Koprivnica
Pécs
Somogyszob
GW depth [cm]

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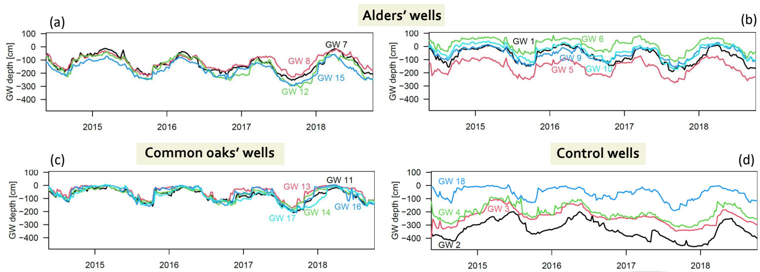
Results: Groundwater levels



Groundwater time series in the monitoring period (01.10.2014 – 09.30.2018) for (a) (b) alder groups; (c) control wells, (d) common oaks' well.

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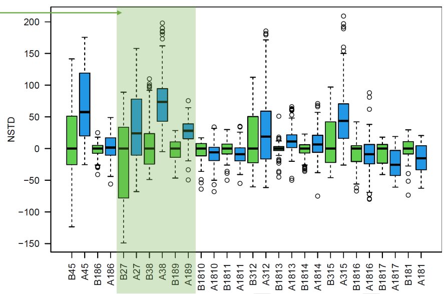
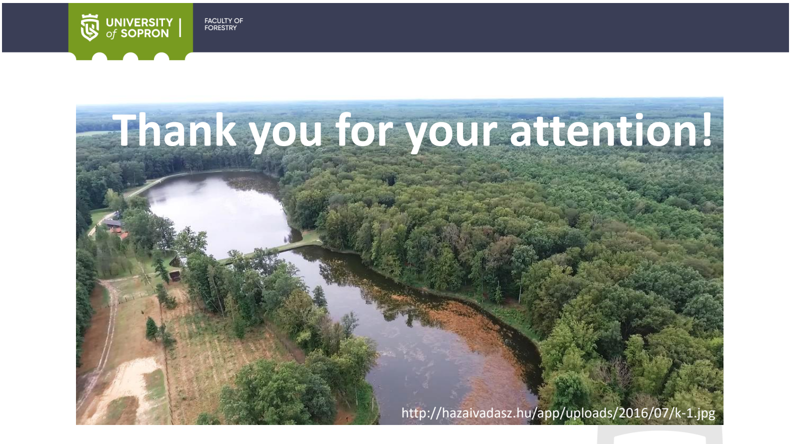
Normalized space and time deviation

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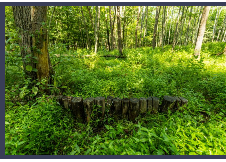

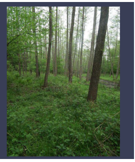

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IMPACT OF THE WATER SUPPLY ON FOREST GROUNDWATER LEVELS: A CASE STUDY IN THE WEST INNER-SOMOGY MICRO-REGION (HUNGARY)

András Herceg[1], Katalin Zagyvai-Kiss[1], Péter Kalicz[1] László Horváth[2], Zoltán Gribovszki[1]

[1] University of Sopron, Faculty of Forestry, Institute of Geomatics and Civil Engineering, Hungary

[2] Kaszó Ltd.

Abstract

Climate change all over Europe can be characterized by a substantial warming trend, but the most significant effect is its impact on the water cycle through altering precipitation patterns and evapotranspiration processes on multiple scales. The anticipated changes may induce a higher rate of water consumption in plants, which could lower the groundwater table, thus the regeneration of groundwater-dependent forest communities in these areas is a significant issue. Forests with high water requirements and biological production on the plains and in the wetland areas of Hungary are particularly affected.

As to groundwater-dependent forest ecosystems a good example of positive water supply interventions is the Kaszó LIFE project, which is aimed at the improvement of the water supply of the forests, small fens and grasslands in the Szentai forest (West Inner-Somogy micro-region). Lake rehabilitation and log weirs were applied to ensure the restoration of the degraded habitats.

The objective of this study is an analysis of the hydrological impacts of water supply interventions on the groundwater level.

The main conclusion is that the construction of the lakes has significantly affected the water levels in the surrounding wells, but the effects of the log weirs are thus for undetectable.

Study Area

In the micro-region of Western Inner-Somogy, the average height is ~130-170 m. The valleys are very flat, and wide north-south valleys developed. The most common soil in the area is clay-washed brown forest soil (83%) (Dövényi, 2010).

The climate of the area is moderately warm, moderately humid climate type. The average annual temperature: 9.8-10.2 °C (during the growing season: ~16.5-17 °C). The average annual rainfall is ~750mm, (430-450mm during the summer). The meteorological data (temperature and precipitation) data was collected in Kaszópuszta using an on-site automatic weather station. The period of the study covers 4 hydrological years from 1 Oct. 2014 to 30 Sept. 2018 (Dövényi, 2010).

Due to its topographic conditions areas with closed drainage is common. The drainless areas at the bottom of the valleys are mostly not connected to each other, small lakes, swampy, marshy areas have been developed, which water supply is provided only by rainfall. In addition dehydrating effects of climate change are strongly affecting the forest wetlands (Dövényi, 2010).

The average depth of the groundwater is 2-4 m. Based on data series of more than 30 years the groundwater level is falling (Déduvizig 2014).

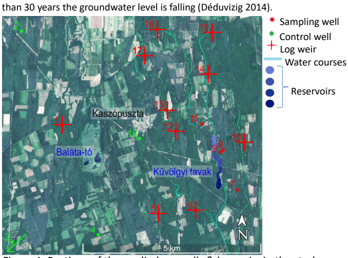


Figure 1. Postions of the applied gw wells & log weirs in the study area.

Table 1. Basic data of the groundwater wells.

Number	GW type	Dominant species	Age	GW depth	Intervention
3.	Control	Common oak	39	241	-
2.	Control	Common oak	63	338	-
4.	Control	Alder	40	208	-
18.	Control	Alder	53	58	-
12.	Sample point	Common oak	30	152	Log weir
8.	Sample point	Common oak	50	117	Reservoir
15.	Sample point	Common oak	53	170	Log weir
7.	Sample point	Common oak	71	130	Reservoir
11.	Sample point	Alder	19	79	Log weir
10.	Sample point	Alder	21	36	Log weir
6.	Sample point	Alder	27	-12	Log weir
16.	Sample point	Alder	43	67	Log weir
14.	Sample point	Alder	47	70	Log weir
5.	Sample point	Alder	49	158	Log weir
1.	Sample point	Alder	49	70	Log weir
13.	Sample point	Alder	50	48	Log weir
9.	Sample point	Alder	50	55	Reservoir
17.	Sample point	Alder	55	78	Log weir

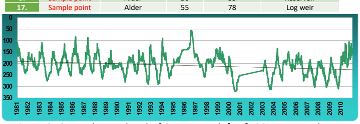


Figure 2. Groundwater level of Somogyszob [cm], 30 years tendency.

Water supply interventions

In the Kaszó project area, new reservoirs regenerated and log weirs have been built in July 2015 as part of the KASZÓ-LIFE project, which serve to reverse the effects of earlier water regulation work (drainage). In order to take into account, the effects of the interventions, the control period was considered to be the hydrological year 2014-2015 and 2015-2016, while the period affected by the interventions was 2016-2017 and 2017-2018. It has to be noted that a hydrological year started on Oct. 01 and finished the next calendar year on Sept. 30.

123 **log weirs** were installed in the bed of 3 intermittent watercourses for 15 km. The log weirs raise the water level of the watercourses by about 30 cm behind them during significant rainy periods and afterwards and during the period of snowmelt.

With the **regeneration of the existing and the construction of new lakes**, the water surface increased from 7.13 ha to 16.57 ha, and the water storage capacity almost doubled. With the renovation of the structures in the old lakes the operating water-level was 30 cm, in the new lakes the water levels have risen to 110 cm - 210 cm.

Figure 3. Reservoirs Kűvölgyi & a newly built log weir.

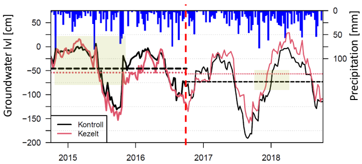
Figure 4. Before (a) and after (b) the construction of Kűvölgyi lake IV.

Method

We performed spatial and temporal differences to examine the effects of the interventions.

First step: calculating the spatial difference in determining the difference between time series of the intervention and control wells.

Second step: the time difference meant the difference between the spatial differences of the time series before and after the intervention.



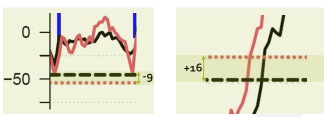


Figure 5. The change of the groundwater depth with the precipitation for groundwater well #9 and #18 (control).

$$\text{Impact} = \Delta H\_\text{before} - \Delta H\_\text{after}$$

$$-25 = -9 - (+16)$$

Results

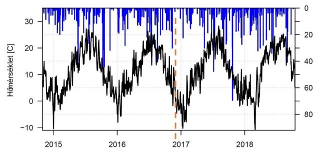


Figure 6. Daily temperature and precipitation time series for the monitoring period (01.10.2014 – 09.30.2018).

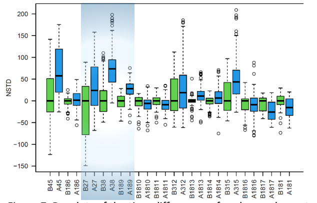


Figure 7. Boxplots of the time differences of each sample-control wells' pairs (normalized).

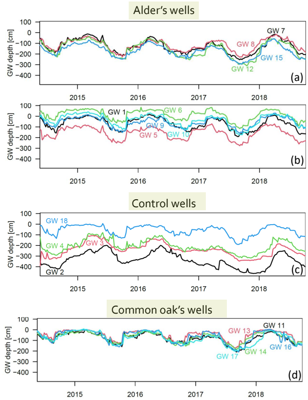


Figure 8. Groundwater time series in the monitoring period (01.10.2014 – 09.30.2018) for (a) alder group I, (b) alder group II, (c): control wells, (d): common oak's wells.

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Reference evapotranspiration in selected stations of Slovakia

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Evapotranspiration is an essential part of the hydrological cycle that affects the humidity/aridity of an area and drought risks; it has an important impact on the generation of surface runoff. It is an important input for hydrological water balance models and the management of watersheds and irrigation; it is also a significant variable representing the character of the local climate. The potential value of evapotranspiration, which is the maximal amount of water that could be evaporated from a surface under the climatic conditions given, is possible to describe by two different concepts, i.e., potential evapotranspiration and reference evapotranspiration. Although the concept of reference evapotranspiration was described more than 40 years ago when the standardized FAO Penman-Monteith methodology was created, it is still rarely used in our region and is often confused with the concept of potential evapotranspiration. The key reason why this concept is seldom applied in hydrology is the requirement for a wide range of input climatological data.

This research is aimed at describing a spatial and temporal pattern of reference evapotranspiration calculated by the FAO Penman-Monteith method in the selected climatological stations of Slovakia, describing trends in this variable and notes the potential impact of these trends in the related climatological variables to trends in the reference evapotranspiration. The results show the different trends and spatial distribution of reference evapotranspiration in Slovakia. The mean monthly values of reference evapotranspiration on Slovakia's western and eastern lowlands indicate the same increasing trends in the summer months, e.g., the mean monthly air temperature. However different trends in reference evapotranspiration were identified in the Juhoslovenska kotlina lowland, where they decreased in the winter months.

Acknowledgement: "This publication is the result of the project implementation: „ Scientific support of climate change adaptation in agriculture and mitigation of soil degradation " (ITMS2014+ 313011W580) supported by the Integrated Infrastructure Operational Programme funded by the ERDF."

Key words: Reference evapotranspiration, FAO Penman-Monteith, evapotranspiration

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REFERENCE EVAPOTRANSPIRATION IN SELECTED STATIONS OF SLOVAKIA

Viera Rattayová , Marcel Garaj, Kamila Hlavčová

1 METHODOLOGY- CALCULATION OF REFERENCE EVAPOTRANSPIRATION

- FAO Penman-Monteith method (P-M)

$$ET_0 = \frac{0.408 * \Delta * (R_N - G) + \Upsilon \frac{900}{T + 273} * u_2 + (e_s - e_a)}{\Delta + \Upsilon * (1 + 0.34 * U_2)}$$

- FAO Hargreaves simplified method

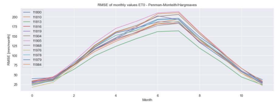
$$ET_0 = 0.0023(T_{mean} + 17.8)(T_{max} - T_{min})^{0.5} R_a$$

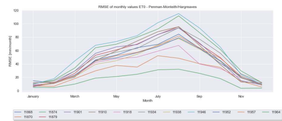
ET_0 reference evapotranspiration [mm day^{-1}]
R_n net radiation at the crop surface [MJ m^{-2} day^{-1}];
G soil heat flux density [MJ m^{-2} day^{-1}];
T mean daily air temperature at 2 m height [°C];
u_2 wind speed at 2 m height [m s^{-1}];
e_s saturation vapor pressure [kPa];
e_a actual vapor pressure [kPa];
D slope vapor pressure curve [kPa °C^{-1}];
g psychrometric constant [kPa °C^{-1}].
Ra extraterrestrial radiation [MJ m-2 d-1];
T_{max} maximum air temperature [°C];
T_{min} minimum air temperature [°C]

2 ANALYSES FOR AREA OF SLOVAKIA

INPUTS AND METHODOLOGY

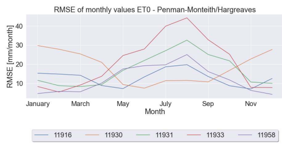
- Dataset of meteorological variables from 65 climatological stations in daily time step(mean, minimum and maximum air temperature, actual vapor pressure, wind speed, sunset duration)
- Period 1981-2020 – period of 2 climatological normal
- 3 samples of stations with different altitude zones (thresholds according vertical vegetation zones of Slovakia); z < 550 , z = 550-1100 , z > 1100





RESULTS

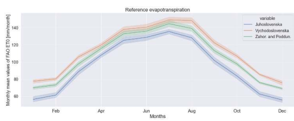
- Seasonal distribution of ET_0 P-M method
- Comparison of monthly ET_0 calculated by Penman-Monteith method and Hargreaves method :
  - Pearson correlation coefficient
  - Root mean square error
- Evaluation of Hargreaves method accuracy with the changes of station elevation



3 REGIONAL STUDY - ANALYSES FOR LOWLANDS OF SLOVAKIA

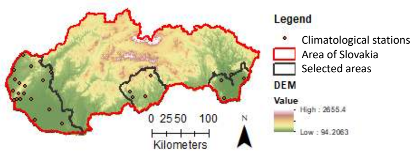
INPUTS AND METHODOLOGY

- Dataset of meteorological variables from 27 climatological stations in daily time step (mean, minimum and maximum air temperature, actual vapor pressure, wind speed, sunset duration)
- Period 1981-2020
- Missing values of Net Radiation was replaced by values from satellite-based dataset of Net Radiation from ERA5 Land, calibrated by linear model with measured data



RESULTS

- Seasonal distributions of ET_0 P-M method for selected lowlands
- Trend analyses of ET_0 and related meteorological variables by Mann-Kendal and Sen's slope

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REFERENCE EVAPOTRANSPIRATION IN SELECTED STATIONS OF SLOVAKIA

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1 INTRODUCTION AND METHODOLOGY

Evapotranspiration is essential part of hydrological cycle, directly affected by climate change, especially by rising air temperatures. Evapotranspiration has an important impact on the amount of surface runoff and the occurrence of drought. Evapotranspiration is not possible to measure directly, and these values are not included in the database of the Slovak Hydrometeorological Institute, although the values of evapotranspiration are necessary for many methods for evaluation of drought, which occurrence is increasing. The aim of this research is to specify the spatial and temporal distribution of reference evapotranspiration and compare the reference method for ET0 calculation FAO Penman-Monteith method, with the method recommended by FAO, when meteorological data are not an available- Hargreaves method. Analyses for the area of Slovakia were realized for 65 climatological stations, where a number of available daily data of sunset duration measurements was more than 20% from a number of days from the selected period (Fig.2). Regional analyses for Slovakia lowlands was realized from sample of 27 climatological stations, missing data of Net Radiation in this dataset was replaced by calibrated satellite-based data from Era5 land dataset.

INPUT DATA PREPARATION

- Climatological data in daily step from Slovak Hydrometeorological Institute for two climatological normal (1981-2020) -minimum air temperature, maximum air temperature, mean air temperature, actual vapor pressure, wind speed and sunset duration)
- Satellite-based dataset of Solar Net Radiation from ERA5 Land (Copernicus): 1981-2020

METHODS FOR CALCULATION OF REFERENCE EVAPOTRANSPIRATION ET0

- FAO Penman-Monteith method (P-M)

$$ET_0 = \frac{0.408 * \Delta * (R_N - G) + \Upsilon \frac{900}{T + 273} * u_2 + (e_s - e_a)}{\Delta + \Upsilon * (1 + 0.34 * U_2)}$$

- FAO Hergreaves simplified method

$$ET_0 = 0.0023(T_{mean} + 17.8)(T_{max} - T_{min})^{0.5} R_a$$

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G soil heat flux density [MJ m^{-2} day^{-1}];
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D slope vapor pressure curve [kPa °C^{-1}];
g psychrometric constant [kPa °C^{-1}].
R_a extraterrestrial radiation [MJ m^{-2} d^{-1}];
T_{max} maximum air temperature [°C];
T_{min} minimum air temperature [°C]

2 ANALYSES OF ET_0 FOR AREA OF SLOVAKIA

ANALYSES OF REFFERENCE EVAPOTRANSPIRATION FOR CLIMATOLOGICAL STATIONS OF SLOVAKIA

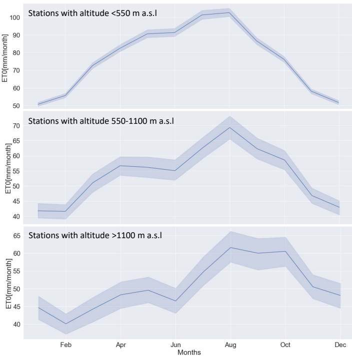

Fig.1: Seasonal distribution of monthly ET_0 values from P-M for stations in selected altitude

Reference evapotranspiration was calculated by FAO P-M method for different samples of stations divided according to altitude. In the case of the sample with the highest altitude of stations, the values of ET0 are the smallest with a minimum in February and a significant local minimum in Jun. The course of ET0 is slowly decreasing to October. The course of ET0 in a sample of stations with smallest altitude is defined by maximum values in August and minimum in December, with a constant increase of ET0 from January. The median values of ET0 are significantly higher than in the other samples, with small variance of values (Fig.1) .

COMPARISON OF METHODS FOR ET_0 CALCULATION

Two methods for calculating ET0 were compared by Pearson correlation coefficient (CC), and root mean square error (RMSE) to evaluate the accuracy of Hargreaves method on the area of Slovakia. Altitude of stations was considered in analyses for determination of changes in accuracy with changes in elevation. The accuracy of Hergreaves method, according Pearson CC is better in monthly time step then in daily time step from FAO methodology (Fig.3). Evaluation of RMSE for samples of stations in different elevation shown that Hargreaves method better estimate ET0 values in stations in higher altitude(Fig. 5-6).

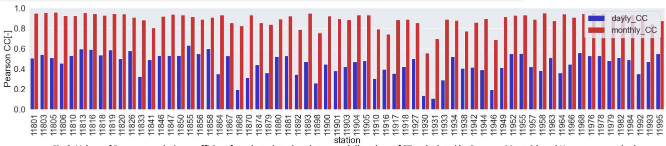

Fig.3: Values of Pearson corelation coefficient for selected stations between daily values of ET_0 calculated by Penman-Monteith and Hargreaves method

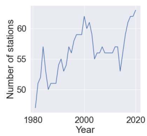

Fig.2: Number of available stations in selected years included to analyses

Graphs of the seasonal distribution of RMSE were created for all samples. The most interesting finding in the seasonal distribution of RMSE is in the case of the highest elevation situated climatological station of Slovakia - Lomnicky Stit (2634 m a.s.l.), where RMSE between P-M and Hargreaves method have different course then a course of RMSE in other stations with local minimum in summer months and maximum in winter (Fig.4).

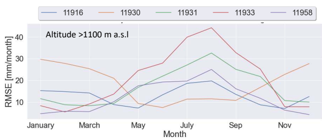

Fig.4: Seasonal distribution of RMSE from monthly values of ET_0 for stations in Altitude>1100mnm

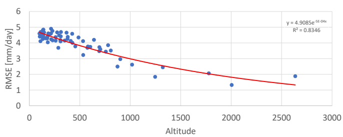

Fig.5: Linear correlation between RMSE from daily values of ET_0 and altitude of stations

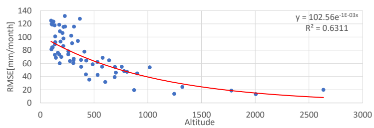

Fig.6: Linear correlation between RMSE from monthly values of ET_0 and altitude of stations

3 ANALYSES OF ET_0 FOR LOWLANDS OF SLOVAKIA

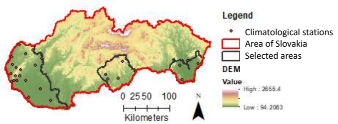

Fig.7: Map of selected stations

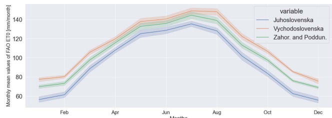

Fig.8: Courses of ET_0 calculated by P-M method for stations in selected Slovak lowlands

Juhoslovenská nížina lowland	Month											
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
ET_0	↓	↓								↓	↓	↓
Precipitation		↑					↑					
Mean temperature				↑		↑	↑	↑			↑	

Zahor. and Pod. Nížina lowland	Month											
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
ET_0						↑						
Precipitation												
Mean temperature				↑		↑	↑	↑			↑	

Východoslovenská nížina lowland	Month											
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
ET_0				↑		↑	↑	↑				
Precipitation												
Mean temperature				↑		↑	↑	↑			↑	

Fig.9: Trends in ET_0 and related climatological variables (α=0.05)

For the calculation of ET0 of Slovakia's lowlands, the list of 27 climatological stations (Fig.7) was divided into three groups based on the lowland geomorphological units of Slovakia. A) Podunajská & Záhorská nížina lowlands – western part B) Juhoslovenská kotlina lowland – central part and C) Východoslovenská nížina lowland – eastern part. For the filling of gaps in measured data of sunset duration, necessary for the calculation of Net radiation, the ERA5 Land dataset was used. The values of reanalyzed remote sensing data were calibrated by a simple linear model with net radiation derived from measured data, with a Pearson correlation coefficient 0.69 - moderate correlation. The missing values of the calculated time series were replaced with data from these calibrated ERA5 land Net Radiation dataset.

Results of spatial and seasonal distribution of monthly values of P-M ET0 showed similar course of ET0 for all Slovakia's lowlands, with highest median ofa monthly mean for stations in Východoslovenská nížina Lowland and the smallest median of monthly mean for stations in Juhoslovenská kotlina lowland (Fig.8). The results of trend analyses of ET0 and related variables (Mann-Kendal test of trends) shown, that increasing trend of ET0 in summer months is probably caused by increasing trends of mean temperature in the case of Východoslovenská, Záhorská and Podunajská nížina lowland (Fig.9). However, in the case of Juhoslovenska kotlina lowland, decreasing trends of ET0 was detected. In the winter months, although the trends of mean temperature in the summer months are equally increasing. Analyses of other related meteorological variables (minimum and maximum air temperature, precipitation) didn't bring any reasoning of this result.

Acknowledgement: "This publication is the result of the project implementation: „ Scientific support of climate change adaptation in agriculture and mitigation of soil degradation ” (ITMS2014+ 313011W580) supported by the Integrated Infrastructure Operational Programme funded by the ERDF."

EVAPOTRANSPIRATION GENERATES DIURNAL DISCHARGE FLUCTUATIONS IN FORESTED MICRO-WATERSHEDS

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[2] Institute for Soil Physics and Rural Water Management (SoPhy), Department of Water, Atmosphere and Environment, University of Natural Resources and Life Sciences, Vienna, Austria

Pronounced diurnal discharge fluctuations are observed at the Rosalia hydrological research watershed (Austria) during precipitation-free days from spring until autumn. The daily discharge amplitudes can be about 30 % of the daily mean discharge and are mostly driven by transpiration. A transpiration rate of 1 mm/h for an area of 27 ha (the Rosalia sub-catchment) would result in a water flux of 75 l/s, which is a multiple of the amplitudes observed. Thus, we can hypothesize that only root water uptake in the close vicinity of the various creeks generates these fluctuations.

This study identifies the riparian root system contributing to such discharge fluctuations by analyzing the underlying processes with a HYDRUS 2D model, which has been set up for a characteristic hillslope of a sub-catchment in the Rosalia watershed.

In our assessment of how the riparian vegetation influences the discharge process, different root distribution scenarios were simulated by a stepwise removal of the roots along the creek in the model. The results show that the root water uptake of plants within a distance of 2 m from the stream primarily causes the diurnal discharge fluctuations observed.

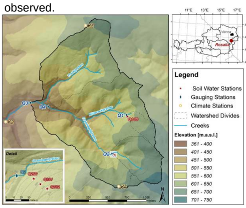
Evapotranspiration generates diurnal discharge fluctuations in forested micro-watersheds

Gabriel Stecher[1], Mathew Herrnegger[1], Reinhard Nolz [2], Josef Fürst[1]

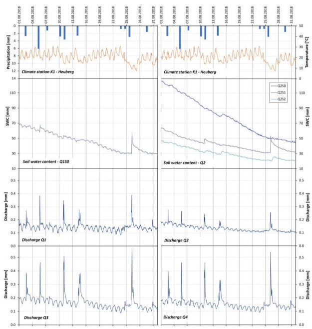
[1] Institute of Hydrology and Water Management (HyWa), University of Natural Resources and Life Sciences, Vienna, Austria
[2] Institute of Soil Physics and Rural Water Management (SoPhy), University of Natural Resources and Life Sciences, Vienna, Austria

Background

At the hydrological research catchment Rosalia[1], strong diurnal discharge fluctuations are observed.



- In precipitation-free periods
- Amplitudes > 30 % of daily mean discharge
- max. Q in the morning (~ 06:00 a.m.)
- Min. Q in the afternoon (~ 15:00 p.m.)



Process is governed by seasonal effects and is driven by evapotranspiration with transpiration as dominant process.

A transpiration rate of 1 mm/h for an area of 27 ha (e.g. Catchment Q2) would result in a water flux of 75 l/s.

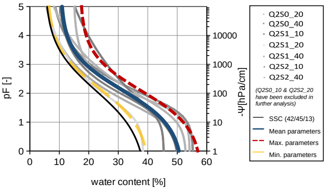
Thus, we hypothesize that only root water uptake in the close vicinity of the various creeks generate these fluctuations.

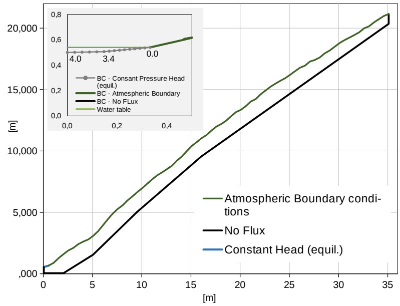
Model set up & Methodology

➢ A HYDRUS[3] 2D model was set up for a characteristic slope transect in the headwaters of the catchment Q2.

Parameters:

- textural soil analyses (42/45/13-SSC)[5] (1 soil sample)
- *(ii)* HYPROP-2[6] automated measurement device (9 soil samples.
- The parameters defining the root water uptake of beech trees are from literature[7]

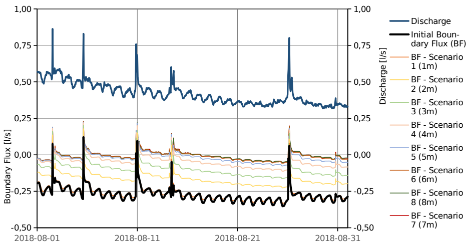


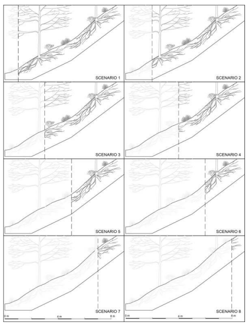


24.11.2022 HydroCarpath 2022

Results

The simulated boundary flux show similar temporal fluctuations and also a comparable magnitude with the observed fluctuations. The simulated root distribution scenarios reveal that diurnal fluctuations of the boundary flux (BF) are only present when roots are defined within 2 m from the creek.





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Conclusion

The results of this analysis show that the root water uptake and therefore the corresponding transpiration of plants within the vicinity (< 2 m) of the creek are the dominant processes leading to diurnal discharge fluctuations in the forested micro-watershed Rosalia. Thus we could determine that only a very small portion of the catchment Q2 transpiration contributes to the generation of discharge fluctuations.

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Evapotranspiration generates diurnal discharge fluctuations in forested micro-watersheds

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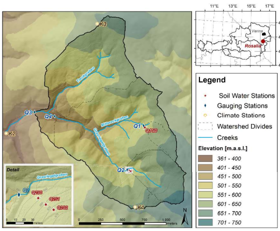
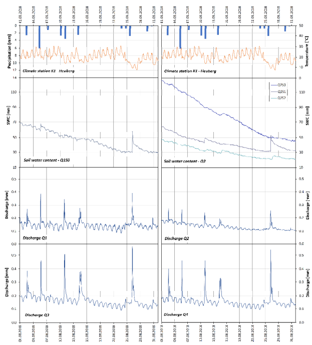
Background

At the hydrological research catchment Rosalia[1], strong diurnal discharge fluctuations are observed. These fluctuations occur only during precipitation-free periods, and the associated amplitudes can be greater than 30 % of the daily mean discharge. The observed fluctuations show a dominant diurnal pattern with maximum discharge in the morning and minimum discharge in the afternoon.



These characteristics would indicate that processes causing diurnal discharge fluctuations are governed by seasonal effects and are driven by evapotranspiration with transpiration as the dominant process[2]. A transpiration rate of 1 mm/h for an area of 27 ha (e.g. Catchment Q2) would result in a water flux of 75 l/s, which is a multiple of the observed amplitudes. Thus, we hypothesize that only root water uptake in the close vicinity of the various creeks generate these fluctuations.

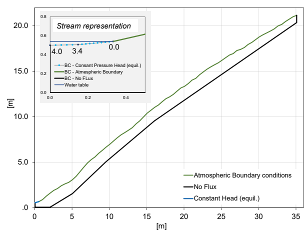
i) Observed data



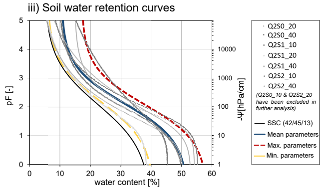
Model set up & Methodology

A HYDRUS[3] 2D model was set up for a characteristic slope transect in the headwaters of the catchment Q2. The soil hydraulic parameters *(van Genuchten[4])* have been derived ***(i)*** based on the textural soil analyses (42/45/13-SSC)[5] and ***(ii)*** using the HYPROP-2[6] automated measurement device for 9 soil samples. Based on the derived parameters, three representative parameter sets capturing the variability of the soil properties have been estimated using a curve fitting approach. The parameters defining the root water uptake of beech trees are from literature[7].

ii) Soil transect



iii) Soil water retention curves

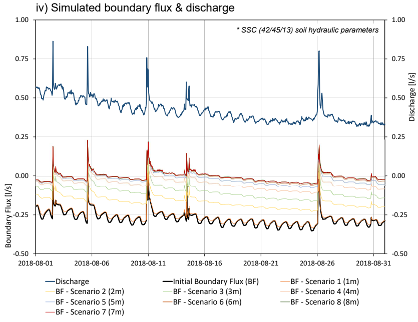


	θr [-]	θs [-]	α [1/cm]	n [-]	m [-]
SSC (42/45/13) parameter	0.0497	0.3983	0.0081	1.5424	0.3516
Min. parameter	0.0587	0.4101	0.0066	1.6092	0.3786
Mean parameter	0.1042	0.5214	0.0077	1.6621	0.3984
Max. parameter	0.1709	0.5857	0.0083	1.6718	0.4019

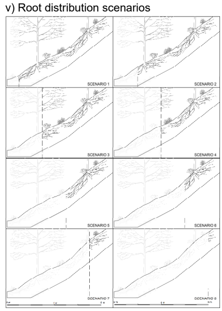
Results

The simulated boundary flux fluctuations show a similar temporal signal and also a comparable magnitude with the observed fluctuations for all simulation periods. The simulated root distribution scenarios reveal that diurnal fluctuations of the boundary flux (BF) are only present when roots are defined within 2 m from the creek. Four different soil hydraulic parameter sets have been used for the simulation to account for the soil heterogeneity. The results show that fluctuations are present independently of the applied parameter sets. However, the magnitude of the boundary flux fluctuations changes.

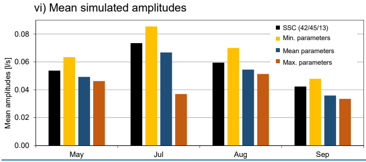
iv) Simulated boundary flux & discharge



v) Root distribution scenarios



vi) Mean simulated amplitudes



Conclusion

The results of this analysis show that the root water uptake and therefore the corresponding transpiration of plants within the vicinity (< 2 m) of the creek are the dominant processes leading to diurnal discharge fluctuations in the forested micro-watershed Rosalia. Thus we could determine that only a very small portion of the catchment Q2 transpiration contributes to the generation of discharge fluctuations.

[1]…Fürst, J., Nachtnebel, H.P., Gasch, J., Nolz, R., Stockinger, M.P., Stumpp, C., Schulz, K., 2021. Rosalia: An experimental research site to study hydrological processes in a forest catchment. Earth Syst. Sci. Data 13, 4019–4034. https://doi.org/10.5194/essd-13-4019-2021

[2]…Gribovszki, Z., Szilágyi, J., Kalicz, P., 2010. Diurnal fluctuations in shallow groundwater levels and streamflow rates and their interpretation - A review. J. Hydrol. 385, 371–383. https://doi.org/10.1016/j.jhydrol.2010.02.001

[3]…Simunek, J., Sejna, M., van Genuchten, M.T., 1999. The HYDRUS2D software package for simulating the two-dimensional movement of water, heat, and multiple solutes in variably-saturate media 227.

[4]…van Genuchten, M.T., 1980. A Closed-form Equation for Predicting the Hydraulic Conductivity of Unsaturated Soils. Soil Sci. Soc. Am. J. 44, 892–898. https://doi.org/10.2136/sssaj1980.03615995004400050002x

[5]…Schaap, Marcel G.; Lej, Feike J.; van Genuchten, M.T., 2002. Rosetta v1.2: A computer program for estimating soil hydraulic parameters with hierarchical pedotransfer functions 251, 163–176

[6]…METER Group AG, 2018. HYPROP User Manual v2018/3, Munich

[7]…Seeger, S., Brinkmann, N., Kahmen, A., Weiler, M., (2015). Tree specific traits vs. Stand level characteristics- investigating plant water uptake in a mixed forest stands. EGU2017 (Poster)

Use of the groundwater of a salt steppic oak forest in Ohat, Hungary, in relation to environmental parameters

Zsombor Kele[1], Csaba László Kiss[1], Zoltán Gribovszki[1], Zsolt Pinke[2], Tamás Ács[3], Zsolt Kozma[3], Péter Kalicz[1]

[1] University of Sopron, Geomatics and Civil Engineering, Hydrology, Hungary
[2] Eötvös Loránd University, Budapest, Hungary
[3] Budapest University of Technology and Economics, Budapest, Hungary

Forest groundwater uptake is an important topic especially in the context of climate change as drought periods become more severe. The categorizations of forest site survey categorization in Hungary does not take into account groundwater under 2.2 meters as a surplus water resource, but research results related to the topic show significant groundwater uptake of trees from a much deeper water table. Diurnal methods are the most classical way to quantify groundwater consumption of ecosystems.

Hardwood forests were historically typical alongside the River Tisza in the Great Hungarian Plain. These ecosystems were supplied by the rivers, directly or indirectly, but today these forests have mostly disappeared because of deforestation. A typical representative of the rest of this ecosystem is a salt steppic oak forest in Ohat, on the edge of Hortobágy. Maps from the 18. century prove, that this area was continuously covered by forests before the great levee-building and water-regulation of Hungary, which drained the significant part of the Hungarian Great Plain. The hydrological year of 2021-2022 is particularly interesting in terms of water uptake analysis because of its extreme dryness and heat.

A groundwater well was settled on 28 May 2021, and on 22 June 2021, a vented pressure transducer was installed to monitor the water table. The water table time series shows strong diurnal groundwater fluctuations, which we used for the groundwater uptake by the oak forest. Within the frame of this research, the groundwater transpiration of this oak stand was analyzed in relation to its environmental parameters.

This research was supported by the NRDI Fund FK 20 Grant Project 134547 and the TKP2021-NKTA- 43 project at the University of Sopron. The TKP2021-NKTA-43 project has been implemented with support provided by the Ministry of Innovation and Technology of Hungary (successor: Ministry of Culture and Innovation of Hungary) from the National Research, Development and Innovation Fund, which is financed under the TKP2021-NKTA funding scheme.

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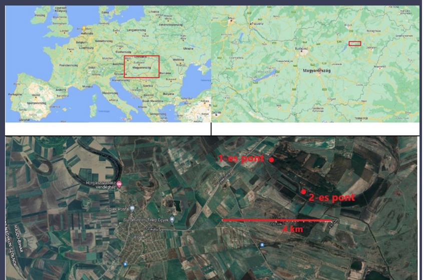
Use of the groundwater of a salt steppic oak forest in Ohat, Hungary in relation to environmental parameters



Kele Zsombor, Kiss Csaba László, Gribovszki Zoltán,
Pinke Zsolt, Ács Tamás, Kozma Zsolt, Kalicz Péter

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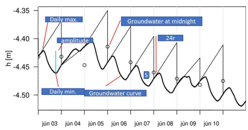
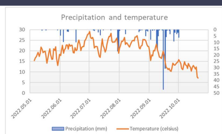
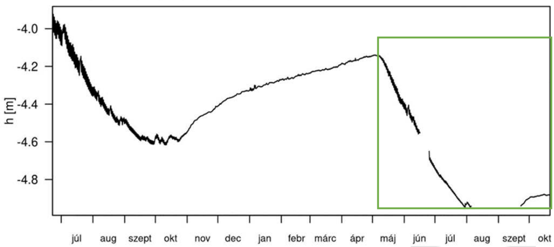
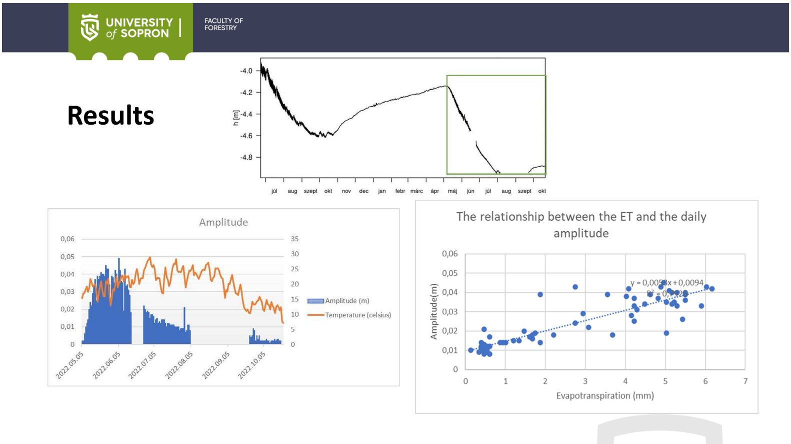
Data and Method





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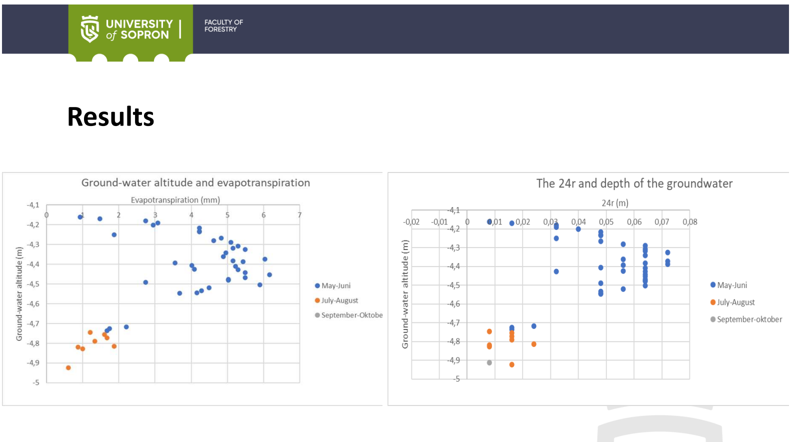
Results
h [m]
júl aug szept okt nov dec jan febr márc ápr máj jún júl aug szept okt
Amplitude
Amplitude (m)
Temperature (celsius)
2022.05.05 2022.06.05 2022.07.05 2022.08.05 2022.09.05 2022.10.05
The relationship between the ET and the daily amplitude
Amplitude(m)
Evapotranspiration (mm)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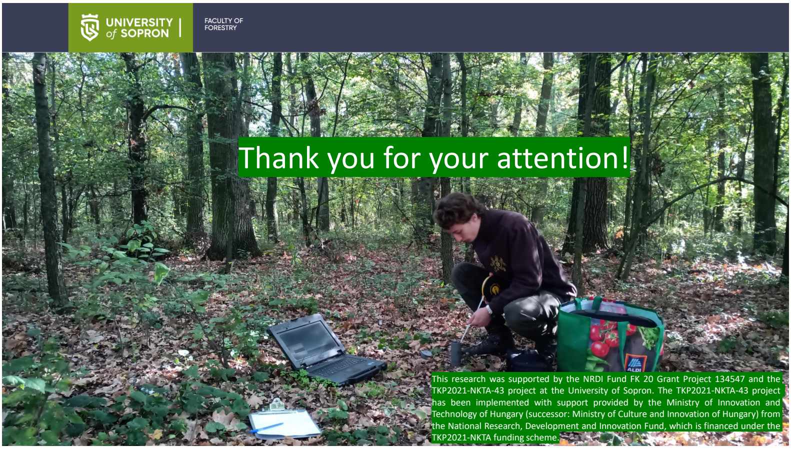
Results
Ground-water altitude and evapotranspiration
Evapotranspiration (mm)
Ground-water altitude (m)
May-Juni
July-August
September-Oktobe
The 24r and depth of the groundwater
24r (m)
Ground-water altitude (m)
May-Juni
July-August
September-oktober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Thank you for your attention!
This research was supported by the NRDI Fund FK 20 Grant Project 134547 and the TKP2021-NKTA-43 project at the University of Sopron. The TKP2021-NKTA-43 project has been implemented with support provided by the Ministry of Innovation and Technology of Hungary (successor: Ministry of Culture and Innovation of Hungary) from the National Research, Development and Innovation Fund, which is financed under the TKP2021-NKTA funding scheme.

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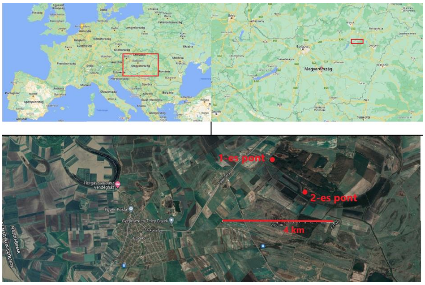
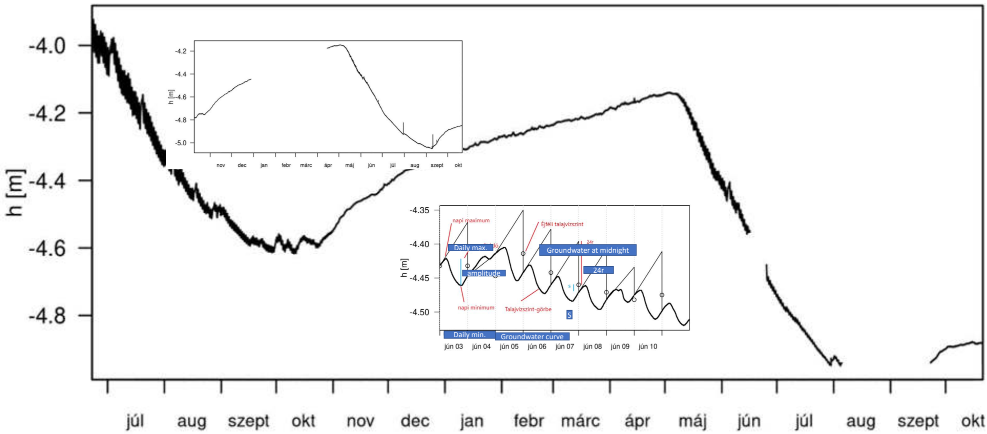
Use of the groundwater of a salt steppic oak forest in Ohat, Hungary in relation to environmental parameters

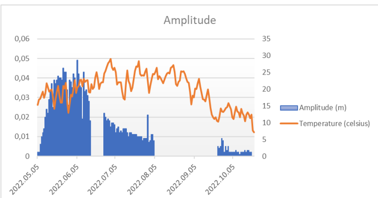
ZSOMBOR KELE[1], CSABA LÁSZLÓ KISS[1], ZOLTÁN GRIBOVSZKI[1], ZSOLT PINKE[2], TAMÁS ÁCS[3], ZSOLT KOZMA[3], PÉTER KALICZ[1]
[1] University of Sopron, Geomatics and Civil Engineering, Sopron, Hungary, [2] Eötvös Loránd University, Budapest, Hungary, [3] Budapest University of Technology and Economics, Budapest, Hungary



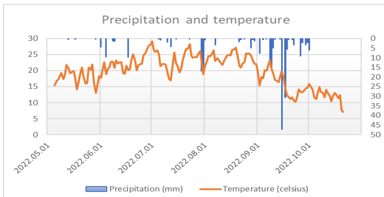
The categorizations of forest site survey categorization in Hungary does not take into account groundwater under 2.2 meters as a surplus water resource, but research results related to the topic show significant groundwater uptake of trees from a much deeper water table.
These ecosystems were supplied by the rivers, directly or indirectly, but today these forests have mostly disappeared because of deforestation. A typical representative of the rest of this ecosystem is a salt steppic oak forest in Ohat, on the edge of Hortobágy in Great Hungarian Plain.
The hydrological year of 2021-2022 is particularly interesting in terms of water uptake analysis because of its extreme dryness and heat.
A groundwater well was settled in 2021, a vented pressure transducer was installed to monitor the water table. The water table time series shows strong diurnal groundwater fluctuations, which we used for the groundwater uptake by the oak forest. Within the frame of this research the groundwater transpiration of this oak stand was analyzed in relation to its' environmental parameters.



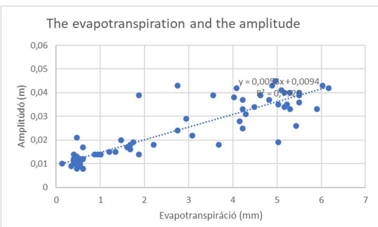
The groundwater altitude of the first fountain (in small: the second fountain) from July of 2021 to Oktober of 2022. There is the figure of the White-method.



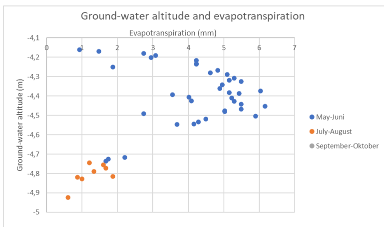
The amplitude of the daily groundwater fluctuation and the temperature



The precipitation and the temperature in the vegetation period of 2022



The connection between the evapotranspiration and the amplitude



The connection between the ground-water altitude and the evapotranspirítion

Acknowledgement: This research was supported by the NRDI Fund FK 20 Grant Project 134547 and the TKP2021-NKTA- 43 project at the University of Sopron. The TKP2021-NKTA-43 project has been implemented with support provided by the Ministry of Innovation and Technology of Hungary (successor: Ministry of Culture and Innovation of Hungary) from the National Research, Development and Innovation Fund, which is financed under the TKP2021-NKTA funding scheme.

Preliminary assessment of the groundwater regime in the Gemenc Region of the Danube-Drava National Park (Hungary)

Zsófia Rusznyák[1], Tamás Nagy[2], Enikő Anna Tamás[1]

[1] University of Public Service, Faculty of Water Sciences, Department of Regional Water Management; Baja, Hungary
[2] Kiskunsági Víziközmű Szolgáltató Ltd.; Kalocsa, Hungary

Data sets of groundwater monitoring wells suitable for characterising the Gemenc and surrounding Danube valley areas were collected. Basic analyses were carried out in order to reveal their relationships with the water flow of the Danube River. The results were compared with the position of groundwater wells, their distance from the Danube, and possible differences in their soil stratification.

In the course of the research, the water level data of the groundwater monitoring wells installed during the GEF project were mainly processed. Of the 13 wells, only 2 wells have recently had data recording instruments, so taking into account the water level of the Danube, manual observation of the wells every two weeks was carried out, and an additional recording instrument was installed.

Based on the available and suitable old and newly collected datasets, part of the area was chosen, and a numerical (computerized) groundwater model (in MODFLOW) was built. During the modeling the various extreme water level ranges of the Danube (persistently extreme low and high water) were taken into consideration, and the effect on the groundwater levels of the floodplain was studied.

HydroCarpath International Conference
Vienna, 24 November 2022

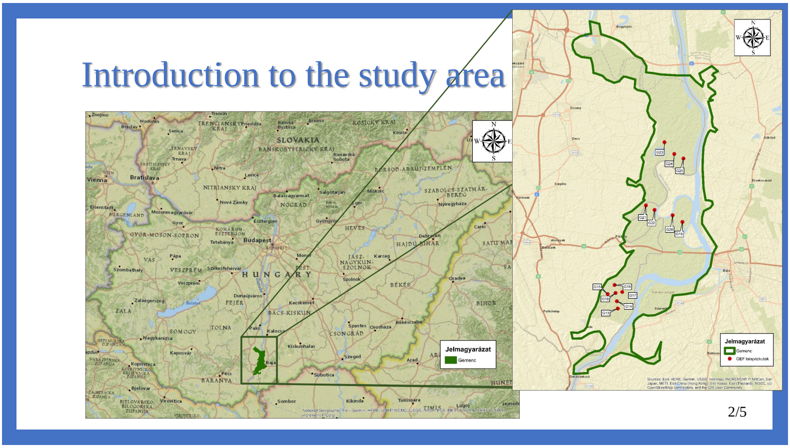
PRELIMINARY ASSESSMENT OF THE GROUNDWATER REGIME IN THE GEMENC REGION OF THE DANUBE-DRAVA NATIONAL PARK (HUNGARY)

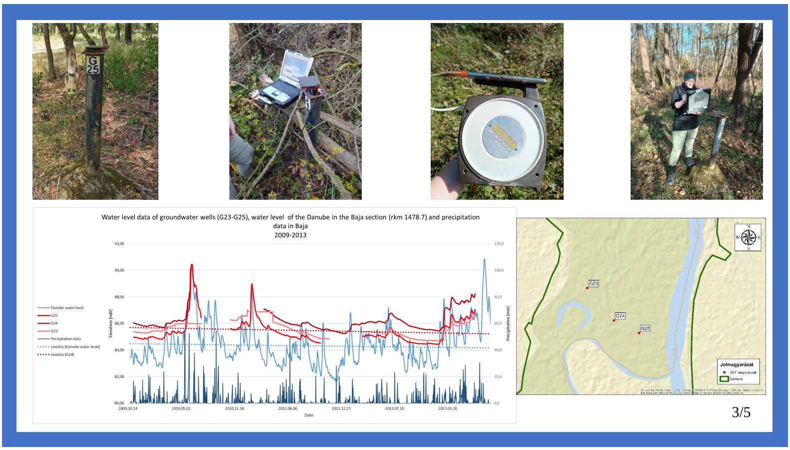
Zsófia Rusznyák (CE student, BSc)
Tamás Nagy (hydro-geologist, mentor)
Enikő Anna Tamás (CE, professor)

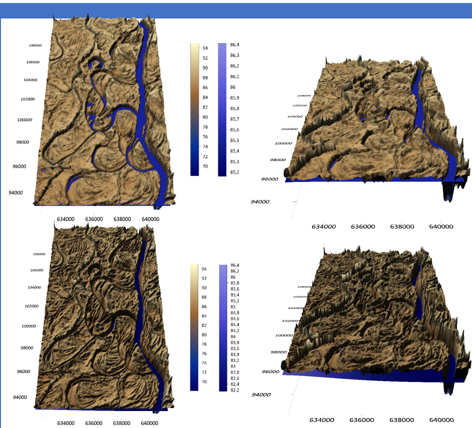
1/5

Introduction to the study area

2/5


Introduction to the study area
SLOVAKIA
HUNGARY
Vienna
Bratislava
Budapest
Jelmagyarázat
Gemenc
2/5


Water level data of groundwater wells (G23-G25), water level of the Danube in the Baja section (rkm 1478.7) and precipitation data in Baja
2009-2013
Danube water level
G25
G24
G23
Precipitation data
Lineáris (Danube water level)
Lineáris (G24)
Elevation [mBf]
Precipitation [mm]
Date
Jelmagyarázat
3/5



Groundwater level in Gemenc
at the mean Danube waterlevels
86,47 m asl

Groundwater level in Gemenc
at a Danube waterlevel half a
meter lower than the ever-
observed minimum
82,18 m asl

4/5

Thank you for the attention!

NATIONAL UNIVERSITY OF PUBLIC SERVICE
FACULTY OF WATER SCIENCES

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Dr. Enikő Anna Tamás
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Faculty of Water Sciences

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tamas.eniko.anna@gmail.com

HydroCarpath International Conference 24.11.2022.

Preliminary assessment of the groundwater regime in the Gemenc Region of the Danube Drava National Park (Hungary)

Figure 1: DATAQUA installation at well no. G25

The aim of this research was to investigate the groundwater balance of the Gemenc floodplain forest, with special regard to the impact of the Danube on groundwater.

The basis of the study was the groundwater level time series provided by the Danube Drava National Park, the Lower Danube Valley Water Directorate and the Central Transdanubian Water Directorate, the drilling sections of the wells, precipitation data and the time series of the Danube water level. Furthermore, from August 2022 to early November 2022, manual detection in most wells was done during field trips, and a DATAQUA water level meter was installed in the G25 well.

On the data measured and recorded in the groundwater wells, the data on the Danube water level and the rainfall data measured in Baja, a comparative study was carried out for the same period, from which we concluded that it decreases simultaneously and at the same rate as the water level of the Danube.

We then examined the groundwater balance of the area using a hydrodynamic model, for which the MODFLOW module of the Processing Modflow 5.3 modeling software was used.

In the first round, a rectangular model area was delimited with a side length of 9 km and a side height of 16 km, the orientation of which is north-south. The model consists of cells with a scale of 50 x 50 meters. I constructed the surface of the model and layer boundaries using Surfer software. Based on the drilling layer rows, two model layers were singled out. The first layer of the model mainly represents fine-grained, clayey aleurite and fine-grained sand aleurite, while in the second layer, in addition to those mentioned above, small and medium-grained sand represents formations with a geological structure.

The model was successfully run, the groundwater level potentials estimated on the basis of the model approximate the values measured in the wells when the water level of the Danube below medium high water (89.00 m B.f.). The difference of more than 2 meters between the modeled and measured values in the large water can be justified by the fact that the Danube completely floods the floodplain forest area at a water level of 92.68 m B.f. In such a case, groundwater level detection and recording instruments are removed from the wells to protect them.

According to the model variants for different water levels, for water levels lower than the medium high water used in my thesis, the model can be a good estimate of the groundwater levels in the studied area.

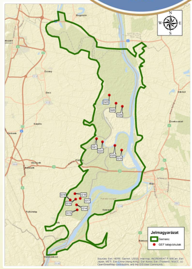


Figure 2 : GEF wells

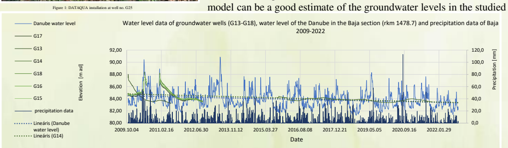


Figure 3: Data of groundwater wells (G13-G18) water level, water level of the Danube in the Baja section (rkm 1478.7) and baja precipitation data 2009-2022

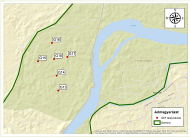


Figure 4: Site plan of G13-G18 wells

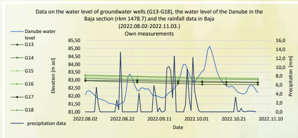


Figure 5: Water level data of groundwater wells (G13-G18), water level of the Danube in the Baja section (rkm 1478.7) and precipitation data in Baja (02.08.2022-02.11.2022) Own measurements

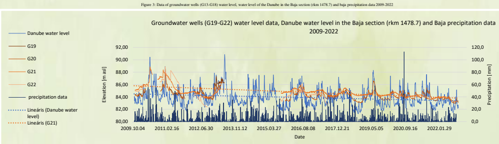


Figure 6: Groundwater wells (G19-G22) water level data, water level of the Danube in the Baja section (rkm 1478.7) and baja precipitation data 2009-2022

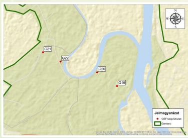


Figure 7: Site plan of G19-G22 wells

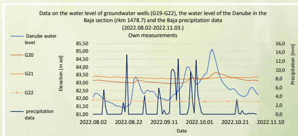


Figure 8: Water level data of groundwater wells (G19-G22), water level of the Danube in the Baja section (rkm 1478.7) and baja precipitation data (02.08.2022-02.11.2022) Own measurements

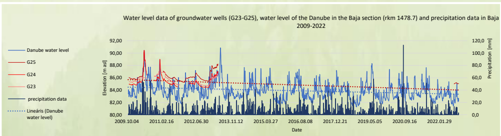


Figure 9: Groundwater wells (G23-G25) water level data, water level of the Danube in the Baja section (rkm 1478.7) and baja precipitation data 2009-2022

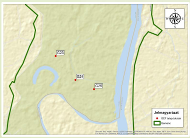


Figure 10: Site plan of G23-G25 wells

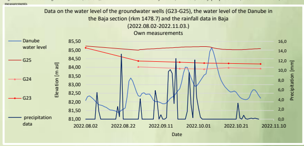
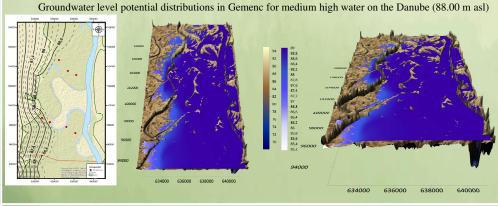
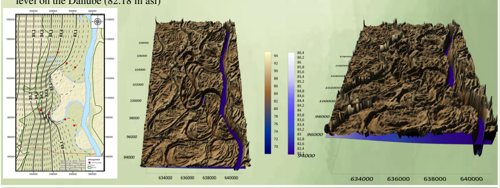


Figure 11: Data on the water level of the groundwater wells (G23-G25), the water level of the Danube in the Baja section (rkm 1478.7) and the precipitation data in Baja (02.08.2022-02.11.2022) Own measurements

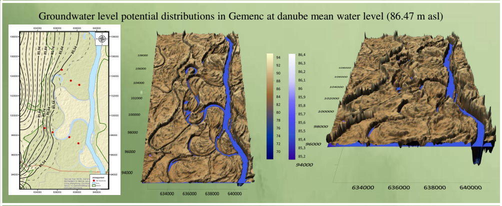
Groundwater level potential distributions in Gemenc for medium high water on the Danube (88.00 m asl)



Groundwater level potential distributions in Gemenc at water levels half a meter lower than the lowest water level on the Danube (82.18 m asl)

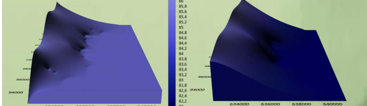


Groundwater level potential distributions in Gemenc at danube mean water level (86.47 m asl)

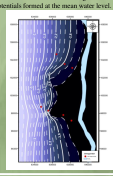


Groundwater level potential distributions in Gemenc at danube mean water level (86.47 m asl)

Groundwater level potential distributions in Gemenc at water levels half a meter lower than the lowest water level on the Danube (82.18 m asl)

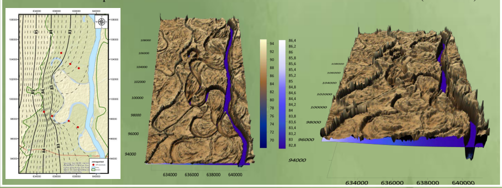


The difference between the water level half a metre lower than the minimum water level ever measured and the groundwater potentials formed at the mean water level.



As a result of the 0.5-meter decrease in the riverbed and water level of the Danube, a drastic decrease in the groundwater level of Gemenc will also be observed. Compared to the middle water level, a decrease in groundwater level of up to -3.4 meters can occur.

Groundwater level potential distributions in Gemenc at the lowest water level on the Danube (82.65 m asl)



Among the model runs, we also examined a water level half a meter lower than the lowest water level on the Danube recorded so far, which, if it occurs, will most likely lead to a decrease not only in the groundwater level, but also in the frequency of flooding and the extent of wetlands, which will make life and food-obtaining conditions difficult for living creatures, thus completely transforming the Gemenc ecosystem.

In order to preserve the species of the countless protected plants and animals found in Gemenc, the reconstruction of wetlands is essential. Native plants can still be found in the heavily weeded undergrowth, if we act in time, the reconstruction of floodplain plant associations can be solved.

Authors
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Differences in the groundwater supply between a forest and agricultural land cover on the Great Hungarian Plain

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As a result of climate change, decreases in the water supply have become a global issue. Due to its positive effects on the local microclimate, forest vegetation could be used as a tool to mitigate this phenomenon. However, the hydrological impact of lowland forests is still a subject of debate. Forest stands on the Great Hungarian Plain need supplementary water, which is usually provided by the groundwater. In order to evaluate the water supply at a forested and a connected control monitoring point, periods without precipitation were selected from a long-term data set, and the night-time groundwater dynamics was used according to the White method. The results showed significant differences between the types of vegetation studied.

This article was made in frame of the project TKP2021-NKTA-43 which has been implemented with the support provided by the Ministry of Innovation and Technology of Hungary (successor: Ministry of Culture and Innovation of Hungary) from the National Research, Development and Innovation Fund, financed under the TKP2021-NKTA funding scheme.

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Differences in groundwater supply between forest and agricultural land cover in Great Hungarian Plain

Szabo A. [1*], Bolla B. [1], Balog K. [2], Kalicz P. [3], Gribovszki Z. [3]

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Hydrocarpath conference 24.11.2022. Vienna , Austria

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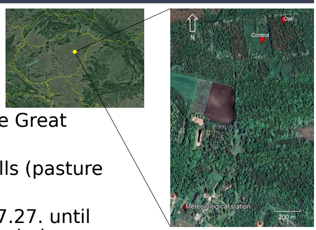
Groundwater supply



- Crucial factor in forest management on the Great Hungarian Plain
- Study site: GW data from 2 monitoring wells (pasture and Oak forest)
- Rainless days were selected (from 2015.07.27. until 2020.06.28.) in dormant and vegetative periods.
- GW supply was evaluated based on the night-time increase of GW (White-method)
- Average GW level and difference in average GW level (forest minus control) were used as independent variables.

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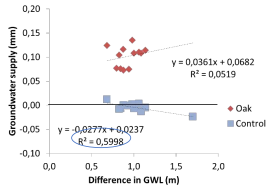
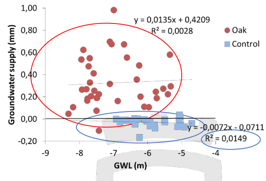
Results & Conclusions

- GW supply has a GW depths dependence under control in the dormant period
- There is no such observable trend in vegetative period
- GW supply is always greater but the spread of the values is bigger in case of forest.





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Thank you for your attention!

Differences in groundwater supply between forest and agricultural land cover in Great Hungarian Plain

Szabo A. [1*], Bolla B. [1], Balog K. [2], Kalicz P. [3], Gribovszki Z. [3]

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Materials and methods

The study site is located on the Great Hungarian Plain at Püspökladány (Fig. 1.) consist of two monitoring points: The Oak (Quercus robur) forest (47°20'029.48" N, 21°50'42.16" E) and the adjacent pasture as control (47°20'026.29"N, 21°50'37.46" E) The area is flat there is insignificant difference in height between the monitoring points. The mean annual precipitation in the area is 520–560 mm/year. The groundwater level (GWL) was measured by a DA-LUB 222-type instrument (Dataqua Ltd.) in every 15 minutes (Fig.2.). Dry periods (when the sum of precipitation were less than 3 mm in every consecutive three days) were selected from the-long term data sets (from 2015.07.27. to 2020.06.28.) With this method 37 and 23 periods were selected in the vegetative period and dormant period respectively.

The average groundwater supply were evaluated by the White-method: 24r*Sy, where: Sy is the specific yield depends on the given soil (dimensionless) and r is the increase of groundwater table (mm).

Connection between the average GWL and difference in average GWL (forest minus control) as independent variables and the evaluated groundwater supply was analysed by linear regression separately. The number of cases is less when difference in GWL was used (30 and 12 in the vegetative period and dormant period respectively), due to the occasional lack of data at the control point. Outliers were excluded.

Fig. 1: The location of the monitoring points

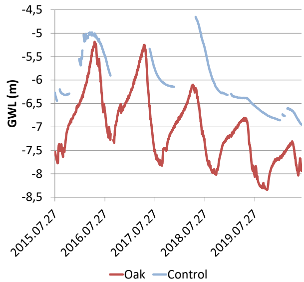
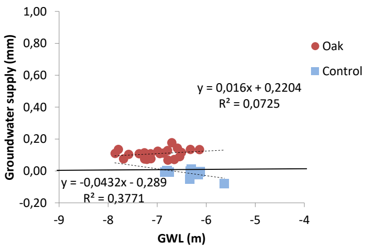
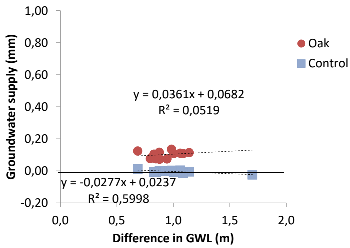


Fig. 2: Groundwater level data from the whole observed period

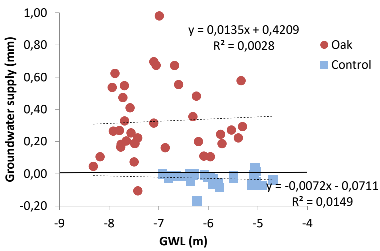


a

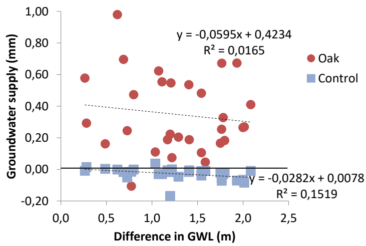


b

Fig. 3: Connection between average evaluated groundwater supply, average groundwater level (a) and differece in average groundwater level (b) in dormant period (GWL: groundwater level)



a



b

Fig. 4: Connection between average evaluated groundwater supply, average groundwater level (a) and differece in average groundwater level (b) in vegetative period (GWL: groundwater level)

Results and Conclusions:

- GW supply is always greater but the spread of point is bigger in case of forest. (Fig.3., Fig.4.)
- GW supply has a GW depths dependence under control in the dormant period (Fig. 3.)
- There is no such observable trend in vegetative period (Fig. 4.), and the GW supply is under the forest is much greater.

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Acknowledgement

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GROUNDWATER DYNAMICS OF A COMMON ALDER FOREST

KATALIN ZAGYVAI-KISS[1], ANDRÁS HERCEG[1], BLANKA HOLIK[1], CSENGE NEVEZI[1], PÉTER KALICZ[1], ZOLTÁN GRIBOVSZKI[1]

[1] University of Sopron, Faculty of Forestry, Institute of Geomatics and Civil Engineering

Forests in valleys are oftentimes strictly protected; thus, understanding the changes in their water balance when considering climate change is crucial for their survival. This especially applies to the vegetation of riparian zones, which strongly depends on hydrological factors.

The hydrology of a riparian alder forest at the outlet of an experimental catchment in the eastern foothills of the Alps (in Hungary) was studied. The meteorological parameters were measured in an open-air plot next to the ecosystems examined. An analysis of the groundwater level dynamics was accomplished using newly installed groundwater wells. The precipitation-groundwater relationship was examined in a complex way. The magnitude of the groundwater recharge from below as well as the temporal and spatial dynamics of the groundwater were evaluated. The vegetation's use of groundwater in the context of the environmental parameters was also analyzed using high frequency groundwater level measurements.

Based on the results, it can be stated that the groundwater uptake of the alder forest is significant in dry periods; consequently, the riparian forests will have increased water demands in the future due to the changing climate.

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Groundwater Dynamics of a Common Alder Forest

Katalin Zagyvai-Kiss, András Herceg, Blanka Holik, Csenge Nevezi, Péter Kalicz, Zoltán Gribovszki
University of Sopron, Faculty of Forestry, Institute of Geomatics and Civil Engineering

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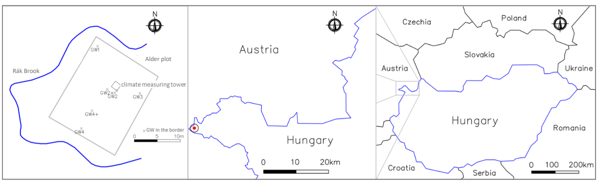
Research area



- six wells in the alder dominated forest ecosystem (depth ~ 1-2 m)
- one well in the border of the forest stand and the meadow
- groundwater level is manually measured on average weekly
- well 4+ both manually and automatically measured
- climatic parameters: nearby meteorological station (precipitation, air temperature and relative humidity)

- sub-alpine climate: average annual temperature of 9.2 °C
  annual precipitation of 750 mm

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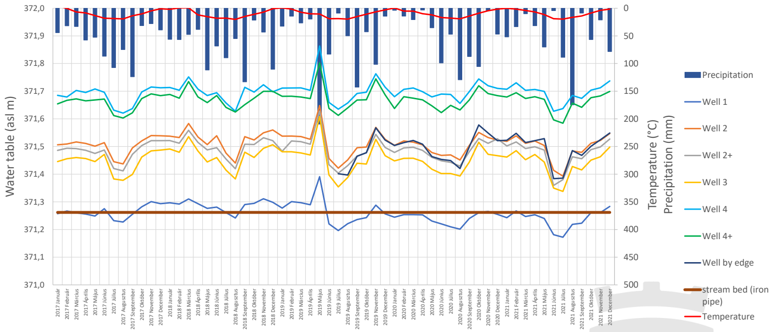
Research area



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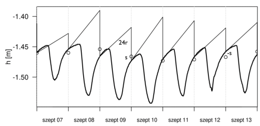
Method



PET after **Hamon** method (1963):

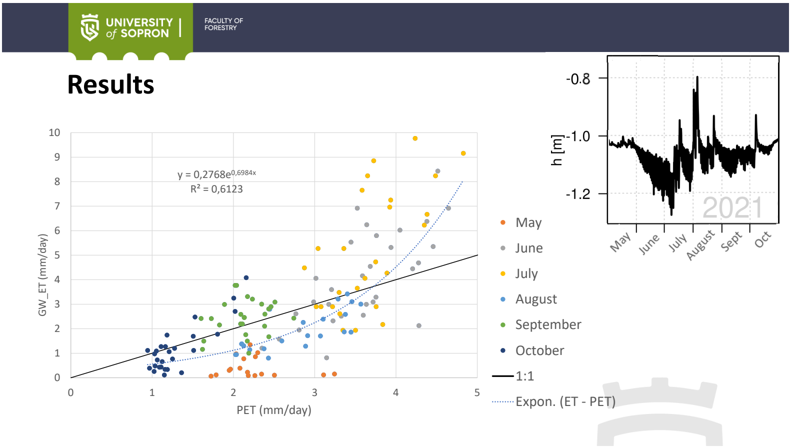
$$PET = 29{,}8 \times D \times \frac{e}{T + 273{,}2}$$

where *D*: length of the day; *e*: saturation vapor pressure; *T*: average daily air temperature.

Evapotranspiration from groundwater (*ET_GW*) after **White** method (1932):

$$ET\_GW = (24 \times r \pm s) \times Sy$$

Where *Sy* Specific yield of the soil (as the ratio of the volume of water that saturated soil yields by gravity to); *r* is the average difference in water level in the period between 0 and 4 hours (mm/hour); *s* is the change in groundwater storage.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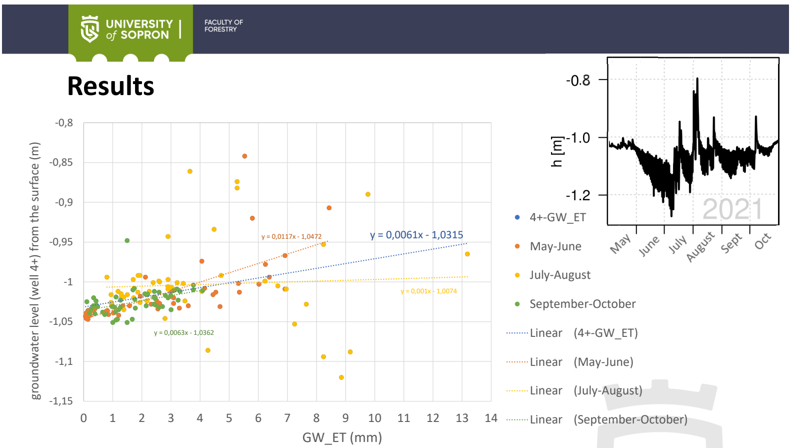
Results
y = 0,2768e^0,6984x
R² = 0,6123
GW_ET (mm/day)
PET (mm/day)
May
June
July
August
September
October
1:1
Expon. (ET - PET)
h [m]
-0.8
-1.0
-1.2
2021
May
June
July
August
Sept
Oct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Results
groundwater level (well 4+) from the surface (m)
GW_ET (mm)
y = 0,0117x - 1,0472
y = 0,0061x - 1,0315
y = 0,001x - 1,0074
y = 0,0063x - 1,0362
4+-GW_ET
May-June
July-August
September-October
Linear (4+-GW_ET)
Linear (May-June)
Linear (July-August)
Linear (September-October)
h [m]
-0.8
-1.0
-1.2
2021
May
June
July
August
Sept
Oct


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Groundwater Dynamics of a Common Alder Forest

Katalin Zagyvai-Kiss, András Herceg, Blanka Holik, Csenge Nevezi, Péter Kalicz, Zoltán Gribovszki

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The hydrology of a riparian alder forest at the outlet of an experimental catchment in the eastern foothills of the Alps (in Hungary) was studied. The meteorological parameters were measured in an open-air plot next to the ecosystems examined. An analysis of the groundwater level dynamics was accomplished using newly installed groundwater wells. The precipitation-groundwater relationship was examined in a complex way. The magnitude of the groundwater recharge from below as well as the temporal and spatial dynamics of the groundwater were evaluated. The vegetation's use of groundwater in the context of environmental parameters was also analyzed using high frequency groundwater level measurements.

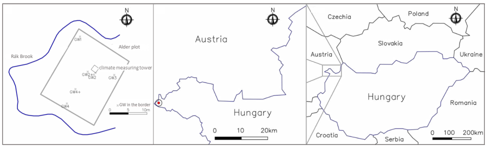

Figure 1. Location of the research area.

Seven monitoring points are in this area, i.e., six wells in the alder dominated forest ecosystem and one well in the border of the forest stand and the meadow. The groundwater level is measured manually on average weekly and in well 4+, groundwater level is recorded both manually and automatically. The climatic parameters such as the precipitation, air temperature and relative humidity are continuously recorded at a nearby meteorological station. Temperature and relative humidity are also recorded in the alder research plot too.
The area enjoys sub-alpine climate with an average annual temperature of 9.2 °C and annual precipitation of 750 mm. Tertiary fluvial sediments (mostly of sandy type) were deposited in the area. The depth of the groundwater monitoring system is 1-2 m.

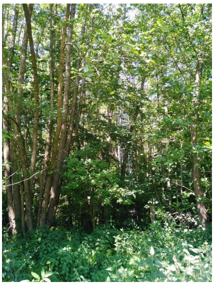

Figure 2. Research site.

The population of the sample area was also recorded to determine the dominant common alder (*Alnus glutinosa*) and the characteristic species appearing next to it, which are the following: Wych elm (*Ulmus glabra*) in the upper canopy level; at bush level: hazelnut (*Corylus avellana*), dog-berry (*Cornus sanguinea*); and in the understory level: hedge nettle (*Stachys sylvatica*), ground elder (*Aegopodium podagraria*) and yellow archangel (*Galeobdolon luteum*) were the most common.

Alder LAI	7 m^2/m^2
Height of dominant trees	22,2 m
Breast height diameter	18-20 cm

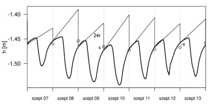

Figure 3. Groundwater dynamics in a week.

The study mainly discusses the analysis of potential evapotranspiration (PET) and groundwater level. Potential evapotranspiration is a theoretical type of evaporation, which is the combined rate of soil and vegetation evaporation in the event that moisture is continuously available without limits, so its magnitude is limited only by the available energy (Thornthwaite 1948).
PET after Hamon method (1963):

$$PET = 29{,}8 \times D \times \frac{e}{T + 273{,}2}$$

where *D*: length of the day; *e*: saturation vapor pressure; *T*: average daily air temperature.
Evapotransiration from groundwater (*ET_GW*) after White method (1932):

$$ET\_GW = (24 \times r \pm s) \times Sy$$

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Hamon, W.R. (1963): Computation of Direct Runoff Amounts from Storm Rainfall. International Association of Scientific Hydrology Publication 63, 52-62.
Thornthwaite C.W. (1948): An Approach Toward a Rational Classification of Climate. Geographical Review 38, 55-94. https://doi.org/10.2307/210739
White W.N. (1932): Method of estimating groundwater supplies based on discharge by plantsand evaporation from soil results of investigation in Escalante Valley, Utah. US. Geological Survey, Water Supply Paper 659 A: 1-105.

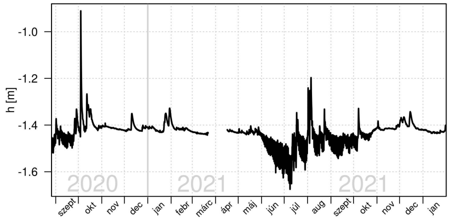

Figure 4. Groundwater-level time series of the Well 4+.

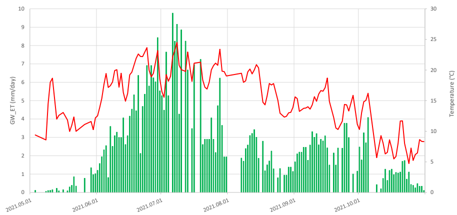

Figure 5. Temperature (red line) and groundwater evapotranspiration of the Well 4+ (green column) during the growing season in 2021.

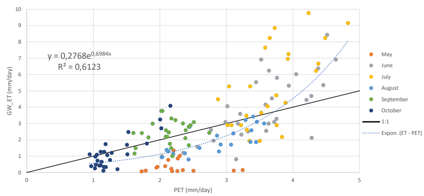

Figure 6. Connection between the daily groundwater evapotranspiration of the Well 4+ and the potential evapotranspiration.

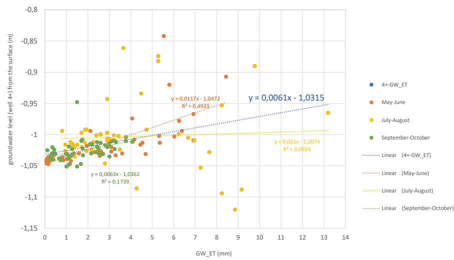

Figure 7. Connection between the groundwater level and the groundwater evapotranspiration of the Well 4+.

Based on the results, it can be stated that the groundwater uptake of the alder forest is significant in dry periods; consequently, the riparian forests will have increased water demands in the future due to the changing climate. A tree growth study was started near the wells with different ground water levels, which will enable a related study of the relationship in the future.

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Impact of climate change on the water resources in the Thaya basin

Juraj Parajka[1], Adam Vizina[2], Jürgen Komma[1], Peter Valent[1], Petr Štepánek[3], Klaus Haslinger[4], Theresa Schellander-Gorgas[4], Marek Viskot[5], Milan Fischer[3], Walter Froschauer[6], Miroslav Trnka[3], Günter Blöschl[1]

[1] Institute of Hydraulic Engineering and Water Resources Management, Faculty of Civil Engineering, Vienna University of Technology, Vienna, Austria (parajka@hydro.tuwien.ac.at)
[2] T.G. Masaryk Water Research Institute: Prague, Prague, Czech Republic
[3] CzechGlobe — Global Change Research Centre AV CR, Czech Republic
[4] Central Institute for Meteorology and Geodynamics (ZAMG), Vienna, Austria
[5] Moravia River Management Company, Brno, Czech Republic
[6] Amt der Niederösterreichischen Landesregierung, Abteilung Wasserwirtschaft, St. Pölten, Austria

The Thaya is a trans-national river that is shared between the Czech Republic and Austria. Multiple water uses and the combined effect of increased water demand and droughts (particularly in 2017 and 2018) have recently resulted in the reconsideration of the water management strategies of the Thaya basin for the climate of the present and future. The aim of this study is to examine the effect of climate change on the water balance of the Thaya, both in the past and in the future. The focus is on identifying the availability of water under various scenarios and how the availability of water may change for future climate scenarios. The evaluation is based on a modelling concept, which includes two hydrological models (the BILAN and TUWmodel), the WATERRES water use module, and a large sample of climate projections (the CMIP5 and CMIP6 models), which represent various socioeconomic pathways combined with projections of possible changes in water use. The results provide an insight into how the water balance in different parts of the Thaya basin has changed in the past and what are the possible effects of climate change on these water resources in the future.

Impact of climate change on the water resources in the Thaya basin

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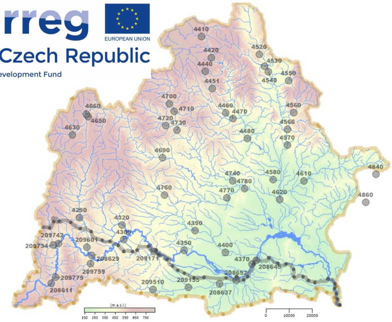
EUROPÄISCHE UNION · TECHNISCHE UNIVERSITÄT WIEN · Czech Hydrometeorological Institute · ZAMG · CzechGlobe · VÚV TGM · POVODÍ MORAVY

Abstract

The Thaya is a trans-national river that is shared between the Czech Republic and Austria. Multiple water uses and the combined effect of increased water demand and droughts (particularly in 2017 and 2018) have recently resulted in the reconsideration of the water management strategies of the Thaya basin under the present and future climates. The aim of this study is to examine the effect of climate change on the water balance of the Thaya, both in the past and in the future. The focus is on identifying the availability of water under various scenarios and how the availability of water may change for future climate scenarios. The evaluation is based on a modelling concept, which includes two hydrologic models (BILAN and TUWmodel), the WATERRES water use module and a large sample of climate projections (the CMIP5 and CMIP6 models), which represent various socioeconomic pathways combined with projections of possible changes in water use. The results provide an insight into how the water balance in different parts of the Thaya basin has changed in the past and what are the possible effects of climate change on these water resources in the future.performance.

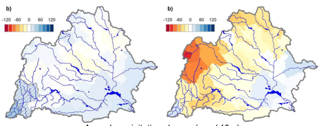
Interreg Austria-Czech Republic
European Regional Development Fund
EUROPEAN UNION
THAYA/DYJE



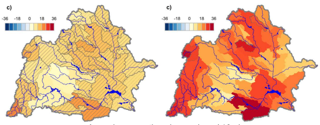
Topography and river network of the Thaya basin and location of discharge gauges.

Trend analyses

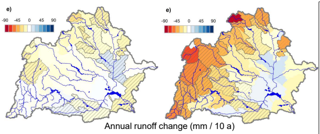
1981-2020 **2000-2020**



Annual precipitation change (mm / 10 a)

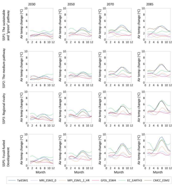


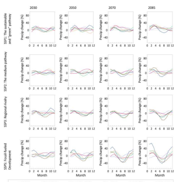
Annual evaporation change (mm / 10 a)

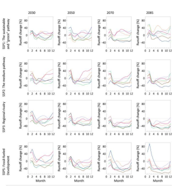


Annual runoff change (mm / 10 a)

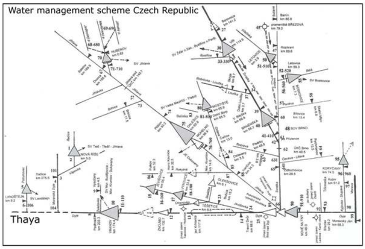
Future projections







Water usage and management



The scheme of water management system in Thaya basin (CZ part)

CMIP5 (ZAMG)	CMIP6 (CzechGlobe)
RCP4.5 (4 models)	SSP126 (7 models)
RCP8.5 (6 models)	SSP245 (7 models)
	SSP370 (7 models)
	SSP585 (7 models)
Downscaled by „EPISODES Method“	Downscaled by „Advanced Delta Method“

+ Water use scenarios:

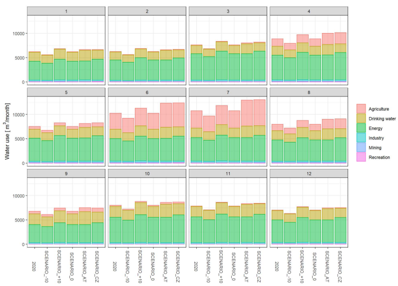
1) SCENARIO_CZ: Scenario based on current studies (from Czech Republic): Industry: + 0 %, Drinking water: + 0 %, Agriculture + 50 %, Energy: + 10 %, Recreation: + 20 %.

2) SCENARIO_AT: Scenario based on current studies (from Austria: Industry: + 5 %, Drinking water: + 20 %, Agriculture : + 50 %, Energy: + 0 %, Recreation: + 0 %.

3) SCENARIO_+10: + 10 % of current values (2019): increase in all sectors (irrigation, increased needs for cooling power plants,....)

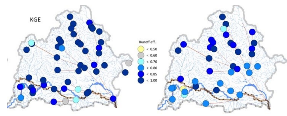
4) SCENARIO_0: 0 % of current values (2019): conservative

5) SCENARIO_-10: -10 % of current values (2019): a scenario involving water treatment

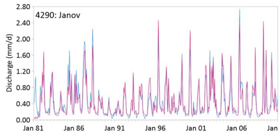


An overview of the individual scenarios for future water use

Hydrological modelling



Runoff model efficiency (monthly Kling-Gupta) obtained in the calibration period 1981-2010.



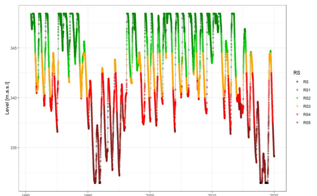
Comparison between observed (blue line) and simulated (red line) monthly discharge for station Janov (517.96 km2) in the calibration period 1981-2010

POVODÍ MORAVY
Povodí Moravy, s. p.
Dřevařská 11, Brno

Schválil:	Odbor VLHZ Jm KNV v Brně
Dne:	14. 3. 1983
Č.j.:	Vod. 60/83-235 Zd
S platností do:	Konec platnosti nebyl stanoven

MANIPULAČNÍ ŘÁD
pro
VD Vranov
na řece Dyji v km 175,405

VN VRANOV – BILAN RCP8.5 MIROC



Influence of climate change on the variability of the forest community

Viktória Gáspár[1]

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Climate change, global warming, and the greenhouse effect originate from both anthropogenic and natural factors, but human activity strengthens these phenomena. These global changes affect forest communities, either their structural composition or the variability of species in the biocenosis. Modifications in the climate and atmosphere disrupt the balance of the interrelationships of individual components and the existence of direct and feedback links in forest ecosystems. Increasing the concentration of CO2 and the average temperature, changes in the amount and distribution of precipitation and subsequent changes in the water balance, increasing UV-B radiation and changes in the frequency and intensity of extreme climatic events directly as well as indirectly affect the composition of forest ecosystems.

Changes in bioclimatic conditions have resulted in the rebirth of forest communities along the Danube River. Due to the urbanization of Petržalka, which is a neighborhood in Bratislava, Slovakia, the forest habitats of some floodplain forests have been divided into smaller areas. This phenomenon has led to changes in the light and thermal conditions in various floodplain communities. Another change in conditions occurred during the construction of the Gabčíkovo waterworks in 1977, which disrupted the water regime of the surrounding floodplain forests. It must be realized that floodplain communities are ecotypes whose tolerance of optimal limits corresponds to local conditions. The regulation of natural conditions can change the optimal tolerance limits of species, thereby reducing the intensity of the vital activity of the species that are typical of floodplain forests.

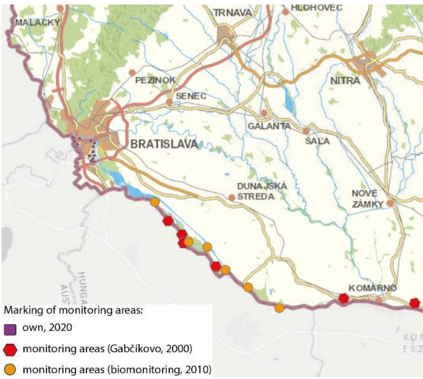
Keywords: forest variability, forest morphology, forest fragmentation

Slovak University of Technology in Bratislava

INFLUENCE OF CLIMATE CHANGE ON THE VARIABILITY OF THE FOREST COMMUNITY

Ing. Viktória Gáspár

Department of Land and Water Resources Management, Faculty of Civil Engineering, Slovak University of Technology



Study Area and Methodology

- We examined phytocenological records from 1990 to 2020 from the annual reports of Gabčíkovo Nagymaros, from the biomonitoring, and from own field records.
- We compared data with historical data from phytocenological records from Gabčíkovo and biomonitoring. After that, we formulated a hypothesis based on which we found that changes in the structure of floodplain forests influence changes in

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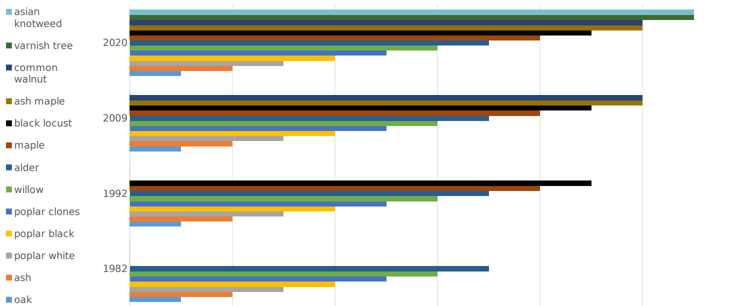
Change in the tree composition of floodplain forests



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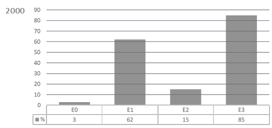
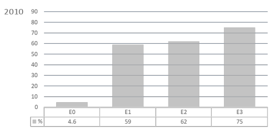
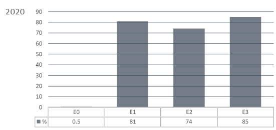
Results

The individual monitored areas had different manifestations, which can be attributed to the different locations of the locations.







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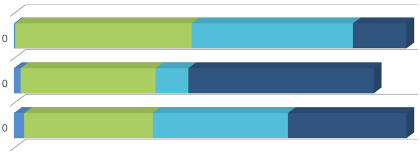
Conclusion

The current condition of the composition of floodplains resulting from phytological records and field surveys indicates an increase in the risk of climate-sensitive species/habitats that have a narrow tolerance limit.



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Thank you for your attention!

INFLUENCE OF CLIMATE CHANGE ON THE VARIABILITY OF THE FORESTCOMMUNITY

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ABSTRACT

Climate change, global warming, and the greenhouse effect originate from both anthropogenic and natural factors, but human activity strengthens these phenomena. These global changes affect forest communities, either their structural composition or the variability of species in the biocenosis. Modifications in the climate and atmosphere disrupt the balance of the interrelationships of individual components and the existence of direct and feedback links in forest ecosystems. Increasing the concentration of CO2 and the average temperature, changes in the amount and distribution of precipitation and subsequent changes in the water balance, increasing UV-B radiation, and changes in the frequency and intensity of extreme climatic events directly as well as indirectly affect the composition of forest ecosystems. Changes in bioclimatic conditions have caused the rebirth of forest communities along the Danube River. Due to the urbanization of Petržalka, which is a neighborhood in Bratislava, Slovakia, the forest habitats of some floodplain forests have been divided into smaller areas. This phenomenon has led to changes in the light and thermal conditions in various floodplain communities. Another change in conditions occurred during the construction of the Gabčíkovo waterworks in 1977 which disrupted the water regime of the surrounding floodplain forests. Must be realized that floodplain communities are ecotypes whose tolerance of optimal limits corresponds to local conditions. The regulation of natural conditions can change the optimal tolerance limits of species, thereby reducing the intensity of the vital activity of the species that are typical of floodplain forests.

1 Study Area and Methodology

Fig 1. Location of the monitoring areas

To determine the changes in forest morphology and forest composition, we used a methodical procedure that is based on comparing field data from several time horizons (using a time series of entries). During the selection of monitoring areas, the first step was the survey of the interest area to determine the selection of reference areas. For the survey of the territory, we used various map materials. The thesis examined phytocenological records from 1990 to 2020 from the annual reports of Gabčíkovo Nagymaros, from the biomonitoring site and own field records. To preserve the homogeneity of the collected data, we also made phytocenological records in the field at the end of October 2020. We selected thirteen reference areas based on detailed analyzes to correspond to different forest conditions. For the year 2010, data from annual reports were used, where 6 reference sections are monitored, and phytocenological records from biomonitoring, of which there were 6 in particular. For the year 2000, we used data only from reference points from Gabčíkovo. These reference areas are along the Slovak section of the Danube in a natural environment, and some of the sections belong to the area with controlled flooding. With the help of these entries, we evaluated the average coverage of individual floors in the reference sections of the Pannonian floodplain forests for the years 2000, 2010 and 2020. Which helped us create a real picture of the change in forest morphology and forest composition.

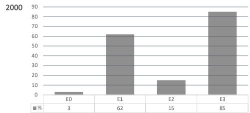
Unlike in Petržalka, 13 areas (with an area of 15x45m) in an urbanized environment are being investigated, which are cut off from surface water fluctuations. In the article, a typical phytocenological record from Veľký Zemník is attached, which describes information about the characteristics of the vegetation, and the coverage of individual floors. This information is important in the synthesis or diagnosis of typological units. Phytocenological record from Veľký Zemník, describes information about the characteristics of the vegetation, and the coverage of individual floors. When analyzing phytocenoses (vegetation), we describe the phytocenosis (subject of investigation) according to certain characteristic features, resulting in a phytocenological record. The following characteristics are usually evaluated: floristic composition (species set), abundance (abundance), coverage (dominance), or sociability and vertical structure (storied). This information is important in the synthesis or diagnosis of typological units (Křížová, 2012). The inventory area had an area of 679m2 and was targeted using the Nautiz X6 GPS receiver and the MAPUJ program, which enabled us to edit the attributes of individual reference areas and points directly in the field. According to map analyses, we determined the coordinates of the reference area; they were corrected in the field because of the dense canopy of vegetation. The first step was to mark out the site directly in the MAPUJ application. This was followed by recording the GPS location of individual trees. The accuracy of the device ranged from 1.5m to 3.4m. In the selected area, we evaluated 21 trees in a dense canopy and approximately 9 pieces of scrub. Inaccuracies could have arisen because of an incorrect determination of the percentage of cover by the ocular method or by different mappers.

Floor	Name Latin	English	invasive	coverage
tree	*Populus alba*	White poplar	-	15
	Fraxinus excelsior	Ash slender	-	6
	Acer campestre	Field maple	-	17
	Populus nigra	Black poplar	-	18
	Populus tremula	Aspen poplar	-	9
	Prunus avium	Bird cherry	-	0,5
	Acer platanoides	Norway maple	-	0,5
	Robidia pseudoacacia	Black locust	+	2
	Negundo aceroides	Ash maple	+	7
scrub	*Ligustrum vulgare*	Wild privet	-	-
	Crataegus monogyna	Common hawthorn	-	+
	Ulmus minor	Field elm	-	-
	Acer campestre	Field maple	-	+
	Sambucus nigra	Black elder	-	+
	Viburnum opulus	Guelder rose	-	–
	Populus alba	White poplar	-	1
	Negundo aceroides	Ash maple	+	-2/-4
	Rosa canina	Dog rose	-	+
	Fallopia japonica	Japanese knotweed	+	–
	Prunus spinosa	Blackthorn	-	–
herbal	*Urtica dioica*	Stinging nettle	-	–
	Stellaria media	Chickweed	-	+[1]
	Parietaria officinalis	Upright pellitory	-	–
	Glechoma hederacea	Ground-ivy	-	-2/+2
	Geum urbanum	Wood avens	-	+
	Brachypodium sylvaticum	Lender false brome	-	–
	Impatiens glandulifera	Himalayan balsam	+	1
	Solidago canadensis	Canadian goldenrod	+	1/-2
	Populus alba	White poplar	-	3
	Fraxinus excelsior	Ash slender	-	+
	Acer campestre	Field maple	-	4/-4

Tab 1. Phytocenological record from the monitoring area Veľký Zemník 2/2 September 2020

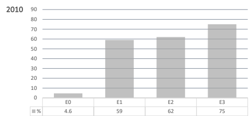
2 Results

The individual monitored areas had different manifestations, which can be attributed to the different locations of the individual locations. In 2000, we already noted considerable changes in the values of the ecological indices for light, moisture, and soil nitrogen. The absence of floods and the change in the average annual temperature caused a violation of the ecological limits of floodplains. The average values of the coverage of individual plant floors can be seen in table 1. The average values of the coverage of individual plant floors can be seen in (Tab. 2).



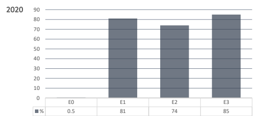
Tab 2. The average percentage value of plant floor coverage for the year 2000

In 2010, because of high rainfall totals, regeneration of the tree floor occurred, specifically the assimilation organs. In some locations, forest management and planting of Canadian poplar monocultures have begun. Therefore, this year there is a meaningful increase in the coverage of the shrub layer since the monocultures have not yet reached a height of 5 m. (Tab. 3) shows us the percentage changes in coverage compared to the year 2000. In several localities, cutting down of willows and ash trees in the marginal part of the plots was recorded. Physiognomically, the composition of the shrub layer has not changed except for the abundant number of Canadian poplar saplings. In locations where flooding did not occur, there was a trend of strengthening the coverage of the plant layer, especially in shady locations where herbaceous species had a lower coverage. From the point of view of species composition, changes were recorded only in the herbaceous layer (decrease in the number of species), but the high values of stand similarity compared to the previous year show stabilization of the layer. The lower coverage of the herb layer and the reduction of a few nitrophilous species were caused by the spring flood. Nitrophilic species were again dominant, but some grasses were also prominent in the summer, although the dominant species was nettle (Urtica dioica).



Tab 3. The average percentage value of plant floor coverage for the year 2010

On the monitoring area Veľký Zemník 2/2, a detailed phytocenological recording of the herbaceous, shrub, and tree layer was made at the end of September 2020. By comparing data with data from phytocenological records from Gabčíkovo and biomonitoring, we formulated a hypothesis based on which we found that changes in the structure of floodplain forests influence changes in ecological limits and the absence of floods. The change in the dendrological composition and morphology of the floodplain forest, which is near the Petržalka, precisely confirms this hypothesis. Urbanization and the construction of roads disturbed the forest stands, which caused a change in the light and microclimatic conditions of the forests. These changes can be seen in (Tab. 2) After evaluating the forms, we found that these changes caused the transformation of floodplain habitats into the forest edge ecotone. After averaging the coverage of the monitoring areas located in the urban environment of Petržalka, we can perceive a high percentage value of the shrub floor. Ideally, this value would be low, and shrubs would be found only on the edges of floodplain habitats. Another fact that confirms our hypothesis about changes in ecological conditions is that Acer campestre is abundant in the given area in all floors, as well as other xerothermic species. The absence of floods and the drying of floodplain forest soils may cause this change in the species composition. Several annual reports from Gabčíkovo mentioned that the presence of invasive species is reduced in the reference sections that were flooded and the regeneration of the habitat occurs.



Tab 4: Average percentage value of plant floor coverage in Petržalka for the year 2020

3 Conclusion

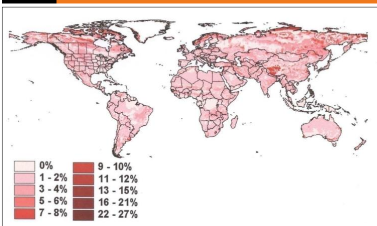


Fig 2. (Malcolm, Markham 2000) Estimated percentage of species loss in climatic conditions

The survey pointed to the impact of climate change on biodiversity. The current state and composition of floodplains resulting from phytological records and field surveys show an increase in the risk of climate-sensitive species/habitats that have a narrow tolerance limit. Changes in the coverage of floors show the sensitivity of floodplain habitats to changes in lighting, climatic conditions, and water regime. Katz et al. in 2005 investigated the delayed effects of flood control on a flood-dependent riparian forest. They found that there is no significant difference between the regulated and unregulated sections of the South Fork River in the forest's structure. The reason for this fact is that there have been no major floods in any of the examined sections since the construction of the Bonny Dam. By comparing the close-to-nature sections of alluvial forests with the urban environment of Petržalka, we could understand the stress these biotopes are exposed to. The absence of floods in Petržalka changes the ecological limits of soil moisture on which several taxa depend. There is a strong pressure on forests also due to urbanization by disrupting the compact area of the forest. Light conditions change and new transitional biotopes are formed. Violation of optimal and tolerance limits has led to changes in the environment, which is limiting for some species and restricts development. That is why floodplains are regenerating into the ecotone on the edge of the forest. By changing the lighting conditions, the temperature in the growth increases, and evapotranspiration from the soil is higher, because of which it dries out. The conditions created in this way are optimal for species that are not native to that environment. Scientists from the Slovak Academy of Sciences have studied long time changes in the structure of softwood floodplain forests in our territory. They discovered these changes were mainly caused by the disturbance of the water regime. They concluded that, during the monitored period, there was a decline in autochthonous species and an increase in neophytes, which are slowly dominating domestic species (Mikulová et al., 2020).

In the annual report on agriculture, they state that the area of forest land in Slovakia has been increasing for a long time. In 2009, it reached 2,009 thousand. ha. Since 1950, it has increased by 238 thousand. ha (13.4%). The area of vegetation also increased, i.e., j. the area of forest stands, by 175 thousand ha (9.9%) since 1950 Forest cover has been increasing for a long time as a percentage of the total area of forest land from the total area of Slovakia, which was approximately 41% in 2006. According to the results of the National Forest Inventory and Monitoring (NIML) of the Slovak Republic, which also included the so-called "white areas" (forest on non-forest land), Slovakia's forest cover is up to 44.3 ± 0.4%. Which is positive, but they do not reflect the structural changes that occurred during that period (Ministerstvo pôdohospodárstva a rozvoja vidieka SR, 2010).

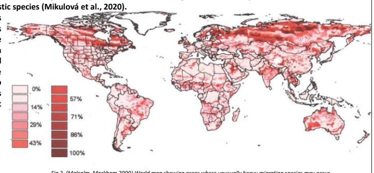


Fig 3. (Malcolm, Markham 2000) World map showing areas where unusually heavy migration species may occur

The hydric function is very variable because of the connection between the forest, water, and other components of the environment. Because of the individual factors that are necessary for the proper functioning of the ecosystem, the ecological conditions and structure of the forest play a central role. By comparing the phytocenological records, the changes that affected the treated area from 2000 to 2020 are clearly visible. The original forest stands were preserved in locations that did not suit anthropogenic activities. From the map data, the fragmentation of the once continuous area of floodplains is clearly perceptible. The field survey confirmed the hypothesis about the state and morphology of floodplains near the built-up area of Petržalka. Mikulová et al. state that in the last 60 years, the soft floodplain forests have been transformed considerably. The plant composition points to the indirect intervention of anthropogenic factors in the structure of the studied biotope.

Water Quality and Commercial Fish Diversity in the Proposed Oxbow Lake Fish Sanctuary

Andri Hendrizal[1,3], **Muhammad Fauzi**[1], **Yudho Harjoyudanto**[1], **Eko Prianto**[1], **Budijono**[1], **Bintal Amin**[2], **Zoltán Gribovszki**[3]

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Most oxbow lakes are still connected to their parent rivers through seasonal flooding, which provides a supply of fish. However, late seasonal flooding has been rare with the same rate of capture. One of the efforts to address this problem is to establish fish sanctuaries. It is necessary to conduct studies on the water quality and types of commercial fish as preliminary data. This study has used a survey method to determine water quality parameters such as the temperature, pH, dissolved oxygen, TSS, TDS, BOD, nitrates and phosphates. The types of commercial fish needed for the study can be collected from fishermen's catches. This research was conducted at one of the proposed fish sanctuaries in Riau Province, namely, Lubuk Siam Lake, in Indonesia. The results showed that the quality of the waters was relatively good. The types of fish caught with high economic value are Osteochilus sp., Thynnichthys sp., Trichogaster sp., Pristolepis sp., Rasbora sp., Ompok sp., Mystus sp., Puntius sp., Megalops sp. and Notopterus sp. The results obtained from this study can be used as preliminary data for the proposed fishery reserves at Lubuk Siam Lake.

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[1] Aquatic Resources Management Department, Universitas Riau, Indonesia
[2] Marine Science Department, Universitas Riau, Indonesia
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Corresponding Author: andri.h@lecturer.unri.ac.id ; andri_phd@uni-sopron.hu

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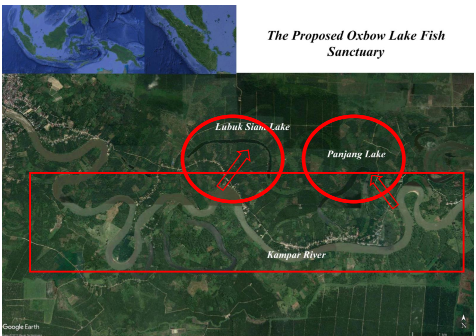
Introduction



- What if seasonal flooding has been rare with the same rate of fish capture?

- The decline of fish population → Small scale fishery
- Un-environmentally fishing gear

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Introduction

- One of the efforts to address this problem is to establish fish sanctuaries

Certain area of lake will be forbidden to catch fish in certain time!!

Why Sanctuary?
The involvement of local people with their indigenous traditional law to protect the lake (sacred place).

- It is necessary to conduct studies on **water quality** and **types of commercial fish** as preliminary data.

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Methods

- This study has used a **survey method** to determine water quality parameters such as the **brightness, pH, dissolved oxygen, TSS, TDS, BOD, nitrates and phosphates**.
- Meanwhile, the types of commercial fish can be **collected from fishermen's catches.**

Results

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Result

Rasbora sp (Pantau Fish)
Rp. 40.000 – 60.000/kg

Pristolepis sp., (Katung Fish)
Rp. 15.000/kg

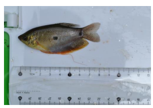
Mystus sp., (Baung Fish)
Rp. 80,000-100,000

Puntius sp., (Bulan-Bulan Fish)
Rp. 20.000-40.000/kg

Notopterus sp., (Belida Fish)
(Protected)

Thynnichthys sp., (Motan Fish)
Rp.25.000/kg

Osteochilus sp., (Paweh Fish)
Rp. 15.000/kg



Trichogaster sp., (Sepat Fish)
Rp. 25.000/kg

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Conclusion

The **quality of the waters** in proposed oxbow lake fish sanctuary is **relatively good**. Various types of **commercial fish can be found** in Panjang Lake. The results obtained from this study can be used as preliminary data for the proposed of fishery sanctuary.

Next study?

- mapping the depth
- biological aspect of the fishes and it's exploitation status

Water Quality and Commercial Fish Diversity in The Proposed Oxbow Lake Fish Sanctuary

Andri Hendrizal [1,3], Muhammad Fauzi [1], Yudho Harjoyudanto [1], Eko Prianto [1], Budijono [1], Bintal Amin [2], Zoltan Gribovszki [3]

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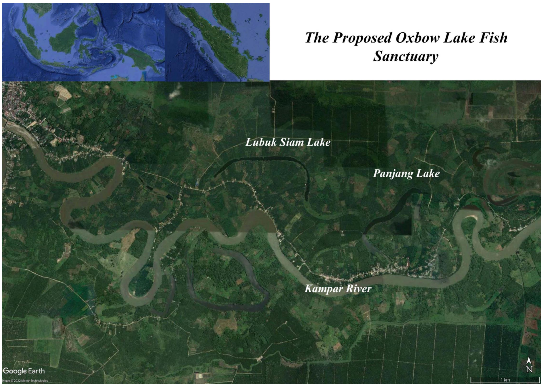
Abstract

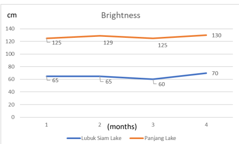
Most oxbow lakes are still connected to their parent rivers through seasonal flooding, which provides a supply of fish. However, late seasonal flooding has been rare with the same rate of capture. One of the efforts to address this problem is to establish fish sanctuaries. It is necessary to conduct studies on water quality and types of commercial fish as preliminary data. This study has used a survey method to determine water quality parameters such as the brightness, pH, dissolved oxygen, TSS, TDS, BOD, nitrates and phosphates. Meanwhile, the types of commercial fish can be collected from fishermen's catches. This research was conducted at one of the proposed fish sanctuaries in Riau Province, namely, Panjang Lake, in Indonesia. The results showed that the quality of the waters was relatively good. The types of fish with high economic value caught are *Osteochilus sp., Thynnichthys sp., Trichogaster sp., Pristolepis sp., Rasbora sp., Ompok sp., Mystus sp., Puntius sp., Megalops sp. and Notopterus sp*. The results obtained from this study can be used as preliminary data for the proposed of fishery reserves in Lubuk Siam Lake.

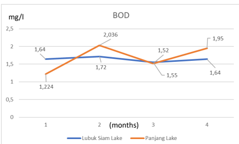
The Proposed Oxbow Lake Fish Sanctuary

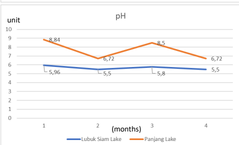


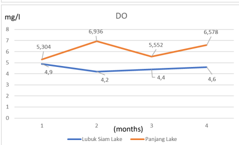
Panjang Lake is one of the lakes formed because of the interruption of the Kampar river flow due to sedimentation. The lake formed from this process is called Oxbow lake.

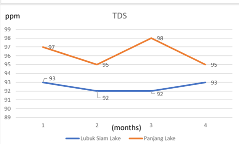
Results

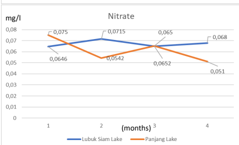


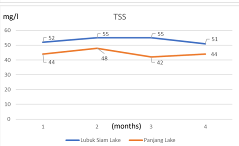


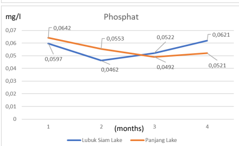


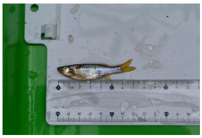












Rasbora sp (Pantau Fish)
Rp. 40.000 – 60.000/kg

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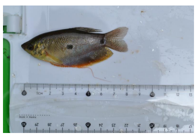

Trichogaster sp., (Sepat Fish)
Rp. 25.000/kg

Conclusion

The quality of the waters in proposed oxbow lake fish sanctuary was relatively good. Various types of commercial fish can be found in Panjang Lake. The results obtained from this study can be used as preliminary data for the proposed of fishery reserves in Panjang Lake.

BENTHIC ORGANISMS OF WATER BODIES AS AN INDICATOR OF WATER QUALITY

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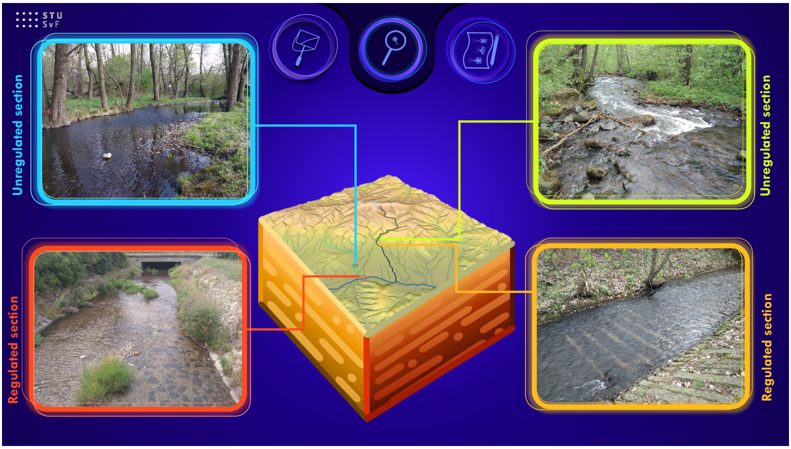
(lynda.paulikova@stuba.sk)

This study presents research dealing with the effect of flow regulations on the composition of benthic fauna. The experimental research took place from 2019 to 2021 on two tributaries of the Nitra River (the Prievidza district in Slovakia). The research was conducted on two small streams, i.e., the Lazný stream, which represents a lowland type of stream, and the Bystrica stream, which represents a foothill type of stream. Two sampling sections were determined on each stream, one representing a regulated and the other a natural part of the stream. A total of 68 samplings of benthic organisms was carried out over three years and represents 17 samplings per section. Collections were made in the months of VII. – X. 2019, III. - X. 2020 and IV. – IX. 2021. More than 29,446 individual speciemens were collected, of which 16,335 (55.47%) individuals belong to the Lazný stream, and 13,111 (44.53%) belong to the Bystrica stream. The total number of individual samples in the regulated sections was more than 16,193, representing 54.99% of all the individual samples. The unregulated stream section thus accounts for 45.01% of the individual samples (which represent 13,253 organisms). The individuals collected were classified into 49 families and two higher taxonomic groups. The research presented is intended to help understand how individual aspects, whether of a natural or anthropogenic origin, affect flow dynamics over time and in space and how these changes could affect these river ecosystems.

Key words: benthic organisms; stream; regulated streams; unregulated streams


BENTHIC ORGANISMS OF WATER BODIES AS AN INDICATOR OF WATER QUALITY
Wiena 2022
Lynda Paulíková


STU
SvF


STU
SvF
Unregulated section
Unregulated section
Regulated section
Regulated section


STU
SvF
17
months
29,446
collected
individuals
51
taxonomic
groups
10,077 pcs
30 taxa detected
6,258 pcs
41 taxa detected
6,116 pcs
36 taxa detected
6,995 pcs
39 taxa detected
Total collected individuals of benthic organisms
55%
45%
Total taxonomic groups detected
50
42
Regulated sections of streams
Unregulated sections of streams

BENTHIC ORGANISMS OF WATER BODIES AS AN INDICATOR OF WATER QUALITY

LYNDA PAULÍKOVÁ, TATIANA KALETOVÁ

1. Slovak University of Technology in Bratislava, Department of Land and Water Resources Management , Radlinského 11, 810 05, Bratislava,
2. Slovak university of agriculture in Nitra, The Faculty of Horticulture and Landscape Engineering, Hospodárska 7, 949 01 Nitra.

1 INTRODUCTION

Streams are very dynamic elements in the landscape. On the one hand, they change by the environment, but on the other hand, they are the environment. If we look around, we see the universe is big. But if we look closer, we see that the universe is much more significant. Life around us is full of microworlds. In these tiny worlds matters everything - from a stone to a dead leaf. What happens when these worlds are affected by human demands? Let's begin our journey through the microcosmos of benthic invertebrates.

2 MATERIAL AND METHODS

First, What are benthic organisms? It is a group of organisms living at the bottom of water bodies. They are the same organisms you found as a child in the stream under stones or in a water bowl that you left somewhere. Beetles, larvae of insects, molluscs, crustacea, ringworms, etc., are widespread representatives.

SAMPLING
A sampling of benthic organisms bigger than 1 mm once a month from four outposts.

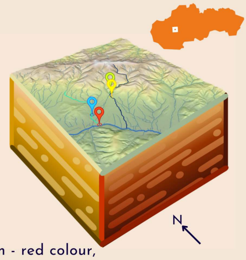
DETERMINATION OF SAMPLES
Sorting and determination to the lowest possible taxonomic level

PROCESSING OF OBTAINED DATA
Comparison of species abundance of benthic invertebrates and species diversity

3 STUDY AREA

The subject of the research was two streams: the Lazný stream and the Bystrica stream. The mentioned streams are located in the Prievidza district in the Nitra river basin (Slovakia).

Two outposts were determined on each stream. One represented a natural section of the stream and the other a regulated section. Each station has its specific colour in this work:

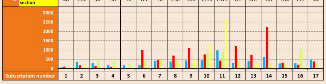


- Regulated section of the Lazný stream - red colour,
- Unregulated section of the Lazný stream - blue colour,
- Regulated section of the Bystrice stream - yellow colour,
- Unregulated section of the Bystrice stream - green colour.

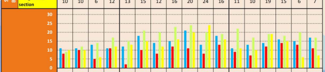
226 m a. s. l. slope 3 - 7°	254 m a. s. l. slope 1 - 3°	365 m a. s. l. slope 3 - 7°	398 m a. s. l. slope 12 - 17°

4 RESULTS AND CONCLUSION

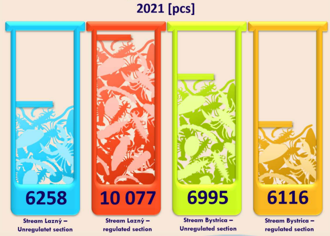
Year		2019				2020							2021					
Month		VII.	VIII.	IX.	X.	III.	IV.	V.	VI.	VII.	VIII.	IX.	IV.	V.	VI.	VII.	VIII.	IX.
Number of individuals [pcs]																		
Stream Lazný	– unregulated section	59	370	287	176	173	194	417	376	435	443	981	301	392	624	274	282	474
	– regulated section	103	172	133	82	29	1001	470	695	1117	758	429	1211	745	2232	316	203	381
Stream Bystrica	– unregulated section	54	72	450	420	253	422	478	461	307	858	862	394	152	275	237	1064	236
	– regulated section	48	214	54	96	56	122	76	230	500	1310	2672	83	287	107	104	113	44
Subscription number		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17

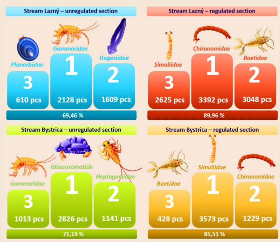


Year		2019				2020							2021					
Month		VII.	VIII.	IX.	X.	III.	IV.	V.	VI.	VII.	VIII.	IX.	IV.	V.	VI.	VII.	VIII.	IX.
Number of taxa																		
Stream Lazný	– unregulated section	11	11	13	11	12	18	14	15	21	13	18	11	13	14	16	15	17
	– regulated section	8	10	5	11	2	10	8	12	11	8	13	9	7	12	14	13	11
Stream Bystrica	– unregulated section	9	12	14	17	15	21	20	23	24	20	19	22	17	19	18	20	17
	– regulated section	10	10	6	12	13	15	12	16	20	24	16	11	10	19	15	6	7
Subscription number		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17



Amount of benthic organisms collected in 2019, 2020 and 2021 [pcs]



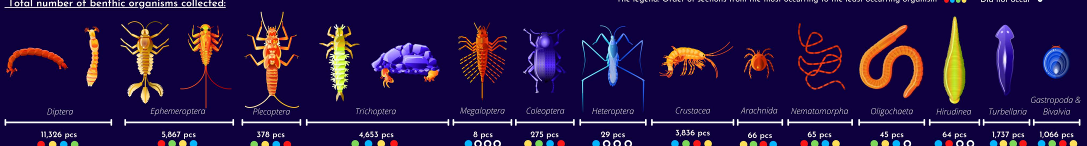


The research took place in 2019, 2020 and 2021. During the three years, 17 samples were taken. Over 29,446 individuals of benthic organisms were collected during this period. Subsequently, they were classified into 49 families and two higher taxonomic groups (these include Watermites and Horsehair worms).

Benthic organisms achieved the highest abundance in regulated sections of streams (55%). These were mainly caused by the increased representation of True Flies (Diptera).

However, in terms of taxonomic representation, the highest values were achieved by unregulated sections of streams. The regulated section of the Lazný stream had the lowest species diversity (30 taxa detected). Next comes the regulated area of the Bystrice stream (36), the unregulated sectionof the Bystrice stream (39) and the unregulated section of the Lazný stream (41). If we look at the most numerous families, we see that the representation does not change in the regulated sections, and they also achieve a significant model (more than 80%).

Total number of benthic organisms collected:



The Nitrogen Load in The Jatigede Reservoir, West Java, Indonesia

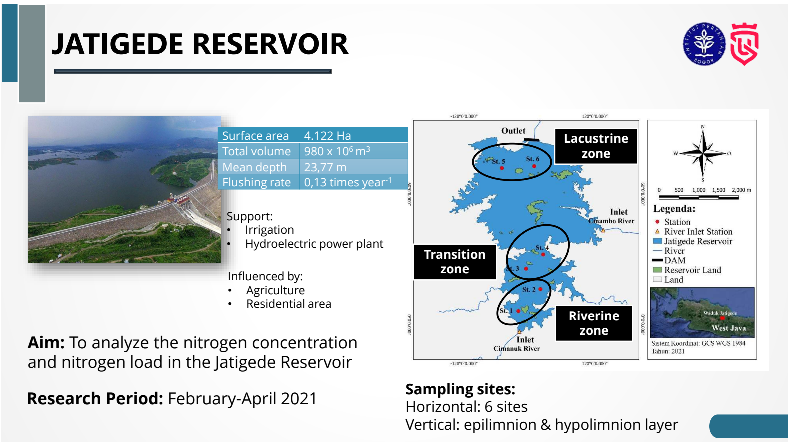
Aliati Iswantari[1,2], Dwi Yuni Wulandari[1], Asri Melani[1], Inna Puspa Ayu[1], Reza Zulmi[1], Niken Tunjung Murti Pratiwi[1], Bálint Heil[2]

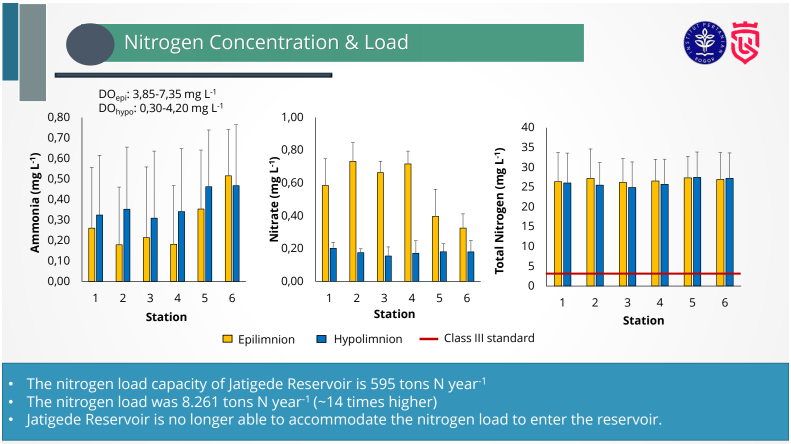
[1] Department of Aquatic Resources Management, Faculty of Fisheries and Marine Sciences, IPB University, Bogor, Indonesia (aliatiiswantari@apps.ipb.ac.id)
[2] Institute of Environmental Protection and Nature Conservation, Faculty of Forestry, University of Sopron, Hungary

Jatigede Reservoir is situated close to residential areas and agricultural activities. Uncontrolled increases in nitrogen levels, which come from the disposal of waste in the reservoir, could induce negative impacts such as eutrophication. This study aims to analyze the nitrogen condition and load in the Jatigede Reservoir, West Java, Indonesia. This research was conducted over three months (February–April 2021) at six sampling sites. Based on the results, the ammonia, nitrite, nitrate, and total nitrogen concentrations were 0.18-0.52 mg L^{-1}, 0.0040-0.0440 mg L^{-1}, 0.15-0.73 mg L^{-1}, and 24.91-27.46 mg L^{-1}, respectively. The nitrogen load in the Jatigede Reservoir is 8.261 tons N per year, which has exceeded the reservoir nitrogen load capacity (595 tons N per year). In conclusion, Jatigede Reservoir is no longer able to accommodate the nitrogen load entering the reservoir.

Keywords: nitrogen load, total nitrogen, Jatigede Reservoir


IPB University
Bogor Indonesia
UNIVERSITY of SOPRON
THE NITROGEN LOAD IN THE JATIGEDE RESERVOIR, WEST JAVA, INDONESIA
Aliati Iswantari, Dwi Yuni Wulandari, Asri Melani, Inna Puspa Ayu, Reza Zulmi, Niken Tunjung Murti Pratiwi, Bálint Heil
HYDROCARPATH CONFERENCE
AUSTRIA, 2022


JATIGEDE RESERVOIR
Surface area 4.122 Ha
Total volume 980 x 10⁶ m³
Mean depth 23,77 m
Flushing rate 0,13 times year⁻¹
Support:
• Irrigation
• Hydroelectric power plant
Influenced by:
• Agriculture
• Residential area
Aim: To analyze the nitrogen concentration and nitrogen load in the Jatigede Reservoir
Research Period: February-April 2021
Outlet
Lacustrine zone
St. 5
St. 6
Inlet
Cinambo River
Transition zone
St. 4
St. 3
St. 2
St. 1
Riverine zone
Inlet
Cimanuk River
N
W
O
S
0 500 1,000 1,500 2,000 m
Legenda:
Station
River Inlet Station
Jatigede Reservoir
River
DAM
Reservoir Land
Land
Waduk Jatigede
West Java
Sistem Koordinat: GCS WGS 1984
Tahun: 2021
Sampling sites:
Horizontal: 6 sites
Vertical: epilimnion & hypolimnion layer


Nitrogen Concentration & Load
DOepi: 3,85-7,35 mg L-1
DOhypo: 0,30-4,20 mg L-1
Ammonia (mg L-1)
0,80
0,70
0,60
0,50
0,40
0,30
0,20
0,10
0,00
1 2 3 4 5 6
Station
Nitrate (mg L-1)
1,00
0,80
0,60
0,40
0,20
0,00
1 2 3 4 5 6
Station
Total Nitrogen (mg L-1)
40
35
30
25
20
15
10
5
0
1 2 3 4 5 6
Station
Epilimnion
Hypolimnion
Class III standard
• The nitrogen load capacity of Jatigede Reservoir is 595 tons N year-1
• The nitrogen load was 8.261 tons N year-1 (~14 times higher)
• Jatigede Reservoir is no longer able to accommodate the nitrogen load to enter the reservoir.


THANK YOU

The Nitrogen Load in The Jatigede Reservoir, West Java, Indonesia

Aliati Iswantari[1,2*], Dwi Yuni Wulandari[1], Asri Melani[1], Inna Puspa Ayu[1], Reza Zulmi[1], Niken Tunjung Murti Pratiwi[1], Bálint Heil[2]

[1]Department of Aquatic Resources Management, Faculty of Fisheries and Marine Sciences, IPB University, Bogor, Indonesia
[2]Institute of Environmental Protection and Nature Conservation, Faculty of Forestry, University of Sopron, Hungary
*Corresponding email: aliatiiswantari@apps.ipb.ac.id

ABSTRACT

Jatigede Reservoir is situated close to residential areas and agricultural activities. Uncontrolled increases in nitrogen levels, which come from the disposal of waste in the reservoir, could induce negative impacts, such as eutrophication. This study aims to analyze the nitrogen condition and load in the Jatigede Reservoir, West Java, Indonesia. This research was conducted over three months (February-April 2021) at six sampling sites. Based on the results, the ammonia, nitrite, nitrate, and total nitrogen concentrations were 0.18-0.52 mg L-1, 0.0040-0.0440 mg L-1, 0.15-0.73 mg L-1, 24.91-27.46 mg L-1, respectively. The nitrogen load in the Jatigede Reservoir is 8,261 tons N per year. It has exceeded the reservoir nitrogen load capacity (595 tons N per year). In conclusion, Jatigede Reservoir is no longer able to accommodate the nitrogen load entering the reservoir.

INTRODUCTION

- Indonesia (Fig 1) has ±205 reservoirs which have various function, such as source of hydropower plant energy, supporting fisheries activities, irrigation, recreation, etc.

Fig 1. Indonesian archipelago

- Jatigede Reservoir is mainly addressed for irrigation and hydropower plant activities which have water quality requirement to fulfil.
- However, the load input from the surrounding is presumably high since there are many anthropogenic activities nearby.
- This research aimed to analyze the nitrogen load in the Jatigede Reservoir, West Java, Indonesia.

MATERIALS AND METHODS

Location

This research was conducted in the Jatigede Reservoir, Sumedang County, West Java Province (Fig 2) with the morphometric characteristic as in Table 1.

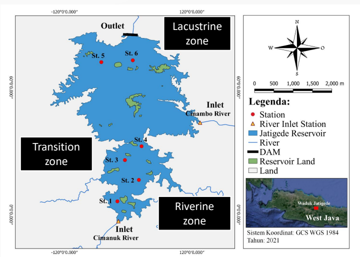


Fig 2. Sampling location in Jatigede Reservoir

Table 1. Morphometric characteristic (RBMO 2020)

Surface area	Total volume	Mean depth	Flushing rate
4,122 Ha	980 x 10^6 m^3	23.77 m	0.13 times $year^{-1}$

Sampling period: February – April 2021 (Rainy season)
Sampling point: 6 stations in Epilimnion and Hypolimnion layer

Water quality parameter

Total nitrogen (TN), nitrite (NO_2-N), nitrate (NO_3-N), ammonia (NH_3-N), Chemical Oxygen Demand (COD), and Dissolved oxygen (DO), and pH.

Data Analysis

Nitrogen Load Analysis (Regulation of the Minister of Environment Number 28 of 2009):

$$La = \frac{\Delta[TN]_d \rho}{1-R}$$

La = amount of nitrogen load capacity in reservoir
$[TN]_d$ = allocation of nitrogen load from waste activities in reservoir
ρ = flushing rate
R = total nitrogen lost to sediment or settle

RESULTS

- Based on the results, several sites has a good water quality condition, while others is already higher than the Class III standard according to Indonesian Government Regulation Number 22 of 2021, especially for Total Nitrogen concentration (Table 2 & Fig 3d).

Table 2. Water quality characteristic

Parameters	Unit	Value Range	
		Epilimnion	Hypolimnion
pH	-	7.87-9.32	6.87-8.44
Dissolved Oxygen (DO)	mg L^{-1}	3.85-7.35	0.30-4.20
Chemical Oxygen Demand (COD)	mg L^{-1}	22.43-64.89	15.21-44.63
Total suspended solid (TSS)	mg L^{-1}	<8-11.50	<8-119.00

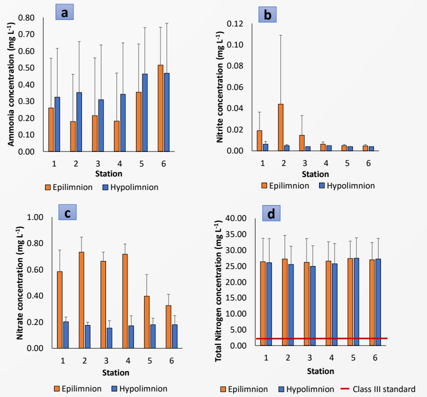


Fig 3. Nitrogen concentration in Jatigede Reservoir

- The maximum nitrogen load of Jatigede Reservoir was 8,261 tons N $year^{-1}$. However, based on water quality standard, the maximum nitrogen load capacity of Jatigede Reservoir was 595 tons N $year^{-1}$.
- High nitrogen concentration in the reservoir could lead to eutrophication that might impact aquatic ecosystem and living organism.

CONCLUSION

- The nitrogen load has exceeded the maximum limit according to the Class III water quality standard for fisheries activity.
- Jatigede Reservoir is no longer able to accommodate the nitrogen load to enter the reservoir.

ACKNOWLEDGEMENTS

This research was supported by the Department of Aquatic Resources Management of IPB University and the River Basin Management Organization (RBMO) for Cimanuk and Cisanggarung.

HYDROCARPATH CONFERENCE
AUSTRIA, 2022

TRANSPORT AND REMOVAL OF *Bacillus subtilis* SPORES IN AN ALLUVIAL GRAVEL AQUIFER AT VARYING FLOW RATES AND THE IMPLICATIONS FOR SETBACK DISTANCES

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To guarantee proper protection from fecally transmitted pathogen infections, drinking water wells should be sufficiently set back from potential sources of contamination, e.g., a nearby river. This study provides insights with regard to the microbial contamination of groundwater under various flow velocities. Field tracer tests were carried out to evaluate the ability of subsurface media to attenuate *Bacillus subtilis* spores, which were used as a surrogate for Cryptosporidium and Campylobacter. The hydraulic gradient between the injections and extractions was controlled by changing the pumping rate of the pumping well on the test site. The attachment and detachment rate coefficients were determined using HYDRUS-3D and ranged from 0.12–0.76 and 0–0.0013 hr^{-1}, respectively. The setback distances were calculated based on a 60-day travel time, as well as a quantitative microbial risk assessment (QMRA) approach, which showed similar results at this site, i.e., around 700 m at the highest pumping rate. The removal rates (λ) in the field tests ranged from 0.2–0.3 log/m, with lower pumping rates leading to a higher amount of removal. It was shown that the scale must be taken into consideration when determining λ for the calculation of safe setback distances.

Key words: Riverbank filtration, tracer test, QMRA, safe setback distance, Cryptosporidium, Campylobacter

Transport of *B. subtilis* spores in an alluvial aquifer at varying flow rates and implications for setback distances

Thomas J. Oudega[a,e], Gerhard Lindner[a,c,e], Regina Sommer[c,e], Andreas H. Farnleitner[b,d,e], Georg Kerber[f], Julia Derx[a,e], Margaret E. Stevenson[a,e], Alfred P. Blaschke[a,e]

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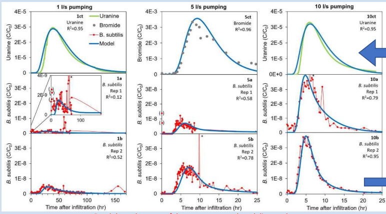
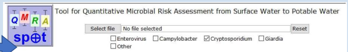


Breakthrough curves of the tracer tests and modeling study.
ct = conservative tracer test.
a and b = duplicates of the microbial tracer test.



Pathogen	Parameter	Unit	Value	Reference
Cryptosporidium	River conc. (mean, 95th %)	n/l	0.15, 0.8	(Demeter et al. 2021)
	First order inactivation	day^{-1}	0.011	(Sidhu et al. 2010)
Campylobacter	River conc. (mean, 95th %)	n/l	0.8, 4.64	(Demeter et al. 2021)
	First order inactivation	day^{-1}	5	(Sidhu et al. 2010)
			0.11	(Ross et al. 2006)

QMRAspot was used to calculate the amount of subsurface removal necessary to get a risk under 10^{-4} infections/person/year.

Transport of *B. subtilis* spores in an alluvial aquifer at varying flow rates and implications for setback distances

Thomas J. Oudega[a,e], Gerhard Lindner[a,c,e], Regina Sommer[c,e], Andreas H. Farnleitner[b,d,e], Georg Kerber[f], Julia Derx[a,e], Margaret E. Stevenson[a,e], Alfred P. Blaschke[a,e]

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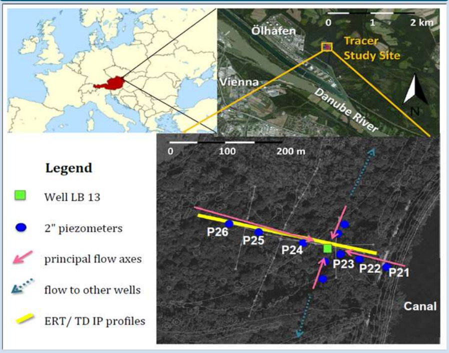
INTRODUCTION

Field tracer tests were done to evaluate the ability of subsurface media to attenuate ***Bacillus subtilis* spores** under varying flow conditions, controlled by a pumping well (LB13). This enabled us to research the influence of flow velocity on the transport and fate of our tracers, and establish a **comparison of removal rates** for *B. subtilis* spores of three different flow rates.

The results were used to investigate the implications for setback distances, based on the rule of **60 day travel time** and based on Quantitative Microbial Risk Assessment (**QMRA**). QMRA was done for ***Campylobacter* and *Cryptosporidium***, using the program **QMRAspot**.

STUDY AREA



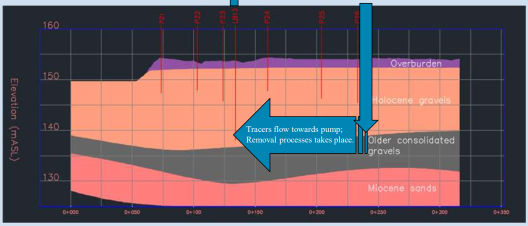
Location and set-up of research area.

- The National Park is designated as a **water protection area**, providing drinking water to the city of Vienna with a capacity of 80,000 cubic meters per day.
- **Forced gradient**: Pumping at 1, 5 or 10 l/s, to compare removal rates at different flow rates.

METHODS

Samples are taken every 10 minutes and taken to TU Wien & Medical University of Vienna for analysis.

Spores & conservative tracers are injected into groundwater directly.

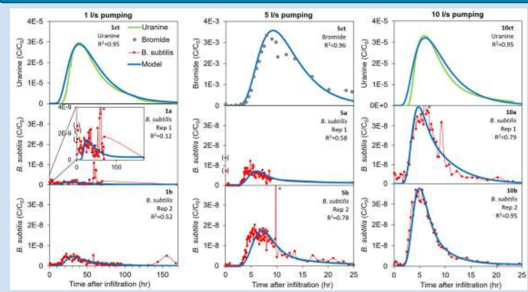


Tracer test schematic set-up and aquifer geology. Injection in P24 (shown differently here for practical purposes) and sampling at pumping well LB13.

Pathogen	Parameter	Unit	Value	Reference
Cryptosporidium	River conc. (mean, 95th %)	n/l	0.15, 0.8	(Demeter et al. 2021)
	First order inactivation	day^{-1}	0.011	(Sidhu et al. 2010)
Campylobacter	River conc. (mean, 95th %)	n/l	0.8, 4.64	(Demeter et al. 2021)
	First order inactivation	day^{-1}	5	(Sidhu et al. 2010)
			0.11	(Ross et al. 2006)

QMRAspot was used to calculate the amount of subsurface removal necessary to get a risk under 10^{-4} infections/person/year, for both *Cryptosporidium* and *Campylobacter*. Top: the program QMRAspot. Bottom: input parameters for each pathogen used for the risk calculations.

RESULTS



The BTCs of the tracer tests and modeling study, where *ct* stands for conservative tracer test, and *a* and *b* are duplicates of the microbial tracer test. Asterisks (*) stand for outliers with concentrations above the maximum y-axis value. Figures *5ct*, *a* and *b* modified from Oudega et al. (2021).

Test	1a	1b	5a	5b	10a	10b
Experimental λ (log/m)	0.284	0.274	0.273	0.257	0.189	0.198
Estimated λ (log/m)	0.028	0.027	0.027	0.025	0.018	0.019
Setback distances (m) based on 60-day TOT						
Model-derived	477	523	585	524	736	657
Austrian regulation	176	174	372	322	493	473
Setback distances (m) based on QMRAspot						
Cryptosporidium spp. (μ = 0.011 log/d)						
Using experimental λ	57	59	59	62	81	78
Using estimated λ	471	487	496	525	709	678
Using $\lambda = 10^{-1}$ log/m	142	142	143	143	143	143
Using $\lambda = 10^{-3}$ log/m	7752	7723	8153	8036	8394	8860
Campylobacter spp. (μ = 5-0.11 log/d)						
Using experimental λ	41-69	39-70	62-72	63-76	84-98	81-94
Using estimated λ	65-479	58-488	168-556	160-576	231-785	221-754
Using $\lambda = 10^{-1}$ log/m	55-164	50-163	109-171	106-170	124-172	123-172
Using $\lambda = 10^{-3}$ log/m	70-2146	62-2111	206-2819	190-2634	278-3176	266-3686

Calculated setback distances based on a 60-day TOT, as well as setback distances based on the QMRAspot for different values of λ

CONCLUSIONS

- When the value of λ is small:
  - Flow rates have a stronger influence on setback distance calculations.
  - Inactivation (μ) becomes very important when using a QMRA approach.
- The range of λ in the literature is very broad, so using these values leads to extremely (and often unnecessarily) large setback distances, when using the most conservative values.
- To determine the value of λ correctly, tracer tests at the site of interest are necessary, but they have to be carried out at the right scale.
- QMRA is a more realistic approach than regulations based on travel times
  - But QMRA is very dependent on accurate measurements of necessary parameters (especially λ), many of which are difficult to measure.
  - Travel time regulations are much easier to implement unilaterally.
- Tracer tests are not always realistic. Therefore, upscaling methods should be further developed, for which we need more research on microbial removal at different field scales, including the mesoscale.

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Vienna Science and Technology Fund (Grant ESR17–070, Grant ESR20-013), the Austrian Science Fund (FWF) as part of the DKplus (Vienna Doctoral Program on Water Resource Systems, W1219-N22),
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APPLICATION OF VERTICAL GARDENS IN URBANISED AREAS: AN ALTERNATIVE APPROACH TO URBAN GREENING

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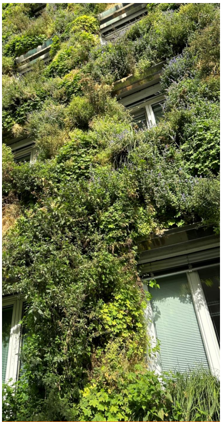
The increase of densely build-up areas has become a global phenomenon and has resulted in the "urban heat island effect". The constant demand for new constructions has reduced the amount of urban greenery and replaced it with sealed surfaces prone to overheating. The creation of horizontal green open spaces is often impracticable, because of existing interlocked urban structures. This is also the case for the historical part of the Old Town district of Bratislava. Using this part of the Slovak capital as a case study, we are presenting an alternative approach to urban greenery by applying vertical gardens. Insted of taking up valuable land space, these stuctures give value to places such as facades, walls or columns, that would otherwise be unused, by improving their aesthetic appearance and also the urban microclimate. The aim of this study is to create various structures on different surfaces based on a field study of the potentially suitable locations. These spots are often located on routes connecting important transport hubs with the city centre; hence we have created a proposal using vertical gardens as a net of navigation points with a positive impact on the urban climate and with a significant aesthetic merit.

Key words: landscape design, vertical gardens, green walls, densely urbanised cities, urban heat island mitigation, green infrastructure



STU SvF SLOVAK UNIVERSITY OF TECHNOLOGY IN BRATISLAVA FACULTY OF CIVIL ENGINEERING

Application of vertical gardens in urbanised areas: An alternative approach to urban greening

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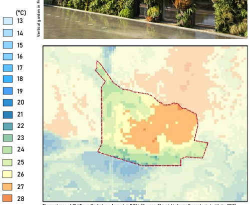
24 November 2022 Vienna, Austria; Bratislava, Slovakia; Sopron, Hungary

Benefits of the vertical gardens


Vertical garden in France (Source: Patrick Blanc, 2016)



Thermal map of Old Town Bratislava, August at 0:00h (Source: Slovak Hydrometheorologic Institute, 2019)

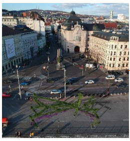

Vertical garden in France before and after (Source: Patrick Blanc, 2008)

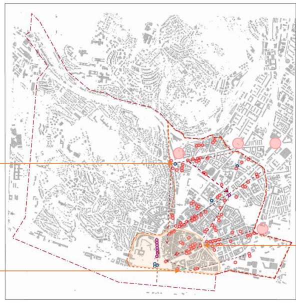

Vertical garden in France after 10 years (Source: Patrick Blanc, 2019)

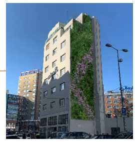
- Intensive urbanization contributes to global warming by eradication of green spaces resulting in the "urban heat island effect"
- Vertical gardens provide alternative solution for urban greening in locations lacking horizontal spaces
- Plants absorb solar radiation, hence restrict absorbance and subsequent release of heat by sealed surfaces. Moreover, they can improve microclimate by evaporative cooling, collecting dust particles and absorbing CO2
- Vertical gardens do not take up valuable land space and give unused and deteriorated surfaces microclimatic and aesthetic value

STU SvF SLOVAK UNIVERSITY OF TECHNOLOGY IN BRATISLAVA FACULTY OF CIVIL ENGINEERING — Benefits of the vertical gardens

Vertical gardens as a navigation points







Vertical gardens as a navigation points

Application of vertical gardens in urbanised areas: An alternative approach to urban greening

Find out more on the poster

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Application of vertical gardens in urbanised areas: An alternative approach to urban greening

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ABSTRACT

The increase of densely build-up areas has become a global phenomenon and has resulted in the "urban heat island effect". The constant demand for new constructions has reduced the amount of urban greenery and has replaced it with sealed surfaces prone to overheating. The creation of horizontal green open spaces is often impracticable, because of interlocked existing urban structures. This is also the case for the historical part of the Old Town district of Bratislava. Using this part of the Slovak capital as a case study, we are presenting an alternative approach to urban greenery by applying vertical gardens.

Instead of taking up valuable land space, these structures give value to places that would otherwise be unused such as facades, walls or columns, by improving their aesthetic appearance and also the urban microclimate. The aim of this study is to create various structures on different surfaces based on a field study of the potentially suitable locations.

These spots were often located on routes connecting important transport hubs with the city centre; hence we have created a proposal using vertical gardens as a net of navigation points with a positive impact on the urban climate and with a significant aesthetic merit.

1 MOTIVATION

Climate change is becoming a significant threat that affects every aspect of our lives. Intensive urbanization contributes to global warming by eradication of green spaces resulting in the "urban heat island effect". This means that sealed urban surfaces are prone to overheating and subsequently increase temperature of the cities by over 10°C compared to rural areas (Fig.1).

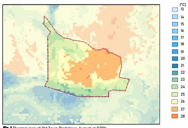

Fig. 1 Thermal map of Old Town Bratislava, August at 0:00h (Source: Slovak Hydrometheorologic Institute, 2019)

Innovative solutions, such as vertical gardens, offer different outlook on urban greening. Sealed surfaces and dense urban development, especially in historical districts, often do not allow creation of new green spaces. Therefore, these structures provide interesting way of using bare surfaces of buildings, walls or columns, transforming them into beneficial green spaces with no land space requirements and significant microclimatic and aesthetic value.

Benefits of vertical gardens are gradually becoming well-known. Plants absorb solar radiation, hence restrict absorbance and subsequent release of heat by sealed surfaces. Moreover, they can improve microclimate by evaporative cooling, collecting dust particles and absorbing CO2. Vertical gardens could also be used as a domestic greywater treatment, since roots and porous planting media serve as a biofilter.

Fig. 2: Vertical garden in France (Source: Patrick Blanc, 2016)

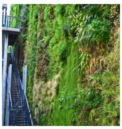

Fig. 3: Vertical garden in France (Source: Patrick Blanc, 2019)

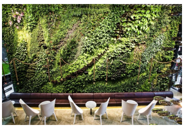

Fig. 4: Vertical garden in Slovakia (Source: Patrick Blanc, 2010)

2 METHODS

Strategies for urban heat island mitigation in Slovakia are yet to be developed. We chose historical area of Old Town district in Bratislava for this case study, since this part is densely built-up and its historical structure does not allow creation of new green spaces, but on the other hand, majorly contributes to urban heat island effect (Fig. 1). As our analysis shows (Fig. 5), there is a considerable amount of unused and deteriorated surfaces that would benefit from creation of vertical gardens.

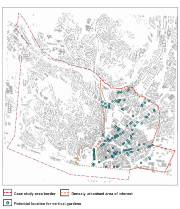

Fig. 5: All suitable locations for vertical gardens (Source: Zaťovičová, 2020)

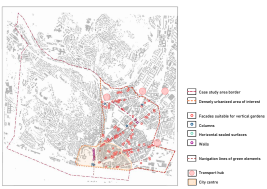

Fig. 6: Construction type categories (Source: Zaťovičová, 2020)

Our in-situ research consisted of a filed study, that was carried out from September till November 2019. We created a map database of potentially suitable locations for vertical gardens and categorized them based on construction types (Fig. 6).

4 CONCLUSION

- Vertical gardens offer various types of construction methods suitable for different surfaces
- Provide alternative solution for urban greening in locations lacking horizontal spaces
- Give unused and deteriorated surfaces microclimatic and aesthetic value
- Our design combines these benefits with the idea of creating a green city navigation system

3 RESULTS

We designed a net of several different vertical garden solutions in historical part of Old Town district, which is considered as a main hub for social life and tourism in Bratislava. Field study map (Fig.6) shows that the potential spaces are located on main traffic routes that connect major public transport hubs (main railway or bus station) with city centre. Thus, we propose a design of a navigation system that uses vertical gardens as a direction points to the city centre. Three construction types of vertical gardens were determined based on the field study:

Facade

For this construction type, we chose a 9-storey building on Kamenné square. The building is currently covered with an advertisement, so vertical garden could improve aesthetic and microclimatic value of this location (Fig.7).

Fig. 7: Visualization of a vertical garden on a facade (Source: Zaťovičová, 2020)

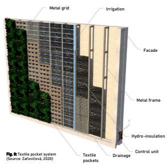

Fig. 8: Textile pocket system (Source: Zaťovičová, 2020)

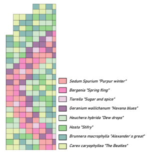

Fig. 9: Planting plan (Source: Zaťovičová, 2020)

Textile pocket system (Fig. 8) is durable, lightweight and gives plants enough space for rooting system. Multi-level irrigation provides even water and fertilizer supply.

Suitable plant selection (Fig.9) ensures that navigation function will be preserved throughout the whole year.

Column

In this case, we chose pedestrian overpass near the main railway station on Pražská street (Fig.11).

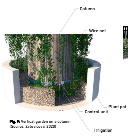

Fig. 9: Vertical garden on a column (Source: Zaťovičová, 2020)

Fig. 10: Vertical garden on an overpass (Source: Zaťovičová, 2020)

Fig. 11: Visualization of a vertical garden on an overpass (Source: Zaťovičová, 2020)

The construction consists of steel wire net mounted onto the columns (Fig. 9). It supports plants planted in a pot located at the foot of the columns. We selected hardy and fast-growing *Hedera helix*, which can climb not only on the steel support structure, but also on horizontal parts of the overpass, enhancing its positive effect (Fig. 10).

Fig. 12: Visualization of a free-standing structure (Source: Zaťovičová, 2020)

Free-standing structure

Substantial paved area without any shade on Rázus embankment (Fig.12) was determined as a suitable location given its historical importance as a port of Propeler boat connecting two sides of the Danube. We created a structure inspired by the shape of the steamboat (Fig.14). Thin and light design will not interfere with views of the historical city centre and lets the vegetation dominate (Fig.13). Columns are interconnected with steel wire supporting plants vertically and horizontally. Navigation idea will be enhanced by *Parthenocissus quinquefolia.*

Fig. 13: Free-standing structure (Source: Zaťovičová, 2020)

Fig. 14: First Propeler steamboat (Source: pinterest.co.kr)

THE IMPLEMENTATION OF BLUE-GREEN INFRASTRUCTURE FOR THE PROTECTION OF NATURAL HABITATS

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The implementation of blue-green infrastructure elements in the landscape consists of a detailed analysis of the existing structures of species and the composition in landscapes.

The municipalities of Rusovce and Čunovo near Bratislava were analyzed, and some elements of the blue-green infrastructure were used. The purpose of the project was to improve the protection and promote the creation of the biodiversity and ecological stability of the landscape. To improve the rainwater management, the drainage of rainwater from the roof of a department store was dealt with in the case of the intravillan area. When the water is diverted to a storage tank, it will provide the water needed to irrigate the central green area of Rusovce.

In the extravillan area (a protected bird area), natural elements have been used in the form of alley near roads with flower meadows, which will provide shelter and sustenance for birds and pollinators. The planting is also intended to mitigate the velocity of surface run-off and to ensure the slow infiltration of water into the soil. As part of the design of the water features, a natural lake has been designed to help prevent public access to the protected areas (Veľké and Malé Čunovské lakes), thereby ensuring the development of high-quality biodiversity.

The choice of vegetation was based on species native to the site of the protected areas to avoid the spread of invasive and non-native plants.

Keywords: landscape, blue-green infrastructure, ecological stability, biodiversity, protected area

The implementation of blue-green infrastructure for the protection of natural habitats

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ABSTRACT

The implementation of blue-green infrastructure elements in the landscape consists of a detailed analysis of the existing structures of species and the composition in landscapes.
The municipalities of Rusovce and Čunovo near Bratislava were analyzed, and some elements of the blue-green infrastructure were used. The purpose of the project was to improve the protection and promote the creation of the biodiversity and ecological stability of the landscape. To improve the rainwater management, the drainage of rainwater from the roof of a department store was dealt with in the case of the intravillan area. When the water is diverted to a storage tank, it will provide the water needed to irrigate the central green area of Rusovce. In the the extravillan area (a protected bird area), natural elements have been used in the form of the alley near the roads with flower meadows, which will provide shelter and sustenance for birds and pollinators. The planting is also intended to mitigate the velocity of surface run-off and to ensure slow infiltration of water into the soil. As part of the design of the water features, a natural lake has been designed to help prevent public access to the protected areas (Veľké and Malé Čunovské lakes), thereby ensuring the development of high-quality biodiversity. The choice of vegetation was based on species native to the site of the protected areas to avoid the spread of invasive and non-native plants.

1 DATA

The project addresses the microregion of the municipalities of Rusovce and Čunovo. The territory is located in the Bratislava region (near Petržalka). The western part of the municipality borders with the Republic of Austria and the Republic of Hungary. The cadastral territory is situated at an average altitude of 136 m a. s. l, with an area of 25,56 km^2. The cadastral territory is located at an average altitude of 130 m a. s. l, with an area of 18,62 km^2. The territory to be analysed has an area of approximately 40 km^2.

Map of Slovak Republic

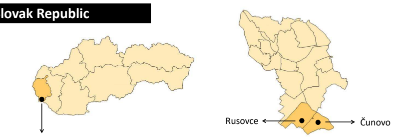

Fig. 1 – Location of the research area

2 LANDSCAPE STRUCTURES

The primary landscape structure

The territory belongs to the Quaternary sedimentary area, the basis of which is the Pannonian Basin. Part of the area is made up of loamy-sandy to gravelly-sandy clays. The western part consists of a cover of sands, sandy gravels to sands. The soil type consists of chernozem (agricultural land). The moisture regime consists of a slightly dry to slightly wet regime. The average annual temperature is more than 12 °C. The average annual rainfall is in the range 550-600 mm. The average wind speed is around 3-4 m.s^{-1}. Potentially natural vegetation in the villages belongs to the riparian woodland.

The secondary landscape structure

The historical landscape structure consists of the first (1782-1785) and the third military mapping (1926), which shows the continuous development of the area. Human activities were gradually developed. Among the greatest interventions were the expansion of the built-up area, the way in which the land was cultivated for agriculture, and the construction of roads and bridges linking the various villages. The course of the Danube was natural and highly indented. Due to frequent floods, the course had to be considerably modified (created branches). The river surroundings were filled with continuous riparian woodland. Along the roadsides, single/group trees were planted with landmark significance. The current state of the villages (2022) provides the public with a large number of attractive features. Significant historic buildings, passive recreation areas (parks), and active recreation areas.

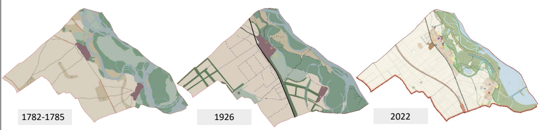

Fig. 2 – Historical and present landscape structures

The secondary landscape structure

In the area under consideration there are several important protected species of plants and animals that have a beneficial effect on the functioning of the landscape. It is necessary to create conditions for these species that will force them to remain in the area. The most important species in terms of plants are the *Orchis, Tragus, Apera, Gentiana , Blackstonia* and animal spiecies *Otis tarda, Triturus dobrogicus, Cerambyx cerdo*.

3 RESULTS

The alley near the roads with flower meadows

The green line will protect agricultural land and the landscape from the adverse effects of traffic. The composition of the new tree planting consists of ornamental and fruit species. Ornamental trees will be planted predominantly in parts close to the villages. The species *Tillia cordata*. Fruit trees planted in the more distant extravillan of the villages for fruit production, food production and shelter for birds (area of protected bird area). Species *Prunus mahaleb, Prunus avium, Malus sylvestris, Sorbus aucuparia*.

Fig. 3 – Visualization of alley with flower meadows

The proposed trees will be followed by a line of flower meadows. Flower meadows planted next to agricultural land to improve biodiversity fulfil a number of functions in terms of adaptation to climate change.

The natural lake with educational trail

The area of designed lake is currently agricultural land (arable land). On the basis of the property-law relationship, the land will be purchased of size approximately 945 600 m^2. The lake itself will have 223 960 m^2 and a depth ranging from -0,40 to -6 m. The water will be acumulated with groundwater. The complex design consists of two recreational parts. The first part consists of a water area designed for active use (swimming, sports). The public who is not interested in activities can use the piers, restaurant (passive use) overlooking the surrounding landscape.

Fig. 4 – Design of the natural lake with educational trail

Fig. 5 – Visualization of natural lake and educational trail

The second part fulfils the function of a forest park in the form of a wooden nature trail with information boards. The information boards raise awareness of the important surrounding protected areas (fauna, flora). Nature trail connects shelters with use of outdoor public galleries/workshops/small concerts.

4 CONCLUSION

- The project aims to implement blue-green infrastructure in the landscape (urbanized and non-urbanized areas) in order to protect important natural habitats.
- The new blue-green features are natural in character with minimal need for maintenance and care in the future.
- The elements have a significant impact on the environment and ecology function.
- An important function is to increase tourism awareness, which will ensure regular use of the suggest features due to the attractiveness of the water area, the forest park and education (e.g. nature trail). Moving the public to another attractive location will ensure the natural development of habitats in protected areas that are currently used for recreation.
- The management of the rainwater itself can be an inspiration for neighbouring municipalities that are considering its reuse.
- The project plan was developed because of the need for vegetation and water retention in the extravillan parts of the agricultural areas.

Analysis of the development of water erosion and sedimentation processes from 2000–2020, Zagozdonka Catchment, Poland

Zuzana Németová[1], **Silvia Kohnová**[1]

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Water erosion and sedimentation processes are included in the dominant manifestations of soil degradation in many countries. Water erosion can cause an irreversible loss of soil and nutrients, damage to vegetation, siltation of water reservoirs, and, in the worse cases, threats to human settlements and lives. The water flowing from fields carries away fertilizers and chemicals together with the soil, which not only poses a risk for water bodies and streams, but also can pollute other areas, fields and meadows; it also potentially endangers animals.

Research on water soil erosion and sedimentation processes is demanding and never-ending. Developing new methodologies that lift the results to a higher level is constantly necessary. Within the study, mathematical models were used, which are a beneficial tool in determining the possible amount of soil loss from the area studied. Currently, mathematical models provide accurate estimates of water and soil carried away from a territory as long as actual measured data are available. In the contribution, the physically-based EROSION-3D model was used, and the modelling was carried out for the Zagozdonka catchment in Poland based on the precipitation events measured.

The development of water soil erosion and transport processes was monitored from 2000–2020. Two management scenarios were created to reflect different conditions in the basin. The first scenario represents the current situation in the catchment, and the second scenario was designed to improve the soil management conditions and thus increase the protection of the territory. The results show the importance of precipitation events and their strong influence on erosion and sedimentation processes. Within the territory, the endangered places were located where it is necessary to pay attention to increased protection of the area, especially in the case of short and intense precipitation. The scenarios created provide ideas for improving soil management in the area, thereby helping to protect the soil from degradation processes.

Key words: water erosion, rainfall event, sedimentation, deposition, soil degradation

HYDROLOGY OF THE CARPATHIAN BASIN: SYNTHESIS OF DATA, DRIVING FACTORS AND PROCESSES ACROSS SCALES

International conference, 24. November 2022

ANALYSIS OF THE DEVELOPMENT OF WATER EROSION AND SEDIMENTATION PROCESSES DURING THE PERIOD 2000-2020, ZAGOŻDŻONKA CATCHMENT, POLAND

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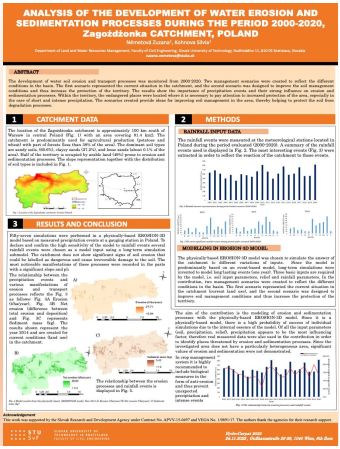
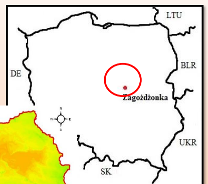
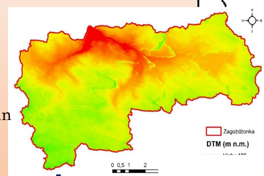
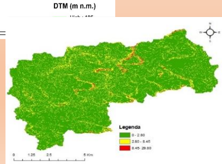


RESEARCH CONTENT

- Zagożdżonka catchment
  - approximately 100 km south of Warsaw in central Poland
  - arable land (49%)
  - forests 39%
  - pastures 13%
- Period under research: (2000-2020)
- Rainfall input data: meteorological stations in Poland

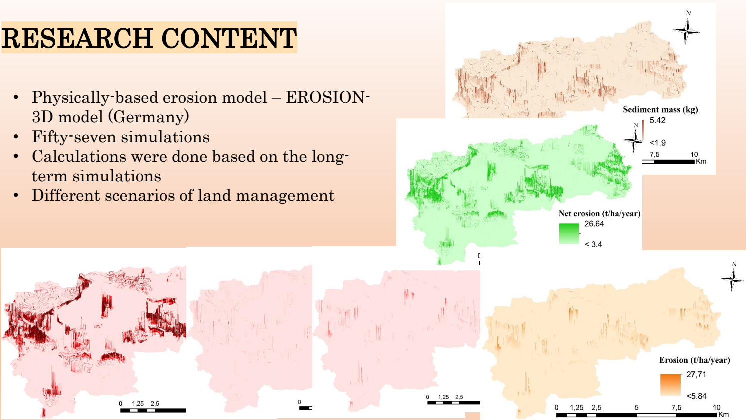






RESEARCH CONTENT

- Physically-based erosion model – EROSION-3D model (Germany)
- Fifty-seven simulations
- Calculations were done based on the long-term simulations
- Different scenarios of land management



Thank you for your attention

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ANALYSIS OF THE DEVELOPMENT OF WATER EROSION AND SEDIMENTATION PROCESSES DURING THE PERIOD 2000-2020, Zagożdżonka CATCHMENT, POLAND

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ABSTRACT

The development of water soil erosion and transport processes was monitored from 2000-2020. Two management scenarios were created to reflect the different conditions in the basin. The first scenario represented the current situation in the catchment, and the second scenario was designed to improve the soil management conditions and thus increase the protection of the territory. The results show the importance of precipitation events and their strong influence on erosion and sedimentation processes. Within the territory, the endangered places were located where it is necessary to pay attention to increased protection of the area, especially in the case of short and intense precipitation. The scenarios created provide ideas for improving soil management in the area, thereby helping to protect the soil from degradation processes.

1 CATCHMENT DATA

The location of the Zagożdżonka catchment is approximately 100 km south of Warsaw in central Poland (Fig. 1) with an area covering 91.4 km2. The catchment is predominantly used for agricultural production (potatoes and wheat) with part of forests (less than 38% of the area). The dominant soil types are sandy soils, (60.6%), clayey sands (27.2%), and loose sands (about 0.1% of the area). Half of the territory is occupied by arable land (49%) prone to erosion and sedimentation processes. The slope representation together with the distribution of soil types is included in Fig. 1.

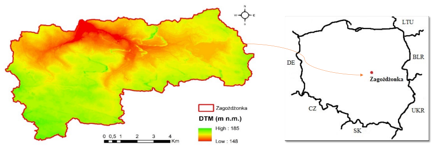


Fig. 1 Location of the Zagozdonka catchment (central Poland)

2 METHODS

RAINFALL INPUT DATA

The rainfall events were measured at the meteorological stations located in Poland during the period evaluated (2000-2020). A summary of the rainfall events used is displayed in Fig. 2. The most interesting events (Fig. 3) were extracted in order to reflect the reaction of the catchment to those events.

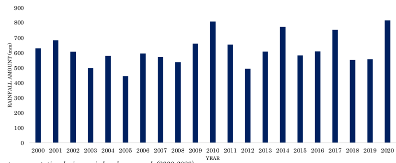


Fig. 2 Rainfall amount representation during period under research (2000-2020)

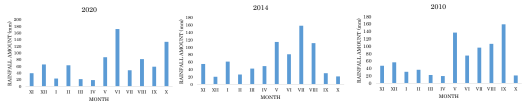


Fig. 3 The most significant rainfall events during period under research (2000-2020)

MODELLING IN EROSION-3D MODEL

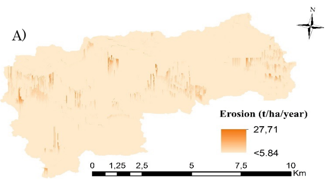
The physically-based EROSION-3D model was chosen to simulate the answer of the catchment to different variations of inputs. Since the model is predominantly based on an event-based model, long-term simulations were invented to model long-lasting events (one year). Three basic inputs are required by the model, i.e. soil input parameters, relief and rainfall parameters. In the contribution, two management scenarios were created to reflect the different conditions in the basin. The first scenario represented the current situation in the catchment (current land use), and the second scenario was designed to improve soil management conditions and thus increase the protection of the territory.

3 RESULTS AND CONCLUSION

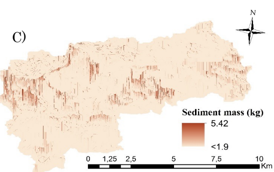
Fifty-seven simulations were performed in a physically-based EROSION-3D model based on measured precipitation events at a gauging station in Poland. To declare and confirm the high sensitivity of the model to rainfall events several rainfall events were chosen as a model input using a long-term simulation submodel. The catchment does not show significant signs of soil erosion that could be labelled as dangerous and cause irreversible damage to the soil. The most noticeable manifestations of these processes were recorded in the parts with a significant slope and pl

The relationship between the precipitation events and various manifestations of erosion and transport processes reflects the Fig. 3 as follows: Fig. 3A Erosion (t/ha/year), Fig. 3B Net erosion (difference between total erosion and deposition) and Fig. 3C represents Sediment mass (kg). The results shown represent the year 2014 and are created for current conditions (land use) in the catchment.

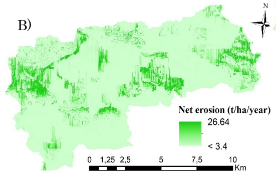
A)



C)



B)



The relationship between the erosion processes and rainfall events is displayed in Fig. 5.

Fig. 4 Model results from the physically-based EROSION3D model, Year 2014 A) Erosion (t/ha/year) B) Net erosion (t/ha/year), C) Sediment mass (kg)

The aim of the contribution is the modeling of erosion and sedimentation processes with the physically-based EROSION-3D model. Since it is a physically-based model, there is a high probability of success of individual simulations due to the internal essence of the model. Of all the input parameters (soil, precipitation, relief), precipitation appears to be the most influencing factor, therefore real measured data were also used in the contribution in order to identify places threatened by erosion and sedimentation processes. Since the investigated area does not have a particularly heterogeneous area, significant values of erosion and sedimentation were not demonstrated.

In crop management system it is highly recommended to include biological measures in the form of anti-erosion and thus prevent unexpected precipitation and intense events

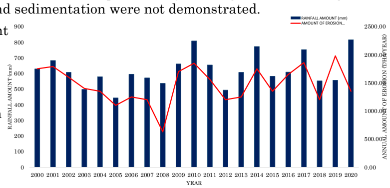


Fig. 5 The relationship between erosion processes and rainfall events

Acknowledgement

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STU SvF

SLOVAK UNIVERSITY OF TECHNOLOGY IN BRATISLAVA
FACULTY OF CIVIL ENGINEERING

Catchment processes in regional hydrology: from plot to regional scales – monitoring catchment processes and hydrological modelling

27 October 2016 Vienna, Austria; Bratislava, Slovakia; Sopron, Hungary

Index

Hydrology of the Carpathian Basin: synthesis of data, driving factors and processes across scales

International conference, 24 November 2022

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Abstract submission deadline: 10th October 2022
Conference: 24th November 2022
Conference papers: 15th December 2022

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PROGRAMME OVERVIEW:
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Gußhausstraße 25-29, 1040 Wien, 6th floor

Date	Time	Programme
24 November 2022	08:30-09:15	Registration
	09:15-09:30	Opening: Günter Blöschl, Jan Szolgay, Zoltán Gribovszki, Hubert Holzmann
	09:30-11:30	1st Oral Block (7 lectures) Chairman: Silvia Kohnová and Péter Kalicz
	11:30-12:15	Sandwich lunch
	12:15-14:15	Poster presentations (2 - 3 min time slots/per poster) Chairman: Kamila Hlavčová, Hubert Holzmann and Zoltan Gribovszki
	14:15-15:30	Poster Session with coffee
	15:30	Closure

Detailed Programme, 24 November 2022
Gußhausstraße 25-29, 1040 Wien, 6th floor

9:30-11:30 Oral Block

Chairman: Silvia Kohnová and Péter Kalicz

Nr.	*Author*	*Title*
1	Peter Valent (TUW) (30 min)	Coupling of a high-resolution weather generator and a rainfall-runoff model in the Danube basin
2	Miriam Bertola (TUW) (15 min)	Comparative analysis of historical flood events in the Danube and Main River catchments between 1845 and 1950
3	Zsolt Pinke (ELU) (15 min)	Developing a climate-smart land use system on reclaimed wetlands in the Carpathian-Balkan Region
4	Zsolt Kozma (BUTE) (15 min)	The effects of drainage on the hydrology of a Hungarian lowland catchment
5	Zoltán Liptay (UoPS) (15 min)	An overview of the possibilities of artificial intelligence-based approaches in Hungarian hydrological practice
6	Martin Kubáň (SUT) (15 min)	The value of ascat data for the calibration of a conceptual hydrological model
7	Martina Majorošová (SUT) (15 min)	The influence of anthropogenic activities on the quality of the landscape and urban landscape

11:30-12:15 Sandwich lunch

12:15-14:15 Poster presentations (2- 3 min time slots/per poster)

Chairman: Kamila Hlavčová, Hubert Holzmann and Zoltan Gribovszki

Nr.	Author	Title
P1	Csenge Nevezi (UoS)	Precipitation data processing from various tipping bucket rain gauges in the Hidegvíz Valley experimental catchment
P2	Klaudia Négyesi (BUTE)	Analyzing the connection between rainfall intensities and times of concentration using rainfall-runoff modeling
P3	Lorenzo Ceretti (PUT)	The runoff coefficient for a T-year design flood, using data from Austrian catchments
P4	Borbala Széles (TUW)	Isotopic hydrograph separation at the Hydrological Open Air Laboratory
P5	Ámon Gergely (SzU)	Impact of hydrological and hydraulic modelling approaches to a flash flood event in the Hidegvíz watershed in Hungary
P6	Caroline Ehrendorfer (BOKU)	Estimation of extreme flood discharge values using synthetic weather data in the Austrian Alps
P7	David Lun (TUW)	Attribution of flood changes with a time series in the presence of autocorrelation: Modifications for Spearman's Rho and Kendall's Tau
P8	Labat Marija Mihaela (SUT)	Estimation of design floods using the CN method and the CLM climate model
P9	Gergely Kökény (VZV)	Effects of an extreme drought in Eastern Bakony, Hungary
P10	Milica Aleksić (SUT)	Using satellite data products in the process of calibration of the hydrological model
P11	Máté Chappon (SzU)	Uncertainties in the calculation of Lake Velence water budget
P12	Attila Kálmán (SzU)	Impact of nature-based solutions on the water balance of Lake Velence
P13	Veronika Bačová Mitková (SAS)	Changes in the hydrological balance in two basins with long-term observations

P14	Zuzana Sabová (SUT)	Seasonal and spatial changes in mean monthly discharges in selected gauging stations of Slovakia
P15	Bolla Bence (UoS)	The dynamics of the soil moisture content under different forest stands in the Sandridge Region of Hungary
P16	András Herceg (UoS)	Impact of water supply on forest groundwater levels: a case study in the west inner-somogy micro-region (Hungary)
P17	Viera Rattayová (SUT)	Trends in reference evapotranspiration in selected stations of Slovakia
P18	Gabriel Stecher (BOKU)	Evapotranspiration generates diurnal discharge fluctuations in forested micro-watersheds
P19	Kele Zsombor (UoS)	Use of the groundwater of a salt steppic oak forest in Ohat, Hungary, in relation to environmental parameters
P20	Zsófia Rusznyák (UoPS)	Preliminary assessment of the groundwater regime in the Gemenc Region of the Danube-Drava National Park (Hungary)
P21	András Szabó (UoS)	Differences in the groundwater supply between a forest and agricultural land cover on the Great Hungarian Plain
P22	Katalin Zagyvai-Kiss (UoS)	Groundwater dynamics of a common alder forest
P23	Juraj Parajka (TUW)	Impact of climate change on the water resources in the Thaya basin
P24	Viktória Gáspár (SUT)	Influence of climate change on the variability of the forest community
P25	Andri Hendrizal (UR)	Water Quality and Commercial Fish Diversity in the Proposed Oxbow Lake Fish Sanctuary
P26	Lynda Paulíková (SUT)	Benthic organisms of water bodies as an indicator of water quality
P27	Aliati Iswantari (IPBU)	The Nitrogen Load in The Jatigede Reservoir, West Java, Indonesia
P28	Thomas James Oudega (TUW)	Transport and removal of Bacillus subtilis spores in an alluvial gravel aquifer at varying flow rates and the implications for setback distances

P29	Miriam Zaťovičová (SUT)	Application of vertical gardens in urbanised areas: An alternative approach to urban greening
P30	Jana Grečnárová (SUT)	The implementation of blue-green infrastructure for the protection of natural habitats
P31	Zuzana Németová (SUT)	Analysis of the development of water erosion and sedimentation processes from 2000-2020, Zagozdonka catchment, Poland

14:15-15:30 Poster Session with coffee

15:30 Closure