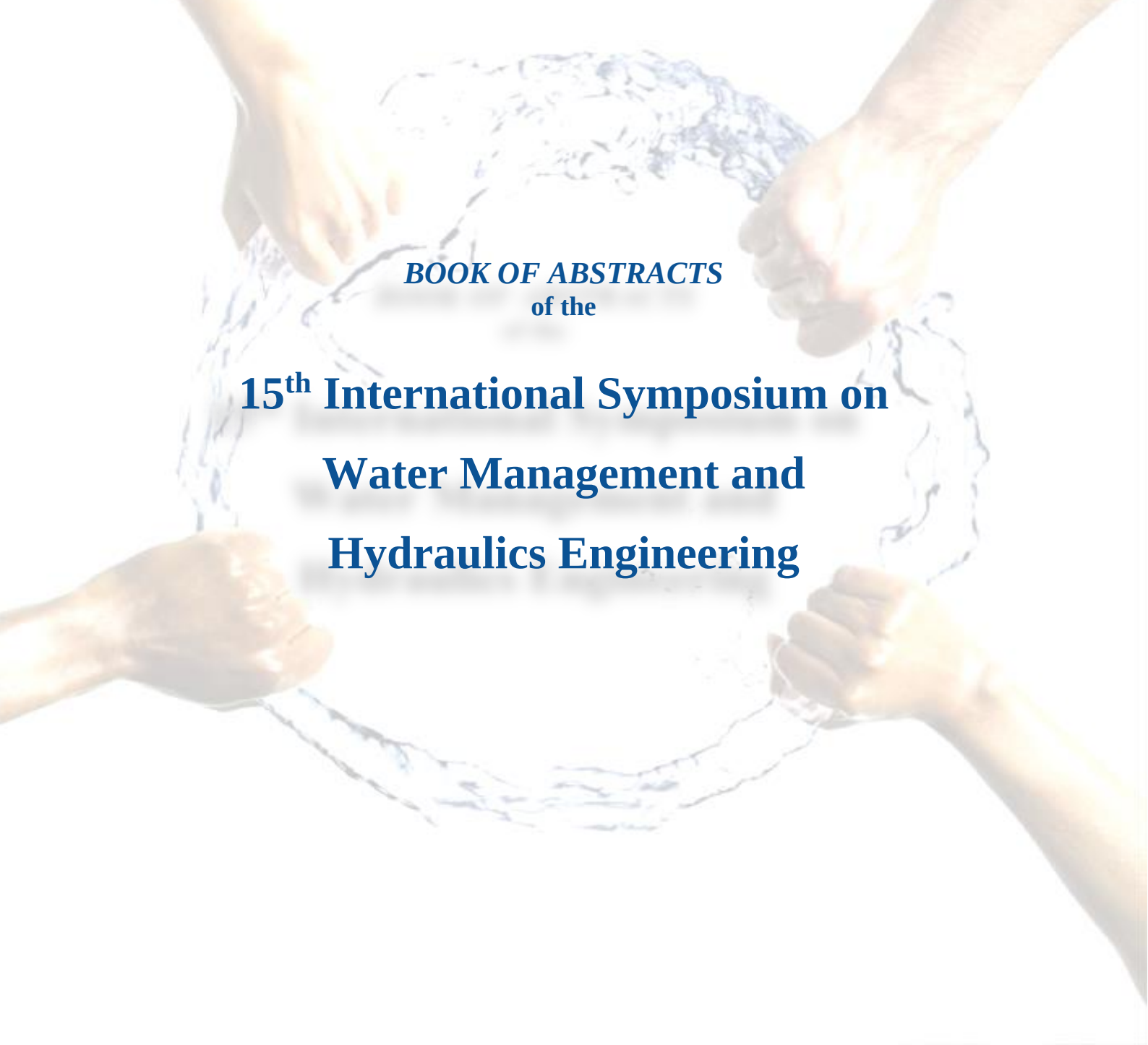

BOOK OF ABSTRACTS
of the

15th International Symposium on Water Management and Hydraulics Engineering

September 6th – 8th, 2017

Hotel Zora / Primošten / Croatia

UNIVERSITY OF ZAGREB
FACULTY OF CIVIL ENGINEERING

SLOVAK UNIVERSITY OF TECHNOLOGY IN BRATISLAVA
FACULTY OF CIVIL ENGINEERING

SS. CYRIL AND METHODIUS UNIVERSITY IN SKOPJE
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FACULTY OF CIVIL ENGINEERING

BOKU UNIVERSITY OF NATURAL RESOURCES AND APPLIED LIFE SCIENCES
INSTITUTE OF WATER MANAGEMENT, HYDROLOGY AND HYDRAULIC ENGINEERING

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Preface

The 15th International Symposium on Water Management and Hydraulic Engineering, WMHE2017, was organised from 6 to 8 September 2017 in Hotel Zora, Primošten, Croatia. This symposium formed the follow-up of the earlier, biannual series. The original bilateral symposium between civil engineering faculties of Gdansk University of Technology (Poland) and University of Zagreb (Croatia) was held back in 1984 in Gdansk under the original name „Research on Hydraulic Engineering". The symposium has since been spread to partner universities: Slovak University of Technology in Bratislava, Ss. Cyril and Methodius University in Skopje (Macedonia), University of Natural Resources and Applied Life Sciences in Vienna (Austria) as well as Brno University of Technology (Czech Republic). This successful series nowdays is regularly organized between partners.
The aim of this conference series is to encourage and facilitate the interdisciplinary communication in the field of water management and hydraulic engineering. Interdisciplinary aspect of symposium is an opportunity for researchers, practitioners, policymakers and industry representatives to meet at one place and encounter industry-academia interaction and collaborative innovation. During this three days event, discussion on different water management issues was encouraged including aspects of ecosystems and sustainable development. Participating countries could rely on similar political and cultural heritage same as similar position in processes of integration into the EU.
Selection of the symposium topics supports interdisciplinarity in new researches among different sectors of water engineering. The papers were presented in seven topics:

1. Climate Change Impacts and Policies
2. Catchment and River Systems
3. Water Supply and Wastewater Systems
4. Hydraulic Structures
5. Coastal Engineering
6. Geotechnical Engineering
7. EU Projects, Societies and Industry

Topic 1 - Climate Change Impacts and Policies deals with climate change impact on aquatic systems, climate change & hydrological modelling and data management, environmental policy and legislation and hydro-meteorological applications, products and services.
Topic 2 - Catchment and River Systems focuses on new trends in flood risk management, flood forecasting and flood management in small catchments, sediment transport and sustainable sediment management, integrated river-basin management and ecosystem restoration, land-atmosphere interactions, quality control of hydrologic simulations, plausibility data and models, groundwater resources - spatial distribution, monitoring, quality and remediation and groundwater-surface water interaction.
Topic 3 - Water Supply and Wastewater Systems deals with urban water systems - modelling, design and management, advanced technologies for water and wastewater treatment, water pollution & water-related environmental and health issues and challenges in final disposal of treated wastewater and sludge.
Topic 4 - Hydraulic Structures gives papers on design and management of dams and reservoirs, development and implementation of hydro power plants, river engineering structures - past and future, bridge scour risk - assessment, monitoring and management and inland navigation - design, implementation and utilisation.
Topic 5 - Coastal Engineering shows coastal & marine physics, ecology and management and costal engineering - climate change and ocean energy.
Topic 6 - Geotechnical Engineering focuses on investigation works for remediation of hydraulic structures, implementation of Eurocode 7 in the design of hydraulic structures and application of geo-synthetics in hydraulic engineering.
Topic 7 - EU Projects, Societies and Industry deals with connecting industry, academia and societies, experiences from EU funded water management projects and experiences from EU funded projects on water supply and wastewater systems.
Two sessions were scheduled for presentations according to specific topics for more than 150 participants. Within the framework of the meeting 63 full papers and 10 abstracts were presented through

55 oral presentations and 14 posters. During the conference there were three keynote lectures. The most interesting papers qualified by the scientific committee board were proposed for publishing in special issues of journals Gradevinar (ISSN **1333-9095)** and Acta Hydrologica Slovaca. Social events included gala dinner, technical tour at Peruča dam and excursions to Split and Trogir.

We thank symposium chairmen, scientific advisory committee and organising committee for their valuable contribution on the ideas and the definition of symposium topics and themes. We also thank all the authors for their excellent contributions to these proceedings and all the participants for their contribution to this successful symposium, either in the form of an oral presentation of poster on in the form of their attention in the presentation and contributions to the discussions.

The symposium was held under the auspices of President of Croatia, Ministry of Environmental and Nature Protection of Croatia and Croatian Waters.

See you all at the 16th WMHE in 2019!

Damir Bekić
Dalibor Carević
Dražen Vouk
Editors

Content

1. CLIMATE CHANGE IMPACT AND POLICIES

SUPERVISED LEARNING MODELS IN LONG-TERM WATER RESOURCES MANAGEMENT

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Abstract

For the purposes of long-term (on time basis of one month) planning and management of water resources systems, long term prediction of inflow is needed. In the last two decades, usage of machine learning is becoming popular in the field of water resources systems management, whether for real time, short-term, mid-term or long-term predictions of hydrological variables. Especially interesting is the usage of supervised learning, defined as the type of machine learning used for model development based on given data, which enables prediction and extrapolation on so far unseen examples. Supervised learning models are able to use arbitrarily huge amount of variables for model development and forecasting. Mentioned facts make the problematics interesting from the climate change point of view, as also from the view of model development for assistance in water resources systems planning and management. By using the models developed on historical data it is able to predict inflows in conditions of future scenario from climate models and get insight in future hydrological conditions and systems management efficiency. Besides classically used rainfall for runoff modelling, other meteorological variables, if they are on disposition, could be included. As searching for appropriate way of prediction and supervised learning models architecture is not an easy task, necessary step is reviewing the literature about long-term predictions. Therefore, the insight in previous research of long-term prediction of inflow using the supervised learning is given in the paper. In the literature review are also included researches with considerations of climate change influence on water resources systems, based on the predictions using the supervised learning.

Keywords: supervised learning, long-term prediction, water resources systems, climate change

EXTRAORDINARY RAINFALLS IN GDANSK (NORTHERN POLAND) IN THE XXI CENTURY

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Abstract

In the XXI century Gdansk had been affected by two rainfall events with a total precipitation amount of over 120 mm each. Rainfall parameters exceeded the regional values of the rain occurring once every 100 years. At the meteorological station of Gdansk University of Technology, July 9th 2001 was recorded 123.5 mm and July 14th 2016, 150.8 mm rainfall (within 24 hour observation period). Despite the same seasons of summer months and a duration of about 16 hours, both rains were characterised by different course and the causes of their occurrence. The study compared the causes, course and consequences of these extraordinary rainfall events each other.

In the paper the precipitation parameters were compared with the intensity-duration-frequency curves (IDF curves) and depth-duration-frequency curves (DDF curves) which were determined on the basis of actual rainfall events that occurred in the twentieth century in the northern Poland. It was found that the analysed rainfalls significantly exceed the theoretical dependence, primarily due to the total amount of precipitation, which accounted for 190% of normal rain in July as well as due to the duration of the phase of the most intense rain (up to 8 hours in year 2016).

The two mentioned rainfall episodes were also compared with the other rain indicators. One of the rain indicator used in Poland is Chomicz rainfall intensity 12 grade scale. This scale classifies rainfall episode as normal rain, storm, heavy storm or torrential rain. Both events are partially classified as torrential rain with grade 5 or 6.

It is worth noting that the losses after the flood of 2016 were tallied many times lower than after the rainfall event 2001. This was possible thanks to massive investment in storage reservoirs on both the natural water and storm sewer systems. Development of the land surface in Gdansk also takes into account the need to better retention of rainwater.

It should be noted that the above two events significantly exceeded the parameters of the precipitation that occurs once in 100 years. The mentioned rainfalls occurred at an interval of only 15 years. It seems to be a proof that the climate changes must be taken into account when estimating the size of precipitation for current and future activities.

Keywords: rainfall, torrential rain, urban flood, Strzyza catchment, IDF curve, DDF curve

THE EVALUATION OF MEASURED AND SIMULATED DATA OF AIR TEMPERATURE AND PRECIPITATON TOTAL

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Abstract

Climate changes are in the last decades a hot topic for scientists and laic public as well. Not all extremes of weather are associated with climate change. Variation of climatic characteristics is a natural process. But the facts, that the three hottest years since 1880 were 2014, 2015 and 2016 and ten hottest years were all after 1998 already show a high degree of probability of climate change. Adaptation to the changes, that climate change brings, is a long process. Very important is prediction of possible changes in climate system. That is why experts tried to simulate climatic processes already in the 70s of the 20th century. Nowadays, with the advancement of computer technology there are several models that most accurately simulate atmospheric processes. The most appropriate models to simulate the climate system are considered connected atmosphere-ocean models GCMs and the results of climate models are the basis for almost all scenarios. These, however, have their shortcomings, so in the development of climate scenarios at regional level modellers are recommended to use a combination of different methods. The climate change scenario for Slovakia uses 4 general atmospheric circulation models (GCMs). Two of them are global (Canadian CGCM3.1 and German ECHAM) and two regional (Netherlands KNMI and German MPI). Ordinary person is particularly affected by air temperature and precipitation total, so this paper is devoted by these two meteorological characteristics. We focused on the evaluation of actual measured data and simulated data after year 1996. We used a climate model CGCM 3.1 and its pessimistic scenario SRES A2 and optimistic scenario SRES B1. The results are from the locality of Záhorie, which is located in the western part of Slovakia.

Keywords: climate change, climate model, measured data, simulation

APPLICATION OF REMOTE SENSING FOR MONITORING DEGRADATION OF WETLAND URBAN LAKES – URBAN LAKE JARUN CASE STUDY

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Abstract

Based on multi-temporal spatial data it is possible to analyze and quantify changes in the topography of the coastal (wetland) areas. Spatial data can be collected using different remote sensing surveying methods such as airborne laser scanning (ALS), UAV photogrammetry and multibeam sonar.
By combination of these methods high resolution geospatial data sets, above and below the water surface, have been obtained. Data was collected at several time periods. Such multitemporal data set is the basis for the research of degradation of wetland in this urban lake Jarun case study. Urban lake Jarun is located in the sports and recreational area of the City of Zagreb.
This paper describes the analysis of the collected multi temporal spatial data by methods of remote sensing, and for the purpose of monitoring and evaluating the degradation of lake shore and riparian buffer of wetland urban lake. Methodology for evaluating the state and temporal dynamics of wetland urban lake is given, including recommendations for lake shore protection.

Keywords: remote sensing, wetland urban lake, airborne laser scanning (ALS), UAV photogrammetry, multibeam sonar

2. CATCHMENT AND RIVER SYSTEMS

FLOOD: NEW CONCEPTS-OLD PROBLEMS

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Abstract

Floods have a significant impact on human beings and environment through whole history causing severe humanitarian, environmental, and financial disasters. Some scientists consider that there have been a large number of major floods in the last years around the world, and suggest that floods will continue to increase in the next decades. Modern societies endeavor to defend against flood hazards by infrastructure protection plans, efficient resource management and insurance plans. Such protection mechanisms can be effective only if they are designed based on scientific methods based on a close cooperation between different branches and institutions.

In fact, floods emphasize the sheer force of natural events and man's inadequate effort to control them. Protective measures often are counterproductive. They may result in higher damages than would otherwise have occurred. The oldest and the most used engineering structure for flood protection is levee. In 1880 William Hammon Hall, first State Engineer of California (USA) had concluded that there are two types of levees, those that have been overtopped by floodwaters, and those that will be. The definite conclusion is that a flood protection system that can guarantee complete safety is an illusion.

The various human civilizations during the more than 6000 years tried to solve the complex flood problems in different way. Human pressure and increased urbanization have led the majority of the world population to live in flood-prone areas. Whether floods will occur more frequently or with bigger magnitudes in the future at a location of interest will depend on changes in many factors, which is very hard to control and/or predict. In some areas changes in the characteristics of the global atmospheric circulation may lead to higher convective precipitation. These changes can be very significantly modulated by soil moisture and snowmelt processes. Land-use changes (such as deforestation and urbanization) effect increasing of flood frequency and intensity. The main parameter controlling the flood peak is the flood retention volume available on the floodplain. Reduction of floodplains by construction of levees caused increasing of flood peak and velocity of flood hydrograph movement. Floodplain restoration is one of the crucial goals of the new integrated flood management approach. Of special importance is to understand the floodplain ecology.

At the same time flooding brings many benefits particularly for ecological variability and soil fertility. Flooding promotes exchange of materials and organisms between habitats and plays a key role in determining the level of biological productivity and diversity. Floodplain restoration is one of the crucial goals of the new integrated flood management approach. The most important prerequisite in improving the management is to understand the floodplain ecology.

The paper treats flood control measures and some different international initiatives organized in order to reduce damages caused by flood and especialy to protect human lives.

Keywords: flood, floodplain, levee, ecology, flood control

OPTIMIZATION OF THE FLOOD RETENTION CAPACITY OF THE LAKE MONDSEE IN AUSTRIA

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Abstract

Lake Mondsee is located in the transition of the Austrian, Northern Alpine range of limestones towards the moderate flysch zone. It was formed by glaciers in the Riss ice-age period and is part of a cascade of several lakes (see fig. 1). Lake Mondsee has a surface area of 13,5 km^2, the outlet of the lake drains an area of approx. 247 km^2 and releases water to the downstream lake Attersee, which is the largest lake in the respective cascade.

All lakes are part of the Salzkammergut district, which is one of the most attractive landscapes in Austria thus intensively used by tourism. The hydrological function of the lake is manifold and deals with the following aspects:

a) Tourism and water sports activities: For this purpose, a stable water table with limited extreme water levels is aimed.
b) Flood retention for downstream areas: The big area of the lake enables a significant mitigation of the inflowing flood peak levels. The retention capacity could be increased by pre-release of lake water in combination with mean-tem flood forecast systems.
c) Runoff regulation to control / optimize the lake water level: The release weir structure enables pre-release and storage of water. Structural adaption can enable stronger pre-release and deeper water levels, which may consequently lead to conflicts with utilisation described in a).

The actual variation of water tables in lake Mondsee ranges from the minimum level 480,80 m a. sl. (weir top) up to the maximum of 482,40 m a. sl. in the year 1964 (period 1925 – 2014). Recently in 2013 a level of 482,24 m a. sl. was observed. During flood events it is not possible to increase the outflow discharge as the downstream runoff capacity is limited and artificial flood must not be generated. A controlled in-time pre-release could mitigate the high lake water levels but requires a flood forecast system, which provides reliable inflow forecasts at reasonable lead times (at least 12 hours ahead).

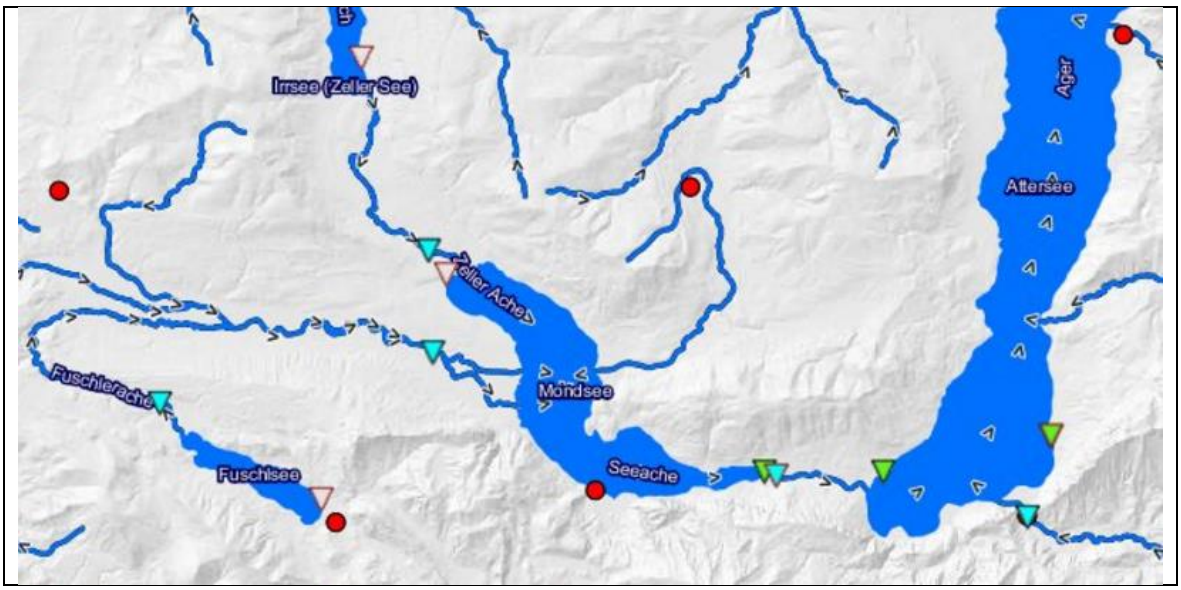

Figure 1. The hydrological system of lake Mondsee including hydro-meteorological gauges (red .. rain gauge, blue ... discharge, green ... stage, white ... water temperature).

In an ongoing research project the potential of an optimization tool for improving the water management strategies in the lake system is analysed. It comprises a) the development of a hydrological model (rainfall-runoff model and lake storage model considering controlled lake release), b) the analysis of the

reliability of potential rainfall forecasts, c) the definition and consideration of a multi objective goal function considering the diverse aspects described above and d) the identification of appropriate optimization algorithms to integrate model scenarios and operational release rules. The presentation at the conference will focus on the hydrological modelling and the potential of forecast information to optimized water level management at the lake Mondsee.

Keywords: Runoff forecasting, water resources management, structural adaptation

GROUNDWATER REGIME IN THE CITY OF KYJOV AFTER TERMINATING PUMPING FROM THE LOCAL MINES

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Abstract

In the vicinity of the town of Kyjov the coal mines were established in 1824. During the mining the groundwater table was drawdown by more than 20 m due to extensive pumping. The mining activities were abandoned in 1961. At the same time historical millrace was cancelled and filled up.
During the next few years the groundwater level raised to its original elevation (approximately before 1824) corresponding with natural surface streams and natural replenishment regime. The problems occurred during late sixties of the last century when numerous local buildings became wet, in some cases it was necessary to initiate individual pumping from the cellars. The affected inhabitants complained to the local authorities and required adequate solution. Numerous layman proposals have been addressed to the officials who decided to elaborate the comprehensive study of the groundwater regime and its changes.
The study deals with the identification of the main factors contributing to the waterlogging of urban areas in the Kyjov town. Prevailing groundwater flow directions and conditions in the area of interest were assessed using previous data about pumping, groundwater monitoring and the water stages at surface streams. An analysis of changes to the groundwater flow was made in context of the geological composition of the area and with historical development of the territory and implemented flood and erosion measures and by evaluation of the interaction between the surface and subsurface water bodies. The arrangements on the Kyjovka river and the Mill race (Fig. 1) were studied, the effect of weirs damming water was analysed, stream water level was compared with the basement of adjacent buildings. The trajectories of surface and subsurface run-off have been identified and related to the affected houses.

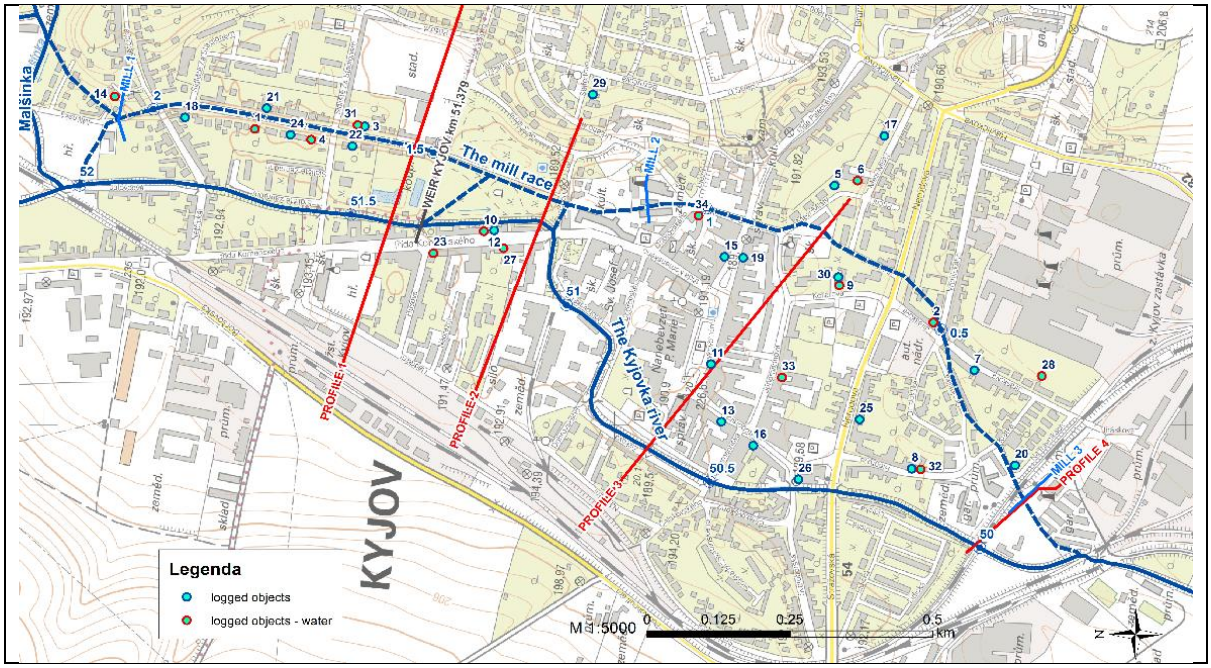

Figure 1. Map of the area of interest with rivers, observation boreholes and water logged structures

The final statement and main conclusion is that the present state corresponds to the natural groundwater conditions which returned after the terminating the pumping in the mine. This is also the main reason of the waterlogging of individual houses. Minor effect is the local surface runoff, potential groundwater level increase due to civil works (river regulation, weirs, abandoned Mill race) and also damaged

isolation of the houses against the soil moisture and groundwater. The possibilities of reducing groundwater levels were studied in localities where the ground water level has increased and also where waterlogged houses occurred.
Possible conceptual measures, respectively their combinations, to limit water logging of individual buildings have been proposed:

- The installation of the drainage system along the affected buildings. The problem consists in hardly predictable efficiency of the system due to variable geological conditions and also in the necessity of permanent pumping drained water to the receiver.
- Construction of individual drainage wells brings the risk of irregular local lowering of the water table in the area and potential danger of uneven subsidence of affected structures. This should be the initiative of individual housekeepers.
- New subsurface isolation of affected existing structures is technically difficult, it is not systematic solution, its success is uncertain and depends on local conditions.
- Reducing of the surface runoff to the area may be effective only where waterlogging is related to precipitation water. It needs local surface modifications and also arrangements along peripheral walls of the houses.

It is evident that the solution is not easy, that the main problem was the historical construction of houses in "dry" areas not considering the temporary effect of artificial groundwater level drawdown. The long-lasting pumping caused misremembering the original conditions at the urban area both by the authorities (during several social and political systems including two world wars) and also local people.

Keywords: ground water, pumping, coal mine, water logging, surface streams

Acknowledgement
This paper has been prepared under projects No. LO1408 AdMaS UP - Advanced Materials, Structures and Technologies and FAST-S-17-4066 The assessment of the possibility of the filtration instabilities origin in soils using limit state method.

EVALUATION OF GROUNDWATER CONTAMINATION IN THE AREA OF FORMER MILITARY AIRPORT

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Abstract

The paper deals with the analysis of the ground water contamination at the former military airport due to fuel tanks leakage and other accidental spills mainly of polyaromatic hydrocarbons (PAH). The main task was to assess potential impact and pollution propagation to the groundwater resources located about 3 km far from the pollution sources in the general groundwater flow direction. Historically the pollution originated at the airport has been spatially restricted and attenuated by 1.7 km long subsurface slurry wall located downstream of the airport and additional hydraulic barrier located upstream of the slurry wall and consisting of 4 pumped wells. The new owner of the airport aims to redevelop the area from pollution sources and consequently stop the pumping at the hydraulic barrier. There is a serious concern of the propagation of residual groundwater and soil pollution further downstream in case of terminating the pumping at the barrier.

In order to quantify the effect of the slurry wall, hydraulic barrier and to assess the system behaviour after stopping the pumping at the hydraulic barrier a numerical groundwater flow and contaminant transport model was set up. The model was proposed as 3D, in horizontal direction it consisted of two principal layers. The upper layer represented relatively impervious and strongly contaminated topsoil, the lower one represented aquifer with thickness more than 20 m. In the model processes like decay and sorption were also taken into account, one of the purposes of the model was to assess the effect of constitutional changes. The numerical ground water flow model was set up using software MODFLOW with the use of MT3DMS module for pollution transport problem.

The assessment of the transport of contaminants has been focused on the hydrocarbons C_{10} - C_{40}, which are the most important components of stored and spilled fuels. The substances were assumed to be completely dissolved in groundwater. The first numerical simulations assuming no constitutive changes indicated that after the terminating of pumping, the contaminant might by-pass the slurry wall around its edges and proceeded towards the withdrawal area (Fig. 1). Further solution focused on the testing the effect of constitutive changes. As the characteristics of constitutive changes (chemical reactions, sorption, decay) and their specification was uncertain, the simplified sensitivity analysis was carried out by solving several variants with different characteristics in order to assess their impact on the resulting course of pollution concentration. It was confirmed that constitutive changes play significant role and are very important factor in transport and dispersion processes in the aquifer and play significant role at the determination of the extent of affected area.

The final statement was that the threat of contamination of water resources is very low, mainly due to the effect of pollution attenuation due to decay and sorption. The potential pollution travel time from the airport to the northern edge takes more than decade, the resulting concentrations at the propagating pollution font are becoming negligible due to the sorption and decay processes. However, the principle prerequisite is high quality redevelopment of the contaminated area and prevention against further soil pollution. It was recommended to establish systematic, reliable and long-term groundwater quality monitoring in existing boreholes and also pumped wells of the hydraulic barrier and to stop pumping after ascertaining clean sampled groundwater.

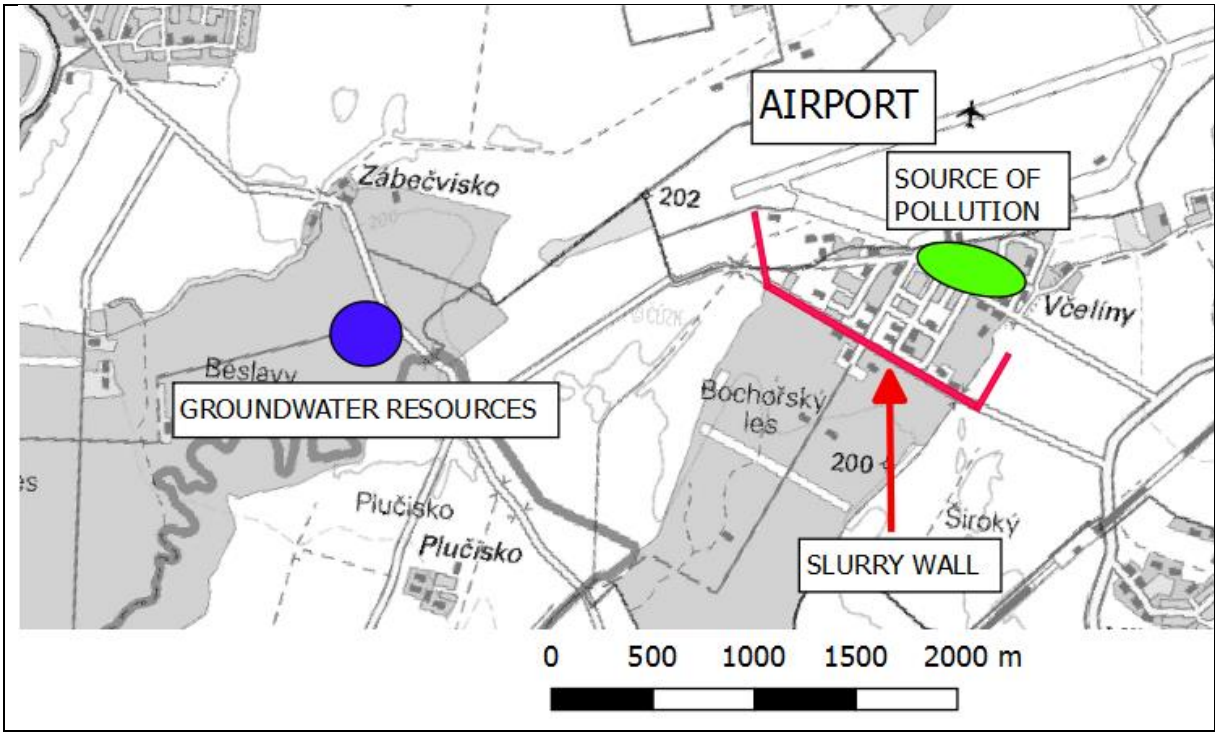

Figure 1. Map of the area of interest

Keywords: ground water pollution, contaminant transport modelling, sorption, hydraulic barrier

Acknowledgement:
This paper has been prepared under projects No. LO1408 AdMaS UP - Advanced Materials, Structures and Technologies and FAST-S-16-3655 Tools for risk assessment of surface water quality under extreme hydrological situations

LOSS OF RESERVOIR STORAGE VOLUME BY SEDIMENT DEPOSITION

VALENTÍN SOČUVKA[1], PETR DUŠEK[1], YVETTA VELÍSKOVÁ[1]

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Abstract

The role of bathymetry as well as recent sedimentation in water reservoir management is very important. Monitoring of the morphological parameters and their changes over the time is crucial information in the field of water reservoir operations. Every year only in the terms of the Slovak Republic is created nearly 40 million cubic meters of bed sediments. The aim of the paper is an analysis of spatial distribution and quantification of bed sediment volume on reservoir Veľké Kozmálovce. Since the start of operations in 1990, enormous accumulations of bed sediments are monitored. Between the years 2012 and 2016 single beam echo sounder SonarMite and Autonomous Underwater Vehicle EcoMapper were used to gather the data information. For the analysis and display the relief of the bathymetry, the Surfer 13 and ArcMap 10.1 software was used.

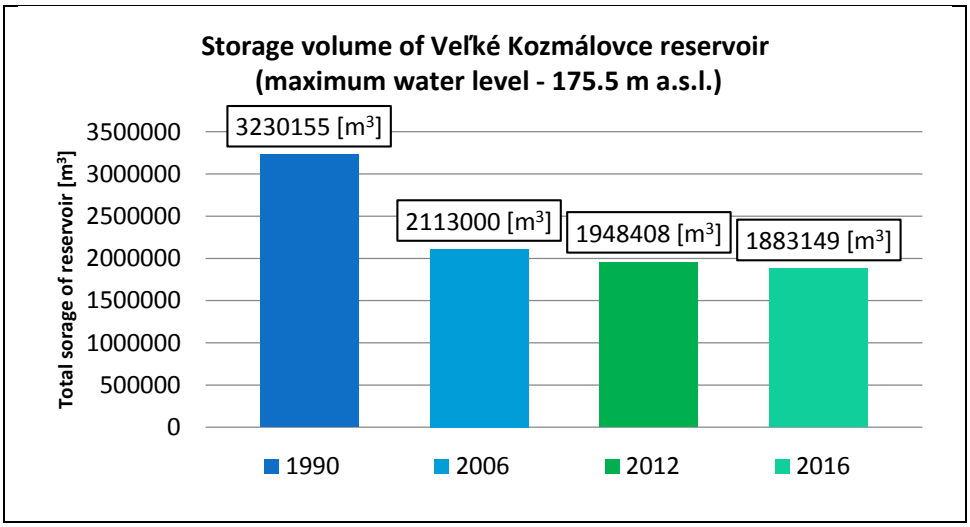

Figure 1. Storage volume of the reservoir Velke Kozmalovce during the period 1990 - 2016

Based on the current status of the bottom bathymetry the current status of clogging the reservoir was evaluated. After an evaluation of all the analyses, we can conclude that during the years 2012 and 2016 increase the volume of accumulated bed sediments about 65 259m^3. From the view of the projected storage volume it means a reduction in the amount of 41.7%.

Keywords: storage volume, reservoir, bed sediment, bathymetry

Acknowledgements

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ASSESSMENT OF THE IMPACT OF PROPOSED CUT-OFF WALLS ON GROUNDWATER LEVEL REGIME DURING EXTREME HYDROLOGICAL CONDITIONS

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Abstract

The river bed capacity of the rivers Váh, Malý Dunaj and the deviation of Nitra River is sufficient in the studied area in terms of transferring flood flow rates, however defects occur in some places especially during long-lasting flood situations. These defects are mainly followed by leakage and seepage of water and waterlogging on downstream side of the flood protective dikes accompanied by leaching of fine-grained particles from the bedrock of the protective dike. Seepage through the dike body can significantly reduce the stability of the dike. If the problem is ignored, different processes may eventually endanger the adjacent territory with residential houses and agricultural land. Other negative impact could be the contamination of water and soil as a result of flooding of the sewage treatment plant located in the area of interest. For these reasons the sealing of the dikes using suspended underground sealing walls was proposed.

The presented article deals with the numerical simulation of the current state of the groundwater flow and groundwater level regime at a relatively steady state (steady flow model) as well as during flood event (transient flow model created for the flood wave based of Q_{100}). It includes also the impacts of the suspended underground sealing walls on the groundwater flow and level regime in a wider area for both mentioned scenarios, i.e. steady and unsteady.

The paper consists of the processing and the evaluation of the available data (morphological, geological, hydrogeological and hydrological), creation of a conceptual model, design of the model, its calibration and verification and last but not least the forecast for the future scenarios.

The issue of designing the numerical model is dealt with the Triwaco-Flairs software simulating the groundwater flow using finite element method.

Keywords: underground sealing wall, numerical simulation, groundwater, flood, Triwaco

HYDROLOGICAL AND HYDRAULIC ANALYSIS OF RIVER CROSSINGS

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Abstract

River crossings are unique component of bridge and pipeline construction projects. River crossings construction techniques typically require devoted crews and specialized equipment, specific engineering design and specific planning and regulatory approval considerations. Crossings pose risks to the success of the projects and to environmental disturbances. Success of the projects depends of the hydrological and hydraulic analysis of the river.

This paper deals with some results out of hydrological and hydraulic analyses of Podmolska River in south-western part of the Republic of Macedonia. The river is a tributary of Crna River and according to the watershed area it is considered as a small watershed. The applied methods in hydrological analysis were defined by the existing and available hydrometeorological data. The obtained flood discharges with different return periods are presented in Table 1. Physical geographical watershed characteristics were defined by Digital Elevation Model (DEM), land use and land cover by CORINE 2006, while in hydraulic modelling HEC-RAS was used.

Additionally, environment impacts are briefly discussed considering that the cumulative effects of construction activities within watercourse and riparian areas can magnify the outcome of a storm or flood event and can stress the aquatic populations.

Table 1. Overview of the maximum discharge

RETURN PERIOD	TOTAL RAINFALL	EFFECTIVE RAINFALL	DISCHARGES
T (YEARS)	P (mm)	Pe (mm)	Q_{MAX} (m^3/s)
10	33.16	4.883	13.682
25	40.93	8.547	23.947
50	46.69	11.682	32.733
100	52.41	15.085	42.266

Keywords: hydrological, hydraulic, drainage basin, discharge hydrograph, fuel pipeline, erosion.

REDUCING RISK OF EUTROPHICATION IN THE CASE OF SUTLA RIVER BASIN

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Abstract

The volume of reservoir Vonarje is 12.4 million m^3. It is located on the river Sutla, which is a natural border between the Republic of Slovenia and the Republic of Croatia. The dam and reservoir were built and filled in 1980 for the purpose of public water supply, irrigation and flood control. Increased eutrophication in the reservoir was found in 1987.

Eutrophication is "the enrichment of water by nutrients, especially compounds of nitrogen and/or phosphorus, causing an accelerated growth of algae and higher forms of plant life to produce an undesirable disturbance to the balance of organisms present in the water and to the quality of the water concerned". The understanding of "anthropogenic" eutrophication corresponds with how the WFD classifies surface water ecological status in relation to type-specific reference conditions. Water bodies that fail to achieve Good Ecological Status due to the effects of human induced nutrient enrichment can be considered to be adversely affected by eutrophication.

This paper aims to show the model of eutrophication process in order to implement measures that could avoid a possible new occurrence of eutrophication, which is one of the biggest challenges in water management. In the case of transboundary river basin, the challenge is even greater because of a range of factors related to diversity of water management, backgrounds, approaches, interests and development scenarios for the defined area.

For all river basin of the EU Member States water management must be organized in terms of implementation of the European water policy and objectives of the WFD. In the case of transboundary river basins, such as the river basin Sutla, it is particularly important.

The problem of eutrophication of natural and artificial lakes is a problem that needs the preventive and continuously work on solving problems.

This paper will present an innovative approach for the eutrophication assessment which is based on the following analysis of the models:

- DPSIR approach to the analysis of human activities in the catchment area and the input of nutrients in the water with the use of spatial data (GIS)
- quantification of input pollution in water using a mathematical models STEPL and SWAT
- analysis of the condition of the water ecosystem in relation to the climatological-hydrological conditions, abiotic and biotic factors.

Using the indicator system, which explains causal relationship of the eutrophication process, special emphasis will be given on the analysis of biological indicators (elements of water quality) that are critical in the assessment of the state of aquatic ecosystems.

The planning and implementation of measures for reducing the risk of eutrophication has to be based on respecting the interests of all users of the river basin, and if is it possible, the ecosystem service and human well-being. The green infrastructure, in addition to the necessary grey infrastructure, makes contributions to the use of ecosystem services, which includes services that nature provides for free, and man use in a sustainable integrated river basin management.

Keywords: integrated water management, EU water policy, DPSIR, eutrophication, good surface water status, models, measures, ecosystem service and human well-being

ANALYSIS OF THE SEDIMENT FROM SMALL WINTER PORT ON THE DRAVA RIVER

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Abstract

Riverbed sediment is affecting form of the river and changing its cross sections on locations where sedimentation is a dominant process. Deposited sediments should be monitored and excessive amounts dredged out to maintain normal river activities, mobility and satisfied minimum depths. This is especially the case in river ports where water velocities are very low.
Generally, dredged sediments are very soft soils with low mechanical strength, extremely high moisture content and usually contaminated with organic and inorganic pollutants or toxic chemicals, especially when they are derived from a toxic industrial areas or port activities . Conventional disposal solutions for dredged sediments, such as depositing into landfills, are gradually becoming restricted in many countries in order to protect environment. The beneficial uses of dredged sediments are becoming increasingly interesting in terms of environmental protection and sustainable development.
For an alternative usage of these sediments in civil engineering or agriculture, detailed research and laboratory analysis are needed. So far, there is no systematical monitoring of sediment quality in any river port in Croatia. This paper will provide insight into sediment characteristics, pollution and its potential use in civil engineering. Sediment samples were taken from Osijek winter port which is a port for small fish boats on the Drava River in the center of the town (Figure 1).

Figure 1. Osijek winter port on the Drava River

Winter port sediment samples extraction was performed using small sampling equipment for extraction of undisturbed samples called sediment core sampler, type Beeker (Figure 2). Sediment samples were divided, according to depths, into lower and upper layer, each approximately 30 cm in length. After sample extraction, laboratory analyisis which included basic engineering physical-mechanical properties, as well as chemical properties, chemical analysis and heavy metal concentrations, were performed.

Figure 2. Sampling extraction using sediment core sampler type Beeker and sediment samples

Some results are shown in Table 1, and the rest of the results will be presented in paper. Lower sediment layer containes higher concentrations of heavy metals, while upper layer, based on this preliminary analysis, can be used in agriculture.

Table 1. Some results of sediment analysis

	TEXTURE	pH	HEAVY METAL-Cd	HEAVY METAL-Pb	HEAVY METAL-As
Upper sediment layer	Loam	7.15	0.83	75.5	12.8
Lower sediment layer	Silty loam	7.15	2.55	305.0	27.2

The paper will also present cross section changes of Osijek winter port which have occurred in last 48 years as well as potential use of its sediment.

Keywords: sediment, small river port Osijek, Drava River, pollution, heavy metals

FROM REGIONAL TO LOCAL MODFLOW SIMULATION OF HOMOGENEOUS AND HETEROGENEOUS AQUIFER

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Abstract

The composition of the geological environment of the aquifer is among the important input parameters of the numerical simulation of groundwater flow. Regional geology can significantly affect the flow of groundwater in aquifer or aquifers and also may affect the degree of interaction between the surface water flow and groundwater flow. Depending on the desired accuracy of the model is therefore important to administer a proper definition and interpretation of geological structure of the aquifer on the basis of available data (hydrogeological and engineering geological boreholes, geological maps, etc.). The numerical simulation was set up using the MODFLOW code in the Aquaveo GMS graphical user interface. The area of interest is a section of an irrigation and drainage channel Gabčíkovo – Topoľníky located in the central part of Žitný ostrov in Slovakia, between the 0th and 17th km of the channel bordered by the Mliečany floodgate and the junction of Gabčíkovo – Topoľníky channel and Klátov channel. The initial homogeneous regional model was then converted to a local model of a smaller area set up with homogeneous environment defined by one-layer stratigraphy and with heterogeneous environment defined by four-layer stratigraphy. Comparison of the outcomes of the local models of homogeneous and heterogeneous environments showed that at even distribution of anisotropy the aquifer can be considered homogeneous, given the differences in the position of ground water levels are minimal and therefore the effect of heterogeneity is not significant enough to make it necessary in the model to reflect the environment as heterogeneous. This statement is applicable mostly in aquifers with less prominent distribution anisotropy, similar to the area of Žitný ostrov where the regional and local model was implemented. It is also possible to follow this simplification in the modelling of a larger area – a regional model, where the distribution of anisotropy has no significant effect on the results of the simulation in comparison with the size of the model. For local models and simulating a specific problem in a small scale, it is important for the factor of heterogeneity to be included in the input parameters of the model.

Keywords: surface water, groundwater, interaction, numerical simulation, MODFLOW

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CALCULATION OF FLOW EVENT EXCEEDANCE PROBABILITY ON SAVA RIVER USING PEAK OVER THRESHOLD METHOD

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Abstract

Estimation of high water discharges described by their reoccurrence frequency is important for many aspects of water management, most of all for flood protection. Implementation of flood protection measures relies on flood hazard assessment used in decision making which justifies the costs of such measures. A scientific approach called probabilistic design has been widely applied to optimize such decision making process. Commonly used methods identify a magnitude of discharge for its probability of occurrence in any given year or the time in years during which an annual maximum exceeds the assessed severity limit once in the mean. The allowable risk depends on the related human safety aspects, the planned lifetime and cost of the structure, as well as the indirect adverse effects of the damage.

There are several approaches to simulate the frequency of extreme events from measured time series data and Annual Maximum (AM) method is commonly used. AM method uses annual extremes as input and therefore can disregard significant events and dive biased estimation of extreme values. Peaks over Threshold (POT) method uses as input all observed independent peaks from time series data which exceed a defined threshold. The POT method is a formal statistical model, consisting of a Poisson process for the occurrence of an exceedance of a high threshold and a generalized Pareto (GP) distribution for the excess over the threshold. The POT models are generally considered to be the most useful for practical applications, due to their more efficient use of the (often limited) data on extreme values.

This paper evaluates applicability of AM and POT methods on calculation of extreme event discharges on Sava River in Croatia. Data used from analysis are historical long-term daily water levels recorded on gauging stations. Predicted magnitude of extreme events using both methods is compared and differences quantified. Watershed area that produces runoff at each gauging station is taken into account to show impact of tributary inflow on flow calculation. Results of this study can be used to improve flood risk assessment in Croatia.

Keywords: flood hazard, flood risk, peak over threshold, exceedance probability, Sava River

JOINT PROBABILITY ANALYSIS OF FLOOD HAZARD ON RIVER CONFLUENCES USING BIVARIATE COPULAS

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Abstract

Estimation of flood hazard associated with design reoccurrence frequency is base for many aspects of water management, most of all for flood protection. Probability of flood occurrence is always present and posing a threat. Europe was exposed to floods several times in 2002 and 2012, which caused significant damage to infrastructure, environment and human lives. According to climate change scenarios, reoccurrence of extreme hydrologic events, such as floods, droughts and storms, can be expected in shorter intervals then in the past. Floods have been highlighted as one of the most common and therefore most notable natural disasters, posing significant risks [Fan et al., 2016]. In traditional approach to water management most used is single design flood event with relevant return period. Return period is calculated using univariate analysis of a governing variable (e.g. discharge or water level). Traditional approach was shown to overestimate or underestimate hazard of the analysed variable, resulting in occurrence of a calculated 100-year flood numerous times in the past decade [Kuspilić et al., 2015; Mkhandi et al., 2005; Ghizzoni et al., 2012; Bezak et al., 2014; Claps and Laio, 2003].

More frequent occurrence of flood events in recent history invoked reconsideration of hydrological scenarios used for estimation of high flow events for design return period. Flood peak is just one characteristics of the flood wave, which is result of interaction of numerous variables such as rainfall intensity, duration and spatial distribution over the catchment area, catchment characteristics and land use, reservoir operation, etc. Multivariate analysis is appropriate for describing a flood event because it has a multidimensional characteristic. Flood events can therefore be described using conditional probability joint return periods of variables controlling flood characteristics, such as flood peak, volume, shape, and duration of the hydrograph [Klein et al., 2010]. Calculation of an event with a given return period is not straightforward using bivariate frequency analysis, because increase in one variable is compensated with decrease of another due to low probability of them coinciding. For the same reason, it is challenging to define flood hazard on river reaches near tributary confluences, where two rivers merge, each contributing with its own water regime to overall flood hazard. Backwater effect of the confluence reflects on both rivers, making determination of discharge rating curve unreliable in the zone of backwater effect.

De Michele and Salvadori [De Michele and Salvadori, 2003] have used copulas for multivariate hydrologic modelling, which came into widespread use, mainly for multivariate flood frequency analysis [Daneshkhah et al., 2016; Huang et al., 2014; Klein et al., 2016; Fan et al., 2016; Masina et al., 2015; Ozga-Zielinski et al., 2016]. Copulas are functions that connect multivariate probability distributions to their one-dimensional marginal probability distributions. Different families of copulas have been proposed and are described in literature. The Archimedean copula family is one of the most desirable for hydrologic analyses, because it can be easily constructed, a large variety of copula families belong to this family, and it can be applied whether the correlation amongst hydrologic variables is positive or negative [Nelsen 1999]. For this reason, the one-parameter Archimedean copulas were applied in this study for determining the joint probability distribution of correlated flood variables. This paper focused on estimation of peak flood discharge at two confluences on Sava River. River confluences are especially challenging because of unknown spatial-temporal distribution of discharges and coincidence of extreme flood peaks.

In the last ten years increased number of the flood events occurrence has been recorded on the Sava River Basin: in 2010, the highest water level on Sava was recorded in Zagreb after the flood in 1964; 2014 in the Karlovac area the Kupa River had discharge with a return period 100 years. Finally, the May

2014 flood in the lower Sava River was marked as the flood with 1000-year return period. Flood event in May 2014 was specifically important. During this extremely high flow event levee was breached after days of high water flow, resulting in disastrous damages and evacuation of the residents from several villages. After a statistical analysis, it was established that the maximum measured discharge of this event (Q = 6000 m^3/s, measured on May 17, 2014) downstream from the Bosna River mouth to the Sava River in Slavonski Šamac had a return period of 1000 years (Abdulaj et al., 2014).

In this paper joint probability of coincident floods of River Sava and its tributaries is evaluated through peak annual discharge data at two river confluences using bivariate copulas. Results obtained using Sava Rivers' discharge upstream of the confluence and tributary discharges is compared to traditional univariate probability estimation using discharge data downstream of the confluence. For analysis were selected confluences of two adjacent right-hand tributaries of Sava River: Kupa River with confluence on rkm 576+000 and Una River confluence on rkm 500+000.

The joint probability between the two flood peaks at the confluences was evaluated by Gumbel-Hougaard copula to describe the overall probability of occurrence of the events resulting from inflow of the Sava River and tributaries in terms of the probabilities of the coincidences of a particular flood event at both rivers. Therefore, corresponding annual flood peaks had to be selected for analysis from available recordings. In cases where the identified flood peak on the Sava River did not coincide with the annual flood peak at the respective tributary, for that annual peak corresponding discharge from tributary was added to the database as a data pair. Same was done for tributary's annual flood peaks where discharge of Sava River corresponding to annual flood peak on tributary was determined. Selection of these data pairs resulted in increase of the total database, from 52 to 90 data pairs for Kupa River confluence and from 75 to 124 data pairs for Una River confluence.

Discharges estimated from copulas are significantly higher than the ones calculated using univariate method. Considering that coincidence of flood peaks is not common on analysed confluences and therefore rarely reflected in gauging station recordings downstream of the confluence, this outcome is expected. For Kupa River confluence increase in calculate discharge ranges from 37 – 44 % for 50-year return period to 38 – 39 % for 1000-year return period. Configuration of joint cumulative distribution function for Kupa River confluence resembles closely to inclined plane, thus giving uniform increase in discharges compared to univariate distribution. For Una River confluence increase in calculate discharge ranges from 55 – 60 % for 50-year return period to 36 % for 1000-year return period. Curvature of joint cumulative distribution function for Una River confluence is higher than the one for Kupa River, therefore giving non-uniform difference in comparison to univariate distribution. When discharge measured during extreme flood event from year 2014 when flow from Bosna River tributary induced flooding downstream from its confluence into Sava River is compared to fitted theoretical distributions, measured discharge is increased between 25 % and 66 %. If we adopt the common conclusion that this is a 1000-year flood, it can be stipulated that this event could be anticipated if copula method was used for flood hazard assessment.

Keywords: flood hazard, flood protection, bivariate copula model, Sava River, confluence

TIME SERIES FORECASTING OF PARAMETERS IN HYDRAULIC ENGINEERING USING ARTIFICIAL NEURAL NETWORKS

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Abstract

Time series of a parameter represent a development of its value in time and from a continuous function. Problems related to time series data, such as pattern recognition, data classification, time series and dynamic systems analysis, as well as time series forecasting problems are frequently solved using Artificial neural networks (ANN). They usually provide an alternative forecasting approach to traditional regression models. The forecasting is usually based on parameter's past values through the process of ANN learning. This process includes the analysis of the past (historical) data with the aim to discover some hidden, not so obvious and non-linear dependencies that can be used for predicting the future values of the parameter under consideration. The learning relies only on past and long enough data collection without any need for further information. Depending on the problem and the available data ANN can provide forecasting functionality with varying degrees of success and setting up the network can also be time consuming. In general, the disadvantage is that the error of prediction cannot be estimated. There are many different ways for using ANN in forecasting and they are usually case specific. This paper presents an overview of some ANN applications in forecasting, with emphasis on design parameters in hydraulic engineering.

Keywords: artificial neural networks, forecasting, time series, network learning, hydraulic engineering

AN ESTIMATE OF WATER BALANCE COMPONENTS ON THE RIVER KRAPINA BASIN

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Abstract

This paper presents the use of the latest technologies (remote sensing) for collecting data on the components of the basin's water balance, as well as the use of new original solutions for processing fully spatially distributed input data (programming in the Python programming language). All with the aim of achieving a more reliable information about relationships between water balance components at the river Krapina basin. The results indicate that compared to the total precipitation average share of basin's evapotranspiration is 62%, surface runoff is 27% and evaporation 11%.

Input data

Data collected by remote sensing refer to data from the Landsat 7 satellite, with the most important instrument on the satellite being Enhanced Thematic Mapper Plus (ETM +).

Data on hourly and daily water levels and discharges for 15 hydrological stations were collected from HIS 2000 database (Figure 1).

Data were also collected from the meteorological and percipitation stations at and around the river Krapina basin for the period 2000-2013 (Figure 1).

There are no measurements of actual evapotranspiration at the river Krapina basin. Only lysimeter measurements in the vicinity of the basin were found near the cities of Zagreb and Varazdin (station Zagreb-Maksimir and station Varkom-Varazdin) and were used for validation of evapotranspiration assessments.

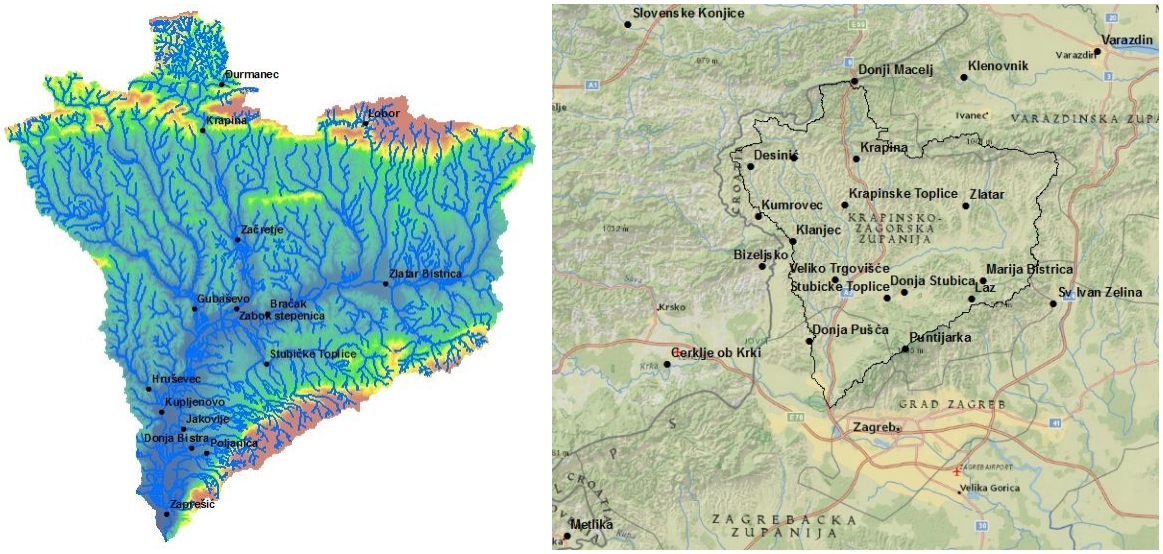

Figure 1. Krapina river basin and locations od hydrological (left) and meteorological (right) stations

Methodology

The general water balance equation is the application of the continuity equation to a basin and can be written as:

$$P=\left(\frac{dS_I}{dt}+E_I\right)+\left(\frac{dS_O}{dt}+E_O+Q_O\right)+\left(\frac{dS_{PP}}{dt}+E_T+E_{PP}+Q_{PP}\right)+\left(\frac{dS_P}{dt}+Q_P\right)$$

Where P is precipitation, and the following processes are separated in the rounded brackets: on vegetation (S_I – interception storage, E_I – evaporation of interception), surface processes (S_0 – surface

water storage, E_0 – surface evaporation, Q_0 – surface runoff), subsurface processes (S_{PP} – subsurface storage, E_T – evapotranspiration, E_{PP} – soil evaporation, Q_{PP} – subsurface runoff) and underground processes (S_P – underground storage, Q_P – groundwater flow).

Conclusion

Defining the entire hydrological cycle, due to the lack of input data, without the use of the latest technologies, such as remote sensing in assessing the actual basin evapotranspiration, would not be possible.

To achieve reliable results, especially when defining a spatially distributed data of the water balance components, there is a need to define new original solutions that enable the processing of large amounts of data, such as programming in Python programming language.

Using these techniques, it was possible to get an insight into the values and relationships between individual components of the water balance at the river Krapina basin. Compared to the total basin precipitation, average share of evapotranspiration is 62%, direct runoff 6%, base runoff 21% and evaporation 11%. If we summarize direct and base runoff in the form of total surface runoff, shares are following: evapotranspiration 62%, surface runoff 27% and evaporation 11%.

Keywords: water balance, evapotranspiration, surface runoff, remote sensing, Python

COMPARISON OF DIFFERENT COMPUTATIONAL METHODS FOR FLOOD MITIGATION

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Abstract

Flood mitigation is one of the most important tasks of water management and hydraulic engineering. One of technical measures for ensuring flood mitigation is certainly reservoir or lake. The role of it is very positive from flood protection point of view and it consists of reducing peak discharge of the flood as well as delaying the peak in time. For flood situations there is a special volume secured in reservoirs called retention volume dedicated to capture the water during a flood. In a special type of reservoir – detention reservoir – major part of its volume is intended for intercepting flood water. The whole process of flood mitigation has to be considered in preparation and projecting phase of each reservoir. In fact, the retention volume is mostly proposed according to this assessment.

There are several methods of flood mitigation calculation used in our country as well as modern programing tools offering another possibility of modelling the flood process. This paper aims to compare results from different methods of flood mitigation calculation using the same prospective reservoir. The methods presented and compared in the article are classical graphic-computational method, numerical modelling method as well as the third one using standard hydraulic equations. The first one comes out from solving four connected graphs characterized function parameters of reservoir - intercepted volumes line, inflow and outflow hydrograph, a function of water level in time and a functionality of outflow according to retention volume. Hydraulic modelling requires input geodetic and hydrological data, the computation itself is realized by chosen software. Flood mitigation can be computed also using balance equation of the inflow-runoff into the reservoir connected with hydraulic equations for outflow process. Results of these three methods are summarized, compared and described in the contribution.

Keywords: flood mitigation, detention reservoir, hydraulic modelling, flood wave, hydrograph

GROUNDWATER VULNERABILITY ASSESSMENT IN PRESPA REGION

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Abstract

The region around Lake Prespa in recent years is under the constant influence of the different activities (natural and human) that endangers the quality of groundwater. Namely, the characteristics of the basin, topographic and hydrogeological, contribute that the ground water in the region is under constant threat of being contaminated.

For these reasons there was appeared a need to make a map of vulnerability of groundwater by the degree of vulnerability and, consequently, to create the conditions for assessment of protection measures for certain areas regarding level of vulnerability of underground water.

For groundwater vulnerability assessment and vulnerability maps preparation DRASTIC method was applied (Aller et al., 1987). This method considered seven hydrogeological factors: water depth, net recharge, aquifer media, soil media, topography (slope), impact of the vadose zone media, and hydraulic conductivity of the aquifer. The sum of these factors multiplied by the appropriate weight for each factor gives the index of vulnerability (I_D) of observed zone. The index of vulnerability is ranked from negligible vulnerability (I_D>30) to extreme vulnerability (I_D>200) and in accordance to the ranking the most vulnerable area is around the lake due to the deposits of gravel, sand and clay – quaternary deposits and fissured karst deposits.

These factors have been evolved on the basis of available data. In the vicinity of the lake 15 wells were established within the project "Hydrogeological Study of Prespa lake" (UNDP Project, 2013) and observed data of groundwater table and quality were used in the vulnerability assessment.

This paper deals with the results out of the vulnerability assessment by DRASTIC method. Prepared maps on the basis of DRASTIC Index will be presented as well.

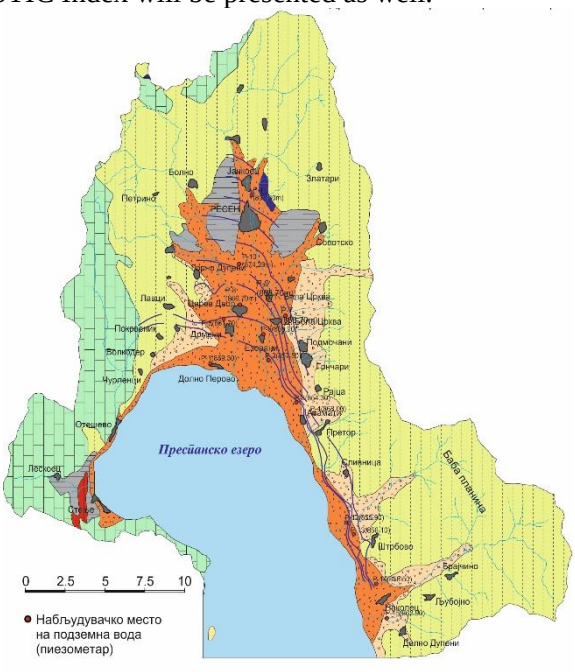

Figure 1. Hydrogeological map of Lake Prespa region – Macedonian part

Keywords: vulnerability, pollution, risk, DRASTIC method, vulnerability map

COMPARISON OF EROSION MODELLING AND BATHYMETRY MEASUREMENT OF SEDIMENT TRANSPORT ON THE SVACENICKY CREEK BASIN IN SLOVAKIA.

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Abstract

Erosion, transport and deposition of sediments in small valley reservoirs represents a significant impact on their operation, mainly with regard to reducing their accumulation volume. The aim of this study was to quantify erosion processes and sediment transport on the Svacenický jarok basin, where a flood protection reservoir was built in 2012. The small water reservoir of Svacenický Jarok is a part of the flood protection measures in Turá Lúka, and is located in western part of Slovakia close to the Myjava City. The Myjava City was in the recent years threatened by frequent floods that caused heavy material losses and significantly limited the quality of life of local residents.

To estimate the amount of transported sediments form the basin we applied the erosion model USLE 2D and compared the results with results of actual bathymetry of the polder. The measurements were provided by the modern hydrographic instrument AUV (Autonomous Underwater Vehicle).

From the measured sediment data and original geodetic survey of the terrain at the time of construction of the polder we calculated changes in the storage volume of the polder during its five years of operation. The results show that in a given area there is gradual clogging of bottom of the polder caused by erosion. We estimated that within five years of acceptance run 10,515 m^3 of bottom sediments on the Polder Svacenický jarok has been accumulated. It therefore follows that a repetitive surveying of the sedimentation is very important for the water reservoir management.

Keywords: soil erosion, reservoir storage volume, sediment, bathymetry, Svacenický jarok

FLOOD MODEL AT RACINOVCI AND RAJEVO SELO USING THE 2D MODEL IN HEC-RAS

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Abstract

In this study conditions in the middle reaches of the river Sava will be analyzed, during April, May and June 2014, when the historical maximum of flow and water level of this river was registered, and when catastrophic floods occurred. Flooding of the territory of Slavonia and Srem will be simulated with the water that reached the defended field by coming through levee breaches at Racinovci and Rajevo Selo, then merged with flood water from the west and formed a parallel stream with the river Sava. As a result of these events villages, fertile agricultural land and forests were flooded causing damage of immeasurable proportions. Based on all measurements directly from the field and the available data from competent institutions1D model for unsteady flow in the river bed will be created as well as 2D model for flooding of abovementioned territories, whose results will show the real situation that occurred in the bed of the river Sava in May 2014. For the purposes of this analysis, it is necessary to form a DTM riverbed, floodplain and potential retentions (flooded areas), from data obtained by the traditional methods and data based on geographic information system (GIS). Hydraulic model will be created by means of software package HEC-RAS 5.0. which has RAS Mapper option with the possibility of importing digital terrain models made in GIS. HEC has added the ability for mapping of the inundated area, as well as animations of the flooding inside of the RAS Mapper features. This study show the visual representation of streamline for flood wave in spring of 2014.

Keywords: Hydraulic analysis, 1D unsteady flow, flooding, river Sava

HYDRAULIC-HYDROLOGY SYNTHESIS OF GOLUBINKA SPRING DISCHARGE HYDROGRAPH

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Abstract

The hydraulic-hydrology results of the discharge hydrograph for karst spring Golubinka, during the period between 7.9.2012.-1.10.2013., have been shown. Two approaches were conducted. First one uses the limnographic data of water level difference between sea water and fresh water side of the partition wall, which is constructed on the spring itself, and the precipitation data from Zadar-airport omnographic station. The calculation is based on the continuity equation. The second approach requires only the precipitation data, which is the reason he is applicable in periods where limnographic data of the fresh water level doesn't exist. The calculation is based on one-dimensional spring hydrograph model with precipitation which varies over time.

Both approaches use the same data for precipitation, infiltration coefficient, effective porosity, area and geometric watershed characteristics. Assumptions were made that the Golubinka spring was the only one spring on the entire watershed, and the total infiltration volume on watershed is equal to total discharge on the Golubinka spring. The results from the first approach determine the appropriate turbulent seepage coefficient in the karstified channel, while the second approach allows quantification of groundwater flow components (diffusive and concentrated flow).

The results from the first approach suggest a weak correlation between spring discharge and precipitation, which indicates possible existence of other springs on watershed or the non-representative precipitation data from the Zadar-airport ombrograph. On the other hand, formed Golubinka spring hydrograph from the first methodology can be very well supported with the results from nonlinear one-dimensional groundwater flow model in a complex karstified channel.

Keywords: Golubinka spring, karst, groundwater flow

FLOOD MODELING OF WETLAND RESTORATION IN EZERANI NATURE PARK, PRESPA LAKE WATERSHED

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Abstract

The development pressures in the Prespa Lake watershed have caused considerable loss of valuable landscape elements that provided critical ecological services and contributed to the watershed's ecological integrity. The combined influence of the natural and human factors has particularly harsh impact on the Ezerani wetland area – a natural high value ecosystem located along the northern shoreline of the Lake Prespa. Created by the river delta of Golema Reka – the largest and currently most degraded tributary of the Lake – the Ezerani wetland has played an important filtering function, helping to mitigate upstream human pressures.

To be able to asses comparatively various wetland restoration alternatives, a few alternatives have been evaluated against a number of assessment factors (financial, economic, environmental and social). As a result a single wetland restoration alternative has been proposed, which includes: a) rehabilitation of the incised section of Golema Reka upstream the existing fishponds – to minimize flooding of the surrounding agricultural land, b) inlet channel to directing the floods through a spillway into the second fishpond.

Due to the rather complex geometric characteristics 2D hydraulic modelling was applied by HEC-RAS. The analyses were performed for the range of long-term average discharges and flood discharges with different probability. The simulations for the flood with return period of 50 years (Q50=45.8m^3/s) are shown in Fig. 1. The results showed that the retention capacity of the designed flood embankment and spillway structure between the shoreline of the lake and the fishponds is sufficient for flood control and minimizing flooding of the surrounding agricultural land.

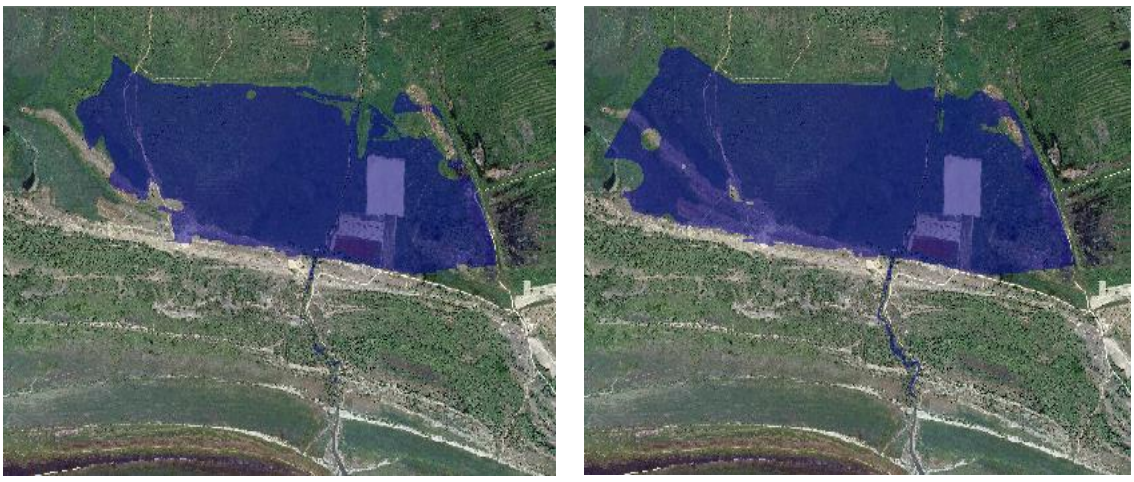

Figure 1. Simulation of flooding at Q50=45.8m^3/s. Left: 27 Sept 2015 at 01:30h (Qinflow=1.5m^3/s, Qspillway=1.5m^3/s, WS=850.60m asl). Right: 27 Sept 2015 at 06:15h (Qinflow=45.8m^3/s, Qspillway=9.39m^3/s, WS=851.1m asl).

Keywords: Ezerani wetland, restoration, flood modelling, flood control

MULTISCALE ANALYSIS OF RIVERBED TOPOGRAPHY

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Abstract

Riverbed topography is characterized by different bedforms, such as ripples, dunes, standing waves and antidunes. Geometrical properties of bedforms are dependent on hydraulic flow conditions and on characteristics of riverbed material. Occurrence of the bedforms can significantly influence the drag component of resistance to flow and therefore present important input information for the hydraulic modelling. Dunes are especially of great interest since their height is of the similar magnitude as the flow depth and length can surpass it several times. For that reason, it is important to conduct field surveys of riverbed bathymetry and classify bedform using statistical analysis of measured data. Superimposition of dunes, where smaller and faster moving dunes migrate over slower moving larger dunes, is process connected with flow conditions and it is present at different spatial and temporal scales. Selection of objective method for classification of migrating superimposed dunes presents challenge for the researchers up to date. Application of spectral analysis, such the wavelet transform, to the temporal and/or spatial riverbed elevation profile enables decomposition of series on different scales and filtering of their geometrical properties. Multiscale analysis of the riverbed elevation profile enables further revealing of bedform dynamics that would otherwise remained hidden under greater morphological shapes within the riverbed. Spectral approach to the classification of bedforms on different spatial scales is examined on the Multibeam Echo Sounding data collected from the field surveys. Results are compared with approach using algorithm pattern recognition method by statistical analysis and discussed regarding applicability of spectral analysis approach.

Keywords: bedform, dunes, Multibeam Echo Sounding data, riverbed, topography, wavelet transform

INVERSE TASK IN WATER QUALITY MODELLING

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Abstract

Currently, in water quality modelling practice are prevailing tasks, for which initial and boundary conditions are known and the model is solving pollution concentration in downstream direction. However, in practice opposite problems may occur: pollution concentration time courses in specific locations are known (e.g. based on the on-line monitoring), but pollution source location, as well as the pollution concentration time course, are unknown. The objective of this task is to determine the location of pollution outlet (localization task) as well as the total pollution mass and time course of pollution. This type of task can occur in case of accidental pollution, if the origin of the pollution is not known, or even with intentional act that can be defined as an offense or crime (illegal business - production of various substances, illegal wastewater outlets etc.).

General and accurate analytical solutions of inverse problems are currently not known, using of any method always gives only the approximate solution or an estimation, eventually the choice of a particular solution – the most probable case from a number of possible simulations, the results of which fits best with monitored data.

Overall, we can divide the solving methods of inverse problems into the following groups:

1. Empirical methods, e.g. [1], [2],
2. Simple methods- based on simplified analytical solutions of the advection – dispersion equation.
3. More complex procedures focused on the inverse numerical simulation in upstream direction. From a mathematical point of view these methods are more accurate, but also more complicated and more difficult to code [3], [4]

The project VEGA Nr. 1/0805/16 focuses on methods for practical solutions of inverse problems, i.e. localisation of pollution sources. The proposed general solution method is based on the computation of simulations for all possible boundary conditions:

1. different distances between the source and the monitoring profile,
2. for the various alternatives of pollution concentrations time courses.

Simulation results of each of these alternatives will be compared with monitored data – the simulation that will match the most closely with the monitored data can be considered as probable solution. The simulation itself is based on simplified analytical solution. In principle, it is a “brute force” method. The risk of such method is in the computer time, because of the necessity to carry out a huge number of numeric simulations.

For project implementation a SW tool was developed (working title Locator Of Pollution Source - LOPS), according to the principles described in the previous section. The basic graphical interface of the LOPS is on the Figure 1.

The first version of the LOPS successfully passed the tests with virtual (modelled) data and was preliminary tested also on real data. The test with real data and various input pollutograms were performed on a small mountain creek. Beside this the LOPS was also tested on real data from earlier tracer experiments on lowland stream, but only with instantaneous pollution injection, thus the tests should be extended with different pollution input conditions on different streams types.

Tests of sensitivity confirmed two important factors, that significantly improves the results of the LOPS computational procedure – pollution input sensitivity parameter and the mean flow velocity.

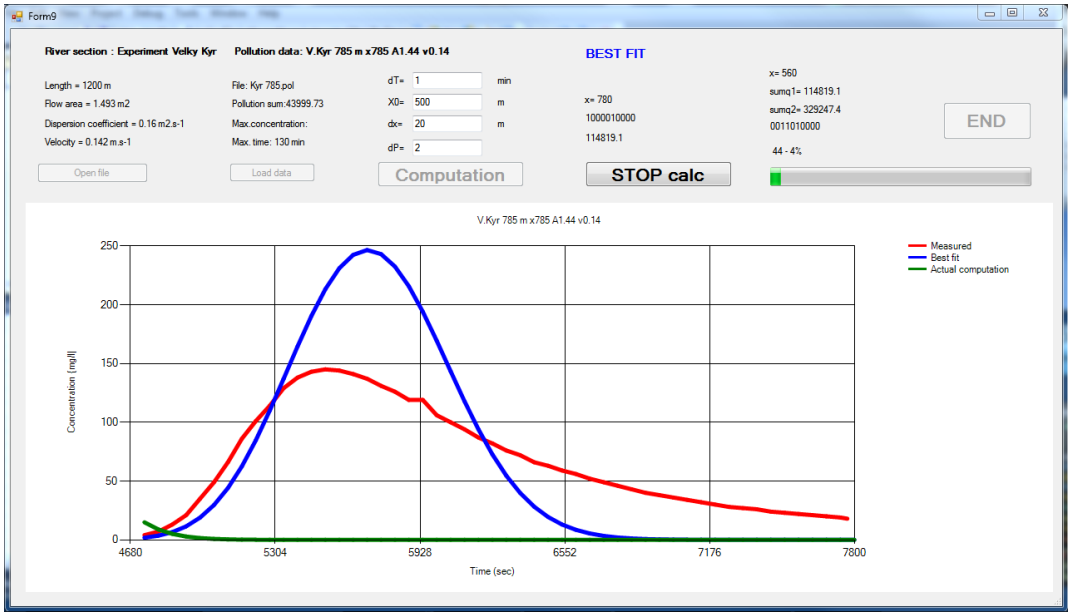

Figure 1. Basic SW computational interface, test on real data

During the LOPS SW test was found an another issue: the localization results are based on the search of the best fit between the monitored and modelled data, but the current (first) version of the LOPS routine is not able to represent some special particular problems, e.g. occurrence of dead zones in the investigated stream, so there is significant shape difference between the modelled and monitored pollutograms (an example is shown on Figure 1). Therefore, one of the main tasks in the future should be to use (or to develop) simple computational routines, based on analytical solutions, which incorporate modelling of particular dispersion problems and irregularities.

Keywords: inverse task, dispersion, pollution, source, localisation, numerical modelling

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Acknowledgment
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ANALYSIS OF ICE REGIMES ON THE DANUBE IN DALJ IN 2012. AND 2017.

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Abstract

The regime of ice in rivers represent the spatial and temporal regularity of occurrence in watercourses. In hydrological terms distinguish ice drift and a static ice. Ice regime of natural rivers is influenced by climate, water regime and channel morphology. Since channel morphology and water regime are influenced by river dams, changes in ice conditions can be expected. Regular ice phenomena observation mostly dates back to the 19th century. During this long-term observation period, the human impacts on the river hydrology and morfology have become more and more intensive. River ice regime could characterise by the date of drift-ice appearance, freeze-up, break-up and river ice disappearance, furthermore the duration of ice-affected and ice-covered season. Ice-on is the date of ice appearance, when ice drifting starts. Freeze-up is the date of continuous and immobile ice-cover occurrence. Break-up is the date, when the ice cover begins to move downstream and open water areas appear. Ice-off is the date of ice disappearance, when the river becomes ice-free. The Danube is the second length of the rivers in Europe, long 2857 km (188 km in Croatia). Flows through the nine European countries or is their border river. For the water regime of the Danube is characterized by big water level fluctuations. Danube freezes only for the strong winter, the lower course of the thickness of the ice is up to 60 cm. Therefore, navigation occasionally suspended from mid-December to early March. In this paper, we analyzed the two ice regime on the Danube in Dalj in Croatia, recorded in 2012 and 2017. Basic hydrological data of these events are shown in Table 1. The consequence of ice on watercourses is to create backflow and reduce the flow profile, which can result in the appearance of ice floods. To prevent the appearance of ice floods on the Danube , the ice was broken by icebreakers (Figure 1.), and in some places are mined with explosives.

Table 1. Data comparison for ice jam on the Danube in Dalj 2012. and 2017.

	DURATION PERIOD	ICE THICKNESS	WATER LEVEL (MAX)	WATER LEVEL (MIN)	WATER LEVEL (APPROX.)
FEBRUARY 2012	7.2 - 22.2. (15 days)	20 – 30 cm	476	269	313
JANUARY 2017	9.1. - 31.1. (22 days)	200 – 300 cm (alluvium)	414	195	270

Figure 1. Icebreaker breaks the ice on the Danube in January 2017.

Keywords: ice regimes, Danube, Croatia, ice flood, icebreaker

METHODOLOGY FOR DEVELOPMENT OF THE HYDROLOGICAL MODEL IN SMALL CATCHMENT

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Abstract

In this paper detailed methodology for hydrological model development based on artificial neural network application in small catchments is going to be presented.
Occasionally, damaging consequences caused by water activities can be reduced or even prevented with the help of an Early Warning System (EWS). The aim of the EWS is timely notification of local population on potentially damaging upcoming event. The most important part of the EWS, among the others, is development of the hydrological model that has sufficient predictive possibilities.
The motivation for this paper is coming from the need to explore the possibilities to foresee such water caused events (torrential and mud flow and debris flood) in small catchments with the main objective for the development of the hydrological model.
For the purpose of the research and analysis, continuous meteorological and hydrological data monitoring, on research area Slani Potok (Vinodol Valley, Croatia) historically known as potentially hazardous area is established. In order to develop hydrological rainfall-runoff model, artificial neural network is used and the methods for model validation and evaluation are defined based on existing guidelines for model development. After conducted research in which training, validation and evaluation of model`s accuracy and precision in rainfall-runoff prediction is conducted it is concluded that it is possible to implement such a hydrological model in small catchment. Research is then continued in the direction of the detailed methodology for the hydrological model development in order to improve existing general methodologies. As a result of the overall research in this paper all the steps for the development of the hydrological rainfall-runoff model is going to be described.

Keywords: early warning system, hydrological model, artificial neural network, implementation methodology

VARIATIONS OF ROUGHNESS COEFFICIENT VALUE DUE TO AQUATIC VEGETATION

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Abstract

The flow in lowland channels during growing season is often very strongly influenced by occurrence of aquatic vegetation. This vegetation may increase resistance to flow, and by this way also change the discharge capacity or cause higher water levels, as well as it affects on the velocity profiles [1-4]. For this reason, it is important to think about this fact, especially if we design, project or operate the hydro-melioration channels in lowland territories.

For evaluation or proposed calculations the steady non-uniform or unsteady flow are considered. The realization of calculations is not problem at the present state of computational technology, although in case of channel systems the calculation can be very serious task. However, the complicated task in these calculations can be the assessment of Chezy's coefficient *C* or assessment of roughness coefficient *n*. The Chezy's coefficient can be calculated by some known empirical formula (Chézy, Bazin, Kutter, Pavlovskij, Forchheimer, Manning, Agroskin, etc.), which express the function dependency *C=f(n)* usually. The next possibility of the Chezy's coefficient assessment is application of theoretical relations based on works of hydraulic researchers, e.g. Prandtl, Kárman and Nikuradze [5]. But these relations are not suitable for practical application.

The aim of this paper is to demonstrate on the base of results from experimental field measurements on the Chotárny channel, which is one channel of channel network at the Žitný Ostrov (Slovakia), how the sprouting of stream bed by aquatic vegetation influences the flow condition in the channel. There are existed a large number of ways how to evaluate the influence of water vegetation on flow in lowland streams. The quantification of water vegetation impact through the roughness coefficient is one from practically suitable methods.

Results of field measurements show that the value of roughness coefficient in sprouted stream bed is changing during the growing season in dependency on water vegetation growth. For this reason, the evaluation of roughness coefficient changes in channel during a year, possibly during a growing season was done. Figure 1 shows one example of this variation - the dependency of *n=f(t)* for cross-section profile No.1 in the third observational year during 7 days in July. This case represents extensively oscillated course of roughness coefficient value from 0.07 to 0.15. All obtained courses of curves *n=f(t)* indicated that the roughness coefficient values have been changed also during the growing season. In spite of the measurements during several days, it is not possible to determine the extremes of values reliably. Data obtained up to this day do not indicate if the changes of *n* in a summer period are higher than in an autumn period. For confirmation of these results, it will be necessary to extend the observation duration in cross-section profiles, perhaps to assign the observation in all cross-section profiles simultaneously.

The rate of vegetation impact on flow regime during the vegetation season had been changed in each year differently, as well. It is reasoned because the each year had different climatic conditions that stimulated water vegetation growth. Besides that, the activities around the maintenance of channel network (cutting, water level regulation, …) influenced also the degree of water vegetation growth.

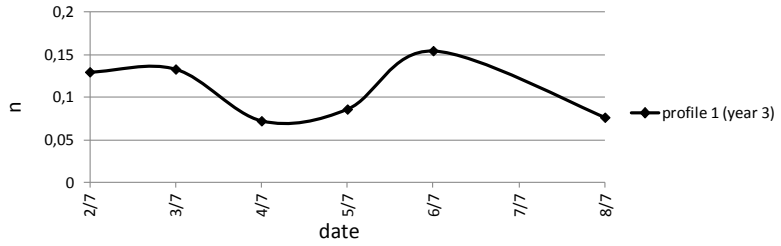

Figure 1. Example of variation of roughness coefficient values during monitored period

The majority of the roughness coefficient obtained during the whole observation at the Chotárny channel is from the range (0.05 – 0.15). By the literature [6-8] it represents, for example, moderately dense grass, weeds, or tree seedlings growing where the average depth of flow is from two to three times the height of vegetation, which blocks flow by approximately 1 to 10 percent. But the extreme value also occurred: 0.3 – 0.42. These values mean that flow is blocked by approximately 10 to 30 percent.
The roughness coefficient *n* is a hydraulic characteristic, which represents a parameter influences stream capacity and also it has been used as a calibration parameter for numerical model application. The database of the roughness coefficient for the Chotárny channel was created. The values are from the range 0.029 to 0.418. The results show variation of this parameter not only during a growing season, but the coefficient value varies by different rate also in each year. Vegetation in the channel evidently impacts its flow capacity, but on the other hand, by regulation of water depth and velocities (or discharge) it is possible to regulate plants growing up.
The relation for approximate estimation of discharge value as a function of the roughness coefficient, valid for the Chotárny channel, was derived.
Analysis of measured data showed and confirmed the complexity of in-channel vegetation impact on flow in a stream and the necessity to continue this problem investigation

Keywords: surface water, lowland channel, discharge, roughness coefficient, water level, aquatic vegetation

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SOCIAL AND ECONOMIC FLOOD DAMAGES ASSESSMENT IN MEDZEV

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Abstract

The costs of damage caused by extreme weather events (among which floods are a major category) have shown a rapid upward trend globally. The total amount of damage caused by flooding is used primarily for the needs of compensation for flood damage, for international comparisons and likewise enter into statistics which deal with the registering the damage caused by floods and other natural disasters. It is not possible to express the objective (so-called completely exact) amount of damage caused by floods, because we are not capable of valuing a significant portion of damages or the valuation techniques are so complicated that we back away from such processes. The scope and extremity of flood episodes point to the need to design and build a comprehensive system of flood protection measures in potential flood areas. The main objectives of management as well as the entire management cycle are regulated in European Union by Directive of the European Parliament and of the Council 2007/60/EC on the assessment and management of flood risks. The aim of the directive is similar to the aim of this paper – to reduce the adverse consequences of floods. The paper presents an application of proposed methodologies for assessment of social and economic flood damages in a modelled territory – the town of Medzev, which was in the scope of preliminary assessment of flood risk in Slovakia evaluated as an area with an existing potentially significant flood risk. Given the preliminary results, we can state that in the studied location Medzev the construction of flood protection measures makes sense, mainly in relation to the protection of property and human lives.

Keywords: flood risk, flood damage, social damage, economic damage, flood protection, effectivness

CONSIDERING THE EFFECTS OF HUMAN ACTIVITIES IN FLOOD HAZARD ASSESSMENT

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Abstract

Increasing trend of a frequency and intensity of flood phenomenon and also even more frequent human encroachment in a water-corridors and floodplains are main reasons for flood being one of most serious disaster. For more effective flood hazard and risk management the European Union adopted Flood Directive in 2007, on base of which all EU nations prepared legislation on the methodology for determination of flood hazard and risk areas. Classification of flood areas is taking into account several criterions and flood hazard assessment for high water scenarios with different return periods. Despite important anthropogenic influences and their impact on flood hazards, legislation on the process of flood hazards mapping usually does not obligate to consider anthropogenically induced scenarios that occur during extreme and extraordinary events like embankment breaching or failure of other flood protection measures, irregular or limited operation of the hydro mechanical equipment at hydraulic structures etc. As important human influence should also be considered stohastic land-use changes in line with economic, environmental and social interests. To reduce the risk in flood prone areas, infrastructure facilities, such as embankments, etc., are being planned as mitigation measures. Such measures can change the runoff regime and divert the hazard of flooding to other areas. Moreover, construction of levees changes the retention capacity of floodplains areas, which can have a significant impact on the peak attenuation and propagation time extension of flood waves and consequently on the flood safety of the downstream areas. The article presents introducing of exceptional events analysis in flood hazard and risk assessment. It presents different examples of direct and indirect human-induced extreme flood events, analysed with detailed hydraulic modelling.

Keywords: flood hazard, anthropogenic effects, flood risk mapping, legislation, runoff regime

UNSATURATED ANALYSES OF EXTREME RAINFALL INFLUENCE ON THE LANDSLIDE STABILITY

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Abstract

In the past couple years, the region of South-East Europe is subjected to gust rainfall events as a consequence of climate change activating many landslides which cause significant losses. Hence, there is a need to revaluate the existing risk maps and set new standards. In this process some old well instrumented case histories are revaluated including the effects of saturation or partial saturation on the slope stability. The behaviour of the slopes is controlled by their hydro-mechanical conditions and by soil-atmosphere interaction. The pore water pressure changes within a slope in some cases significantly reducing the soil strength. Climatic factors such as precipitation, evapotranspiration and runoff may also have a substantial impact on slope stability.

This paper presents two case histories of landslide instabilities subjected to excess climatic perturbations, namely the „Stanjevci" cut-slope near the railway line in North-East of Slovenia; and the „Ramina" a natural landslide in urban area near the city of Veles in Central Macedonia. They are subjected to specific short and gusting rainfall considered as possible trigger.

Stanjevci tunnel and the cut slope in its vicinity are located in the northern, central part of the Goričko hills in north-eastern Slovenia, that are dominated by sediments of the middle Pliocene, both marine and brackish, as well as fluvial and lacustrine origin. The landslide is located on the hillside, where a cut slope was made with slope direction towards north. The excavation pit is in the deepest part more than 30 m deep.

The „Ramina" is natural landslide located in highly urbanized hilly area of city Veles, Macedonia, on the left bank of the river Vardar. In the past it had been reactivated several times, last time in 2002 with major deformations leading to severe damage of the infrastructure and buildings. The landslide is about 500 m long with average width of about 100 m and height of 95 m. The estimated maximum depth of the shear zone is 24 m. The total area of the landslide is estimated to be 37,600 m^2 with around 475,200 m^3 of sliding mass, ranking it as the biggest in the Balkans, and possibly in South East Europe.

In the analyses both deformation and groundwater flow calculations are performed in coupled manner. A coupled hydro-mechanical approach is adopted to determine the influence of soil-atmospheric interaction and rainfall water infiltration. The analysis considered partially saturated soil behaviour calculating in account the evapotranspiration and vegetation effects. Such approaches require input data obtained from the Soil Water Retention Curve (SWRC) and the unsaturated hydraulic conductivity function. In the figure 1 we present the measured data of the silty-clay material of both sites. Hence, van Genuchten's hydraulic model is used in combination with elastoplastic material models. The results are summarized with critical comments regarding the safety factor in comparison to the results from the mechanical stability analysis.

The analyses produced wide range of results clearly depicting the influence of the heavy rainfall on the hydro-mechanical material parameters. Generally, the position of phreatic level and the distribution of pore water pressure are governed climate conditions (groundwater flow boundary conditions) with suction above phreatic level where with time in the case of downward flux (i.e. precipitation) suction decreases (and degree of saturation increases) and the water level rises. The figure 2 present the results obtained from the coupled flow-deformation analysis and development of suction for both cases.

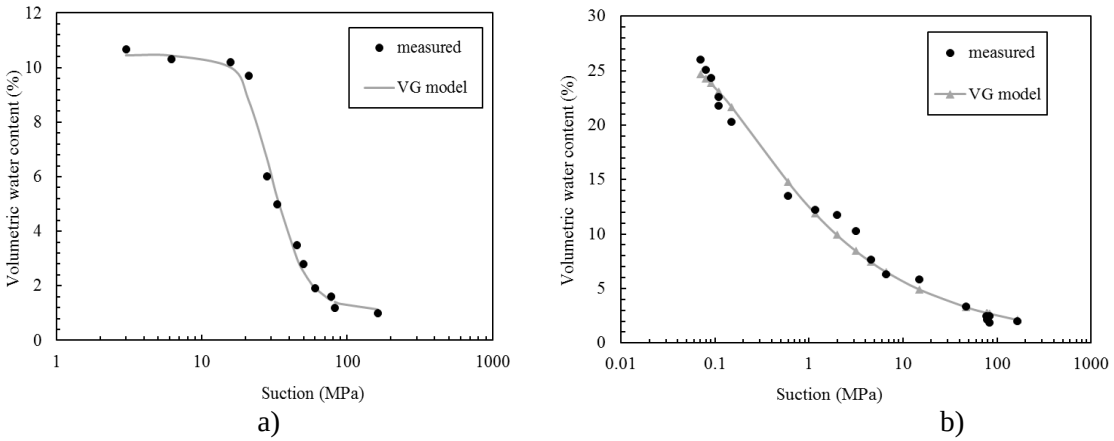

Figure 1. SWRC of a) Sandy-Clay from the „Ramina" and b) Clay from „Stanjevci" cut-slope

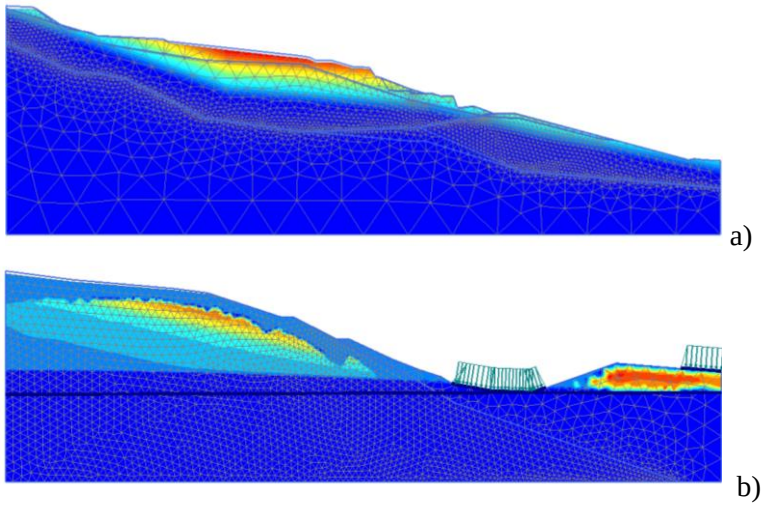

Figure 2. Suction profile for a) „Ramina" landslide and b) „Stanjevci" cut-slope

In case of „Ramina" landslide, the mass sliding had occurred just before 12 h of rainfall triggering displacement of 0.8 m at the top of the landslide. The sliding mechanism had developed first in the upper part triggered by in PWP build-up establishing different GWL in the upper and lower part. Realistic simulation of the sliding mass behaviour has been obtained where after the registered sliding a mass stabilization occurred defined by FoS = 1,3.

The simulation of hydraulic conditions on „Stanjevci" cut-slope leads to a saturation profile with a raise in GWL producing 20% increase of PWP and reducing the suction to 12,81 kN/m^2. This is followed by a global displacement with maximal value of 0.6 m being realized before the 12 h of precipitation. The ultimate limit state and global cut-slope destabilization is ensured by FoS = 1,22.

The concluding remarks describe the influence of suction and different aspects on the accuracy. The consequences of climate change on landslide rate, size and frequency are difficult to predict because they depend on a range of variables. The precipitation (mostly in rainfall) is among the most important factors especially severe storm would cause flash floods with intense erosion and landsliding. The modelling has shown that suction responses to rainfall vary on a number of different timescales. On shorter timescales (ranging from minutes to hours and days) heavy rainfall which was of primary interest in this study produced very interesting results. The rainfall infiltration effects in the literature are usually critical for shallow landslides, but here it proven that also the deep sited landslides with high GWL could be destabilized. It was also proven that relatively short (12 h) but gust rainfall (10 - 15 mm/h) could have a significant influence on the overall (global) stability.

Keywords: unsaturated soil, landslide, climate change, rainfall, coupled hydro-mechanical analysis, suction.

FLOOD MANGEMENT IN URBAN BASINS OF THE CITY OF GDAŃSK

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Abstract

Over the last years the City of Gdańsk suffers twice from flash floods. Both events were caused by - intense storms which produced significant surface runoff and caused inundation privet and cities properties. The first case of July 2001 flood was the turning point for the city authorities, who decide to look close on the flood management in small urban catchments. The aim of research projects was to establish technical solutions and procedures to be applied in case of risk of flooding due to heavy rain on all Radunia Channel tributaries. The largest basin is the catchment of Oruński Stream. The area was recently intensely developed and according to the spatial planning the urbanisation process will proceed. The project's closure took form of decisions concerning technical solutions modifying operation mode of Gdansk Water Junction System in order to ensure an optimal distribution of flood water. After 2003, Gdansk Floodway System rebuilding propositions started to be regularly implemented. Thanks to actions initiated in the river basin of Radunia channel, no more emergency situations were observed during the flood in 2016. In the paper the hydrologic model of the water system of Oruński Stream will be presented with particular effort paid to the new and renovated retention structures. Hydrological modelling system of HEC HMS was used to simulate the basin response on precipitation. The 16,4 km^2 model domain was divided into 35 sub-basins according to storm water drainage system. Both, current and proposed land use of the basin was taken into consideration. The operation of six existing and two proposed flood detention reservoirs were included in the simulations. The results showed the importance of reservoirs and water diversion structures on flood surge routing.

Keywords: Flood Management, Urban Basin, HEC HMS Modelling, Oruński Stream, Gdańsk

MULTILINEAR MUSKINGUM METHOD FOR THE SIMULATION OF FLOOD WAVE MOVEMENT ON THE DANUBE RIVER IN SLOVAKIA

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Abstract

The Muskingum method, as one of the hydrological models which describe the transformation of discharge waves in the river beds with lumped parameters, is widely used in hydrological forecasting. In this study the multilinear version of the model was used, which was based on the discrete state space formulation of the model equations. The differential equation was integrated under the assumption of stepwise constant function of the input discharge. Multilinearity was introduced by allowing the time parameter of the model is to vary with discharge.

The multilinear Muskingum method was applied on the Danube river reach between Bratislava – Medveďov in Slovakia. Parameters of model can be estimated by several methods. We had compared the graphical method with a method where genetic algorithms (GA) and harmony search (HS) were used for optimization. The parameter X was found as the average of all the flood waves used (as one constant value) and K was a function of the travel time parameter (K) and discharge was optimized for large flood wave or, in some cases, the almost biggest wave in selected sets of flood waves.

The results of the classical approach of McCarthy were compared with model setups based on genetic optimization and harmony search of the parameters and with the multilinear version of the model. The results obtained were very satisfactory and because of the advantage of the small number of data required it could be used in suitable river reaches for the estimation of wave travel time or for the approximate forecast of discharge.

Keywords: Muskingum method, flood wave, parameters of the model (K, X), travel time, Danube River

3. WATER SUPPLY AND WASTEWATER SYSTEMS

ANALYSIS OF WATER QUALITY OF VUČICA-KARAŠICA RIVER

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Abstract

Constantly increasing world population leads to intensive agricultural production and fast urbanization. With every year, agricultural production implements more and more of various types of fertilizers, especially nitrogen fertilizers which not only increase yield of agricultural products, but are a significant source of water pollution. In the last several decades, increasing attention has been dedicated to the problem of water quality and pollution, especially by nitrates. Though nitrates are necessary for growth and development of plants, increased concentrations are toxic for aquatic organisms and have a negative impact on the environment, such as eutrophication, which is especially pronounced in lowland rivers of Europe. Problem is further complicated by negative impact of nitrates on human health, such as development of methemoglobinemia and some types of cancer.

This paper gives an overview and an assessment of water quality of Karašica-Vučica River, which is located in area with intensive agricultural production. Samples were taken over the period of ten years, and cover several locations along the river flow. Obtained results indicate that Karašica-Vučica River is facing eutrophication. Analysis of physical and chemical parameters indicates a decrease of water quality, depending on location and year. Generally, water quality of Karašica-Vučica River, upstream form industrial complex (Kudeljara, Črnkovci; Našicecement d.d., Našice), can be characterized as moderately polluted, with no odor and sufficient concentration of oxygen. Such conditions are ideal for excessive algal and aquatic plant growth, leading to increased eutrophication. Downstream from industrial complex, level of water pollution is greater, water has decreased amount of oxygen and a specific odor. Water quality at two locations, canal Karašica and Karašica Črnkovci, is very poor, but on one location, Crnac-Krčenik, water quality was determined to be very good.

Obtained results indicate that it is necessary to take actions to protect Karašica-Vučica river form further pollution. Potential sources of pollution (agriculture, sewage, industry) should be minimalized, systems for water purification should be modernized, by agricultural production already jeopardized and vulnerable areas should be identified and protected, for instance by limiting application of nitrogen fertilizers. Further continuous monitoring of water quality is necessary to insure adequate implementation of the aforesaid measures.

Keywords: water quality, nitrogen compounds, nitrates, nitrites, ammonia, surface waters, agricultural activity, eutrophication

REMOVAL OF IRON AND MANGANESE FROM GROUND WATER WITH MODIFIED ZEOLITES

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Abstract

The objective of the technological experiments in the locality of Kúty (a water treatment plant) was to compare the efficiency of manganese and iron removal in water treatment using a filtration medium based on a chemically modified natural zeolites from different deposits (Klinopur-Mn, Klinomangan) and monitoring the influence of water quality (pH, concentration of oxygen, iron and manganese) on efficiency removal iron and manganese from water.

One of the methods for elimination of dissolved manganese is the elimination by means of the oxidized coat on the grains of filter medium. By addition of potassium permanganate (not only $KMnO_4$, but also other strong oxidizing agents) there is the coat form on the surface of filter medium, and this coat serves as a catalyst of oxidation. The oxidation condition of the medium coat $MnO_{x(s)}$ plays the obvious role in elimination of dissolved manganese, and the efficiency of manganese elimination is the immediate function of $MnO_{x(s)}$ concentration and oxidative condition. There is the formation of coats with different abilities to eliminate dissolved manganese from water on the various filter medium [1-6].

Tab. 1 shows the chemical composition of used zeolites after activation with $KMnO_4$ and the content of MnO_2 on the surface of filter media.

Table 1. Chemical composition of the Klinopur-Mn and Klinomangan

Material	**Content [%]**									
	SiO_2	Al_2O_3	K_2O	CaO	Fe_2O_3	P_2O_3	MgO	Na_2O	TiO_2	MnO_2
Klinopur-Mn	69,56	8,19	5,58	3,79	3,32	1,08	0,81	-	0,74	**6,92**
Klinomangan	61,68	8,29	4,77	3,51	2,87	0,81	0,27	2,56	-	**15,16**

The experiments were designed to optimize the filtration rate (contact time of the raw water with the filter media) and washing and regenerating the filter materials (filter length of cycles). The quality of the raw water (Fe and Mn content) and treated water at the outlet from the separate filtration columns was monitored during the experiments.

The water was supplied to filtration columns from two different sites for the technological water treatment process. The water for Experiment 1 (sampling point No. 1) was taken after aeration and lime dosing, where the optimal conditions for the removal of the iron and manganese (increased oxygen content and a pH of more than 8) were achieved. The water for Experiment 2 (sampling point No. 2) was taken after aeration of the water, where the content of the oxygen in the water had increased. During the Experiment 1, an average concentration of iron and manganese in raw water were 0.506 $mg.l^{-1}$ for manganese or 3.92 $mg.l^{-1}$ for iron and during the Experiment 2, an average concentration of iron and manganese in raw water were 1.124 $mg.l^{-1}$ for manganese or 3.28 $mg.l^{-1}$ for iron. The technological scheme of the WTP Kúty is shown in Fig. 1.

Obtained results prove the possibility to use Klinopur-Mn for removal of iron and manganese in water treatment process. Klinopur-Mn is comparable with imported filtration material Klinomangan. The materials observed exhibit different efficiencies of manganese removal from water, since the quality of the treated water play a major role (oxygen content and pH value). For the efficiency of the manganese removal from the water (in case of Experiment 2) Klinopur-Mn and Klinomangan were necessary to modified by the gradual backwashing and regeneration with 2,5% solution of $KMnO_4$. The filtration time without regeneration was gradually extended.

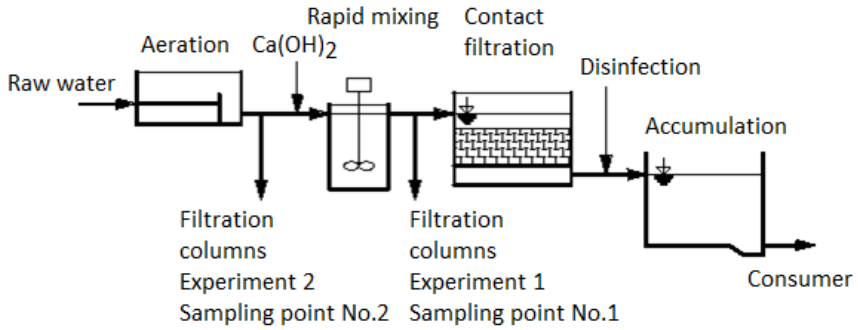

Figure 1. Scheme of the technology of WTP Kúty and the location of the filter columns

In the case of the removal of the iron from the water, the quality of the raw water is not a limiting factor; both materials removed Fe from the water to below the limit value (0.20 mg.l^{-1} – limit for the drinking water defined under Regulation of the Government of the Slovak Republic No. 496/2010 on Drinking Water).

The content and form of occurrence of iron and manganese in water as well as water pH and dissolved oxygen concentration (min. 15 % of Fe + Mn content) are among the important criteria for Fe and Mn removal efficiency (lower efficiency in removal of iron bound to humic acids). The efficiency of Mn removal is influenced by the contact time between water and filter material (height of filtration layer, filtration time), properties of preparation active layer, i.e. layer thickness and its chemical composition, regeneration method, $KMnO_4$ concentration as well as the time of backwashing and regeneration.

Keywords: treatment of ground water, removal of iron and manganese, modified clinoptilolite, Klinopur Mn, Klinomangan

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HYDRAULIC MODELLING FOR WATER LOSS ANALYSIS AND OPTIMIZATION OF WATER SUPPLY SYSTEMS

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Abstract

A hydraulic model is a mathematical model of a water system and is used to analyse the system's hydraulic behaviour. Hydraulic models of water supply systems have mainly been used by engineers for dimensioning pipe network, pumping stations and water storage. This paper is showing real-life examples on how to use hydraulic model for different applications in process of analysing and operating water supply systems.

Using hydraulic model for water loss analysis can improve results by using modern methods of calculating average pressure, analysing pressure impact on pipes and nodes, data management, etc. Further, hydraulic model can improve water loss reduction calculation using real time pressure management or calculating the impact on water losses due to pipe replacement. Paper is showing some examples on how to use advanced zone calculation for water loss reduction and energy consumption optimization.

Water utilities can benefit using hydraulic model for decision making on network improvements, network expansion, impact of pressure reduction on water sales by calculating pressure depended demands, etc. Case study will be showed on how a good model prevented a bad decision in a real-life scenario of network expansion.

By modelling a water supply system, utility companies and designers will gain a full understanding of its hydraulic behaviour. Model is used as a tool to plan infrastructure improvements, develop operational maintenance strategies and to proactively manage water supply system. Final chapters of paper will show all the benefits on having a model and its relatively small cost in comparison to its benefits.

Keywords: Hydraulic Model, Water Supply, Water Loss, IWA, Pressure

AVERAGE PRESSURE IN A WATER SUPPLY SYSTEM

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Abstract

Average water pressure is usually determined as the weighted value of all pressures (in each pressure zone or in the whole water supply system). It is a characteristic pressure value which results in an average water losses in the study zone or the whole water supply system. In IWA water balance methodology average pressure is used for calculation of 'Unavoidable Annual Real Losses' (UARL), which represents the lowest possible, i.e. tehnically achievable value of water losses that is a core component of deriving the Infrastructure Leakage Indeks (ILI index). This paper gives an overview and the comparison of several approaches for determining the average pressure required for the calculation of UARL. The average pressure for gravity water systems, as well as for the systems whose pressure depends on the work of pumping stations, is determined. Also, the possibility of applying hydraulic mathematical model to determine the average pressure is analyzed. The advantages and disadvantages of each method is pointed out.

Keywords: average pressure, water losses, water systems, UARL, hydraulic mathematical model

REMOVAL OF ARSENIC FROM WATER

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Abstract

Since 1998, an intensive attention has been paid to the presence of heavy metals in the water, when standard „STN 75 7111 Drinking Water“ was introduced into the Slovak legislation. By transposition of European Direction 98/83/EC and WHO recommendation [1] into our legislation, the limit concentrations of some of the heavy metals (e.g. As, Sb) were decreased, resp. determined for the first time which caused that some of the Slovak water sources has become nonconforming and they need to be adjusted properly for their next use. The knowledge about the health aspects of heavy metals presence in drinking water are included in the paper Water Quality and Treatment, A Handbook of Community Water Suppliers [2].

Adsorption on a suitable adsorption material is among the most frequently used methods in water treatment. In terms of plant operation, two stage filtration process represents a simple, effective and economical friendly method of heavy metals removal namely for the possibility of using a large scale of substances with a sorption ability – sorbents. Oxides, oxihydroxides containing iron, activated alumina, a sand covered by some hydroxide containing iron, activated carbon, media with the TiO_2 or MnO_2 surface layer etc. [3] are among the most frequently used sorbents of the heavy metals. The quality of the treated water (pH, silica, phosphorus, fluorides, sulphates, chlorides, vanadium, total mineralisation, iron and manganese), redox conditions and the valency has the impacts on heavy metal removing efficiency [4].

The objective of this work was to verify the sorption properties of granular filter materials READ-As (hydrous cerium dioxide adsorbent) in removal of arsenic from groundwater source in Jasenie. WTP Jasenie treats the spring water with the yield of 15 $l.s^{-1}$. Water contains arsenic at the concentration of approx. 0.060 $mg.l^{-1}$. In connection with the hydrological conditions the values are used to be higher in certain seasons.

The pilot-plant equipment in which the treated water is flowing through the sorbent READ-As in a regime of two stage filtration was used for verifying the efficiency of arsenic elimination from water while the total volume of the sorbent was approx. 50 litres and the equipment capacity was 250 $l.h^{-1}$. Used filter was of one of the closed type filters and was plastic with the inner diameter of column 24.4 cm, surface of 467.6 cm^2, column depth 1m and filling depth 53.4 cm. Water flowed through filtration equipment from the top to the bottom direction.

READ-As was provided by the company Global Water KFT. Material, the granulated ceric oxide (88% CeO_2 and 12% ethylene-vinyl alcohol copolymer) has been developed by Company Nihin Kaisui Co Ltd in Japan. READ-As is a material produced for removal of the arsenic from water in a large scale of conditions and it is sorbing efficiently both the arsenate and arsenate (III). The oxidation of arsenate (III) to arsenate is not needed. Nor adjusting the pH of the water before and after the sorption is needed. It is possible to regenerate this material by the addition of natrium hydroxide, sodium hypochlorite after it and by washing with water at the end. Regenerated material needs to be neutralized by hydrochloric acid and needs to be washed with water before the next use. In dependence on the amount of the sorbent and a chemical composition of the water the regeneration should be performed after 4-12 months [5]. Physical and chemical properties of READ-As and filtration conditions are listed in the Table 1.

Table 1 Physico-chemical properties of READ-As and filtration conditions during the experiments

Parameter	Properties	Parameter	Filtration conditions
Matrix/ Active agent	CeO_2 >88%	Medium height [cm]	53.4
Physical form	moist granular	Volume of adsorption column [cm^3]	24.97
Color	yellow	Mass of sorption material [g]	18980
Bulk density [$g.cm^{-3}$]	0,76	Average flow [$l.hour^{-1}$]	250
Grain size [mm]	0.3-1.0	Average filtration rate [$m.hour^{-1}$]	5.35
Specific Surface Area [m^2/g]	195	Empty Bed Contact Time [min]	5.99

Figure 1 shows the arsenic concentration progress in dependence on ratio V/V_0 (so-called bed volume) for two stages filtration as well as the calculated values of READ-As adsorption capacity (in $\mu g.g^{-1}$) and outfl owing the column bed volume from column no. 1 and at the end of two stage filtration (columns 1 and 2 together, joined one by one in series) for concentration of arsenic 10 $\mu g.l^{-1}$ is also shown in Figure 1.

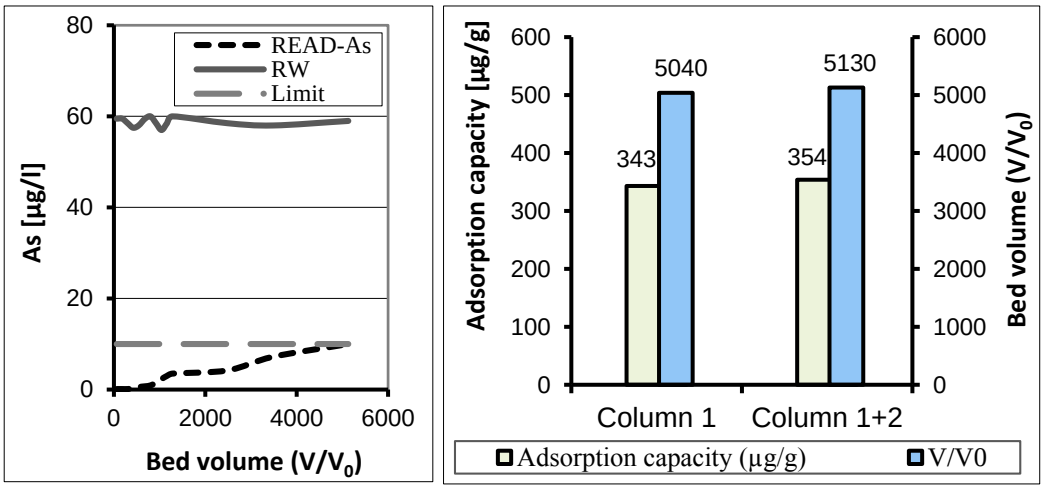

Figure 1 The concentration of arsenic ($\mu g.l^{-1}$) at the outlets of adsorption media in relation with V/V_0 (left) and the values of V/V_0 ratio and adsorption capacity ($\mu g.g^{-1}$) for each sorption material (right) when was reaching the limit concentration of arsenic (10 $\mu g.l^{-1}$)

At the current operational conditions (average As concentration in a raw water 58.71 $\mu g.l^{-1}$, filtration rate 5.35 $m.h^{-1}$) the As amount of 6.51 g was adsorbed in a column no.1 by READ-As material (18.98 kg). By performing two-step filtration with the filling mass of 37.96 kg, 13.4 g of Arsenic was adsorbed while the amounts of absorbed arsenic are calculated for value 10 $\mu g.l^{-1}$ of arsenic at outflow of the filtration columns. According to these results the adsorption capacity of the READ-As was 343 $\mu g.g^{-1}$ when was used column no.1 and 354 $\mu g.g^{-1}$ when was used both columns joined in a serie.

Keywords: groundwater treatment, removal of arsenic, cerium dioxide, sorption,

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Acknowledgements
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ISLAND OF CRES WATER RESOURCES CARRYING CAPACITY ASSESSMENT

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Abstract

Access to sufficient amount of water resources is a crucial requirement for survival, development and overall well-being of a society. Availability of water can dictate the health of a society and impose constraints on its progress and growth. This paper examines how regional availability of water resources influences the society's maximum population size. Maximum sustainable human population size limited by availability of water resources is referred to as the water resources carrying capacity (WRCC).
Region chosen for WRCC assessment is the island of Cres, located in the northern part of the Adriatic sea. Water supply of the island relies completely on rainfall which drains from the island's surface into the Vransko lake, a natural reservoir located in the central part of the island. Both the amount of rainfall, the only renewable source of water for water supply, and the demand for water have substantial seasonal variations. Generally, summer periods are dry and accompanied by an increased demand for water, mainly caused by a large influx of tourists to the island. This scenario usually puts significant pressure on the water supply, and information on maximum sustainable population supported by regional water availability (i.e. WRCC) can be very useful in regional planning and water management activities, especially when sustainability is the goal of such activities.
WRCC assessment, like most ecological modelling tasks, usually yields best results when a stochastic approach in calculations is used, rather than deterministic. Parameters needed for the assessment, such as rainfall intensity, volume of underground water reserves, evapotranspiration, municipal and industrial water consumption etc. can rarely be predicted with sufficient accuracy to produce a reliable deterministic WRCC result.
Method proposed by the paper is based on a probabilistic approach, it relies on Monte Carlo simulations to provide a probability distribution of WRCC values. Sensitivity analysis is performed as well in order to identify the most influential parameters of the assessment; results are presented as scatter plots and indices resulting from variance based sensitivity analysis.

Keywords: water resources carrying capacity, sustainable water resources management, uncertainty analysis, Monte Carlo simulation, sensitivity analysis

DETERMINATION OF THE DURATION OF DESIGN STORM FOR MODELING RUNOFF FROM URBAN CATCHMENT

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Abstract

Design storm is the precipitation pattern defined for the use in planning, design and capacity verification of engineering projects concerning e.g. sewerage systems. Design rainfalls are input data to hydrodynamic modeling of runoff from the catchment and can be defined by synthetic hyetographs (time distribution of rainfall). The Euler rainfall hyetographs of II type (according to German Standards ATVA118) were developed with the use of IDF (Intensity-Duration-Frequency) Curves based on IMGW formula, for the frequency c = 5 years of the rainfall exceedance recommended by Polish Standard (PN-EN 752) for downtown development. The peak of rainfall intensity was set at 0.3 of the rainfall duration (according to ATV118) and at 0.4 of the rainfall duration (according to own research made for Poznan). The rainfall time durations used during the computer simulations varied from 15 min to 360 min. The computer model was built on basis of real urban catchment. The catchment of area of ca.6,7 km2 was located in the city of Poznan, Poland. For the storm water outflow simulation the EPA SWMM5 package was used. The aim of the research presented in the paper was to determine the design rainfall duration for which the outflow from the experimental catchment reaches maximum intensity. The analysis of the maximum flow as the function of design rainfall duration was performed. It allowed to evaluate the rainfall durations for which the outflow in the considered cross-sections reaches maximum intensity. Obtained results can be useful for determination of design storm duration in hydrodynamic modeling of storm sewer systems.

Keywords: design rainfall, runoff hydrograph, SWMM5, synthetic hyetograph, urban catchment

MANAGEMENT OF SEWAGE SLUDGE - NEW INSIGHT INTO VALORISATION AS SUPPLEMENTARY CEMENTITIOUS MATERIAL

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Abstract

Wastewater treatment and management of the generated by-products has become a very important global problem which is specially the case in developing countries like Croatia, where the number of wastewater treatment plants (WWTP) is increasing to meet stringent EU requirements. This is resulting in the production of increasing quantities of sewage sludge. Thermal processing of sewage sludge can facilitate its further management by reducing the total mass and volume. Sewage sludge ash (SSA) is the main by-product formed in the combustion processes.

Most of the generated SSA worldwide is still landfilled but this is a significant additional cost for utilities since it is usually classified as a non-hazardous waste depending on a results of leaching tests. Therefore, use of SSA is desirable and it may be possible to use it in the concrete industry as a partial cement replacement. This is because the main chemical elements present in Portland cement (Ca, Si, Al and Fe) are also present in SSA.

The research presented in this paper is part of a wider feasibility study on the possible recycling and use of Croatian sewage sludge ash. Sewage sludge was sourced from WWTP Karlovac and SSA was produced by laboratory incineration at temperatures of 800 and 900°C. The possibility of SSA use depends a great deal on its composition so physical and chemical characteristics of SSA were investigated.

SSA was also tested for heavy metals leaching and results were analysed in the context of EU landfill Waste Acceptance Criteria. Main elements of concern when SSA alone was analysed were successfully immobilised in cement matrix when SSA was used a partial cement replacement in mortars (Table 1).

Table 1. Leaching concentrations [µg/L] of selected elements from SSA obtained at 900°C and crushed SSA-mortars with liquid to solid ratio L/S = 10 (leaching of all other analysed elements was bellow detection limits)

PARAMETER	SSA	CRUSHED SSA-MORTARS
Cl^-	215,000	2,800
F^-	900	210
Zn	< DL	38
Pb	< DL	0.38
As	2.87	< DL
Cr	39.33	4.66
Se	6.21	0.94
Mo	169.8	11.05
Sr	19.20	9.03

*< DL – bellow detection limit

Technical requirements for mortars and concrete were not significantly influenced when shares of up to 20% of SSA replacing cement were used. The main negative effect was reduced workability of experimental mixes due to the increased need for water in the mixes which is attributed to the rough texture of ash particles. Use of superplasticizer has successfully overcome this problem. Strengths of experimental mixes (incorporating SSA) of mortars and concrete were at par the strengths of reference mixes, and in some cases these were even topped (Figure 1).

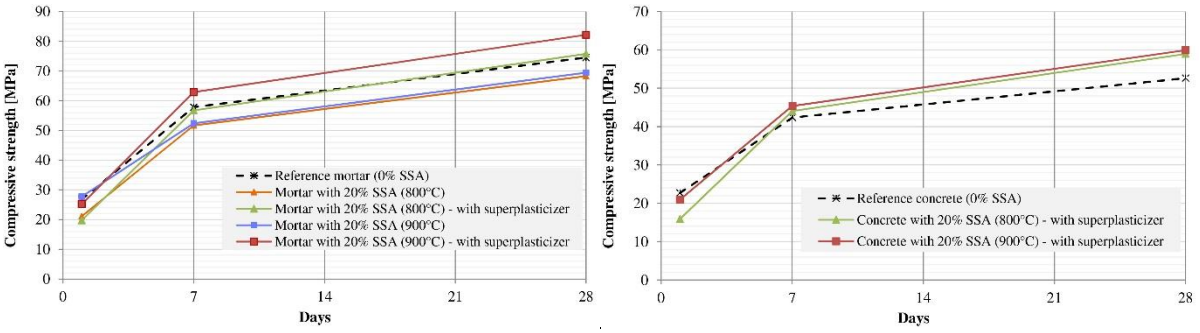

Figure 1. Compressive strength development of experimental SSA-mortars (left) and SSA-concrete (right) and their comparisson to reference mixes

Obtained results indicate that environmental and economic benefits from using SSA in concrete industry can be significant. This practice is technically feasible, but with certain limitations so it can be concluded that use of SSA in cement based materials represents a good alternative to landfilling. This research may serve as a good base in the process of decision making on the method of SSA disposal if sludge from Karlovac WWTP is sent to incineration. The presented methodology can be directly applied to other WWTPs, because there is a need for separate analysis on each of the different SSA.

Keywords: sewage sludge ash, incineration, cement, strength, leaching

Acknowledgement
This work has been fully supported by Croatian Science Foundation under the project "7927 - Reuse of sewage sludge in concrete industry: from microstructure to innovative construction products".

URBAN SEDIMENT MANAGEMENT – FROM THE RIVER TO THE SEWER

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Abstract

Aims and Problems:
In some sections of the Viennese sewerage system there are problems caused by sedimentation. The Wienerwaldcreeks (Krottenbach and Erbsenbach rising in the Wienerwald) and sediments from the urban catchment area are probably the source of these sediments. First the Wienerwaldcreeks have a free flowing section from about 3,2 km with a natural catchment area of 3,1 km² and a mean annual flow of 0,04 m³/s. Afterwards the creeks discharge into the sewerage system of Vienna (19th district). The vaulted section is about 2,0 km long and at the end of the mixed water sewer, there is a sand trap located which should reduce the sediment input into the following sewer section called "right main sewer". The sand trap is 12,0 m long and consists out of two 2,0 m wide pools. The depth of the sand trap is 1,2 m and each pool has a slope of 0.025. Especially at large discharges, the accumulated sediment in the sand trap flushes out. Accordingly, these leads to sedimentations in the right main sewer. In this area, an automatic excavation of the sediments is not possible which means that the excavation must be done manually. The primary goal of this study is to find the source of the accumulated sediment and to prove the hydraulic operational capability of the sand trap.

Methods:
For detecting the source of the sediments, sediment samples at ten positions (four samples in the free flowing section – two samples in the sand trap and the right main sewer – four samples in the sand interceptors from the urban catchment area) have been taken and analyzed regarding to the grain size and to the geological composition. With a Helly Smith Sampler, a hand catcher and a fixed sediment sampler the bed load transport at the free flowing sections of the Wienerwaldcreeks have been surveyed. For proving the hydraulic capability of the sand trap, a physical 1:10 scaled model of the sand trap was built. With laser Doppler anemometry the horizontal and the vertical velocities have been recorded for three different discharges ($Q_{1,m}$=2,0 l/s, $Q_{2,m}$=8,0 l/s, $Q_{3,m}$=16,0 l/s). According to the grain sizes from the sediment samples a flushing experiment with a sediment fill level of one third of the sand trap volume have been performed.

Results:
After comparing the grain sizes and the geological composition of the different samples, it is likely that the sediment from the sand trap derive from the urban catchment area. Table 1 shows the geological composition of the sediment samples. Sample one to four have been taken (from upstream to downstream) form the bed level of the Erbsenbach located in the natural catchment area. There the dominating rock is flysch, which fits to the geological map of this area. In contrast to the samples from the natural catchment area, the dominating rock at the sand trap and the right main sewer is lime and rest. The rest consists out of concrete, brick and organic material.

Table 1. Geological composition of the sediment samples in percent (Ottner, 2017)

Sample	FLYSCH	LIME	REST
1.SAMPLE	100	0	0
2.SAMPLE	93	0	7
3.SAMPLE	85	0	15
4.SAMPLE	89	0	11
5.SAND TRAP	2	27	71
6.RIGHT MAIN SEWER	4	62	34

In addition, the results from the bed load measurements suggests that the sediments do not have their source at the natural catchment area of Krottenbach and Erbsenbach (Wienerwaldcreeks). Under conditions with increased discharge (up to 0,3 m³/s), the amount of the caught bed load material achieves less than one kilogram per meter width. The measured velocities in the model of the sand trap had their maximum at a discharge of 16,0 l/s, with 1,1 m/s. Under nature conditions, this is equivalent to 3,2 m/s.

Table 2. Allowed velocities to achieve sedimetation in the sand trap according to the grain size

	GRAIN SIZE DIAMETER [mm]	HORIZONTAL VELOCITY [m/s]	SEDIMENTATION LENGTH [m]
d_{10}	0,70	0,4	12
d_{50}	3,57	1,1	12
d_{80}	8,96	1,8	12

Table 2 shows the maximal allowed velocities according to the grain size and the length of the sand trap under nature conditions. In case of the $d_{80,}$ this means that the maximal velocity must be smaller than 1,8m/s to achieve sedimentation in the 12,0m long sand trap. For the scenarios with a model discharge of 8,0 and 16 l/s, which conforms 2,5 and 5 m³/s under nature conditions the velocities in the sand trap are partly higher than the shown velocities in Table 2 and full sedimentation for all fractions of the grains is not possible. The results from the flushing experiment fit to the previous perceptions. At a flow rate of 8,0 l/s (equal to 2,5 m³/s under nature conditions) the accumulated sediment starts to flush.

Conclusion

Caused to the achieved results during the measurement period the Wienerwaldcreeks are not the primary sediment suppliers into the researched sewerage system. It is likely that most of the accumulated sediments in the sand trap have their source in the urban catchment area. Because of the high velocities during periods with high discharges, full sedimentation is no longer possible and the already accumulated sediment flushes out. For the future, the focus will be to optimize the hydraulic capability of the sand trap and to reduce the flushing of the sediments.

Keywords: urban sediment management, hydraulic assessment of sand trap, physical model, laser Doppler anemometry, sediment transport, sediment source

STORMWATER MANAGEMENT IN THE URBAN ENVIRONMENT

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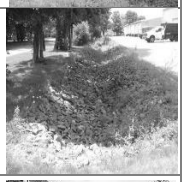
Abstract

In Europe, around 75 % of the population live in urban areas and this is projected to increase to about 80 % by 2020. The environmental elements of good quality of life include good air quality, low noise levels, clean and sufficient water, good urban design with sufficient and high-quality public and green spaces, and a good local climate or opportunities to adapt to climate change. Well-designed, well-managed urban settings offer great opportunities for sustainable living. The impermeability of the sealed areas reduces natural drainage and increases water run-off, which in particular during heavy rains can lead to urban floods. However, urban design aimed at tackling climate change, as through boosting green infrastructure, could have numerous co-benefits, including improved air quality, support for biodiversity and enhanced quality of life. These paper will present the various possibilities of using rainwater as a resource as opposed to considering it as something that simply needs to be hidden in sewers. Several benefts can be achieved by using rainwater to help cities keep a sustainable

water balance through various treatment. In order to protect the groundwater, runoff must be of an appropriate water quality. Especially runoff from streets needs some kind of treatment before it is infltrated technologies. Drainage of storm water is solved integrated with multidisciplinary teamwork and applying a series of administrative and technical measures aimed at reducing the negative impact of a switched hydrological regime of runoff and pollution of rainwater entered into the water recipient. This approach involves a precise timetable for natural and engineering technologies that provide for: the re-use of water retention, infiltration into the underground, evaporation, filtration and purification plant, the overall system in order to: control of peak runoff, reducing the volume of runoff, improve the quality of runoff and water conservation. Sustainable urban drainage systems(SUDS) are systems designed to efficiently manage the drainage of surface water in the urban environment. SUDS techniques might include: filter strips and drains, swales, permeable surfaces, basins and ponds, underground storage, wetlands, green roofs, rainwater harvesting. Some of the stormwater management device with their functions and characteristics are shown in Table 1.

Table 1.Stormwater management device

Device	PRIMARY FUNCTION	PRIMARY CHARACTERISTIC	EXAMPLE
WATER BUTTS, RAINWATER TANKS, GREYWATER TANKS, ROOFTOP GREENING	Collection and re-use of surface water	Provides offline attenuation of stormwater	
INFILTRATION TRENCHES, SOKAWAYS, PERMEABLE PAVEMENTS	Encourage stormwater to soak into the ground while filtering pollutants	Permeable features allowing vinfiltration	
SWALES, BIO-RETENTION SYSEM, FILTER STRIPS, FILTER DRAINS	Capture heavy metals, grase, oil, nutrients and sediment	Grassed or planted features such as channels	
RETENTION PONDS, OIL INTERCEPTORS	Primarily designed to retain pollutants	Artificial lake with fringing vegetation	
DETENTION BASINS	Primarily designed to reduce the runoff rate	Vegetated depressions	
STORMWATER WETLANDS	Filter stormwater and reduce runoff rate while prowiding a wild life habitat	Heavily vegetated, hydrologically charged area	

Keywords: urban environment, stormwater, management, treatment, device

ERRORS CAUSED BY UNCRITICAL USE OF MATHEMATICAL MODELS OF SEWERAGE SYSTEMS

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Abstract

Although in recent years the overall planning and design of sewerage systems, including wastewater treatment plants (WWTP) is mainly done by using hydraulic mathematical models, in practice, very often an uncritical acceptance of certain solutions and the results obtained are present. The aim of this paper is to point out some very frequent errors that are usually made during modeling of sewerage systems and defining the hydraulic load of WWTP. Three hypothetical case studies are created and described.

First one shows the importance of using dynamic models and time regulation of pump operations in the definition of relevant hydraulic load of WWTP when there is an inflow from multiple directions (multiple pressure pipes). Any other practice often leads to unjustified oversizing of WWTP resulting in both operational and economic disadvantages.

The importance of detailing of certain critical sections of pipelines and their influence on the model results when analyzing the backflow is described within the second example. In practice, due to the averaging of the results for the water depth along the long gravitational pipes, unrealistic results are frequently obtained which may lead to undersized systems.

Understanding the definition of critical flow at specific locations in the modeled sewerage system (weirs, retention basins etc.) during the coincidence of wastewater inflow from different directions is shown in the third example. Not understanding the character of mixed inflows downstream of joints from multiple directions can result in overflow of critical inflow and not meeting the basic environmental criteria or on the other side can lead to retention of unjustified quantities of rainfall runoff within the sewerage system.

Keywords: wastewater, hydraulic load, mathematical model, pipeline, critical inflow

SEWAGE SLUDGE DISPOSAL – CASE STUDY SPLIT-DALMATIA COUNTY

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Abstract

Sewage sludge is generated in all technological processes of wastewater treatment, as a by-product of accumulation of solids, primarily through separation from the primary and secondary settling tanks. The construction of wastewater treatment plants (WWTP) in Croatia has intensified due to the commitments towards EU. Sewage sludge disposal is expensive and environmentally and socially highly sensitive process and it is therefore clear why it had become a significant burden to almost all utility companies, as well as to certain aspects of the operation of local governments. Sewage sludge disposal is not only technical issue, but is a result of different approaches that depend on the natural and social givens of each state (region). Therefore, there is no single approach nor guidelines for the disposal of sludge at the global level. It is not only important in terms of meeting the regulations, but also in terms of selecting the optimal treatment concepts, including the sewage sludge treatment procedures. The possibilities of use and recycling of sewage sludge and by-products of its processing as raw materials within the framework of circular economy have become especially attractive solutions recently.

The paper presents critical overview of current practices and technical solutions of sewage sludge treatment and disposal with special emphasis on EU countries. On a case study given for the Split-Dalmatia County in Croatia technical and financial aspects of different disposal routes are analysed.

Usual procedures of sludge treatment generate stabilized and dehydrated sludge that requires additional treatment. Many of the following sludge treatment processes also generate sludge, compost or ash that should be further disposed. Different options for final disposal stand out: disposal of treated sludge in landfills (restricted or totally banned), disposal of sludge or ash on agricultural or non-agricultural areas, disposal of ash in specially regulated non-hazardous landfills, use and recycling of sludge or ash in the construction industry, co-incineration of sludge with the municipal solid waste or its co-incineration in cement and power plants (with further disposal of ashes). There is also possibility of exporting dehydrated or dried sludge or ashes resulting in its thermal treatment procedures outside the state borders.

So far, the disposal of sludge in Croatia can be classified as individual, where utilities for each WWTP perceive their own needs and capabilities in more or less accordance with the relevant legislations. As a case study Split-Dalmatia County is selected and all agglomerations of more than 10.000 PE are taken into consideration (excluding islands). Four variants of final sludge disposal were analyzed: mono-incineration on the location nearby Split, co-incineration in existing cement plants (also near Split), disposal on agricultural land (with included transportation outside the borders of the karst area according to the requirements of the legislation) and export outside the Croatian borders (in particular in Hungary due to the positive experience of other regions).

Based on the conducted technical-economical analysis of the sludge disposal in the Split-Dalmatia County, it is evident that co-incineration in cement plants represents the most economical solution (Figure 1). Therefore, there is the need for an integrated consideration of this issue at the regional and national levels, with a review of conclusions of some previously issued study analyzes that promote mono-incineration of sewage sludge as the optimal solution for the whole Croatian territory. The results also indicate the need for a critical consideration of the statutory newly adopted regulations that favor the disposal of sludge on agricultural and non-agricultural land. Before making final conclusions, complete analysis should definitely cover other factors, such as environmental impact, for example by conducting life cycle analysis for each of selected solutions.

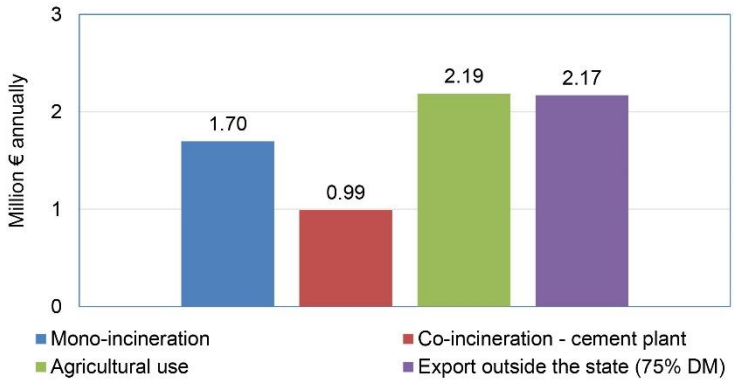

Figure 1. The caption heading for a figure should be placed below the figure, centered

Keywords: sewage sludge disposal, agriculture, incineration, cement plant, landfilling

Acknowledgement
This work has been fully supported by Croatian Science Foundation under the project "7927 - Reuse of sewage sludge in concrete industry: from microstructure to innovative construction products".

APPLICATIONS OF NANOTECHNOLOGY IN WASTEWATER TREATMENT

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Abstract

According to some expert estimates, world's population will rise u to 9 billion by 2050. In addition to the shortage of drinking water, this phenomenon will cause problems with water pollution and the increasing amount of waste that will accumulate in water bodies. The World Health Organization (WHO) has estimated that about 80% of all illness and disease in the developing countries are caused by water pollution and lack of sanitary protection. Around 3.3 million people die every year because of infection caused by E. Coli, Salmonella, Cholera etc. To avoid these problems, water requires treatment. Waste water has to be recycled, respectively it will be necessary to purify it so it can be reused in some particular purposes.

Conventional wastewater treatment methods include various physical, chemical and biological processes which can be limited because of high investment cost or in some cases due to poor purification efficiency (stricter legislation, new compounds in wastewater, higher concentration of heavy metals, etc.). Because of that, new approaches are continuously being examined to supplement traditional water treatment methods. In this context also nanotechnological approaches are considered.

Current research in nanotechnology offers the possibility of developing technically and economically viable alternatives to conventional wastewater treatment. This technology is based on the application of materials at the nanometer scale, to build new structures, components and materials at this (atomic) level. The whole theory is actually based on the fact that the properties of materials at the nano level are completely different from those at the macro level. Because of its properties, in the last 10 years, the development of nanotechnology is significant.

The paper will give a brief overview of the nanotechnology development through history, as well as the current state of the field. The main part of the paper deals with nanotechnological methods of wastewater treatment which are described in more detail (nanofiltration, nanomaterials for disinfection, nanomaterials for pollutant adsorption, etc.), with all its advantages and disadvantages compared to conventional methods of treatment. Certainly one of the key themes is the impact of nanomaterials on human health and the environment. At the end the paper will address the future trends of development of nanotechnology with a focus on the challenges in terms of their future commercial use.

Keywords: nanotechnology, wastewater, treatment, nanomaterials, nanoparticles, nanofiltration, nanoadsorbents, nanocatalysts

SOLAR DRYING OF SEWAGE SLUDGE

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Abstract

Solar drying of sewage sludge is a (thermal) sludge treatment method to reduce its volume, also the total cost of its final disposal. This method represents an economically feasible alternative to conventional heat treatment processes, since the main source of energy used is solar irradiation. In addition to reducing operating costs, this treatment method also affects the quality of the sludge, because the solar sludge drying reduces the concentration of pathogens in the sludge, it is further stabilized, so there are much more possibilities for its reuse.

Based on previous knowledge and constructed plants, solar sludge drying process constantly provides high concentration of dry matter (75-90% DS), which among other things allows its energy-efficient incineration, in the case of further heat treatment. The biggest advantage of solar drying sludge is in the energy balance, or much less specific energy consumption. Depending on the pre-treatment of sludge, the total amount of energy required to evaporate 1 m^3 of water with solar drying is approximately equal to the amount of energy that is consumed by conventional drying processes. The advantage is that with the solar drying most of energy is provided from natural renewable sources.

The paper will describe the technological process of the solar sludge drying. Within the description of the process, we will give an overview of the complete solar drying plant (schematic review of plant is shown in Figure 1). There will be specified all the main features of the plant. A special emphasis will be given to the technical and economic characteristics (simplicity of the process, the maximum reduction in operating costs, dependence on local climate conditions, etc.).

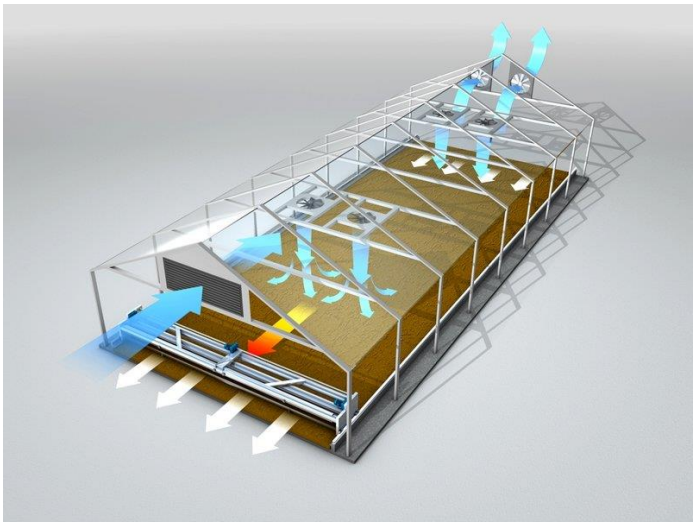

Figure 1. Schematic review of solar drying plant

Also, the technical calculation of the solar drying plant will be presented on concrete examples. Since the total area requirement of the solar drying plant, including the technical characteristics of the electro-mechanical equipment, largely depends on the climatic conditions, the paper analyzes the cities of Zagreb and Split, as a reference points of two different climate conditions in Croatia. The paper will also submit proposals of using the dried sludge, in order to achieve better energy efficiency in its further processing and / or use.

Keywords: solar, drying, sludge, energy, climate, solids

COMPUTER ANALYSIS OF HYDRAULIC CONDITIONS IN A SANITARY CHAMBER

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Abstract

When designing a sanitary sewage system very common problem is connection of sewerage collectors located on different heights. In such cases, the collecting sanitary chambers are used. Streams are combined in the chamber by proper shaping of the slipways. The dimensions of these chambers are limited, and the ordinates of the collectors outlets are very different. In this case important is proper shaping of the ramp surface at the juncture of the wastewater streams. In an improperly designed chamber it will be occurred the collision of wastewater streams and the formation of strong turbulence and eddies. This increases the velocity of wastewater, which grabs a significant amount of air and injects into drains. Then air is blown out through the sewer manholes, causing an unpleasant odour, often at a considerable distance from the chamber. Therefore, an important part of a well-made design of such a chamber are appropriately contoured surfaces of slipways and stilling basin to dissipating the flow energy of wastewater, which will minimize the adverse effects of rapid mixing of the streams. One method is to verify proposed design solutions by mathematical modelling. These simulations can be done within the existing programs performing calculations in the field of CFD, but it is a very expensive venture and may concern only of the chamber, without taking into account the network of collectors. In practical applications, you can use the available software to perform the calculation of flow in sewers.
This paper presents analysis of hydraulic conditions of sewage flow down the slipway in the collecting sanitary chamber connecting 3 collectors on the inlet: DN600, DN800 and DN1400 and one on the outlet DN1600 (Fig.1), with a maximum difference of elevation 5 m. Adhesion of flux to the surface of the slipway and conditions of energy dissipation in the basin below the ramp (the junction of collectors: inlet DN800 and outlet DN1600) were also checked.

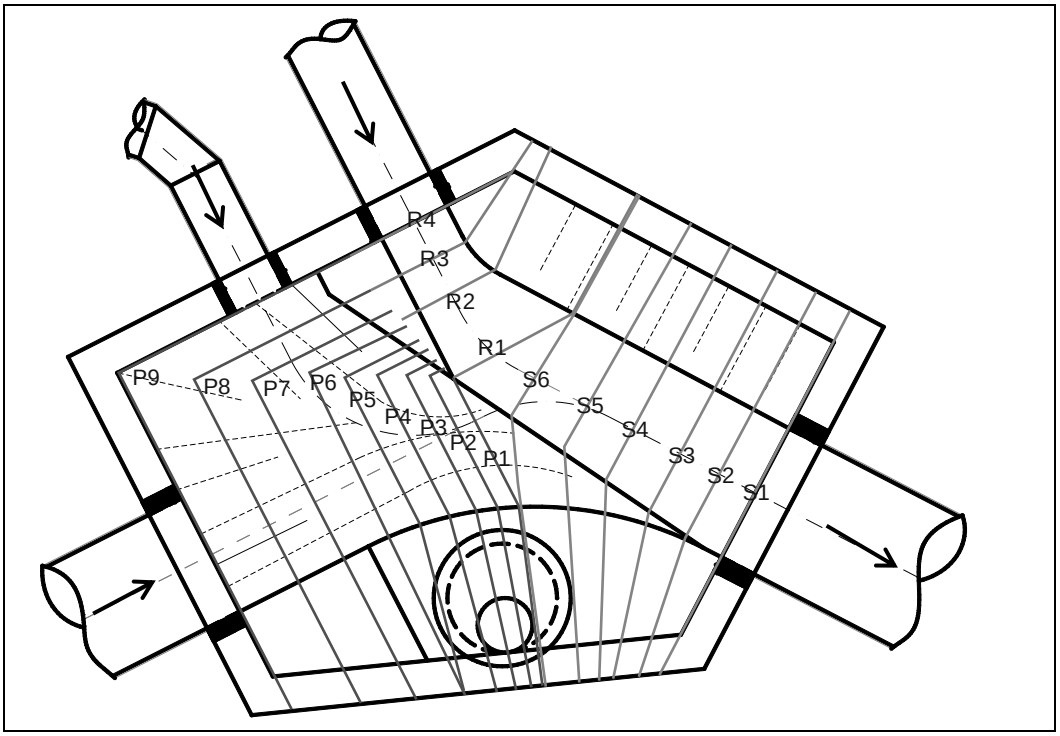

Figure 1. Adopted computational cross-sections in mathematical model of sanitary chamber

The mathematical model has been made in HEC-RAS program on the basis of the available project documentation (Fig.2). This model take into account the data on the position of the collectors adjacent

to the chamber, the geometry of the chamber together with shape of the slipway and dissipation basin inside.

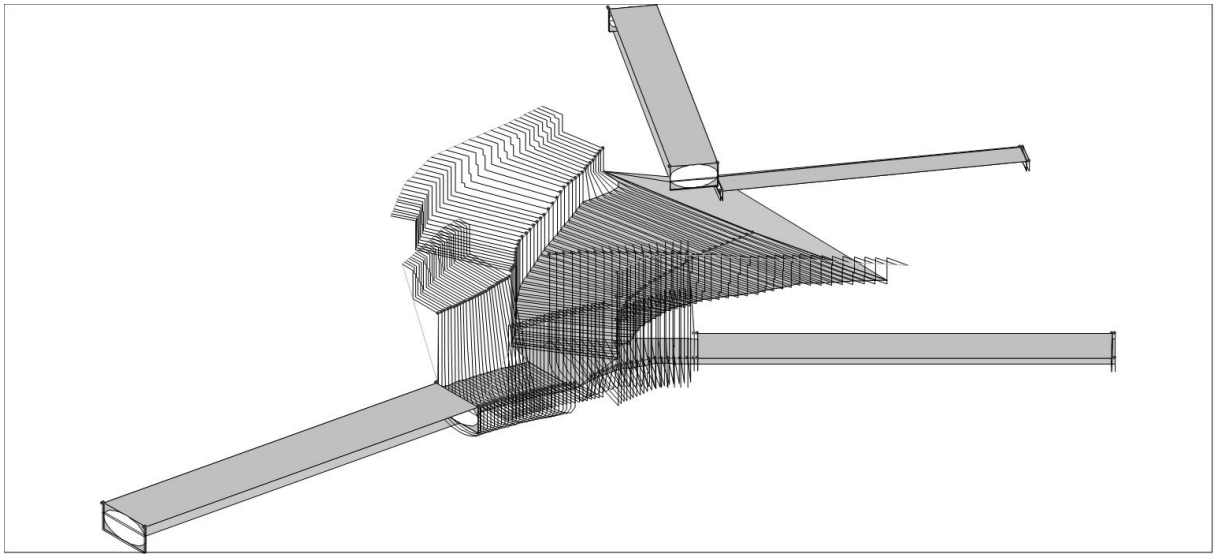

Figure 2. Numerical model of sanitary chamber and adjacent sections of collectors – (source: HEC-RAS)

Then, hydraulic calculations were carried out in steady flow conditions. First, flow rates and appropriate boundary conditions in all collectors were adopted. And then wastewater surface elevation, energy line elevation, critical depth and the value of average velocity were computed in adopted cross-sections of the model. The fulfillments of the collectors DN1400 and DN600 were below the critical depth, and flow was supercritical (Froude number Fr>1) with velocity respectively: v = 2.24 m/s and v = 2.06 m/s. Then the two wastewater streams merge together and run down reaching velocity at the base of ramp v = 8.53 m/s and fall into the dissipation basin. There is energy dissipation, connection to the stream from collector DN800 and flow out by collector DN1600 in subcritical conditions (Fr<1, depth greater than the critical depth, velocity in the basin v = 0.85 m / s, velocity in the collector v = 1.26 m/s).
In the last stage of the work has been done verification of conditions of stream adhesion to the slipway. Different curvatures of surface of ramps for collector DN1400 (main part of slipway) and DN600 were adopted in the chamber project. For this reason they have been checked independently. Two approaches were used here. In the first it has been calculated position of the stream which would has been formed as the free outlet from the collector (assuming given flow rate and slope of collector). In the second approach the shape of the slipway surface was compared to Creager curve. The results of calculations showed that the designed curvature of the slipway should ensure adherence of stream of sewage for the part the ramp under outlet of collector DN1400 (even for maximum flow). However, in the case of part of the slipway surface under collector DN600, the condition of stream adhesion is satisfied only in the case of the first of the adopted methods of verification. But despite this, it was decided to accept the designed shape of the slipway surface.
The calculations have been confirmed by the observation of flow through the chamber after its construction and putting into operation.

Keywords: sanitary chamber, sewage system, hydraulic calculations, sewage flow, collectors connection

OSIJEK WASTEWATER NETWORK - OBSERVATIONS AND CHARACTERISTICS OF RAINFALL

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Abstract

Osijek is the largest city in eastern Croatian lowland region of Slavonia. Some specific stages observed in developing of its urban drainage system. From simple urban sewer network, over the past decade, a system of urban conglomerates has been established. Today urban drainage system is marked by the reconstruction of the older Northern main collector and preparing for the construction of the central wastewater treatment plant.

The basic concept and design elements of the sewer system are based on the characteristics of local rainfall. Also, extreme rainfall events are particularly interesting for system efficiency and management capabilities. Because of that, observations of rainfall events began at the end of the last century at five locations with automatic ombrograph. The paper presents rainfall measurements and certain problems in their implementation.

Preliminary analysis of registered rainfall events indicate their characteristics. Analysis of the extreme rainfalls, which are reported in form of one-minute rainfall, indicate a significant change in this century. Ombrographs recorded short-term rainfall events with amounts equal to the range of average monthly values. Finally the paper points out the necessity of a more detailed analysis of rainfall events in the Osijek**'s** area because of urban flooding risk, which could be mitigated by establishing a system real time control.

Keywords: Osijek, urban drainage, rainfall distribution, extreme rainfall events

LIQUID RESIDENCE TIME IN VORTEX CHAMBERS

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Abstract

Liquid circulation in vortex chambers generates centrifugal force which has considerable effects on the flow. Centrifugal force enhances gravitational separation of suspension (vortex separators), as well as allows regulation of liquid discharge or division of liquid stream (vortex flow control devices). Furthermore, many researchers claim that fluid circulation elongates the effective residence time of liquid inside a vortex chamber in comparison to non-circulative flow. Residence time is a very important parameter of each fluid-flow system, particularly in these cases when the moving medium is subject to some reactions or transformations (chemical, physical or biological). Full specification of this value belongs to rather difficult tasks, as it varies along different trajectories of fluid elements, what means that it should be given by a specific function. An especially convenient version of this function has the form of residence time distribution (RTD). However, in practice (both scientific and technological) specialists use simplified methods of the real residence time description – plug-flow time (more popular) and average residence time (first moment of the RTD curve). The paper presents authors' research on this issue, i.e. investigation of centrifugal force influence on the real residence time. Measurements performed on a laboratory test stand indicate that liquid average residence time for circulative flow exceeds 50% of plug-flow time, whereas, for non-circulative flow residence time reaches only 10% of plug-flow time. Table 1 includes relative values of average residence time t_A and modal time t_M related to plug-flow model time t_{PF} calculated for a known value of discharge Q and height of water surface H, and for fixed diameter of the test chamber. Designations from "PG" to "TF" refer to specific configurations of inlet and outlet pipes in the test device.

Table 1. Time characteristics of liquid flow in the test vortex chamber

CONFIG.	Q [l/s]	H [m]	t_{PF} (sec)	t_A (sec)	t_A/t_{PF} (–)	t_M (sec)	t_M/t_{PF} (–)
PG	0.340	0.240	355	217	61	42	12
PP	0.335	0.133	199	116	55	32	16
PD	0.315	0.132	210	118	56	29	14
WP	0.60	0.266	223	57	26	16	7
WD	0.60	0.270	226	66	29	15	7
TA	0.60	0.263	220	21	10	8	4
TB	0.60	0.255	213	23	11	10	5
TC	0.60	0.260	218	24	11	15	7
TD	0.60	0.269	225	30	13	19	8
TE	0.60	0.261	219	36	16	24	11
TF	0.60	0.253	212	40	19	27	13

Keywords: centrifugal force, circulative motion, residence time, storm waste water, vortex chamber

HYDRAULIC MODELLING OF DEMAND GROWTH IN TOURIST ISLANDS, CASE STUDY: GALÁPAGOS, ECUADOR

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Abstract

Tourist islands worldwide have five main characteristics in common: (1) natural beauty, (2) generally sunny and dry climate, (3) travellers who like to enjoy both at maximum affordable luxury, (4) local population who wish to capitalise with income from tourism, and (5) vulnerable environment with scarce potable water and energy resources that need protection. Renowned for its unique wildlife, Galápagos Archipelago in Ecuador is one of the most challenging examples where all these issues have to be brought in optimal balance. Wider research has been conducted to analyse the demand growth resulting from steep increase in number of tourists and local population in the last two decades, and propose environmentally friendly options to mitigate it with adequate water services. This growth is expected to continue in Santa Cruz, the most popular island of the archipelago, and is in this stage already threatening the environment. Options to match the supply and demand include desalination and wastewater reuse, but also a specific demand management by more economic tariff setting and leakage reduction. This manuscript presents the latter part related to the network hydraulic modelling in Puerto Ayora, the main tourist hub of Santa Cruz. Currently, the water supply there is characterised by insufficient quality and quantity of brackish, untreated and practically non-potable water. The distribution is intermittent with households massively relying on individual roof tanks and bottled drinking water, however with surprisingly wide range of specific demands between 50 and well above 400 lpcpd. That raises concerns about illegal tourist water use and negligence while filling the tanks causing lots of unnecessary spilling. The hydraulic model built in EPANET software was used with two main objectives: (1) to assess the levels of water losses from the spilling of the roof tanks and actual justification for the applied intermittency regime, and (2) check conveying capacity of the network and propose rehabilitation measures for what is recommended as the most environmentally responsible future demand growth scenario. The hydraulic simulations to address the first objective were run in pressure-driven demand mode (PDD) using emitter coefficients for different scenarios of supply, while the future demand scenario was analysed in standard demand-driven mode of calculation (DD) with specific objective of assessing the need for intermittent supply and preservation of water in roof tanks. The results show significant water losses from the tanks contributing to the intermittency purely as a negligence of local population. Furthermore, a moderate network renovation will be needed for future demand scenario in case of continued (limited) use of the roof tanks. Although done on a relatively small case, the research points that the hydraulic modelling of distribution networks in tourist islands poses quite a complex problem due to: (1) transient flow conditions caused by intermittency, (2) numerical instability caused by numerous tanks existing in the model, and (3) difficult calibration from lots of unknown and inaccurate data needed to build reliable model. Yet, these analyses have a high relevance for the environment even though it has been impacted by comparatively small hydraulic network.

Keywords: water distribution, network modelling, tourist demand, intermittent supply, PDD analysis, water leakage

NUMERICAL MODELLING OF GROUNDWATER EXTRACTION SYSTEM

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Abstract

There are abundances of groundwater resources in Slovakia that are mainly used to satisfy different demands. However, the availabilities of the groundwater resources vary from place to place due to geological, geomorphological and physiographical conditions. In some places they can be easily extracted while in another places we need to apply expensive extraction systems. Depending on the accessibilities of the resources, different extraction systems are needed for sustainable utilization. The main challenges are commonly experienced in several catchments which are mostly located at lowland areas of Slovakia (i.e. along the Danube, Nitra, Vah River, etc.). Therefore, the objective of this paper is to model groundwater extraction system from proposed 38 groundwater network wells for sustainable utilization of the resources (i.e. without groundwater depletion).
To address this challenge, we applied numerical groundwater modelling system using TRIWACO simulation package. The modelling package utilised finite element method that can handle complex aquifer parameters for running quasi three-dimensional groundwater flow model. Based on available hydrological, geological and hydrogeological data numerous simulations were carried out for both - steady state and transient flow conditions. Due to scarcity of data and heterogeneity of hydrogeological parameters in time and space, the created model was calibrated through proper calibration system where computed and measured piezometric heads in the observation well system has shown acceptable match. In order to implement the transient simulation system, a 1000-year instantaneous flood wave (Q_{1000}) was considered.
This research paper will present numerical modelling results on design of groundwater extraction system to maintain the groundwater level to acceptable elevation as well as parameters and uncertainties for design purposes.

Keywords: Groundwater extraction, Piezometric head, Pumping rate, Transient simulation, TRIWACO

4. HYDRAULIC STRUCTURES

LAB TESTING OF FLOW VELOCITY PATTERN AROUND BRIDGE ABUTMENTS

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Abstract

Bridge piers and abutments disturb water flow pattern which may induce river channel changes and scour around bridges. Scour at piers and abutments disturbs the stability of a bridge and is the leading cause of bridge collapses. Depending on the ratio between the flow area and the size of bridge substructure, there is an increase in flow velocity and flow turbulence around the bridge. In the lab experiment we analysed the impact of different discharges and bridge spans on the flow velocity and flow turbulence at and around the bridge. Tests were conducted for a single span bridge structure and velocities were measured by using Acoustic Doppler Velocimetry (ADV), Vectrino by Nortek. ADV records instantaneous velocity components at a single-point with a relatively high frequency. We used horizontal type of ADV head which was located at half water depth. Based on the initial analysis, one minute was selected as an appropriate sampling time. Lab tests were performed for three different discharges and for five different bridge span lengths. ADV velocity measurements were on several locations at and around the bridge which allowed for point analyses as well as spatial analyses. On each location, flow velocities were analysed in three dimensions: x, y and z. The results show that with a decrease of bridge span length the increase in turbulence is experienced in much longer extend than the increase in velocity, and that the spatial distribution of flow velocity is different than turbulence distribution.

Keywords: bridge, scour, laboratory, velocity, turbulence, ADV

BRIDGE MANAGEMENT STRATEGIES: CURRENT AND FUTURE TRENDS

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Abstract

For critical transportation networks, efficient management has become an imperative component to provide optimal and continuous services. This is particularly true for bridge stock which form critical elements as part of rail and road networks and which are experiencing increased vulnerability due to a range of issues, such as aging infrastructure and increased hydro-hazards due to the effects of climate change. The effects of such increased risks to critical infrastructure threaten not only the economic prosperity, but also the social fabric, of the societies they serve. It is therefore necessary to have bridge management strategies and systems that are proactive and dynamic when assessing hazards and risks from an individual to a network bridge level to ensure continuous, efficient operation of a transportation network.

This study investigates current and future trends in bridge management strategies for the effective assessment and management of bridge infrastructure. In this regard, current practices used for the assessment of both the hydraulic and structural hazards associated with bridges over waterways are evaluated to determine their strengths and weakness. For underwater inspections, when considering the effects of scour, this evaluation will consider the criteria, methodologies and assessment methods currently being used worldwide to determine the bridge vulnerability to the influence of scour. Also investigated are the current practices evaluations of the extent of damage due to scour, their overall classification of the health of a structure, as well as their recommendations for action, both present and future. Similarly, the current practices for structural inspections, assessments and classifications are also evaluated and the inclusion of both practices as part of overall bridge management strategies is considered.

Finally, this investigation details future evolutions in bridge management strategies, through which both structural and hydraulic hazards are assessed and controlled by a web-based monitoring platform. The platform provides an advance in bridge management strategies as it contains modules for the assessment, evaluation and prediction of both hydraulic and structural hazards. Also, as the platform is web-based, it allows for more efficient data acquisition, tracking of bridge components degradation over time and automated decision taking in critical cases. This study provides a benchmark through which current bridge management strategies are assessed, as well as guidance on predicted future trends in providing efficient and safe continuous operation of bridge infrastructure.

Keywords: Bridges, Asset Management, Hydraulic hazard, Structural hazard, Scour, Climate change

Acknowledgement

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FISH PASS UNDER THE RECONSTRUCTION

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Abstract

Original constructed solid weir in the east part of Slovakia with pool fish pass is nowadays rebuilt to the bag weir with small hydropower plant on the Torysa River. To fulfil conditions and standards for the migratory fish fauna the existing fish pass is under reconstruction as well. The new fish pass will incorporate the original fish pass with rearranged internal environment and will be extended downstream as well as upstream whereas this reconstruction has to respect existing structures (weir, water intake structure, river channel reconstruction). Reconstructed fish pass should meet new elaborated methodology of the Ministry of Environment of the Slovak Republic: Identification of the appropriate fish pass types according to water body typology (2015).
Assessment was done in terms of the existing migratory fish fauna and hydraulics, as well as considering the routing, designed resting pool and proposed internal environment. New reconstructed fish pass is slot pass with parameters suitable for barbell zone. Proposal (with suggestions, small remarks and some modifications) is currently in realization.

Table 1. Design parameters for the slot fish pass/barbel zone according to the annual average discharge Q_a

Parameters	$Q_a \geq 5\ m^3.s^{-1}$	$Q_a < 5\ m^3.s^{-1}$
MAX. VELOCITY IN SLOT (m.s^{-1})	≤ 1,5	≤ 1
WATER LEVEL DIFFERENCE IN SLOT (cm)	≤ 12	≤ 5
SLOT WIDTH (cm)	≥ 50	≥ 20
SLOT DEPTH (cm)	≥ 50	≥ 30
WATER DEPTH IN POOL (DOWNSTREAM/UPSTREAM) (cm)	≥ 60/72	≥ 40/45
WATER LEVEL WIDTH (m)	≥ 5	≥ 2
MIN. BARRIER DISTANCE (m)	2,5 - 5	1,5 - 3

Figure 1. Illustration of the fish pass site

Keywords: Fish Pass, Design Parameters, Hydraulic Consideration, Fish fauna, Bag Weir

EFFECT OF VERTICAL SHAPES OF SHAFT INTAKE STRUCTURES ON FLOW VELOCITY DISTRIBUTION

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Abstract

In Slovakia, several small hydropower plants utilising the hydropower potential at existing water structures have been built. The design of these structures has been effected by the need of low investment costs and short construction times minimizing the impacts to the existing water structure and their operations. Therefore, a shaft intake - a specific design of intake structures has been used overcoming the vertical difference in water levels over a short distance. The shape of these structures is characterized by a vertical shaft, which leads the water from headwater to turbines. The flow conditions in these "shaft intake structures" are often complicated and the flow conditions at the turbine intakes are inhomogeneous, which is caused by sudden changes in flow direction. The inhomogeneity of water flow causes asymmetrical load on the mechanical parts of the turbine units, which leads to their problematic behaviour and defects in performance. An experimental research in the hydraulic laboratory of the Department of Hydraulic Engineering of the Faculty of Civil Engineering in Bratislava has been realized. It was focused on determination of the effects of vertical shape of a "shaft" intake on flow conditions at the turbine intake with respect to vertical homogeneity of velocity distribution. For these purposes a model of a shaft intake in experimental flume has been built. The experimental results have been compared with results of mathematical modelling of flow in the shaft intake. The results prove effecting the vertical flow velocity distribution in the turbine intake profile by the vertical shaping of the "shaft" intake structure.

Keywords: intake structures, low-head small hydropower plants, shaft intake, flow velocity distribution, flow homogeneity, hydraulic research

ANALYSIS OF UNCERTAINTIES IN BRIDGE SCOUR ESTIMATION

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Abstract

Different studies (e.g. Yao et al., 2015; Maddison, 2012; FEHA, 2012; Wardhana and Hadipriono, 2003) indicate that from all natural hazards, scour is the most common cause of the bridge failures worldwide. The EU/FP7 funded project Bridge SMS combines hydraulic, hydrologic, geotechnical and structural expertise and incorporates them into a complete bridge management system. Under the Bridge SMS management system, scour depth is estimated for selected pilot bridges taking into account flow and soil characteristics data. The proposed methodology considers discharge-stage and discharge-velocity rating curves as inputs for scour depth estimation based on empirical models. For most of the bridges the flow parameters are not readily available at the bridge site and are required to be acquired indirectly through numerical models. In many cases, the long-term flow regime is also unknown due to lack of hydrometric stations and detailed field data in the vicinity of the bridge site. For such cases, specific design flow events can be computed with the rainfall run-off models using rainfall Depth Duration Frequency (DDF) curves and catchment characteristics as inputs. Results from the rainfall-runoff models are calculated as flow hydrographs at the designated locations along the catchment/watercourse. However, uncertainties within the proposed methodology arise from unreliable input data and tools that simplify physical processes. This includes complex rainfall and run-off patterns and catchment characteristics, among other reasons. This study focuses on the quantification of the effect of uncertainties for scour depth estimation during flood events (with Annual Exceedance Probability 1%) associated with hydrological and hydraulic input variables. A range of rainfall events with different durations from 100-year return period DDF curves are simulated using different rainfall-runoff model set-up in order to obtain peak hydrographs, the peak hydrograph is then fed-in the hydraulic model and detailed flow environment at the bridge profile is computed. The calibration of the hydraulic model is carried out using water levels recorded during bathymetry survey, i.e. during low flow conditions, and as such might be unsuitable for high water flows. For different combinations of input variables scour depths are obtained from empirical equations. The impact of the uncertainties associated with the input variables at the final scour depth calculation is analysed and quantified for various pilot bridge sites. The quantification of these uncertainties will help to understand the accuracy level required for scour hazard estimation, providing also important information for the implementation of the bridge management system.

Keywords: bridge scour, flood hazard, uncertainty estimation, hydraulic model.

Acknowledgement

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INVESTIGATION OF FLOW PATTERN AT SCOURED ABUTMENT IN NON-UNIFORM GRAVEL BED

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Abstract

Presence of scour at abutments significantly influences flow pattern in their vicinity, increasing turbulence and inducing vortexes in the flow field. Size of scour hole depends on flow parameters and is proportional to flow augmentation. Scour hole equilibrium depth is achieved under long-term exchange of high and low flows, but greatest scour hole depth occurs during high flows. Hydrographic surveys deployed for flow field measurement are influenced by high flow conditions, making acquisition of reliable results uncertain and survey procedure dangerous. For this reason, survey is mostly conducted during low and mean flows, when water depth is shallow and flow velocity slower. Survey conducted this way may not be representative of flood induced hazard on bridge safety as bed-load material can be deposited in scour hole during low flows and conceal its final depth. Therefore, the quantification of final scour hole depth generally involves coupled hydrodynamic and sediment transport models for a range of hydrological events covering both high and low flows and comparison of results to measured data.

Sediment transport process associated with scour is especially complicated to describe in gravel bed rivers. Application of empirical relations developed for gravel-bed rivers can result in sediment transport scour depth estimation using flow data as input, but cannot give estimate of turbulence characteristics that are primary generator of local scour t abutments. Continuous long-term water levels and discharge measurements are rarely readily available on smaller streams, so probability of occurrence for significant high flow events can be challenging to calculate. Therefore, most reliable results can be achieved using physical modelling in laboratory conditions.

Research has been conducted on scoured bridge abutments of a single span masonry arch bridge in south Ireland. Riverbed material is sand-gravel mixture, with coarse cobbles armouring the riverbed and hiding finer grains. The numerical and physical sediment transport model are established based on detailed bathymetry data surveyed along a rectangular grid of 50cm spacing. Aim of the research was to determine critical conditions for sediment incipient motion under which mass movement of bed material occurs and resulting flow pattern in the bridge profile. Flow field investigation on physical model is conducted under two flow regimes: fixed bed and mobile bed. Flow velocity profile is measured on 4 verticals (from left to right: A, B, C, D) at profile immediately upstream (BUS) and downstream (BDS) of the bridge.

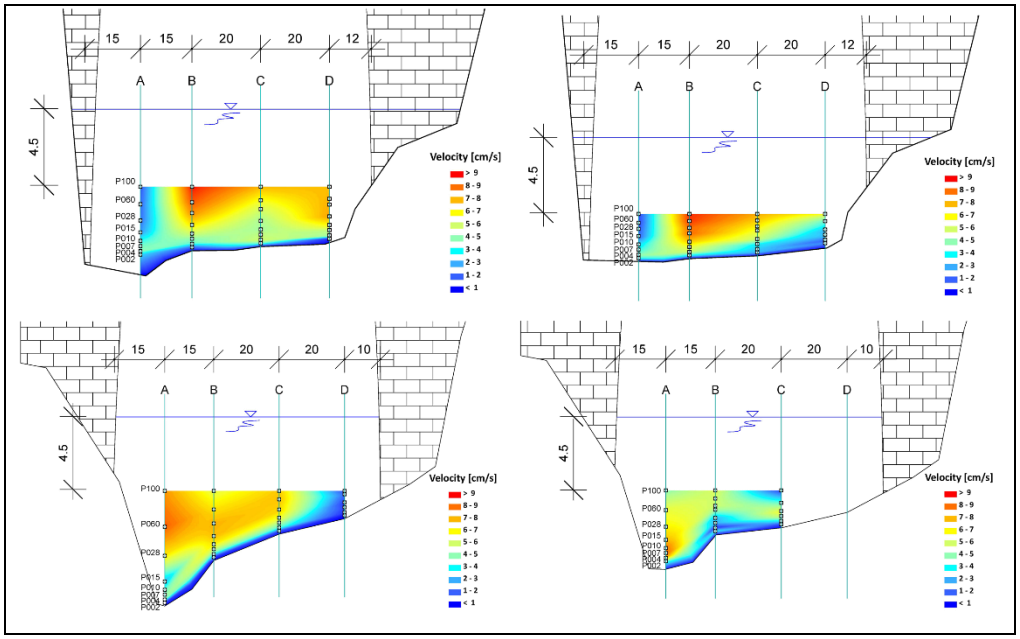

Figure 1. Contour plot generated for flow field at BUS for fixed bed (a) and mobile bed (b); at BDS for fixed bed (c) and mobile bed (d)

Complex flow field characteristics extracted from measurements justify use of physical model for investigations of abutment scour and resulting flow field in steep streams. Physical model results correlate well with numerical model results. Abutment scour is shown to be related with local flow field, making it difficult to estimate using conventional empirical methods. Accurate determination of incipient motion for bed-load material provides important information needed for assessment of structural risk associated with flood events.

Keywords: abutment scour, sediment transport, physical model,

Acknowledgement

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MORPHODYNAMIC IMPACT OF SCOUR COUNTERMEASURES ON RIVERBED DEVELOPMENT

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Abstract

Local scour at bridges is natural phenomenon that occurs when structure is placed in riverbed in a way that effects flow pattern. Riverbed can be protected from scour by implementation of scour countermeasures on riverbed section that is expected to be eroded. Scour countermeasures most commonly placed in the vicinity of bridge piers or abutments. Placement of scour countermeasures must be evaluated using numerical models in order to investigate their influence on flow pattern. Inadequately placed scour countermeasures can have adverse effect on morphodynamic development of riverbed, initiating scour hole development further away from the bridge, thus causing bank undermining and flow displacement. In cases where riprap is used as scour countermeasure it can be of large proportions and have significant influence on the flow, sediment transport and consequently riverbed erosion. This paper investigates morphological development of Sava River reach at the bridge that has 3 groups of piers located in the riverbed around which riprap scour countermeasures were placed. Flow is accelerated through constricted bridge openings, inducing erosional and depositional patterns that are evident in bridge profile and on downstream reach. In addition to scour countermeasures, weir has been constructed immediately upstream of the bridge profile. Flow overtopping the weir creates hydraulic jump in the bridge profile behind the weir, in which energy is dissipated and riverbed is further deepened. For analysed river reach coupled hydrodynamic/sediment transport model is established in order to describe flow patterns and estimate morphodynamic development of the riverbed. Three different scenarios are evaluated under three characteristic flow events and variables that indicate further riverbed development are compared. It is shown that riverbed hasn't reach equilibrium state at this point and further erosion and riverbed evolution can be expected on this river reach. This insight highlights the need for plan of action on scour-susceptible bridges.

Keywords: Bridge scour, local scour, sediment transport, morphodynamic development, Sava River

PERFORMANCE TESTS AND EVALUATION OF A HYDRO POWER PLANT WITH A DOUBLE ROTATING HYDROPOWER SCREW

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Abstract

The hydropower screw turbine is a technology based on a reversal of the old Archimedean pump recently increasingly being implemented for small low-head hydropower installations. Concerning the low-head conditions, the screw turbine disposes of several advantages like a good efficiency, robustness and low investment and maintenance costs. The newly developed Archimedean double screw concept [1] with low rotation frequency and therefore insignificant shear forces or pressure changes combines hydroelectric power generation and bi-directional fish passage in a single device. The first commercial installation was commissioned in Retznei, Austria, in 2015 [2]. The installed double rotating screw was designed with the gross head of 5.5 m and the flow rate of 380 l/s for potamal fish migration.

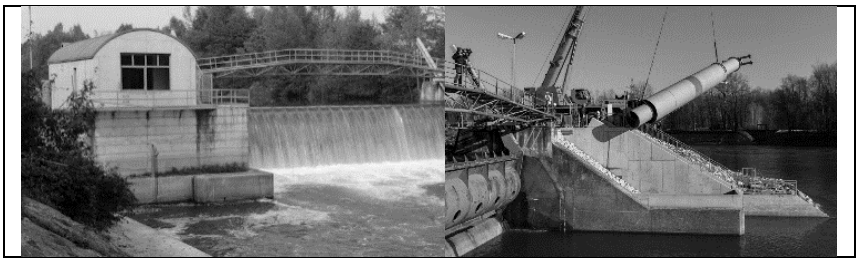

Figure 1. View of the Retznei barrage with the old hydro power plant (on the left) and the new installation of the hydro power plant with the tube-type double rotating screw on the left bank side (on the right).

To verify the design data fish migration monitoring [3] and hydraulic efficiency tests [4] had to be carried out. While the downstream migration has been proven before the fish behaviour at the study site demonstrate the operational capability for the upstream migration. Most species of fish and life stages were able to migrate upstream. Further, it was the first time the hydraulic efficiency was determined at this type of power plant being in normal operation. The efficiency chart shows the tendency of the hydraulic behaviour of the machine.

The precise measurement of the efficiency was carried out using absolute discharge measurement methods with fully opened inlet gate, and relative discharge measurement methods with reduced water levels at intake. Efficiencies were calculated for a regular grid of speeds (5 – 20 rpm) and water depths (50 – 90 cm), normalized with a global efficiency maximum and plotted in the hill chart as shown in Figure 2. The red dashed line in the hill chart (Figure 2, left) shows the optimal relation between the intake depth and the turbine speed. It is evident that normally operated water levels at the intake (fully opened inlet gate, $h_1 \cong 90$ cm) induce overfilling of the hydropower screw and a reduction of the efficiency. An appropriate reduction of the intake water level or lift of the screw intake (by tilting it up) would decrease the intake depth and would thus help to enhance the efficiency.

A method of torque measurement using strain gauges was developed and implemented and the mechanical power, P_m, could thus be also determined. The hydraulic efficiencies (including hydraulic losses and hanging flat belt bearing losses) were determined between 80 and 90 % maximum. The higher the speed and intake depth (and finally also the discharge), the higher the generator power and the mechanical efficiency, see Figure 2, right. The torque increases with decreasing the speed.

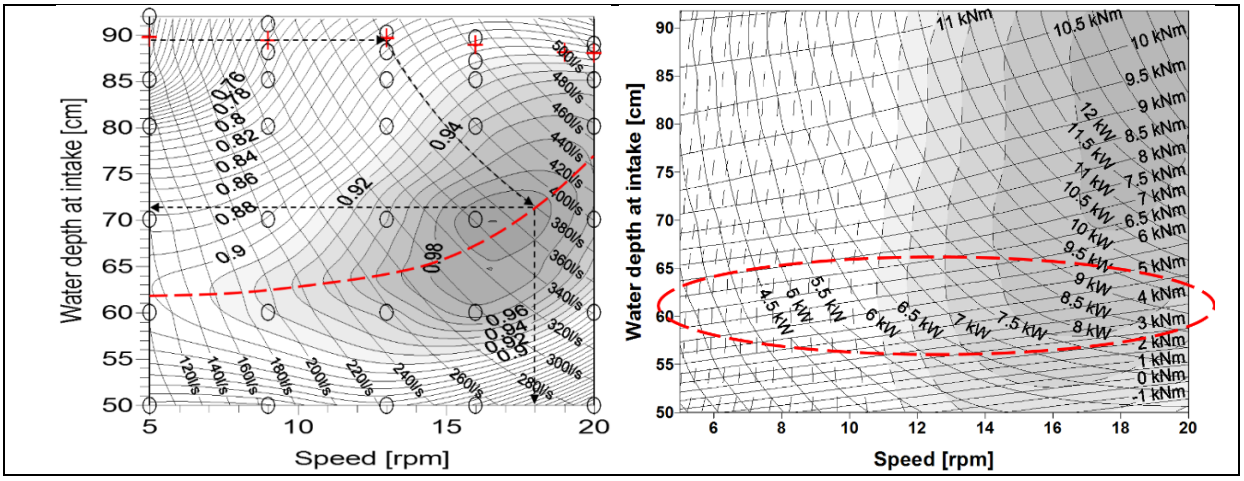

Figure 2. On the left: Hill chart with relative efficiency η_{rel} [-] = η/η_{max} and total discharge Q_{tot} [l/s]. The source data is labeled with circles, data points based on absolute hydrometric measurements are labeled with crosses (left), and on the right: Mechanical efficiency hill-chart with generator power and torque lines. The dashed-line ellipse shows the region of maximum hydraulic efficiency.

The double rotating screw in Retznei is the first bi-directional fish pass in this design using the double rotating screw technology. The first two years of operation have shown that this system works really well. It is possible and profitable to use this system as a small hydro power plant under proper conditions. To maximise the efficiency it is important to run the double rotating screw with the optimal speed for the rated flow and also to design the optimal water depth at the intake as indicated from the measurement results. Nowadays the company Hydroconnect GmbH develop several projects in Canada and also in middle Europe. The biggest double rotating screws are currently being projected for heads of about 40 m. In this case 3 screws should be installed in series. They are designed to transport fishes up to 1.5 m length. The first fish ascent (single rotating) screw will be built in Austria at the end of 2017.

Keywords: Low-head, hydropower screw, fish-lift, hydraulic efficiency, fish migration

Literature:

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RESILIENT DAM INFRASTRUCTURE: PREPARING FOR CLIMATE CHANGE IMPACTS

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Abstract

It is estimated that in Europe there exist over 7000 large dams, classified as having heights greater than 15m, with thousands more planned to be built in the next years. According to the ICOLD register, worldwide the are more than 58000 large dams, with millions more in existence that are currently un-registered. More than 85% of the existing dams worldwide is expected to exceed their average 50-year lifespan within the next two decades. Future projections also highlight that the frequency of shifting weather events is anticipated to increase, with severe consequences on the structural integrity of hydro-infrastructure due to high potential of extreme drought and flood events. As a result, hydro-assets that they were initially constructed for flood control and hydro-electric purposes may actually be the cause of more destructive hazards due to their potential failure, with significant environmental, social and economic risks and consequences. The ageing dam structures alongside with shifting environmental conditions are considered major factors contributing to the growing infrastructure crisis.
Relationships and models describing the short and long-term behaviour of dams are still based on empirical relationships, usually not considering the changing environmental conditions. Such models are also not always representative as dams of similar size and type can behave differently. Of particular importance is therefore the assessment of the on-going performance of a dam, the validation of laboratory and empirical models and the assessment of different engineering designs. Investigations about the post-construction behaviour of dams will also enable to deliver key information about the climate change effects on hydro-assets, provide early warning signs of an impending failure and ensure operation within safety limits.
This study initially presents recent cases of incidents and failures of high-hazard dams triggered by severe environmental events. An overview of the methods that are currently employed to monitor and assess the condition of dam infrastructure is also presented. This investigation then focuses on providing an insight of the complexity of the deformation mechanisms for earth-fill dams during critical periods in their lifespan, such as the first impoundment of the reservoir and their long-term mature behaviour. The post-construction behaviour of two of the largest earth-fill dams in Europe is investigated and compared with models derived from other dam studies that are described in the international literature. Finally, existing and future challenges for climate-resilient dam infrastructure are discussed.

Keywords: dams, floods, deformations, infrastructure, climate change, long-term behaviour, water management, infrastructure crisis

POOL FISHWAY HYDRAULIC ANALYSIS

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Abstract

Artificial barriers such as dams, weirs, drops, gates, etc. interrupt fish migration on natural watercourses. Pool fishways are one of the most commonly used structures for enabling fish to pass such an obstacle. The main principle of pool fishway consists in dividing up a channel from the headwater to the tailwater by building cross-walls to form a succession of stepped pools and riffles. The flow passes through small openings in the cross-walls, causing tailwater to raise and form pools. Pools with their low flow velocities offer fish shelter and opportunities to rest and fish encounter high flow velocities only during their passage through the walls.

Pool fishway built on the small hydropower plant (SHPP) Ilovac on Kupa river is a concrete channel with constant slope from headwater to tailwater, divided in 14 pools. The difference in water level between individual pools is 0.2 m and each pool has dimension 2x2.5 m.

Conditions in the fishway have been determined by field measurements using ADV instrument to measure water depth and flow velocity. Furthermore, in order to establish a tool that enables accurate determination of the hydraulic characteristics of the flow in pool fishways, a 3D numerical model has been established and calibrated using field data.

In order to convert the existing fishway into a hydraulically more appropriate channel for fish migration several openings geometries have been evaluated. Using simple empirical approach each geometry was calculated in order to convey flow through adequate openings for fish migration. The geometry of the opening is rectangular and located on the bottom of the channel arranged alternately on the left or the right side of the pool and in the middle.

Figure 1. Pool fishway at SHPP Ilovac under construction

The desired geometry of the pools was initially evaluated using 3D numerical model. Once the resulting hydraulic conditions in the fishway formed designed pools, the numerical model was verified using field conditions as a physical model in scale 1:1. Measurements confirmed the appropriateness of the proposed model which can be used for dimensioning of new pool fishways.

Keywords: pool fishway, numerical model, physical model, small hydropower plant Ilovac

HYBRID MODELLING OF OVERFLOWING BROAD-CRESTED WEIR PHYSICAL AND NUMERICAL COMPARISON

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Abstract

Sharp crested weirs with its multiple purpose possibilities are widely used across the hydraulic engineering. Normally used in medium and large rivers and canals for water regime control, flow behaviour for sustained smoothed water surface by ensuring the subcritical regime and as measuring tool. Standard criteria in terms if the weir is sharp or broad-crested is $t > 2 \div 3\ h$ and one of most common empirical calculation of discharge above the sharp-crested weir is

$$Q = \frac{2}{3}\mu_P b\sqrt{2g h_0^{2/3}}$$

Where Q is discharge, b is width, μ_P is discharge coefficient and h_0 is upstream total head according the Figure 1.

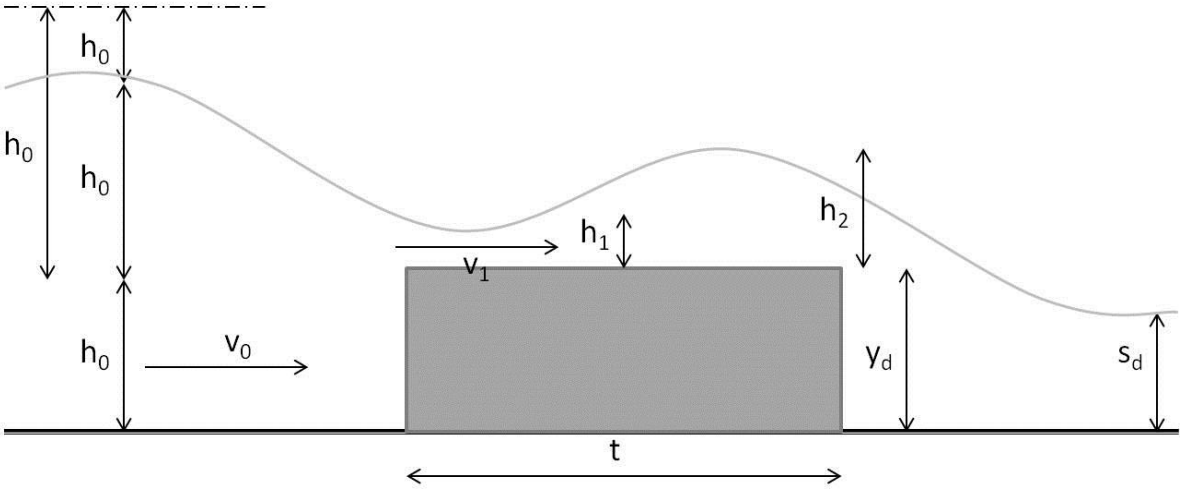

Figure 1. Sharp-crested weir scheme

The project developed at the department of hydraulic engineering, Faculty of Civil Engineering STU in Bratislava consist of two main branches involved to cooperate and control the results of each other. The first branch was the physical model of sharp-crested weir installed in collapsible canal (Figure 2) in hydraulic laboratory and the second was numerical CFD model of sharp-crested weir created in same scale.

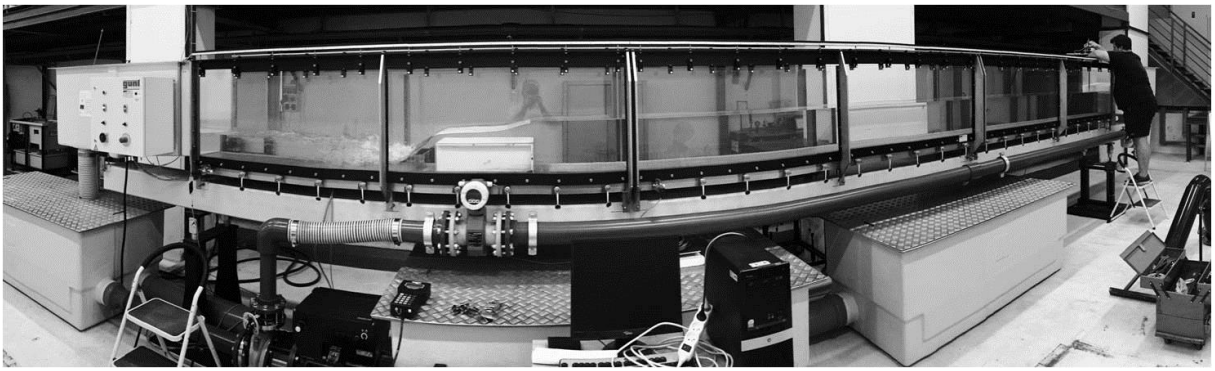

Figure 2. Physical model of sharp-crested weir

The main task was to compare the results of different parametric set-up of the numerical simulation of water flow above the structure of sharp-crested weir. As the benchmark of comparison was set-up the physical model with total discharge of 25 l/s.
Comparisons were carried out in several aspects. Measurements of water level and six profiles of velocity field measurements with up to 11 locations for each profile.
According the compared results, parameters of CFD model were tested and modified to get the best possible conformity. Modified parameters such as mesh resolution, turbulent model, air entrainment effect were systematically modified and compared with physical model through the water level and velocity field measurements.

Keywords: sharp-crested weir, physical model, CFD, hybrid modelling, hydraulic research

INCREASE OF EFFECTIVITY, RELIABILITY AND SAFETY OF SHIPPING OPERATION ON THE GABČÍKOVO WATER STRUCTURE ON THE DONAU

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Abstract

Task of shipping operations control of the Gabčíkovo water structure (GWS) is to synchronise several requirements. These come from versatility of GWS and must meet following goals :

- operation of GWS must be effective (maximization of the ship locks capacity, maximization of income from electricity production in hydropower plant),
- reliability if operation of the ship locks must not be limited or endangered by defects on technology parts of the ship locks caused by illegal parameters of water flow in the filling and emptying system,
- shipping safety must not be endangered or limited by unsuitable parameters of river way (navigable depth below minimal shipping depths in ford sections caused by flow changes on GWS and ships crushing into riverbed of the Donau river)

By taking these goals into account, we can, in general, define operation of GWS as complex multicriterial optimization task with many technological, water management, energetic and environmental constrains. Standard approach in solving this problem includes elaboration of optimization or simulation model of GWS operation. If mathematical description of problem does not exist, "classic" expert control system management must be applied. Based on above stated criteria, most effective approach to this problem appears to be creating software application, that combines both approaches.

Expert control system of shipping operation on GWS will, in this case, be software application, that will model hydraulic links and hydraulic regimes (discharges, water levels and flow velocities) based on relevant inputs on the ship locks and whole section of the Donau river, that is affected by GWS operation. Model of shipping operation should be modelled to meet following goals :

- minimalization of transition time spend in the ship lock and minimalization of destruction parameters due to fast flowing water in the filling and emptying system,
- assuring the shipping safety by keeping parameters of river specially on ford sections of river on whole part of river affected by GWS

The paper describes architecture of proposed Expert control system and focuses mainly on analysing suitability of heuristic optimisation methods for solving above the stated optimization problems.

Keywords: the Gabčíkovo water structure, Donau, expert control systems, optimization model, heuristic optimization methods

BED ROUGHNESS EFFECT ALONG SUBMERGED HYDRAULIC JUMP

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Abstract

Hydraulic jump leads to a significant turbulence and dissipation of energy whenever occurs. The important parameters of the hydraulic jump are the conjugate depth, the length of the jump and the energy dissipation. Conjugate depth refers to the upstream depth or the super critical depth (y_1) and the downstream or the subcritical depth (y_2) of the hydraulic jump. Belanger (1828) by applying momentum equation in the direction of flow had obtained an equation that demonstrates the depth ratio in hydraulic jump, which occurs in a smooth rectangular channel (Eq. 1).

$$\frac{y_2}{y_1} = \frac{1}{2}\left(\sqrt{1+8F_1^{\,2}} - 1\right) \quad (1)$$

where y_1 is the upstream depth and y_2 is the downstream depth of the jump, F_1 is the upstream Froude number, which is

$$F_1 = \frac{u_1}{\sqrt{gy_1}} \quad (2)$$

where u_1 is the average velocity of the upstream flow and g is the gravitational acceleration. Belanger equation is valid for smooth rectangular channels where the effect of friction is neglected. As soon as the bed roughness's become significant Belanger equation needs to be modified and a new definition must be proposed.

The response of the hydraulic jump to rough beds has been analyzed from the point of view of conjugate depths, dimensionless friction effect and the amount of energy dissipation. Based on the assumption that the friction force due to surface roughness follows power relationship with the flow velocity, one dimensional momentum and continuity equations are solved to obtain a new relationship for the well-known Belanger equation. This has been achieved by integrating the effect of friction force into the theoretical solution of the momentum equation written for hydraulic jump.

The resultant dimensionless friction effect was successful to help deriving a relationship between different parameters enrolled in the friction effects on hydraulic jump. Using the experimental results of previous studies, the parameters like dimensionless roughness effect (ratio between friction and energy dissipation) and dimensionless friction effect, β were analyzed and evaluated. The results show that friction force has a significant effect on hydraulic jumps on rough surfaces. It was important to define a relationship for friction coefficient, C_f, in terms of dimensionless friction effect. This help to use friction coefficient to develop well known semi-empirical roller length equation theoretically for hydraulic jumps. The resultant roller length equation is defined in terms of conjugate depths and upstream flow velocity. The developed equation has been tested for different type of rectangular cross section roughened beds as well.

Mean Absolute Percentage Error and coefficient of determination values show that there is a strong relationship between dimensionless roughness effect, dimensionless friction effect, friction coefficient and the dimensionless roller length. Totally, it can be said that, derived relationships are satisfying previously conducted experimental results very well. Even though in most of the analyses good trends are obtained between the parameters (Fig.1 and Fig. 2), yet it is not possible to obtain only one equation representing the effect of bed roughness on the magnitudes of dimensionless friction effect, or dimensionless roller length. It is expected that in the future studies, the outcomes of this study can be further developed with new generation models of optimization theories like genetic algorithm to simulate all the variables in one relation.

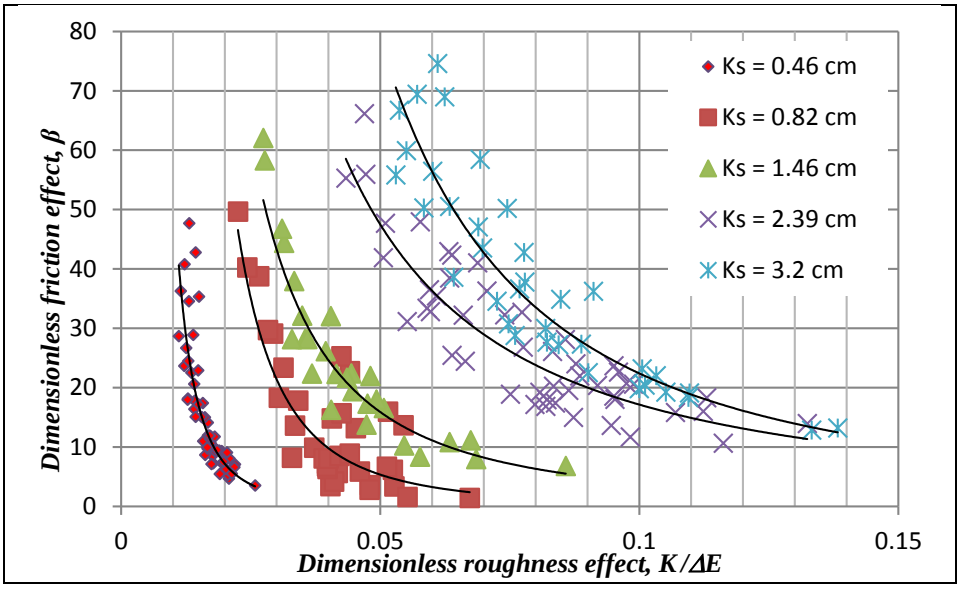

Figure 1. The relationship between dimensionless friction effect, β and dimensionless roughness effect, K/ΔE in steady jump condition.

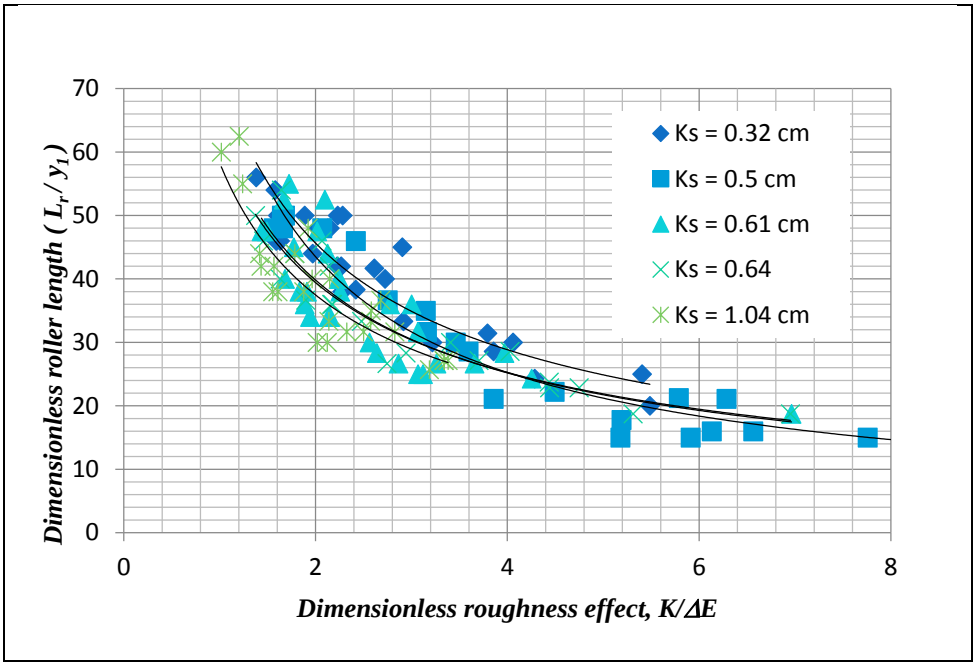

Figure 2. The relationship between K/ΔE and dimensionless roller length,Lr/y_1

Keywords: hydraulic jump, bed roughness, roller length, conjugate depth, Froude number, friction force

EXPERIMENTAL RESEARCH ON FLOW CONDITIONS AT SELF-CLEANING RACKS

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Abstract

An important part of any small hydropower plant is the intake structure. Its main function is to provide sufficient discharge of water for the hydropower plant and to prevent the large floating objects carried by the stream to get to the hydropower plant. In many cases, this structure requires a weir construction across the riverbed which is often environmentally unacceptable. In cases where such a construction is not possible, another kind of the intake structure has to be used, for example a bank water intake. An important parts of these low-head intakes are the coarse racks which prevent floating objects to get in the hydraulic system of the turbine and endanger the operation of the entire hydropower plant. These floating objects are captured on screenings and afterwards they should be cleaned (removed from the screening). The cleaning for low-head small hydropower plants is usually manual. A new type of self-cleaning racks has been tested in the hydraulic laboratory of the Department of Hydraulic Engineering at the Faculty of Civil Engineering in Bratislava. Compared to the conventional design of the racks with minimal flow resistance, the new design of racks has far larger hydraulic resistance in order to effect the flow to float the object along the racks. The experiments were aimed to determine the optimal inclination of the racks to minimize the hydraulic resistance on the flow in the intake structure and achieve a self-cleaning effect keeping the racks clean of the floating debris. The experiments were realized on a model in experimental flume for different variations of water level and flow rate.

Keywords: low-head small hydropower plants, intake structures, coarse racks, hydraulic research, physical modelling, velocity fields

5. COASTAL ENGINEERING

IMPACT OF WIND, TIDAL VARIATIONS, WAVE FIELD AND DENSITY GRADIENT ON THE SEAWATER EXCHANGE TROUGH FLUSHING CULVERTS IN MARINAS

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Abstract

In this work 3D numerical circulation model was used aiming to quantify flushing culverts impact on the seawater exchange between a marine harbour and the connecting sea. The analysis included the effects of natural parameters, such as the local tidal variations, wind speed and direction and seawater density differences.

The analyses was carried out at hypothetical marina (figure 1) for following environmental and construction conditions: marina length 300 m and width 150 m, bottom constant slope from 3 m to 7 m depth, entrance width 25 m and 50 m, flushing culverts placed at the 4 different positions along the breakwater, 8 wind directions (N, NE, E, SE, S, S, SW, W, NW), 3 wind speeds (1 ,3 ,5 Bf), two geographical locations (North Adriatic Sea – Rovinj and South Adriatic Sea – Dubrovnik) with and without sea density gradient impact. One flushing culverts, constructed in breakwater, contains 8 circular pipes, of 10 m length and 1 m diameter (Figure 1). Circulation caused by gravitational waves were not taken into account. Furthermore, numerical simulations for marina Ičići (real breakwater geometry and hydrographic conditions – Figure 1) was done.

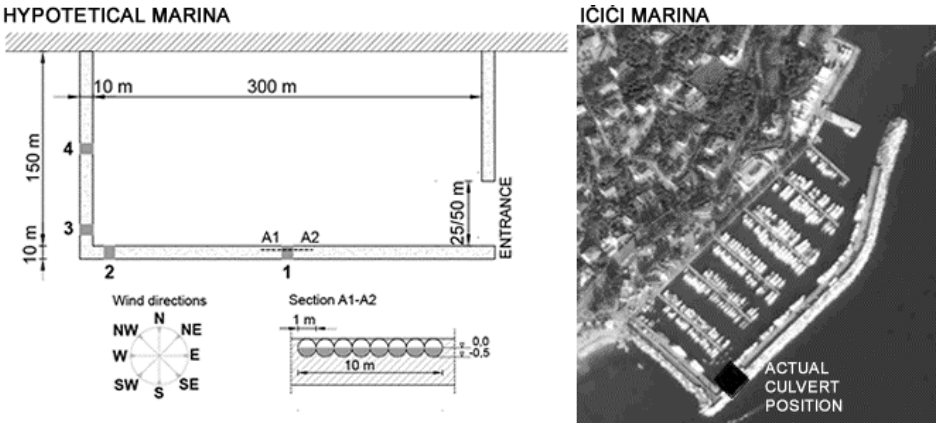

Figure 1 The hypotetical marina scheme with basic geometric features (left) and marina Ičići with actual culvert position (right)

Wind has a primary impact on the spatial flow distribution, whereas density differences impact is reflected in the flow modification. Tidal variations have only minor contribution to the currents generation within marina seawater. The entrance width affects flow field only locally in the near of the entrance. If there is no density gradient seawater exchange trough entrance profile is increased for 71%, by increasing entrance width from 25 to 50 m, (average for the location Rovinj and Dubrovnik, and for all analysed directions and wind intensity) and if there is density gradient, exchange is increased for 74%. Discharge trough culverts for wind speed of 5 Bf is increased 3.6 and 17 times in relation to situations of 3 Bf and 1 Bf. By increasing entrance width from 25 m to 50 m seawater exchange trough flushing culverts is average 8% higher (for all culvert positions, all wind directions and speeds). Discharge trough marina entrance (for both widths) is dominant on marina flushing characteristics in relation to discharge trough flushing culverts. In hypothetical marina, the most significant impact in terms of seawater exchange, has a flushing culvert at position 4. The practical application of the obtained results was presented on the example of the Ičići marina.

Keywords: flushing culverts, marina, Adriatic Sea, numerical model

THE ROLE OF NUMERICAL MODELS IN ENVIRONMENTAL STUDIES

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Abstract

During the last few decades, accuracy of the ocean hydrodynamic models tremendously increased due to the increased computer power and due to our increased understanding of marine dynamics, subgrid scale parameterisations and numerics. The practice of numerical modelling is growing rapidly also due to increased understanding of the limitations of the alternative and more traditional methodologies of making field measurements and developing analytic theories of highly nonlinear dynamical systems.
Environmental studies require accurate knowledge of the marine environment dynamics. Field measurements in oceanography are usually complex and expensive, and in general result with sparse data sets compared to requirements. One of the important task for numerical models is to help marine scientists and practitioners to overcome insufficient space and time resolution of the collected data.
Numerical hydrodynamic models are mathematical formulation on basic physical laws (Newton's Laws, conservation principles) applied for marine systems. They provide information of three dimensional circulation and density fields and are used to improve our understanding of ecosystem and to predict its future state. Ocean models consist of set of partial differential equations which due to turbulent nature of the sea circulation, complicated shape of basins and strong nonlinearity of the marine system cannot be solved using known analytic methods. The equations require numeric computational methods using discretized equations on finite grid.
In oceanography models can be used for scientific research in process oriented studies and realistic simulations, and in various application studies. In both cases the objective of the numerical model is to predict the future state from the knowledge of the present state by use of the dynamical equations. To fulfil this objective the following information is required: (1) the initial state of the field variables, (2) a closed set of prediction equations relating the field variables, (3) a method of integrating the equations in time to obtain the future distribution of the field variables.
One of the greatest advantages of the models for the environmental studies is their possibility to predict future hypothetical state and aid in strategic decisions related to marine environment. Precise and well defined model can predict the influence of the planned coastal infrastructure on circulation and ecosystem. In general, impact of all changes in the marine ecosystem that can be numerically formulated can be assessed by modelling system.
But nevertheless, numerical model results due to the used numerical techniques and parameterization of the sub-grid scale processes which affect their accuracy should be considered with particular care. Having in mind limitations of both measurements and numerical models, design of optimal assessment study should incorporate both components. Careful selection of the sampling sites and frequencies and appropriate modelling system can give the best results with significantly reduced expenses.

Various accomplishments and possibilities of numerical models in environmental studies will be illustrated through examples of oil spill modelling, sewage system impacts and early fish stage dynamics, all based on ROMS hydrodynamic model.

Keywords: modelling, environmental study, prediction, coastal circulation, ROMS

ANALYSIS OF WATER EXCHANGE THROUGH THE FLUSHING CULVERTS IN SMALL HARBOURS

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Abstract

Flushing rate in harbour can be improved using the flushing culverts (pipes or rectangular openings in a breakwater body, diameter/dimension D~1m), which is the most cost-effective method used in port engineering. The purpose of culverts is to enable the exchange of open sea water and the sea water contained within a protected maritime zone.

During the summer, a period when harbours are loaded most (development of micro-organisms and pollution), the winds are usually rather weak. That is the period when the only circulation that flows through pipe culverts is the one caused primary by tidal oscillations. Parameter which is usually used as a measure of the flushing effectiveness is a residence time T_f, (de Kreeke, 1983). "Residence time" is the time until the water parcel at a specified location leaves the water body (e-folding time). In the case of small water bodies, the assumption of well mixed basins simplifies the meaning of residence time as the time until all water in the harbour is renewed by outer water. For small harbours, where the assumption of well-mixed basins is acceptable, the residence time could be calculated using the tidal prism model (Sanford, 1992, Luketina, 1998). In the classical approach to the tidal prism model, the flushing time can be calculated as the ratio of the volume of water in the system and the volumetric flow rate through the system (Monsen, 2002). Thus, volumetric flow can be a strong indicator of water renewal efficacy without examining the underlying physical processes.

Maybe the most dominant mechanism of sea water exchange in harbours is provided through the agency of winds, which set the surface of the sea in motion, ultimately leading to sea entering into harbour through a mechanism of horizontal and vertical compensation (Lončar et al., 2011). In such cases, the sea water exchange does not occur evenly across the whole of the harbour basin, but primarily around the entrance into harbour. Researches on numerical models (Stamou et.al., 2001) show that the additional impact on sea exchange through pipe culverts may come with the occurrence of local sea level rise (tilt) within harbour generated by wind. That is how the difference in sea levels between the inside and outside of the breakwater cause the sea flow in culverts. The principal challenge in quantifying the relation between wind speed and flow through the culverts is in establishing a relatively analytical model which includes all important physical parameters. Authors have derived a simple analytical model, using measurements recorded in the field, for predicting water renewal through the flushing culvert forced by winds and influenced by sea level.

Keywords: sea water exchange, harbour, flushing culverts, tidal oscillations

MEASUREMENTS OF WATER CIRCULATION IN MARINA OPATIJA-CROATIA

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Abstract

The circulation of water between a harbor and the connecting sea is generally the result of natural parameters such as local tidal range, wind conditions, wave climate and water density differences. Depending on the geographical location, one or more of these variables can dominate the exchange properties of a harbor. If pollutant concentrations are allowed to increase above critical levels, then the result is sub-standard water quality as characterized by a reduction in dissolved oxygen and the presence of algal blooms. The water flushing rate is affected by structural factors such as the plan form geometry of harbor, entrance dimensions of harbor; water depth, bed slope, etc.
This paper will present site measurements conducted in marina Opatija(Croatia) during 30 days of winter period (Figure 1). The next results will be shown: sea currents at the positions of five ADCPs and water level change, results of wind waves in positions of ADCP1 and 2, wind speed and direction measurements and finally discharge and salinity in flushing culvert.

Figure 1. Layout of measuring devices in small harbour Opatija; ADCP- sea current profiler, CTD-salinity; PCM-discharge in flushing culvert

Using such meaurements we are able to get an insight in real processes, i.e. wind influence, which is hard to produce in a laboratory; the influence of wave actions, or some other phenomena which could be observed only in nature.

Keywords: water renewal, flushing culvert, field measurements, breakwater, wind waves

SOME COMPUTATIONAL ASPECTS OF AN INTEGRATED MODEL FOR SIMULATING THE SEA ORGAN IN ZADAR, CROATIA

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Abstract

The Sea organ in Zadar, Croatia, is a unique architectural, hydraulic and acoustical achievement, constructed in 2005. This object is an integral part of the Zadar promenade, built in the step-descending seawall. The organ is driven by dynamics of the sea waves – vertical motions of the sea surface force the water into the polyurethane pipes of different diameters, and the motion of water pushes the air through the pipes and out of acoustical pipe endings placed in the resonating corridor.

An integrated approach is presented here for simulating both the hydraulic and acoustical aspects of the Sea organ. The computational model was developed by combining a two-dimensional algorithm for generating sea waves, a one-dimensional numerical model for water mass oscillations, and a musical sound model. The wave algorithm is based on the linear wave theory and the principle of superposition of harmonic wave components, which are synthetically generated from a given wave spectrum. This algorithm includes stochastic variations of the wave height, length, phase, and the propagation direction. The governing equations for water mass oscillations are derived from the Continuity equation and the Bernoulli's equation for unsteady flow. The system of two ordinary differential equations is solved through direct time integration by the implicit trapezoidal rule. Once the water oscillations in pipes are known, a musical model is applied to generate the sinusoidal sound, which is based on a predefine frequency for each pipe. The amplification of the sound is considered proportional to the positive rate of change of the water level in the corresponding pipe.

One characteristic example is presented to demonstrate the capability of the proposed model in simulating the hydraulic and musical aspects of the Sea organ. A common summertime wave scenario was considered, defined by the Tabain wave spectrum and a NW wind direction. The model results are illustrated by a time series of the sea surface and water level oscillations, and the corresponding water level rate of change (Figure 1). Finally, a sound recording is derived by combining individual sounds generated in the pipes located at two adjacent segments.

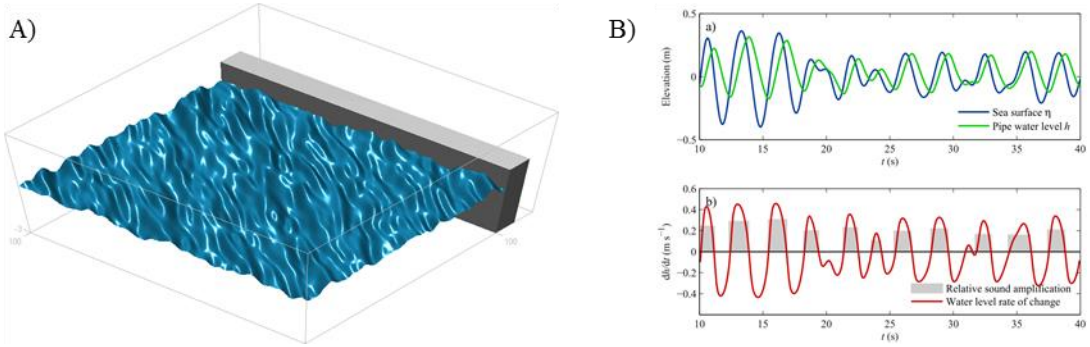

Figure 1. Model results: A) syntetically generated wind-waves and B) water mass oscillations in organ pipes

Keywords: Sea organ, Zadar, harmonic waves, spectral waves, water mass oscillations, numerical model, sound frequency, sound amplification

6. GEOTECHNICAL ENGINEERING

IMPLEMENTATION OF EUROCODE 7 IN THE DESIGN OF FLOOD PROTECTION EMBANKMENTS

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Abstract

The introduction of Eurocode standards in civil engineering design procedures led to a necessity for certain modification of designer's mindset. Eurocode standards define principles of design (which are mandatory) as well as rules of application which satisfy principles, but which are non-mandatory and somewhat too general and where designer needs to adapt by using some other, more straightforward, standards or relevant literature. The significance of this design approach come to fore during design of particular structures such as flood protection embankments. The methodology for their design consists of several stages whose final aim is to ensure hydraulic and geotechnical stability in short-term and long-term conditions. To fulfil this, a designer must consider series of design situations, which are reasonably expected during the lifetime of an embankment. These design situations, from construction phase and normal operating conditions to the flood event, rapid drawdown and seismic condition, present the core of design using Eurocode 7 and it is crucial to identify them. Taking a step forward from conceptual level design (crest level, embankment alignment, slope angle etc.) this paper deals with design procedure starting from proper identification and interpretation of investigation works in order to obtain relevant ground model to analysis of both ultimate limit states (ULS) and serviceability limit state (SLS). A concept of partial factors, defined by Eurocode 7 and National Annexes, which gives a 'translation' from a characteristic to design value of certain parameter is given through prism of flood protection embankments. A critical review of Eurocode 7 in flood protection embankment design and comparison of previously used design standards in Croatia is also given. Further, as a verification of rationally determined embankment's resistance and resilience, an observation and quality control methods are stressed out.

Keywords: flood protection embankment, Eurocode 7, design situations, ultimate limit states, serviceability limit states, partial factors

REMOTE SURVEYING OF FLOOD PROTECTION EMBANKEMENTS

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Abstract

The need for assessment of existing condition of flood protection embankments is becoming more important in recent years. But besides the standard in-situ and laboratory methods for identification of their condition, some novel methods are entering through 'a backdoor' and showing high potential, even though designers and investor's are in generally not familiar with their possibilities. One of such methods, which can be useful for assessment of current condition, is method of Unmanned Aerial Vehicle (UAV) also known as 'drone' which is characterized by the increasing number of engineering applications. First benefit of method is in interactive approach for visual assessment of condition where a wider, aerial, picture can be obtained by having a sole operator on site, while the other participants in design of embankment's remediation (persons who conduct investigation works, designers, investor etc.) can interactively be involved while not being present on site. Also large areas, which is the case for linear structures such as flood protection embankments, can be surveyed in fast manner, reducing the time necessary for standard visual assessment. However, full potential of method is in its possibility in advanced engineering analysis through the formation of orthophoto maps and 3D models using aerial photogrammetry. From this type of models, a complete spatial characteristics of existing embankment can be obtained with provisional cross sections extrapolated, thus avoiding a current practice where surveying activities are conducted along several profiles. The paper presents the possibilities of using Unmanned Aerial Vehicles on flood protection embankments, emphasizing their advantages and shortcomings.

Keywords: unmanned aerial vehicle, remote survey, flood protection embankment, interactive condition assessment, photogrammetry

APPLICATION OF GEOSYNTHETICS FOR REINFORCEMENT OF FLOOD PROTECTION EMBANKMENT

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Abstract

In Croatia, a large number of flood protection embankments were constructed many decades ago and their deterioration is inevitable. These embankments are subjected to series of factors making them prone to different types of failures. Also, a lack of vision for their remediation led to many problems in past few years, such as large-scale flooding events. In the same time, mandatory design standards, which ensure overall stability of embankments, are becoming stricter making the remediation procedure more complex. Designers need to cope with investor's constant aspiration to keep the remediation costs as low as possible. In order to satisfy strict standards and investor's mentioned aspiration, a relative modern solution for reinforcement of embankments is shown in this paper. This solution comprises of application of geosynthetics where, among vast range of types, geogrids are most often used for reinforcement of flood protection embankments. Main advantage of geogrids is in increasing safety aspects, extending embankment work life and potentially reducing overall remediation cost through reduction of earthworks. Characteristics of geogrids, as well as mechanisms, which drive their behaviour through interaction with soil materials, are also presented in paper. Other than reinforcement, geosynthetics can be efficiently used in embankments by means of material separation, filtration, drainage or to ensure its impermeability. A design procedure for remediation of deteriorated flood protection embankment in Croatia will be shown, with focus on application of geogrids, which will ensure its stability. Besides satisfying standards, a most important benefit of geogrid application was reduction of earthwork and, consequently, cost of project. This was accomplished by utilization of the existing embankment and its upgrade by applying geogrids.

Keywords: geosynthetics, geogrid, reinforcement, flood protection embankment, remediation measures

INVESTIGATION WORKS FOR REMEDIATION OF HYDRAULIC STRUCTURES

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Abstract

Remediation of hydraulic structures, such as flood protection embankments, came to fore in recent years due to fact that they were constructed many decades ago while in same time they are subjected to loads for which they were not primarily constructed (higher water levels due to climate changes etc.). In order to cope with mentioned factors, but also taking into consideration stricter design procedures with implementation of Eurocode, a current state of embankments must be identified. This is done by conducting investigation works, which include an overview, collection, systematization of available information following in-situ and laboratory investigations. Still most widely used in-situ used method is borehole drilling which gives unique information on type of material of existing embankment and foundation soil. Along with laboratory tests on samples obtained from drilling, an insight in physical – mechanical characteristics of soils can be obtained which is of significance for remediation design. Besides drilling, many other methods can be employed, such as cone penetration test whose results can be used for estimation of physical - mechanical characteristics of soil by established correlation. However, it is the fact that these methods provide a level of information which representative only in a discrete area and in order to obtain a greater quantity of data due to the greater volume soil taken in investigation, a geophysical one should be taken into account. Methods like geoelectrical resistivity, seismic refraction, multichannel analysis of surface waves or ground penetrating radar can give a better insight in overall geological stratigraphy and can also be used for estimation of some engineering parameters (namely seismic methods). These methods, however, need to be used in combination with borehole drilling and are optimal to use during preliminary phase of investigations in order to provide a general picture of the soil and on the basis of such data, an optimal number and position of investigation boreholes are then determined. Eurocode 7 - part 2, however, does not give specifications for investigation works for construction or remediation of flood protection embankments. It gives some general remarks on raised earthworks for roads and highways, but these can't be taken as relevant due to specific nature of flood protection embankments. Therefore, this paper goes one step forward by proposing a set of guidelines for the future application of ground investigation methods for remediation of flood protection embankments.

Keywords: flood protection embankment, investigation works, borehole drilling, geoelectrical resistivity, seismic refraction, multichannel analysis of surface waves, ground penetrating radar

7. EU PROJECTS, SOCIETIES AND INDUSTRY

BRIDGE SMS PROJECT – THE CORK COUNTY COUNCIL EXPERIENCE

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Abstract

Cork County Council has approximately 3,000 bridges under its control. County Cork is the largest county in Ireland and represents about 10% of the land area of Ireland. There are 11,500km of roads of all types in the County. The BRIDGE SMS project, funded under the FP7 Marie Curie IAPP programme, has given the Council personnel an increased awareness and appreciation of the importance of the role that scour plays in the deterioration of bridges. The project has assisted the Council Engineers in developing new ways in which we carry out our work, i.e., we have become more proactive rather than reactive in relation to extreme weather events. As a result of our participation in BRIDGE SMS, Council Engineers have a better understanding of the potential consequences of exceptional rainfall and following such an event, will actively look for damage to bridges. The project also has the capacity to give Council Engineers the ability to identify which of our bridges may be vulnerable to a major weather event. This will improve the Risk Management of the Asset and will enable the Engineer to prioritise future monitoring of bridges, focussing on the critical ones. The software being developed by the project will be a valuable management tool and will enable the Council to better manage our bridge stock. This in turn, will lead to lower maintenance costs and will provide a more secure bridge management system. In the light of constantly reducing engineering and financial resources, this is a considerable benefit to the Council.

One of the main aspects of the IAPP programme is the knowledge transfer between industry partners and research organisations. The Council has benefited considerably from the Knowledge Transfer aspect of the project. We have had a significant number of meetings with the personnel both from UCC and from UNIZAG. At these meeting, there has been a sharing of experiences from both sides to our mutual advantage. We have brought an awareness of the importance of on site Health and Safety issues to the members of the BRIDGE SMS team in the course of developing new systems for Scour Management. This Health and Safety Culture is now embedded in all aspects of the project. The Council has a data base of suitable contractors with appropriate experience in bridge rehabilitation and in undertaking in-river works. We have arranged for some of these contractors to assist the Team in installing test equipment for the Scour monitoring exercise, and for the Weather Information Logging Device and the Bridge Information Recording Device and other real time monitoring devices.

Within the past three years, the Cork County Council Road Design Office has rehabilitated or replaced of the order of 80 bridges, some of which were in very poor structural condition. This work has given the Council vast experience in dealing with local issues in relation to bridges. This includes potential difficulties in liaising with land owners, utility companies, Inland Fisheries Ireland, National Parks and Wildlife Service, the Office of Public Works and The Department of Heritage. We have brought this experience to the BRIDGE SMS project. This has assisted the project in addressing these issues which can sometimes be quite complex. We have been able to advise the BRIDGE SMS project on what is acceptable or otherwise to these semi state organisations. We are sharing our Knowledge with the Research Team. This knowledge will be incorporated into the deliverables currently being developed, such as software and to the outputs from the Real Time Monitoring. Examples of Bridge Rehabilitation will be discussed.

The Council has contributed significantly to the drafting of the 'Guidelines for the Structural and Scour Inspection of Bridges'. We attended a workshop on them at the outset. This was followed by site visits to a number of bridges where we assessed the bridges in accordance with the draft Guidelines. At a subsequent (Skype) meeting, we suggested a number of opportunities to improve the draft. These suggestions were virtually all adopted and subsequently incorporated into the document.

The Council envisages that there will be further International networking opportunities as the project progresses. This will be to the benefit of both Cork County Council and the BRIIDGE SMS Project. One of the potential collaboration is with the Irish Department of Transport through the Bridge Asset

Management Project (BAMP). Its objective is to develop systems for the management of the Bridge Stock in Ireland, under a number of headings, including Guidelines and Standards, Procurement, Software Development and Training. The members of the group are drawn from various Local Authorities throughout Ireland. We have introduced the Senior Members of the BRIDGE SMS research team to the Department of Transport BAMP. The senior officials in the Department have stated that they wish to establish a working relationship with the BRIDGE SMS project. This will be to the mutual benefit of both, as each party will be able to draw on the knowledge and experience of the other side.

Keywords: Marie Curie IAPP, asset management, bridge scour, Cork County, knowledge transfer

PREPARATION OF EU FINANCED WASTEWATER COLLECTION AND TREATMENT PROJECTS IN CROATIA WITH REGARD TO DIFFICULTIES IN PROJECT APPLICATION

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Abstract

The Republic of Croatia's accession to the European Union has triggered the commitment of meeting the requirements of Urban Waste Water Directive (91/271 EEC) and the Water Framework Directive (2000/60/EC).
Key element of fulfilling the requirements relates to construction of wastewater infrastructure, namely collectors and wastewater treatment plants, which will enable achievement of required connectivity rates and levels of wastewater treatment in accordance with agglomeration size and position.
In this paper authors will give an overview of necessary documentation for application of infrastructural projects in wastewater sector, with the focus on development of Feasibility studies and Application packages.
Preparation of infrastructure projects of substantial magnitude requires a holistic approach, from an analysis of the existing input data (population, tourism economy, consumption of drinking water), definition of optimal measures regarding agglomeration size and technical solutions applied within, cost-benefit analysis of the project, as well as environmental protection aspects.
Main focus of the paper will be on difficulties in project application, shown through each step in the development of a Feasibility study for EU co-funded wastewater infrastructure. Special attention will be given to geographical distinctions throughout the Republic of Croatia, since the problems in project applications are clearly diverse. Continental Croatia suffers from declining demographic trends and decreasing water consumption, sensitivity of the area and issues with financial capacity to carry out projects of this magnitude, including affordability deficiencies. On the other hand, the main issue in coastal Croatia is the dominant influence of tourism on all aspects of the project, such as agglomeration size, varying seasonal loads, financial approach to occasional system users (State Aid), etc.
Apart from highlighting the difficulties, the authors will provide insight into possible solutions, stemming from their experience in the field.

Keywords: EU, Directive Requirements, Project Preparation, Project Application, Difficulties, Geographic Distinctions

FLOOD RISK SLOVENIA-CROATIA OPERATIONS - STRATEGIC PROJECT 1 - NONSTRUCTURAL MEASURES (FRISCO1)

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Abstract

FRISCO1 is a Project of the cross-border programme that intends to focus to the river basins and flood risk management issues that can only be addressed through joint intervention of Slovenian and Croatian water authorities. The main outputs will be sets of joint models, maps and tools for each of the six target transboundary river basins (Kupa/Kolpa, Sutla/Sotla, Drava, Mura, Dragonja and Bregana) with the associated design documentation for optimal structural measures, improved physical alert systems, and the outputs of awareness rising/capacity building activities. The Project will address the needs of a wide range of target groups, and the ultimate beneficiary of the Project is the affected population. The Project's objectives can only be achieved through cross-border cooperation because, in line with the Floods Directive, the flood risk management planning should be done following the river basin approach in order to determine the optimal measures. This Project (Flood Risk Slovenia-Croatia Operations - Strategic Project 1 - Nonstructural Measures (FRISCO1)), will serve two key purposes: to improve coordinated flood risk management and reduce flood risks through implementation of non-structural measures, and to prepare documentation (studies and design) for the optimal structural measures that will be implemented in subsequent strategic project or projects.
This presentation and or paper has focus on main outputs of FRISCO1 Project in connection with complex management structure of the Project. The main outputs will be sets of joint models, maps and tools for each of the six target transboundary river basins. Complex Project management structure reflects the need to interact in cross-border manner between all involved partners, states institutions, and is further reflected through main outputs. The main method is harmonization and joint intervention established through management of the Project and applied at known procedures, data collection and tools selection and all in the frame of the Programms requirements.

Keywords: Cross-border programme, flood risk management, harmonization.

AUTHOR INDEX