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Content

Stability of a designed retention dam

Katarína Cipovová

Abstract

In this contribution I would like to describe a design of a retention dam as a flood protection of Adamovské Kochanovce village. The design of such a concrete building contains also a stability examination – slope stability (Bishop, Petterson, Sarma methods), side-tilt stability, stability against horizontal movement and ground bearing capacity. This paper contains stability calculations and possible solutions of inconvenient conditions.

Keywords:
ground bearing capacity, retention dam, stability, slope stability,

Introduction

Village Adamovské Kochanovce lies at the foot slopes of the White Carpathians Mountains. It is often threatened by floods, which cause significant material, cultural and natural damage. Floods occur especially during summer storms when runoff from short, intense torrential rains concentrates in the valleys and pours out of bed of the stream, and then when the snow melts and rainfall also occurs. Then the water infiltration into the saturated soil is near zero and water also rolls into the valley and causing damage in the village.

Afret an agreement with the leadership of the village we decided to solve the flood protection of the community by construction of a retention dam on Adamovský stream and regulate its part. This dam will be tasked to capture the flood wave and let out only harmless amount of water. This will provide protection against static effect of water (flooding of adjacent areas) and the dynamic effects of water (erosion and leaching of materials, damage to roads and bridges).

This paper contains the basic information about designing the dam and especially its geotechnical part – stability of the structure, and slope stability.

Materials and methods

Adamovský Creek is a right tributary of the river Chocholnica. The main stream has a length of 5.172 km and has three right tributaries. Almost half of the basin is forested; the rest is used primarily for agricultural purposes. The highest point of the river basin is 566 m n. m. and lowest at the mouth of the Chocholnica of 197 m n. m. Above the village the flow creates meanders and cuts into the bedrock (Fig. 1, 2).

Fig. 1 A score formed by retroactive erosion

Fig. 2 Waterfall upstream

For the design data from GÚDŠ were used, Landscape Atlas of the Slovak Republic and the results of geological reconnaissance. On the left there were found soil river gravel terrace on the neogenic clay subsoil. On the right side there are also mainly clays and soil gravels, but the slopes are steeper. The soil throughout the site is neogenic clay. Around the construction of dam there are no active landslides; one potentially dangerous landslide is located beyond the swell. This section of the flow is strongly affected by the retroactive erosion, as shown in Fig. 1. Before the construction the data should be supplemented by field survey with four planned drillings 15 m deep on both sides of the river bed. 40% of the catchment soils are and modal candizem and saturated cultizem and 60% is brown earth.

Approximately 200 m above the profile of designed dam there is a waterfall (Fig. 2). Any little flooding causes the errosion and more sediments clogg a tank for fire purposes, located about 450 m below the profile of the dam; the agricultural land is being devastated and the risk of landslides increases.

Brief description of the invention

Proposed dam is 5 m high, concrete structure, the outlet is of the rectangular shape of 1 m wide and 0.66 m high. Trapezoid spillway is 1 m high and 2 m wide. A dam should capture the designed flood wave calculated using DesQ software - required retention volume of 56 200 m^3. A regulation of a stream will be made on a length of 600 m into trapezoid shape with a width of 1 m in slope 1:2 and fortifications of slopes with quarry stone below the water level and grass-concrete blocks above the water level in the dam. Under the of dam there will be a concrete stilling basin 30 cm deep and 5 m long according to the calculations [Hulla, Turček, 2002], [Lukáč, Bednárová, 1992]. Slopes in the flooded area and 5 m below the polder construction will be stabilized by the gabions.

Results and discussion

Classification of soils according to STN 731001

In the dam cross-section there are two types of soil [STN 731001] according to the geological reconnaissance. Their standardized characteristics are shown in Table. 1. Since the exact composition of the soil will be known only after detailed geological survey, I present both maximum and minimum possible characteristics for that type of soil, and I further work with both variants.

Tab. 1 Guide standardized characteristics of soils

		Name of soil	Clay (high plastic)		Clayey gravel
		Class	F8		G4
		Symbol	CH		GM
	symbol	unit	min	max	
Density	γ	kN.m^{-3}	20	21	19.5
Friction angle	φ	°-	15	19	28
Cohesion	c	kPa	10	20	2
Young´s modulus	E_{def}	MPa	4	6	60

Slope stability

Slope stability was calculated using the Geo5 software, which uses three methods to compare active and passive forces and active and passive moments (M_A, M_P). (Hulla, Turček, 2002).

Petterson´s method is the oldest method of calculation of slope stability. It´s based on the principle of balance in the plane conditions. Slip surface is cylindrical in this case. The soil above the slip surface is divided into n vertical strips, examine the forces acting on the slip surface and determine the moment of passive and active forces to the centre of rotation, while not considering inter-strips forces.

The actual weight of the i-th strip G_i to slip surface extends in the direction of tangents Q_i and normal N_i. Then the degree of safety Fs is defined as the ratio of passive to active moments. R arm on which all the forces are acting rolls after substituting into the equation. Δl_i is the length of the shear area of the i-th strip. If there is leaking water, to the active torque value is added the water jet pressure Pv, on the moment arm r_v.

$$Fs = \frac{M_P}{M_A} = \frac{\sum_{i=1}^{n} N_i tg\phi + \sum_{i=1}^{n} c\Delta l_i}{\sum_{i=1}^{n} Q_i + P_V \frac{r_v}{r}} \qquad (1)$$

Bishop's method is very similar to the method of Petterson, but also takes into account inter-strip forces and besides the torque equilibrium conditions it also takes into account the totalized condition in the vertical direction. The degree of stability is calculated by iterating the equation:

$$Fs = \frac{1}{\sum_{i=1}^{n} G_i \sin\alpha} \sum_{i=1}^{n} \frac{c_{ef,i} b_i + (G_i - u_i b_i) tg\phi_{ef}}{\cos\alpha + \frac{tg\phi_{ef} \sin\alpha}{Fs}} \qquad (2)$$

where u is a pore water pressure and α is a vertical deviation from the normal.

Sarma´s method differs from Petterson and Bishop by the shape of the slip surface. It is not circular, but polygonal. The principle is also a method of balance in the strip.

Slope stability was calculated for two variants - the minimum and maximum values of standard characteristics of soils. The calculation is still not considering the impact of water. The minimum degree of stability is 1.5. Degrees of stability for all three methods are shown in Table 2. Variability of results is highly dependent on the shape of the most unfavorable slip surface for different method. Slip surface shapes for the calculations are shown in Fig. 3 - 6.

Tab. 2 Values of stability degree (Fs) for different soil characteristics

		Bishop	Petterson	Sarma
Left slope	min.	1.52	1.36	1.53
	max.	2.23	2.04	2.18
Right slope	min.	1.46	1.04	1.44
	max.	1.16	1.11	1.18

Although the left slope meets almost all cases, it is only provided the dry dam. After the flood, when the slopes are saturated with water, and the dam is almost empty, there will be a leakage of water from the slope and the rapid decrease in stability on both slopes. Solution - fortification with wire-stone mattresses (gabions). Slope stability after fortification with gabions has been calculated in the MacSTARS 2000 software again for dry dam, but also for the worst case, the sudden emptying of the dam.

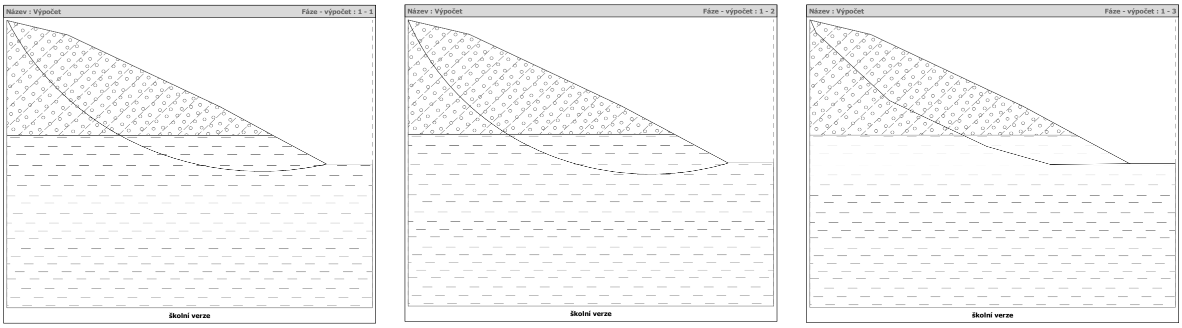

Fig. 3 Shapes of a slip surface for a minimum soil characteristics - left slope, according to Bishop (left), Petterson (center) and Sarma (right)

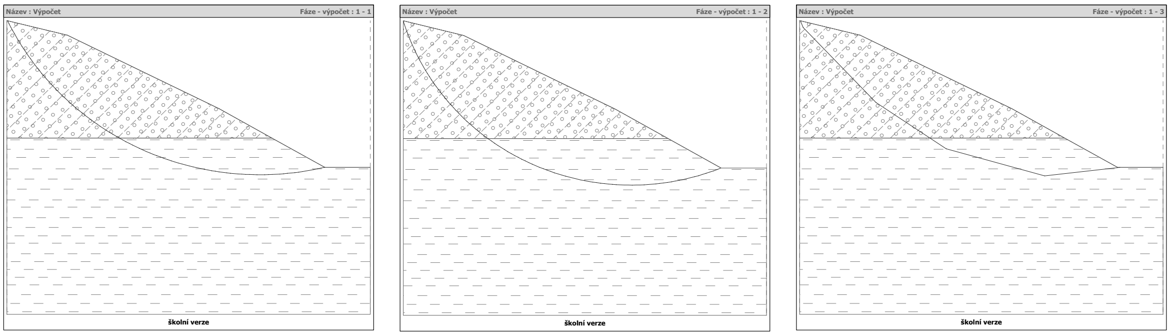

Fig. 4 Shapes of a slip surface for a maximum soil characteristics - left slope, according to Bishop (left), Petterson (center) and Sarma (right)

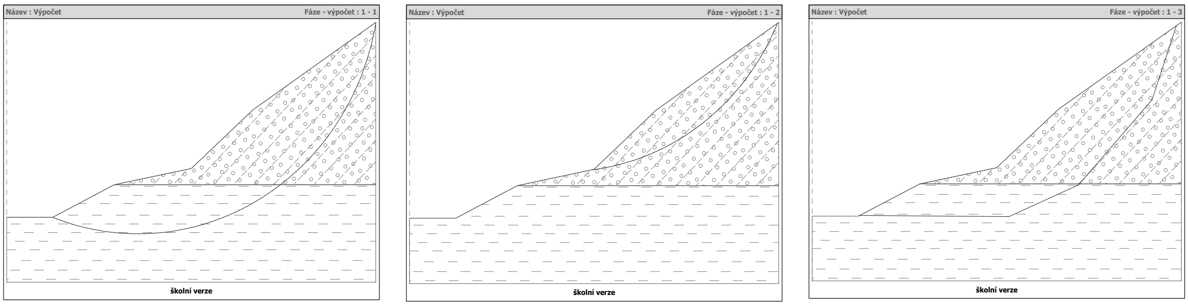

Fig. 5 Shapes of a slip surface for a minimum soil characteristics - right slope, according to Bishop (left), Petterson (center) and Sarma (right)

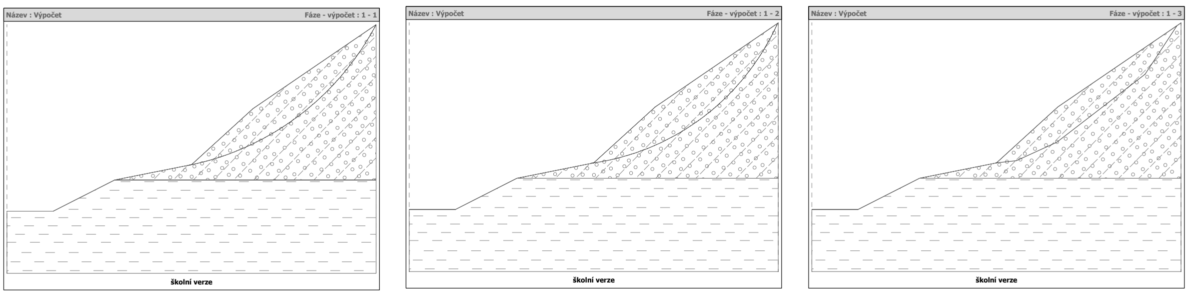

Fig. 6 Shapes of a slip surface for a maximum soil characteristics - right slope, according to Bishop (left), Petterson (center) and Sarma (right)

Stability of the structure

The stability of the substructure is necessary to consider three situations: tilting around the air toe of the dam, movement in the foundation and the load bearing capacity of the background [Lukáč, Bednárová, 1992]. The degree of stability for the tilting around the heel (point A) can be determined from the ratio of stabilizing moments to tilting moments. According to the calculations, FS = 2,58, since the degree of stability when considering similar structures is at least 1.3 to 1.5, given structure meets the stability for tilting around the point A. Shear stres in the background caused by the base load structure shall not exceed the shear strength of soil. Of these requirements leads the condition of stability against displacement. For minimum characteristics of soil (c=10 MPa, φ= 15 °), the shear strength is 32,64 MPa, for maximal 49,1 MPa. It means that in the first case F_S = 1,31 and second F_S = 1,97. In such case, minimum stability factor should be more than 5, we need to stabilize the structure for example by building a stabilization tooth and toothing the background. Load bearing capacity If the load exceeded the designed limit of load bearing capacity the soil structure would lose stability. Here σ = 174,99 kPa, so after detailed geological survey we will know exact values of characteristics c, φ, and γ, calculate R and compare it with the load σ.

Conclusion

Solution described in article reduces the culmination and protects the village against flood events. During the planning, many problems can appear. Usually the biggest problem is purchasing detailed input data. Small streams such as Adamovský Stream are not usually monitored, there are no information about n-year discharges or rainfall intensities, there is no topographical survey realized. It means that in the first phase of the project, we have to rely on uncertain sometimes even estimated values, which come into calculations.

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Use of eCognition Developer software for forest stands heights assessment

Martin Machala

Key words: eCognition Developer, OBIA, forest stand heights assessment, LiDAR

Abstract

In the field of remote sensing research the need for reliable and time saving methods of image analysis has always been obvious. Taking these needs into consideration the different semi-automated methods are more and more often used in recent times. A specific Object-Based Image Analysis (OBIA) methods are being developed focused especially on facilitating the image data analyses especially of data sets covering large areas. This attitude can save enormous time and costs compared to purely manual interpretation and classification of the images. Working with two-dimensional image data the different types of Landuse or Landcover outputs can be generated, but when adding the third dimension, the heights of objects can be estimated as well. This paper describes study assessing the heights of forest stands working with the DSM and the DTM layers extracted from the aerial LiDAR data.

Introduction

One of the main advantages of the OBIA approach is that it enhances the efficiency of analysis processes by utilization of enormous computing power of contemporary computers. It is trying to combine this power with human knowledge and cognitive capabilities simulating the principles of manual image interpretation.

Using OBIA software the image data are analysed using several iterative processes. Firstly the process of segmentation is applied, when the image is divided into many relatively homogenous objects according to the user settings. Properties of these objects (instead of simple pixels used in pixel-based methods) are then assessed and analyzed. All required areas represented by specific objects are classified into predefined classes afterwards. During this procedure the attributes of the objects such as shape, colour, texture and size of objects as well as their context and mutual relationships (instead of only spectral information of lonely pixels) are assessed to help to classify these objects correctly.

Methodology

One of the longest period developed OBIA software is the eCognition® Developer by Trimble®, which had been also used in this study. Different data types had been applied for the analysis. Besides the aerial orthophoto images captured in visible spectrum (Red, Green, Blue – RGB) and Near-Infrared image layer (NIR) it was also the Digital Terrain Model (DTM) and Digital Surface Model (DSM) derived from the laser scanning LiDAR pointcloud data.

The area which had been analysed is situated in the Czech Republic; in South-Moravian District nearby the north-east edge of the City of Brno mainly around the town Bílovice nad Svitavou. The research area covers 8 km^2 (i.e. 800 ha) and approximately 77% of the area is covered by forests.

By the thorough analysis of the data in the eCognition software firstly all non-forest areas had to be distinguished (containing built-up areas, water surfaces, agricultural land and all non-forest greenery). Afterwards the forest area as such was analyzed in detail and these six categories were distinguished: Broadleaf forest, Coniferous forest, Mixed forest, Young forest, Plantation, Clear-cuts and Bare ground.

The accuracy of this semi-automated classification made purely based on remote sensing data had to be verified. That was made by collecting the reference data in terrain when the information about the forest stands composition was recorded into GPS device Trimble Juno ST. Simultaneously the heights of trees were measured by the Leica DISTO™ lite^5 Laser Distancemeter and “Blume-Leiss” Mechanical Altimeter. Comparing these reference data with the classification results the error matrix has been generated and the overall classification accuracy was found out. In this case the accuracy was 90%.

The height of stands in the research area was the subject assessed in the next step. Similarly to the first classification, also in this case the image data were segmented into plenty of relatively homogenous image objects according to empirically adjusted parameters.

Table 1: Absolute and proportional values of representation of different Forest Height Levels.

	Height Levels	Area [m^2]	% of total
Forest area	0 – 5	778,670	13.12
	5 – 10	972,464	16.38
	10 – 15	1,264,324	21.30
	15 – 20	1,801,849	30.35
	20 – 25	985,511	16.60
	25 +	133,473	2.25
	Sum	5,936,291	100

The size of the objects was highly variable, when they contained for instance crowns of only one single tree (in the case of easily recognisable alone standing solitary trees) up to several tens of trees in the stands with continuous canopy.

Both, the orthophoto images and the LiDAR data were used for the segmentation with emphasis put on the digital elevation models. The forest stands heights were then estimated on the basis of difference between DSM and DTM layers counted for each individual object. Based on these differences were all the objects classified into height levels graded by 5 metres (0-5, 5-10, 10-15, 15-20, 20-25, a 25+ metres). The accuracy was also in this case verified by comparison with the reference data, when the error matrix showed the overall accuracy of 70%.

Finally the graphical visualisations of the results were made and the areal representations of different classes were counted in the ArcGIS 10 software.

Results and Discussion

Altogether two maps gained purely on the basis of information contained in the remote sensing data are the outcome of the study. One map shows the results of classification of forest area from the perspective of representation of all the forest and non-forest classes. The second map than shows the representation of all the height levels in the forest area graded by 5 metres.

When looking at the overall accuracy of classification of heights, the value of 70% can seem to be low. But if the actual form of segments used for classification is taken into consideration, the result does not have to seem so bad. According to the error matrix, the inclination to usually underestimate the heights of forest stands was apparent in the case of almost all height classes. There can be several reasons clarifying these findings. First of all, the image objects used in the classification process usually contained several individuals, up to few tens of trees. The used method of calculation of the height of these areas did not include the maximal heights of trees, but was counting only with the Mean values of DSM and DTM.

Since the Mean value of Digital Surface Model is counted from all the values contained in the object, including the tree tops (First laser returns) but also often the ground (Last laser returns) and many values also in between, the results just cannot fully correspond to the heights of tree tops measured in the terrain, when using such a large segments for classification.

This inaccuracy is logically getting larger with increasing age of forests, when the stands are often pruned and getting sparser. The Mean of DSM is then significantly decreased by the fact, that the laser scanner reaches more times up to the ground and less often hits the tree crowns. This problem could have been probably avoided by using smaller segments for classification (ideal could be one segment for each tree crown). This could be for sure a subject of further studies, since such research would require basically different approach.

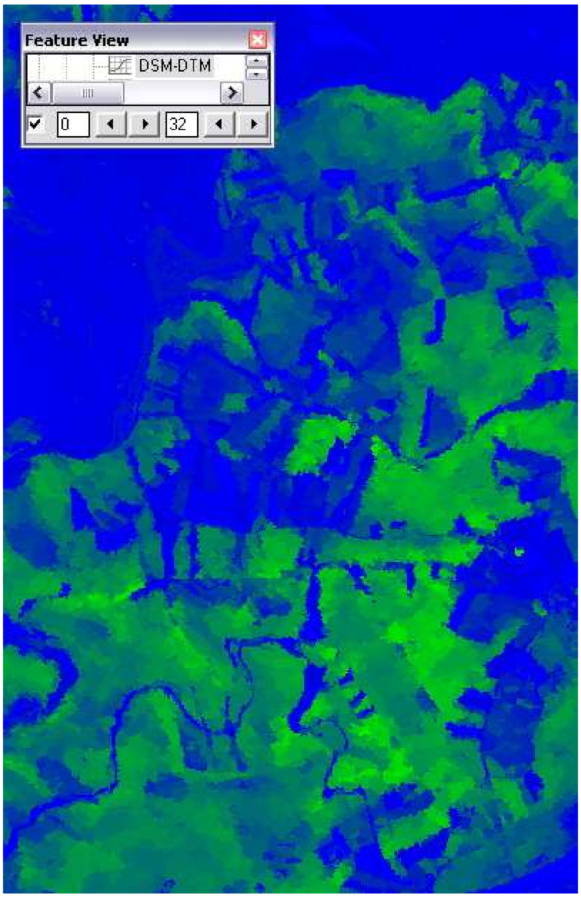
As we can see in the work of Tiede D., Langa S. and Hoffmann Ch. (2006), already the demarcation of single tree crowns is a big deal. They approached this task by using a region growing segmentation algorithm in eCognition software taking the local maxima (tree tops) as seed points. They experienced some difficulties especially in the dense forest stands where it was not easy to identify individual tree tops. Much better results were achieved in the case of well spaced stands (what is generally opposite to the difficulties registered in this study). Goulding C.J., Fritzsche M. and Culvenor D.S. (2009) reached very satisfactory results when identifying individual tree tops using the TIMBRS software. But the fact they were working with even-aged plantation pine trees has to be taken into consideration.

None of these two researches was striving to measure the heights of trees. They were attempting just to distinguish the individual trees what could be considered a precondition when downscaling the segments size to the scale of tree crowns. Application of similar approach can be considered to be a potential solution which could probably make possible to reach better accuracy of stands heights assessment.

Values of heights gained in this study by classification say more about the average height of the canopy, than about the maximal height of the stand, which is usually measured. The results are the better corresponding to the ground truth, the younger the forests are. In some cases the inaccuracy can be also influenced by the fact that the trees can grow up a little from the time of remote sensing data acquisition to the time of reference data collection. And some portion on the deviations can undoubtedly bear also the mistakes made during the terrain heights measurements.

Conclusion

As there was proved in this study, that eCognition software can be used for classifying forest stands from the composition point of view with satisfactory results, from the perspective of stands heights estimation there were found some reserves. There are several



Picture 1: Visualization of the difference between the DSM and the DTM. The brighter the green, the taller the forest stand.

reasons why the accuracy of heights assessment was lower than the landuse classification, but the main reason was found in the size of objects gained during the process of segmentation. Making the method more accurate e.g. by minimization of image objects could be the subject of further studies.

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Optimizing the Operation of the Ipeľ Pumped Storage Power Plant

Miroslav Tvrdoň, Ján Rumann

Abstract
The designing of pumped storage power plants is very important nowadays. The operations of these power plants have to cover the power system's requirements and achieve an appropriate degree of economic effectiveness. One of them is a pumped storage power plant Ipeľ, which is prepared to construction for decades as a weekly operation pumped storage project

Key words:
Pumped storage power plant, optimization

Introduction

The principle of secondary hydraulic accumulation provided by pumped storage power plants is presently the only appropriate possibility for accumulating, on a large scale, surplus electrical energy produced by not regulating sources. Pumped storage power plants are regulating sources of electrical energy. In time of increasing electricity consumption these power plants generate required peak energy (on-peak power). When the electricity consumption decreases the pumped storage power plants use the surplus energy produced by not regulating energy sources (off-peak power) for pumping (the accumulation of energy in an upper reservoir). Due to their dynamic regulating abilities, pumped storage power plants provide additional support services for a power system. The operation of these facilities has to fulfil the requirements of the power system and simultaneously achieve an appropriate degree of economic effectiveness. Under the present conditions of the energy market, the operational effectiveness of these power plants is the crucial criterion for their versatility and further development.

In a power system, pumped storage power plants fulfil the requirements for the quantity and quality indicators of the electricity produced, and they increase the operational safety of the whole system. The functions of pumped storage power plants in a power system can be defined as static and dynamic. Static (planned) functions are defined as planned power generation and energy transfer. Dynamic (not planned) functions provide support services such as the regulation of frequency and power generation (primary, secondary, tertiary), power backup, compensation operation or "black start". These functions are realized by power generation.

In the Slovak power system pumped storage power plants are important regulation elements. The total installed capacity of Slovak pumped storage power plants is 1046.4 MW, which is more than 40 % of the installed capacity of all the Slovak hydropower plants and more than 10% of the total capacity of the Slovak power system. However, their share in the total production of electric power is only 0.75%. Every existing pumped storage power plant in Slovakia operates on a daily regulation cycle (Tab. 1). The planned development of the Slovak power system anticipates construction of several large pumped storage power plants (Ipeľ, Hrhov, Malá Vieska) due to the construction of planned nuclear power plants. These new classic types of pumped storage power plants should operate in weekly cycles. Their operation should be designed in a way that fulfils the technical requirements of the power system at the most effective level. That is the purpose of optimizing operations.

Tab. 1 Overview of existing pumped storage power plants in Slovakia (Sládek, 1996).

Power plant	Year of construction	No. of units	Power generation [MW]	Power consumption [MW]
Dolný Jelenec	1948	2	0.91	0.92
Dobšiná	1954	2	24	18
Mikšová II	1960-1965	1	2.38	3.13
Ružín	1972	2	60	66
Liptovská Mara	1975	2+2	198	106
Čierny Váh	1981	6	734.4	600

Operation of classic pumped storage power plant on a weekly cycle

The principle of classic pumped storage power plant operations is the cooperation between two reservoirs, where the volume and water level regime in the reservoirs is affected only by the actual performance of the power plant in the power system. Other factors and water losses can be ignored. Functions of pumped storage power plants in a power system are realized by producing or consuming electrical energy, which directly affects the regime in reservoirs. During on-peak power generation, water flows from an upper reservoir to a lower reservoir (the upper reservoir is emptying and the lower is filling). During off-peak power consumption, water flows from a lower reservoir to an upper reservoir (the lower reservoir is emptying and the upper is filling). Thus the pumped storage plant operation can be described by the volume equations of the reservoirs. The condition of the volume balance of the storage reservoirs in a regulation cycle has to be fulfilled.

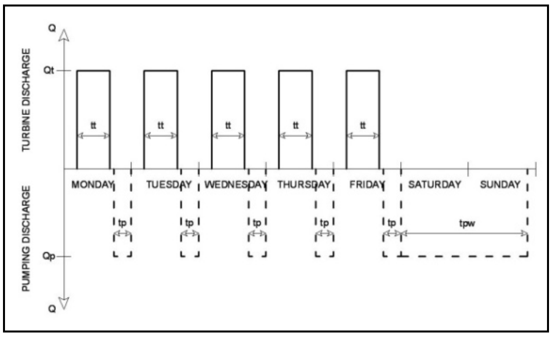

Fig. 1 Operation of weekly cycle pumped storage power plant – discharge

The operating volume of a weekly cycle pumped storage power plant is as follows:

$$V_O = 3600.Q_t.n_t.t_t.5 - 3600.Q_p.n_p.t_p.4 = 3600.Q_p.n_p.t_p + 3600.Q_p.n_p.t_{pw} \quad [\mathrm{m}^3], \qquad (1)$$

where V_o - the operation volume [m^3],
Q_t - the turbine discharge [m^3.s^{-1}],
n_t - the number of turbines,
t_t - the daily duration of the power generating operation [hours],
Q_p - the pump discharge [m^3.s^{-1}],
n_p - the number of pumps,
t_p - the daily duration of the pumping operation [hours],
t_{pw} - the duration of the pumping operation during the weekend [hours].

The maximum operating volume V_o^{max} of the power plant should not exceed the maximum storage volume of the reservoirs and the maximum volume pumped during the weekend. In order to comply with these two conditions for the given daily duration of the power generating operation, the maximum daily duration of the power generating operation is defined by the following equations:

$$t_{t\max A} = \frac{V_o^{\max} + 3600.Q_p.n_p.t_p.4}{3600.Q_t.n_t.5} \quad [\text{hours}] \quad (2)$$

and

$$t_{t\max B} = \frac{3600.Q_p.n_p.48 + 3600.Q_p.n_p.t_p.5}{3600.Q_t.n_t.5} \quad [\text{hours}] \quad (3)$$

For the given power plant parameters, the lesser value of t_{tmaxA} and t_{tmaxB} is the maximum duration of the daily power generating operation.

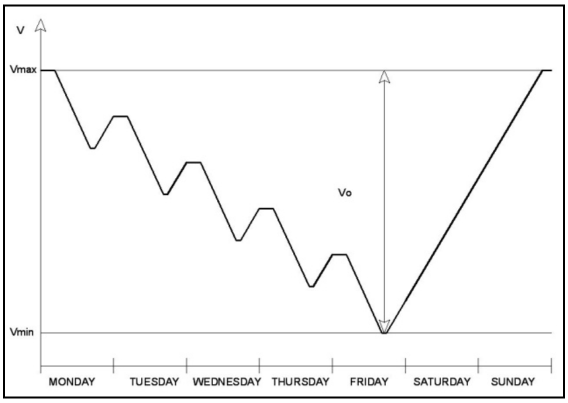

Fig. 2 Operation of weekly cycle pumped storage power plant – reservoir storage

When the volume regime of the power plant reservoirs is determined, the power generation and consumption can be estimated. Technical aspects such as the duration of the on-peak generation, off-peak pumping, power generation and pumping capacity, etc., define the pumped storage plant's operation.

Optimalization of operation of pumped storage power plant Ipeľ

The pumped storage power plant Ipeľ has been prepared for construction for more than 30 years as a weekly operation pumped storage project. It has been designed to utilize the maximum of the potential of the plant locality (Dušička et al., 2005). Under the present conditions the concept of this power plant did not seem effective, due to the new economic conditions and power system requirements. The described methodology has been used to examine the possibilities of operating this plant under the present conditions. Different operating scenarios have been simulated and evaluated under the present economic conditions.

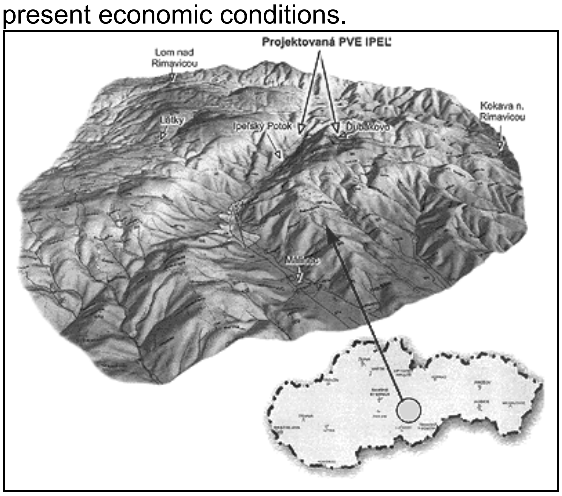

Fig. 3 Planned pumped storage power plant Ipeľ

Fig. 4 Planned pumped storage power plant Ipeľ - The upper reservoir

A comparison of the results of the simulated scenarios to the planned operating scenarios showed that the planned operation of this pumped-storage project is not effective and is unfeasible under the present conditions. It has also been proved that according to the effectiveness results of the planned operation of PPS Ipeľ under the present conditions, the whole project is unfeasible, and serious modifications to the planned operations but also to the entire plant concept must be made. However, the methodology has been used to determine the optimal operation for the present conditions. The operating effectiveness of the PSP Ipeľ has been increased by focusing the operation on providing support services to the power system. Further optimization showed that the power plant Ipeľ should be operated only as a large system backup to achieve maximum effectiveness.

Conclusion

The optimization of the operation of every system is an important issue for achieving its maximum effectiveness. Such an important source as a pumped storage power plant has to be operated effectively to ensure its versatility in the energy market. As the application of optimization methodology to the pumped storage power plant Ipeľ showed that, especially for new projects, it is necessary to operate at the best efficiency level to get a reasonable payback of the investment. In a larger scope it is not only the operation that can be optimized by new projects of pumped storage power plants, but also the whole power plant concept, which can be modified as an input to a simulation model.

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Aspects of Technical and Economical Evaluation of Small Hydro Power Plants in Slovak Republic

Martin Kubala, Michaela Macková, Ján Rumann

Abstract
This article discusses aspects of hydropower potential utilization in small hydropower plants in the Slovak market conditions. The main objective of the article is to show the way of technical and economical evaluation of small hydropower plants in Slovakia, with respect to their further development.

Keywords:
hydropower, SHPP, economical evaluation of SHPP

Introduction
Energy demand of countries rises according to their industrial and economic development. The “pressure“ on energy sources haven’t been so large, as it is in last years. By the present speed of fossil fuel utilization are raising justified concerns about serious environmental, economic, healthy, social and safety impacts. A solution to this situation could be increasing of effectively of electric power production, as well as its consumption. Although there are reserves in the field of power consumption (power savings, consumers habits), it is in a certain manner limited by the life style of the society, which determines the pattern of the consumption. These arrangements are not sufficient therefore it is necessary to increase power production from national energy sources. The attention paid to the increase of power generation from renewable sources of energy (RSE) is still growing, because the fossil fuel reserves are limited. Among the RSE are ranked:

- hydro power
- biomass energy
- wind power
- geothermal power
- other (tide, wave power

which are so far due to complicated technical design not very utilized, but are considered very perspective.
Biggest share in power production from RSE in Slovakia, up to 98% has the hydropower. 90% of the hydropower production is belonging to the large hydropower plants and the remaining 8% belong to small hydropower plants (SHPP). Technical hydropower potential (THP), which is 6607 GWh/year, is utilized up to 57%. The THP for SHPP has been estimated up to 25% (Doubrava et. al., 2006). As a member of European Union, is Slovakia bound, according to the program of utilization increase of RSE, to increase the power production from these sources. The increase of power generation in SHPP is assumed according to the tab. 1.

Tab. 1 Power generation in 2010 and investment costs (Doubrava et. al., 2006).

Source / Year	Small hydroplants
2005 [GWh]	250
2010 [GWh]	350
Generation increase [GWh]	100
Inst. capacity [MW]	20
Investment cost [mil. Sk]	1 800

Material and Methods
It is apparent, that there is still plenty of space for construction of new ones and reconstruction and production optimization of existing SHPP in Slovakia. Investments in this field are mostly of private character. Therefore not only technical and ecological, but also economical effects of hydropower plant operation are monitored in present market conditions. For project economic appraisal are generally two analysis approaches used. It is the static and the dynamic analysis.
Static analysis consists of cost, benefit and rentability comparison, with no regard to time factor or with very small regard to it. With extending of an investment lifetime period and increase of rates of interest, the error in the accuracy of the analysis will rise. Such static methods are:

- Payback Period
- Account Rentability
- Average Costs

Classic dynamic analysis of effectivity is based on comparison of effective incomes (gainings) and expenses (costs during entire lifetime of the project – planning and calculation lifetime – tab. 2) in present value terms. These methods take the time factor into account. Such dynamic methods are:

- Net Present Value
- Internal Rate of Return
- Rentability Index

These methods consider time value of money. Therefore it is necessary to discount incomes and expenses to the terms of given reference point. The discount index can be evaluated as follows:

$k = (1 + i)^n$

where i – discount rate (8% - for SHPP investment appraisal)

n – distance to the reference point on the timeline (years) (*Gresecke, Mosonyi 1997)*.
When evaluating the sums from the reference point backwards, the sums are divided by the discount index. When evaluating the sums

from the reference point forward, the sums are multiplied by the discount index.

Tab. 2 Average lifetime of general groups of SHPP equipment (MHSR, 2007)

Type of equipment	Average lifetime (years)
Constructions	50 – 60
Mechanical equipment	33 – 40
Electro-technology	25 – 30
Equipment with short-term lifetime	10

For SHPP effectivity monitoring is usually the net present value method used and one of the most important approaches is small payback period of investments. That means elaboration of SHPP's construction and operation financial plan - cash flow. In principle it is balancing of single-shot investment costs and incomes during entire lifetime of the project. The incomes from an investment are taxed profit increases and depreciation increases. To costs belong financial expenses caused by loans. The result of the financial plan is a cumulative value at the end of every year. When this cumulative value equals zero, the investments are paid back. Objectivity of expenses and future incomes estimation is determining the quality and feasibility of the effectivity appraisal results (*Gresecke, Mosonyi, 1997).* Economic effectivity was and still is one of the major reasons for stagnation of SHPP development in Slovakia. Although the stagnation, the SHPP development moves slowly forward and the activities in this field are in last years rising. Payback period of such investment for financing from own sources of the investor or for low interest rate of loans (about 4%) ranges from 10 to 15 years (Dušička et. al. 2003). But the investment will several times pay back in following years, because of long lifetime period of SHPP (50 to 70 years) and low operation costs. For illustration are in tab. 3 (Dušička et. al. 2003) shown investment and operation costs per 1 kW of installed capacity in different types of SHPP. The values are informative and actual in 2002.

To achieve objectives of European agreements it was necessary for the Slovak government to support economics of SHPP. Such supporting legislative arrangements are involved in several laws.

According to *Energy act 656/2004* is electric power production from RSE in general economic interest and therefore has its transfer, distribution and supply to the system priority. Next it has the right to get certificates of energy origin or "green" certificates and does not need allowance for enterprising in SHPP power generation, if the capacity of SHPP is less than 5 MW.

Tab. 3 Informative overview of investment costs and average annual operation costs per 1 kW of installed capacity for different SHPP types

Type of SHPP	Investment costs per 1 kW of installed capacity (1000 Sk/1 kW)		Average annual operation costs per 1 kW of installed capacity (1000 Sk/1 kW)	
	max.	min.	max.	min.
Weir SHPP with new weir structure	133	53	-	0,4
Weir SHPP with existing weir structure	116	25	5,4	2,6
Non-pressure derivation SHPP	75	54	0,8	0,5
SHPP on water supply conduit	176	25	5,3	3,3
SHPP on scour sluice conduit	142	58	19	7

According to *Regulation act 658/2004* is the buy-out value of electricity produced in RSE regulated by definition of fixed prize. This prize is for SHPP for 2007 given by the edict no. 2/2006 according to conditions shown in tab. 4. When using governmental support or grants from European funds, the fixed prizes are decreasing according to the range of the support.

According to *Environmental impact assessment act 24/2006* are SHPP with capacity under 5 MW free of all assessment. SHPP with capacity from 5 up to 50 MW are obliged to examination processing.

According to *Income tax act 659/2004* are finances granted according to international funding contracts free of taxes.

Results and Conclusion

Lack of own resources is typical problem of many projects in Slovakia. The solution is properly selected sort of financing. It is the equity (capital) or long-term financing. The simplest and most important source of finances is equity co-financing (financing form own resources). It is required on every project. Banks, leasing companies or other sources of capital almost always require co-financing from own resources. The more risky for the financial institute the project is, the larger own capital share is required. Long-term financing is based on credit loans or leasing. In the past, as well as in the present is the credit loaning from banks limited, due to risks of the SHPP projects. When granted, the loans have the interest rates from 4,8% and payback period between 15 to 20 years (Dušička et. al. 2003).

The most lucrative financial support are grants, donations and advantageous loans. Such support increases the cash flow and so it decreases project risks and increases its attractiveness for other investors. When using finances from loans or support funds, precise timing of their use during the investment process to avoid possible delays during construction. Typical projection process with costs progress is shown in fig. 2.

Tab. 4 (Prizes are converted according to the exchange rates of NBS 1,- € = 33,48,- Sk at July 6, 2007)

Condition	Fixed prize (without VAT)
Source with installed capacity up to 5 MW, and given into operation before January 1st 2005	1950,- Sk/MWh (6 cent/kWh*)
Source with installed capacity up to 1 MW, and given into operation after January 1st 2005	2360,- Sk/MWh (7 cent/kWh*)
Source with installed capacity from 1 to 5 MW, and given into operation after January 1st 2005	2750,- Sk/MWh (8 cent/kWh*)
Increase of capacity and power production in a reconstructed facility after January 1st 2005	2460,- Sk/MWh (7,5 cent/kWh*)

In Strategy of higher utilization of RSE in Slovak Republic are proposed precautions, which should positively influence technical and economical assessment of SHPP and so increase their share in power production from RSE. The precautions are:

- simplification of administrative procedures for small hydropower plant construction permissions,
- including the hydropower utilization into basic urban portfolio and documentation (municipal plans of towns, zones, regions…),
- verification and review of equipment condition of SHPP out of service and propositions for return into operation or revitalization,
- elaboration of regional energetic conceptions, which will lead to regional development and information of broader public with possibilities of energetic utilization of concerned region (town, zone, region..),
- utitilization of hydropower potential at water supply conduits, where are appropriate conditions for it,
- focus the development conception especially on sufficient energetic utilization of existing water structures,
- planning of hydropower utilization and SHPP design with taking into account documentation for environmental protection and preservation of biologic diversity, whereby for SHPP design it is necessary to complexly assess all water structures on the entire range of the river and elaborate general water management plan, which will define quantity and location of SHPP for hydropower utilization of concerned river to avoid chaotic SHPP design and above all negative environmental impacts,
- locate designed SHPP at appropriate localities with sufficient head and discharge with respect to elements of regional system of ecological stability, so that their functionality and homogeneity is assured to a maximum level and stress factors affecting these elements are eliminated by systematic precautions,
- exclude the construction of hydropower plants from the regions classified as regions of European significance.

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Interaction processes of surface and ground water flow simulated by means of TRIWACO modelling system.

Tomáš Andrássy, Dana Baroková, Andrej Šoltész

Abstract

Properly defined interaction between surface and groundwater is a complicated process which requires the use of hydrodynamic and water-balance equations. Study of the interaction between surface and groundwater is of great importance in theoretical as well as in applied research. Quantitative assessment of the interaction can be performed using Cauchy-type boundary conditions with different resistances for discharge or recharge. Cauchy boundary condition is needed for proper representation of surface water alternatively loosing water through the bottom (high resistance) or gaining water mostly near the water surface (low resistance). Groundwater simulation package TRIWACO is a program which enables the representation of a Cauchy-type boundary condition with different resistances for discharge or recharge conditions presented in the paper.

Introduction

Properly defined interaction between surface and groundwater is a complicated process which requires the use of hydrodynamic and water-balance equations. Quantitative assessment of the interaction can be performed using Cauchy-type boundary conditions with different resistances for discharge or recharge. Cauchy boundary condition is needed to properly represent surface water alternatively loosing water through the bottom (high resistance) or gaining water mostly near the water surface (low resistance). Groundwater simulation package TRIWACO (Baroková, 2006; Pařílková, Ševčík, 2010, www.triwaco.com) is a program which enables the representation of a Cauchy-type boundary condition with different resistances for discharge or recharge conditions presented in the paper.

Materials and methods

The problem of the resistance of river bottom sediment layer (drainage and infiltration resistance) is closely connected with the interaction of surface and groundwater as well through a clogging river bed. Generally, the drainage or infiltration resistance of the river bed is dependent on hydraulic conductivity and the thickness of clogged layer. It is very complicated to determine the hydraulic conductivity and the thickness of the clogged layer separately (Mucha, Šestakov, 1987; Šlezingr et al., 2010). Mostly, the bottom layer resistance is a model parameter used as an estimative one. It is determined by calibration process.

Many natural processes and human activities are influenced by surface and groundwater interaction (Šebová, Velísková, 2011). For better understanding of interaction processes between surface and groundwater (Burger, 2010; Burger, Čelková, 2007; Burger, Čelková, 2009; Gomboš et al., 2011) it is necessary to know the relation between the water level in the river bed and groundwater level (GWL). Infiltration (percolation of surface water into groundwater) or drainage (groundwater flow from the aquifer into the river) is given by hydraulic gradient between the surface and groundwater. Distribution of river bed sediment permeability and thickness of sediment material is called clogging of the river bed (Velísková, Dulovičová, 2008), i.e. clogging means a certain degree of reduction of the water flow through the river bottom.

The problem of the interaction between the surface and groundwater flow is solvable only when boundary conditions as well as initial conditions (unsteady flow) are given. Three types of boundary conditions can in such a case appear (Šoltész, Baroková, 2010; Mucha, Šestakov, 1987)

- Dirichlet (stable) boundary condition. It determines on the part of the boundary Γ_1 directly the value of the searched function (piezometric head) h

$$h = h_0(x, y) \quad \text{on} \quad \Gamma_1 \qquad (1)$$

- Neumann (unstable) boundary condition. It determines on part of the boundary Γ_2 the derivation of the searched function in the direction of the external normal $\boldsymbol{n}(n_x, n_y)$

$$\boldsymbol{n}\left(\boldsymbol{k}\nabla_{xy} h\right) + q_0(x, y) = 0 \quad \text{on} \quad \Gamma_2, \qquad (2)$$

where q_0 is a specific discharge through defined part of the boundary. If the solved region Ω is anisotropic and anisotropy axes are parallel to coordinate axes the condition can be written as

$$k_x \frac{\partial h}{\partial x} n_x + k_y \frac{\partial h}{\partial y} n_y + q_0(x, y) = 0, \qquad (3)$$

where n_x and n_y are directional cosines to external normal line to the boundary part Γ_2.

- Cauchy (combined) boundary condition. It determines on part of the boundary Γ_3 the derivation of the searched function (piezometric head) depending on its value

$$\boldsymbol{n}\left(\boldsymbol{k}\nabla_{xy}h\right)=\alpha\left(h-h_0\right) \quad \text{on} \quad \Gamma_3, \qquad (4)$$

where $\alpha = k_0/b_0$ is the characteristics of the clogged layer, i.e. the ratio called by (Mucha, Šestakov, 1987) as induced bank infiltration, k_0 is the permeability of the clogged layer on the river bed bottom $\left(m \cdot s^{-1}\right)$ and b_0 is the thickness of the clogged layer on the river bed bottom (m). The reciprocal value of parameter α can be determined as the resistance of the layer $c_r = 1/\alpha$.

Modelling and practical solution of the interaction

Rivers and drainage channels are linear sources generally located in the upper aquifer. Putting them into a numerical groundwater modelling system mostly they are substituted by sink/source nodal points defining the water level course. Similarly as in previous text was mentioned the recharge into the river can be defined in two ways:

- by means of water level in the river and the water flow will be calculated,
- water flow (infiltration, drainage) is given and subsequently the water level (piezometric head) in river nodes will be calculated.

For each river node the inflow value is calculated according to the relation:

$$Q_r = A_r \frac{\left(h_r - h\right)}{c_r}, \qquad (5)$$

where

Q_r is infiltration from (or drainage to) river node of the mesh $\left(m^3 s^{-1}\right)$,

A_r - area belonging to the river node $\left(m^2\right)$ given by conjunction of the wetted perimeter and relevant length between two river nodes.

h - groundwater level $(m\ a.\ s.\ l.)$ (unknown value –calculated using modelling),

h_r - water level in the surface flow $(m\ a.\ s.\ l.)$,

c_r - infiltration ($c_r = CI$) or drainage($c_r = CD$) resistance of the river bed bottom is determined in (s) or in (day).

Values of the resistance c_r differ in the nature depending on the relation between the surface water level and groundwater level. In case of infiltration $h_r > h$ and for the drainage $h_r < h$. Numerical models mostly offer the possibility to define different values of the resistance for infiltration and drainage processes (CI and CD) (Zaadnoordijk, 2009; Rushton, Zaadnoordijk, 2010). Determination of river bed (channel) bottom resistance is the matter of model calibration. Investigation of k_0 and b_0 parameters separately is very complicated. There are no relevant river bed resistance values in the available literature recommended for the modelling purposes.

Results and discussion

The groundwater modelling system TRIWACO (www.triwaco.com) has been used for solving interaction processes of surface and groundwater flow according to the proposed methodology. The chosen territory for the modelling research was a locality where a water structure with a small hydropower plant is assumed to be built in the vicinity of the Hron River – the tributary river of the Danube River.

All necessary hydrological and meteorological, hydro-geological and morphological data were available for definition of a solved locality. Missing data have been accomplished by geodetic measurements. As boundary conditions the surface water levels in the Hron River as well as water levels in adjacent boreholes of Slovak hydro-meteorological institute have been taken into account, i.e. Dirichlet boundary condition has been used for the groundwater numerical modelling.

2-D numerical modelling by means of finite element method has been used for determination of the groundwater level course in steady as well as unsteady conditions. Piezometric head contour map in Fig. 1 is one of the output results of the groundwater level numerical modelling. In this figure is also shown subject area with boreholes and sections where the measurement was carried out. The groundwater modelling process was supplemented by simulation for several CD and CI values. The CD (CI) values were changing from 0.02 d, 0.2 d, 2d and 20 days (Fig. 2 and 3). The general finding was that if the CD or CI value was higher the groundwater level changes were smaller and slower.

On base of given outputs the modelling process has been taken precisely for a particular chronological interval from March 2005 to June 2005. For this time period consequent calibration has been performed for more precise comparison of modelled and measured groundwater level values. Results of such a calibration are illustrated in the Fig. 4.

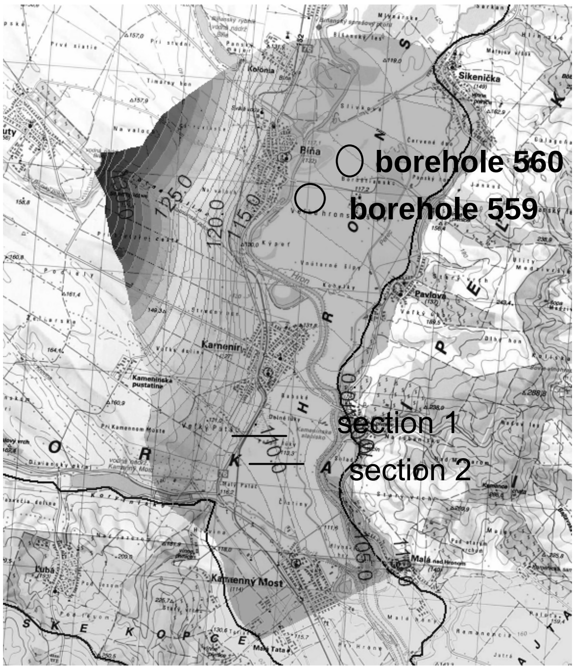

Fig. 1 Piezometric head isolines course – TRIWACO modelling system output (Andrássy, 2010).

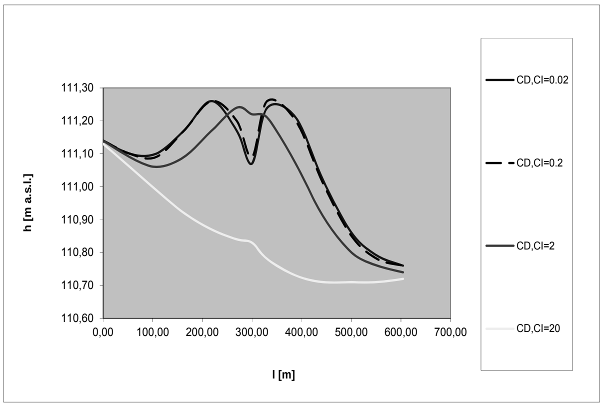

Fig. 2 GWL regime course in section 1, with different CD/CI

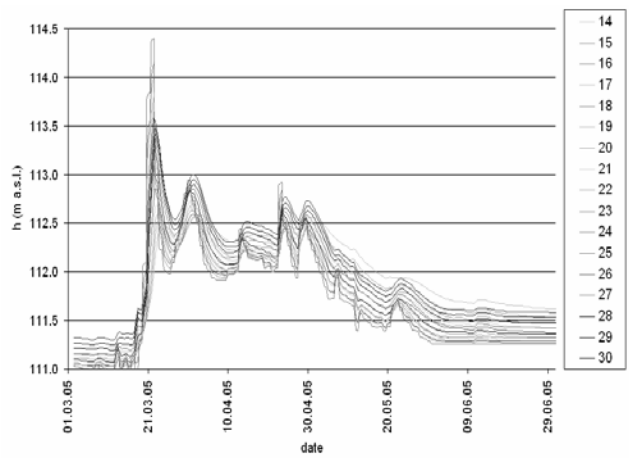

Fig. 3 GWL course in the points of the section 1, CD=CI=0.02 day

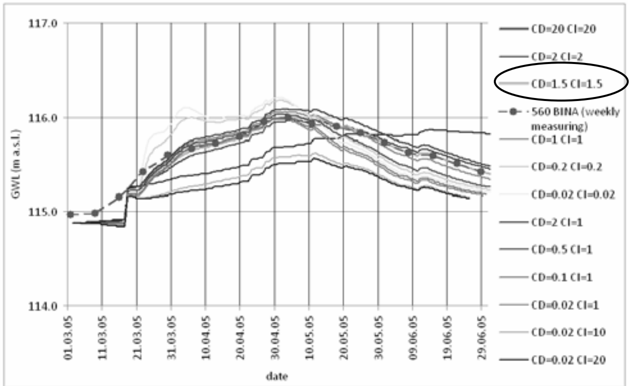

Fig. 4 Comparison of measured and modelled groundwater level in the borehole 560.

Conclusion

An enhanced numerical modelling of surface and groundwater interaction has been analysed for illustration of the influence of the river bed bottom resistance on groundwater level course. The proposed numerical analysis compared with measured groundwater level data is a good basis for obtaining an overview about the problem of clogged layer in the bottom of the river bed. For more precise investigation a coupling of detailed laboratory research (Mati et al., 2011, Velísková, Dulovičová, 2008) and numerical modelling would be the correct direction of the future research.

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Drought regionalization by using geograpical information systems

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Abstract
The paper presents a methodology for evaluating hydrological drought based on statistical analysis of observed minimal flows at selected 66 gauging stations in Eastern Slovakia in time period 1975-2006 and the grafical reprezentation of obtained results from this analysis. The existence of a trend in a hydrological time series is detected by statistical non-parametric Mann-Kendall test. Aim of this work is to determine the vulnerability of the territory of hydrological drought, and to classify the degree of its risk in each month. Maps with classification of drought risk were created in ArcView GIS. These maps present regionalization of hydrological droughts and they are important in the design of organizational and functional measures to mitigate droughts effects.
Key words: hydrological drought, statistical tests, trend analysis, minimal stream flows

Introduction

A natural hazard is a threat of a naturally occurring event that will have a negative effect on people or the environment. Drought is a kind of natural hazard which is further aggravated by growing water demand. Droughts rank first among all natural hazards when measured in terms of the number of people affected (Wilhite, 2000).
In principle, the concept of drought is a deficiency of water in the atmosphere, soil and plants. Depending on where it shows a lack of water by the World Meteorological Organization - WMO (2004) classifies four basic types of drought, including: meteorological, hydrological, agricultural and socio-economic droughts (Mishra et al., 2010). Hydrological drought rise with existence of occurrence of no- precipitation period coupled with extreme temperatures. This type of drought is defined by long-term decrease in levels of surface water bodies (e.g. rivers, lakes, reservoirs and other) and drops in groundwater levels (Demeterová, 2008).
The article presents a methodology for prediction of hydrological drought based on statistical testing of minimum monthly stream flows with nonparametric statistical test. The main objective is to identify minimal stream flow trends in the selected 66-five gauging stations in Eastern Slovakia in the time interval 1975-2006. The Mann-Kendall nonparametric test has been used to detect trends in hydrological time series. Values of statistically significant trends formed the basis for the processing of spatial analysis of hydrological drought risk. It was created a graphical representation of hydrological drought risk in each months of year for the whole territory of eastern Slovakia by using ArcView GIS 3.2.

Materials and methods

Study area, as was mentioned, is situated at eastern part of Slovakia (Figure 1). In this territory 66 gauging stations are located. Evaluated stations are divided at stations affected by human activity and without human influence. The affected hydrometric stations are considered as a station where the hydrological regime altered the flow by interference of human activities (by water works, by excessive water abstraction, etc.).
The first step in the evaluation was to obtain values of the minimal monthly flow for selected hydrometric stations. Hydrological data were provided by the Slovak Hydrometeorological Institute, Regional Centre Košice. Complete methodology at prediction of hydrological drought risk is as follows:

1. Creating a database.
2. Modification of existing files with respect to further processing.
3. Testing the statistical files by Mann-Kendeall test.
4. Size of the statististically significant trends in low stream folows are identified by directives of the trend lines.
5. Graphical representation of statistical analysis results.

Basic databases were created by collecting the values of minimal stream flows to the statistical files. One set of values is for one gauging station in period of years 1975-2006.
Modification of existing files was made by calculation of directives according (1). This relation was used for each month of hydrological year and in each gauging station.
For $x_2 \neq x_1$ applies (Santos et al., 2007), (Dreveňák et al., 1980), (Dub, 1969):

$$K = \mathrm{tg}\varphi = D_{ij} = (y_j - y_i)/(x_j - x_i) \quad \text{for } i > j \qquad (1)$$

Where y_i - is the value of the minimum monthly stream flow in year x_i.
Modification (1) was necessary because the period of monitoring was short, had only 32-years interval and in this case it was not possible to used a Mann-Kendall test. According to (WMO, 2008) a correct the course of the Mann-Kendall test is needed more than 40 data. For statistical tests were used directives D_{ij} as random variables Y with a values q_i.

Mann-Kendall test is used as a rule by which is possible to decide whether to tested hypothesis H_0 is rejected or not rejected (Šťavina, 2010). The test is based on the statistical value S. Comparing any two values q_i, q_j, (i > j) a random variable Y can be determined if $q_i > q_j$ and $q_i < q_j$. Number of pairs of the first type is denoted as P and the number of pairs of the second type as M. Then S is defined as (Onoz et al., 2003):

$$S = P - M \qquad (2)$$

Mann-Kendall following statistics based on standard normal distribution (Z), where:

$$Z = (S - 1)/\sigma_s 1/2 \quad \text{if } S > 0$$
$$Z = 0 \quad \text{if } S = 0$$
$$Z = (S + 1)/\sigma_s 1/2 \quad \text{if } S < 0 \qquad (3)$$

Where the variance is defined as:

$$\sigma_s = n\,(n - 1).(2n + 5)\,/18 \qquad (4)$$

and n is a size of sample.

Hypothesis H_0 - no trend is accepted if the following applies: $Z < Z_{\alpha/2}$ or refused, if applies, that $Z > Z_{\alpha/2}$, then is accepted H_1- exist a statistically significant trend. Significance level is chosen as $\alpha = 0.05$ and $Z_{\alpha/2}$ is a value for normal distribution, in this case $Z_{\alpha/2} = 1.95996$. The sign of Z statistic indicates whether the trend is growing (Z > 0) or decreasing (Z < 0). Estimate the size of the trends obtained can not be determined with this test (Onoz et al, 2003; Santos et al., 2007), and therefore the size of the trends in the stream flow were calculated using relation (1).

All mathematical relations from (1) to (4) were programmed in Visual Basic in Microsoft Excel 2003. The results of statistical analyses were recorded in the table in MS Excel. To each gauging station was assigned a trend of minimum flows in individual months. Using ArcView GIS 3.2 was created 12 thematic maps (Fig. 2, 3) from geographical map of eastern Slovakia (Fig. 1) and calculated sizes of significant trends in individual stations.

Map of gauging stations (Fig. 1) was created from the basic geographical map of eastern Slovakia in ArcView GIS 3.2 In this map positions of monitored stations were identified using Editor. Stations were edited according to their identification numbers. On that basis new layer was created with name "gauging stations". Other important layers as rivers, regions, flat seats have already been shown on the map (Fig. 1). The results of analyses from the table in MS Excel were exported to Fig. 1 in ArcView GIS 3.2 by using the icon Add data. File of significant trends were linked with a layer of "gauging station" using their identification numbers.

Maps of hydrological drought risk classification (Fig. 2, 3) were created by spatial interpolation sizes of trends in individual months. Levels of risk of hydrological drought are divided to 4 intervals incurred by interpolation of raster.

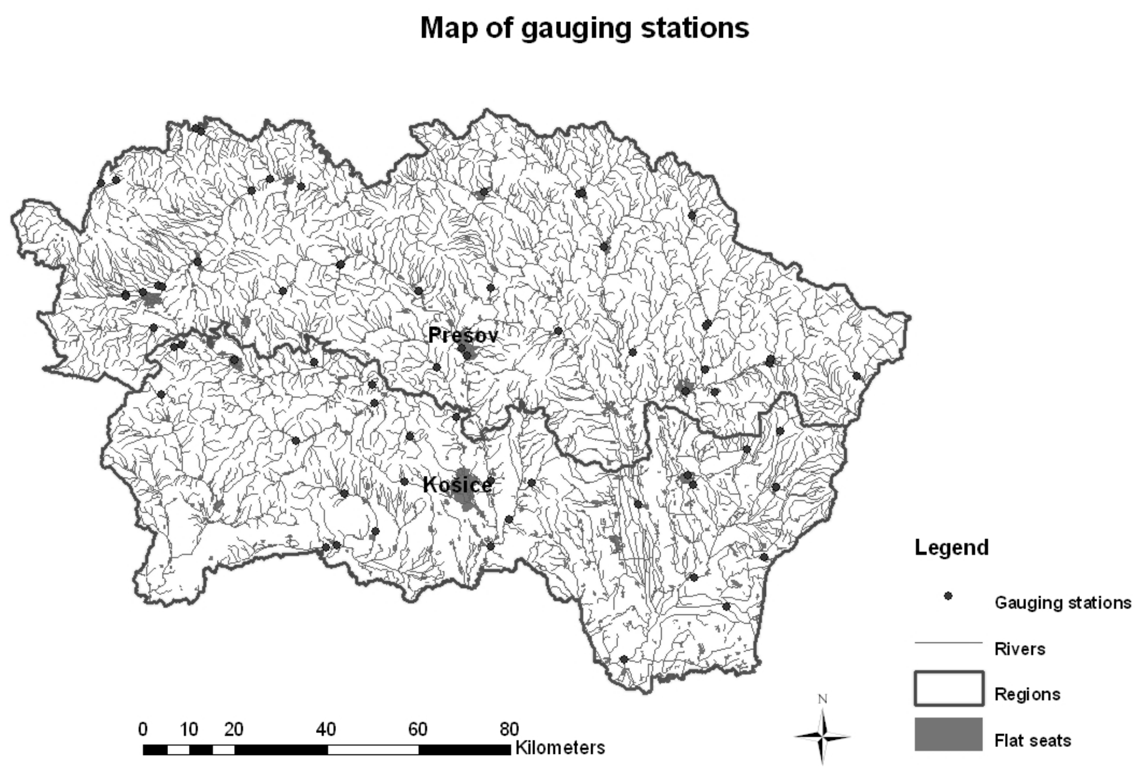

Fig. 1 A spatial distribution of gauging stations in Eastern Slovakia

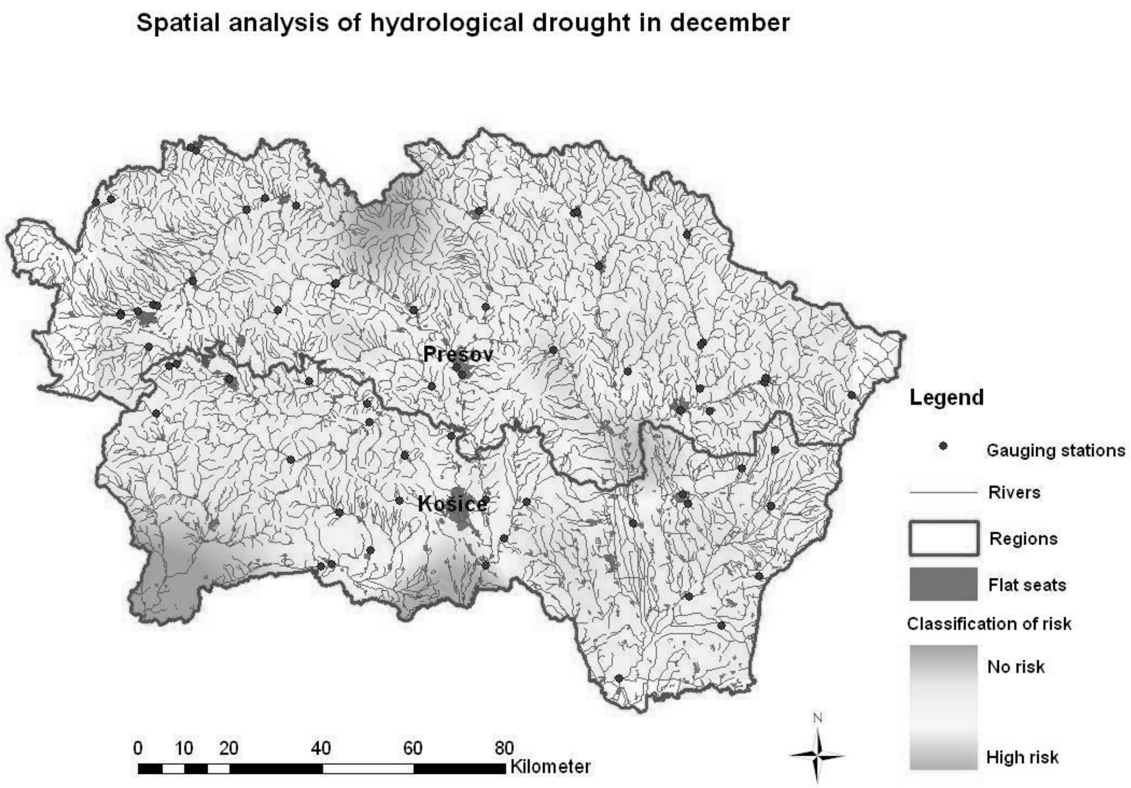

Fig. 2 Cartogram of hydrological drought risk classification in Eastern Slovakia in December

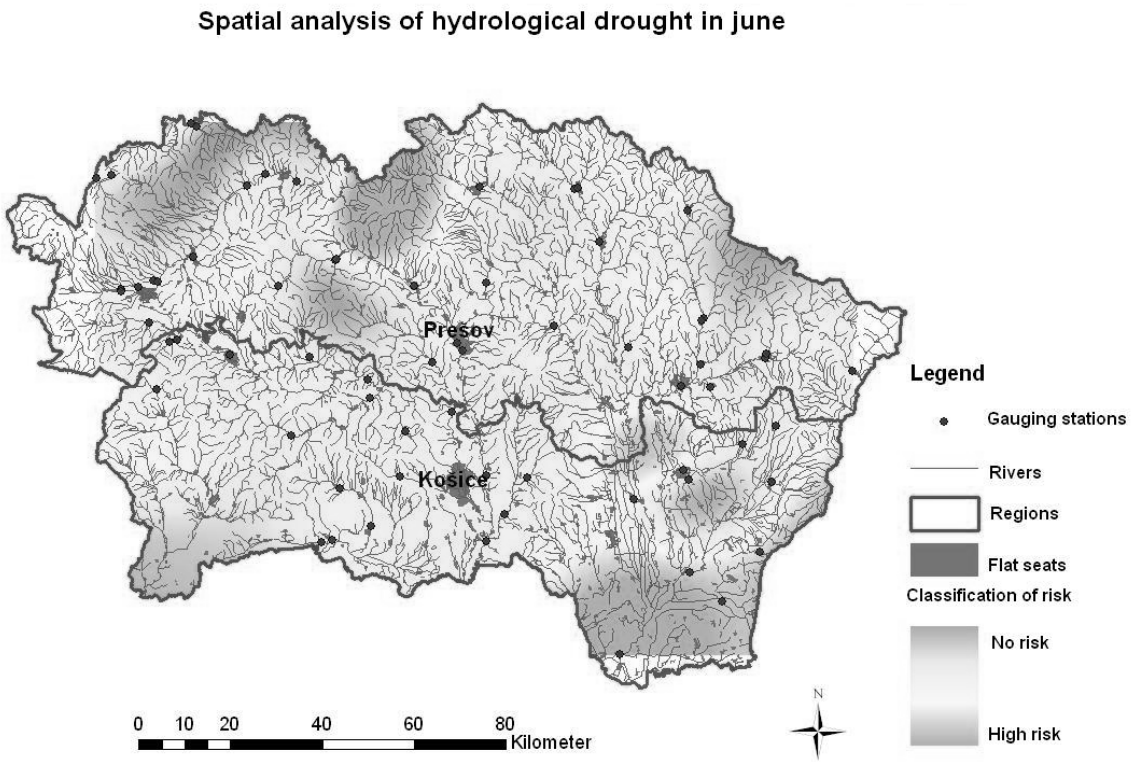

Fig. 3 Cartogram of hydrological drought risk classification in Eastern Slovakia in June

Results and Discussion

Graphic evaluation of the statistical analysis of the monthly stream flow series at 66 gauging stations in river basins namely Poprad, Hornad, Bodva and Bodrog in the eastern Slovakia in 32 years time period is recorded in 12 maps. Map of the hydrological drought risk classification (for example Fig. 2 and 3) contains a schematic network of evaluated stations, and also the classification of hydrological drought which has four levels: high, medium, low and no risk of hydrological drought.

In the river basin: Poprad is expected high and medium probability of hydrological drought in December, March, June and October. From November to April is dominated high risk of drought in the river basin Hornad. River basin Bodva is one area that is most vulnerable to hydrological drought, and its incidence is expected in each month and almost all monitored stations. In the southern part of the river basin Bodrog is expected a decreasing trends of stream flows in November, January and February. The Bodrog has an optimal regime of flows, but in June, July, October is the highest probability of hydrological drought occurrence.

In Eastern Slovakia, in general decreasing trends of the flows is dominated mainly during the winter season (December, January, February) and in summer (June, July).

Conclusion

ArcView GIS is the simplest module of ArcGIS. Using the analytical aspect of ArcView GIS 3.2 and mathematical-statistical module Visual Basic in Microsoft Excel 2003 was created risk modeling of hydrological drought in eastern Slovakia. Generated maps predict the vulnerability of drought in individual months. We can determine the exact area and degree of vulnerability drought‘s area from maps.

Presented method can be used in the risk analysis of hydrological drought in individual regions and in complex analysis of drought too. In the complex vulnerability assessment of territory owing to drought is essential to take into account also the parameters as temperature, precipitation and groundwater levels.

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Specialities by the Whitewater Course Design

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Abstract

There are only two professional whitewater courses (Liptovský Mikuláš and Čunovo) in Slovakia with stationary obstacles. Article is presenting specialities of the designed whitewater courses, which are planned in different places in Slovakia (Trenčianske Biskupice – next to the weir, Košice – directly in the river bed of the Hornád River and Červený Kláštor – at the Dunajec River in old riverbed).

Key words:

Basic Parameters, Design Specialities, Slovak Whitewater Courses

Introduction

A whitewater course is an artificial channel, in which obstacles are placed (stationary or movable) to achieve suitable flow conditions for wild water sports (slalom, rafting, freestyle, etc.) and to create areas for the gate attachments. The design of such a construction is very difficult as well as its realization and operation. Artificial whitewater course serves for the professional sport, recreation and hobbies.

The first whitewater slalom race took place in 1933 on the Aar River in Switzerland, but on the natural river. History of the modern whitewater courses started in Augsburg (Germany) in 1972, where the first artificial whitewater course on the so called Eiskanal was created for the slalom canoeing in the Olympic Games in Munich. Its parameters are suitable for the international competitions and championships until today. The next Olympic whitewater course was built in 1992 for the Olympic Games in Barcelona, when it was included back into the olympic disciplines after a 20 year break (Tab. 1).

The original stationary obstacles were replaced by the movable obstacles, which enable variability of the course and its difficulty as well as attractiveness for a wide range of water sports. The whitewater courses or their sections can be divided into competitive and training sections, according to achieved parameters (Čubanová, Rumann, 2009).

All Olympic whitewater slalom competitions have taken place in artificial courses. Now whitewater courses exist in 16 countries on seven continents.

The unique of the whitewater courses is obvious from the description and the parameters overview of the existing Slovak courses (Tab. 2).

Tab. 1 World's whitewater courses overview (Čubanová, Rumann, 2009)

City, State, Year	l (m)	H (m)	Q ($m^3.s^{-1}$)	b (m)	y (m)	i_o (%)
Augsburg, Germany, 1972	305	3.2	10	6 – 15		
Dickerson, USA, 1991	274.32		5.7 – 17	12.19		
Barcelona, Spain, 1992	340 (300)	6.5	10 (12)	5 – 17		
Atlanta, USA, 1996	600	12	25 – 70	30		
Sydney Australia, 2000	320	5.5	14	8 – 14	0.8–1.2	
Athens Greece, 2004	270	6	17.5		1.9	1 - 2
Zoetermeer, Netherlands, 2006	300	5	4.25 – 20.25	13 – 20	1.6	
Peking, China, 2008	280	5.88	17.5	10	1.2	2.1

The first artificial whitewater course in Slovakia (The Ondrej Cibák´s water slalom complex) has been put into the operation in 1978 in Liptovský Mikuláš (Fig. 1). This course is situated on the left riverside of the Váh River. The course is created by a conduit channel, which ends in the starting basin with total length of 680 m. From the basin two separate courses rise, which unite approximately in the middle into one course and then continue back to the Váh River. The left course with easier difficulty is called the „Váh" and the right one, which is shorter and more difficult, is called the „Orava". The courses were artificially excavated but the round stones facing of the banks give to the channel river bed a natural look. The whole complex of the whitewater course is supplied by the discharge from the Váh River, thus the water levels in the course depends on the water levels in the Váh River. The best flow conditions are in the months May and June, but the operational period of the complex is since the April until the October (ME vo vodnom slalome, 2007).

The other whitewater course in Slovakia is situated at the Čunovo water structure and it was built as a part of the Gabčíkovo water structure (Fig. 1). The complex is used for competitions and its closed circle consists of these parts (Technické údaje areálu vodných športov Čunovo):

- the 20 m long and 40 m wide starting basin, with the depth of approximately 1,5 m. The left or the right courses are supplied with water from the basin according to requirements. In the basin ends also the return channel.

- two competition courses – 2 channels, with combination possibilities, create five course variants with the difficulty for beginners as well as the best sportsmen. The movable obstacles are placed in the course river bed too. They enable to change configuration and difficulty of the course.

Tab. 2 Slovak whitewater courses

River / City	Váh / Lipt. Mikuláš		Dunaj / Čunovo		Váh / Žilina
Description	course no. 1	course no. 2	right course	left course	placed in biocoridor
Length *L* (m)	450	350	460	356	450
Gradient *H* (m)	7.5		6.6		4.76 – 8.4
Discharge *Q* ($m^3.s^{-1}$)	12 – 15		7 – 12	7 – 22	6 – 8
Width *b* (m)					5 – 8.3
Depth *y* (m)	0.5 - 1.5				
Velocity *v* ($m.s^{-1}$)					0.8 – 1.5

- the boat lift enables the sport boat transport from the end of the course back to the starting basin. So the sportsmen can reach the start without getting off the boat after finishing of the course.
- the return channel is 255 m long, and about 14 m wide. The channel is easily accessible from the dock. The return channel is suitable for the preparation of the sportsmen before the competition and also for the training of the beginners and children.

The next whitewater course is a recently established whitewater course at the biocorridor of the Žilina water structure, which is used only for the training purposes. It is situated in the lower part of the biocorridor, which leads into the Váh River under the water structure (Fig. 1). It is operational since the April until the October (7 months), 5 days per week, 4 ours per day.

Fig. 1 Whitewater courses in Liptovský Mikuláš, at the Gabčíkovo and Žilina water structures

Material and methods

From the description of the existing whitewater courses is evident, that every project is utilizing different side attributes and possibilities. Of course whitewater course, which was built special for the sport purposes, has better parameters like course, which is just established into the existed river bed.

For achieving the best parameters of the course, it is necessary to follow some recommendations. The whitewater course design parameters take into account the character of the course (race or training), the character of the water sports performed on the course (slalom, rafting, freestyle), the sportsmen abilities (professional, recreational) as well as the safety regulations, correct placement of obstacles, local widenings and drop ditches. Therefore, for the whitewater course design it is necessary to cooperate with experienced watermen, with the knowledge of the wild water sports rules.

Recommendations for design parameters of whitewater courses (Snel, 1999):

- course length – minimum 300 m, because of international competitions and championships,
- cross section – simple shaped (trapezoid, U – shape),
- profile width – optimum width should be 10 - 12 m, whereby it must not be less than 8 m,
- water depth – minimum 0.4 m, this dimension secures safe swimming, average depth should be approximately from 0.75 to 0.9 m, what serves for safe Eskimo roll, for freestyle kayak the depth should be approximately 1.5 m,
- flow velocity – approximately 2 $m.s^{-1}$, for beginners around 1.4 – 1.7 $m.s^{-1}$, whereby some areas with higher velocity can occur,
- roughness – channel surface should be the smoothest considering the possibility of ships damaging, suitable material is concrete with the smooth surface arrangement, to the concrete will be embedded or stationary obstacles or platforms with openings for movable obstacles.

International Canoe Federation (ICF) presents following Olympic Standard Projects requirements for the river bed of the whitewater course (International Canoe Federation: Beijing):

- length l = 250 m,
- width b = 7 m,
- depth y = 1.2 m,
- discharge Q = 14 $m^3.s^{-1}$,
- gradient H = 5 m.

Well designed whitewater course must be suitable for the wide range of the water sports, it means for several types of boats, which are

characterized by their length and minimum depth for their safety navigation (Snel, 1999):
- hydro speed: l = 1 m, y = 0.3 m,
- raft: l = 3.5 – 5 m, y = 0.4 m,
- kayak: l = 2.7 – 3.3 m, y = 0.3 m,
- freestyle kayak: l = 1.8 – 2.2 m, y = 0.3 m,
- slalom kayak K1: l = 4 m, y = 0.3 m,
- slalom canoe C2: l = 4.5 m, y = 0.4 m.

Whitewater course design is divided into these parts:
- cross section – its dimensions are depended on local conditions and the course purposes (top competitions, junior competitions, trainings, ...),
- longitudinal section – according to the area topography (most courses are placed in or near the river, because of needed discharge, in some cases of Olympic whitewater courses is water even pumped),
- design and placement of the obstacles – they are used experiences of the top sportsmen (different shapes and position of the obstacles, sudden restrictions and widening, ditches), by using of the fixed obstacles variability of the course parameters is not secure, by the movable obstacles bigger investments are required, but unlimited variability and course difficulty could be achieved,
- design optimization – course parameters verification (depth, velocity), perhaps some obstacles rearrangement, till appropriate design is achieved.

Results and Discussion

The popularity of wild water sports (paddle sports) in Slovakia aroused from the success of our sportsmen at the Olympic games, World championship, etc. Therefore some municipal regions decided to build whitewater course areas in their regions.

The first course planned in Trenčianske Biskupice will be placed on the left bank of the Váh River next to the weir. The left bank's inundation area provides sufficient space for a whitewater course. The course is planned to consist of two sections, the upper section is the race section with the length of 325 m, the head of 5.5 m, the width of 7.5 m and the average depth of 1.0 m. The lower stage is planned as a training course with the length of 300 m, the head of 3.65 m, the width of 8 m and the average depth of 1.0 m, this stage includes also two play spots for the freestyle training. Both sections should be supplied with water from the reservoir above the weir, the maximum discharge is 10 $m^3.s^{-1}$. The existing weir has on the left bank also technical fish pass, but it is old fashioned and it does not provide suitable conditions for the existing fish fauna (small depths, big velocities). Therefore the course is planned to fulfill also the function of a fish pass for the weir. In the design of the cross section were taken into account dimensions, which are appropriate for the sport boats as well as for ichthyofauna. The combination of the trapezoidal cross section with asymmetrical triangle in the river bed bottom seems like a suitable compromise. Triangle cross section will be in operate yearly like a fish pass, which will be doped with lower discharge and by the 10 $m^3.s^{-1}$ discharge the whole designed cross section would be filled and will serve for the white water sports. Result of this project should have been yearly operational fish pass and also white water course operated during the trainings and competitions. In the channel movable obstacles are planned, which will provide many combinations of the variability and difficulty of the course, but also secure possibility for fish fauna migration (Andrássy, 2008).

The second is the whitewater course complex in Košice at the Hornád River. It consists of three sections. The first stage is a course directly in the river bed of the Hornád River with the length of 200 m, the head of 1.48 m, the width of 7 m and the average depth of 0.7 m and planned discharge of 8 $m^3.s^{-1}$. The second stage is a freestyle play spot above the first stage in the Hornád river bed. The third stage is the course in the new fish pass of the reconstructed Ťahanovce Weir. The courses should be used for trainings and junior competitions. The white water course inside the Hornád river bed was designed till now. The first were considered existing conditions in the river bed, because protection of the Košice urban area must be kept on the discharge Q_{100}. Present state is not convenient, contiguous dikes must be increased (built dikes were designed for Q_{20}), therefore the planned project of the whitewater course could be approved. The course river bed was designed according to the sketch of the experienced sportsman Mr. Dojčan (Fig. 2).

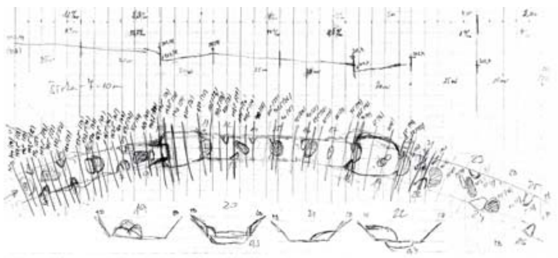

Fig. 2 Sketch of the whitewater course

From his scheme the cross sections were digitized and embedded into to level following current measurement of the Hornád river bed.

Than the water level for the designed white water course was simulated to find the conditions for the water sports. Afterwards the Hornád cross sections were covered with the whitewater course cross sections and water level regimes for several discharges were simulated. Calculated water levels (for Hornád river bed and for Hornád river bed with the white water course) were compared to determine influence of the whitewater course on the water level regime of the Hornád River. Whitewater course influence on the water level regime is minimal (depth increase maximum about 35 cm) and will be incorporate into the flood protection of the Košice. For the creation of the course river bed nearly in river bed middle was designed sheet pile wall with length of 450 m. Water supply will be secured by the low fixed weirs, which will divide the discharge into the course and to the Hornád river bed (Čubanová, 2009). White water course operation will be influenced by the flow regime in the Hornád River.

The third course is planned in Červený Kláštor in the old river bed of the Dunajec River. The course consists of lateral intake (joint (inverted siphon) at the Dunajec right bank, under the Lipník stream (2 steel pipes, D = 1500 mm)), starting channel (parameters: length - l = 360 m, longitudinal slope - i_o = 0,5 ‰, width - b = 7 – 12 m, bank slope - 1:m = 1:1,75 (right bank), 1:2 (left bank)) and the course itself with the length of 200 m, the head of 1.2 m, longitudinal slope of 6 ‰, the width of 7 m and the average depth of 0.7 m, bank slope of 1:1,75 (right bank), 1:2 (left bank) and planned discharge of 5 - 8 $m^3.s^{-1}$ (Čubanová, Rumann, 2009). The obstacles placement and parameters of the course are similar to the Hornád white water course. This whitewater course is planned for recreational activities and junior competitions. Informative budget is about 2.3 million € (Dušička a kol., 2008). Discharges of the Dunajec River are influenced by the water structure Czorsztyn-Niedzica (Poland) and continual measurements are missing. White water course building should be included into to operational manual of the water structure.

Conclusion

Every whitewater course design is unique, because the particular design has to be adjusted to the particular conditions of the course's locality. From the described planned whitewater courses are obvious different conditions and specialities, which have to be taken into account:

- Trenčianske Biskupice – requirements of the two purposes in the artificial channel (white water course and fish pass), therefore the physical research is strongly recommended, water demand for water sports could be in the conflict with the operation of the neighboring small hydropower plant (near the weir), except that in the inundation is also planned road bridge pier (the route of the white water course will be influenced by the road bridge),
- Košice – the white water course inside the Hornád River can not influenced the flood protection of the urban area, planned course must be fixed to the existing dike heel, also configuration of the whole white water stadium (dedans, changerooms, toilets, access road, paths) must be designed with the harmony of the existing environment, except that the course is located between two bridges (road and railway) and the railway safety zone must be kept, the operation of the course is hardly influence by the Hornád flow regime,
- Červený Kláštor – discharge for the whitewater course is influenced by the polish water structure (period of the course operation should be included into the water structure operational manual), the problem could be location of the course in the Pieniny National Park (troubles with the building permit), except that Dunajec River is border river and all projects must be approved by the transboundary waters committee.

It is important to take into account the race course parameters defined by the ICF and design new courses according them. The design and placement of the course elements such as the obstacles, basins, etc. should be consulted with experienced wild water sportsmen, who can give valuable advice and opinions for the design. The design should be verified on mathematical and physical models, so the hydraulics of the course will fulfill the requirements of the sportsmen and other users of the course.

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Hydrological and hydrogeological conditions for rainwater infiltration and percolation

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Abstract
Closed continuous process of water circulation in the world, is the basic condition for balanced state of water in the nature. An important prerequisite for percolation and infiltration is hydro-geological survey, which is often restricted to a minimum or only to the reading data from maps and hydrological records. To tackle rainfall infiltration from surface runoff into the soil, there should be a new standard / technical advice, which would take care of setting the conditions of rainwater infiltration. Infiltration of rainwater is not addressed in separate standard or regulation in Slovak republic.
Keywords: rainwater, infiltration, percolation, hydrology conditions, hydrogeology

Introduction
Infiltration can occur naturally following precipitation, or can be induced artificially through structural modifications in the ground surface. Some water that infiltrates will remain in the soil layer, where it will gradually move vertically and horizontally through the soil and subsurface material. Eventually, it might enter a stream by seepage into the stream bank. Some of the water may continue to move deeper (percolate), recharging the local groundwater aquifer. A dry soil has a defined capacity for infiltrating water. The capacity can be expressed as a depth of water that can be infiltrated per unit time, such as inches per hour. If rainfall supplies water at a rate that is greater than the infiltration capacity, water will infiltrate at the capacity rate, with the excess either being ponded, moved as surface runoff, or evaporated. If rainfall supplies water at a rate less than the infiltration capacity, all of the incoming water volume will infiltrate. In both cases, as water infiltrates into the soil, the capacity to infiltrate more water decreases and approaches a minimum capacity. When the supply rate is equal to or greater than the capacity to infiltrate, the minimum capacity will be approached more quickly than when the supply rate is much less than the infiltration capacity. The emerging goal of urban rain water management is to achieve effective control of pollutants in rain water runoff and reduce the volume and rate of runoff to control downstream impacts from flooding and stream-channel erosion (ISM, 2008).
Hydrological situation
Year 1995
The map in Figure 1 presents the water withdrawals in different river basins, the bottom map the water availability (sum of annual runoff plus shallow groundwater recharge). These calculations are representative of 1995 conditions, assuming that climate conditions in 1995 were close to climate normal conditions. Data in both maps are given in mm/annually so that the maps can be visually compared. Note that the highest density of water use occurs as expected in the high population areas of Japan, Coastal China, India, Pakistan, Central Europe, and the east and west coasts of North America. In the water availability map, the rainy parts of the world clearly stand out. Also, a visual comparison of both maps shows that in some areas, such as Southern Asia and in the Aral Sea Basin, water availability is relatively low and withdrawals are relatively high, indicating potentially high stress on water resources.

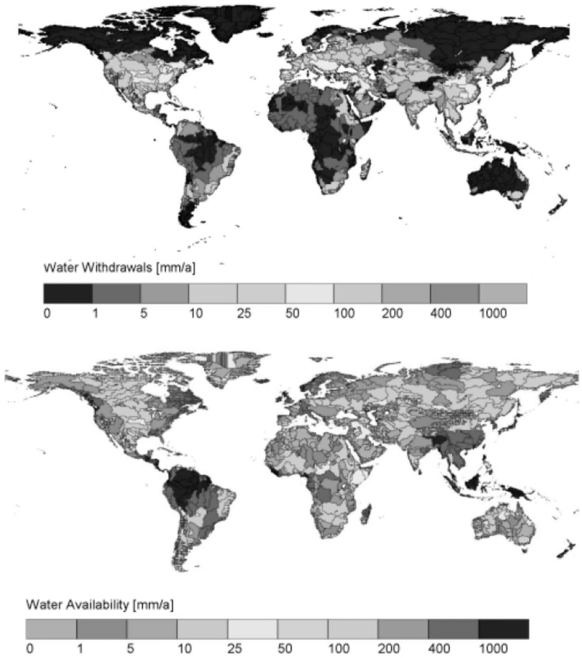

Fig. 1 The world today (1995): Withdrawals (top map), Water availability (bottom map)

To compare the level of water scarcity in different river basins we need a measure that incorporates the data in Figure 1. One transparent measure is the “criticality ratio” (CR) which is the ratio of average annual water withdrawals to water availability. The higher the criticality ratio, the more stress placed on available water resources by water use. In principle, the higher the value of CR, the more intensively the waters in a river basin are used, and the lower the water quality for downstream users. Hence, at high values of CR, the usage of water by downstream users can be impaired. Also, the higher the CR, the greater the chance of absolute water shortages during low flow periods.

At this time, there is no objective basis for selecting a threshold of CR between low and high stress. However, such thresholds are needed for global and regional assessments of water resources and therefore they should be given attention by researchers. In the meantime, for this paper we use the commonly used set of thresholds shown at the bottom of Figure 2. In this scheme, criticality ratios between 0.4 and 0.8 indicate “high water stress”, and greater than 0.8 “very high water stress“. One can argue that the risk of absolute water shortages during low flow periods will be especially high if the average annual CR value is at or above 0.4.

Figure 2 shows the criticality ratio for 1995. As expected, most of the world’s desert areas are in the severe water stress category (i.e. CR > 0.4).

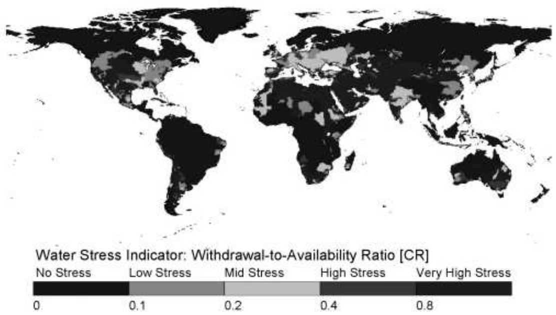

Fig. 2 The world today (1995): Water Stress (note that the ‘high stress’ and ‘very high stress’ categories are labelled as ‘severe stress’ category when referred to jointly)

Also in the high or very high stress categories are some of the large basins of China (including the Yellow River), the Krishna in India, much of Central Asia, coastal areas in Latin America, parts of Europe, and much of the Western United States. The percentage of area in the severe water stress category varies from 5% (Central Africa) to 88% (Middle East). Globally, 25% if the earth’s terrestrial surface (excluding Greenland and the Antarctica) is under severe water stress. Approximately 2.1 billion people live in river basins where the stress on water resources is severe, and nearly half of these people live in Southern Asia and China (Acamo et al., 2000).

Year 2000

Over 1.4 billion people live in river basins where high water-stress levels threaten the environment, illustrating that we are withdrawing too much water from our rivers, streams and lakes. The 'global environment water scarcity map' is the first effort to look at the requirements of freshwater ecosystems on a global scale. It shows where and to what extent water diversions impact on freshwater ecosystems downstream, and enables researchers to look at the trade-offs between agriculture and the environment.

Figure 3 shows environmental water scarcity in year 2000.

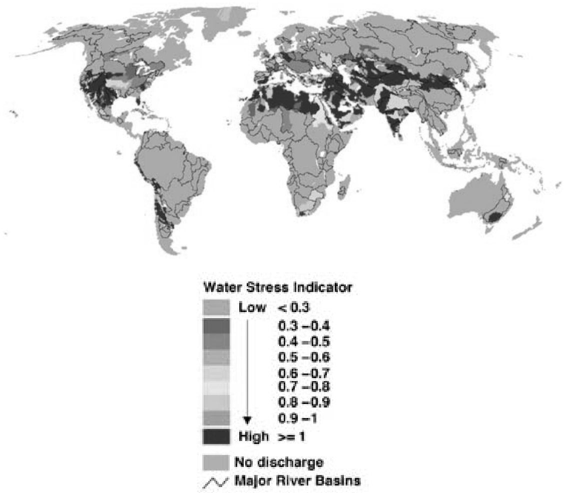

Fig. 3 Environmental water scarcity (2000)

The map is a product of a joint study by the International Water Management Institute (IWWI), the World Resources Institute (WRI), and the Centre for Environmental Systems Research of Kassel University (KU) and IUCN - The World Conservation Union (People & the planet, 2012).

Year 2011

The major industrial economies of Australia, India, China and USA have been rated as ‘high risk’ in a new study evaluating the vulnerability of 159 countries to water stress, whilst the regions of the Middle East and North Africa are highest overall risk.

The Water Stress Index (Figure 4) is developed by global risks advisory firm Maplecroft to identify the risks to governments, populations and business. The index is calculated by evaluating the ratio of a country’s total water use, from domestic, industrial and agricultural use, to the renewable supply of water from precipitation, streams, rivers and groundwater. The index is accompanied by a sub-national map, which utilises GIS (Geographic Information System) technology to pinpoint global water stress down to 50km^2 worldwide.

At a national level, the Water Stress Index identifies the Middle East and North African countries of Egypt (1), Kuwait (2), UAE (3), Libya (4) and Saudi Arabia (5) as exposed to the most overall risk. Water stress in this region is not surprising as it only receives 1% of the world's precipitation, of which 85% is lost, for example through evaporation. However, the key economies of Australia (19), India (29), China (40) and USA (51) have all been rated as 'high risk' due to massive 'extreme risk' areas of water stress, where demand is exceeding 80% of total renewable water resources.

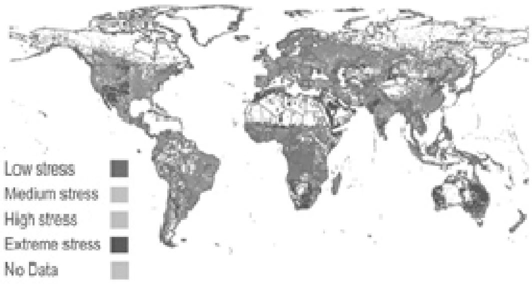

Fig. 4 Water Stress Index in 2011

Maplecroft's water stress map identifies vast swathes of Australia as 'extreme risk.' The issue has particular resonance in the south, as it is subject to increasing climate variability characterised by declining rainfall. South Australia has nearly 1 million km^2 at 'extreme risk' of water stress, which represents 12.8% of the total land area. Poor water governance in the past compounded the situation by over-allocating surface and ground water, which has negatively impacted many rivers and watersheds. Subsequently, there is competing user demand from the agricultural, domestic, industrial and mining sectors.

In India and China, high demand for water is driven by climbing populations and rising industrial and agricultural use. The latest available figures from the UN's Food and Agricultural Organisation estimate the annual growth in industrial water withdrawal in India at 8.91%, whilst municipal water withdrawal in China is rising at 10.38%. In north and eastern China, which are home to the cities of Beijing, Tianjin and Shanghai, water supplies are being used at a higher rate than available supply. This has prompted the planning of the South-to-North Water Diversion Project, a scheme to transfer water from the wet south to the dry north. The water stress issue in both India and China is especially important to business as many companies have crucial facets of their supply chains based there.

Across the USA there is a wide range of water stress diversity with the Great Plains and the southwest areas of the country suffering severely due to intensive farming and low precipitation, whilst the northwest and northeast states have high precipitation rates and low levels of water stress. In Texas 690,438 km² are subject to extreme water stress, equal to 7.27% of the state's land mass. In western parts of the United States groundwater is being consumed faster than it is being replenished, and groundwater tables are steadily falling. The Colorado River in the western United States often runs dry before reaching the sea. The river now serves 30 million people in seven U.S. states and Mexico, with 70 percentage or more of its water siphoned off for irrigation.

"Water stress has implications for where and how companies should operate, as well as the sustainability of their activities," said Principal Environmental Analyst at Maplecroft, Dr. Matthew Bunce (Maplecroft's, 2012).

Hydrogeological characteristics

Important prerequisites for the percolation of precipitation water are the sufficient permeability of the soil as well as of the loose and solid rock in the subsoil. Attention is to be paid that the surface, possibly artificially applied, has a lower permeability than the subsoil and thus represents the relevant k_f - value. With k_f - values of less than 1.10^{-6} drainage exclusively through percolation with temporary storage is not guaranteed from the outset, so that a supplementary possibility for discharge is to be planned.

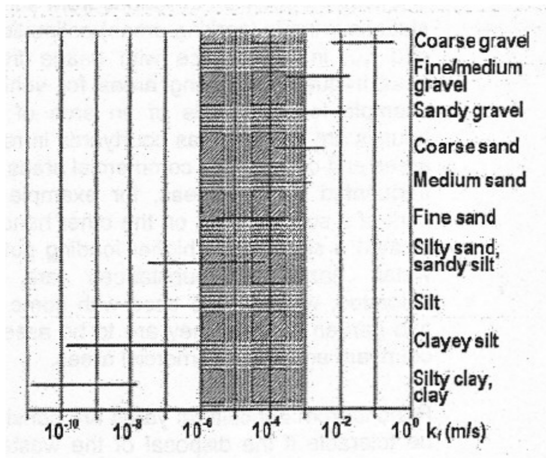

Fig. 5 Water permeability coefficients of loose rock and percolation range for technical drainage

The permeability of the loose rock depends predominantly on the size and distribution of its particles and compactness; with soils also decisively on soil structure and the water temperature, and is given through the permeability coefficient *(k_f - value)*. With loose rock it varies in general between 1.10^{-2} and

1.10^{-10} m/s (Figure 3). The k_f - values apply for flow processes in the watersaturated zone. Decisive for the spreading of water content substances into the unsaturated zone and for the protective effect of the groundwater cover is not the k_f - value determined for the saturated zone, but rather the smaller $k_{f,imp}$ - value in the unsaturated zone. The percolation, range relevant for technical drainage lies around a k_f - range from 1.10^{-3} to 1.10^{-6} m/s (Figure 5) (DWA, 2005).

Facilities for percolation and infiltration of rainwater

Facilities for the percolation of precipitation runoffs can be differentiated according to following criteria:

- decentralised or centralised,
- storage capability,
- surface requirement,
- hydraulic charging.

The principle technical solutions for facilities are:

- surface percolation,
- swale percolation,
- swale-infiltration trench element,
- infiltration trench and pipe-infiltration trench percolation,
- shaft infiltration,
- basin percolation,
- swale-infiltration trench system.

The storage capability relates to the facility specific capability to store precipitation runoffs temporarily until gradual percolation. With surface percolation the storage capability is dispensed with.

The surface requirement of facilities for percolation through planted soil such as surface or swale percolation is naturally higher than with "underground" facilities such as shaft infiltration or infiltration trench percolation. The former are, however, from the point of view of environmental protection always to be preferred.

The hydraulic charging is a further criterion in order to differentiate between above ground decentralised and centralised facilities. Materially and hydraulically highly loaded are those with which the ratio $A_{imp} : A_p \geq 15$. From this result that different conditions for possibilities of employment (DWA, 2005).

More about these facilities are in DWA-A 138E Planung, Bau und Betrieb von Anlagen zur Versickerung von Niederschlagswasser.

Conclusion

The percolation and infiltration of precipitation water is, in many cases, the most sensible ecological prerequisite so that conventional combined and separate sewer systems are converted into modified networks with considerably smaller pipe cross sections and reduced loading potential for wastewater treatment plants and running waters. Through, the decoupling of drainage areas from the sewer network and through the percolation and infiltration of precipitation water, bottlenecks in the sewer network can be avoided or the security against flooding increased. A prerequisite for the percolation and infiltration is the technical drainage separation of the drainage areas according to the anticipated characteristics of the surface runoff. Therefore, in each case, it is to be considered carefully, which drainage concept in combination with the percolation and infiltration of precipitation is ecologically sensible, technically possible and economically justifiable (DWA, 2005).

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Environmental risk assessment in condition of Libya by using pairwise comparison

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Abstract

Many nations experience fatalities and injuries, property damage, economic and social disruption resulting from natural disasters. The environmental risk assessment evaluates the potential adverse effects that human activities and natural disasters have on the plants and animals that make up ecosystems.

Multi-criteria analysis as a method of environmental risk assessment is designed to help the individual make a choice among a set of pre-specified alternatives. The Multi-criteria analysis ends with a more or less stable ranking of the given alternatives and hence a recommendation as to which alternative(s) should be preferred. Regarding our problem of natural hazards – environmental risk assessment, the result will be a ranking or categorisation of hazards with regard to their risk level.

Key words: Natural hazards, Environmental risk assessment (ERA), Libya, Multi-criteria analysis, Pairwise comparison

Introduction

Natural hazards such as earthquakes, hurricanes, flash floods, volcanic, etc. have always constituted a major problem in many developing and developed countries. The hazards kill thousands of people and destroy billions of money worth habitat and property each year. The rapid growth of the world's population has escalated both the frequency and severity of the natural disasters (Yalcin and Akyurek, 2004).

The research focuses on the study of environmental risks assessment with results to reduce their impacts. Environmental risks are consequent on manmade as well as natural hazards. The risk assessment process provides a way to develop, organize and present scientific information so that it is relevant to environmental decisions. When conducted for a particular place, the environmental risk assessment process can be used to identify vulnerable and valued resources, prioritize data collection activity, and link human activities with their potential effects. Studies of natural hazards provides necessary information and data to know the time and location and size of these risks to determine the early preventive methods to protect humans and human societies and reduce the devastating effects and benefit from the positive side to them.

Environmental risk assessment is an objective, scientific process of identifying and evaluating the adverse risks associated with a hazardous substance, activity, lifestyle or natural phenomenon that may detrimentally affect the environment and human health. It is process to collect, organize, analyze and present scientific information to improve decision making. Risk assessment methods can help bring scientific data into environmental decisions. Multi-criteria analysis (MCA) is very useful for evaluating the relative importance of multiple risks. Multi-criteria analysis helps to determine which risk is more important. The determination of hazards vulnerable areas are important for decision makers for planning and management activities.

Libya is witnessing of acceleration from the various aspects of development economic, industrial and social. For the success of development plans is important to formulate preventive strategies, plans and warning mechanisms. Risk assessment protects the lives and the devastation resulting from the natural as well as manmade hazards and disasters.

Pollution in Libya is one of the main environmental problems in this country. Located in a rather dry area where rainfall rarely occurs, the country's climate plays a very important factor to its pollution problem. Apart from harmful emissions from vehicles that traverse the desert, the desert itself is a cause of air pollution. The particles blown by the wind coming from neighbouring areas makes the air dusty but that dust is also accompanied by other types of pollutants. Natural hazards such as earthquakes, hurricanes, flash floods, volcanic, etc have always constituted a major problem in this country.

The objective of this paper is to increase awareness of hazards and risks with aim to prevent their occurrence, to limit their impacts and minimize its losses.

Material and Methods

Decision analysis looks at the paradigm in which an individual decision maker (or decision group) contemplates a choice of action in an uncertain environment. The theory of decision analysis is Multi-criteria analysis is designed to help the individual make a choice among a set of pre-specified alternatives. The decision making process relies on information about the alternatives. The quality of information in any decision situation can run the whole gamut from scientifically-derived hard data to subjective interpretations, from certainty about decision outcomes (deterministic information) to uncertain outcomes represented by probabilities and fuzzy numbers. This diversity in type and quality of information about a decision problem calls for methods and techniques that can assist in information processing. Ultimately, these methods and techniques may lead to better decisions. Our values, beliefs and perceptions are the force behind almost any decision-making activity. They are responsible for the perceived discrepancy between the present and a desirable state. Values are articulated in a goal, which is often the first step in a formal (supported by decision-making techniques) decision process. This goal may be put forth by an individual (decision- maker) or by a group of people. The actual decision boils down to selecting "a good choice" from a number of available choices. Each choice represents a decision alternative. In the Multi-criteria decision-making context, the selection is facilitated by evaluating each choice on the set of criteria. The criteria outcomes provide the basis for comparison of choices and consequently facilitate the selection of one, satisfactory choice (Yahaya et al., 2010).

Multi-criteria analysis has many advantages over informal judgment unsupported by analysis (Hokkanen, 2011):

- It is open and explicit.
- The choice of objectives and criteria that any decision making group may make are open to analysis and to change if they are felt to be inappropriate.
- Scores and weights, when used, are also explicit and are developed according to established techniques. They can also be cross referenced to other sources of information on relative values, and amended if necessary.
- Performance measurement can be subcontracted to experts, so need not necessarily be left in the hands of the decision making team itself.
- It can provide an important means of communication, within the decision making team and sometimes, later, between that team and the wider community.
- Scores and weights are used, it provides an audit trail.

Disadvantages of Multi-criteria analysis are following (UNESCAP, 2011):

- There is a possibility that community preferences will be determined, not by the community, but by a single decision-maker, without consultation with the community.
- Although MCA does not necessarily require quantitative or monetary data, the information requirements to compile the effects table and derive the weights can, nevertheless, be considerable.
- Although the weights used in the process are explicit weights, the analyst may unintentionally introduce implicit weights during the evaluation process. If not properly used MCA has the potential to become a 'black box', producing results that cannot be explained.

The selection of criteria that has spatial reference is an important step in Multi-criteria decision analysis (Malczewski, 1999). The criteria used in this study were selected due to their relevance in study of natural hazards assessment.

Criteria and their weights are entering into the decision making process as "fixed" data, there can users change under certain conditions. Each expert shall have the right to exercise its criterion in defining its relationship to the problem and determine whether a higher value criterion has a positive or negative effect.

Pairwise comparison

The one of known MCA method, used for environmental risk assessment in Libya in this paper, is Pairwise comparison. Pairwise comparison is a method that is informed by research showing that when quantitative ratings are unavailable, humans are still adept at recognizing whether one criterion is more important than another.

Generally refers to any process of comparing entities in pairs to judge which of each entity is preferred, or has a greater amount of some quantitative property. The method of pairwise comparison is used in the scientific studies of preferences, choices, attitudes, voting systems, and multiagent systems.

Results

The used MCA method for determining the most serious hazard facing Libya is Pairwise comparison**.**

We have assessed the following hazards:

1 - Drought
2 - Volcano
3 - Earthquake
4 - Pollution
5 - Flood
6 - Tsunami

All pairs of hazard from 1 to 6 were mutually compared.

Twenty people were asked to allocate the priority which hazard is the most dangerous for environment in Libya. They were: university staff - teachers (5 people); PhD students in civil engineering (5 people); PhD students in Economic (5); researchers (3); public (2).

Calculation of a standard weight criteria $w_j^{(N)}$ is calculated using the following equations:

$$w_j^{(N)} = \frac{w_j}{\sum_{j=1}^{n} w_j}$$

$$\sum_{j=1}^{n} w_j = \frac{n}{2} \cdot (n-1)$$

where

w_j^N- standardized weight of the hazard;
w_j - score (points) associated with *j* criterion;
n - total number of hazards.

The individual hazards were compared by Fuller's triangle in Fig. 1 and the points were assigned to them.

1 2	1 3	1 4	1 5	1 6
	2 3	2 4	2 5	2 6
		3 4	3 5	3 6
			4 5	4 6
				5 6

Fig. 1 Comparison of hazards with Fuller's triangle

The points were counted and their sum is allocated to priority under Table 1. The following results were obtained.

Tab. 1 The allocation of priority to each parameter

Hazard	Assigned priority
Drought	85
Pollution	79
Flood	76
Earthquake	36
Tsunami	21
Volcano	6

The assessment shows that the drought has the highest score than the other hazards.

Discussion

The MCA method for determining the most serious hazards facing Libya was Pairwise comparison. The total number of investigated assets determines the weight $w_j^{(N)}$ of each hazard criteria, calculated according above mentioned equations.

The results in Table 2 show the drought as the most dangerous environmental hazard in Libya.

Tab. 2 Weight assessment of environmental hazards in Libya

Hazard	Weight
Drought	0.2733
Pollution	0.2633
Flood	0.2533
Earthquake	0.1200
Tsunami	0.0700
Volcano	0.0200

The Multi-criteria analysis ends with a more or less stable ranking of the given alternatives and hence a recommendation as to which alternative should be preferred (Zelenakova et al., 2011). Regarding our problem – hazards risk assessment of natural and man-made hazards; the result will be a ranking or categorization of hazard with regard to their risk level.

Conclusion

The main aim of this paper was determined the most dangerous hazard effecting Libya country using Multi-criteria analysis method – Pairwise comparison. Quality of background information is very important to make good Multi-criteria decisions analysis.

The obtained results indicate that the risk of drought is the greatest hazard threats Libya. This result helps managers to do steps to deal with this hazard.

Acknowledgements

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Characterisation of sediment from the Smolnik creek by FTIR and XRD methods

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Abstract

The increase awareness and concern about the environment has motivated in the recent years extensive research into developing new efficient technologies for the acid mine drainage remediation. AMD is characteristic by high contents of acidity, heavy metals and sulphates and its potentially damaging impact when it in corporates into the surface and groundwater system has been reported. Major changes in organic and inorganic properties present in sediment can therefore be qualitatively identified from the FTIR spectra.
The aim of this article is comparison of the sediments composition from three sample sites in Smolnik creek using XRF and FTIR.

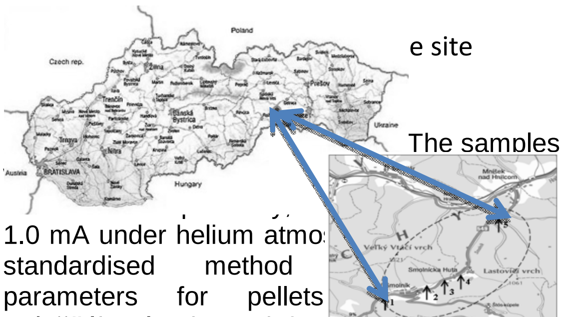
Keywords: Acid main drainage, sediments, heavy metals, FTIR, XRF

Introduction

Acid mine drainage from abandoned mines poses a long-term threat to the environment and directly impacts it by polluting streams, rivers, waterways drinking water, and groundwater, disrupting wildlife habitat, and destroying the natural landscape. Runoff from mining operations can have negative impacts on the surrounding aquatic environment including heavy loads of suspended solids, decreased pH levels and increased levels of heavy metals. In Slovak republic there are some localities with existing AMD generation conditions. The most critical values were observed in the abandoned deposit Smolnik. It is a historical Cu, Fe, Ag, Au-mining area that was exploited from the 14th century to 1990. The mine-system represents partly opened geochemical system into which rain and surface water drain. The Smolnik mine was definitely closed and flooded from 1990 till 1994. Smolnik is situated in the south eastern Slovakia between villages Smolnik and Smolnicka Huta in the valley of Smolnik creek, 11 km south–west of the village Mnisek nad Hnilcom. Geomorphologically, the locality is situated in the area of Slovenske Rudohorie (Slovak Ore Mountains - West Carpathians) (Šlesárová et al.,2007, Luptáková et al., 2005, Luptáková et al., 2008, Špaldon et al., 2006, Bálintová et al., 2010).

Materials and methods

Sediment sampling localities are shown in Figure 1. Two localities were in the upper part of the Smolnik creek without contamination by acid mine waters from shaft Pech (1 – outside the Smolnik village, 2 - small bridge - crossing to the shaft Pech) and another two sampling localities were located under the shaft (4 - cca 200 m under the shaft Pech, 5 – inflow to the Hnilec river). The sediment from basin near outflow of AMD from shaft Pech (Smolnik mine) has number 3. For our research was used sediments from sampling sites 1,3,4.



e site

The samples

Samples of sediment were taken off from the Smolnik creek at the places showed in Fig. 1. The sediment was dried, homogenized and sieved bellow 0,063 mm. Chemical analyses was realised by the XRF and the functional groups were determined using IR method.
The sediment samples were prepared as pressed tablets with diameter of 32 mm by mixing of 5 g of cement and 1 g of dilution material (M-HWC) and pressed at pressure of 10 tons. The prepared tablets were studied by X-ray fluorescence spectrometry. The chemical composition of sediments was determined by using SPECTRO iQ II (Ametek, Germany) with silicon drift detector SDD with resolution of 145 eV at 10 000 pulses. The primary beam was polarized by Bragg crystal and Highly Ordered

1.0 mA under helium atmo
standardised method
parameters for pellets
Palaščáková, L.). For infra-red spectroscopy in this study, was used spectrum through 4000 cm^{-1} to 600 cm^{-1} (Alpha FT-IR Spectrometer, BRUKER OPTICS).

Result and discussion

Table 1 describes the results of the XRF method for the sampling sites 1, 3, 4. Results of FTIR are showed in figures, 2,3,4.

Tab. 1 Results of analysis for chosen elements by XRF method for sample site 1, 3, 4

Symbol	Element	S1 Concentration [%]	S3 Concentration [%]	S4 Concentration [%]
Al	Aluminum	6,51	1,37	7,19
Si	Silicon	19,65	2,54	17,48
Fe	Iron	3,49	37,89	5,12
S	Sulphur	0,04	2,89	0,14

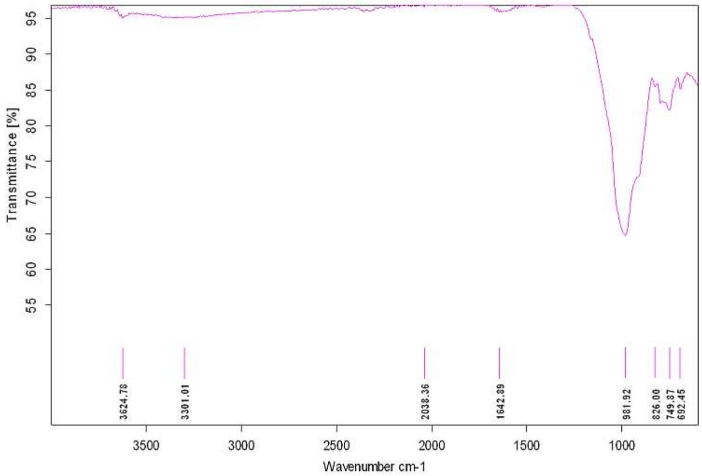


Fig.2 FTIR method for sediment from sample site1

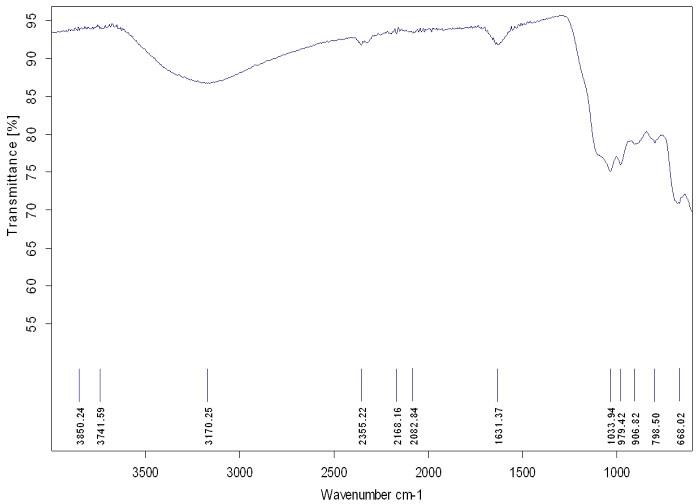


Fig.3 FTIR method for sediment from sample site 3

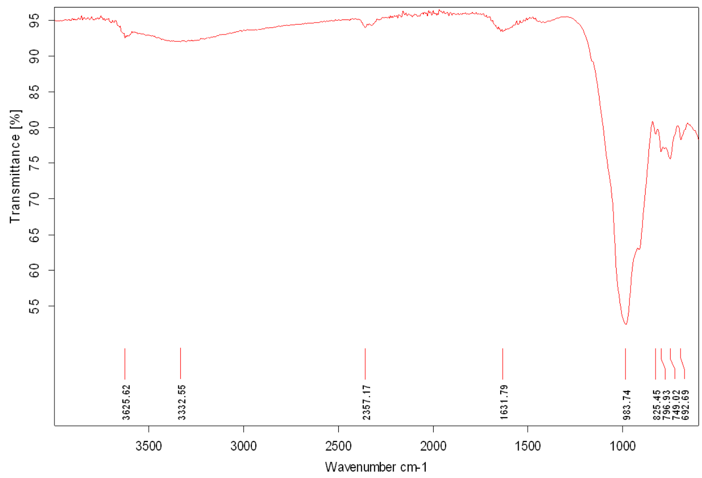


Fig.4 FTIR method for sediment from sample site 4

FTIR spectra of all homogenised sediment samples showed similar features. Based on results presented in Table1 and IR spectrum it can be say, that main part of components in sediment 3 and hydroxides broad band (300-3600 cm^{-1}) and 1631 cm^{-1}. The small band at approximately 110 cm^{-1} are sulphates and silicates (1093, 979, 906, 798, 668 cm^{-1}) are present, too (Pacáková et al., 2000; Howe et al., 2002). Phosphates can be excluded because their concentration is low. S1 and S4 have the similar spectra and the main part of compounds are only silicates (982, 825, 796,7 49, 692 cm^{-1}), but in S4 is bigger portion of hydroxides (3600-3650 cm^{-1}).

Conclusion

Fourier Transform Infrared spectroscopy (FTIR) allows the analysis of a relevant amount of compositional and structural information concerning environmental samples (Kögel-Knaber, 2000) and recently, it's has improved the performance of this technique in the studies of complex environmental systems (Noda and Ozaki, 2005).
An Infrared absorption method has been developed in order to measure sediment of Smolník creek. Based on XRF and FTIR methods was the intensity of absorption bands in various regions of the IR spectra for sediment S1 (1093, 979, 906, 798, 668 cm^{-1}) and S4 (982 cm^{-1}, 825cm^{-1}, 796 cm^{-1},749 cm^{-1} and 692 cm^{-1}). In all three samples studied, there is broad band of hydroxides (3600-3000 cm^{-1} and 3650-3600 cm^{-1}).

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Surface water regime control possibilities in drainage system of the Eastern Slovak Lowland

Zuzana Pálinkášová, Andrej Šoltész

Abstract

The contribution deals with few possibilities of surface water regime control in one of the most critical regions in Slovakia from hydrological, pedological and orographical point of view (Bella, 1971). Results of the research show the necessity of optimisation of internal water drainage in the Eastern Slovak Lowland. Particular attention is devoted to the drainage system named ESL-3. The research is concentrated on the evaluation of the pumping plant operation with regard to the flow capacity of drainage canal and parameters of pumping devices installed on the pumping station.

Keywords:

Water surface regime, Eastern Slovak Lowland, control possibilities, numerical modelling in drainage canals, HEC-RAS modelling system

Introduction

Water management improvements have several centennial traditions in the Eastern Slovak Lowland (ESL). In this region there was a problem with periodic floods as well as with disorder runoff conditions. It has been gradually solved by building-up pumping stations, dams, embankments and river control. The dams and embankments along the rivers worsened internal water runoff. This induces the waterlogging and flooding of agricultural land. Internal waters appeared mainly in the spring time after snow melting or during the vegetation period after intensive or long-lasting rainfall. In that case problems with waterlogging occur in the summer time mainly after heavy rain storms. Large drainage systems in the Eastern Slovak Lowland (bordered by the Ondava, Laborec, Uh, Latorica and Bodrog rivers) are built to solve this problem (Gyalokay, 1969).

The examined ESL-3 region (i.e. region between the Uh, Laborec and Latorica River) is part of the drainage system built up on the big area of the Eastern Slovak Lowland. The considered drainage region is more than 186 km^2. The ESL-3 drainage system includes following pumping stations (PS): Čičarovce, Ptrukša and Pavlovce above Uh. The situation of the area can be seen in the Fig. 1. In the mentioned area a network of drainage canals is built-up, where the main canal is named Udoč. It leads the internal water towards the oldest PS of this region – the Čičarovce PS and it is approximately 14.89 km long. Other canals are Ortov, Maťovský, Ptrukša (leads internal waters towards the Ptrukša PS), Dolný (leads internal waters towards the Pavlovce above Uh PS). The mean value of the longitudinal slope of these canals is only around 0.2 ‰. All mentioned drainage canals collect internal waters from the whole area. The water flows in the canals towards the PS to pump it back into the Latorica river (Čičarovce and Ptrukša PS) or into the Laborec river (Pavlovce above Uh PS). There was never made any hydraulic research with regard to the co-operation of all three pumping stations. Therefore it is important to come up to water surface regime control optimisation.

Fig. 1 Situation of the ESL-3 drainage area (source: SVP, s.e., Košice)

Material and Methods

For the hydraulic solution of the problem the mathematical modelling of the surface water regime in the drainage canal of the Pavlovce above Uh PS has been introduced. The methodological procedure came out from solution of Saint-Venant equations for unsteady surface water flow in open canals.

For surface water level simulation the HEC-RAS 1-D software (version 4.0) was used which is freely available.

In the research, the mathematical model was calibrated on the basis of measured data and afterwards used for design of computational scenarios for improving the hydraulic situation in the drainage system. The results of scenarios show the surface water regime control possibilities.

Results and discussion

The part of draining to the Pavlovce above Uh PS will serve as the example for designing control possibilities.

The most significant idea in scenarios determination was to find such a pumping process, in order to observe the operation rules as well as the consideration of

continuous surface water flow with respect to endangered banks of the Dolný canal. It seems to be very important an introduction of preventive pumping to ensure continuous water flow towards the PS. It can provide continuous draining of the water in the canal at so small slopes as are given in the drainage canals. This is an example of possibility which should lead to the pumping improvement at the Pavlovce above Uh PS. The designed scenarios were based on calibrated situation (Fig. 2) where the real pumping rate (Bodrog and Hornad Catchment Management Košice, 2005-2010) was involved into calculation.
Scenarios were introduced on preventive pumping into the modelling procedure of the unsteady water flow in the canal for different periods of preventive pumping. The most important indicator for the pumping should not be the maximum acceptable surface water level (as it is usual in operation rules) but the weather development (temperature, rainfall, snowmelt, etc.).

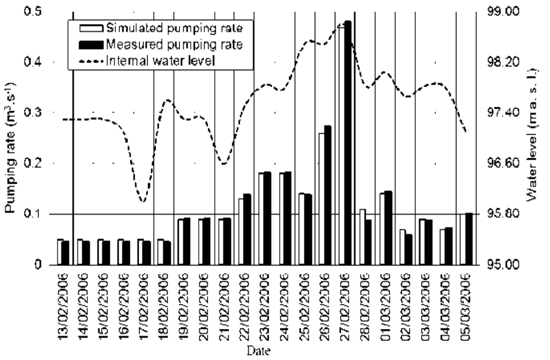

Fig. 2 Calibrated situation of the flood period in the spring time 2006

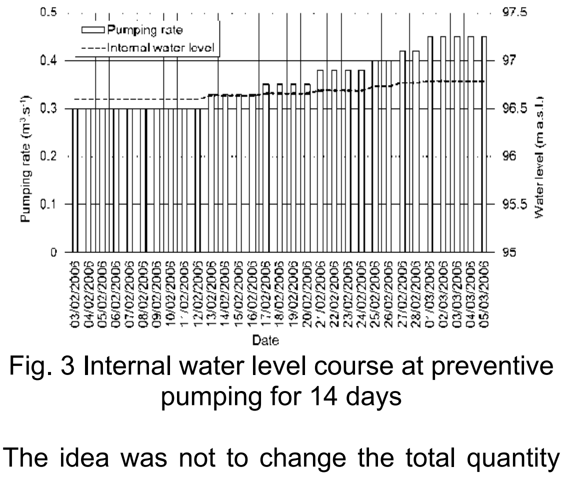

Fig. 3 Internal water level course at preventive pumping for 14 days

The idea was not to change the total quantity of pumped water, but only to start with pumping earlier with smaller rates (Šoltész, 2006). It is apparent that the internal surface water level in the drainage canal decreased by more than 1.9 m in the most critical period and it is more convenient to operation rules given at the pumping station (Fig. 3).
The preventive pumping period in that case was 14 days with regard to the bank endangering on the drainage canal. The same and slightly better results were obtained for longer periods of preventive pumping. Co-operation of additional PS - Pavlovce above Uh and Ptrukša) with the main Čičarovce PS in the whole drainage basin will be investigated in the future, as well. It would certainly help to avoid flood events in the river basin of the ESL-3 drainage region.

Conclusion

Eastern Slovak Lowland is a very complicated river basin because of large areas with heavy (clayey) soils where the runoff coefficients can increase to highest values, especially in winter and spring period. There are typical natural no-runoff areas where the water surplus goes up until late May. Results of the hydrodynamic analysis can lead into better understanding of control possibilities of internal water flooding in this region.
Until now, the negative impact of waterlogged areas by internal waters in Eastern Slovak Lowland was especially marked in 1967, 1980, 1988 and 1999 or 2004 and 2010. For the area of the ESL-3 drainage system region were the years 2000, 2006 and 2010 determined as critical. The results of mentioned scenarios should give the possibilities of surface water regime control in ESL-3 region. Efficiency of pumping stations and refinement of operation rules can be improved by applying this knowledge in areas with similar hydrological, climatic, geological and soil conditions. It would avoid a long-term agricultural waterlogged land, which caused retardation of starting agricultural works.
The co-operation of the research team, authors as well as faculty, with the operating organisation – Water Board of the Bodrog River – will certainly lead to the improvement of surface water regime in the whole river basin of the ESL-3 drainage region.

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Rainwater harvesting potential and precipitation monitoring at the University campus

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ABSTRACT

This article is focused on precipitation monitoring at the campus of the Technical University of Košice. We will describe methodology, type of rain gauge, location and present the first measured data gathered from April 2011 to December 2011. Since the precipitation has the major influence on rainwater harvesting potential and its effectiveness, we will describe our research more in detail. Rainwater harvesting (RWH) is just one type of the storm water management (SWM) techniques. It is source control type of SWM technique, and its main aim is to decentralize storm water from the very beginning to avoid reaching the combined sewer system. SWM is still a quite new topic and there is no legal framework or standard how to apply new sustainable SWM techniques in our country. There are many kinds of approaches or technologies how to promote sustainable SWM, especially in the urban areas. That is the reason why we are dealing with this topic at Civil Engineering Faculty.

KEYWORDS

RWH, Stormwater, SWM, sustainability

INTRODUCTION

There has been an increasing interest in sustainable storm water management in recent years. The contributing facts are mainly events influencing everyday lives of people, such as heavy rain, floods, and slumps or opposite extremes such as longer droughts, decreasing water level of the rivers and ponds. Intergovernmental Panel on Climate Change in 2008 published document named „Climate change and water“. This document released predictions for further weather development as well as summarized observed climate changes.

Flood risk is projected to increase throughout the continent. The regions most prone to a rise in flood frequencies are Eastern Europe, then northern Europe, the Atlantic coast and central Europe, while projections for southern and south-eastern Europe show significant increases in drought frequencies. In some regions, both the risks of floods and droughts are projected to increase simultaneously (Bates B.C., et al., 2008). Climate change predictions have also been released for Slovakia and The Fifth National Communication of The Slovak Republic on Climate Change presented all observed changes and discussed them. It is supposed that heavy precipitation events will appear more frequently than in the past by approx. 25 up to 50% despite the annual precipitation decreased by approx 3,4%.

These climate change facts confirm necessity to be interested in the SWM in the context of sustainability.

MATERIAL AND METHODS

For our research purposes and under the auspices of the project “Increasing of the rain water management efficiency for the purpose of energy demand minimization” we have started our own measurements at the campus of the Technical University of Košice (TUKE). All our devices are located directly at the university campus. The advantage of this location is their vicinity and its good accessibility. We are measuring precipitation amount, roof runoff, groundwater level, water level in the infiltration shaft and qualitative parameters of the storm water. Target of this paper is to introduce precipitation monitoring at the university campus and the data application.

Rain gauges are the most common devices for measuring rainfall. Non-recording gauge collects rain falling on a standard area over a known period of time and the volume of stored rainfall is measured manually, compared to recording gauges which are able to provide continuous record of rainfall. (Butler, Davies 2011)

Our rain gauge type MR2H is located on the roof of the university library. Rain gauge’s (Fig. 1) round catchment area is 200 cm^2 and it is calibrated to 0,2 mm for a single tip. The mechanism of measuring of this type is based on tipping bucket which is divided into two parts where one part is filled with calibrated amount of water, then it tips and second half of bucket can be filled with rainwater. Tipping continues during the length of rainfall event. We use recording heated rain gauge for all year round measuring. Its operating temperature is between -30 to +60 ℃. Tipping bucket is made of plastic with very thin layer of titanium and it is hanged on stainless steel axial holder, the body of gauge is made of stainless steel and it is insulated. Each tip is recorded and transmitted by telemetric station (Fig. 2) which is datalogger together with GSM/GPRS communication module. Data are sent to server every 10 min but for more detailed measuring, this interval changes to 1 minute the moment it stars to rain. One minute interval gives us exact information about the rainfall amount throughout the event, its intensity and duration. Data are then stored at server by data hosting.

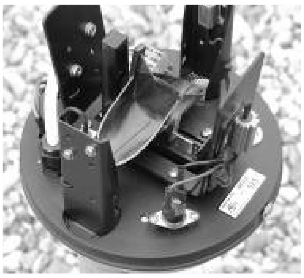

Fig. 1 – Open rain gauge

Fig. 2 – Rain gauge with telemetric station

For various purposes, data can be downloaded from the server at any time in the requested format (chart or table).

RESULTS

Rainfall amounts measured at the TUKE campus from April 2011 to December 2011 are shown in the chart below (Fig. 3)

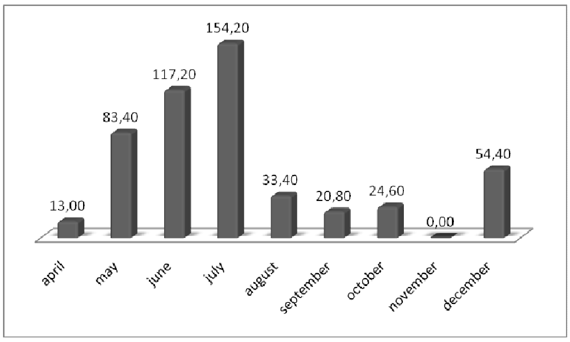

Fig. 3 – precipitation measured at the university campus from April to December 2011

During the observed period, the highest total rainfall was recorded in July. Table 1 shows days with rain in July 2011. The lowest rainfall amount was recorded in November 2011, with the amount of 0,00 mm which is quite unusual as shows Table 2. Data from Košice airport shows the amount of 3,00 mm for November 2011 (Bulletin MaK, 2011). This confirms the fact that distribution of rainfall in various parts of the city is different. That is the reason why we should always consider using data from the closest weather station to the place of our interest/design/valuation.

Tab. 1 – days with rain – July 2011

Day	***mm/day***
02.07.11	10,80
04.07.11	0,40
05.07.11	7,20
06.07.11	7,20
08.07.11	2,40
11.07.11	13,60
12.07.11	0,20
18.07.11	0,20
19.07.11	0,40
20.07.11	7,20
21.07.11	20,00
22.07.11	8,20
24.07.11	3,40
25.07.11	14,00
26.07.11	19,20
27.07.11	9,80
28.07.11	5,00
29.07.11	3,20
30.07.11	16,80
31.07.11	5,00

Table 1 shows that the heaviest rainfall was recorded on the 21st of July. Next figure shows distribution of rainfall throughout the day.

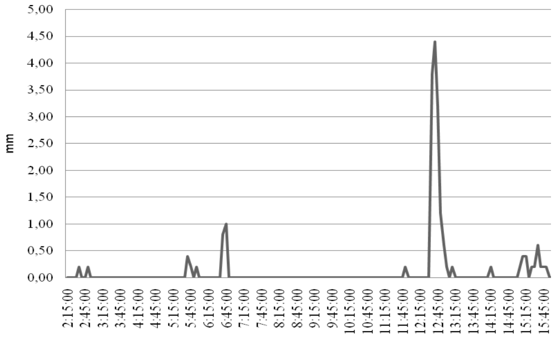

Fig. 4 – rainfall distribution on 21st of July

Tab. 2 – November precipitation amounts from 2004 to 2008 compared to 2011 (SHMU)

November 2004 - 2008 compared to 2011					
2004	2005	2006	2007	2008	**2011**
49,00	22,90	16,50	27,20	24,80	**0,00**

RAINWATER HARVESTING POTENTIAL

One of the ways how to promote sustainability in SWM is rainwater harvesting. It is possible to use rainwater instead of potable water anywhere where there is no need for such high quality water for example for flushing toilets, cleaning and maintenance, car washing, irrigation, laundry etc.

We have used data measured at the campus of our university to show what would be the rainwater volume (Tab. 4) obtained from different roof sizes with different runoff coefficients (Tab. 3).

Tab. 3 – runoff coefficients according to DIN 1989 (Hlavínek et. al., 2007)

roof shape	**roof covering**	**runoff coefficient**
flat	*metal*	0,7
	asphalt	0,6
	plastic	0,7
sloped	*roof tile*	0,8
	concrete	0,8
	slate	0,8
	wood	0,75
	metal	0,9
	plastic	0,9

The volume of rainwater depends on the area, rainfall, size of the roof and the runoff coefficient. We can calculate it according to the following formula. (Hlavínek et. al., 2007)

$$Q_m = \psi \cdot A \cdot Z_M \ (m^3/month) \qquad (1)$$

Ψ – runoff coefficient (-)
A – roof area (m^2)
Z_M – monthly rainfall (mm/month = l/m^2.month)

Tab. 4 – potential volume of rainwater in m^3 from the roofs of different sizes and different runoff coefficients during July 2011 at the TUKE campus

Ψ	roof area m^2			
	10	50	100	150
1,00	*1,54*	*7,71*	*15,42*	*23,13*
0,90	*1,39*	*6,94*	*13,88*	*20,82*
0,80	*1,23*	*6,17*	*12,34*	*18,50*
0,70	*1,08*	*5,40*	*10,79*	*16,19*
Ψ	roof area m^2			
	200	250	300	350
1,00	*30,84*	*38,55*	*46,26*	*53,97*
0,90	*27,76*	*34,70*	*41,63*	*48,57*
0,80	*24,67*	*30,84*	*37,01*	*43,18*
0,70	*21,59*	*26,99*	*32,38*	*37,78*
Ψ	roof area m^2			
	400	450	500	550
1,00	*61,68*	*69,39*	*77,10*	*84,81*
0,90	*55,51*	*62,45*	*69,39*	*76,33*
0,80	*49,34*	*55,51*	*61,68*	*67,85*
0,70	*43,18*	*48,57*	*53,97*	*59,37*

Just to give an idea how much potable water can be substituted to rainwater, here are some water consuming human activities and their corresponding amounts of water adapted from Hlavínek et. al., 2007 and decree 684/2006 (Tab. 5).

Tab. 5 – average water demand for different purposes

average water demand for:	amount
flushing toilets	45 l/person.day
cleaning	6 l/person.day
washing	15 l/peprson.day
irrigation	60 l/m2.rok
flushing toilet - student	6 l/student.day
flushing toilet - employee	12 l/employee.day
washing a car	200 l/wash
washing a truck	700 l/wash
washing a bus	1000 l/wash

Every single rainwater harvesting project needs to assess real water demand, calculate the size of the tank, return on investment analysis as well as cost and water savings.

CONCLUSION

Using rainwater for flushing toilets and maintenance is just one example how to support sustainability in SWM and water management in general. There is also possibility to use different infiltration facilities for stormwater disposal instead of discharging it directly into combined sewer systems. It is for example green roofs, swales and trenches, bioretention, permeable paving etc. There is necessity to raise people's awareness in SWM because new approaches usually don't have only environmental function but aesthetic, economic and educational as well.
This paper briefly described one part of our research at the Faculty of Civil Engineering. Precipitation monitoring is just one part of hydrologic database what we have started to built up for research and educational purposes, it is long term and continuous process.

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Post-industrial buildings in Poland as a part of town cultural landscape

Alicja Kot-Niewiadomska*, Slávka Gałaś*

Abstract

The cultural landscape is the result of human impact on the environment lasting for many centuries, which has been more frequently harmful than harmonized and results in impaired cultural-natural relationships and degradation of the landscape. Its common symptoms are vast post-industrial areas with accompanying buildings. Due to the deficit of investment areas in many towns and cities, adaptation of single buildings as well as large historical industrial premises, still being valuable elements of the cultural landscape, have been being made for several years. Multi-directional processes of revitalisation enable to use the problematic sites for museum-historical, entertainment, commercial, residential, service or production purposes.

Key words: cultural landscape, industrial facilities, revitalisation

Introduction

The landscape may be regarded as a reflection of natural and anthropogenic processes in the mega-system of the geographical environment. Following this concept, several types can be distinguished, depending on the intensity of human impact on the environment. Such a classification should start from an original landscape, then a natural, cultural and devastated ones, the latter is the one which was the result of strong impact of the anthropogenic environment (Degórski, 2007). The cultural landscape which is in the middle of this classification is usually associated with historical monuments such as churches or other masterpieces of architecture. However, any objects which are the product of human activity belong to it. Considering the fact that such activity has frequently been uncontrolled, it is difficult to find harmony in creation of such types of landscape. Concurrently, it includes effects of activity of many cultural groups and overlapping cultural elements of different age.

Those features of the cultural landscape can be perfectly observed by analysing the structure and the layout of industrial sites and buildings existing there. The industrial development of the nineteenth and the early twentieth century had a profound impact on land use in many towns in Poland. Especially those where some particular branches of production were the driving force of the development of the region. Lower and Upper Silesia with the booming mining and processing industry or Łódź as the centre of modern textile industry of that time should be mentioned here. A new type of industrial architecture, whose form was primarily dependent on the scale and production technology, started to develop on the outskirts of those and dozens of other towns. The dynamic spatial development after 1945 and political changes after 1989 caused that residential areas have been surrounded by industrial ones. The realities of the market economy, have led a substantial part of the companies to bankruptcy. Privatization of state-owned factories launched the transformation processes of the size and the organization structure, followed by the production and functional ones, which took place in many companies already by the end of 1997. The existing situation caused that the amount of brownfield sites in Poland has been growing at a rapid pace. At the beginning they were enclaves, abandoned places, potentially dangerous and simply ugly. In recent years, those premises, although they have irretrievably lost their original function, have again become in many ways an interesting field for investors and local authorities. Dynamic development of many towns and cities has generated a significant demand for abandoned industrial premises located in the city or town centres.

Cultural landscape and its protection

As stated in the introduction, the space of nature, which is within the sphere of human interactions becomes a cultural form, which appears as a cultural landscape. The landscape can be comprehended as an anthropogenically shaped part of the geographical space, created by combination of environmental and cultural impacts (Myga-Piątek, 2005). In Poland, the cultural landscape is also defined by the Ancient Monuments Protection and Care Act (2003). According to it, the cultural landscape is "a space historically shaped by human activities, comprising products of civilization and natural elements." The predominant type of activity and the degree of transformation of the geographical environment allows to distinguish several subtypes of the cultural landscape: agricultural, industrial, urban and historic as well as harmonious or devastated landscapes (Komorowska, 2004).

The article presents the problem of an industrial cultural landscape, including the post-mining one. The objects associated with mining, heavy industry, power, processing, textile, ceramic and paper industry are its main components. This group of elements can also include facilities associated with railway, river and land transport. They also include such engineering achievements as bridges, viaducts, dams, and hydro-technical facilities.

The cultural landscape is protected (applying the same rules as for nature protection) in Poland and it is regulated by several acts. The following acts should be mentioned here: Ancient Monuments Protection and Care Act (2003), Spatial Planning and Development Act (2003) and Nature Conservation Act (2004). Poland also participates in several government programs and EU agreements, under which provisions of the International Bill of Historic Gardens and the European Convention on the Landscape are implemented. It also contributes to the World Heritage List. The Ancient Monuments Protection and Care Act (Ustawa, 2003) cited above says: "historical monuments which are in particular: cultural landscape (...), engineering facilities, especially mines, steel mills, power plants and other industrial plants, (...) are subject of protection and care, regardless of their preservation state." "(…)

The role of post-industrial premises

There are many ways to use brownfield sites and premises within their limits. Apart from demolition, valuable and interesting premises are frequently adapted to different functions: museum-historical, entertainment, commercial, residential, service or production. The revitalisation processes are carried out to revive the neglected areas and/or to increase their attractiveness and even to bring degraded areas back to life.

Reuse for new production activities or acquisition for commercial purposes or storage are the most common directions of transformation of brownfield sites in Poland. Regaining the production function occurs mainly due to the activity of medium and small businesses (Domański, 2001). Creation of special economic zones and technological parks located in former industrial sites, mainly due to their convenient location, complete infrastructure and vast areas, and sometimes even buildings whose technical conditions allow their re-usage is an excellent example of such activities. Tarnobrzeg Special Economic Zone (TSEZ) with a sub-zone Tarnobrzeg is an excellent example (total area about 120 km^2). Those are the areas of industrial premises of Tarnobrzeg Sulphur mine and Processing

technological products, especially equipment, vehicles, machines and tools proving the material culture, characteristic of the old and new forms of economy, documenting development of science and civilization, (...)". Hence, movable monuments also require protection in accordance with Article 6 of the cited Act. According to EU and national regulations, there are almost 57 thousand historical monuments in the register of monuments in Poland Nearly two thousand of them belong to industrial facilities (www.nid.pl). Most of them are situated in Lower Silesia (304) and Mazovia (238), Wielkopolska (273) and Warmia-Mazury (202). Those are mainly: production halls in industrial complexes or other accompanying facilities, engine houses, boiler houses, mines and their components, power stations, gasworks, waterworks single production buildings, forges, oil-mills, mills, windmills, hydro-technical and water-pipe facilities, water towers, bridges and viaducts (www.nid.pl). Moreover, among 11 Polish sites included in the UNESCO World Heritage List there is one post-industrial site - Wieliczka Salt Mine. The remaining 14 thousand sites connected with industry are not covered by protection.

Plant in Tarnobrzeg and Sulphur Mine "Machów", while the investment region Jeziórko is located near the Frasch Mine in Jeziórko. The continuous process of the mine liquidation has been being conducted there and the post-mining areas are being reclaimed and new industrial branches are being introduced, among them machine industry, household chemicals, petrochemicals, artificial fertilizers, building materials or industrial constructions. Further 19 sub-zones can be distinguished in the same zone, among them five ones (Stalowa Wola, Nowa Dęba, Radom, Staszów, Przemyśl) use industrial areas, where various branches of production developed or have been developed.

Maintaining the original form of the post-industrial facilities is necessary in case of their adaptation to museum-historical functions. Such facilities are also frequently recorded in the register of monuments. Underground mines, which have been made available to the public, obviously maintain most of their original character. Such facilities are especially numerous in Lower (e.g. the gold mine, "Aurelia") and Upper Silesia (e.g. the "Guido" coal mine in Zabrze, the silver mine in Tarnowskie Góry) and in the vicinity of Kraków (the salt mines in Wieliczka and Bochnia). The values of the facilities are not determined by surface premises, they are quite interesting but do not have any specific features that may distinguish them from other post-industrial sites in the town or region. The major attractions are the preserved underground workings. They allow visitors to get familiar with the geology of the region, the character of miners' job in such difficult conditions as well as mining traditions existing in the most important mining regions in Poland. A group of flint mines in Krzemionki Opatowskie, considered as one of the most interesting of its kind in the world, can also be an interesting example. The museum located in industrial buildings serves an extremely important educational and historical function. Apart from illustrating the history of the mine the exhibitions present also the history of the whole industrial branch. It is also worth to mention here the Brewery Museum in Tychy. Tychy Brewery, the plant that has been in operation for over 400 years, has been restored and adapted to the touristic needs. The plant has become the first place in Poland where visitors can familiarise with the history of beer. This place is so unusual because the museum is a part of the operating and constantly modernized brewery. The most valuable historical buildings have been restored, and new production lines are fit into the historic interior (Szmygina [red], 2009). This is a positive example of leaving the historic building and its adaptation to the needs of a museum and it is also a proper example of the use of historic structures for current production. There are many more similar examples in Poland and it is worth to mention here at least some of them: "Stary Browar" (Old Brewery) in Poznań, Museum of Matches in Częstochowa, "Zawiercie" Glass works, Museum of Silesian Press in Pszczyna. Adaptation of historic buildings and post-industrial constructions and premises for museum purposes or turning them into an open-air museum guarantees the most appropriate form of protection (Karczmarczyk and Rawicka, 2009).

Also adapting such places to new functions ensures maintaining the most essential values of the post-industrial premises (Karczmarczyk and Rawicka, 2009). However, this concept is sometimes put into practice in really extreme ways. This is particularly evident when the buildings are adapted for shopping and entertainment needs. Actually making large shopping centres has become a popular trend in brownfield sites transformation. Just in Kraków only there are three shopping centres („Bonarka", „Solvay" and Galeria „Kazimierz") that adapted such premises. The centres also take over the name, building their brand and promoting history of the place. Unfortunately, quite frequently the name is the only thing left after the original site as the rest is demolished during the refurbishment. It happened with Kraków Sodium Plant „Solvay" where a multifunction shopping centre was built and Kraków Chemical Plant „Bonarka" where the illuminated chimney is the only reminiscence of its former industrial function. However, there are numerous examples of almost perfect revitalisation of post-industrial premises. The most famous ones are „Manufaktura" in Łódź or Silesian „Silesia City Center", where characteristic features of particular buildings and facilities have been skilfully adapted to the market needs.

Housing function is also carried out in two ways in Poland. Most frequently old industrial facilities are completely destroyed and new housing developments are built in the place. Such situation occurred for example in case of Wedel's former factory in Kraków. However, so called "lofts" have gradually started to become popular in the Polish real estate market. The idea originated in the early twentieth century, when the interior of abandoned factories and warehouses began to be converted to studios and apartments. In time, the post-industrial premises attracted more and more interest, especially among people with refined taste and an extraordinary sense of aesthetics. Currently, lofts are one of the most expensive housing offers and they have started to be interesting for Polish customers too. Following the trend, the first lofts are being built in Krakow where a historical mill "Ziarno" is being converted. It is necessary to recall here the example of the town Żyrardów, a pearl of industrial architecture. Lofts that have been adapted in a historical housing development of the second half of the 19th century are an example of almost perfect conversion to a new function with coincident exposure of the history of the place. It is the only place in Europe where an urban complex of the turn of 19th and 20th centuries has been perfectly preserved. Żyrardów Local Revitalization Program, basing on the premises, sets development of cultural, recreational and conference tourism as a target.

Summary

"A new function in the old form is the best binder of two contradictions, creating permanent possibilities of creating more and more new functional and spatial values. The uniqueness of the results of revitalization results in occurrence of multi-layer architecture, where the past mingles with modernity, creating in result new architectural quality that has not been know so far" (Gawdzik, 2006). The is a sentence that could be the best summary of the analysed problem and it should become a "motto" of investors and local authorities who undertake actions involving brownfield sites, but especially of those who do nothing with such sites letting them to decline and to lose their historical (and not only historical) value. The choice of new functions is the result of many internal (volume of buildings, technical conditions and ownership issues) and external factors (location, local market demand, planning conditions, the degree of the environment degradation). But regardless the secondary function the industrial facilities will be converted to, it is important they become a harmonized element of the local cultural landscape, the function attributed to them is consistent with the surrounding natural and cultural environment.

The article mentions many (most of them by names only, due to its limited volume) examples presenting the process of properly conducted revitalization of valuable sites and post-industrial premises and constructions. Some of them are especially valuable not only in the country scale, but also European and the world ones, such as Wieliczka Salt Mine, Żyrardów or banded flint mines in Krzemionki Opatowskie. Those are the places where properly carried out adaptation not only allows to preserve the sites, but also helps to emphasise their historical value and unique character.

However, there are still numerous places in Poland where that type of places and facilities are still a disgraceful element of the cultural landscape of the town or region. Those are the places where the landscape has been altered and shaped by humans in an unsustainable way, and the transformation has been mostly focused on exploitation. Those are usually relics of industrial activities which have been creating the economic nature of the region for many decades or even centuries. Revitalization of problem sites is also the area of activity which allows, both local authorities, as well as entrepreneurs, to obtain substantial funds from the European Union. It can definitely facilitate comprehensive reconstruction and development of many such places in Poland.

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Water level regime for different variants of the navigable „Zemplín Waterway“

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Abstract

Within “Zemplín Waterway” was prepared several variants Bodrog river navigable, which was necessary to set minimum and maximum water levels of complying with navigational parameters of the waterway and the safety of navigation. Specific modifications of the waterway to achieve the desired parameters have been recommended by water level regime simulation.

Key words:
Waterway, fairway parameters, water level regime, mathematical modelling

Introduction

“Zemplín Waterway” is formed on the Slovak territory with Bodrog river, Latorica river and Laborec river in the stretch from the border with Hungary to Vojany (Fig. 1). Bodrog river is connected to Danube and European network of waterways through Tisa to which Bodrog discharges. Total length of “Zemplin Waterway” is approximately 35 km. Today it is not used as regular waterborne, except in the stretch from the border with Hungary to harbour Ladmovce. This short part of waterway is used as transport of gravel.

Fig. 1 “Zemplin Waterway” in stretch Tokaj (Hungary) – Vojany (Slovakia)

Actual knowledge and modern methods of flow adjustment, hydro engineering, nautical and evaluate the current state of water management and environmental conditions in the region have been used in the options for regulation of the waterway. Mileage of estimated modification of the respective stretches of the waterway is listed in the Tab.1. Navigation conditions on Bodrog river, Latorica river and Laborec river differ from conditions on Danube and Váh river, where a navigation traffic has already performed. While the non-backwater sections of Danube or Váh river have problems with navigation depths by lover discharges, mainly higher discharges seem problematic on the eastern rivers, where rapid increase in discharge causes a reduction of navigation height under bridges. Some objects crossing a waterway such as bridges, power lines and pipelines have also problematic parameters.

Tab.1 Mileage sections

River	Stretch (km)	description
Bodrog	49.680 ÷ 64.850	Border with Hungary ÷ junction of Latorica and Ondava
Latorica	0.00 ÷ 9.500	junction Latorica and Ondava ÷ outlet of Laborec
Laborec	0.00 ÷ 10.969	outlet to Latorica ÷ weir Vojany

All three rivers - Bodrog, Latorica and Laborec - have extensive been regulated in the past. Originally they have a character of strongly meandering rivers and their route was shortened by cut-off. Eastern Slovak rivers were regulated in 1953 – 1963. Today stream channels are shorter and more stable than in the past. The bank lines are changing during floods what lead to displacement of the bottom material, especially on the lower part of the Slovak stretch of Latorica river.

The banks of stream channels are overgrown with vegetation which has stabilizing effect. As the bottom and banks composed of loose materials (clay, loamy sands with an admixture of clay), in regular navigation banks will be loaded with water from the propulsion equipment of vessels, which over time causes the growing need for fortification of banks despite the fact that also today banks are stressed by frequent fluctuations in discharge and water levels (analogous from the lower Vah). Navigability of waterway will ensure by the removal of tree trunks that are fallen into the basin profile, especially into Latorica river and Laborec river. (Možiešik, Ľ. (2008)).

Mathematical Model for Calculation of Water level regime

For research of navigational parameters of fairway it is important to know a position of water levels by low and high discharges. Subsequently, after assessment of actual navigational parameters it is possible to establish a methodology for determination of the course of navigation water levels. Based on the analysis of the underlying materials bed topography of Bodrog river, Latorica river and Laborec river has been prepared in the stretch from the Hungarian border to Ižkovce weir. Data from gauging stations in Streda nad Bodrogom on Bodrog river, in Veľké Kapušany on Latorica river, in Horovce on Ondava river and Ižkovce on Laborec river have served as

hydrological data. Stream cross-sections with the placing the axis of the stream channel were created by the processing of topographic data. Boundary conditions (discharge and associate water level) resulting from hydrological data were the primary input for the mathematical model from which the subsequent variants of the navigable "Zemplín Waterway" might be derived. In this stage water levels have been studied for minimal and maximal navigation discharges. Border navigation water levels on the stretches of naturally navigable waterways are determined by the navigation discharges. Minimal and maximal navigation discharge is determined from curve crossing of discharge to a fixed percentage of excess (Tab. 2) (Hašková, Kamenský, 2008).
Under methodology of Danube waterway minimal discharge is defined as the discharge with 94% assurance of curve crossing of discharge. Maximal discharge is 1% of curve crossing of discharge.
Maximal navigation discharge on "Zemplín Waterway" is recommended to evaluate Q20% with regard to parameters of existing objects in Streda nad Bodrogom (Bridges). Curve crossing of discharge to gauge Streda nad Bodrogom is on Figure 2. According to this curve crossing of discharge on Bodrog river minimal navigation discharge is 28 $m^3.s^{-1}$ and maximal is 160 $m^3.s^{-1}$.

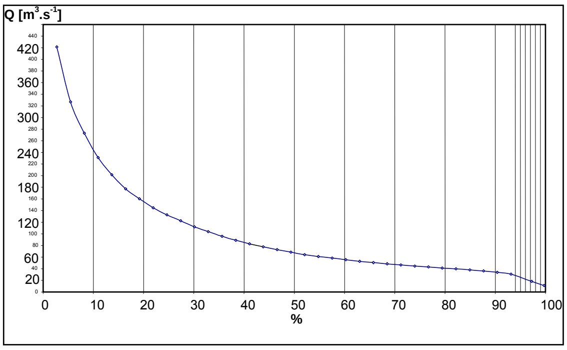

Fig. 2 Curve crossing of discharge to gauge the Streda nad Bodrogom (Bodrog)

Navigability of waterway depends on performance of parameters of fairway. Main parameters of fairway are:

1. Navigation depth; 2,8 m by low navigation water level, by planned draft 2,3 m,
2. Navigation width; by low navigation water level 45 m abreast of maximal draft,
3. Radius of fairway axis in the curve; is planned alternative – 800m, 650m, and 650m with exception 300m,
4. Navigation height under Bridges; is planned 5,25m, to parameters of Bridges in Streda nad Bodrogom is adapted temporary maximal navigation water level.

Due to consideration of a stream channel capacity we needed solution of water level regime. As navigation is possible only during usual hydrological situation (floods or dry periods are excluded) water level regime was counted for interval of discharges bounded by minimal or maximal navigation depth (Možiešik, Šulek, Cabadaj, 2008).

Tab.2 Basic values for calculating of the water levels

Value	stretch, profil	Navigation Discharge			
		minimal		maximal	
		Q	*m-day. / % of crossing*	Q	*m-day. / % of crossing*
Discharge (m^3s^{-1})	Bodrog	28.0	*343 / 94.0*	160.0	*70 / 19.18*
	Ondava	7.5	*230 / 63.0*	20.8	*93 / 25.55*
	Latorica	7.6	*330 / 90.4*	49.6	*78 / 21.35*
	Laborec	12.9	*280 / 76.7*	89.6	*49 / 13.43*
		water gauge			
Altitude (m a.s.l.)	Streda nad Bodrogom	94.21		96.39	
scale reading (cm)		277		495	
Navigation height (m)		7.58		5.40	
		water levels			
Altitude (m a.s.l.)	junction Latorica - Ondava	94.35		96.99	
	junction Latorica - Laborec	94.65		97.82	
	Laborec under weir Vojany	94.96		98.20	

A process of fairway project has been optimizing which based on analyse of water level flow of current state resulted into a modification of the water line and longitudinal bottom slope. The new draft of the fairway has resulted in a total of 10 variants of solutions that differed from each other directional solution riverbed and flow adjustments, a longitudinal gradient of the modified bottom of the river, location of its ports and Ladmovce weir. From the hydraulic point of view, these variants reduced to 7.
To solve the surface mode was used one-dimensional mathematical model HEC-RAS, where as a boundary condition were awarded flow (taking into tributaries) and elevation levels in the lowermost profile. Model formed the basis for geodetic survey topography flows from 2006/2007. The calibration model was carried out according to the current state of the

various stages of the measurement of transverse profiles. For each measured by trough cross-profile was focused level and connected to the system Balt elevation after settlement (BPV). Flow rates for the calibration of the model were determined statistically for each stage of gauging stations daily observations related cross-section measurement date. The data on the maximum deviation of the measured and calculated levels is obvious that the established model, notice the high value is mainly due to the current focus topography, was well calibrated. Based on the level regime addressing the current state of interest in the mathematical model were other possible options proposed solutions "Zemplín Waterway".

Several options of said fairways solutions – Bodrog, Latorica, Laborec have been projected. The main differences among them are minimal radius of fairway axis in the curve, location of harbour and realization of Ladmovce weir (see Tab. 3). These influence the length of modification of fairway as well as yardage of ground works (Hašková, Kamenský, 2008).

Tab. 3 Solution Overview alternatives

Variant	Minimal radius (m)	length of model (km)	number of profiles	average slope (‰)
0		36.0	301	0.0965
1 (4) *	650. except. 300	33.9	338	0.0725
2 (5) *	650	33.5	335	0.0740
3 (6) *	800	32.8	328	0.0664
7 $^{\Delta}$	650. except. 300	25.4	254	0.1090
8 $^{\Delta}$	650	25.1	251	0.1100
9 $^{\Delta}$	800	24.5	245	0.1510

* - identically variants from hydraulic point of view, different number and localization of ports

$^{\Delta}$ - variants with planned Ladmovce weir

Conclusion

Several variants of Bodrog river navigable have been projected within "Zemplín Waterway" where was necessary to set minimum and maximum water levels with regard to navigational parameters of the waterway and the safety of navigation. By the mathematical model HEC-RAS there were calculated simulation of water level regime for every each proposed option of solutions from minimal modification (recreational navigation) to extra large modification including vessels Europa IIb with the navigation opportunity to Vojany, harbour, Ladmovce weir and small hydro power plant.

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Evaluation of influence of acid mine drainage on surface water and sediment quality

Marián Holub, Magdaléna Bálintová, Eva Singovszká

Abstract

Acid mine drainage (AMD) belongs together with heaps and ponds to the negative effects of mining activities. The problem arises especially at the end of the mining and closure of mining area. This is the case of the mining areas between the villages Smolník and Smolnícka Huta in Slovakia. After the decrease in interest of pyrite and its cost increasing were deposits in 1990 closed. Subsequently, the mined area was gradually flooded and in 1994 were spotted the first intensive mining waters leakages. These are receiving through the shaft Pech from flooded mining works into the Smolník creek, where impact on local water and sediments quality. The contaminated sediments are gradually transported across the river Hnilec to a water reservoir Ružín. In this study the qualitative parameters of water and sediments sampled from 5 sites in the Smolník creek in years 2006-2011 are compared.

Keywords: Acid main drainage, heavy metals, sediment

Introduction

Discharges of acidic, highly mineralized water (AMD) belong to accompaniment of mining activities that have a negative impact on the environment. These phenomena are also observed in the Slovak Republic where mining activities have had a long tradition. The largest deposits in Spiš - Gemer Ore Mountains also include Smolník deposit. Original harvest was focused on precious metals and later switched to iron and copper mining. 29.12.1989 - gradual reduction of commercial components in the ore resulted to the cessation of mining after over 700 years.

The mine was flooded till 1994. In 1994 an ecological collapse occurred, which caused the fish-kill and the global negative influence on the environment. The mine-system represents partly opened geochemical system into which rain and surface water drain. That was the reason for starting a systematic monitoring of geochemical development in acid mine drainage in 2004 in order to prepare a prognosis in terms of environmental risk and use of these waters as an atypical source of a wide range of elements (Šlesárová et al., 2007, Luptáková et al., 2005, Špaldon et al., 2006, Singovszká, Bálintová, 2009, Bálintová et al., 2010)

The aim of this paper is evaluating the actual impact of AMD from shaft Pech (mine Smolník) on surface water and sediment quality in Smolník creek.

Materials and methods

In order to study the interaction between AMD and sediment, five sampling localities along the Smolník creek were chosen. Two localities were in the upper part of the Smolník creek without contamination by acid mine waters from shaft Pech (1 – outside the Smolník village, 2 - small bridge - crossing to the shaft Pech) and another two sampling localities were located under the shaft (4 – approx. 200 m under the shaft Pech, 5 – inflow to the Hnilec river). Also there was monitored the AMD quality from the shaft Pech (3 - shaft Pech-accumulated AMD water tank).

Sediment sampling localities are shown in Fig.1. The sample points were assigned serial numbers (S1 – S5). The chosen physical and chemical parameters were determined by multifunctional equipment METTLER TOLEDO in situ and chemical analyses of water and sediment samples were realized by AES – ICP method in accredited laboratory of State Geological Institute of Dionyz Stur Spišská Nová Ves.

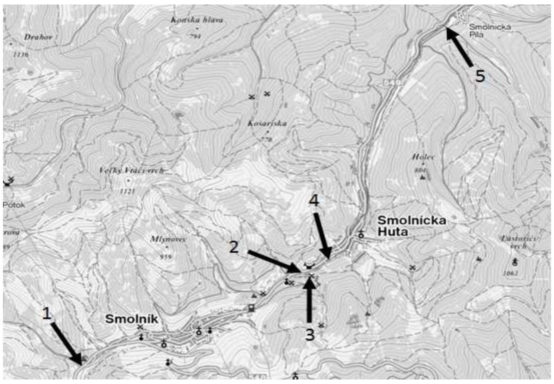

Fig.1 Sampling localities

Results and discussion

The results of chemical analysis of sediments (samples S1 - S5) in the Smolník creek in 2006 - 2011 are presented in Table 1.
The results were compared with the limit values according to the Slovak Act No. 188/2003 Coll. of Laws on the application of treated sludge and bottom sediments to fields. Surprisingly, only limits of arsenic concentration in all samples of sediments and concentration of lead in three samples were exceeded.

Tab.1 Results of chemical analyses of sediments from the Smolník creek and the shaft Pech in 2006 and 2011

No.	Year	pH	SO_4^{2-}	Ca	Mg	Fe	Mn	Al	Cu	Zn	As	Cd	Pb
		-	[%]						[mg/kg]				
S1	2006	5,4	<0,01	0,45	0,93	3,96	0,108	7,02	176	171	50	<0,5	50
	2007	6,0	<0,01	0,30	0,74	3,88	0,044	7,14	103	123	35	<0,5	39
	2008 A	5,45	<0,01	0,26	0,70	3,49	0,062	6,88	114	140	31	<0,5	44
	2008 B	5,46	<0,01	0,30	0,73	4,01	0,116	7,67	128	157	52	<0,5	43
	2009	5,52	<0,01	0,21	0,85	4,57	0,09	7,68	111	143	47	<0,5	35
	2011	6,29	0,07	0,36	0,81	4,92	0,12	8,08	148	179	52	<0,5	43
S2	2006	5,57	1,00	0,21	0,81	6,76	0,040	7,32	234	183	84	<0,5	82
	2007	6,58	0,4	0,22	0,73	5,70	0,051	6,76	282	186	88	<0,5	100
	2008 A	5,18	0,10	0,37	0,70	4,13	0,073	6,43	252	196	64	<0,5	89
	2008 B	5,58	0,75	0,14	0,72	7,27	0,051	7,21	237	180	104	<0,5	93
	2009	5,76	0,40	0,16	0,72	4,63	0,04	6,63	196	131	65	<0,5	59
	2011	6,17	0,12	0,32	0,79	5,83	0,08	6,77	467	273	81	<0,5	147
S3	2006	3,88	19,08	8,73	1,38	23,6	0,096	2,52	448	313	909	<0,5	135
	2007	4,11	14,01	0,09	0,21	39,7	0,012	0,46	215	58	1465	<0,5	38
	2008 A	4,01	8,80	0,03	0,72	34,6	0,022	4,01	689	150	2206	<0,5	1557
	2008 B	3,98	7,83	0,07	0,86	26,6	0,024	4,65	663	168	2439	<0,5	2731
	2009	3,94	14,12	0,10	0,21	37,4	0,01	0,74	143	45	1500	<0,5	48
	2011	3,97	10,9	0,12	0,44	33,0	0,02	2,37	756	128	1975	<0,5	1081
S4	2006	4,98	2,42	0,19	0,64	13,8	0,051	6,09	445	172	154	<0,5	172
	2007	5,76	0,96	0,40	0,83	12,3	0,084	6,46	903	328	253	<0,5	282
	2008 A	4,92	0,30	0,57	0,78	4,97	0,067	6,16	365	214	201	<0,5	328
	2008 B	5,26	1,21	0,19	0,80	8,90	0,048	6,84	295	172	161	<0,5	198
	2009	5,19	0,30	0,21	0,72	5,07	0,05	6,91	281	165	68	<0,5	101
	2011	5,1	0,36	0,27	0,80	5,42	0,06	6,54	363	191	92	<0,5	110
S5	2006	4,93	0,38	0,14	0,66	7,84	0,044	6,55	506	250	97	<0,5	111
	2007	6,17	0,29	0,25	0,83	8,82	0,057	6,29	661	320	146	<0,5	159
	2008 A	5,34	0,27	0,32	0,79	6,24	0,068	6,39	404	193	135	<0,5	176
	2008 B	5,2	-	0,17	0,44	13,2	0,045	7,26	527	192	83	<0,5	106
	2009	5,4	4,90	0,08	0,27	31,7	0,03	2,62	836	200	84	<0,5	15
	2011	5,16	0,32	0,32	0,79	5,73	0,07	6,71	427	242	93	<0,5	117
Limits			-	-	-	-	-	-	1000	2500	20	10	750

The results of chemical analysis of water samples (S1 - S5) in the Smolník creek in 2006 - 2011 are presented in Table 2.

They were compared to the limit values according to the Regulation of the Government of the Slovak Republic No. 269/2010 Coll. stipulating the requirements for a good water stage achievement. Based on the results in Table 2. we can state that acid mine drainage flowing from the shaft Pech has an adverse effect on the surface water quality in Smolník creek and causes exceeding the limit values according to the Regulation of the Government of the Slovak Republic No. 269/2010 Coll. From chemical analysis follows, that AMD exceeds each evaluated indicators, with the exception of Ca. After AMD dilution with surface water in the Smolník creek, the concentrations of Fe, Mn, Al, Cu, Zn are exceeded, too.

Tab.2 Results of chemical analyses of water from the Smolník creek and AMD from the shaft Pech in 2006 and 2011

No.	Year	pH	Ca	Mg	Fe	Mn	Al	Cu	Zn	As	Cd	Pb
		-	[mg/L]					[µg/L]				
1	2006	5,4	10,9	3,64	0,05	0,01	0,02	4	2	2	<0,3	<5
	2007	6,0	9,51	3,48	0,07	0,01	0,05	2	6	1	<0,3	<5
	2008A	5,45	9,1	3,31	0,06	0,01	0,12	2	5	<1	<0,3	<5
	2008B	5,46	10,6	3,69	0,7	0,01	<0,2	<2	3	1	<0,3	<5
	2009	5,52	10,1	3,56	0,06	0,01	0,02	<2	3	2	<0,3	<5
	2011	6,29	12,4	3,94	0,038	0,015	<0,02	3	4	<1	<0,3	<5
2	2006	5,57	15,5	7,19	1,72	0,30	0,03	12	134	<1	<2	<5
	2007	6,58	11,1	4,45	0,79	0,09	0,28	12	25	<1	<0,3	<5
	2008A	5,18	11,3	6,03	3,0	0,28	0,18	14	82	<1	0,4	<5
	2008B	5,58	13	5,27	0,62	0,12	0,12	9	38	<1	<0,3	<5
	2009	5,76	13,9	6,43	1,34	0,27	0,74	34	93	<1	<0,3	<5
	2011	6,17	13,8	4,36	0,351	0,065	0,09	11	17	<1	<0,3	<5
3	2006	3,88	176	344	463	36,5	107	3263	12600	18	15	71
	2007	4,11	166	295	433	32,2	79,8	1379	8958	20	27	56
	2008A	4,01	170	264	291	22,5	53,9	1311	6750	50	14,9	59
	2008B	3,98	158	242	392	28,5	69,7	1642	7665	30	21,5	56
	2009	3,94	176	258	351	28,4	67,6	1740	7250	50	14	61
	2011	3,97	151	265	312	25,8	75,3	1700	7996	6	17,8	52
4	2006	4,98	31,9	33,2	31,8	2,7	2,03	203	923	1	<2	<5
	2007	5,76	18,3	13,0	108	0,96	0,61	14	187	<1	0,3	<5
	2008A	4,92	17,9	12,5	4,93	0,78	4,14	384	338	1	0,7	<5
	2008B	5,26	23,2	17,6	16,8	1,32	0,13	50	383	1	1,5	<5
	2009	5,19	23,4	20,2	18,8	1,84	4,15	97	379	3	0,7	8
	2011	5,1	28,3	24,5	19,8	1,89	1,33	164	655	<1	1,9	<5
5	2006	4,93	28	26,9	17,8	2,22	2,46	207	757	1	<2	<5
	2007	6,17	17,7	117	5,38	0,73	0,12	7	176	<1	0,5	<5
	2008A	5,34	11,5	6,18	2,52	0,30	0,32	14	68	<1	<0,3	<5
	2008B	5,2	23,7	16,8	1,11	1,21	0,02	42	349	<1	<0,3	<5
	2009	5,4	23,3	16,4	10,5	1,3	0,43	31	280	<1	0,5	<5
	2011	5,16	28,9	22,0	11,8	1,56	0,35	120	491	<1	1,1	<5
Limits		6-8,5	200	100	2	0,3	0,2	20	100	30	5	20

Conclusions

Smolník deposit belongs to many localities in Slovakia, where the unfavourable influence of acid water on the surface water can be observed. From the measured data we can conclude that AMD has a direct negative impact on water quality and sediment quality in the area.
AMD discharged from abandoned mine Smolník (shaft Pech) contaminates the downstream from the Smolník mine works to confluence of the stream with the Hnilec river, because of decreasing pH and heavy metal production. This fact was confirmed by exceeding the limited values of followed physical and chemical parameters in water and sediments in Smolník creek according to Slovak legislation.
The variability of pH also influences the sediment - water partitioning of heavy metals (e.g. Fe, Cu, Zn, Al, Mn) in Smolník creek polluted by acid mine drainage from shaft Pech, that has been confirmed by presented results.
In the longer term, we can conclude that the concentration of metals in water flowing out from the shaft Pech gradually decreases. Spot growing of concentration in individual years can explain the change in hydraulic regime due to differences in rainfall. These hydrological changes do not have substantial effect in changing the pH of the water flowing from the shaft.
Because AMD generation at the Smolník locality is not possible to stop and there is no chance of self- improvement of this situation, it is necessary to respect this fact, monitor the quality of these waters and develop treatment methods.

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Influence of the entered geometry to the water level regime calculation

Zuzana Šebestová, Lea Čubanová

Abstract
The article is presenting water level regimes simulations computed by the mathematical software HEC-RAS with different entered geometry of the river bed, for the steady state and results (water level regimes) were compared. Outputs show the possibilities to simplify some components of the river bed geometry without negative results influence.

Key words:
HEC-RAS, water level regime, river bed geometry

Introduction

Mathematical modeling utilization for various computations is very common nowadays. One-dimensional models are the most available and for the inputs at least data-intensive. Inputs are river bed topography expressed by the river bed geometry and boundary conditions specified for the certain type of the flow simulation. Geometry is entered by the measured cross sections (or subtract from the river map), which are embedded in certain stationing on the river reach and the roughness coefficients express materials in the river bed, on the banks or in the inundation.

Material and methods

For the simulation of the water level regimes by the different set geometry was used HEC-RAS software, version 4.1 (Hydrologic Engineering Center – River Analysis System), which was created by U.S. Army Corps of Engineers, and free download is on the web page:
http://www.hec.usace.army.mil/software/hec-ras/hecras-download.html

The U.S. Army Corps of Engineers´ Analysis System (HEC-RAS) is software that allows you to perform one-dimensional steady and unsteady flow river hydraulics calculations, sediment transport-mobile bed modeling, and water temperature analysis. The HEC-RAS system contains four one-dimensional river analysis components for: steady flow water surface profile computations, unsteady flow simulation, movable boundary sediment transport computations and water quality analysis (HEC-RAS User´s manual).

Steady flow component is capable of modeling subcritical, supercritical and mixed flow regime water surface profiles. The basic computational procedure is based on the solution of the one-dimensional energy equation. Energy losses are evaluated by friction (Manning´s equation) and contraction/expansion (coefficient multiplied by the change in velocity head). The momentum equation is utilized in situations where the water surface profile is rapidly varied. These situations include mixed flow regime calculations (i.e., hydraulic jumps), hydraulics of bridges and evaluating profiles at river confluences (stream junctions). The effects of various obstructions such as bridges, culverts, dams, weirs and other structures in the flood plain may be considered in the computations (HEC-RAS User´s manual).

After cross section data entering it is possible to add bridges or culverts according to the river bed topography. HEC-RAS computes energy losses caused by the structures as bridges (culverts) in 3 parts. The 1st part consists of losses that occur in the reach immediately downstream from the structure where an expansion of flow takes place. The 2nd part is the losses at the structure itself, which can be modeled with several different methods. The 3rd part consists of losses that occur in the reach immediately upstream of the structure where the flow is contracting to get through the opening. The bridge routines in HEC-RAS allow analyzing a bridge with several different methods without changing the bridge geometry. The bridge routines have the ability to model low flow, low flow and weir flow, pressure flow, pressure and weir flow, and high flows with the energy equation only (HEC-RAS User´s manual). The bridge influence must be considered by the entering of contraction and expansion coefficients in the cross section data of the geometry. Contraction and expansion losses are described in terms of coefficient times the absolute value of the change in velocity head between adjacent cross sections (HEC-RAS User´s manual).

Results and Discussion

It was defined the river reach described by the 24 cross sections. The length was 319.4 m and in the two thirds of the modeled reach was a bridge. The average cross section density was 13.3 m and average river bed slope was 2.47 ‰. Difference in river bed bottom elevation upstream and downstream of the river reach was 0.79 m.

The task was to calculate the rating curve nearly at the end of the modeled reach (it is because the rating curve will be not affected). Modeled river reach has nonprismatic trapezoidal cross section, average river bed width in the bottom is 15 m (mostly it is a simple trapezoid, in some cross sections was partially compound). In the 0.1985 km the bridge with 3 piers was considered, but

modeled was just 1 pier inside the river bed (by the left heel of the bank), two other piers are situated outside the modeled reach. Influence of the existed bridge was considered by the entered coefficients of contraction and expansion recommended for the bridges (typical bridge sections – contraction 0.3 and expansion 0.5) (HEC-RAS User´s manual). The modeled river reach is regulated with dikes on the both sides of the river. The Manning roughness coefficient expresses material inside the river bed and on the banks also. It was selected n = 0.030 - dry rubble, earth bottom and gravel sides (Raplík a kol., 1989).
It started with modeling of the available geometry, but it was not complete or very old information about the bridge. Therefore the bridge was primary entered by simplification as cross section shape and also for verification as the obstructions possibility in the 2 cross sections, which bounded the bridge position (Fig. 1, 2).

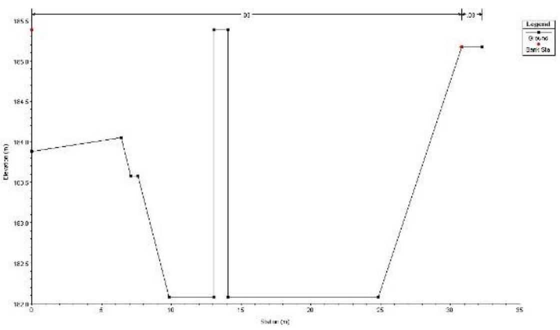

Fig. 1 Bridge simplification as cross section shape

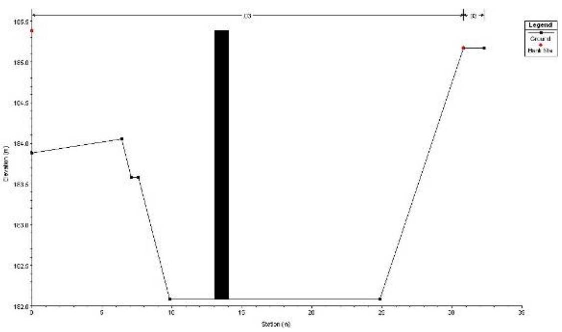

Fig. 2 Bridge simplification as obstruction in the cross section

Boundary condition for the water level regime calculation by the nonuniform steady state was entered a rating curve of the chute at the downstream end (beginning) of the modeled river reach. Consequently the water level regimes for both geometry data (bridge as cross section shape and as obstruction) were compared – the water levels were the same (Fig. 3).

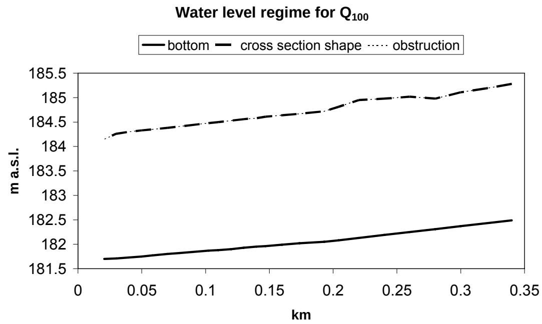

Fig. 3 Water level regimes comparison for different entered geometry data of the bridge

Later the bridge was newly geodetic measured and therefore it was correctly entered to the model (Fig. 4).

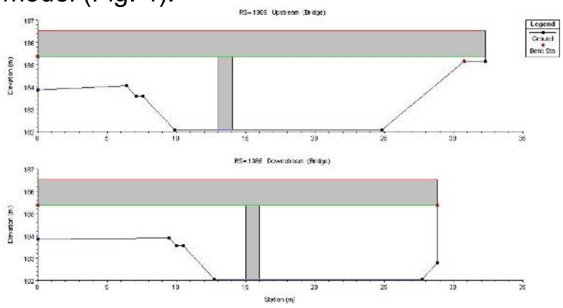

Fig. 4 Bridge entered in HEC-RAS

It was chosen computational methods for low and high flow simulation (by HEC-RAS predefined methods). Boundary conditions were the same like for the previous simulations (rating curve of the chute). The water level regimes were simulated (Fig. 5). Added cross sections (interpolated from the existed cross sections) in the bridge area should be no influence on the water level regimes. In our case, bigger concentration of the cross sections near the bridge only in more detail describe the water level regime behind the bridge, but it has no influence on the rating curve nearly at the end of the modeled geometry.

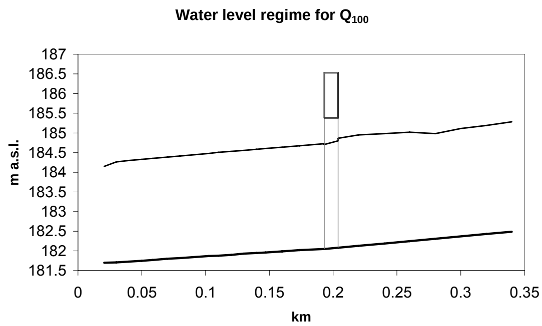

Fig. 5 Water level regime for geometry data with properly entered bridge

By the water level regimes comparison for the different entered bridge data were determined these maximum deviations (bigger depths in cross section immediately behind the bridge for the geometry with properly entered bridge):

- for Q_1 it was 1 cm
- for Q_5 it was 3 cm,
- for Q_{20} it was 4 cm,
- for Q_{100} it was 6 cm.

But the task was to calculate the rating curve in the semifinal cross section of the modeled area, these curves were also compared. All rating curves were the same.

Of course this knowledge is affected by the very simple bridge geometry, as well as its adequate capacity (pressure or weir flow did not occur, the bridge was not overflowed) and by the regulated river bed.

Conclusion

From the described simulations result that by the water level regimes simulations in the one-dimensional model is possible to simplify some geometry inputs without negative results influence.

This information is useful, when we need to know results very quickly or the input data are not appropriate.

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Proposal of a siphon for water supply of the Rusovce arm

Andrej Pršo, Peter Šulek, Ján Rumann

Abstract

Bratislava intends to contribute to the revitalization of channel Rusovce – Čunovo and its surrounding by creating potential opportunities for a stable water supply. Channel Rusovce – Čunovo will be flow-through by constant flow rate Q = 1,50 m^3s^{-1}, which will be taken from the polder area on the right side of the reservoir Gabčíkovo. Technically, the simplest way is transportation of water over the dam against the flood on the Danube through the siphon. Siphon object may consist of one or several lines. Ultimate solution to ensure water supply of Rusovce arm is the possibility to construct the filling object in dam reservoir Čunovo.

Key words:

Siphon, inlet pool, airproof pipe, riverbed, the underground tank.

Introduction

Channel Rusovce – Čunovo has already been built earlier to lead away the inside water and for the landscaping around the mansion in Rusovce. When the mansion was constructing the remnants of old Danube arms were effectively used. Therefore the route leads partially through the remains of the original right-branch system and sometimes is used the name Rusovce arm accordingly. In the past, after the construction of flood dam line on the right bank the channel was supplied by water from the Danube, while the inflow was regulated by the object in the 8,00 km of the old Danube dam. This section has already been built up during the reign of Maria Theresa in the second half of the 18th century. During high water levels in the channel excess water was drained into the Danube riverbed near the village Čunovo.

Materials and methods

Siphon can be defined as short hydraulic hermetic pipe which can transport water without usage of pump across the barrier that is situated higher than the water level in the inlet pool.

Supply of water to flow into the siphon

The old dam does not meet the original flood protection function any longer and this fact allows to improve the initial conditions for the operation of a siphon to supply Rusovce arms by possibility of zooming into the inlet pipe close to the buffer zone on the upstream side of the reservoir dam Čunovo (Fig. 1).

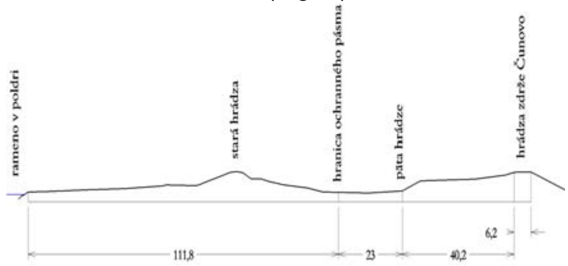

Fig. 1 Crosscut through the ground in front of the water side of the Danube dam

The inlet pool is needed for siphon and also for the object to fill the Rusovce arm. This pool should be located close to the boarder of the protective zone of reservoir dam Čunovo.

Inlet object to siphon pipe

I propose to build up Čunovo inlet pool in front of the protective zone of the reservoir dam, which will be directly connected to the Danube in order to achieve a relatively stable conditions to ensure the necessary quantity of water to siphon or to object filling the channel Rusovce – Čunovo. Suitable connecting element might be as appropriately sized pipe profile. The connecting pipe should be designed to ensure that there are not too large energy losses at water flow. In such case the water level in the inlet pool would follow the level in river only with little delay in profile to the inlet pipe on the right bank of the Danube riverbed at about the field of 1858,5 km. Flow of the water would be streaming in the connecting pipes which would be taken by siphon or filling object from the inlet pool ($Q \approx 1,5$ $m^3.s^{-1}$). After discontinuing of offtake to Rusovce arm if operation of siphon would be turned off or object would be blocked water levels in the Danube and in the inlet pool would be equalized like water levels in connected containers. Whole profile has to be below the minimum water level in the inlet pool. This is necessary, but not sufficient condition for vertical positioning of inlet to the siphon pipe. The inlet to the siphon should be strictly protected by screenings against entering of various objects into the pipeline. The shape of the inlet to the siphon should be constructed in order to reduce the energy losses of water. In fact the hydraulic loss in the inlet consists of two partial losses. First partial inflow loss occurs immediately when water leaks into the water pipes, where the stream narrows first. Behind the input profile may occur streamline separation from the wall under certain conditions which causes the creation of local vortex zones. The second partial inflow loss occurs in certain distance behind the inlet profile, where a narrow water jet extends to the entire area of the profile of the pipeline.

Closures of the inlet and outlet from the siphon
For installation of a siphon into the operation there are usually used two technological methods: 1 – Siphon pipe closes by closures in inlet and outlet and the siphon will be filled with water through the valve in the top B. The valve in the top is closed after filling the pipe, the closure in inlet will be opened and subsequently the closure in the outlet and then water begins to flow in the pipeline in a consequence of the force. 2 – The air is sucked through the valve at the top of the siphon. This creates a vacuum in the siphon and the whole area of pipeline will be filled by the effect of the air pressure on the water levels in connected pools and the water begins to flow without additional pulses. Using such technological methods of installation of the siphon into active operation there is no need to use closures of the inlet and outlet. This does not increase the local losses in the pipeline related to flow losses through the profiles of closures.

Structural design of the siphon
Construction of the outlet pool from the siphon behind the right-sided seepage channel we consider as the best solution in the given circumstances. We assume that the object of the siphon outlet could be located approximately 2 m from the right bank of the channel seepage. Pipe siphon would fall under the water level in the underground tank. Water from the underground tank would drain out through the connecting pipeline of the large enough profile in regime of flowing with free surface directly into the arm Rusovce - Čunovo. Underground tank (outlet pool) and the connecting pipeline will have to be designed to not trigger the excessive losses of energy flowing water, to not surge water level in the outlet pool uselessly and therefore to not reduce the slope of the siphon. Between the water level in the outlet point of the connecting pipeline to Rusovce arm and the water level in the outlet pool should be kept a minimum height difference. The hydraulic calculation of the siphon must contain hydraulic losses incurred by the friction and also all local losses. Energy losses by the friction are caused by the friction of water on the pipeline walls and the internal friction between the particles of water which pulse irregularly also in the transverse direction in a turbulent flow regime along the dominant longitudinal movement. Hydraulic literature contains many formulas to calculate the size of the coefficient of friction losses λ. Most of the equations, which are considered to be relatively reliable in hydro-practice, were derived based on the evaluation of experiments in hydraulic laboratories, while the artificial homogeneous roughness of the pipelines was commonly used. Wall roughness in the technical pipelines is considerably irregular. At first the water spins behind the largest projections on the surface of the wall. But when the speed of streaming increases, then the number of vortex fields expands at the walls of the pipelines and their scope is extending. These facts in comparison with laboratory homogeneous pipeline roughness are shown in the form of slightly continuous fall of the loss coefficient by friction λ and by increase of the size resistance.

Results and Discussion
For proposed water level conditions: inlet pool H = 129,65 m n. m.; outlet pool H = 128,58 m n. m. we determined all parameters of flowing for siphons by hydraulic calculation. Their averages were chosen from averages of pipelines according to standard product range of pipes from the high density linear polyethylene (HDPE): D = 200; 315; 355; 400; 450; 500; 560; 630; 710; 800; 900 a 1000 mm. Siphon should be transported into channel Rusovce – Čunovo flow Q ≈ 1,5 $m^3 \cdot s^{-1}$ under the suggested water level conditions. We can select some from the following alternatives (HDPE): 3 pipelines with average D = 630 mm and flow Q = 3·0,627 = 1,881 $m^3 \cdot s^{-1}$; 10 pipelines with average D = 355 mm and flow Q = 10·0,158 = 1,580 $m^3 \cdot s^{-1}$; 40 pipelines with average D = 200 mm and flow Q = 40·0,038 = 1,512 $m^3 \cdot s^{-1}$.

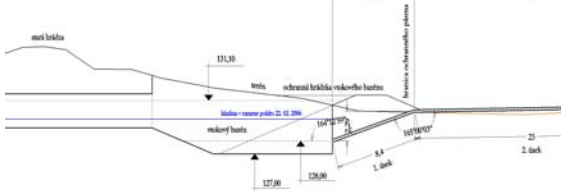

Fig. 2 Diagram of the inlet pool, 1. and 2. part of section for siphon pipe

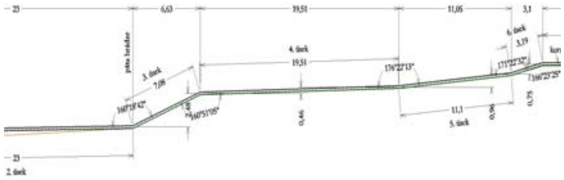

Fig. 3 Part 2. and 3 – 6. of section for the siphon pipe

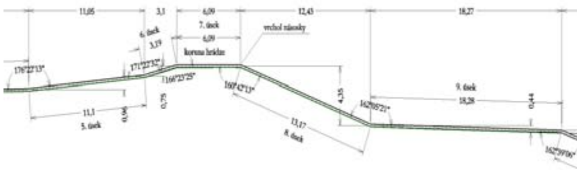

Fig. 4 Part 5. – 9. of section for the siphon pipe

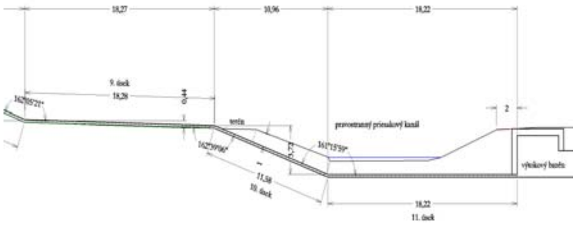

Fig. 5 Diagram of 9. – 11. section for the siphon pipe and exit to outlet pool

Conclusion

Siphon can be defined as a hydraulically short airproof pipe, which can transport water without help of a pump over an obstacle situated higher than the water level in the inlet pool. To create stable hydraulic conditions it is necessary to build an inlet pool before the siphon. After the siphon outlet we suggest to build an outlet pool (Fig. 5). Our proposal of the pipe counted with the material of highly dense linear polyethylene (HDPE). The pipe will secure for reliable operation of the siphon. The diameter of the pipe was chosen according to the standard production line of pipes from highly dense linear polyethylene (HDPE): D = 200; 315; 355; 400; 450; 500; 560; 630; 710; 800; 900 a 1000 mm.

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