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AN INTERACTIVE MAP OF MOUNTAIN RIVER HYDROMORPHOLOGICAL DIVERSITY – CASE STUDY

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Summary

New means and forms of media develop dynamically in the contemporary world. Field researches results do not have to be popularized only in text or tabular static elaborations forms. Widely available computer techniques and tools can be used to their presentation equally well. They enable creating internet applications which make interaction with a user possible through various components.

The aim of the paper is to present topic internet conception of a map which shows mountain river's hydromorphological diversity on the example of Wieprzówka stream. Project assumes spatial relation of objects observed in the field by means of geographic coordinates plotted on the interactive globe's map. Its informative and multimedia character was presumed in the map's project.

Field tests the results of which were presented on the map were performed within the frames of initiative to create given watercourses base proposed by the international ecological organization called in short WWF (World Wide Fund for Nature) and Poznań University of Life Sciences.

Keywords

RHS method • mountain river's hydromorphology • internet cartography

1. Introduction

Rivers and streams' beds are particularly sensitive elements of river systems in Poland [Korpak et al. 2008]. In XXI century, Little Beskids rivers were subjected in many fragments to considerable anthropogenic impact on the environment. Anthropogenic changes can be very intensive and dynamic and with results often difficult to predict. To evaluate these changes' scale is not easy because in many areas anthropogenic factors affect omnidirectionally [Szwalec et al. 2007]. This influence has got complex character and far-reaching consequences [Wyżga et al. 2008].

In many Little Beskids rivers' fragments, riverbeds' systems are being interfered by not always reasonable technical regulation and also debris's exploitation. Riverbeds' narrowing was observed in fragments of watercourses subject to regulative works and human interference in a riverbed often caused that natural multi-thread simple river-

beds were transformed into one-thread ones with an even bottom and reinforced banks [Bojarski et al. 2005; Wyżga 2008]. Riverbeds regulation as well as debris material loss often caused bottom erosion and quick regression of river bottoms. Beds capacity increase and radical decrease of possibility to contain bankfull water in flooding areas resulted in growth of flood danger in the lower rivers fragments [Bojarski et al. 2005, Wyżga 2008]. These phenomena had to be minimized by damming up barrages which, however, caused watercourses permeability loss for fish [Bojarski et al. 2005].

Problems of protection from flood and riverbeds erosion have got global character. Negative phenomena connected with interference in watercourses run were also noticed in mountain European regions [Habersack and Piégay 2008]. Wyżga and co-authors [2008, p. 275] underline that "*interference in a riverbed also leads to loss of vertical riverbeds stability and radical decrease of biodiversity of fluvial and riverside ecosystems*". Therefore, numerous activities are performed to restore natural watercourses' profiles including riverbeds morphology, flow regime, and biodiversity of fluvial and riverside ecosystems [Nachlik 2005].

In the light of presented deliberations, permanent monitoring of anthropogenic impact on the environment degree in riverbeds and catchment area as well as its influence on natural environment are reasonable. Field researches results can be gathered in database of spatial information system [Król and Salata 2013] and presented in the form of an interactive map of spatial phenomena.

Internet applications can be successfully used to present surface waters and their catchment area profiles [Stachura et al. 2014a]. It can comprise a kind of fulfilling to field researches [Król and Szomorova 2015]. Their publication can influence increase of ecological consciousness as well as local societies focus on environment protection and shaping aspects [Stachura et al. 2014b, Król and Bedla 2015]. Various techniques and numerous computer tools including internet applications can not only serve to promote and inform but also collect opinions and comments of residents which can contribute to identify local environmental problems.

The aim of the paper is to present a project of topic internet map showing mountain river hydromorphological diversity on the example of Wieprzówka stream and to identify natural conditions that occur in its chosen fragments. Moreover, profile of chosen techniques and computer tools that can be used to create topic maps with use of open data sources and free software were presented in the paper.

2. Network application – project assumptions

Common access to open data resources and appearing of different geo-information tools including API (Application Programming Interface) programistic interfaces gave rise to internet cartography and formed the mainstream of "geographic information created by users" (VGI – Volunteered Geographic Information) [Goodchild 2007]. This trend reflects state of opinion and social changes that lie "*at the bottom of values and social attitudes*" within the frames of inhabitants' approach to spatial phenomena occurring in their contiguity [Kostecka 2010]. Animation in the range of shaping and

strengthening of civil attitudes, developing and supporting of any initiatives that look for new ways of reconciling development of civilization with concern for natural environment can be noticed in the society [Sporek 2008, Hull 2008]. Great involvement of local societies in protection and promoting ecological space values can be observed in the last years. As a result of urban processes, most of human population of the world lives nowadays in cities. However, most often ecological consciousness of people comes beyond and over reality formed by things [Kostecka 2010]. Environmentally friendly initiatives can be realized by little research projects, spontaneous actions, often initiated in social media as well as information placed in the Internet in the form of web sites, blogs or topic maps [Król and Bedla 2013].

The main project assumption was to create interactive presentation of location of chosen hydromorphological points of Wieprzówka river in tested fragments with use of widely available computer tools and techniques as well as databases. The application's task was spatial reference and presentation of research results. This aim will be realized by text description and also graphics and photographs joined with POI points (point of interest, pushpin) marked on an interactive map according to geographic coordinates.

To create map application, data made accessible within the frames of OpenStreetMap (OSM) project were chosen. OSM is one of the best known and dynamically developing VGI projects. Its imperative aim is to deliver ready maps and "*rare geodata to all who need them*" [OSM 2015].

OSM map is a social project created by users from all over the world on the basis of data gained from various sources including own GPS measurements, air photos and others [Cichociński 2012].

OpenStreetMap databases are made accessible within the framework of the open licence ODbL (Open Data Commons Open Database License). It is the licence of "*authorship recognizance*" type, "on the same conditions" (attribution, sharealike). The licence enables redistribution, modification and usage of data with maintenance of the same liberties for the other users.

Leaflet library [2015] (BSD License, GPL – compatible free software licenses) was chosen to map POI points. Leaflet is the JavaScript library published in 2011. The tool supports creating internet maps and is placed next to OpenLayers and Google Maps API in the group of the most popular mapping JavaScript libraries. Leaflet's popularity results most of all from great efficiency and simple API and its usage does not need from a user advanced knowledge from the range of GIS spatial information systems [Donohue et al. 2014].

3. Tested object's profile

Wieprzówka is a mountain stream with length of about 28 km with special natural and landscape values. The watercourse flows in Rzycka Valley where numerous streams and brooks enter. Most of them carve deep and long valleys similar to ravines [Znikow 2001, Michalec et al. 2007]. The stream flows through such places as among others: Andrychów, Wieprz or Gierałtowice (wadowicki district, Małopolska). In Grodzisko

it flows into Skawa river forming one of its bigger left tributaries. The river is drinking water intake for Andrychów inhabitants.

The stream's sources are placed on the height of over 880 m asl. In Wieprzówka water supply system, the surface type prevails as its share is estimated at about 80% and the watercourse's bottom is covered with coarse-grained bottom material composed mainly from stone and graveled fractions [Książek et al. 2007].

Wieprzówka is an example of a mountain river which in the course of last dozen years was put to strong though spatially diverse anthropogenic impact on the environment. The river is characterized by numerous hydromorphological elements including billowses, waterfalls and plunge pools that occur in particular in the mountain fragment over Andrychów where interference in natural character of the watercourse is limited. In its lower fragment below Andrychów, the watercourse receives low-lying character [Zieliński 2003].

4. Field researches

Hydromorphological tests of Wieprzówka river were performed in June and September 2014 on six fragments (two tests in three locations), below and in Andrychów town (Table 1). The works were performed within the framework of social initiative proposed by international ecological WWF organization (World Wide Fund for Nature) and Poznań University of Life Sciences. The initiative presumes to prepare database of watercourses or their fragments and to include that database in the process of elaboration of key documents from the range of water management. The example of such documents can be water management plans in the basins' areas or plans of water maintenance [Ustawa... 2001].

Table 1. Tested Wieprzówka fragments' profile

Fragment	Fragment's beginning coordinates	Fragment's end coordinates	Riverbed's width [m]	Fragment's length [m]	Threads' number	Number of point bars / middle bars
$W_{1/1}$ $W_{1/2}$	49,834149N; 19,368339E	49,834592N; 19,367706E	12–13	50	1	2
$W_{2/1}$ $W_{2/2}$	49,838294N; 19,355196E	49,838757N; 19,353136E	21–44	50	1–2	2–1
$W_{3/1}$ $W_{3/2}$	49,851958N; 19,338931E	49,853079N; 19,337686E	12	50	1	1

Source: authors' study

Wieprzówka was chosen because of its diverse hydromorphological and natural character and social functions including its landscape and tourist ones. The river in its fragments preserved many environmentally valuable morphological elements including various accumulative forms (sand bars and gravel bars), bank erosion (a bank cut) and multi-thread fragments [Szoszkiewicz et al. 2012].

In the tests, focus was put on river's hydromorphological conditions evaluation as its fragments are very diverse. Particular attention was paid to natural morphological elements (bars, bank cuts, multi-thread) and transformations within banks and riverbeds (Fig. 1). Conducting research, elements of anthropogenic origin were also catalogued including bridges, banks and riverbeds' strengthening, banks profiling and others.

Together with changes of natural character of watercourses the reason of which is seeked in keeping endeavours and regulations of their flow, the trials were started to elaborate methods valorizing their state [Frankowski 2011]. Gebler and Jusik [2012, p. 4] state that [quote] "*only ecosystem approach to waters estimation that contains a row of biotic and abiotic elements will allow to know properly processes occurring in fluvial systems*". In the field tests, the Polish adaptation of the British method of ecomorphological valorization called River Habitat Survey (RHS) was used [Raven et al. 1998a, 1998b, Environment Agency 2003, Szoszkiewicz et al. 2012]. Works over RHS method were carried out within the European programme STAR (Standardization of River Classifications). Its aim was to standardize research procedures and by that to receive comparable evaluation of European rivers' ecological state [Bis et al. 2005].

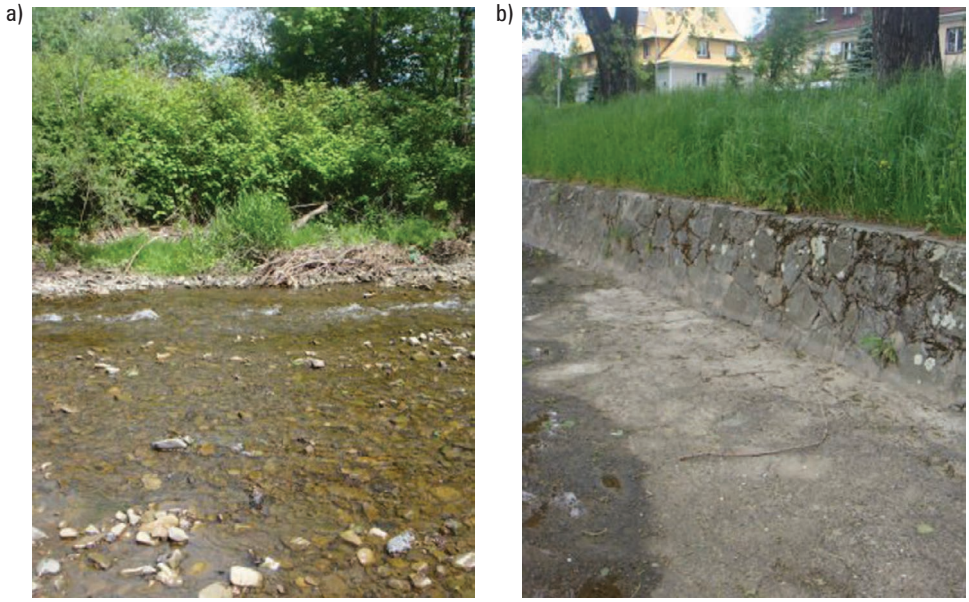
RHS is rivers' ecological state evaluation system with reference to their hydromorphological causations. This method is widely used in Great Britain and also in Germany, Sweden, Denmark, Czech Republic, Latvia and also in modified version in Italy, Greece and Portugal [Szoszkiewicz et al. 2005, Bielak et al. 2012]. The method gains popularity in Polish scientific centres as well [Frankowski 2011, Osowska and Kalisz 2011, Raczyńska et al. 2012, Spieczyński et al. 2013].

Description of river environment in RHS system can be used in statistic analyses and the method allows to classify and lead watercourses monitoring. Moreover, the method is precise, relatively simple in usage and does not need much financial investments. It is successfully used in local endeavours devoted to river valleys protection, watercourses restoration, monitoring as well as in researches of various kind [Trząski and Mana 2008]. Results collected in such a way were put to analysis and presented in the map's application form.

Results of field tests were used to calculate HMS factor (Habitat Modification Score). This factor determines total degree of anthropogenic changes in rivers hydromorphology and allows to present in numerical way the range of river habitat's changes made by human beings [Wasilewicz and Oglęcki 2006]. HMS factor takes watercourse morphology transformations range into consideration including:

- banks transformations evaluated in control profiles (strengthening, profile, retrenchment, multilevel bed, scarp trampling),
- riverbed transformations also estimated in control profiles (strengthening, profile, bars/dams, fords, culverts),
- transformations evaluated in the whole tested fragment which were not stated in control profiles (number and kind of water buildings, strengthenings, profiles and bank scarps rampart),

- the other transformations (water relation disturbance by dams, banks shift, waterbed realignment, widening and deepening, plants carving [Trząski and Mana 2008].



Photos by Dawid Bedla 2015

Fig. 1. Fragments $W_{1/1}$ and $W_{1/2}$, a) Wieprzówka thread, b) riverbed with concrete bottom and concrete bank reinforcements

HMS factor assumes value from the range from 0 to 100 points. Low values of HMS point at the lack or slight transformations of watercourse hydromorphology, whereas high ones testify to strong anthropogenic impact on the environment.

5. Field researches results and conclusions

First two sections of Wieprzówka river are characterized by similar (low) transformations within the riverbed and banks, hence total HMS values are similar (Table 2). For the test fragment limited with $W_{3/1}$ and $W_{3/2}$ sections, the highest values of habitat modification score factor were stated which testifies to the greatest anthropogenic impact on the environment among tested sections. It is the one that flows through Andrychów town where: two culverts (16 points), banks (2 points) and the riverbed strengthenings (2 points), banks/bottom profile (1 point), two bridges beyond control profiles (2 + 2 points), two culverts beyond sections (16 points), two damming buildings (2 + 2 points), backwater as a result of damming building's presence (1 point) as well as strengthening of the whole bank's profile (3 points) were stated in research profiles.

The result of regulated fragment's valorization was in total 49 points (per possible 100), whereas in natural sections these values were 6 and 7 points (non-transformed fragments) (Table 2).

Table. 2. Evaluation of Wieprzówka river habitat's transformation – HMS factor

Tested fragments	Estimation of modification in control profiles	Estimation of modification beyond control profiles	Total HMS
$W_{1/1}$ $W_{1/2}$	2	4	6
$W_{2/1}$ $W_{2/2}$	4	3	7
$W_{3/1}$ $W_{3/2}$	16 + 2 + 2 + 1 = 21	4 + 16 + 4 + 1 + 3 = 28	49

Source: authors' study

Gained points evaluation allows to conclude that despite considerable anthropogenic transformations observed in the area of tested fragments, their spatial diversity as well as relatively rich river-side flora create potential for rebuilding of river ecosystem.

6. Form and result of application's introduction

The map and application menu were written in the frames of HTML (HyperText Markup Language) hypertext document in the range of HTML5 specification [W3C 2015]. Particular application's components were formatted by means of cascading style sheets CSS (Cascading Style Sheets). The whole was placed on the data server as a web page.

Source: authors' study based on OpenStreetMap

Fig. 2. Map application "Chosen hydromorphological conditionings of Wieprzówka" fragment

Four kinds of POI points according to accepted division: road bridges, bars, footbridges and rock outcrops were mapped. Every kind of object was marked with a separate icon prepared in the form of PNG file. Icons were connected with text description and also graphics to characterize the given object (Fig. 2). The map created in such a way is elastic in edition and development and has got all features of internet dynamic maps as well (objects' symbols and descriptions in space, possibility to explore the whole globe's area, change of degree of map view's approach and others). Moreover, every element of the map can be modified both with respect of contents, elements' number and their location and web site within the frames of which the map was published fulfills international standards of creating web sites established by World Wide Web Consortium [W3C 2015].

7. Conclusion

Technical and practical aspects of elaborating a spatial phenomena digital map were presented in the paper. Net applications can be a perfect supplement for field research. They make possible to create interactive presentation of spatial phenomena and to popularize research results. Chosen computer techniques and tools accessible free of charge can be used to their composing.

Characterizing the tested river, it can be stated that its source part is particularly precious environmentally with rock outcrops, material bars or bank cuts. Below the river's source part, both natural morphological elements and infrastructure integrated in the flowing river can be met. From among tested fragments, the one that flows through Andrychów town turned out to be the most transformed.

River Habitat Survey method as well as interpretation of HMS synthetic factor enables to evaluate and characterize anthropogenic transformations of riverbeds. The researches show that fragments of the same river can distinguish with diverse value of the factor which indicated changeable dynamics of anthropogenic impact on the environment in the riverbed. HMS is a parameter that supports evaluation of ecological state of upland and mountain rivers. On the basis of its value, the degree of transformations caused by human activity can be concluded which simplifies evaluation and comparison of tested river fragments.

During the field tests, it was noticed that history of the river's knowledge is important for RHS method. Field interview with local inhabitants which revealed that Wieprzówka is a serious flood danger with regard for area dwellings in flood plains zone can also be helpful. Moreover, riverbed's transformations in the watercourse made in the past, for example route's changes, scarps' modification or backwaters' cutting off can be evaluated as natural elements which may influence the research result. Information of such kind makes up an important aspect while preparing restoration works and internet application can be a good tool of their presentation.

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