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EVALUATION OF THE HUMAN IMPACT ON HYDROLOGICAL CYCLE IN THE SLOVAK CARPATHIANS (HISTORICAL AND THEORETICAL ASPECTS)

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The history of human impact on hydrological cycle of the landscape in Slovak Carpathians from neolit period untill socialist period is described. The intensity of the human activities in landscape are getting more and more intense during this period. Resulting from this also hydrological cycle in the Carpathian regions was strongly affected by numerous direct and indirect impacts. The only way how to improve these undesirable changes is to introduce sustainable water management practicies based on more natural and environmentaly sound approach.

Key words: history of human impact, Slovak Carpathians, hydrological cycle,

INTRODUCTION

The territory of Slovakia, like most of European ones has been for centuries exposed to ever increasing human impact which is also manifested by changes in quantitative and qualitative regime of hydrological cycle (HC). Hydrological cycle is understood as a permanent process of motion of water in atmosphere, hydrosphere and litosphere determined by solar radiation and gravitation energy.

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1. Human impact on hydrological cycle till the end of 18th century

The history of human impact on landscape in Slovak territory goes back to years 5000-4500 B.C. (Neolithic period) when permanent man-induced transformation of nature has began (Ložek 1973). But a long time before traces of the Paleolithic settlements can be found. They were concentrated in outlets of the Pannonian basin but partly also in lower Carpathian basins. Settlement spread from warmer steppe-forest areas to forest areas. Already in this time first traces of human impact on HC can be noticed, e.g. deforestation around settlements, but due to low density of settlements these impacts were negligible. Moreover, settlements were situated mostly on river plains and river terraces, i.e. localities with low energy of relief which has also contributed to low dynamics of harmful processes. During the Bronze Age (1900-1700 B.C.) hand with hand with the use of improved instruments, transformation of forests to arable land accelerated. Populated areas began to spread up from lowlands and big basins upstream along the valleys of big and mid size rivers and they got to immediate contact with mountains (Orava, Slatina, Topľa, Ondava valleys). After temporal retreat of settlement during the Iron Age (about 0 A.D.) and after resettling the primary areas, the next spread of settling began after the arrival of the Slavonic tribes (400-600 A.D.). After that hand with hand with population growth agricultural practises got more advanced. Since about 8-10 ct. a three-field agricultural system has been introduced which remained on the scene for almost the next 1000 years, legaly till the end of the serfdom era, effectively the remains of this system survived in some Slovak regions till the 20ies of this century (Jůva et al. 1981). Though from the point of view of its impact on agriculture and forest productivity this system is assessed as of low efficiency (e.g. due to overgrowing of fallows by low quality natural seeded forests), its role in HC can be presented quite positively. Regular alternating of arable land, pastures and fallows naturally reduced development of erosion processes. Arable land beeing not a long time on the same spot was not subject of longterm erosion processes. During this period a distinct deforestation was caused by increasing acreage of arable land and pastures. Grazing became an important activity in hilly-land and mountainous regions. But on many places mining activity rather than grazing affects the environment. Already from 10-12th ct. a large consumption of wood for charcoal furnaces in Slaná and Bodva basins (SE Slovakia) is reported (Halaga 1979). Later on (in 14-15th ct.) overconsumption of wood and destruction of forests caused conflicts between mining towns and local landlords (Halaga 1979). Local impact on forest landscape (and on HC indirectly) was presumably relatively strong in medieval period. Intensity of erosion, runoff amplitude, flood occurence and flood intensities were rising. First simple watermanagement interferences e.g. wells, levees and weirs were introduced. Irrigation works are documented on meadovs in Žehra in 1318. Having only very local impact they were far from long-lasting constructions. In 13th ct. after the end of invasion of Tatars, the main period of settling so called "big collonization" began. Afterwards numerous settlements also in some mountains could be found (Štiavnické vrchy, Strážovské vrchy, Krupinská planina, Spiš area). Population concentrated to towns, specialization of production, new technologies in guilds and progress in mining technologies began to produce new kinds of wastes in relatively big amounts concentrated mostly over a small area. This was the first serious threat for water quality regime. Already in 14th ct. a simple mining water supply system in Kremnica was put into operation.

Perhaps the most distinct impacts to natural landscape accompanied two colonizational waves: the Walachian one since half of the 16th ct. and the Kopanitse one in

16-18th ct. Rather extensive settling in higher and more remoted areas connected with deforestation, digging and grazing is common for both. All these activities led to strenghtening of before existing human impacts on HC mainly due to settling in higher and more humid areas with bigger energy of relief. Along with these indirect impacts on HC also direct and systematic impacts can be noticed. A good example is a construction of water reservoire system in Štiavnické vrchy mts. in 16-18th ct. at a top level of technical design for that era. These were actually the first dams in Slovakia. During the 18-19th ct., water engeenering activities focused in river training in lowlands (Danube, Tisa basin) usually followed by flood plain forests retreat and expansion of the arable land. In smaller extent and later on, these activities began also in mountain river stretches, evoked by increasing need for efficient forest management. These watermanagement measures were mostly systematic with long-term perspective, using up-to-date knowledge of science and technology. E.g. drainage project from upper Orava region performed by W.Rovland in 1866-1878 should be mentioned here.

2. From industrial revolution till 1948

After bondage was abolished (1848), industrial growth began also in the Hungarian part of the monarchy. Standard of living and population density were rising. Big industry and railway appeared on the scene. Huge amounts of above all beech wood was processed for railway sleepers, for construction and work of developing paper mills, glass factories and foundries. This has led in many places to destruction of natural fir-beech and beech forests (Slivka 1979). Many formerly ecologically stable forests were replaced by monocultures. In this way the portion of forests in landscape did not have to be dwindled, it could even increase, but its ecological-stabilizing function, and hydrological included, worsened. On the other hand also the beginning of big landscape arrangement works must be mentioned. Their goal was to mitigate consequences of undesirable human impacts. They were performed in 9 localities (Brezovské hills, Banská Bystrica vicinity and other). With the beginning of alternating agriculture system fallows were transformed to arable land and to pastures using more advanced agrotechnologies. In spite of continuing population growth this progress calmed down efforts for obtaining new arable land by cutting the forests. Large scale interferences in landscape which should eventually influence HC were performed under supervision of new specialized and professional authorities. Their headquarter offices were first located in Budapest (or Vienna), after 1918 in Prague and later on branch offices were opened in Slovakia (Department for torrent training, opened in 1926 in Bratislava, watermanagement co-operatives etc.).

Important turning point was foundation and next spreading of water gauges network. First water gauges were installed on Danube in Bratislava (1823) and in Komárno (1830). Covering the whole Slovak territory with accetably representative network of gauges became real more than 100 years later. This period represents a principal threshold in possibilities of evaluation and estimation of human impact on HC. Permanent obtaining of correct empirical data has opened new ways for research of human impact on HC and of course for day-to-day practice too. Assessment of human impact on HC before that time was demanding, it referred to only rough estimations or mostly subjective and unreliable data from various chronicles and other historical documents. Though the data concerning e.g. flood size or flood frequency in historical periods can be obtained with the help of various dating, geomorphological or other indirect methods, assessment of the role of human activi-

ties on particular events or processes still remains uncertain. This method, better said historical reconstruction calls for a team approach of hydroecology, paleohydrology, paleoclimatology, history and perhaps another experts.

3. Socialist period (1948-1989)

Probably the most crucial intervention to HC in the Slovak Carpathians started after the political and social transformation in 1948. Abrupt collectivization of agriculture followed by unification and enlargement of field spots, increased use of agrochemicals and above all large- scale, schematically excercised mostly environmentally not allways very sound watermanagement practice gave rise to many undesirable changes in HC. Their intensity has far surpassed everything what have been done in this field before.

Let us look more closely at the particular impacts:

Unification of field spots during land reform after 1948 has principally changed the original crumbled pattern of agricultural landscape which originated from old Hungarian succession right, ordering splitting of inheritance in equal portion among all heirs. This has led to nearly permanent splitting and dwindling of field spots. Before WW II there were in Slovakia several milion field spots with mean acreage of some 24 ars (Jůva et al. 1981). Though this pattern did not meet demands for efficient and sufficient agriculture productivity, from the point of view of water regime in landscape it was quite acceptable. Narrow field strips in contour-like arrangement divided by grassy or bushy balks represented a relativelly environmentaly sound system protecting surrounding area from development of harmful processes, it slowed down runoff and increased infiltration capacity of the landscape at the same time. Grassy or bushy balks situated on the most inclined parts were the most efficient agent for improving of infiltration ability of basins. On the contrary, unification of spots led to breaking and even removing of this pattern. New, large field spots were not well, enough adjusted to the relief forms. Length of fields was sufficient for development of erosion processes. Lowered infiltration ability of the basin led to unbalanced runoff regime, erosion processes produced increased portion of suspended solids. All these processes resulted in changes in river bed and flood plain morphology.

Use of chemicals in agriculture. Even though the substantial acreage of agricultural land in Slovakia can be found in lowlands or basins, i.e.outside the proper Carpathian massifs, the use of chemicals has partly touched also agriculture in hillly lands, submountains and plains. Regarding the lower intensity of agriculture the amount of chemicals introduced here was also lower . While in the most productive lowlands the mean annual use of pure nutrients was more than 300 kg/ha, in higher altitudes this amount did not exceed 150-200 kg (Zelenský 1980). Except for arable land a part of agrochemicals (mostly fertilizers) were applied on intense pastures. The amount of pesticides introduced to landscape can be only hardly estimated.

The use of agrochemicals affects mostly qualitative regime of HC. From this point of view the most serious problem is caused by residuals or remnant nutrients. These are washed away or bound by soil solutions. This process causes eutrophication of waters, disturbing of ecological bindings in ecosystems of river beds, floodplains and wetlands resulting in general lowering of landscape stability.

Improvement of runoff properties is a term used in watermanagement practice during the last decades. It comprises the whole set of measures and impacts on runoff

process. Among the most performed ones construction of drainage systems, construction of water reservoires of various kinds and river training belong. Unfortunately, the philosophy of these measures in former Czechoslovakia was pure technocratic. First-rate proclaimed goal was draining of superfluous water off the landscape as fast as possible, eventually its storing in man controlled reservoires. This strategy met the demands for flood protection but partly also agriculture of socialist type. For the purpose of design and performing of improvement of runoff properties big enterprises were founded. Their human and financial potential exceeded the real and rational needs for construction designed and performed by them. Large and often doubtful impacts resulted from nearly permanent exploitation of activity of these authorities. Regarding the principles of socialist economy they could not be simply abolished or silenced.

Drainage systems accelerate soil water runoff which can in many cases lead to general draining of the landscape, retreat of hygrophilous plants and wetlands lowering both landscape diversity and stability. In reasonable measure the drainage systems can improve water-air régime of soils and their productive ability.

Drainage systems were mostly designed for agriculture land in lowlands. But preferably on hilly-lands ecologically and economically rather doubtful drainage systems were installed. In 1970 in Slovakia there were 4313 sq.km of drainage systems, in 1991 rising to 4700 sq.km. Thanks to certain revaluation of ideas and also "thanks" to lack of financies, the trend in building of new drainage systems in last years tends is slowing down, if not stopping. Altogether with a priori improper installing of drainage systems (regarding to the local hydrophysical soil properties or morphometry of relief), their low efficiency was caused also by low-quality of installation works followed by minimum or none maintenance. In this way there exist in Slovakia hundreds of hectars of non functional or half-functional drainage systems.

Construction of water reservoires belongs to the most radical impacts on HC. It is out of goals of this paper to deal particularly with problems of water reservoires. In 1970 there were in Slovakia 26 reservoires (with volume over 1 mil.m^3) and storage coefficient was 6% . In 1994 there were 46 reservoires and storage coefficient raised to more than 10% (Generel ochrany a racionálneho využívania vôd). It means that within 24-year period storage coefficient has rised by 66%. Water reservoires on upper streams in mountains protect the area from flood, on the other hand by retaining of suspended solids they are silted and their storage volume is lowered. This process is bound to cause troubles in the future.

River training represents probably the most current human impact on HC in the Slovak Carpathians. Its intensity can be manifested in various forms from simple embankments to conversion of natural flow to concrete channel. In 1970 there were in Slovakia 5700 km of trained river stretches (12,6% from total length), from this about 452 km (2%) were managed by forest administration. In 1985 here were 17,3% of trained river stretches, 693 (3%) out of them under forest administration (Smerný vodohospodársky plán SSR 1988). In 1994 here were 7300 km of trained river stretches within river basin authorities which is managing about 50% of total river network. Another portion of stretched rivers is managed by other authorities (forest administration preferably). River training is focused mostly on river straightening and on bank and bottom reinforcing. This leads to several consequent harmfull processes. Distribution of velocities in cross-sectional profile is changing. Stable laminary flow as a result of these impacts does not differentiate sedimentation of suspended solids which makes impossible natural development of river bed. As a result river beds are silted on many places and because of poor or none maintenance

(cleaning) the original idea i.e. fast draining of the area is missing its target mainly due big hydraulic roughness. Common trait of these processes is removal of the riparian vegetation. This lowers biodiversity and buffering (protective-purgative) ability of the landscape. In this way agrochemicals and various pollutants can freely penetrate to river flows.

CONCLUDING REMARKS

As it can be seen, history of man impact on HC in the Slovak Carpathians is long and has many faces. The general knowledge that intensity of impact is increasing hand with hand with development of society can be unambiguously confirmed. Fortunately this finding is not very encouraging. Concentration on immediate profit, short-eyed solutions with consequent rising and accumulating of new problems create something a vicious circle absorbing human societies regardless to the level of their development or political system. We only believe that in the future we shall avoid the past mistakes and that man will finally realize his responsibility to nature, landscape and next generation. A good opportunity for such approach is offered by introducing of the ideas of sustainable water management. The leading idea of sus-tainable water management is to intake only minimal amount of water hand to hand with its efficient and rational (re)use, protection of diversity and natural accumulative ability of landscape.

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HODNOTENIE VPLYVU ČLOVEKA NA HYDROLOGICKÝ CYKLUS V PODMIENKACH SLOVENSKÝCH KARPÁT (TEORETICKÉ ASPEKTY)

História vplyvu človeka na krajinu Slovenska siaha do obdobia 4500-5000 rokov pr.n.l.(neolit), kedy možno hovoriť o počiatku sústavného pretvárania prírody. V dobe bronzovej (okolo r. 1900-700 pr.n.l.) v dôsledku účinnejších nástrojov sa urýchlil aj proces odlesňovania a následného využívania pôdy na poľnohospodárske účely. Približne od 8.-10. stor. sa rozšírilo trojpoľné hospodárstvo, ktoré sa s rôznymi obmenami udržalo u nás takmer 1000 rokov, formálne do konca obdobia nevoľníctva. Aj keď sa tento systém hospodárenia z hľadiska produktivity

poľnohospodárskej výroby či lesníctva nehodnotí priaznivo, z hľadiska vplyvu na hydrologický cyklus územia možno trojpoľný systém hodnotiť celkove kladne. Objavujú sa prvé jednoduché vodohospodárske zásahy, akými sú napr. výstavba studní, hatí, náhonov a hrádzí. Koncentrácia obyvateľstva do miest, špecializácia výroby v cechoch a rozvoj banskej činnosti začínajú produkovať v relatívne veľkých množstvách nové druhy odpadov, ktoré sú často koncentrované na malom priestore. Išlo o prvé vážnejšie ovplyvnenie kvalitatívneho režimu hydrologického cyklu.

Veľmi výrazné zásahy do prírodnej krajiny nastali po dvoch kolonizačných vlnách (valaská od polovice 16.storočia a kopaničiarska v 16.až 18.stor.).

Po odstránení nevoľníctva a poddanstva (r.1848) dochádza aj v Uhorsku postupne k ďalšiemu rozmachu priemyselnej výroby. Zvyšuje sa životná úroveň, ako aj počet obyvateľstva. Objavujú sa nové fenomény - železnica a veľkopriemysel. Mnohé pôvodné, ekologicky stabilné lesné spoločenstvá boli nahradené monokultúrami. Na druhej strane nemožno nevidieť aj počiatok veľkých krajinných úprav, ktorých cieľom bolo zmierniť predošlé nevhodné zásahy do krajiny.

Vari jeden z najradikálnejších zásahov do hydrologického cyklu v slovenských Karpatoch priniesli spoločenské zmeny po roku 1948. Násilná kolektivizácia poľnohospodárstva spojená so sceľovaním pozemkov, rozvoj chemizácie poľnohospodárstva, a najmä masívne, a schematicky uplatňované, environmentálne nie vždy vhodné vodohospodárske zásahy spôsobili výrazné zmeny v hydrologickom cykle. Intenzita týchto zásahov ďaleko prekonala všetko čo sa v tejto oblasti urobilo predtým.

Sceľovanie pozemkov pri pozemkových úpravách po r.1948 zásadným spôsobom zmenilo pôvodne rozdrobenú štruktúru poľnohospodárskej krajiny, ktorá historicky vyplývala z uhorského dedičného práva. Aj keď tento stav nevyhovoval z hľadiska výkonnosti a efektívnosti poľnohospodárskej výroby, z hľadiska hydrického režimu krajiny predstavovali úzke políčka sledujúce vrstevnice a oddelené trávnatými alebo krovinatými medzami relatívne optimálne usporiadanie. Pri sceľovaní pozemkov dochádzalo k rozrušovaniu a odstraňovaniu medzí, vytvárali sa veľké lány polí, s dostatočnou dĺžkou svahov umožňujúcou iniciáciu a rozvoj odnosových procesov. Týmto spôsobom sa znižovala infiltračná a akumulačnú schopnosť územia, zvyšovala sa nevyrovnanosť odtoku a produkcia plavenín, čo následne vyvolávalo zmeny v morfológii korýt a nív.

Úpravy odtokových pomerov je termín používaný vo vodohospodárskej praxi posledných desaťročí. Zahŕňa celý komplex opatrení a zásahov do odtokového procesu. Medzi najviac realizované patria výstavba drenáží (odvodnenie), výstavba vodných nádrží s rôznou funkciou a úpravy tokov. Žiaľ, filozofia týchto opatrení v podmienkach bývalého Československa bola rýdzo technokratická. Prvoradým proklamovaným cieľom bolo čo najrýchlejšie odvedenie prebytočnej vody z krajiny, prípadne jej retencia v človekom kontrolovaných systémoch (nádržiach). Takáto stratégia bola poplatná protipovodňovej ochrane územia a sčasti aj socialistickej poľnohospodárskej veľkovýrobe.

Ako môžeme vidieť, história vplyvu človeka na hydrologický cyklus je v slovenských Karpatoch dlhá a má mnohoraké podoby. Jednoznačne možno potvrdiť známu skutočnosť, že s rastom poznania a rozvojom spoločnosti rastie aj intenzita takéhoto vplyvu. Jediným spôsobom zlepšenia nežiaducich zmien v hydrologickom cykle slovenských Karpát je zavedenie praktík trvale udržateľného vodného hospodárstva, ktoré je založené na prírode bližších a environmentálne vhodnejších prístupoch.