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title: **Ecohydrology — challenges and opportunities from the perspective groundwater surface water interactions**

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In the face of global challenges such as changes in geopolitical and economic centers, as well as demographic processes, combined with progressing degradation of the environment its resources and climate changes, there is an urgent need to formulate a new proactive strategy that harmonize the humanity needs with water resources and ecosystem potential . The one of the critical issues of the integrated water resources management is sustainable use of groundwater resources by society.

Ecohydrology (EH) is defined as sub-discipline of hydrology that focuses on ecological processes occurring within the hydrological cycle and strives to utilize such processes for enhancing environmental sustainability (Zalewski, 2000, 2006; Zalewski et al., 1997). It has been developing in the framework of the International Hydrological Programme of UNESCO is focused on regulation of water biota interplay from the top of the river basin up to the bottom of the reservoir and costal zones, toward slowing down transfer of water from sky to the sea, enhance groundwater resources and maintaining critical habitats for water, energy and nutrients circulation, which in turn maintain biodiversity. Also for reduction of the input and regulate allocation excess nutrients and pollutants toward reversing ecosystems degradation and improvement of human well being.

This follows the three criteria by ICSU, which define that the science of the XXI century has to be (1) integrative, (2) problem solving and (3) policy oriented. Integrative because integrates ecology and hydrology as a sub-discipline of environmental sciences. Problem solving because considering society priorities such as water quality, food production, flood protection, drought compensation, cultural aesthetic values and truism. Policy oriented because sustainable development and reversing biosphere degradation is the MDG GOAL.

What kind of "know how" Ecohydrology propose to achieve those three goals?

The general assumption is that water is major determinant of carbon retention in terrestrial ecosystems, biomass and plant production and ecological succession in different climatic (zones) (Zalewski, 2002).On the other hand the diversified plant biomass efficiently reduce leakage of nutrients from terrestrial to aquatic ecosystems and to costal zones. Ecohydrology due to methodological specifics has been based on interconnected two phases- terrestrial and aquatic. The terrestrial has been focused on water plant soil/ground waters interactions and plant cover is first important filtering system and system enhancing the infiltration and stabilizing water circulation within the catchment. In the aquatic phase, the content of the nutrients in surface and ground water to great extent determine freshwater and costal zones ecosystem biological productivity and in consequence biodiversity.

As far as Ecohydrology is not only curiosity driven but also problem solving science three principles are provides framework for research and problem solving

The hydrological principle — The quantification and integration of hydrological and biological processes at the basin scale is based on the assumption that abiotic factors are of primary importance and become stable and predictable when biotic interactions start to manifest themselves (Zalewski, Naiman, 1985) The quantification covers the patterns of hydrological pulses along the river continuum and monitoring of point and nonpoint source pollution. (Fig. 1).

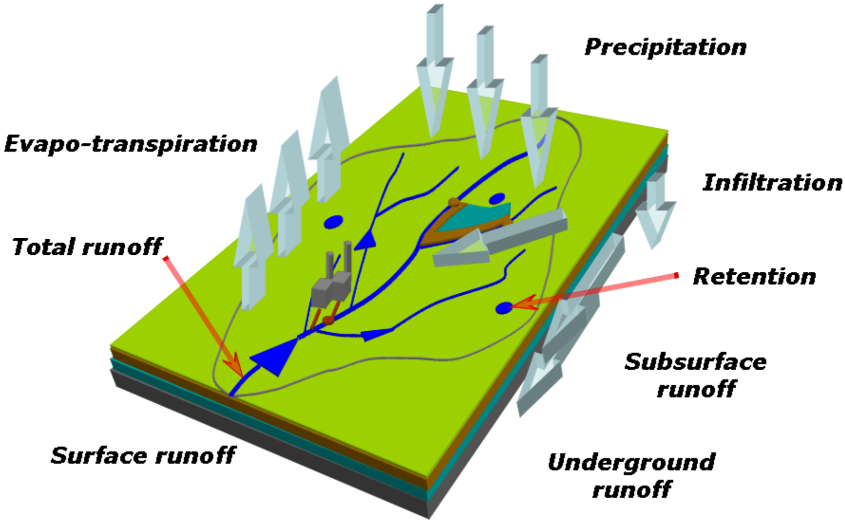

Figure 1. First Principle – Hydrological - quantification of hydrological cycle analysis from the point of view of socio-economy and spatial-temporal dynamic vs. various forms of human impact.

The ecological principle — The ecological principle is based on the assumption that under intensive global changes it is not enough to protect ecosystems against increasing energy consumption and pollutants emission. It is necessary to regulate ecosystem structure and processes toward enhancement of the "carrying capacity" (water quality, restoration of biodiversity, ecosystem services for society, resilience of river ecosystem). Understanding the role of vegetation in water cycling as far as hydrology-biota interplay from molecular to landscape scale processes is of crucial importance (Vorosmarty, Sahagian, 2000) (Fig. 2).

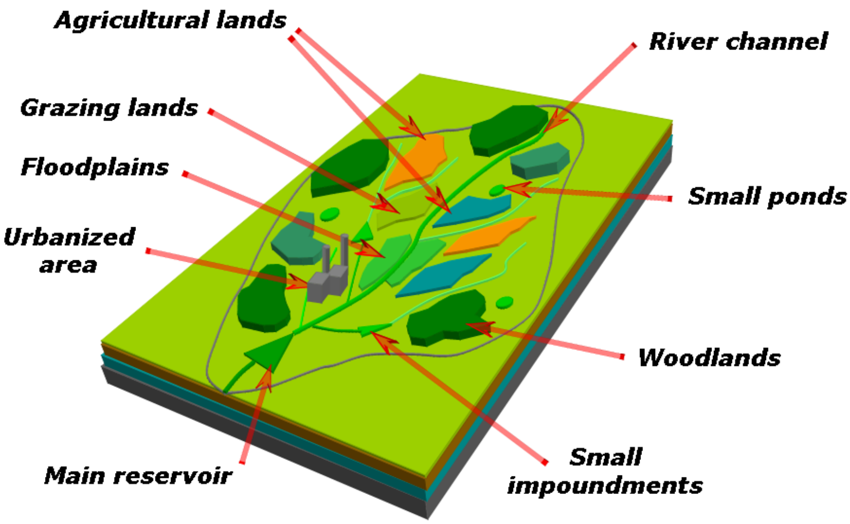

Figure 2. Second Principle – Ecological – the analysis of distribution of various types of biocenosis and its potential to enhance resilience and absorbing capacity for human impact (GIS).

The ecological engineering principle — The use of ecosystem properties as management tool is based on the first and second principles of EH. (Fig. 3).

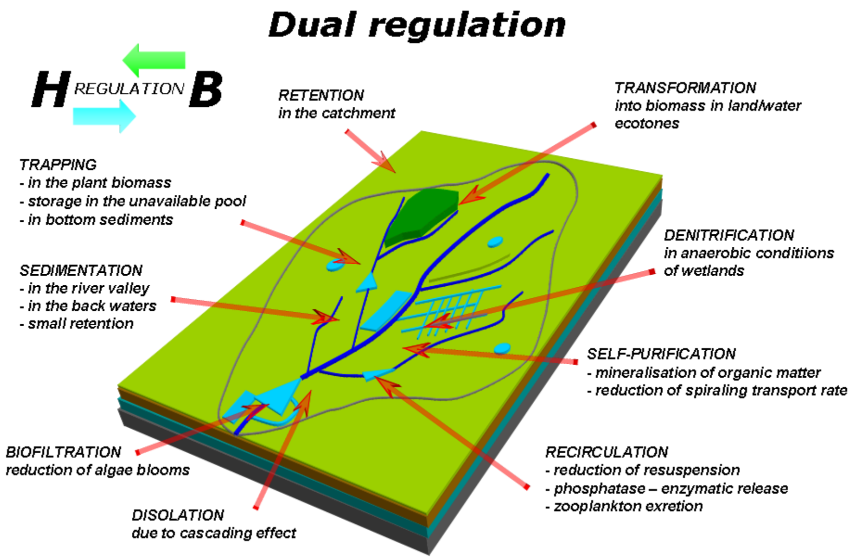

Figure 3. Third Ecological Engineering Principle — using of biota to control hydrological processes and vice versa, using hydrology to regulate biota.

This principle features three steps of implementation:

1. 'Dual regulation'–biota by hydrology and, vice versa, hydrology by shaping biota or regulating interactions.
2. Integration at the basin scale of various types of biological and hydrological regulations toward achieving synergy to improve water quality, biodiversity and freshwater resources.
3. Harmonization of ecohydrological measures with necessary hydrotechnical solutions (dams, irrigation systems, sewage treatment plants, etc).

As far as the freshwater ecosystems are situated in depressions in the landscape where all forms of human activities in catchment are cumulated dual regulation can be done toward changing the allocation of excess nutrients and pollutants in to no available pool (soil, sediments, wood, biomass/bioenrgy, fodder) or at least from more dynamic -opportunistic (e.g. toxic cyanobacteria) to less dynamic pool within organisms (zooplankton, fish, macrophytes).

To define the role of EH for sustainable water and ecosystems services , the analysis the pattern of the scientific methodologies in environmental sciences the three stages can be distinguished:

INFORMATION, structure, states, relationships (First hydrological principle EH). Hydrological–based on GIS analysis of the abiotic structure of the river basin, quantification of the hydrological processes and different forms of the anthropogenic impacts distribution ;

KNOWLEDGE, the synergies between information from the different scientific disciplines is helpful in highlighting the patterns and processes toward basin resilience enhancement (Second ecological principle EH).

WISDOM, ability to use the information and knowledge to develop innovative solutions ecological biotechnologies "dual regulation" of the environmental problems with the consideration of the society priorities. (Third ecological engineering principle EH) (Fig. 4).

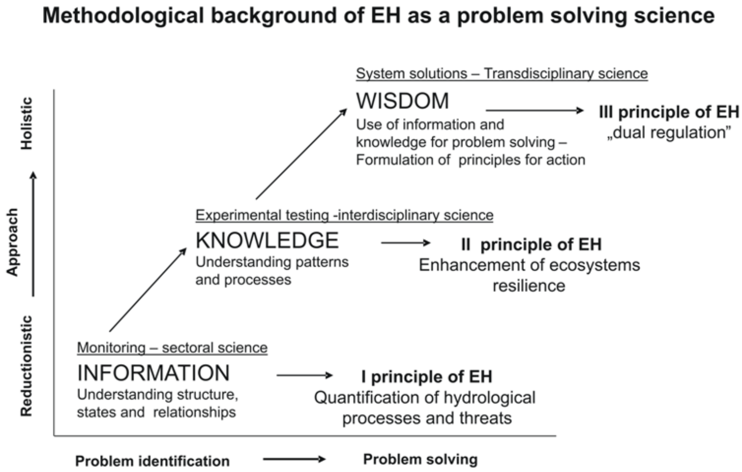

Figure 4. Methodological background of Ecohydrology.

Thus Ecohydrology improves the potential to regulate the complexity of interactions between, water cycle, ecosystems and societies by :

1. Reduction of threats of **floods and droughts** by control of stochastic character of hydrological processes in catchments by: Incorporation of an understanding the past (e.g. paleohydrology, ecological succession patterns, human settlements spatio-temporal dynamics). Integration of specific environmental science knowledge, e.g hydrogeology ,soil, groundwater, plant cover and the floodplain characteristics used for understanding the specific patterns of hydro peaking process and its reduction . Use of social learning and communication methodology for harmonisation of society's priorities with enhanced ecosystem carrying capacity.
2. Increasing the food /bioenergy productivity, reducing diffuse pollutant emission and enhancement of biodiversity in the agricultural landscape ecohydrological biotechnologies (based on "dual regulation).
3. Improve quality of life and reduce cost of functioning in urban areas by consideration in the city spatial planning the enhancement of the retention purified storm water in "green areas". Such change of management and perception storm waters in urban water management, due to applying ecohydrological methodology for purification reduces energy consumption, pollutants transfer and accumulation and improves human health, aesthetic and cultural values.
4. Reduction of fluxes of nutrients and pollutants into costal zones by ecohydrological measures application in the basin scale.

To achieve Millennium Development Goals and adopt to global changes the proactive strategy should be based on holistic, trans-disciplinary environmental science system approach, foresight methodologies, and social dialogue. It has to be done by broader involvement of trans disciplinary team of scientists in large scale projects on environmental processes regulation from molecular to landscape scale with special emphasis in understanding the socioeconomic processes and dynamics of ground water resources, which are critical for compensation and adaptation to increasing stochastic character of the climatic processes and sustainable future.

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