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Ecohydrology for harmonization of societal needs with the biosphere potential II

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Ecohydrology: process-oriented thinking towards sustainable river basins

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Abstract

Regarding recent progress in climatic change, the decline of water resources, degradation of soils and changes in demographic dynamics, this paper postulates that attempts to maintain the good ecological status of the biosphere based on the classic paradigm of nature-oriented thinking, embodied by conservation and restoration of nature, have to be expanded by environmental process-oriented thinking. Insofar as water has been a major driving factor of biosphere evolution and productivity, any profound understanding of fundamental ecological processes, such as hydrology and nutrient (C, N, P) cycles, on the scale of entire basins should be based on highlighting the biota response to various water pulse patterns in certain geographical regions, understanding of the role of biotic structure and the interactions present in shaping water and nutrient dynamics. This knowledge of ecohydrology principles provides the scientific background for regulating the processes and interactions for: enhancing water resources, maintaining and restoring biodiversity, providing ecosystem services for societies and building resilience to climatic and anthropogenic impacts (WBSR), from the molecular to landscape scale. The above four goals will be instrumental in the harmonization of biosphere potential and satisfaction of the needs of humanity postulated during EcoSummit 2012 and expressed in the Columbus Declaration. Process-oriented thinking should create the fundamentals for the integration of ecohydrology with environmental biotechnologies, hydro-technical and civil engineering.

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A biogeochemical barrier to enhance a buffer zone for reducing diffuse phosphorus pollution—preliminary results

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Abstract

As an example of the application of biotechnologies, highly effective buffer zones were designed and implemented in the direct catchment of the Sulejow Reservoir, an area characterized by heavy pollution of groundwater with phosphorus from nonpoint source pollution. Due to the high concentration of phosphate in the groundwater (>3.00 mg PO₄/l), a biogeochemical barrier based on limestone was constructed to reduce phosphorus levels through absorption by the barrier. The preliminary results of the barrier's effectiveness indicate that the phosphate concentration in the groundwater was reduced by 58% following its flow through the barrier. A biogeochemical barrier is one of key elements of the buffer zone; however, the effect of shaping plant structures in the buffer zone to increase their efficiency regarding nutrient uptake was also analyzed.

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The role of ecohydrology in creating more resilient cities

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Abstract

The increasing global rate of urbanisation and concurrent global climate changes create new challenges and new opportunities for managing cities, water resources and related quality of life. In most strategies, however, water ecosystems, which are the fundamental component of the integrated urban water resources management (IUWRM), are regarded as objects of protection or rehabilitation; not, as postulated by ecohydrology, as management tools. This paper addresses the possibilities of: (i) the functional incorporation of aquatic ecosystems into the IUWRM; (ii) optimising their functioning by local ecohydrological approach; and (iii) integration of ecosystem functions on a city scale to build system solutions for more resilient cities. Two case studies of the UNESCO MAB/IHP demonstration network representing different urban development patterns are given. The City of Łódź (Poland) uses water-resource based urban retrofitting for improving the quality of life and attracting inhabitants, departing from the analysis of longitudinal dynamics of nutrient transition in the river–reservoirs system, towards proposing an alternative concept of spatial city development. The city of Lyon (France), with intensive periurban development and population growth, provides a hierarchy of stream reaches to cope with combined sewer overflows to help municipalities to better position future urban runoff outlets. This article envisions also the future management of urban waste and storm waters using urban rivers, assuming resilient cities will depend on the integrity of environmental, technical and spatial planning decisions. The virtues of ecohydrology are discussed in this respect.

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Public perceptions of papyrus: community appraisal of wetland ecosystem services at Lake Naivasha, Kenya

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Abstract

Papyrus wetlands form ecological buffer zones, protecting lake shallows from sedimentation and open water from eutrophication. Multiple wetland processes and functions also support the livelihoods of adjacent riparian communities. However, ecohydrologists have in the past typically placed insufficient emphasis on social and cultural factors operating within the catchments that they study. Here we outline a process that better integrates social science research methods within ecohydrology, using the 'language' of ecosystem services to prioritise objectives for the rehabilitation of papyrus wetlands at Lake Naivasha in Kenya. Reference is made to Lake Victoria for comparison and to illustrate how and why stakeholders' perceptions of wetland services may vary over even short distances.

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Remote sensing the hydrological variability of Tanzania's Lake Natron, a vital Lesser Flamingo breeding site under threat

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Abstract

Landsat satellite imagery was used to investigate the ecohydrological sustainability of Tanzania's Lake Natron. The lake is of critical importance as the sole breeding site for East Africa's population of Lesser Flamingos (*Phoeniconaias minor*), a species which is classified as near-threatened due to decreasing numbers and limited suitable breeding sites (IUCN). Lake Natron is threatened by two proposed developments: a multi-purpose dam, to be built on the Ewaso Ngiro (South) River (45% of the lake's catchment area), and a soda ash extraction factory. Both developments will significantly alter the hydrology and ecology of the lake and could impact flamingo breeding. In addition, local environmental change and global climate change over the past 50 years have altered the hydrological characteristics of the catchment.

Archival Landsat imagery (1984–2011) has been used to establish baseline data about the past hydrological variability of the lake by applying the Modified Normalised Difference Water Index (MNDWI). A time series of lake surface area has been produced which shows a high degree of variability in lake levels. Comparison to infrequent observations of flamingo breeding at Natron are consistent with the prevailing hypothesis of the importance of receding lake levels. Analysis of lake features in the imagery, including the presence of salt islands, has been used to set lower and upper limits to lake areas suitable for flamingo breeding. Our results will assist the future sustainable management of Lake Natron and will contribute towards Lesser Flamingo conservation.

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Impacts of domestic and agricultural rainwater harvesting systems on watershed hydrology: A case study in the Albemarle-Pamlico river basins (USA)

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Abstract

Rainwater harvesting (RWH) is increasingly relevant in the context of growing population and its demands on water quantity. Here, we present a method to better understand the hydrologic impacts of urban domestic and agricultural rainwater harvesting and apply the approach to three diverse watersheds within the Albemarle-Pamlico river basins in the southeastern USA. We summarize the design strategy of RWH and use of the Soil and Water Assessment Tool (SWAT) model to simulate baseline and RWH scenarios for urban and agricultural land uses. A high adoption rate (75–100%) of RWH throughout the watersheds reduced the downstream average monthly water yield up to 16%. A lower adoption rate (25%) reduced water yield approximately 6% for the Back Creek watershed (NC). We also present a ten-year average monthly low flow-based rainwater-harvest yield index (rainwater-harvest/water yield) as a RWH metric when comparing downstream impact on flows. The current study is intended to inform water resource sustainability and management decisions at the watershed scale.

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