НОВЫЕ МЕТОДЫ И РЕЗУЛЬТАТЫ ИССЛЕДОВАНИЙ ЛАНДШАФТОВ В ЕВРОПЕ, ЦЕНТРАЛЬНОЙ АЗИИ И СИБИРИ

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Монография содержит информацию о самых современных методологиях и результатах в ландшафтных исследованиях. Она может быть использована в качестве руководства для исследователей, преподавателей, студентов и всех, кого интересует тема ландшафтной науки и смежных дисциплин. Монография является особо ценной информационной базой для лиц, принимающих решения на различных уровнях, от местных до международных органов по принятию решений. Приведенная в монографии информация представляет собой современный уровень ландшафтной науки в очень краткой форме.

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This monograph shall inform you about up to date methodologies and recent results in landscape research. It is intended as a guide for researchers, teachers, students, decision makers, stakeholders interested in the topic of landscape science and related disciplines. It provides information basis for decision makers at various levels, from local up to international decision bodies, representing the top level of landscape science in a very short form.

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ABSTRACT. In the face of progressive degradation of biodiversity and rising food production costs worldwide, and considering the overall state of the environment, existing measures used to counteract these changes appear wanting. In Europe, 70% of the land comprises highly-modified agricultural and urbanised landscapes. In such a transformed environment, sustainable development can only be ensured through the regulation of ecological processes, i.e. by increasing water retention in the modified agricultural landscape and more closely regulating hydrological processes (dual regulation) [1; 2; 3]. It is also necessary to limit the amount of matter and energy used per unit of gross national income [4] through technological progress and increasing public awareness.

Резюме. Перед лицом усиливающейся деградации биоразнообразия и роста издержек производства продуктов питания во всем мире, а также с учетом общего состояния окружающей среды, имеющиеся меры для противодействия этим изменениям оказываются недостаточными. В Европе 70% земель занимают сильно измененные сельскохозяйственные и урбанизированные ландшафты. В такой трансформированной среде устойчивое развитие может быть обеспечено только посредством регулирования экологических процессов, то есть путем лучшего сохранения воды в измененном сельскохозяйственном ландшафте и более строгого регулирования гидрологических процессов (двойное регулирование) [1; 2; 3]. Необходимо также ограничивать количество вещества и энергии, потребляемое на единицу валового национального дохода [4], за счет технологического прогресса и повышения осведомленности общественности.

KEYWORDS: ecohydrology, modified landscapes, sustainable development

INTRODUCTION: EUROPEAN WATER IN AGRICULTURE IN THE FACE OF CLIMATE CHANGES

Population growth, greater demand for food and increased agricultural activity all contribute to the increasing pressure which man is placing on the environment. FAO reports predict the global population to exceed nine billion by the year 2050, and that to provide adequate access to food, production needs to increase by about 60%. Greater production will in turn have an influence on the rate of degradation of ecosystem structure and the modification of processes shaped during the course of evolution, such as the circulation of water and biogenic elements. Today, we see a phenomenon characterised by the overlap of global demographic change, climate change and socio-economic priorities, and its destructive effects on the local environment. Growing awareness of the these processes, which constitute a threat on a global scale, has forced changes in the role of Science, particularly Environmental Science. As it is unfeasible to avoid all the consequences of climate change, even with the effective implementation of ambitious policies to limit the global growth of greenhouse gas emissions, the international community has considered it necessary to take action to adapt to its inevitability. The basis for creating innovative solutions for climate change adaptation in a given geographical area is an understanding of the relationship between the dynamics of water and plant communities that can be used to shape the structure of the organic landscape. This approach, based on the integration of hydrological and ecological knowledge, is the essence of a new discipline in Environmental Science, Ecohydrology, which has been formulated by the International Hydrological Programme and the Human and Biosphere program of UNESCO.
ECOHYDROLOGY AND ECOSYSTEM BIOTECHNOLOGIES IN THE CATCHMENT ECONOMY

Ecohydrology (EH) is a transdisciplinary science whose aim is to enable sustainable development [1; 5]. Its foundations are based on the principle that hydrological phenomena can be manipulated to increase the ecological potential of ecosystems by regulating biological processes and vice versa. There are three steps and three dimensions of analysis which can clarify the underlying ecohydrological processes present in a given catchment and allow informed solutions to be implemented; they also provide a systemic framework for integration into integrated water resources management (IWRM). The first principle of EH, the hydrological principle, implies that quantification of the hydrological processes at the basin scale and the entire hydrological cycle can serve as a template for the quantification of ecological processes. This quantification encompasses the patterns of hydrological pulses along the river continuum and the identification of various forms of human impact, e.g. point and nonpoint sources of pollution. This principle assumes the superiority of abiotic factors over biotic interactions [6]. The second principle of EH, the ecological principle, requires an understanding of the evolutionarily-established interplay between water and biota, and hence a quantification of the nutrient flows and energy flux dynamics within the water cycle and catchment templates defined in the hydrological principle. It also requires an analysis of the spatial distribution of different types of ecosystems, i.e. pristine, degraded and modified, to identify the novel ecosystems that are subject to dual regulation. The principle is based on the assumption that during intensive global change, it is not enough to protect ecosystems, but the processes within them require regulation. The third principle, the ecological engineering principle, defines the ecosystem properties given in the framework of the first and the second principles as management tools. These tools complement the hydrological solutions described above and should be used with the aim of enhancing the ecosystem carrying capacity for WBSRC, defined by Ecohydrology as five components. In the context of the sustainable development goals of the United Nations, ecological potential is understood in terms of water resources (W), biodiversity (B), ecosystem services (S), the ability of ecosystems to respond flexibly to the various forms of stress and adapt to climate change (R-resilience) and the cultural heritage of the basin (C). Ecohydrological biotechnologies are fundamental to the development of the low-cost and low-energy solutions recognized in the European Commission’s strategic documents under the term green infrastructure.

THE USE OF ECOHYDROLOGICAL BIOTECHNOLOGIES FOR ENHANCING NUTRIENT AND CARBON RETENTION IN SOIL

The fundamental knowledge needed to apply such biotechnologies in the framework of EH stems from an understanding of the dynamics of surface runoff in relation to reservoir, lake or river level oscillations, and the potential of plants or bacteria to convert the mineral forms of nutrients into biomass or gas. Until now, the problem of pollution and its reduction has been focused on point sources, which can be easily managed using advanced technological solutions. However, dispersed sources of pollution might constitute over 50% of the nutrient loads to reservoirs and costal zones delivered through rivers [7]. Such natural resource management applications can be called ecohydrological biotechnologies. Low-cost and efficient ecohydrological biotechnological solutions can be used to address such problems. For example, the denitrifying activity of microbes can be augmented by the addition of carbon to enhance the removal of nitrogen from polluted groundwater [8] and excessive nutrient allocation in the aquatic trophy pyramid can be regulated through hydrobimaniupulation [9; 10; 11].

The primary factor shaping the evolution of ecosystems is water. Hence, in response to the ongoing change experienced by the climate and landscape, the starting point for the regulation of ecological processes is threefold: (i) the restoration of rivers and maintenance of small bodies of water, (ii) increasing the complexity of the landscape with the aim of improving the heat budget, (iii) to increase the amount of organic matter in the soil. The principal practical objectives of the Ecohydrology concept are twofold. The first aim is to slow the transfer of river basin water from the landscape to aquatic ecosystems and its subsequent outflow to the sea. This requires the stabilisation of the hydrological and biogeochemical cycle, which can be achieved by strengthening biological phenomena. It is also important to increase the biomass of plants in the basin; a greater biomass would maintain the heat budget at an stable level during the summer, reduce evaporation and the leaching of organic matter by erosion, assist the regeneration processes and improve the retention of the landscape. The second aim of Ecohydrology is to slow soil erosion; erosion results in the loss of organic matter, the reduction of the production potential of agroecosystems and increased water pollution [12; 13]. Of particular significance are point and non-point pollution, which is generated mainly by agriculture as a result of tillage and the application of mineral fertilizers and manure [14]. These substances, particularly nitrates,
easily penetrate light soils, resulting in eutrophication. Such pollution can be managed with the use of ecotone zones: transitional zones which exist between the aquatic ecosystem and the neighbouring land, which are usually stocked with vegetation that tolerates humid conditions while accumulating biogenic compounds in their biomass. In the absence of the land needed to create an appropriately wide ecotone zone, it is a good idea to construct a denitrifying barrier inside it, at a depth of about 1 m below the surface (Fig. 1); inside this barrier, nitrogen dissolved in the water will be reduced to gaseous forms by microbial pathways. Catchment areas intensively exploited by agriculture demonstrate much greater surface runoff of organic matter and nutrients to surface waters when deprived of ecotone zones. As the transport of this runoff along the river results in greater eutrophication of reservoirs, lakes and seas [12], an important activity in agricultural catchments is the deployment of high efficiency ecotone zones and reinforced denitrification barriers to transform nitrates to gaseous forms while simultaneously assimilating nutrients in plant biomass [11;15]. However, one of the cheapest and most effective ecohydrological solutions is to use denitrifying barriers / beds to secure sites where natural fertilisers are stored directly on the ground Fig. 2 [8; 16;17]

This is an alternative solution for protecting ground water from leachate compounds in small and medium-sized farms other than using concrete manure slabs. The starting point for achieving these objectives is the development and implementation of ecohydrological biotechnology and system solutions. The next step is the generalization of mathematical models and the integration of this knowledge to raise public awareness of their causative role in achieving sustainable development goals, thus enhancing decision making and education at various levels.

CONCLUSIONS
1. In order to support sustainable development on a global scale, it is crucial to move from a sectoral approach to a systems approach.
2. A holistic approach must be adopted which incorporates transdisciplinary environmental management, which takes into account thinking orientated towards the adoption of service processes to allow sustainable resource use and optimize its benefit for society
3. However, reducing the consumption of energy and natural resources used for technological improvement or other ongoing activities also remains a priority.
4. New paradigm should shift at various levels should lead to the harmonisation of the needs of society with the absorptive and regenerating potential of the environment.
REFERENCES


