A new environmental discipline

Engineering Harmony

Professor Zalewski, is among the pioneers of ecohydrology – a new branch of science combining technical and environmental skills

MACIEJ ZALEWSKI
International Center for Ecology, Łódź
Polish Academy of Sciences
University of Łódź
mzal@biol.uni.lodz.pl

The teaming up of hydrology and ecology offers one source of hope that the world's water crisis might be kept under control. But how can hydrology, a technology-oriented field, be integrated with ecology, which prioritizes living organisms?

The current geological epoch has been dubbed the "Anthropocene," because nowadays it is man that will probably be most responsible for shaping natural processes that transpire on a global scale. Without a doubt, our understanding of the interactions between abiotic and biotic processes is becoming crucial for curbing this human impact. This pertains in particular to the most dynamic abiotic factor of all: water.

Until the EU Water Framework Directive began to be implemented, water management was oriented towards eliminating the threat of floods, droughts, or so-called point sources of pollution, and this was tied to classical hydrology. Nowadays the documents of such UN bodies as UNESCO and UNEP, as well as of the EU, have recognized that water quality is a crucial factor for meeting mankind's needs and for achieving sustainable development, and that it depends on the condition of the ecosystem.

Live fast, die small

The first visible effect of a water shortage on the landscape and decline of quality is the disappearance of species of high biomass which have a long and complicated life-cycle. Large mammals, birds, and fish such as the salmon and sturgeon come under threat. These species are usually supplanted by animals that can proliferate rapidly under favorable conditions, such as insects and small rodents. Among plants, a reduction in the diversity of species, such as for cultivated crops, makes them significantly less effective in absorbing biogenic substances (phosphorous and nitrogen) and pollutants, and thus they less effectively prevent the outflow of such substances to water ecosystems.

Rich botanical diversity, in turn, serves to curb concentrations of phosphorous and nitrogen in ground waters, and as a consequence prevent the overfertilization of inland waters. When vascular plants (such as reeds) which form habitats for various sets of organisms (such as filtering zooplankton), disappear, algae begin to overproliferate in the water. Such toxic algae blooms pose a serious threat to human health and life.

In the early 1990s, awareness of the ongoing degradation of water resources in the world led to an international conference held in Dublin, Ireland in 1992, and the UNESCO International Hydrological Program (IHP). The teaming up of hydrology and ecology holds vast potential for improving world water resources. But how can highly mathematized hydrology, which deals with macro-scale problems, be integrated with ecology, which prioritizes living organisms?

Roots of ecohydrology

The key here should lie in identifying the fundamental principles of this new field of

Małgorzata Tarczyńska

Toxic "water blooms" pose a serious threat to the environment and to human health (including chromosomal abnormalities) – particularly when they appear in drinking water reservoirs

Piotr Skórnicki/Agencja Gazeta

science. The concept of "AB Regulatory Continuum," originally published by the present author and Robert J. Naiman in a FAO document in 1985, was set as the point of departure for the new hypotheses. Ideas for how ecohydrology should function also originated from research at the Sulejowski Reservoir in Poland in the 1980s. Such studies showed that hydrology could be harnessed to precisely regulate the structures of a biological ecosystem in order to improve water quality. No less important was research on the role of littoral vegetation in improving water quality and on shaping artificial "constructed wetlands." The results of these and many other studies led to the formulation of the fundamental principles of ecohydrology, as follows: hydrological processes can be utilized for regulating biological processes, while techniques for modifying biological processes can be applied to the regulation of hydrological processes, especially as concerns water quality. These two types of regulation should be harmonized with the existing hydrotechnical infrastructure.

From hypotheses to practice

Since abiotic factors are predominant over biological ones, the water circulation cycle should serve as the point of departure for solving existing problems. The aforementioned Sulejowski Reservoir research has indicated that biological processes can indeed be regulated using hydrology, thereby reducing the negative impact of human activity. It suffices, for example, to regulate the water level in order to control the proliferation of fish that feed on plankton. Maintaining their numbers on a low level enables crustacean plankton to intensively filter algae, thus preventing them from blooming (cf. biological methods for preventing algae "blooms" on p. 37). This mechanism is so robust that it even functions effectively after 20 years, despite the accumulation of pollutants carried in by the river. These facts give rise to the next tenet: On the river-basin scale, the collaborative goal of hydrology and ecology is to increase ecosystem resistance to human activity.

While this method treats the symptoms of eutrophication, another method can be used to counteract its causes: encouraging the growth of vegetation in the river's flood zone so as to catch and retain sentiments and phosphorous compounds there. Such a solution is now being implemented along a segment of the Pilica River above the Sulejowski Reservoir, where the amount of phosphorus was reduced by some 150 kilograms/year using an area of 24 grass-covered hectares. However, when selected species of willow trees are introduced to frequently flooded areas, the amount of retained phosphorous can be increased to over 350 kilograms. Note that each kilogram of phospho-

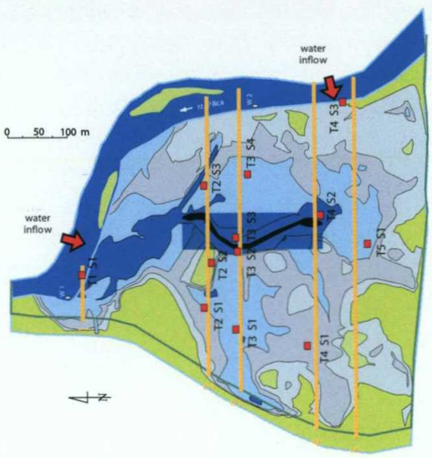
The main goal of ecohydrology is to increase the ecosystem's resistance to human activity. Researchers believe that a properly managed environment can cope with this task


Iwona Wagner

The Pilica River is an example of the successful application of biological control to improve water quality. Carefully selected varieties of willows were planted next to an ineffective sewage treatment plant

rous leads to the appearance of some two tons of algae in the reservoir. Draining systems constitute an element of controlling hydrological and biological processes which require intensive research. If all of these solutions are organized into systems on a river-basin scale, their effects will be incomparably greater.

It is very important for the systems to be adapted to the socioeconomic conditions present in the region. One example in the Pilica River valley can be found at Przedbórz - a town of 8,000 inhabitants in which an ineffective sewage treatment system has been combined with a filtering system set up using... willow trees. Plants with varying tolerances for high groundwater levels catch and retain excessive phosphorous, which comes from incompletely treated sewage and overfertilizes the Pilica. Phosphorous becomes tied up in the tissues of the plants, forming biomass, which can later be burnt in order to heat public buildings. Biomass and the energy gained from it can also be utilized in technologies for transfering waste plastics into analogs of petroleum. In this way, not only is the condition of the environment improved (generating conditions for developing recreation), but through integration



Willows were planted according to their tolerance for high groundwater levels (left). This biological filtering system traps excessive phosphorus and converts it into biomass

with socioeconomic processes and waste management, new jobs can be created.

Worldwide ecohydrology

Systemic solutions stemming from the concepts of ecohydrology are not just a subject of scientific publications nowadays; in many countries they are in an advanced state of development and implementation under the UNESCO International Hydrological Program. Two such examples:

In Hungary, owing to an addition to the waste treatment system in the basin of the Zala River, involving an arrangement of specially constructed reservoirs and intermittently flooded areas covered in vegetation, the load of phosphorous discharged into Lake Balaton has been reduced by as much as 80%. This method has proven so effective, that toxic algae blooms have not occurred in the lake over the past three years.

In Brazil, one of the dams on the Parana River is situated upriver from the Itaipu Reservoir and a natural, intermittently flooded river valley with rich biodiversity. Unfortunately, the dam's construction disrupted certain hydrological processes, upon which fish migration and spawning ground access hinge. The failure of fishing along a more than 100 km segment of the river led to the cutting and burning of forests in the valley, changing them into pastures and fields. This process not only failed to supply the needs of local population, it also contributed to the appearance of toxic algae blooms in the Itaipu Reservoir.

In order to reverse this progressive environmental degradation, a mathematical model is being developed under the UNESCO IHP to optimize the water level management at the reservoir, enabling fish to access habitats during the migratory and reproductive period, while at the same time reducing the losses of energy generated by the dam. Furthermore, reservations that have been set up aid in boosting tourism and provide an additional source of income, increasing the economic awareness of the local population.

Since we live in this age called the Anthropocene, we need to make a breakthrough in how mankind protects the environment. The conscious harnessing, based on interdisciplinary knowledge, of an ecosystem's own properties as tools for increasing the environmental "carrying capacity" is becoming a necessity. Only in the last decade has ecology evolved to the point where it can be integrated with hydrology. Developing environmental protection systems that improve the state of natural resources while generating positive socioeconomic feedback is made possible by an integrative combination of earth sciences, biology, mathematical modeling, and socioeconomics.

In view of the import of these issues and the urgent need for comprehensive research, the PAN International Center for Ecology will in the near future be transformed into the International Center for Ecohydrology, under the auspices of UNESCO. ■

Further reading:

www.unep.or.jp/ietc/Publications/Freshwater/FMS5/index.asp

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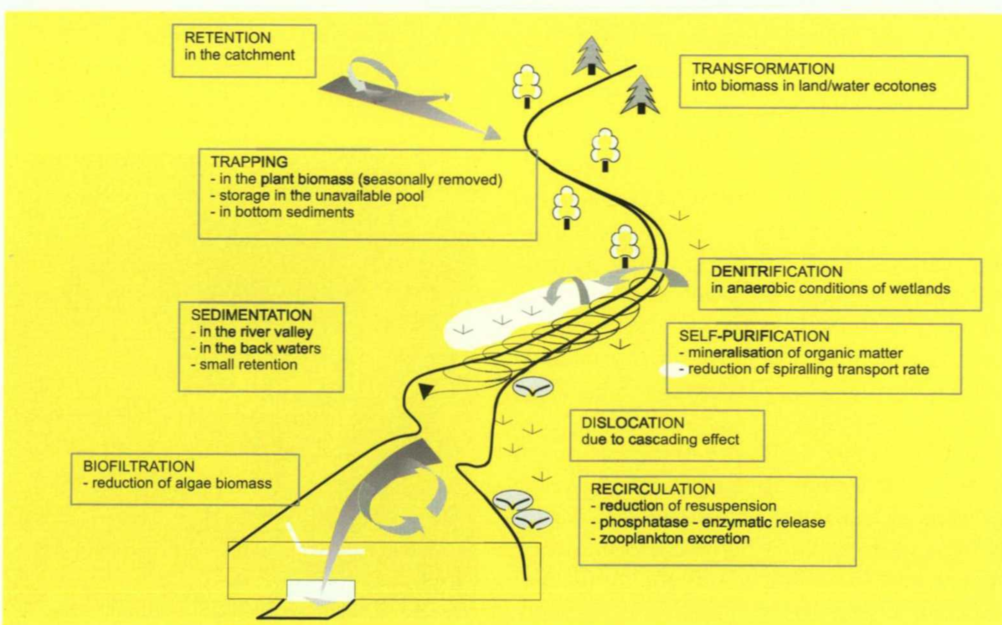

Maciej Zalewski

An example of synergistic interactions between different processes to enhance a river basin's capacity for self-purification