General Aspects of Aquatic Environment Management

Assoc.Prof. GOLDAN Tudor, Min.Eng.Ph.D., goldan_t@yahoo.com
Prof. COZMA Eugen, Min.Eng.Ph.D., University of Petroşani
Prof. ONICA Ilie, Min.Eng.Ph.D., University of Petroşani

Abstract: *A crucial importance must be dedicated to fresh, drinking water. The management of this resource will be one of the major challenges for the new millenium, as well as the allowance for the whole population to reach fair conditions of nourishment and hygiene.*

Contacts between different scientific groups will serve to build a proactive ecohydrological network, at the catchments scale, which ultimate goals is the management and the perennial of freshwater, essential for life and the economy of territories.

Introduction

The Brundtland report (WCED) edited in 1987 and the International Conference of Rio in 1992, both organized by the United Nation Commission for Environment and Development, obviously showed the endless damage to environment and the unconditional report of application of draconian solutions towards the coming generations. Both manifest plead for a sustainable development able to assume, simultaneously and at long term, economic growth, improvement of environment and protection of natural resources.

Among the latest, a crucial importance must be dedicated to fresh, drinking water. The management of this resource will be one of the major challenges for the new Millennium, as well as the allowance for the whole population to reach fair conditions of nourishment and hygiene.

Since 1970, UNESCO has launched studies of integrated management of watershed throughout the world, through the development of two programs: “Man and Biosphere”, followed by the “International Hydrological Program” in 1975. The fifth phase of the latest program begin in 1996 with ecohydrology as a major theme.

1. Evolution of sciences in water management

Ecohydrology, considered as a new paradigm, is a neologism arising from the coalescence of both terms “hydrology” and “ecology”. It was first postulated in Dublin in 1992 at the International Conference on Water and Environment [11] and suggest a new watershed approach methodology. Scientists wished to bind biological and physical sciences together with the goal of a better understanding of the studied ecosystems [10].

The concept “ecohydrology” is aimed at scientists working in the water domain. It tries to heighten the awareness of engineers in hydrology to more ecological methods and vice versa. Indeed up to now, many scientists and industrialists take into consideration solutions from their own skills, whilst into consideration solutions from their own skills, whilst a co-operation between hydrologists and ecologists would result in more adapted solutions for the aquatic environment.

Figure 1, taken from the Fifth Phase booklet, sets ecohydrology as a link between past and future in water management. Ecohydrology is a current phase which will allow at middle term a development and a management of aquatic environments. Up to now, water management is limited to the reduction or even to the elimination of periodical phenomenon such as catastrophic floods, droughts, pollution or erosion. The future must go beyond this concept and “amplify the chance” through ecohydrology. Indeed, biological methods allow to strengthen technical methods for an equivalent price and moreover rise their efficiency. Unfortunately this amplification of opportunities is, nowadays, still too often neglected.

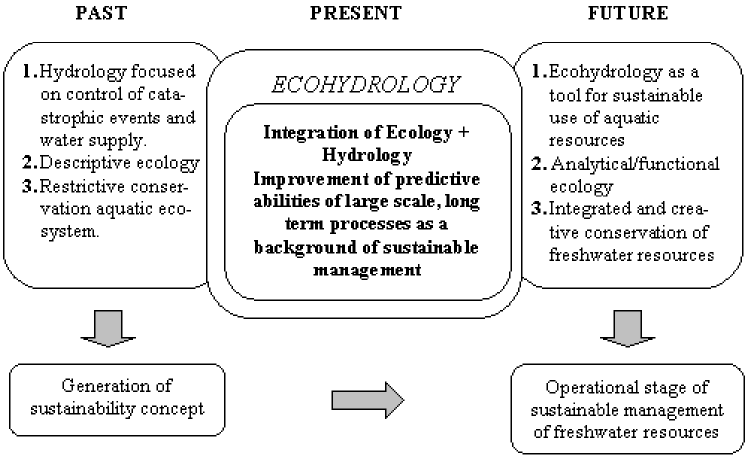

Figure 1. Evolution of ecological and hydrological sciences

The postulate of ecohydrology considers the watershed as a "super-organism" (ecological macrosystem) where an action in a local ecosystem generates a reaction in an another one, through the hydrographical network, which is equivalent to both a receiving and transmitting system. The environment "physiology" (functioning) and its water dynamics must be understood above all. Three main objectives are described:

- the knowledge of "hydrosystems" (aquatic ecosystems) and comprehension of their relations with climatology, biology, hydrology, water, chemistry, toxicology, biology, geology, physical as well as biological processes, and mankind;
- integration of computerized models based on this knowledge;
- prediction of changes in the hydrosystem – simulations, scenarios – with random variations of hydroclimatological, chemical and biological data or variations due to management politics.

Through the analysis of ecological and hydrological components, ecohydrology takes place in various and interconnected sectors, i.e. water storage, denitrification, water self-purification, biofiltration. The paradigm is applicable to natural as well as to artificial aquatic ecosystems. The itinerant course provided practical applications in ecohydrology through four cases described below. A last case will be discussed as a recent appraisal conducted by the Ecology Laboratory.

As far as we know, Pedroli [8] first used the term "ecohydrology" in an underground water study. However the correlation of both domains was evoked one year before [3]. They tackle respectively the hydrological impacts on vegetation ecology, and the use of ecological ranges of plant communities to estimate the quality of surface and underground waters [5]. The term remains use in both international journals and in search engines of websites specialized in hydrology.

Ecohydrology brings an additional dimension to water management. The paradigm consists in a thought process which allows a synergy through the complementarity of various research sectors. The concept was first dedicated to civil engineers and to hydrologists sensu stricto. Hydrology has neglected the natural environment for too long. Ecohydrology is a way to open up to this green wave, to apply methodologies in association with environmental solutions and co-operate with other scientists, ecologists in particular.

2. INTERCONNECTION BETWEEN SCIENCES IN WATER MANAGEMENT

The above examples show that bioengineers cooperate with other actors such as civil engineers, physicists, meteorologists, chemists. A multidisciplinary reflection rallies all scientists in such a way that each of them is able to step into his own domain. Similarly, ecohydrology represents a way to share knowledge for a better identification of adapted solutions for the aquatic environment. A large network is thereby constituted by actors involved in water management, linking international specialists of various disciplines.

Let's emphasize that the perception of the problem will be different according to the involved specialist – hydrologist, ecologist or bioengineer – and therefore, distinct processes will succeed. For instance, the hydrologist will consider the paradigm as a growing awareness for a "more ecological" hydrology in partnership with actors working in the environment. In particular, this was the case during the itinerant course above quoted, where hydrologists represented the majority. On the contrary, the ecologist will discover applied hydrological methods, which will bring him a relevant information for the management of biotic systems. Through his multidisciplinary education, the bioengineer has a thorough knowledge of hydrology and ecology which allows him to build up complementary ecohydrological solutions in partnership with other actors. Ecohydrology will be valorized by a better knowledge of this science and the spread of the concept. It is important to link partners between them and promote exchanges of knowledge, experiences, solutions. Each actor, working in his own domain, will provide, according to his sensibility, elements adapted to the aquatic environment. The joint examination of sector-related propositions should come out on an optimal collegial proposition (figure 2).

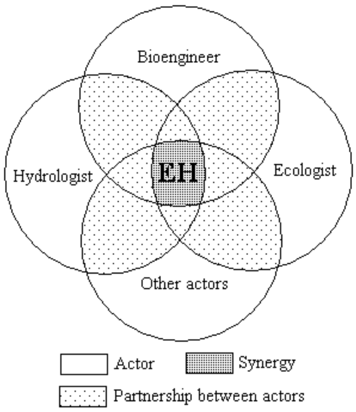

Figure 2. Multidisciplinary approach of ecohydrology.

Ecohydrology objectives show by themselves the framework for the methodology (summarized in figure 3). This is based on three steps:

- the preliminary study of a catchments starts with an in-depth ecological understanding of the environment (climate, soil science, vegetation, human occupation);
- the prevention of pollution, basement of a sustainable development, represents the second step. This implies to establish a catchments model in view to precise sources and to assess pollutants fluxes. From this model, a sustainable land-use management programs will be constituted for the catchments;
- bioengineers implement several technologies to strengthen the ecosystems, like phytoremediation and biomanipulation. They consider long-term management scenarios, in particular through the model previously established.

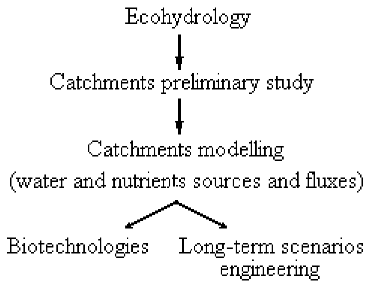

Figure 3. Methodology for ecohydrological research.

It is advisable to insist on phytoremediation and biomanipulation, both important innovative research axes for ecohydrology.

Phytoremediation consists of using vegetation for in situ treatment of polluted ecosystems [9]. When two biotic communities overlap without defined limits we are in presence of a continuum. But when there is, between these two ecosystems, a tight zone with its own characteristics and species, we have an ecotone [4]. Several different ecotone exist, depending on whether they are located between two terrestrial ecosystems, two aquatic ecosystems or a terrestrial and an aquatic ecosystem. Ecotones studies have been for a long time the subject of numerous researches, in ecohydrology particularly.

In an aquatic ecosystem the purification function of the aquatic vegetation is an important measure for the water biological treatment.

Conservation and management of ecotones by phytoremediation studies are called to play an important role at long-term in freshwater quality.

The "trophic cascade theory", postulated for the first time in 1992 [2], must be understood before suggesting a definition of biomanipulation and assessing its importance.

The trophic cascade is a theory in which the manipulation of a trophic pyramid level induces modifications in the immediate upper and/or lower levels. These modifications will further create by a cascade phenomenon, changes in upper or lower levels an so on [6]. When these changes go up the trophic pyramid, the manipulation is called “bottom-up”. On the contrary, when they go down, it’s called “top-down” [l]. Both models are complementary and non-contradictory [2].

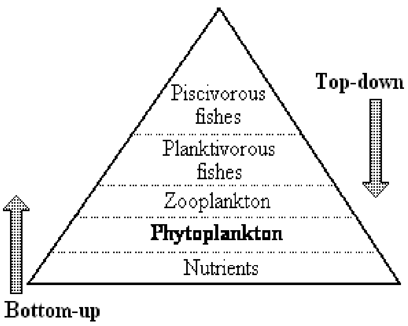

Figure 4. Trophic cascade theory applied to aquatic ecosystems.

The control of the trophic pyramid by “top-down” is biomanipulation [1]. Moss [7] provided a good example of a strategy for the control of internal lake processes through a deliberated ichtyologic community modification {figure 4). On the other hand, the “bottom-up” strategy will consists of a reduction of external nutrients, pollutants and organic matter supplies. The figure 4 shows these manipulations.

The concept was first formulated by Shapiro [1].

3. CONCLUSIONS

Nowadays, ecology is a well-considered value in the scientific world. Particularly, the complementary effect between ecological solutions to hydrological problems constitutes a paradigm in the search of sustainable projects. The originality of ecohydrology consists of using well-known concepts (e.g. ecotone, biomanipulation) and gathers them in an innovative, integrated and intellectual network leading to a synergy for the aquatic ecosystems management. The paradigm, new for some scientists, should be diffused and spread among all as a modern transdisciplinary approach. Contacts between different scientific groups will serve to build a proactive ecohydrological network, at the catchments scale, which ultimate goals is the management and the perennial of freshwater, essential for life and the economy of territories.

REFERENCES

1. **Benndorf, J.,** *Possibilities and limits for controlling eutrophication by biomanipulation,* Int. Revue ges. Hydrobiol., No.80, 1995, p.519-534.
2. **Carpenter, S.R., Kitchell, J.F.,** *Trophic cascade and biomanipulation: Interface of research and management,* Limnol. Oceanogr., No.37, 1992, p.208-213.
3. **Falkenmark, M., Chapman, T.,** *Comparative hydrology: an ecological approach to land and water resources,* UNESCO editions, Paris, 1989.
4. **Fischesser, B., Dupuis-Tate, M.F.,** *Le guide illustré de l’écologie,* Édition de la Martinière – Cemagref editions, Paris, 1996.
5. **Hobma, T.W., Gibert, J.E., Mathieu, J., Fournier, F.,** *Hydrochemistry and ecohydrology of the transition area of the Netherlands Delta and the Brabantse Wal,* in “Groundwater/surface water ecotones: biological and hydrological interactions and management options”, Cambridge University Press, 1997.
6. **Lampert, W.,** *The relationship between zooplankton biomass and grazing: a review,* Limnologica, No.19, 1988, p.11-20.
7. **Moss, B.,** *Ecology of fresh waters. Man and medium,* London: Blackwell Science, 1988.
8. **Pedroli, B.,** *Ecohydrological parameters indicating different types of shallow groundwater,* J.Hydrol., No.120, 1990, p.381-404.
9. **Schnoor, J.L.,** *Phytoremediation of organic chemicals at hazardous waste site. COST Action 837,* Workshop “Phytoremediation 2000 – State of the art in Europe (an intercontinental comparison)”, Hersonissos, Greece, 2000, p.21-22.
10. **Viville, D., Littlewood, I.G.,** *Ecohydrological processes in small basins,* IHP, Paris, 1997.
11. **Zalewski, M., Janauer, G.A., Jolánkai, G.,** *Ecohydrology. A new paradigm for the sustainable use of aquatic resource,* Technical Document in Hydrology, Paris, 1997.