2.A. WHAT IS ECOHYDROLOGY?

INTEGRATION OF SCIENCES...

According to the strategy defined by ICSU, science in the 21st century should actively participate in creating a vision, strategy and implementation methodology essential to the support of sustainable development. The approach that accelerates the above actions should be based on the integration of various interdisciplinary and transdisciplinary fields of science. The developmental conditions required for comprehensive, integrative and interdisciplinary scientific research is „maturity" of the empirical disciplines that participate in the integration process.

The progress that took place in ecological sciences in the last years of the 20th century, allowed for major advancements of knowledge. A level was attained that permitted an attempt to integrate ecological sciences with the more advanced scientific fields to great extend expresses by phisics and mathematics hydrology. This integration created a platform for the development of a new discipline (Zalewski et al., 1997; Zalewski, 2000). Ecohydrology (EH), has been formulated and developed within the framework of UNESCO's International Hydrological Programme, IHP -V.

DEFINING ECOHYDROLOGY...

The basis for the development and advancement of interdisciplinary science and related research should be the defining of a new scope and formulation of new key questions to be answered (Keyfitz, 1993). In the course of the genesis of ecohydrology, it was assumed that the questions should meet the two following fundamental conditions:

1. They should be related to the dynamics of two entities in such a way that the answer without consideration of one of the two components (both ways E <-> H) would be impossible. In other words, this question should enable the defining of relationships between hydrological and biological processes in order to obtain comprehensive empirical data at the same spatial and temporal scales.
2. The results of the empirical analysis should test the whole range of processes (from a molecular to catchment scale), should enable their spatial/temporal integration and should be convertible to large-scale management measures in order to enable further testing of the hypotheses.

Taking into account the above conditions, the key questions for ecohydrology have been defined based on an in-depth understanding of the interplay between biological and hydrological processes and the factors that regulate and shape them. The hypotheses have been defined in the form of the following questions:

Hypothesis H1: „The regulation of hydrological parameters in an ecosystem or catchment can be applied for controlling biological processes".

Hypothesis H2: „The shaping of the biological structure of an ecosystem(s) in a catchment can be applied to regulating hydrological processes".

Hypothesis H3: „Both types of regulation (H2 and H3) integrated at a catchment scale and in a synergistic way can be applied to the sustainable development of freshwater resources, measured as the improvement of water quality and quantity (providing of ecosystem services)"(Zalewski, 2000).

It should be stressed that according to the ecohydrology concept, the overall goal defined in the above hypotheses is the sustainable management of water resources. This should be focused on the enhancement of ecosystem carrying capacity against anthropogenic stresses.

WHAT IS ECOHYDROLOGY?

Ecohydrology is a scientific concept applied to environmental problem-solving (Zalewski et al., 1997). It quantifies and explains the relationships between hydrological processes and biotic dynamics at a catchment scale.

The concept is based upon the assumption that **sustainable development of water resources is dependent on the ability to restore and maintain evolutionarily established processes of water and nutrient circulation and energy flows at the basin scale.**

This depends on an in-depth understanding of a whole range of processes involved that have a two-dimensional character:

- **temporal**: spanning a time frame from the past to the present with due consideration of future global change scenarios; and
- **spatial:** understanding the dynamic role of aquatic and terrestrial biota over a range of scales from the molecular- to the basin-scale.

Both dimensions should serve as a reference system for enhancing the buffering capacity of ecosystems against human impacts by using ecosystem properties as a management tool. This, in turn, depends on the development, dissemination, and implementation of interdisciplinary principles and knowledge based on recent advances in environmental science.

ECOHYDROLOGY KEY ASSUMPTIONS AND PRINCIPLES

Up to the time when the ecohydrology concept was defined, hydrologists considered aquatic biota mostly as an indicative system for monitoring while hydrobiologists considered hydrological processes as a disturbance factor.

The ecohydrology paradigm, which is based on functional relationships between hydrology and biota (Zalewski et al. 1997, Zalewski 2000; 2002), can be expressed in three key assumptions.

Key assumptions of EH

- **REGULATION** of hydrology by shaping biota and, vice versa, regulation of biota by altering hydrology.
- **INTEGRATION** - at the basin scale various types of regulations (E <-> H) act in a synergistic way to improve and stabilize the quality of water resources.
- **HARMONIZATION** of ecohydrological measures with necessary hydrotechnical solutions (e.g., dams, sewage treatment plants, levees at urbanized areas, etc.)

Following these assumptions the concept of ecohydrology is based on three principles.

Principles

1. **FRAMEWORK** - Integration of the catchment, water and its biota into one entity, including:
   - **Scale** - the mesoscale cycle of water circulation within a basin is a template for the quantification of ecological processes;
   - **Dynamics** - water and temperature are the driving forces for both terrestrial and freshwater ecosystems;
   - **Hierarchy of factors** - abiotic (e.g., hydrological) processes are dominant in regulating ecosystem functioning. Biotic interactions may manifest themselves when abiotic factors are stable and pre-dictable.
2. **TARGET** - Understanding evolutionarily established ecohydrological processes is crucial for a **proactive approach** to the sustainable management of freshwater resources. It assumes that it is not enough to simply protect ecosystems but, in the face of increasing global changes (such as increasing population, energy consumption, global climate change), it is necessary to **increase the carrying capacity of ecosystems, and their resistance and resilience, to absorb human-induced impacts**.
3. **METHODOLOGY** - ecohydrology uses ecosystem properties as a management tool. It is applied by using biota to control hydrological processes and, vice versa, by using hydrology to regulate biota. Scientific basis for the methodological aspect of using biota for water quality improvement has been seriously advanced by ecological engineering (e.g., Mitsch & Jorgensen, 2004).

Technical approach is not enough...

The importance of the effort to develop the ecohydrology approach increased with the publication of the paper by Meybeck (2003) in which he justifies the name of Anthropocene for the present era. Based on an in-depth analysis of published studies, he demonstrated that the modification of aquatic systems by human pressures (e.g., flood regulation, fragmentation, sedimentation imbalance, salinization, contamination, eutrophication, etc.) has increased to a level that no longer can be considered as being controlled by only natural processes (climate, relief, vegetation, limnology), thus defining a new era that we have already entered.

The decline in water quality and biodiversity, observed at the global scale in both developed and developing countries, has provided evidence that the traditional „mechanistic" approach focused on **elimination of threats**, such as point source pollution and flood control, is crucial but not sufficient. This is because purely technical control, without understanding and considering biotic dynamics, constitutes a more trial and error approach to water management than the imple-mentation of a policy toward sustainable water use. While elements of this approach remain valid and viable, a technical solution alone is clearly insufficient for the sustainable use of the world's water resources. To guarantee the sustainability of freshwater resource use, it is necessary not only to reduce or eliminate the discharge of pollutants, but also to extend the number of potential tools to manage the degradation of ecological processes in landscapes. Such a more efficient approach must be based on an understanding of the temporal and spatial patterns of catchment scale water dynamics.

ECOHYDROLOGY - CREATING OPPORTUNITIES

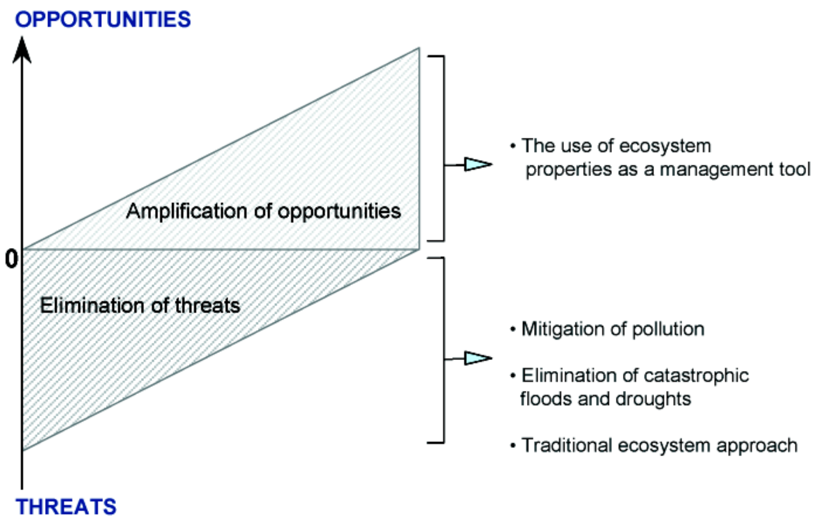
Human survival and the preservation of biodiversity on Earth are dependent on our ability to maintain the integrity of ecological processes. Therefore, one of the fundamental tenets for the sustainable development of water resources is the main-tenance of a homeostatic equilibrium within an ecosystem.

At the present level of human impacts on ecosystems, it is necessary to **increase the opportunities** for ecosystems (Box 2.1). It can be achieved by increasing the absorbing capacity of ecosystems against human impacts that continue to increase. Ecohydrology as an approach provides tools to achieve this goal by defining new approaches to freshwater protection, restoration and management.

ECOHYDROLOGY AS AN INTEGRATIVE APPROACH

The formulation of the ecohydrology concept defined in UNESCO IHP V was to a large extent a logical consequence of the progress of river ecology (Zalewski, 2000; Zalewski & Robarts, 2003). The awareness of a need for integration of hydrology and ecology appears in the hydrobiology and hydrology scientific papers of the 1970`s (Zalewski et al., 1997). However, only in the 1990`s did

BOX 2.1
Application of Ecohydrology as a Factor Maximizing Opportunities in a Successful Strategic Scenario of Sustainable Freshwater Management

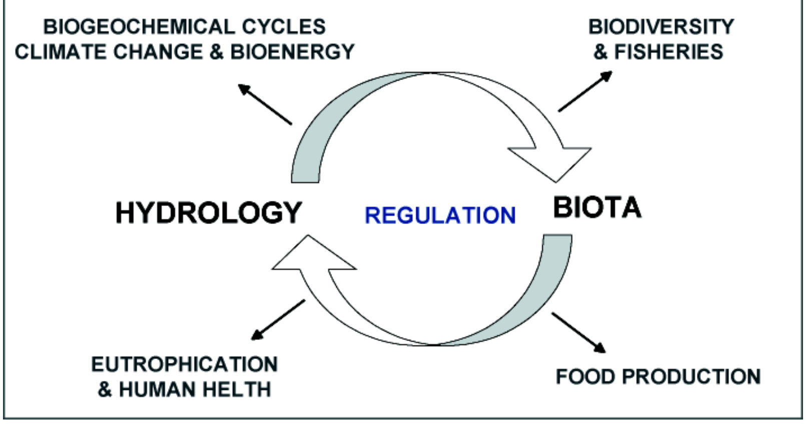


(modified from Zalewski, 2002)

independent research directed to the interactions between the hydrosphere and biosphere become a subject of research for scientists in various fields. This created a basis for the holistic approach to understanding interactions between ecological and hydrological processes at a catchment scale and directed at the development of practical approaches for sustainable watershed management (Box 2.2). Among others, the broad scope of the research covered the following aspects:

- The relationship between vegetation, soil and water based on an understanding of the physiological properties of plants was presented by Baird & Wilby (1999).
- Considerable progress was made in understanding the role of vegetation in water cycling processes in a landscape through research by Rodriguez-Iturbe (2001) and that done within the IGBP BAHC programme (Vorosmarty, 2000).
- The multidimensional role of the buffering by ecotone zones between land and water have been well defined within the framework of the UNESCO MAB Programme (Naiman et al., 1989; Zalewski, Schiemer Thorpe, 1996, 2001; Gilbert et al.,1997).
- Application of ecological engineering, e.g., to the management of wetlands for water purification from excessive nutrient loads based on ecological theory and mathematical modelling, has been developed by Jorgensen & Mitsch (1996).
- Effect of hydrological regimes on vegetation succession of grasslands and swamps has been analysed by Witte & Runhar (2001).
- Reduction of nutrient loads to lowland reservoirs by enhancement of their retention in floodplains has been demonstrated by Wagner & Zalewski (2000).
- Control of eutrophication symptoms (elimination of toxic algal blooms through regulation of water levels for control of trophic cascades) has been evidenced by Zalewski et al. (1990, 2000).
- Some research has been undertaken on the control of water quality and dissolved oxygen content under ice cover during winter in dam reservoirs by regulation of the outlet (Timchenko et al., 2000).
- Regulation of the timing of water release on the Parana River (Porto Prima Vera Dam) in order to maintain fish migration, preserve biodiversity and fish production, has been investigated by Agostinho et al. (2001).
- Examination of the possibilities of managing coastal waters and diminishing their eutrophication using ecohydrology at a basin scale has been initiated by Wolanski et al. (2004).

Box 2.2
Application of Ecohydrology in problem solving



MAKE SURE TO CHECK THESE RESOURCES:
Guidelines: chapters 1, 2

2.B. WHAT IS PHYTOTECHNOLOGY?

WHAT IS PHYTOTECHNOLOGY?

In general, the term **phytotechnology** describes the application of science and engineering to examine problems and provide solutions involving **plants**. The term itself is helpful in promoting a broader understanding of the importance of plants and their beneficial role within both societal and natural systems. A central component of this concept is the use of plants as **living environmentally sound technologies** (ESTs) that provide services in addressing environmental issues. In the context of this manual phytotechnologies are related to environmental problems and the provision of solutions within Integrated Watershed Management.

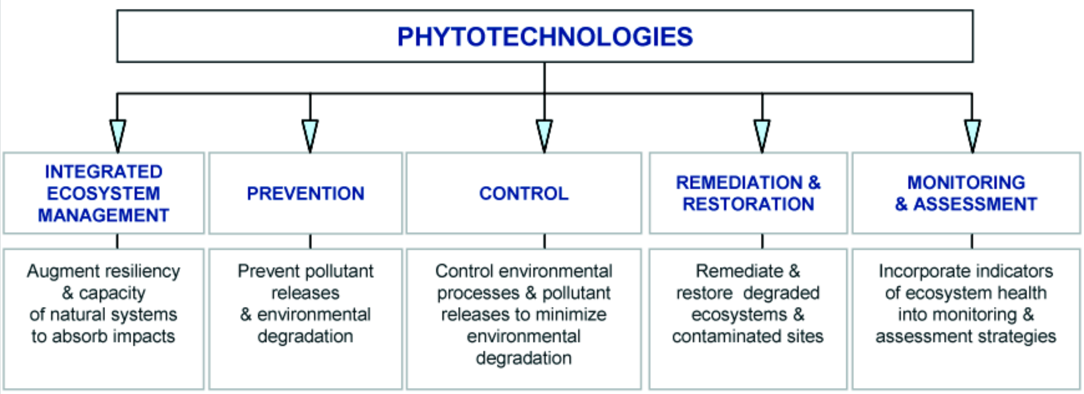
Phytotechnological applications employ **ecological engineering** (Mitsch & Jorgensen, 2004) principles and are considered to be ecotechnologies. Ecotechnologies are dependent on the self-regulating capabilities of ecosystems and nature. The focus on, and use of, biological species, communities, and ecosystems distinguishes ecotechnologies from more conventional engineering-technological approaches, which seldom consider integrative ecosystem-based approaches (UNEP, 2003).

WHAT ARE THE ENVIRONMENTAL APPLICATIONS FOR PHYTOTECHNOLOGIES?

General categories for phytotechnological applications

Environmentally beneficial applications of phytotechnology can generally be divided into five categories (Box 2.3). The **integrated ecosystem management** component focuses on the use of phytotechnology to augment the capacity of natural systems to absorb impacts by serving as natural buffers. The **prevention** component is related to avoiding degradation effects originating from the release of pollutants into the environment or destruction of habitats (this also brings together the need to modify non-sustainable habits and behaviours of society). The **control** component mainly addresses the management of pollutants releases while rendering them harmless through natural processes. The **remediation and restoration** component considers methods and applications to bring back degraded ecosystems or the construction of artificial ones. **Monitoring and assessment** involves the use of bioindicators to follow up and assess conditions and changes in the environment due to natural and/or anthropogenic disturbances.

BOX 2.3
Environmentally beneficial applications of phytotechnology



(modified from UNEP, 2003)

Benefits of the applications of phytotechnologies

Their application may increase the functioning of ecological systems and hence the value of natural capital and natural services provided by ecosystems as a whole. The term „ecosystem services" or „natural services" refers to the conditions and processes through which natural ecosystems sustain and fulfill human life (Daily, 1977). These services are the result of complex natural cycles driven by solar energy, influencing the functioning of the biosphere in a number of different ways. Ecosystem services maintaining biodiversity and the production of ecosystem goods, such as food, timber, energy and natural fiber, as well as many pharmaceuticals, industrial products, and their precursors. The harvest and trade of these goods is based on „natural capital" and hence are an important part of the global economy. In addition, ecological services include life support functions, such as protecting watersheds, reducing erosion, providing habitats for wild species, as well as the cleaning, recycling, and renewal of systems.

Plants are a fundamental part of the world's natural capital base due to the services they provide. The value of natural capital is increased by augmenting the capacity of ecological systems to function effectively. Some examples of the benefits of ecological services are:

- purification of air and water;
- mitigation of floods and droughts;
- detoxification and decomposition of wastes;
- generation and renewal of soil and soil fertility;
- translocation of nutrients;
- pest control;
- biomass production from simple elements through photosynthesis, and
- moderation of temperature, wind force and wave action.

Examples of phytotechnological applications

Phytotechnology can be applied for solving several ecological problems by the direct use of plants for in situ (or „in place") removal or degradation of contaminants or improving the physical structure of an ecosystem and hence it's functioning. Phytotechnology covers a variety of low cost, solar energy driven cleanup techniques. At some sites with low levels of environmental degradation they can be used in place of conventional technical solutions. In other cases, they can be applied together with them a final step towards refined environmental improvement. Some specific examples of phytotechnological applications include (UNEP, 2003):

- Reduction and management of problems related to **point and non-point sources of pollution** through the use of natural or constructed wetlands (usually coupled with conventional methods).
- Facilitating the **recovery of degraded ecosystems and soils**, such as brown fields or post industrial sites, or, for example, in the case of mine-tailing fields and dumping sites. Also they are widely used for aquatic and terrestrial ecotone recovery.
- **Sinks for carbon dioxide** to mitigate the impacts of climate change through refo restation and afforestation.
- Augmentation of the **environmental capacity of urban areas** to mitigate pollution impacts and moderate energy extremes. An example is the use of rooftop vegetation, or „green roofs" to thermally insulate buildings as well as to avoid or reduce the formation of „heat islands". They can also be used to increase land beautification and urban biodiversity.

WHY IS PHYTOTECHNOLOGY USED IN IWM?

Specific applications of phytotechnologies in integrated watershed management are complementary to ecohydrology. The biota, hence plants, are key players in restoring water and biogeochemical cycles augmenting the carrying capacity, resilience and functionality of ecosystems (UNEP, 2003). In Box 2.4 the role of phytotechnology in IWM is presented in schematic form while in the following information some of the reasons behind their application are given:

- Plants form the first level of ecosystem structure (primary producers) and, therefore, control energy flow and nutrient cycling in landscapes. Control of vegetation structure can be used for **transformation and retention of nutrients and pollutants**.

- Plant cover is one of the most dynamic and vulnerable components for the regulation of the water cycle in a watershed. It is fundamental to the evapotranspiration rate and, therefore, can help to **mitigate effects of floods and droughts**.
- Production of plant biomass provides **alternative sources of energy (bioenergy)**, resulting in reduction of CO_2 emissions from burning fossil fuels.
- Some **other benefits** from using plants include: production of materials for housing, food, forage medicine production and the creation of employment opportunities.

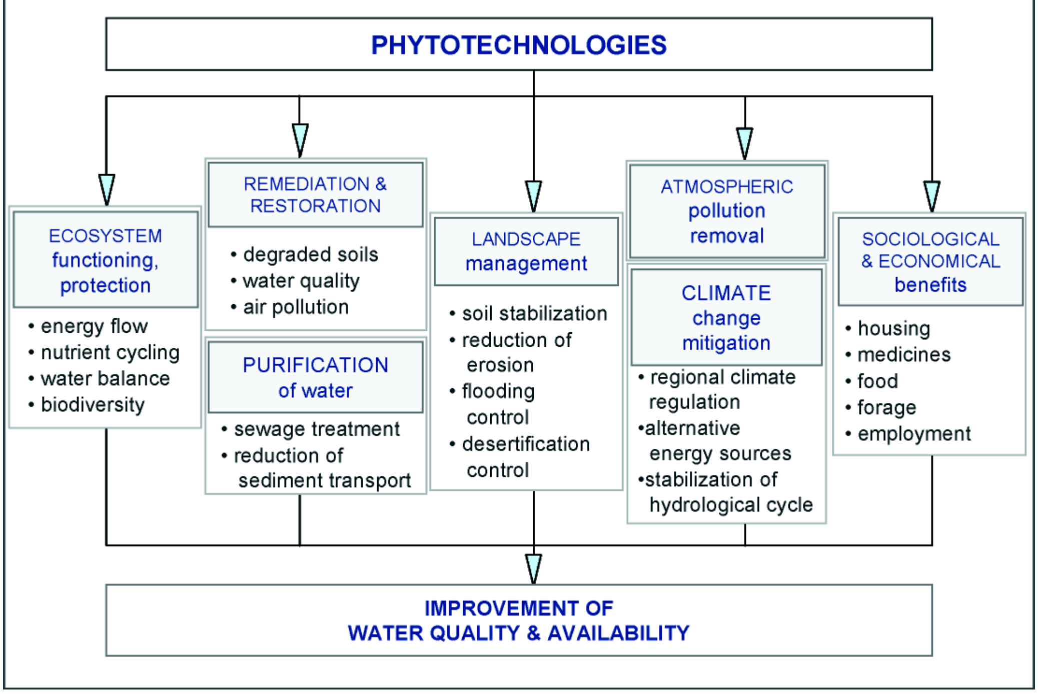
An understanding of the potential and the limitations of phytotechnologies would ensure success when they are applied. Insufficient knowledge and expertise regarding selection of species, distribution and disposition requirements, factors influencing plant growth, as well as public and regulatory acceptance of their use, will cause the use this technological approach to fail. Each application of phytotechnologies involves site-specific considerations and should be evaluated on a case-by-case basis. The developers and proponents of phytotechnological applications must be able to demonstrate environmental performance of the selected technique based on objectives and economic benefits and minimizing potential environmental and human health risks (the latter particularly in cases of phytoremediation applications that are undertaken to clean polluted sites).

The effectiveness in the short and long term of the application of phytotechnologies would also depend on having both broad-based and expert input into their development, adoption, maintenance and monitoring by those utilizing them. The involvement in some cases of local citizens will also ensure their performance and sustainability.

Specific examples of phytotechnological applications in IWM

The major goal of applying of phytotechnologies and ecohydrology in IWM is to improve water quality and quantity as well as to stabilize the hydrological cycle. To achieve this, applications of

BOX 2.4
Role of phytotechnology in IWM



phytotechnologies should cover activities at all spatial levels in the watershed (see chapter 1.C), which include the landscape, land-water ecotone zones, freshwater bodies and estuaries. The most commonly used applications of phytotechnology for management of water resources include the following:

- **phytoremediation of soils** to reduce landscape pollution impacts on fresh waters (e.g., chapter 9.A);
- **vegetation cover management** (forestry and agriculture practices) in order to control the water cycle in landscapes and reduce nutrient leaching and erosion from a catchment (e.g., chapters 9.B, 9.C);
- **ecotone protection and rehabilitation** for reducing diffuse pollution from agricultural lands and others (e.g., chapters 10.B, 11.C);
- **water quality improvement** and eutrophication control through the use of **natural and constructed wetlands** and **floodplains** (e.g., chapters 10.A, 10 C);
- **enhancement of biodiversity** through the growth of aquatic vegetation (e.g., chapters 11.B, 12.C); and
- **production of alternative fuels** or bio-energy production to reduce oil and charcoal use as the main sources of energy mainly in rural areas (e.g., chapters 2.C).

Socio-economic benefits of phytotechnological applications in IWM

Phytotechnologies are considered as low cost environmentally sound technologies and may provide high environmental efficiency at reduced costs. While applied together in some cases with conventional methods, they can provide socio-economic benefits on their own. For example:

- provision of **alternative sources of energy** (bioenergy), resulting in a decrease of per capita outflows of capital for fossil fuel use;
- **fertilizer** source for agriculture, forestry and bioenergetic plantations;
- production of material for **housing, food, forage and sources of medicine**;
- creation of **employment** opportunities for local residents;
- increase of the **quality of life through** rural development and more livable cities; and
- contribute to the **inflow of capital** resulting from the activities based on the quality of water and environment (e.g., tourism).

MAKE SURE TO CHECK THESE RESOURCES:

Guidelines: chapters 1, 4, 5
http://www.unep.or.jp/ietc/Publications/Freshwater/FMS7/index.asp
http://www.unep.or.jp/ietc/Publications/Freshwater/FMS2/index.asp
http://www.rtdf.org/public/phyto/bib/default.cfm
http://www.itrcweb.org
http://www.ec.gc.ca/etad/default.asp?lang=En&n=510541DD-1

2.C. APPLICATION OF ECOHYDROLOGY AND PHYTOTECHNOLOGY FOR WATER RESOURCES MANAGEMENT AND SUSTAINABLE DEVELOPMENT. UNESCO / UNEP DEMONSTRATION PROJECT

Demonstration projects aims at developing, validating and implementing ecohydrology and phytotechnology in integrated watershed management, and are joint UNESCO/UNEP initiatives. Based on the above concepts, demonstration projects endeavour to develop a cost-effective, comprehensive strategy, not only for improving water quality and quantity, but also for meeting local concerns in a given region.

The Pilica River Demonstration Project was designed to mitigate point and non-point sources of pollution entering a river, reduce the risk of toxic algal blooms appearing in a shallow reservoir and converting these threats into opportunities for the regional economy.

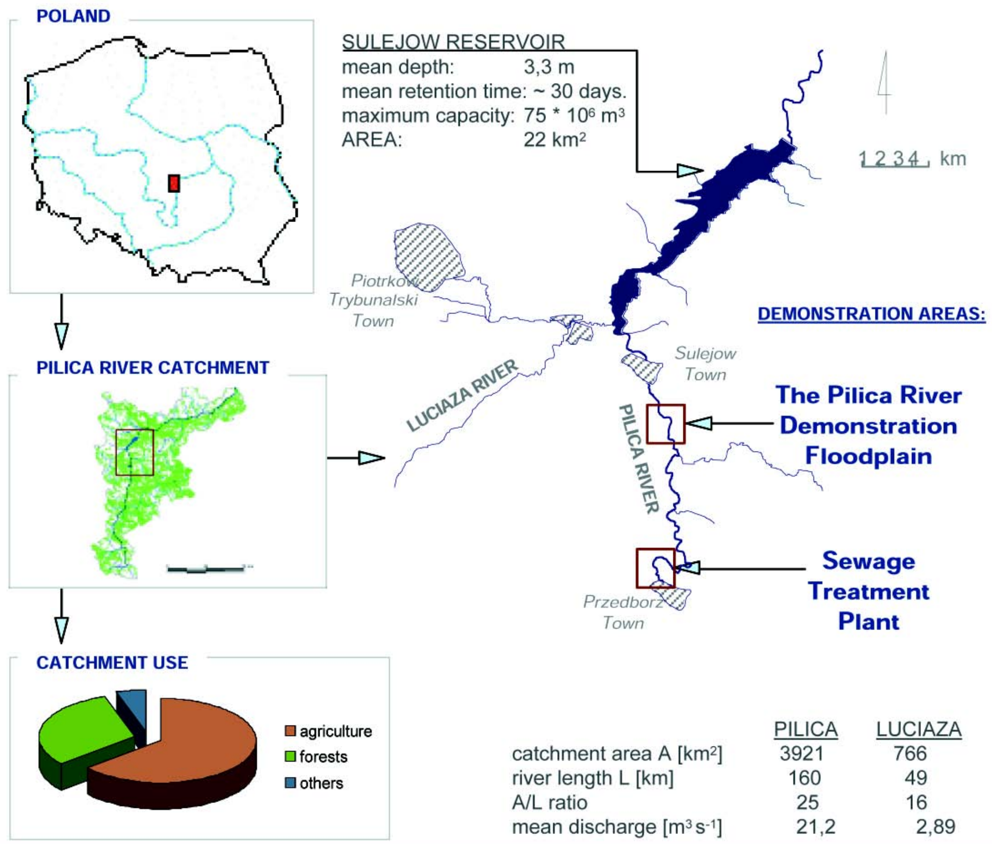
Fig. 2.1
The Pilica River
(photo: B. Sumorok)

LOCATION OF THE DEMONSTRATION PROJECT

The Pilica River Demonstration Project is located in **central Poland**. It is comprised of a **catchment - river - reservoir** system, including the Pilica Ri-

BOX 2.5

UNESCO / UNEP Demonstration Project on Ecohydrology and Phytotechnology - location of two demonstration areas in Poland



ver (Fig. 2.1) and a lowland reservoir located in its middle reach (the Sulejow Reservoir; Box 2.5). For nearly 30 years the main function of the reservoir has been to supply the City of Lodz (about 800 000 inhabitants) with drinking water. This purpose has lately been restricted because of water quality concerns. It serves now as an optional source of drinking water and recreational area for about 1 million people.

KEY ISSUES

Key issues have been classified into ecological and socio-economic categories (Box 2.6).

BOX 2.6
Key issues in the Pilica River catchment

ECOLOGICAL ISSUES
Non-point pollution sources of the river resulting from agricultural use of the catchment
- high nutrient loads transported by the river, especially during flood periods;
point sources of pollution severely impacting water quality of the river;
- unstable and outdated treatment technologies at the sewage treatment plants;
- exceeded chemical and biological standards in the sewage released to the river from the treatment plants;
- eutrophication and periodically increased bacterial numbers in a river;
toxic algal blooms in the reservoir;
- Eutrophication and toxic cyanobacterial blooms restricting use of the reservoir as a drinking water supply and recreational area;
SOCIO-ECONOMIC ISSUES
unemployment ratio over 20%
agriculture development limited by low soil quality
limitation of the development of tourism by low water quality of the Pilica River and the Sulejow Reservoir

Ecological issues

The Pilica River catchment is a beautiful, picturesque area, with several landscape parks and preserved old forests, as well it has high cultural and historical values. The river itself - although over most of it's length has an undisturbed character - it is, however, impacted by **point-sources of pollution** due to unstable and outdated sewage treatment technologies. These affect the chemical and physical components, bacteriology and biotic structure of the river. A large part of the pollution also comes from **non-point sources**, which is derived mostly from agriculture in the catchment (Box 2.5).

The pollution not only effects the quality of the river, but is transported to the Sulejow Reservoir located downstream. Large amounts of the inflowing sediment and nutrients are retained in the reservoir, resulting in eutrophication and the occurrence of **intensive cyanobacterial blooms** during summers. The maximum cyanobacterial biomass observed in 1995 reached 60 mg L^{-1} (Tarczynska, 1998). Several studies revealed **cancerous and toxic effects** of the toxins produced in the reservoir by the cyanobacteria (Microcystis aeruginosa) (Mankiewicz, Tarczynska, Walter, Zalewski, 2003; see chapter 7.D).

Socio-economic issues

The area is characterized by a high unemployment rate, locally reaching more than 20%. At the same time agriculture, considered traditionally to be the main income for a large part of the local population, has been limited by low soil quality in a competitive economy.

High value of the region's natural resources could make it a good area for future development of recreation, tourism and eco-tourism. However, there is a need to **improve the water quality** and reduce the occurrence of toxic algal blooms, which reduce the appeal of the area for potential investors and can restrict the development. Another opportunity is development of alternative agricultural production, e.g., **production of biomass**.

GOAL OF THE PROJECT

The major goal of the project has been to validate application of ecohydrology and phytotechnology for **converting of nutrients** from point and non-point sources of pollution into **biomass and bioenergy**. This is not only to **improve the quality of the environment**, but also to provide additional alternatives for **development of the region and employment**.

DEMONSTRATION AREAS

The project has been developed in the two demonstration areas (Box 2.5):

- **The sewage treatment plant in Przedborz Town** (4,000 inhabitants), where treated sewage from the plant has been disposed directly into the river, until now. According to the **phytotechnology approach**, establishment of a **constructed wetland together with a willow plantation** as the final step of treatment, could diminish the impact on the river. Additionally, the biomass produced in the wetland could be utilized as **bioenergy**, and cover part of the energetic needs of the treatment plant, reducing costs of it's maintenance.
- **Demonstration floodplain of the Pilica River**, where a method for **reduction nutrient loads transported by the river** down to the reservoir was to be developed and quantified. Nutrient retention can be enhanced by two groups of processes: physical ones (intensification of sedimentation by regulation of floodplain hydraulics) and biological ones (uptake of the dissolved fraction by **biomass** through the management of the natural floodplain vegetation communities and patches of planted willow).

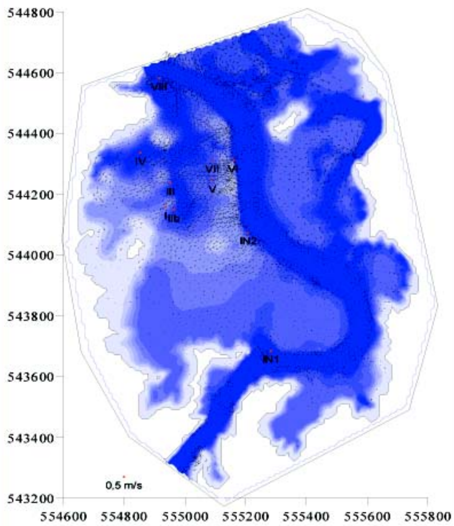
PROJECT IMPLEMENTATION

The implementation of the project has been developed through five parallel lines of action:

- **research** - providing scientific evidence of the hydrological and biological processes;
- **development and implementation of technologies** for applying ecohydrology and phytotechnology in the research areas;
- **Meetings** with local government, stakeholders and landowners, for dissemination of information and facilitation of implementation;
- **Training and education** - including primary and secondary schools in the region, national and international university students and young scientists;
- **Dissemination** of the information and experiences about the project at the national and international levels;

Fig. 2.2
Sampling of mycorrhizal samples on the Pilica River demonstration floodplain (photo: I. Wagner-Lotkowska)

BOX 2.7
Hydraulic model of the demonstration floodplain of the Pilica River



Example of the visualisation of the hydraulic model constructed for the Pilica River demonstration floodplain.
Co-operation with the Department of Hydraulics and Hydrology of Gdansk Technical University and Faculty of Geography and Regional Studies of University of Warsaw (Poland).

(Szydlowski, Magnuszewski, Wagner-Lotkowska, unpublished data)

GENERAL RESULTS

The results of the first year of project implementation include the following:

- **Development of hydraulic models of the demonstration floodplain**, for optimization of sedimentation processes and nutrient and water retention (Box 2.7);
- Elaboration of recommendations for **vegetation management** in order to enhance the ability of the system to retain nutrients in biomass.
- **Elaboration of a draft management plan for a water treatment plant in Przedborz**, including recommendations for both technical upgrades and justifications for a phytotechnological application.
- **Elaboration of a management strategy for the use of biomass produced in the area**. Following the idea presented in the summary of the UNESCO/UNEP Guidelines (Box 2.8), the strategy should generate a positive socio-economic feedback based on the use and management of environmental resources. The potential for bioenergy production in the region has been estimated using various scenarios of energetic needs.
- **Increase of knowledge and awareness about ecohydrology and phytotechnology, their application in IWM and benefits for sustainable development in the region**, by training, education and dissemination. Several trained target groups includes local, regional and national authorities, NGOs, stakeholders and landowners, which have been involved in implementation of the project during the latter stages. Another group of activities was aimed at researchers, young scientists, university teachers, students, youth and children, primary and secondary teachers. The outcomes and results of the project have been disseminated during a number of national and international meetings and conferences, by distribution of informative materials and a website written in both Polish and English.

Fig. 2.3. Education for primary schools (photo: I. Wagner-Lotkowska)

Fig. 2.4. Extensive planting of willows on the Demonstration Floodplain (photo: I. Wagner-Lotkowska)

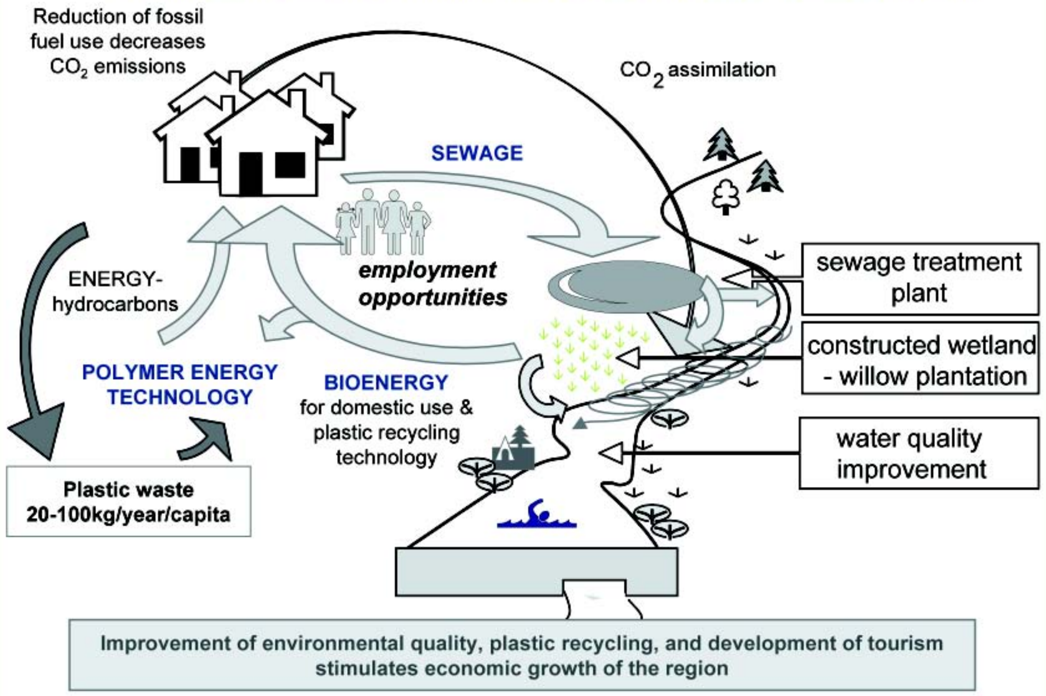
FUTURE PERSPECTIVES

The results of the first phase of the project implementation show the potential for the application of ecohydrology and phytotechnology measures in the Pilica Region, which has attracted the interest of local and regional authorities. Further development of the project is to be focused on the following aspects:

- **Continuation** of the tasks developed in the first phase of the project;
- Preparatory work for implementation of the achievements of the project's first phase at a **larger scale**;
- Elaboration of a strategy for biomass use for **solving other environmental problems** in cities in the region, such as conversion of polyolefin wastes into energy.

BOX 2.8

Incorporation of socio-economic aspects into constructed wetland planning



Zalewski 2002, see Guidelines: chapter 10

MAKE SURE TO CHECK THESE RESOURCES:

Guidelines: chapters 2, 7, 10

www.biol.uni.lodz.pl/demosite/pilica