Building integrated strategy to increase resilience of urban catchments – Ecohydrological approach

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Abstract

The City of Lodz, as many other cities in Europe, suffers due to the urban sprawl. It is driven by economic (decline of textile industry – main driver of the past city development, new investments), societal (consumption pattern), and demographic (population decrease, migrations) changes on the one hand, and lack of an appropriate planning regulations at different levels of national decision making process on the other. The consequence is a damage of the natural environment, loss of cultural and historic heritage and decrease of the quality of life of people living in and around the city. That reviled a need for a new strategy of city development, what became a target for the cooperation between scientists from Department of Applied Ecology University of Lodz, International Centre for Ecology of Polish Academy of Sciences, the Municipal Office of Lodz, and NGO's, that has been established in 1998. Recent activities have been focused on the development of two city river catchments – the Sokolowka and the Ner. They are to provide a backbone and pilot studies for further restoration and revitalization projects. The milestones include: 1) recognizing spatial relationships between factors that influence environmental conditions in study areas, 2) evaluating the inherent capacity of given areas based on their biophysical attributes, 3) assessing current environmental state, 4) defining main trends of changes and associated drivers (policy changes, people's attitudes), and 5) identifying social and cultural values and expectations.

The applied approach is based on two concepts: *environmental securability* – defined as the potential of an environmental system to provide components of environmental security, and *ecohydrology* – postulating use of synergies between catchment water cycle and dynamic of its biotic component as management tool, and harmonization of existing and planned hydrotechnical solutions with ecological biotechnologies at all scales.

The aim of a paper is to present the state of art of EH solutions implementation with special focus on: 1) identification of areas that could catalyze restoration and revitalization processes, 2) elaborating on methods that could be applied at those areas at different ecological scales – river bed, valley, and catchment.

Introduction

The City of Lodz, is located in central Poland and inhabited by 800 thousands people. It arose during the industrial revolution in the early 30's of the XIX century, due to development of textile industry. The city population and its area grew exponentially and by the end of XIX century it had already been inhabited by 100 thousands people, while by 50's of XX century population increased seven times. Many outstanding environmental challenges result from this industrial history of the city, e.g.: devastation and loss of forests and other green spaces, soil contamination, scarcity of good quality drinking water, and degradation of rivers being incorporated into sewage and storm water systems. The others are linked to recent factors, like: political and economic transformations of 90's (collapse of industry, unemployment, lack of investments), changes of people's aspirations and expectations, urban sprawl, marginalization of some city districts and communities, transformation of green spaces and historical quarters into residence areas and inadequacy of environmental and water management systems to current demands.

The challenges reviled a need for a new strategy of city development, based on one hand on co-operation between scientists, authorities, NGOs and citizens, and on the other hand on launching a pilot studies, to test solutions proposed for restoration and revitalization projects. The new strategy should be aimed at: 1. adaptation of small city rivers and catchments for interception of large storm water and pollution loads, 2. elaboration of comprehensive concept of wastewater treatment plant management, addressing issues of sewage sludge conversion into biomass, and river rehabilitation, 3. elaboration of plans for improvement of city landscape towards providing attractive recreational and residential areas and refuges for urban biodiversity, 4. improvement of quality of water, air, and soil to decrease health risks related to living in urban and industrial areas.

Two catchments (of the Sokolowka and the Ner rivers) have been selected as pilot studies that allowed tackling a comprehensive scope of water related issues specific for the city of Lodz, and validating ecohydrology solutions in meso scale (Zalewski, Wagner, 2005)

Scientific approach – from environmental securability to ecohydrological solutions

Rehabilitation of urban river and its surroundings results from spatial planning, people perception of current and desirable state of the river and landscape, availability of resources and local policy goals. Hulse and Gregory (2004) described a decision making process related to both - launching or not a rehabilitation project and setting feasible goals - as balancing between two extremes of socio-ecological system state - systems having low ecological potential and burdened with high ecological and economic constraints and systems of high ecological potential and low demographic and economic constrains. The main criteria for making decision are potential increase of ecological benefits (and possibly human well-being) and spatial, demographic, economic limitations together with economic gains and loses. Very high constraints and critically low ecological potential may even lead to the decision of dereliction (Fig.1.). On the other hand, due to location of urban catchments and therefore strong interplay between nature and society, an environmental security becomes a core issue that can outbalance negative evaluation of a system state in favour of rehabilitation.

The assessment of starting point and base line for the action involves landscape level insights into spatial relationships between factors influencing environmental conditions (e.g., drivers and pressures), the inherent capacity or resiliency of given areas based on their biophysical attributes (e.g., an area's sensitivity/exposure to different drivers and pressures), and the area's environmental condition (state) and trends (impact and trajectory). When combined information on social and cultural values and expectations, the landscape approach provides a way to evaluate an area's relative environmental *securability*, e.g., the likelihood of being able to change to or maintain a landscape state whereby important landscape services are obtained or preserved over long periods of time (Jones et al. 2007). Areas with low levels of *securability* would require greater levels of attention, human and capital investments, dialogue between actors and parties and broad scale planning, which enable capacity building through bridging to other initiatives, more sustainable areas, and ecosystems of higher resistance to human pressure. Areas with relatively high *securability* would require less intervention but would still require monitoring, and precautionary management.

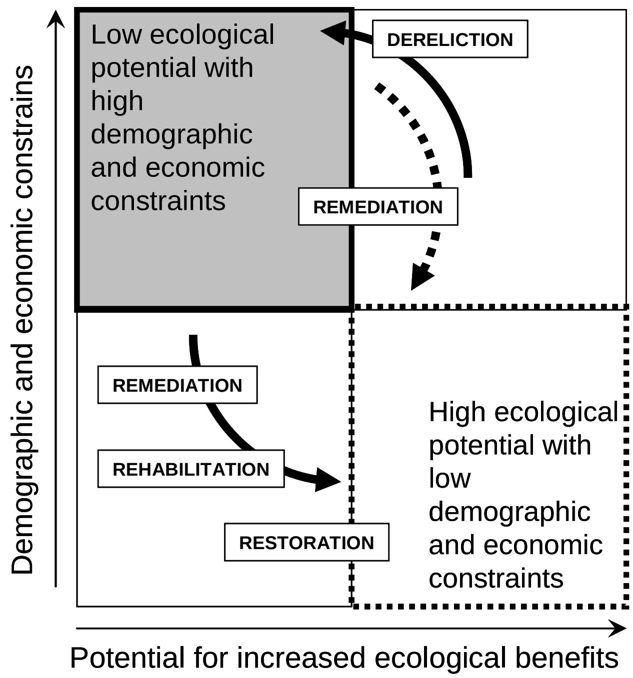

Fig.1. The framework for decision making process on restoration activities objectives and techniques (modified after Hulse and Gregory, 2004).

Understanding a context of catchment rehabilitation and water management planning gives a plea for implementation ecohydrological solutions, depending on and target at the quality of aquatic habitats and determinants of rivers ecological status. The ecohydrology approach helps to develop management tools based on the relationships between hydrological features and biological processes summarized by three tenets: i) dual regulation of hydrology by managing biota and, vice versa, regulation of biota by altering hydrology, ii) integration of various types of regulation at the catchment scale to achieve synergy, serving to stabilize and improve the quality of water resources, iii) harmonization of ecohydrological measures with hydrotechnical solutions e.g. reservoirs, by-passes, dykes and dams, irrigation systems, sewage treatment plants, levees in urbanized areas, etc. (Zalewski, 2006, Zalewski et al. 2004).

With regard to the both adopted approaches, a current phase of the SWITCH project realization in the Sokolowka River catchment has been streamlined towards:

- construction of 2 new reservoirs for reduction of storm water peaks;
- adapting hydrotechnical infrastructure of the new and old reservoirs for reduction of storm water peaks and improvement of the water quality in the Sokolowka system;

- drafting of recommendations for re-meandering and floodplain restoration of the Sokolowka river sections and their possible replication for other Lodz rivers;
- supporting development of green areas in the river catchment based on hydrological regulation;
- recognition of fields for social participation to increase effectiveness of applied measures and to create a positive socio-ecological feedback.

The Sokolowka River catchment rehabilitation and revitalization - preliminary results

Identification of areas that could catalyze restoration and revitalization processes

The first phase research has been focused on improvement of water quality in the Sokolowka River through using of cascade of reservoirs. There are four of them already constructed and varying in characteristics and ecological potential e.g.: light intensity, biotic structure and nutrient supply. The two year sampling conducted at 10 stations located along the river (Fig.2.) seemed to confirm their crucial role in achieving a good biochemical status of water. The TP and TN concentrations decreased after flowing across reservoirs. The highest reduction of nutrient concentrations was observed at first reservoir at Station 3. The TP concentration of 0.77 mg/l at Station 2 was reduced to 0.30 mg/l at Station 3. However it has been observed that storm water outlets located between the reservoirs, diminish their positive effects and contribute to further decreasing water quality (Wagner at al. 2006).

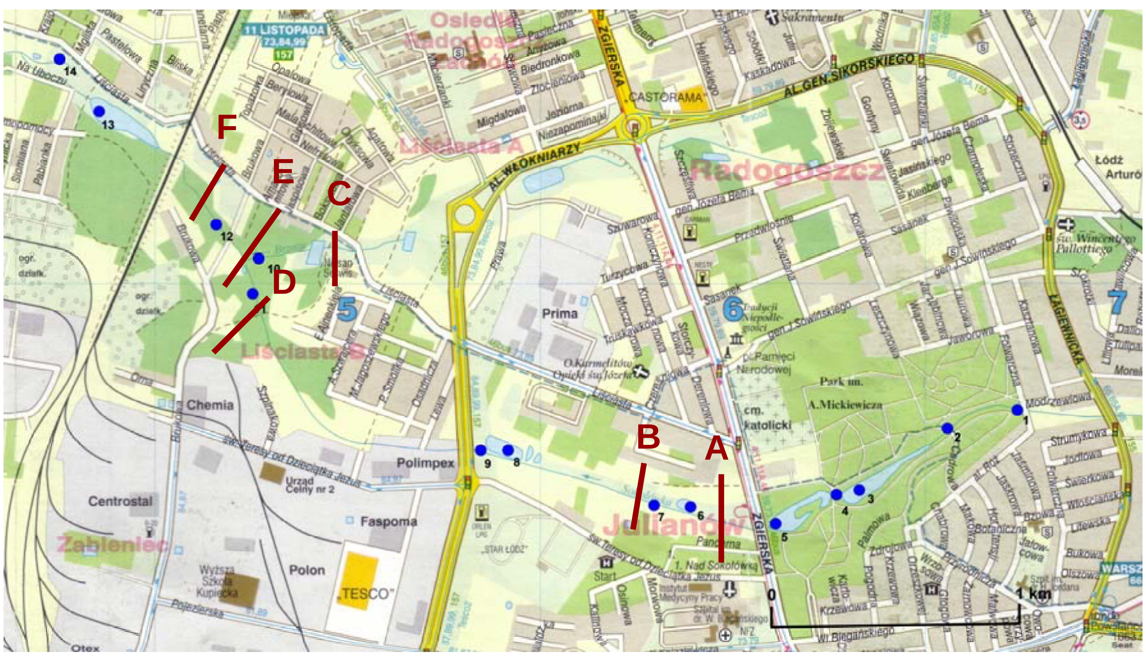

Fig.2. Location of the water sampling stations (blue circles), and transects of ground water and vegetation analysis along the Sokolowka River.

In such conditions further improvement of water quality depends mostly on enhancement of biological processes in river bed in-between the reservoirs and an increase of a buffering role of valley vegetation, especially downstream storm water outlets. The first step towards this goal has been an inventory of existing vegetation types. It was followed by establishing of six piezometer transects across the most representative ones and another six sites to detect ground water dynamics. The aim was to use indicatory species to identify the main environmental stressors and to understand the dynamics of a plant-water interplay along modified river channel. Simultaneously studies on a nutrient uptake potential of different plant communities have been initiated. In order to protect valuable sections of the Sokolowka valley and catchment, and improve the degraded one, in detail analysis of species composition and richness has been started this year. It has been assumed that protection of valley naturalness and improvement of landscape aesthetics positively influence people perception of nature and will stimulate local activities leading to increase of people's awareness and willingness to participate in creation of a new image of the city.

The initial results indicated that despite of regulation of the river channel, the connectedness between the river and its valley has been maintained at least in some sections (e.g. transect E). In some other areas the water enrichment with nitrogen and phosphorous due non point source pollution must be considered prior starting any construction work (e.g. transect A).
There are also areas of low natural values that have to be prioritized in the river rehabilitation project and coupled with city revitalization plans. They include sites currently used for recreation even if lacking suitable infrastructure and degraded / undeveloped urban areas located in proximity of the river and the valley woodlands (examples on Fig.2.). In the first case the goal should be not only adjusting an infrastructure to people needs, but also obtaining social approval and wider recognition of the project. In the second case the aim is to invest in precautionary measures in order to diminish risks related to implementation of the rehabilitation project.

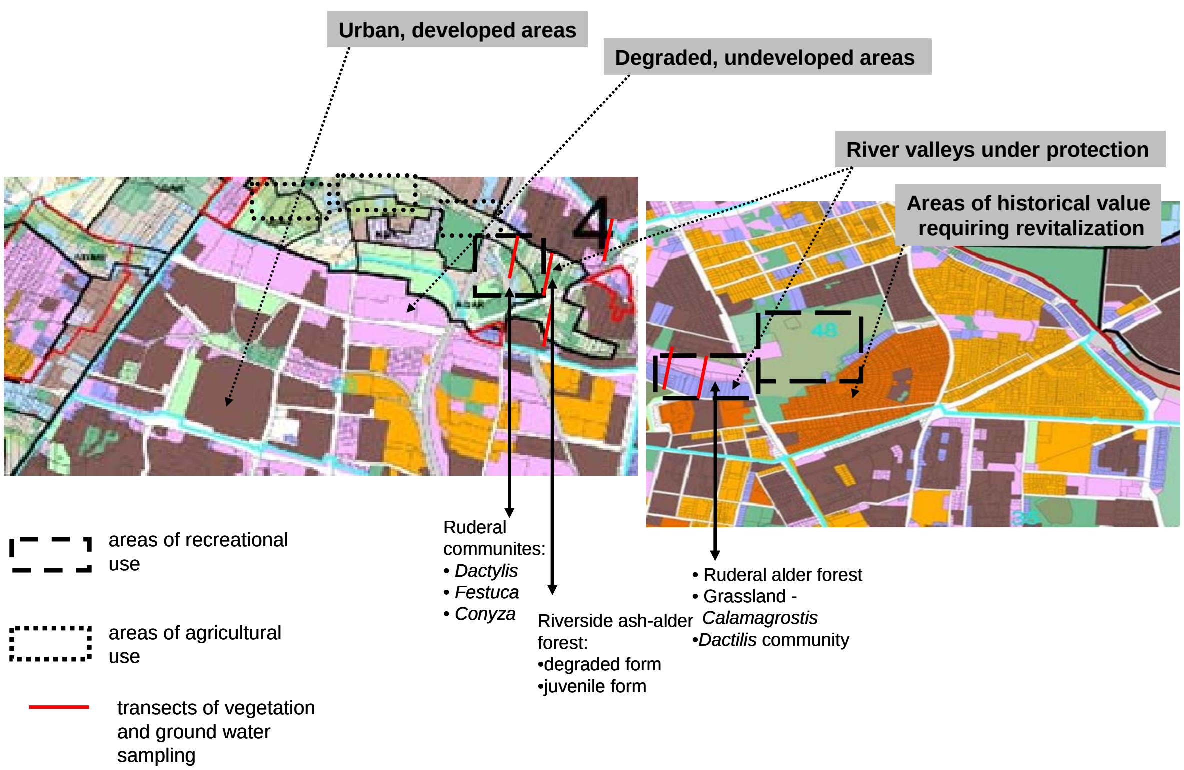

Fig. 3. Land use in the Sokolowka River catchment.

Defining methods to be applied at those areas at different ecological scales – river bed, valley, and catchment

The next step in the Sokolowka rehabilitation plans includes: i) improvement of the river ecological state through facilitation of macrophytes' development in chosen sections of river channel and the reservoirs, ii) indication of areas for constructing wetlands (water purification system) and by-passes (habitat improvement and peak flow reduction), taking into account existing vegetation and environmental constraints, iii) harmonization of existing hydrotechnical constructions with ecological and eco-technological solutions (e.g. by combining sedimentary ponds with constructed wetlands).

At broader (catchment) scale a work is to be focused on: 1) recognizing spatial relationships between factors that influence environmental conditions in study area, 2) evaluating the inherent capacity of given areas based on their biophysical attributes, 3) assessing current absorbing capacity of target ecosystems, 4) defining main trends of changes and associated drivers (policy changes, people's attitudes), and 5) identifying social and cultural values, and expectations being catalysts of change. To achieve the aims in-situ data obtained from ecological and social monitoring have to be confronted with GIS landscape data for the whole catchment and generalized. The background for analysis will be also provided by the city spatial development plans that have recently been completed.

Figure 4 presents an example of the connection of different elements proposed for rehabilitation of the Sokolowka river valley, including rehabilitation of physical structure of aquatic habitats, reestablishment of vegetation cover and its integration with a sewer system.

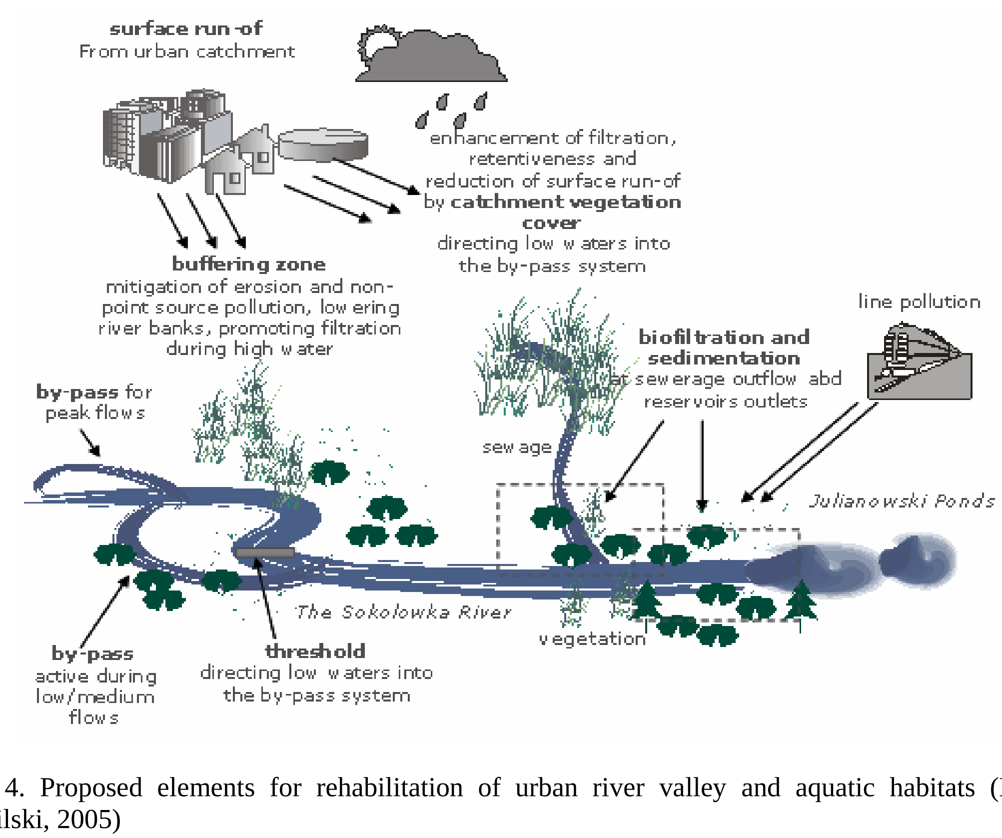

Fig. 4. Proposed elements for rehabilitation of urban river valley and aquatic habitats (Bocian, Zawilski, 2005)

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