Ecohydrology for enhancement resilience and ecosystem services of river basins

Prof. dr hab. Maciej Zalewski

United Nations Educational, Scientific and Cultural Organization

ERCE European Regional Centre for Ecohydrology Under the auspices of UNESCO

EUROPEAN REGIONAL CENTRE FOR ECOHYDROLOGY
under the auspices of UNESCO

- the International Institute of Polish Academy of Sciences
- UNESCO'S Category 2 Water Centre

in strong cooperation with
Department of Applied Ecology, University of Lodz

The scientific profile of the Centre is focused on development of ecohydrological science and its implementation for restoring freshwater resources in the framework of the UNESCO International Hydrological Programme.

EU's Framework Programmes projects

- **EXPEER:** Distributed Infrastructure for EXPErimentation in Ecosystem Research. INFRA-2010-1.1.17 262060.
- **ALTER-Net:** A Long-Term Biodiversity, Ecosystem and Awareness Research Network. (Network of Excellence, 6th FP EU)
- **FAME:** Development, evaluation and implementation of standardised fish-based assessment method for the ecological status of European rivers. A contribution to the Water Framework Directive. (EC Project EVK1-CT-2001-00094).

In cooperation with University of Lodz.

- **SWITCH**: Sustainable Water management Improves Tomorrow`s Cities' Health. (EU, 6 PF)
- **TOXIC:** Barriers against cyanotoxins in drinking water.(EC Project EC-EVK1-2001-00182).
- **MIDI-CHIP-TOX:** Linking cyanobacterial diversity and cyano-toxins. (EC Project EC-EVK2-2002-00546).

EU's LIFE+ projects

- **EKOROB**: Ecotones for reducing diffuse pollution LIFE08 ENV/PL/000519.

- **ENVEUROPE**: Environmental quality and pressures assessment across Europe: the LTER network as an integrated and shared system for ecosystem monitoring

The Ministry for Foreign Affairs Polish Aid Programme

- Implementation of Ecohydrology - a transdysciplinary science - for integrated water management and sustainable development in Ethiopia

FIELD STATION

NEAR THE SULEJOW RESERVOIR
(Tresta village)
University of Lodz
Faculty of Biology and Environmental Protection
www.biol.uni.lodz.pl
DEPARTMENT OF APPLIED ECOLOGY
www.kes.uni.lodz.pl





Why does world become dry and water ecosystems polluted?
Earth at Night
More information available at:
http://antwrp.gsfc.nasa.gov/apod/ap020810.html

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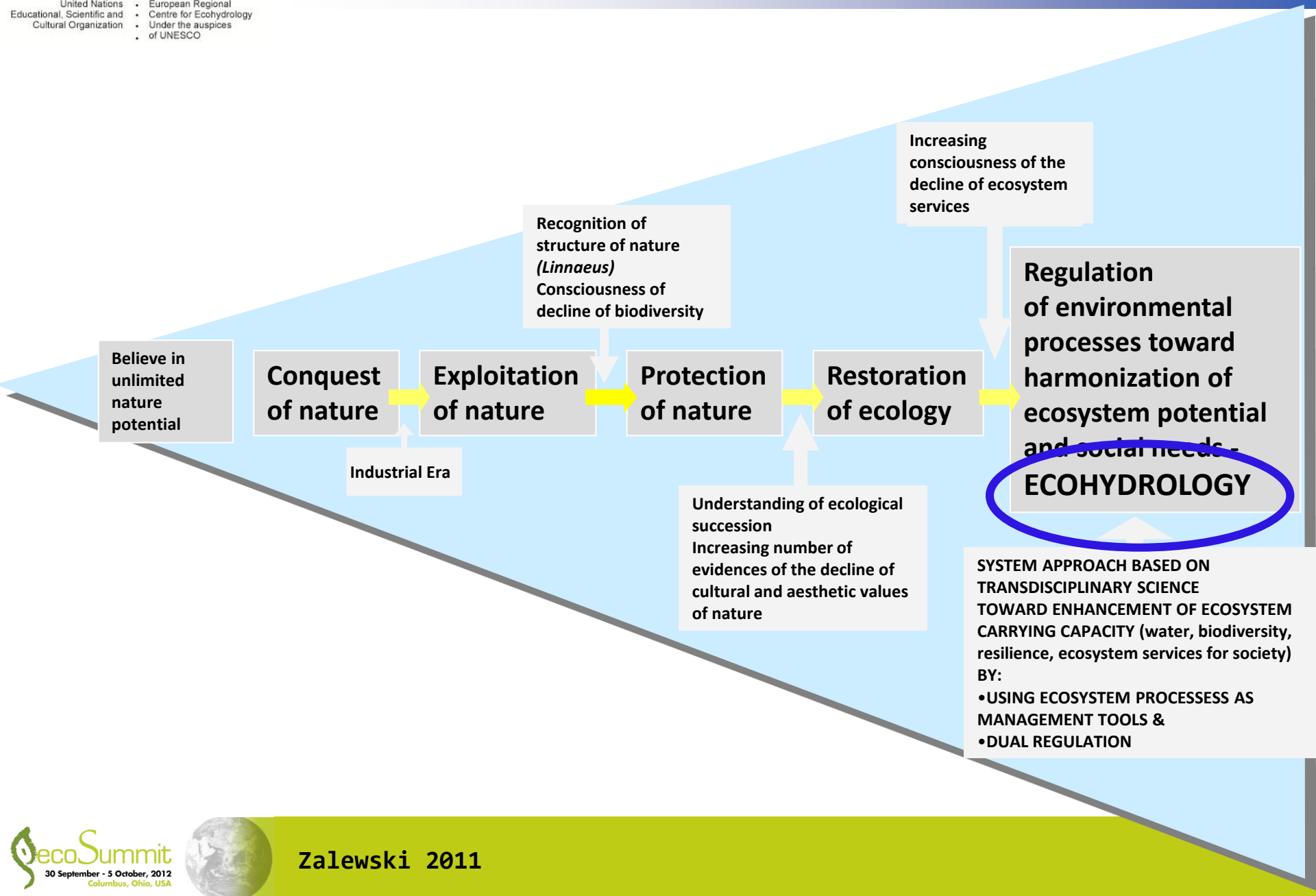
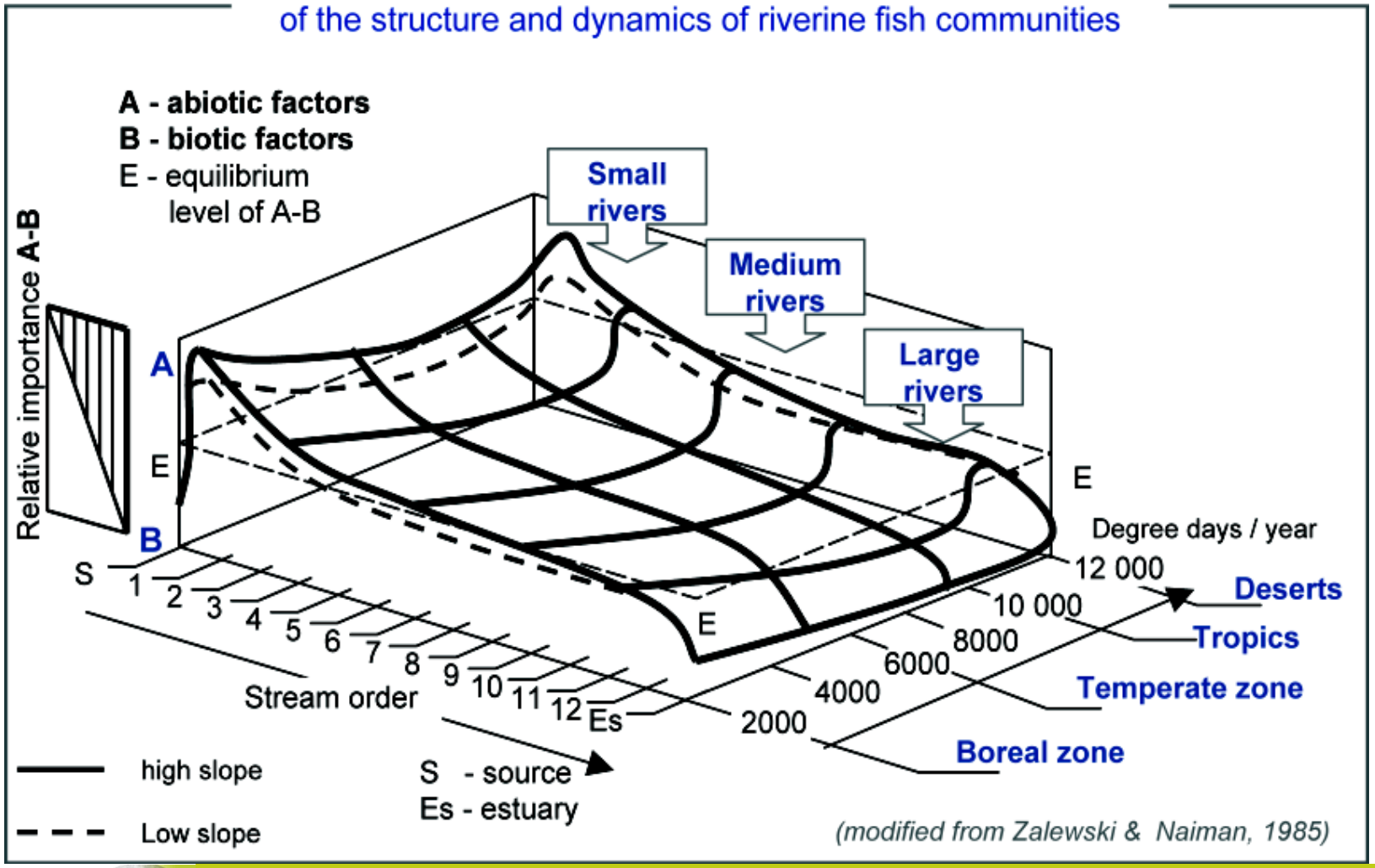
Evolution of relations between Man & Environment



Deductive background of Ecohydrology theory



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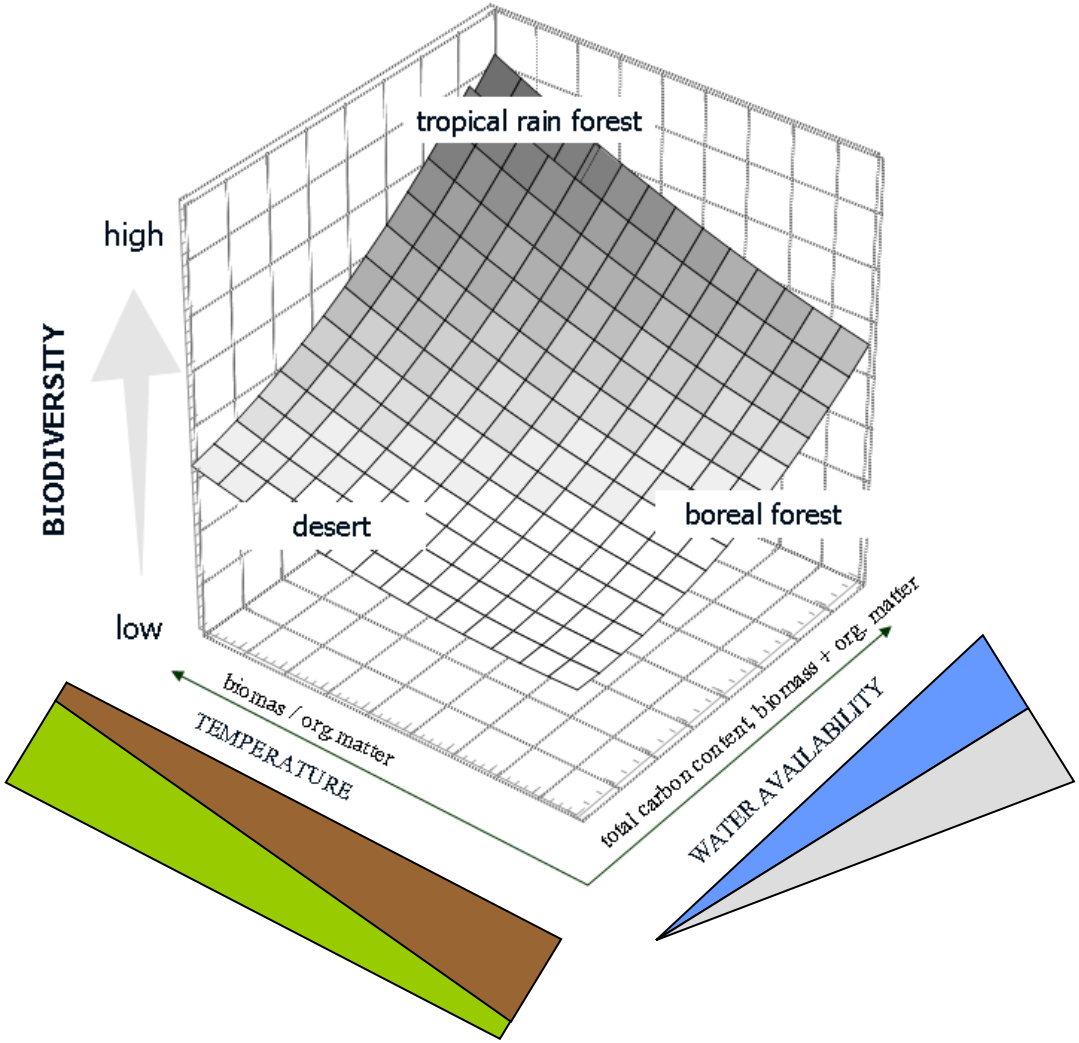
Deductive background of Ecohydrology theory



Zalewski 2010

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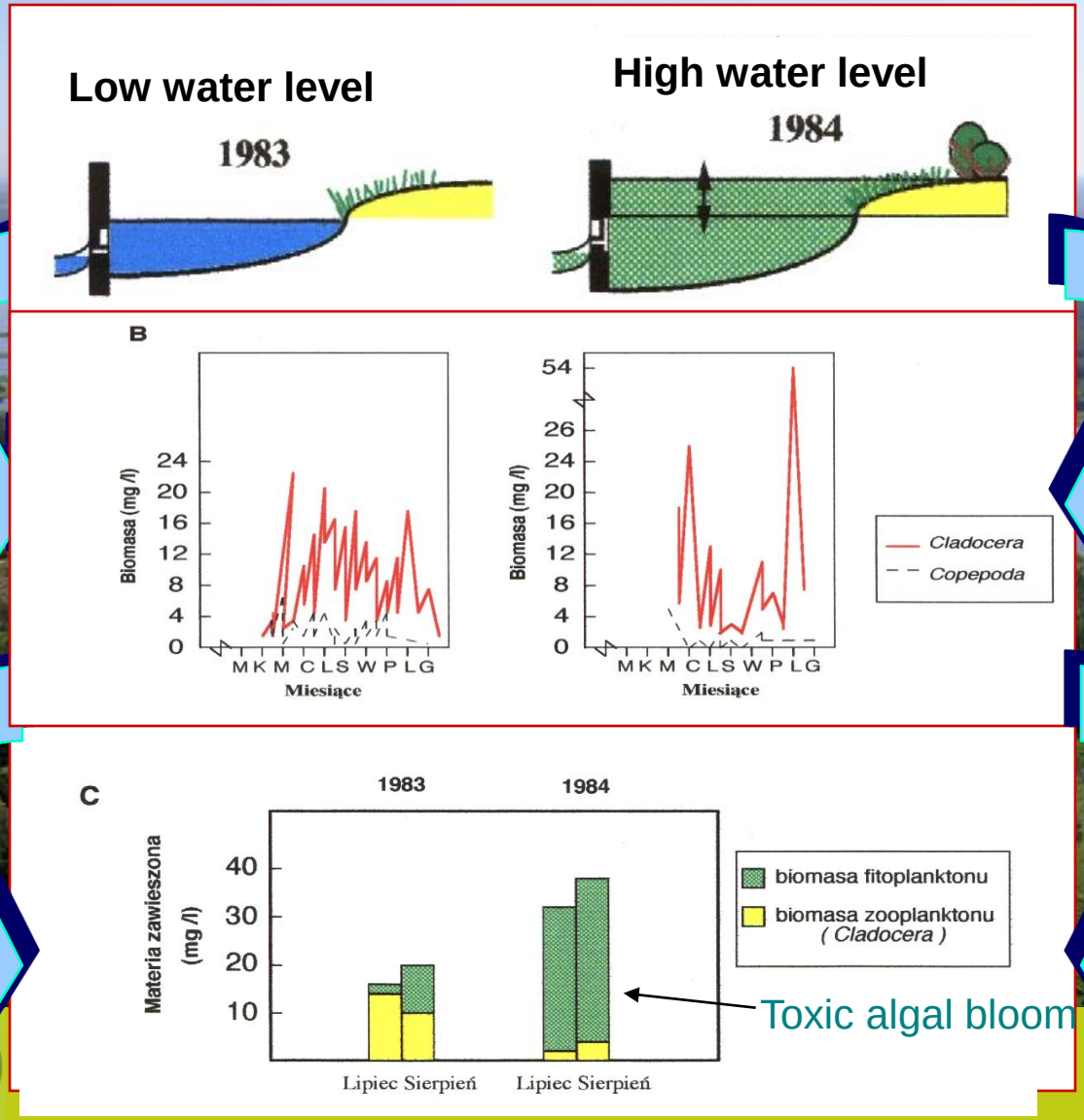
Inductive background of Ecohydrology theory

The regulation of water level in eutrophic reservoir for change of excess nutrients allocation toward the reduction of toxic algal blooms



Zalewski et al. 1990

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MITIGATION of environmental processes degradation – structure oriented thinking – conservation and restoration

Conservation

Restoration

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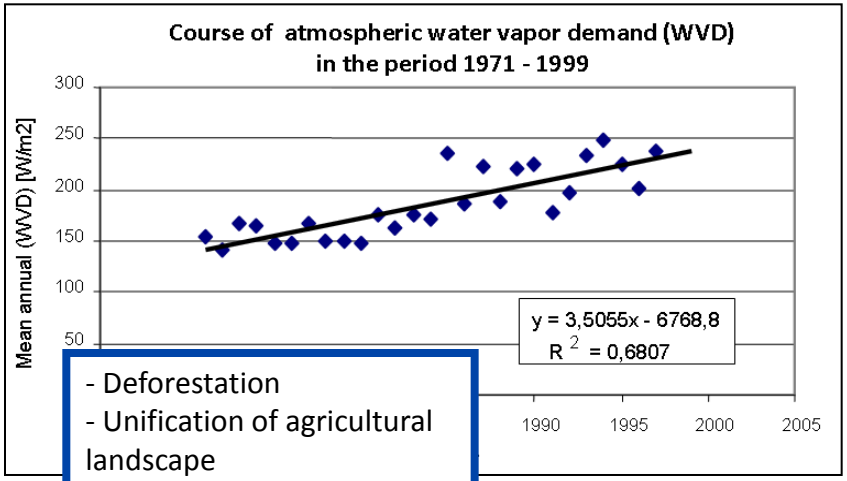
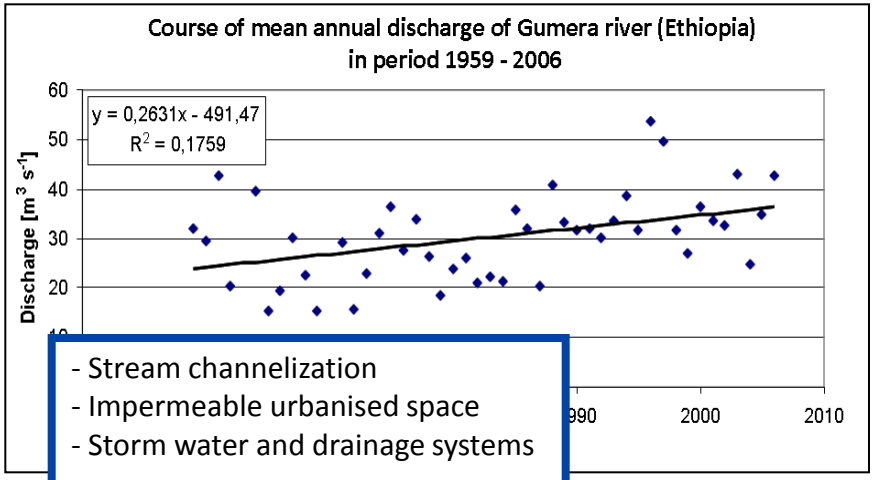
REGULATION of environmental processes degradation – process oriented thinking – Ecohydrology (EH) based integrative scientific and applied approach



- Deforestation
- Unification of agricultural landscape



- Stream channelization
- Impermeable urbanised space
- Storm water and drainage systems

two sides of the road

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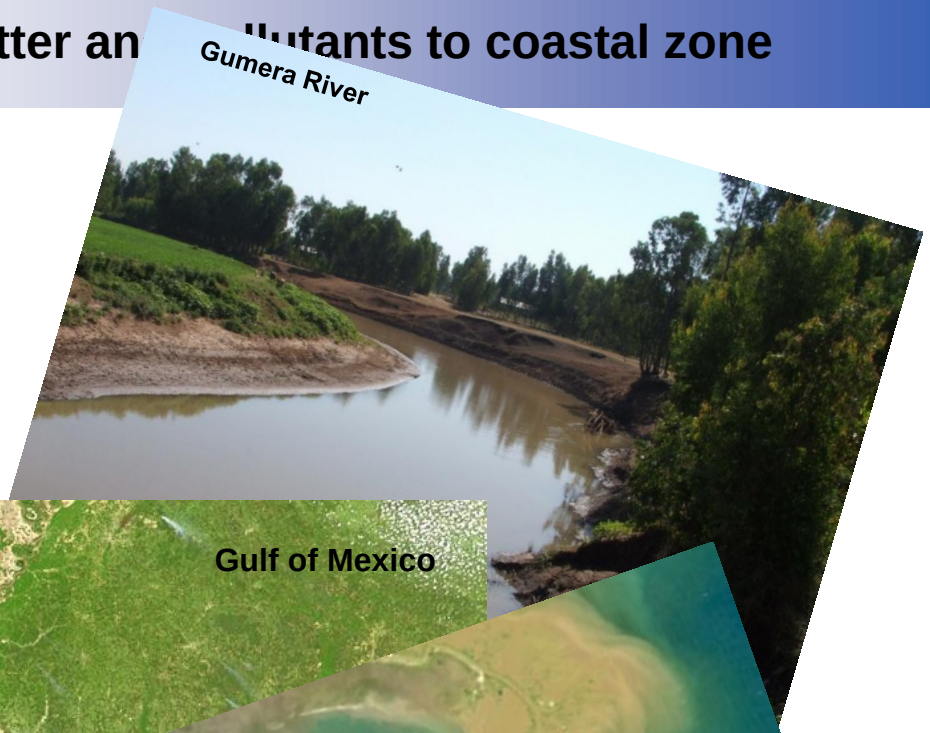
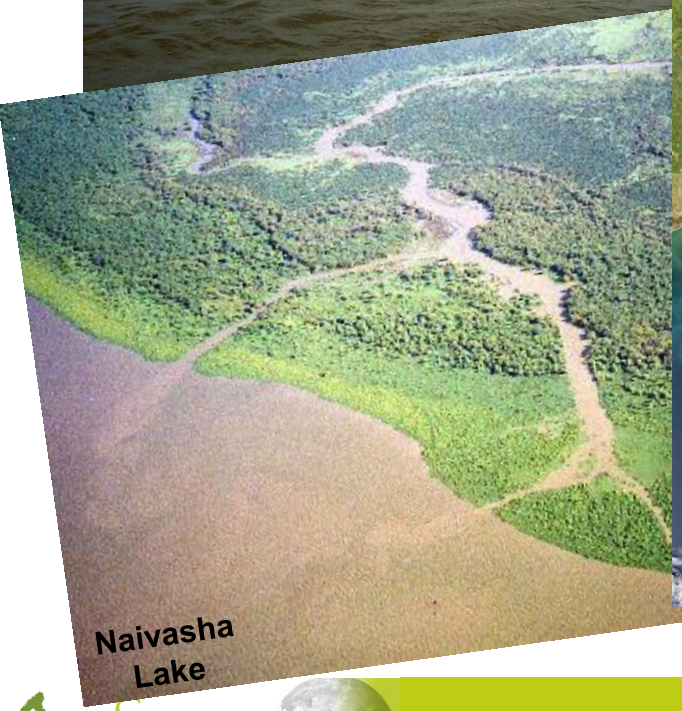
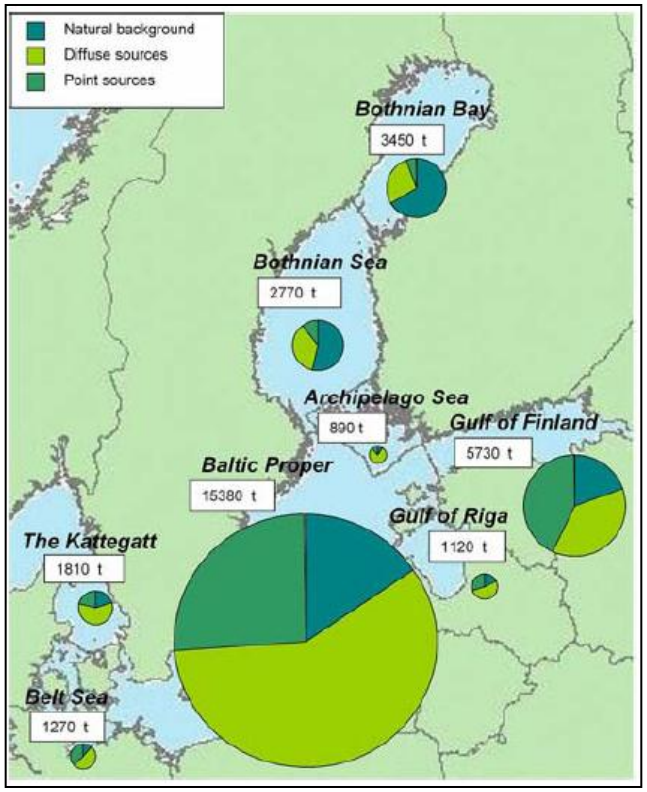
Transfer of organic matter an[illegible]utants to coastal zone

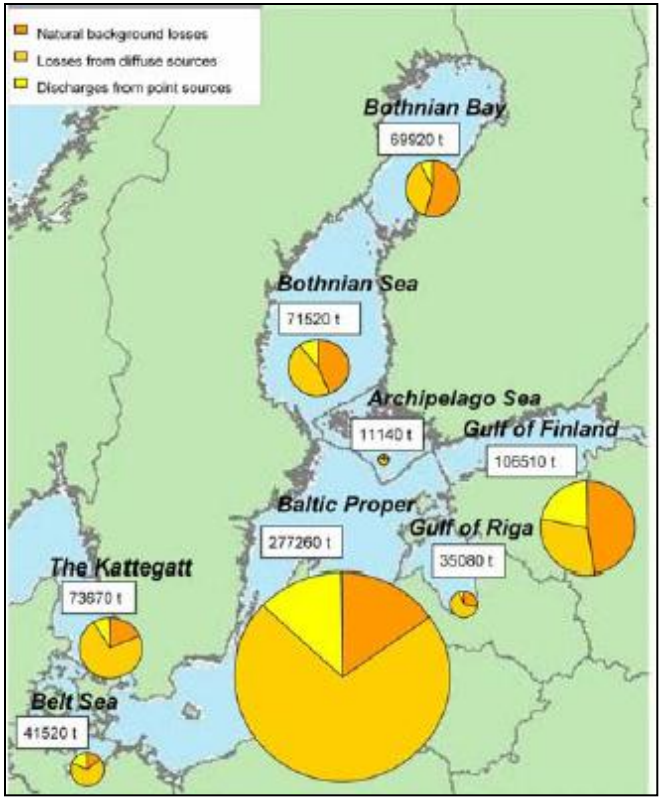




Proportion of sources contributing to phosphorus and nitrogen input into the Baltic Sea sub-regions



Phosphorus



Nitrogen

(HELCOM 2004)

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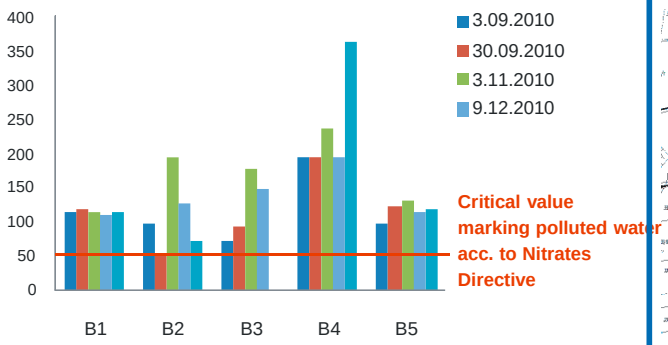
ECOTONE ZONES: LIFE+ EKOROB project

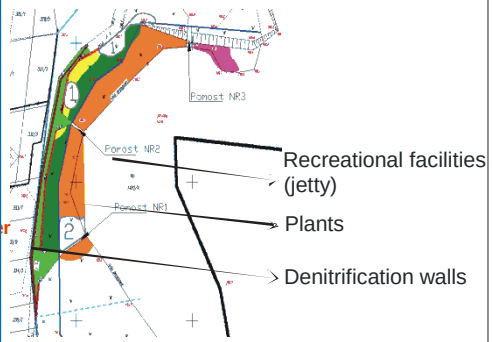
IDENTIFICATION OF PROBLEMS

DEVELOPMENT OF SOLUTIONS

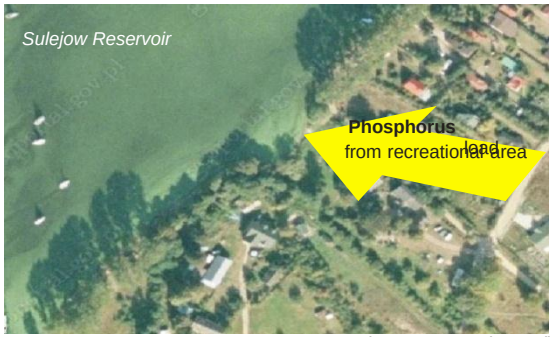
Reduction of **nitrogen** pollution from diffuse source by enhancement of plant buffering zones with denitrification walls

(www.geoportal.gov.pl)

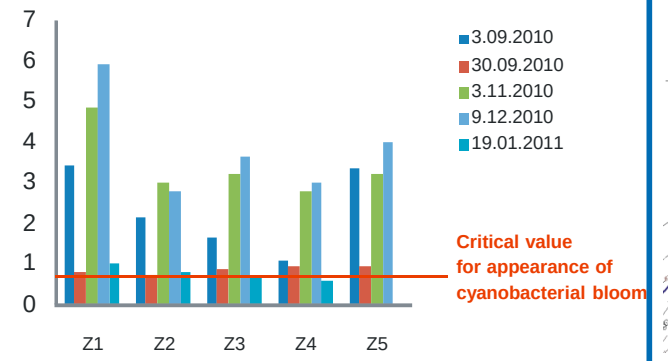


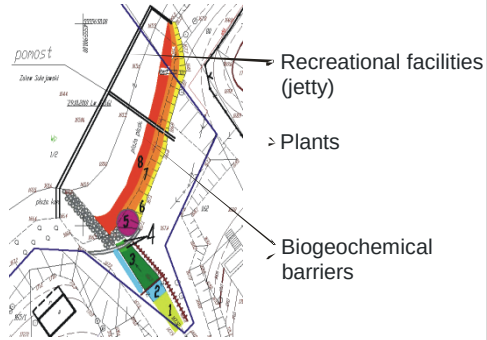


Reduction of **phosphorus** pollution from diffuse source by enhancement of plant buffering zones with biogeochemical barriers



(www.geoportal.gov.pl)





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Demonstration side of LIFE+ EKOROB project

EKOROB

Life

NFOŚiGW

Implementation of knowledge, Recreation, Education

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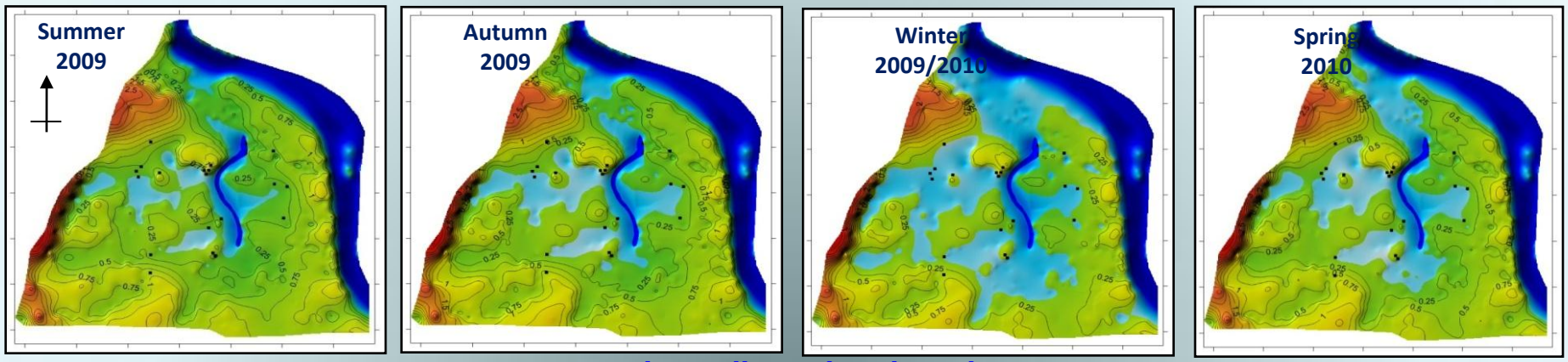
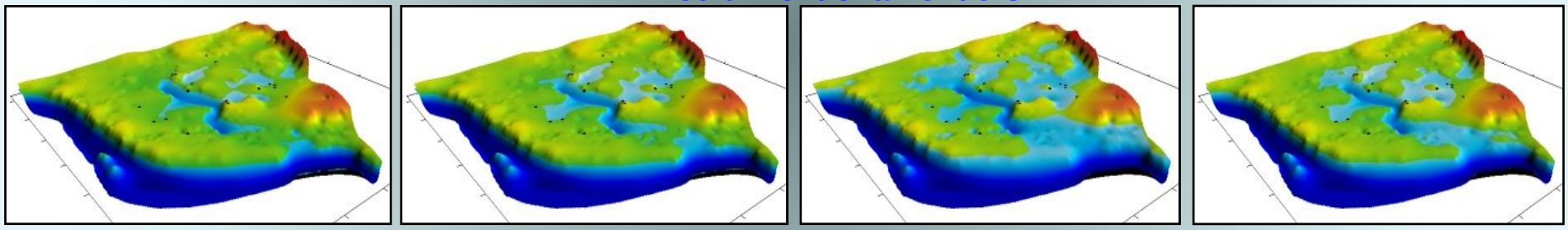
DYNAMIC OF GROUNDWATER LEVEL IN THE EXPERIMENTAL PILICA RIVER FLOODPLAIN

Maps of hydroisobaths



Three-dimentional renders

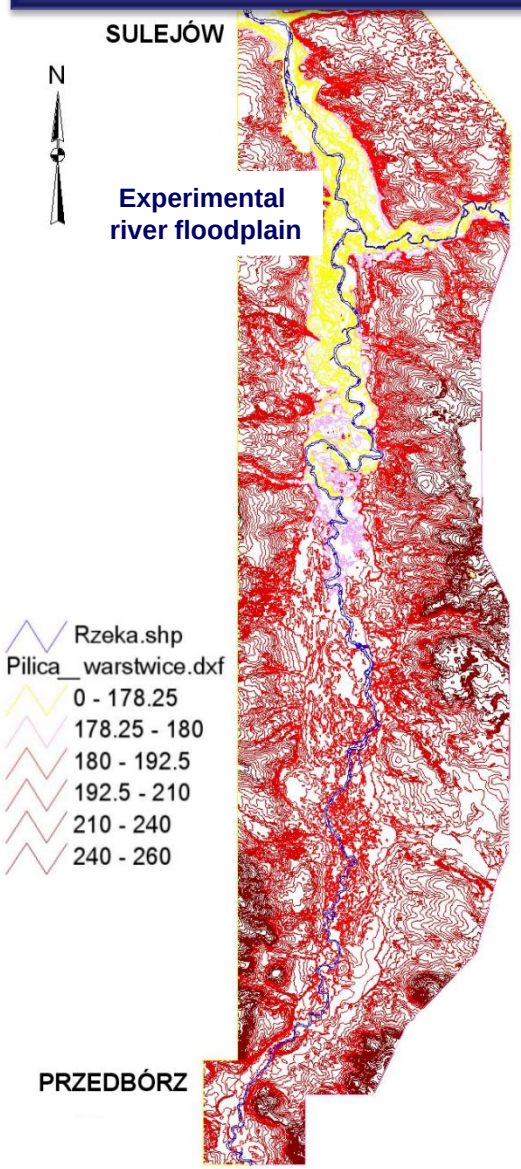


Kiedrzyńska E. Kłosiński M., Zalewski M. (in preparation).

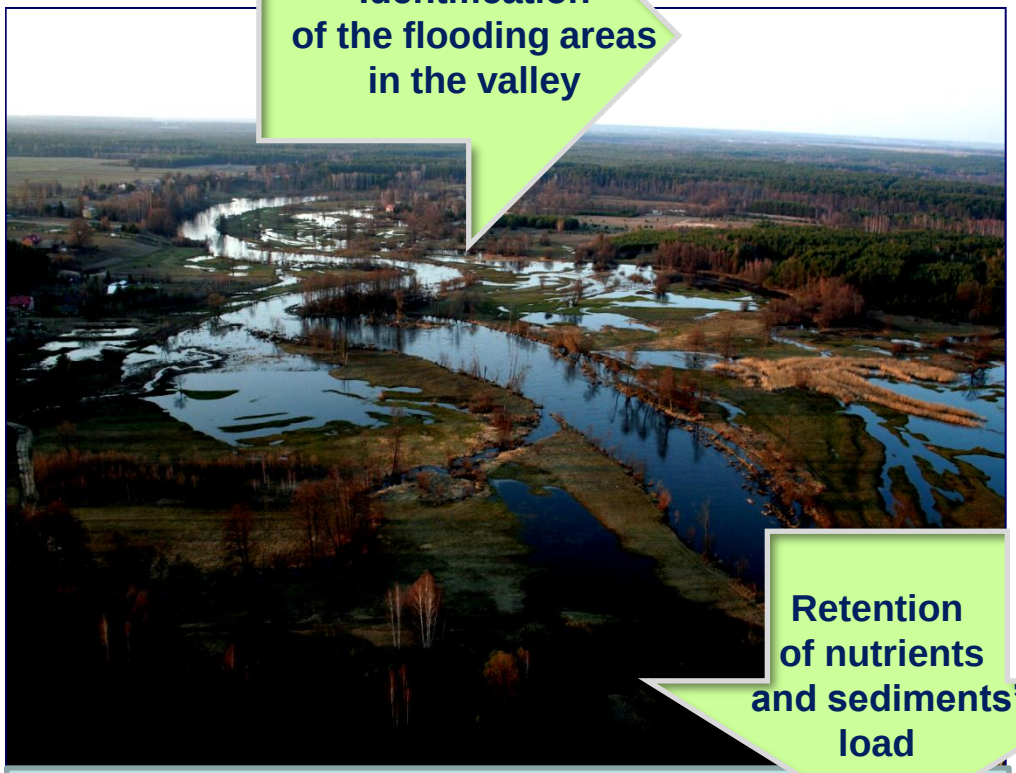
QUANTIFICATION OF FLOOD PROCESSES AND SEDIMENTATION IN THE PILICA VALLEY

United Nations · European Regional

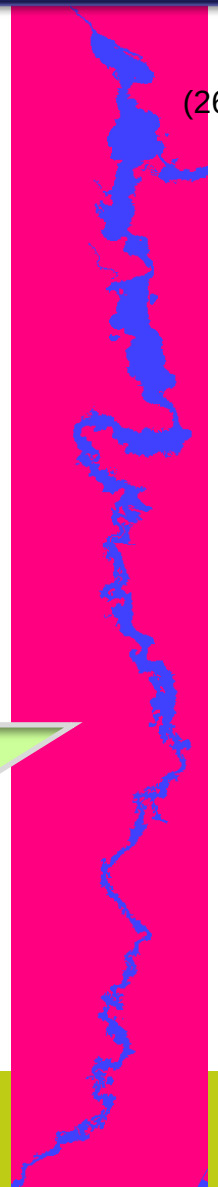
DTM of the 30 km section of the Pilica River valley



Identification of the flooding areas in the valley



Model of the flooding for the highest water level



Retention of nutrients and sediments' load

RETENTION			
Flooding areas	Sediments load	TN load	TP load
1007 ha	560 tons	8 tons	129 tons

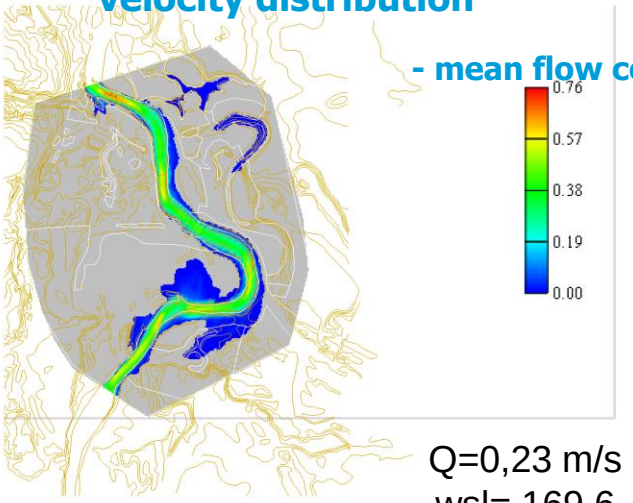
Kiedrzyńska E. et al. (in preparation).

„CCHE2D" MODELS FOR THE EXPERIMENTAL PILICA RIVER FLOODPLAIN

Oxford – Mississippi USA
United States – Poland
Technology Transfer Project

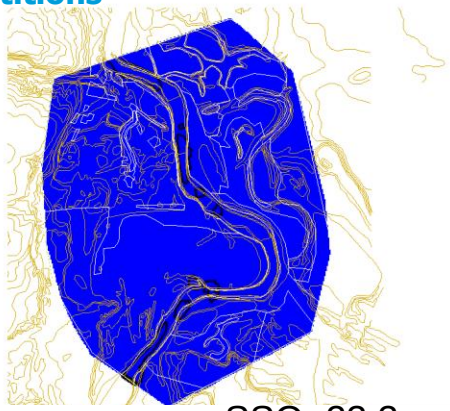
Simulation of water velocity distribution

- mean flow condtitions



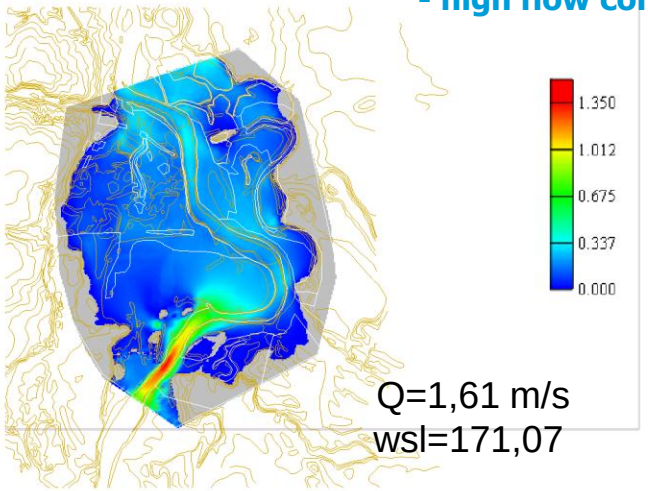
Q=0,23 m/s
wsl= 169,6

Suspended and bedload transport

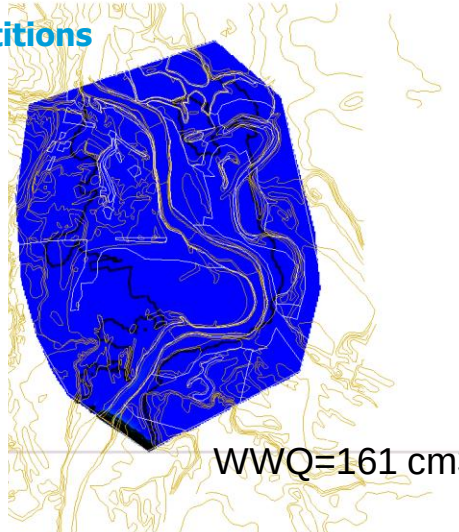


SSQ=23.3 cm3/s

- high flow condtitions



Q=1,61 m/s
wsl=171,07



WWQ=161 cm3/s

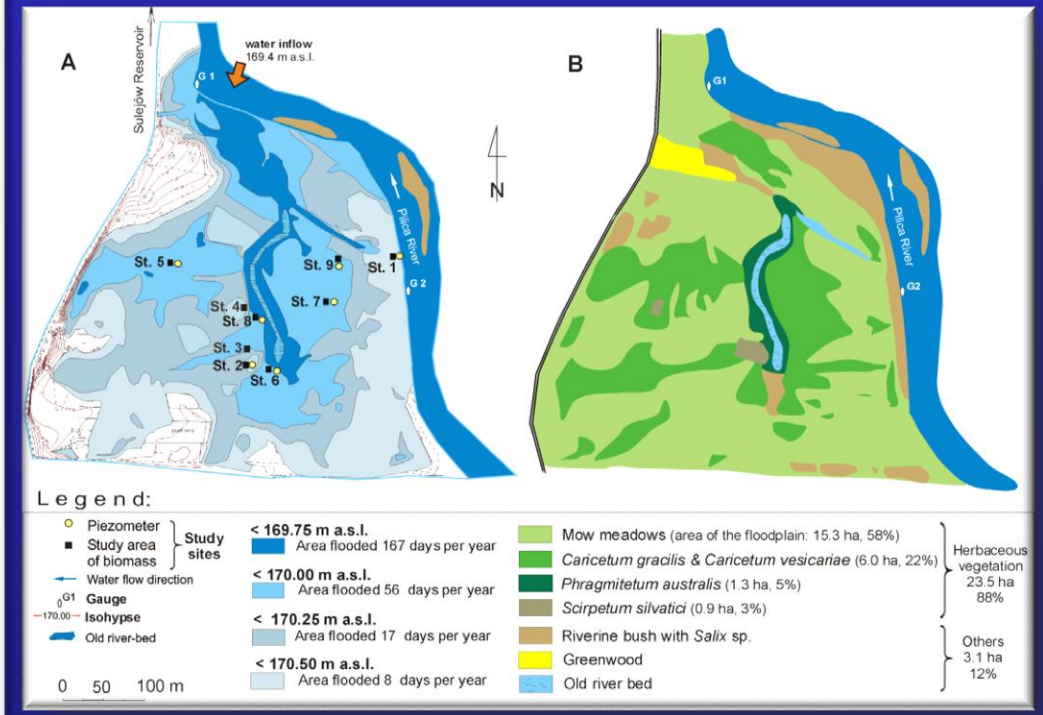
Altinakar M., **Kiedrzyńska E**., Magnuszewski A. **2006.** Modelling of inundation pattern at Pilica river floodplain, Poland. In: Demuth S., Gustard A., Planos E., Scatena F. & Servat E. (Eds) Climate Variability and Change—Hydrological Impacts. **IAHS Publ.** 308. 579-585**.**

ROLE OF THE RIVER FLOODPLAIN IN PHOSPHORUS ACUMULATION AND WATER PURIFICATION

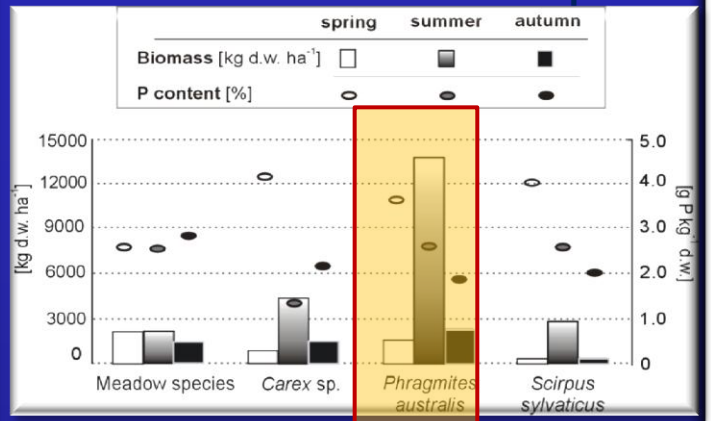
Quantification of phosphorus accumulation by vegetation of the Pilica River floodplain

The Inundation Model represents sequences of floodplain overflowing

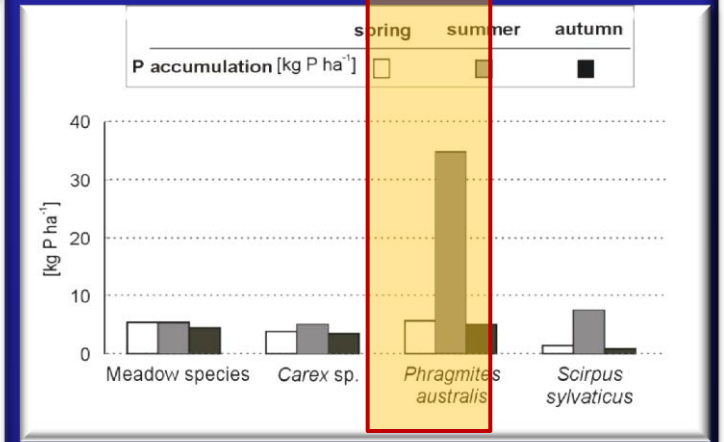
Distribution of plant communities coresponds to the hydrology of the area



Biomass and P content in plant



P accumulation for predominant species

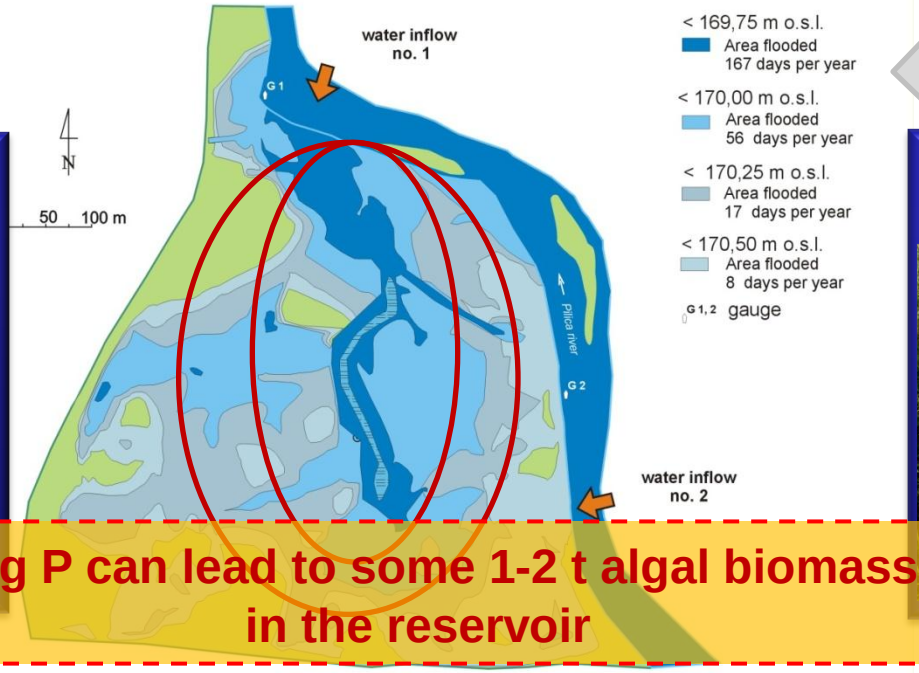


Kiedrzyńska E., Wagner I., Zalewski M. **2008**. Quantification of phosphorus retention efficiency by floodplain vegetation and a management strategy for a eutrophic reservoir restoration. **Ecological Engineering**, 33: 15-25.

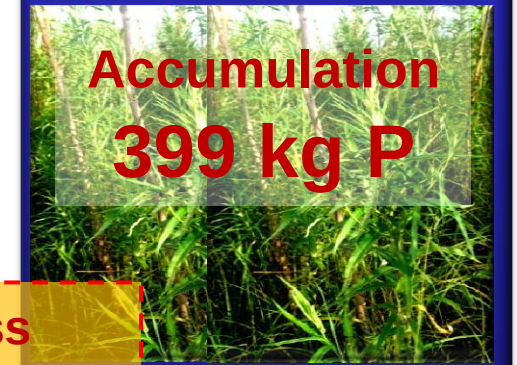
ROLE OF THE RIVER FLOODPLAIN IN PHOSPHORUS ACUMULATION AND WATER PURIFICATION

Summer phosphorus accumulation in the macrophytes

24% of area with willows



48% of area with willows



1 kg P can lead to some 1-2 t algal biomass in the reservoir

Kiedrzyńska E., Wagner I., Zalewski M. **2008**. Quantification of phosphorus retention efficiency by floodplain vegetation and a management strategy for a eutrophic reservoir restoration. **Ecological Engineering**, 33: 15-25.

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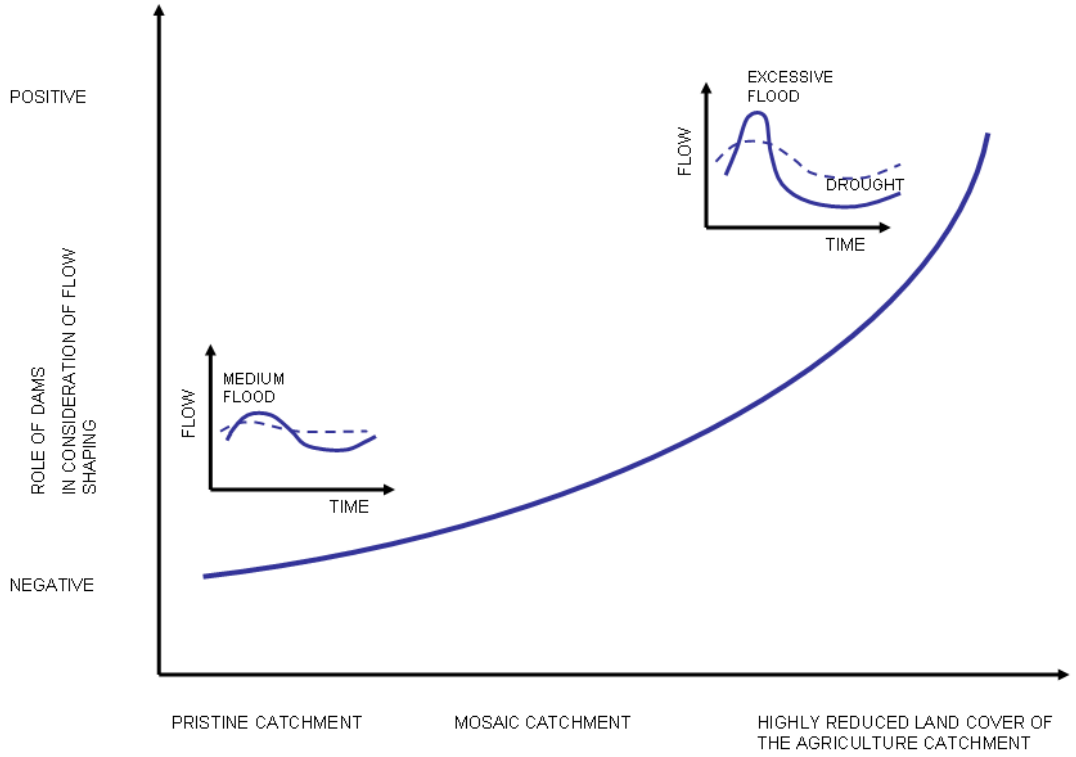
RESERVOIRS & DAMS: How to convert threats into opportunities for sustainable river basin using EH processes oriented thinking

If we accelerate river outflow and enhance evaporation from the landscape we need reservoirs to compensate human impact on water cycle



Zalewski, 2010

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RESERVOIRS & DAMS: How to convert threats into opportunities for sustainable river basin using EH processes oriented thinking

Improvement of water quality downstream

Renewable energy (null CO_2 emissions)

Transfer of mineral fraction downstream at flood peak

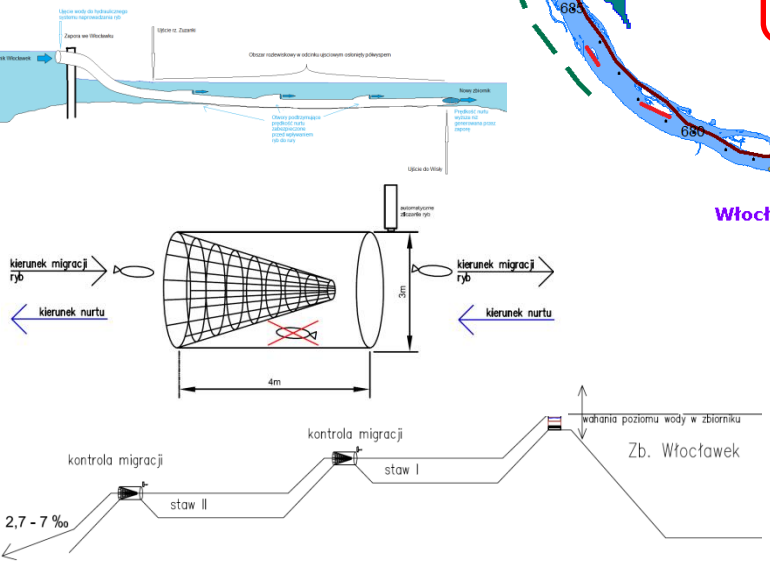
Restoration of lateral ecological connectivity in the valley, refuge areas for wildlife

Renewable energy (null CO_2 emissions)

Reduction of pollutants transfer into the sea and fish, reduction of dioxins

Sedimentation zone: u of organic fraction fo bioenergy productio biomass plantations

By-pass channel for fish and aquatic organisms migrations – restoration of longitudal connectivity of the river valley



Based on Zalewski 2006, modified by Zalewski and Belka

Energa ARUP

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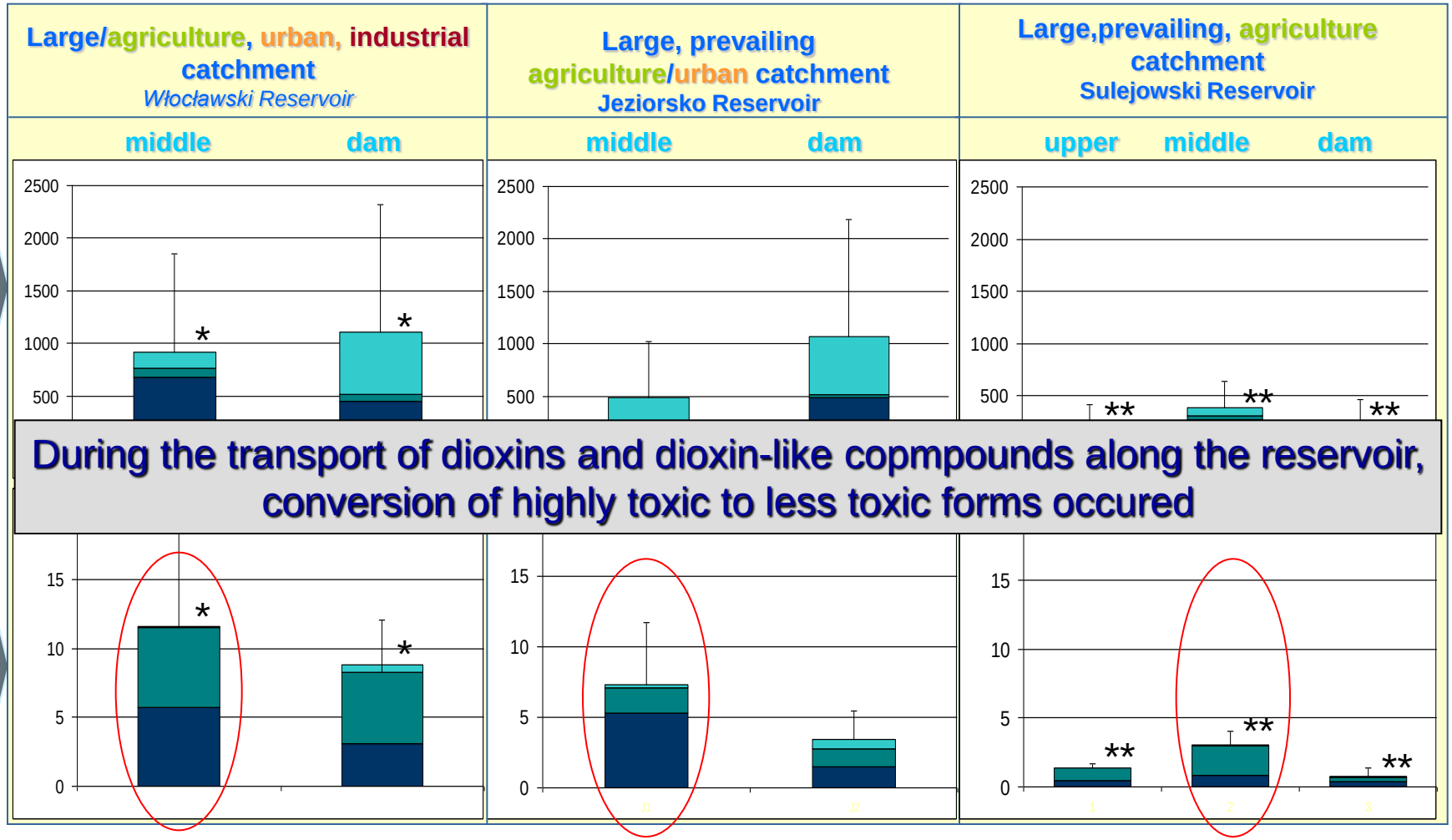
Spatial distrubution of dioxins and dioxin-like compunds along large reservoirs of different catchment land use



Urbaniak M., Zalewski M.,2010. ***Large dams as purification systems for toxic PCDD/PCDF and dl-PCB congeners [in:] Hydrocomplexity: New Tools for Solving Wicked Water Problems***, Khan S., Savenije H.H.G., Demuth S., Hubert P., IAHS Publ. 338: 256-257.

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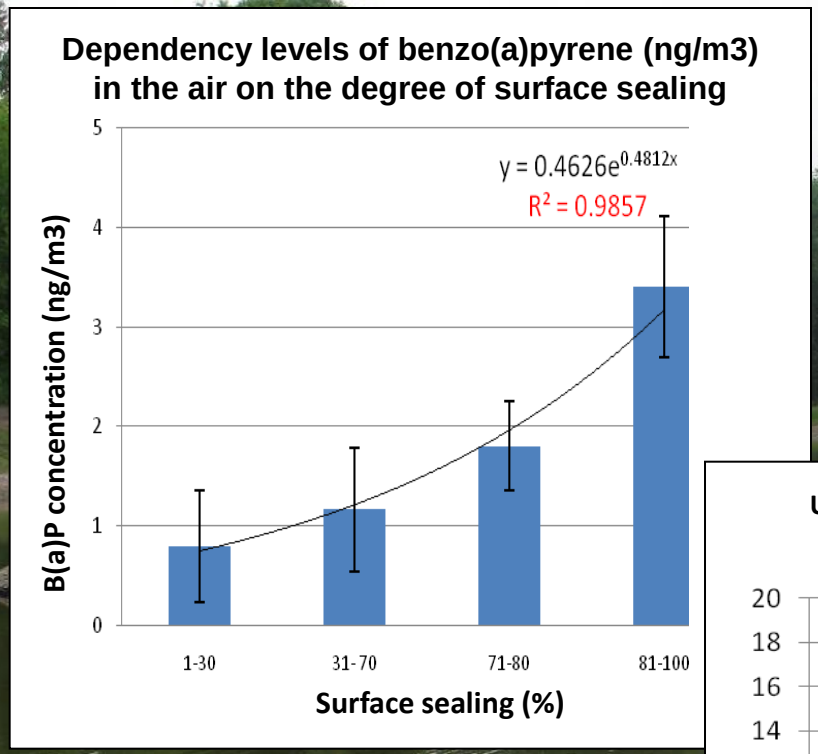
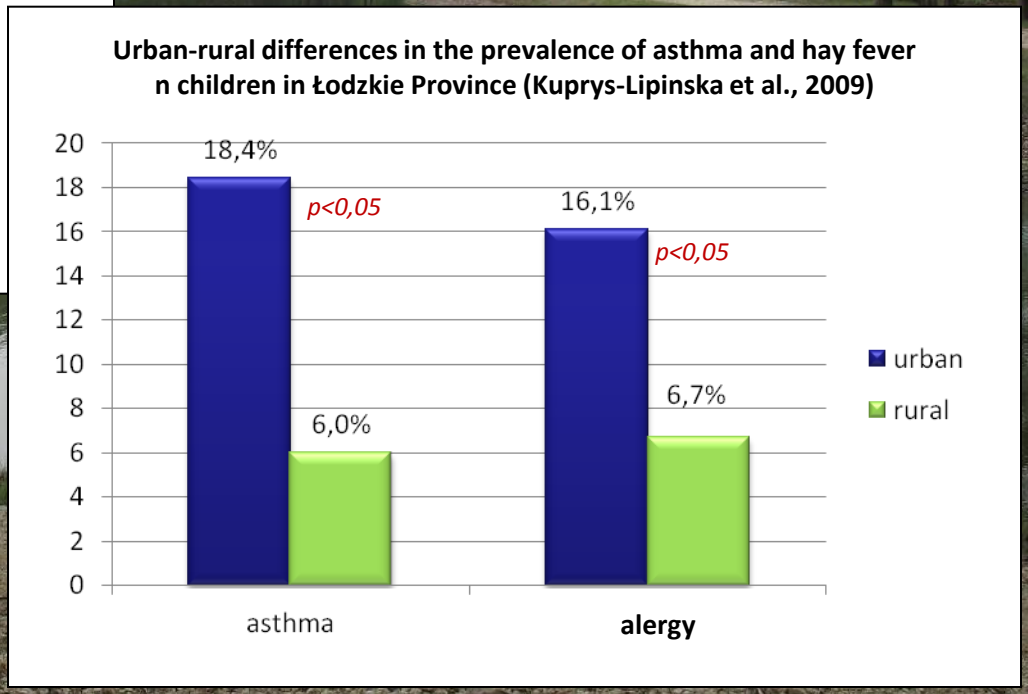
Urban Ecohydrology

Fot. Gazeta Wyborcza

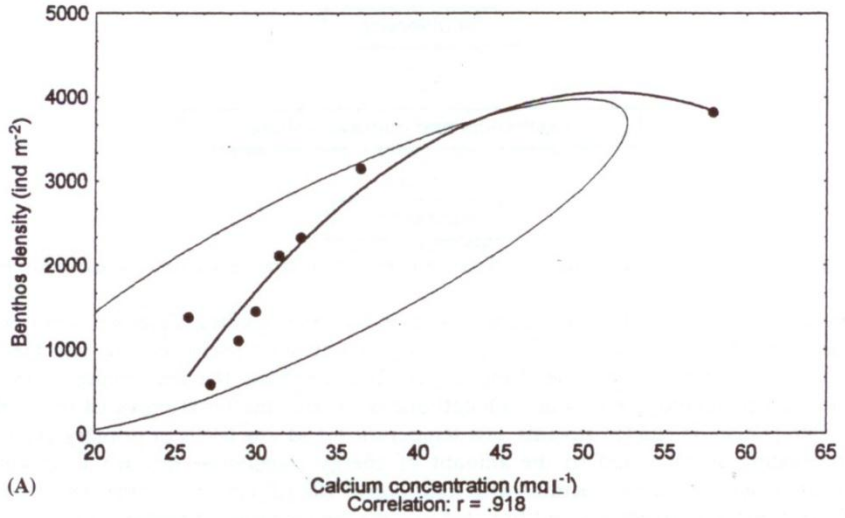
Teresa Reservoir





The importance of ecological structure and processes understanding for development of Ecohydrological biotechnologies

Importance of geology for determination of the structure fish and invertebrates communities in rivers and river selfpurification process



The relationship between calcium concentration and (A) annual average benthos density, and (B) annual average fish biomass. (Thin lines show 95% confidence limits.)

Zalewski et al. 1996

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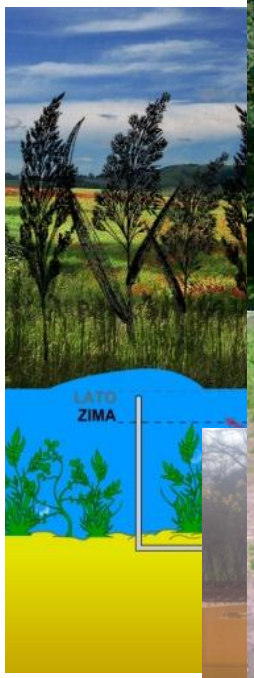
System Solutions - Biotechnologies

The sequential biofiltration system for urban stormwater purification on Sokołówka River




Blue – Green Network
New concept for the spatial development of Lodz
Las Grotnicki
Las Kiloguski
Bzura
Park Krajobrazowy Wzniesień Łódzkich
Las Olechy
Las Lagiewnicki
Aleksandrów Ł.
Sokołówka
I etap rewitalizacji doliny Sokołówki
Las Wiączyń
Bzura
Piotrkowska
Nowe Centrum
Rewitalizacja Doliny Jasienia
Park Doliny Dobrzeni
Andrespol
Młynek
Stawy Jana
Las Rudzki
Stawy Stefańskiego
Elements of the Blue – Green Network
Proposed new municipal parks, necessary for maintaining integration of natural and cultural elements, increased access for residents to recreational areas and lowering costs of municipal maintenance
Existing parks and forests
Rivers and water reservoirs
Existing and proposed protected areas and buffer zones: maintenance of the continuum of ecological processes, maintenance and improvement of the quality of life and residents' health, securingcity's sustainable development
Existing bike routes
Bike routes concept for 2008 – 2020 developed by sp. Teren for ZDIT Lodz
PAN
SWITCH
TVP 3 Łódź
gazeta

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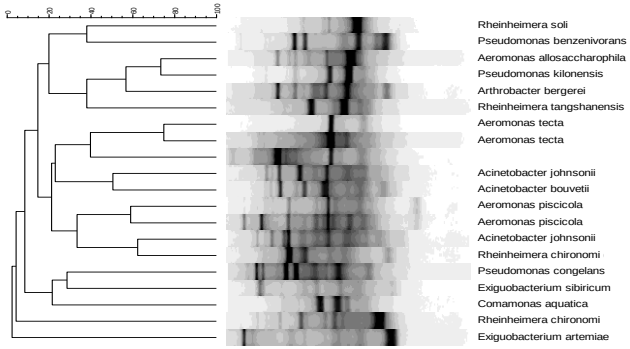
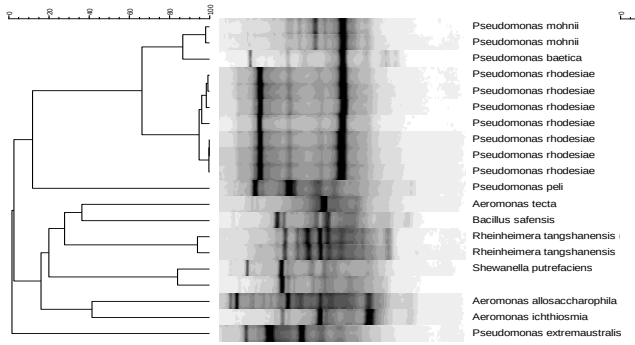
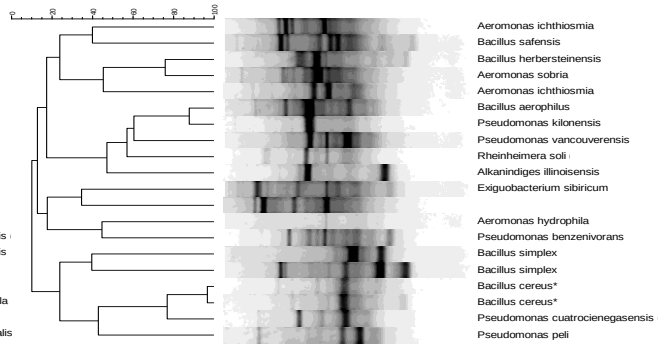
Molecular biology for ecohydrological biotechnologies

Diagnosis of quality of environment
Identification of patogenic bacteris
Increase of the effectiveness of stormwater purification

Bacterial diversity in different zones of the Sequentional Stormwater Purification System assessed by the TRS-PCR (1-3) and partial 16S RNA gene sequencing







Sequentional Stormwater Purification System

(Zalewski, Mankiewicz-Boczek, Parniewski et al., 2012)

Molecular biology for ecohydrological biotechnologies

Diagnosis of quality of environment
Toxic cyanobacteria – early warning with molecular markers

First determination of toxic genotypy of cylindrospermopsin-producing cyanobacteria in the Polish waterbodies

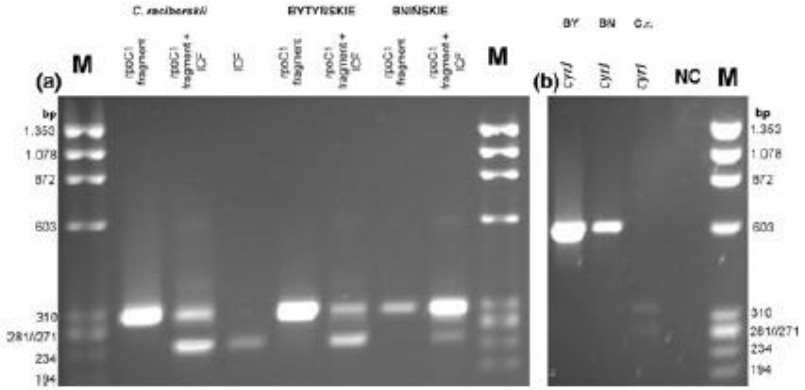


Fig. 2. *Cylindrospermopsis raciborskii*-specific PCR based on amplification of *rpoC1* gene (305 bp) (a) and PCR amplification of *cyrJ* gene (578 bp) (b). Genomic DNA from *C. raciborskii* (C.r.) laboratory culture and environmental samples from Bytyńskie (BY) and Bnińskie (BN) lakes (18 August 2006) were used. M, marker ΦX174 DNA-HaeIII digest; NC, negative control.

(Mankiewicz-Boczek et al., FEMS Microbiology Letters 326: 173-179, 2012)

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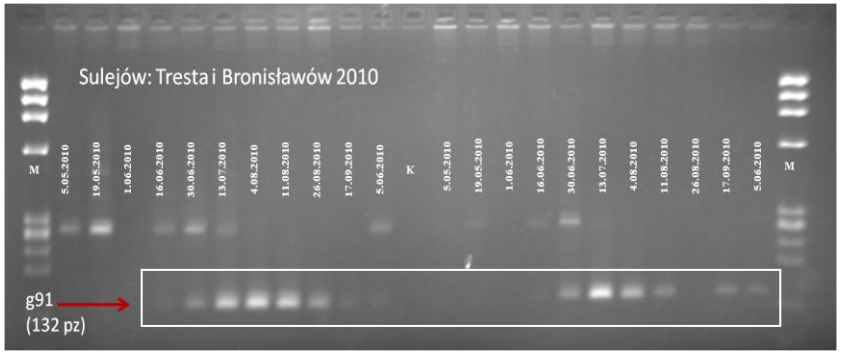
Molecular biology for ecohydrological biotechnologies

Biodegradation of hepatotoxic cyanobacteria

Cyanophage can degrade cyanobacterial cells

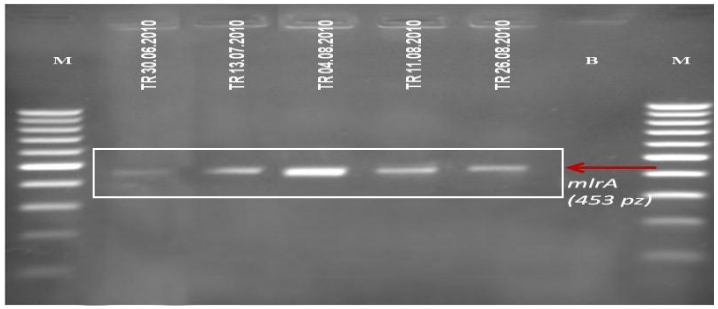


The BLAST homology search revealed 90% similar of the Polish samples to *g91* gene of cyanophage Ma-LMM01, described before by Yoshida et al. (2008).

(*Mankiewicz-Boczek, Gągała, Dziadek in progress)*

Bacteria can degrade microcystins

Bacteria capable of degrading microcystins in the Polish lowland reservoir



The BLAST homology search revealed 95% similar of the Polish samples to *mlrA* gene of *Sphingopyxis* sp. C1, described before by Okano et al. (2009).

(Mankiewicz-Boczek, Gągała, Dziadek in progress)

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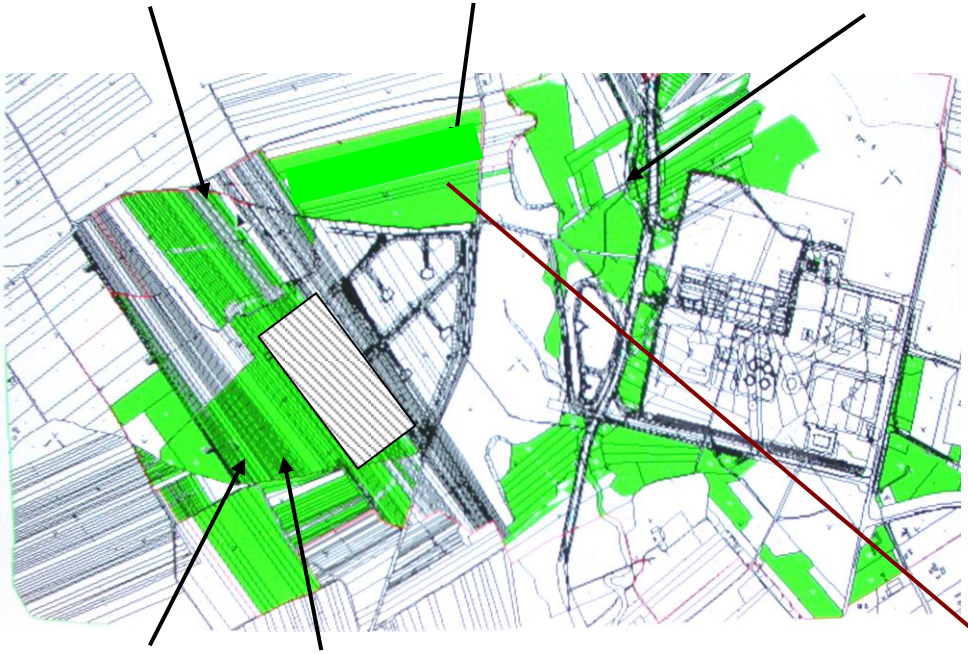
Conversion of sludge in to bioenergy at willow plantation at buffer zone of sewage treatment plant

Plantation



Comparative experiments on different species and varieties of willow

I: Salix viminalis clones;
II: Tordis (Salix schwerini x S. viminalis) x S. viminalis;
III: Salix viminalis gigantea;
IV: Salix viminalis (clone 192)

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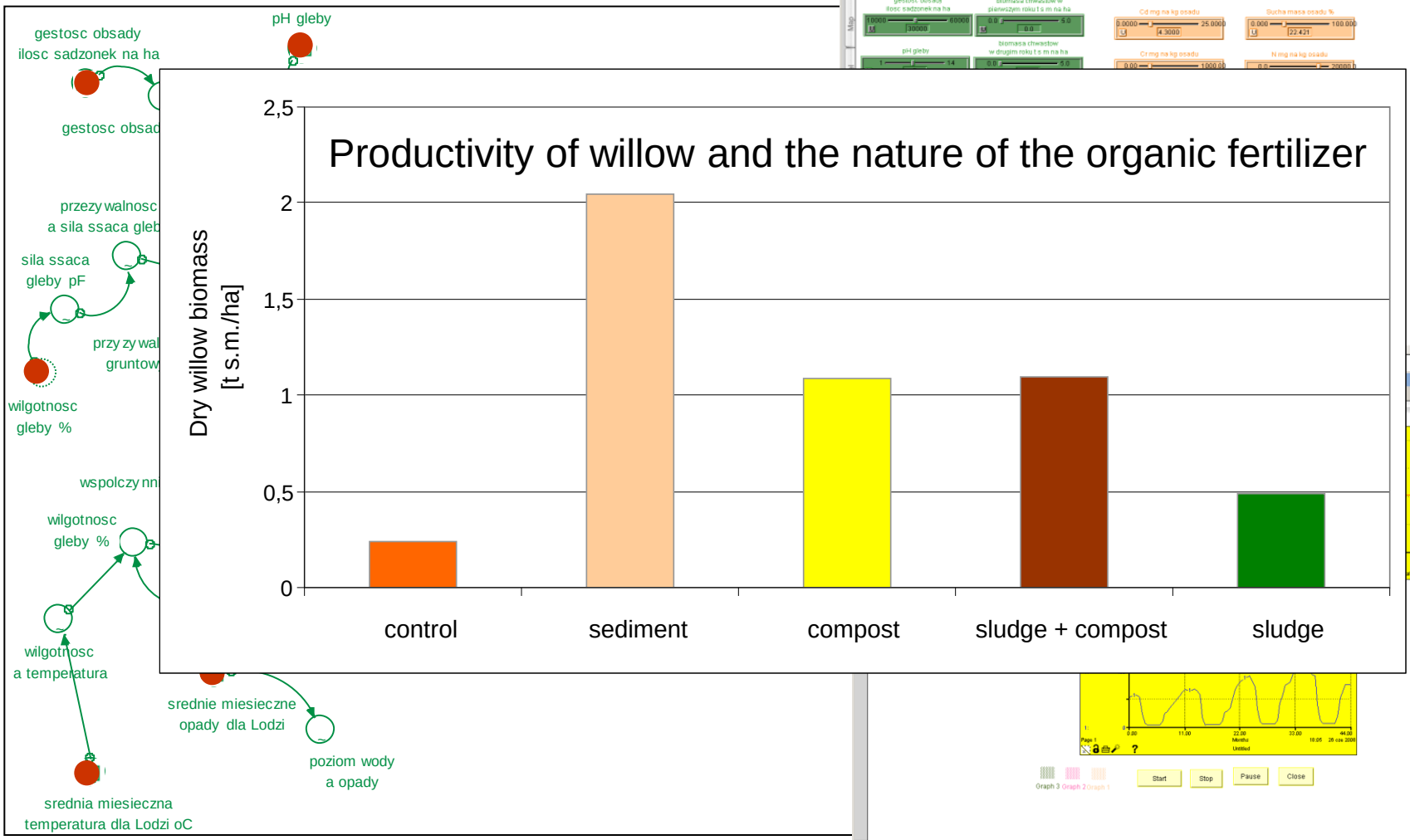
The mathematical model decision support system for bioenergy production from the sludge



Polish Aid Programme for the year 2008,2009 and 2010
no. 1280/2008/AD, 1018/AD/2009/3 and 944/2010

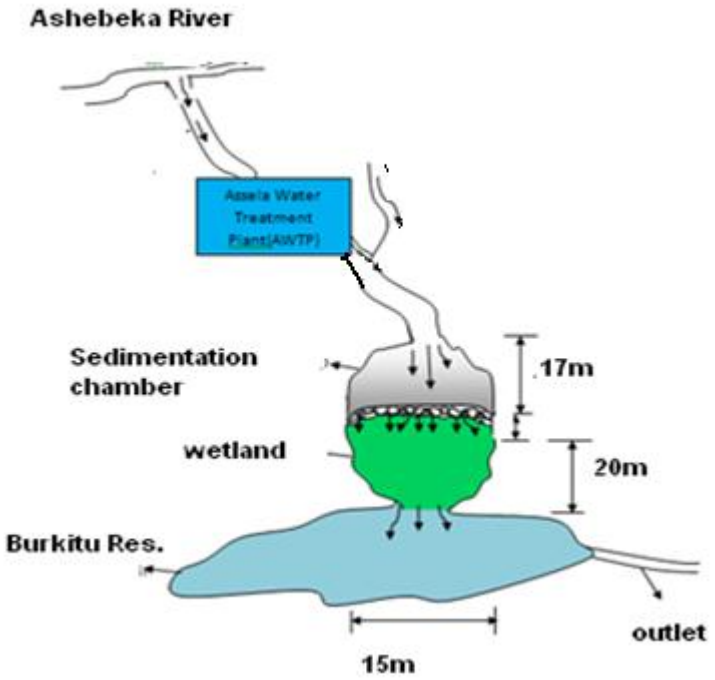
"Implementation of Ecohydrology – a transdisciplinary science for integrated water resources and sustainable development in Ethiopia"

Polish aid

PARTNERS:

European Regional Centre for Ecohydrology under the auspices of UNESCO, Poland
Department of Applied Ecology, University of Lodz, Poland
Division of Water Science of UNESCO
Ministry of Water Resources, Federal Democratic Republic of Ethiopia

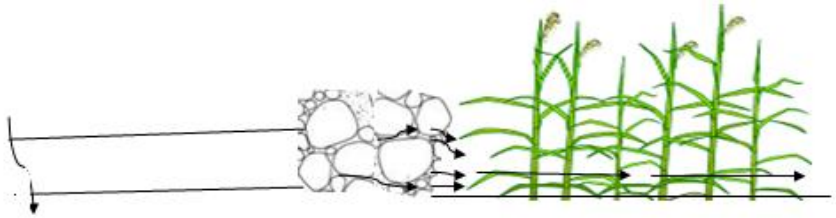
Asella Sequential Biofiltration System (Biofarm Park, Asella)



(a)

(b)

Schematic representation of the location of ASBS (without Scale)



Sediment trap:
(a) full of sediment and (b) dredged

Zalewski, Urbaniak, Negussie

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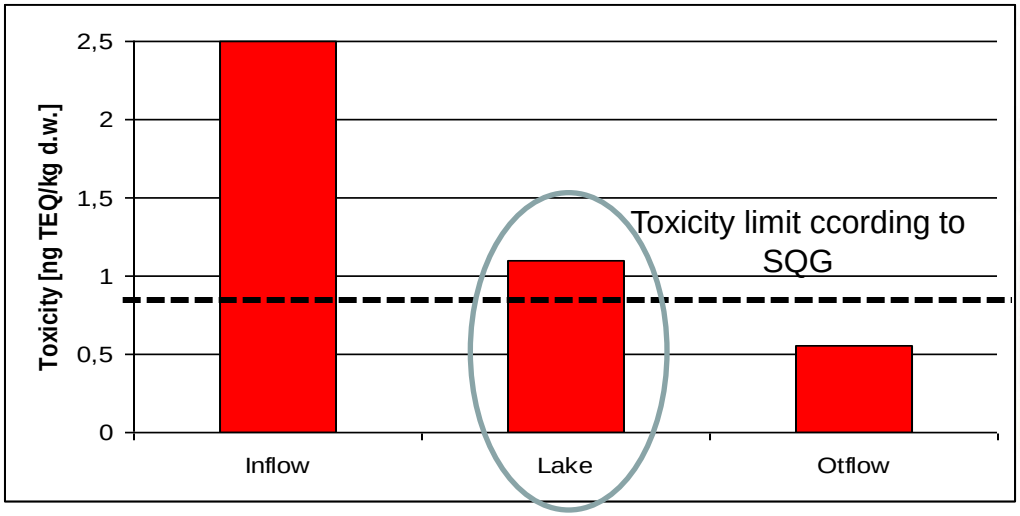
Concentration of the dioxins before and after construction of biofiltration system

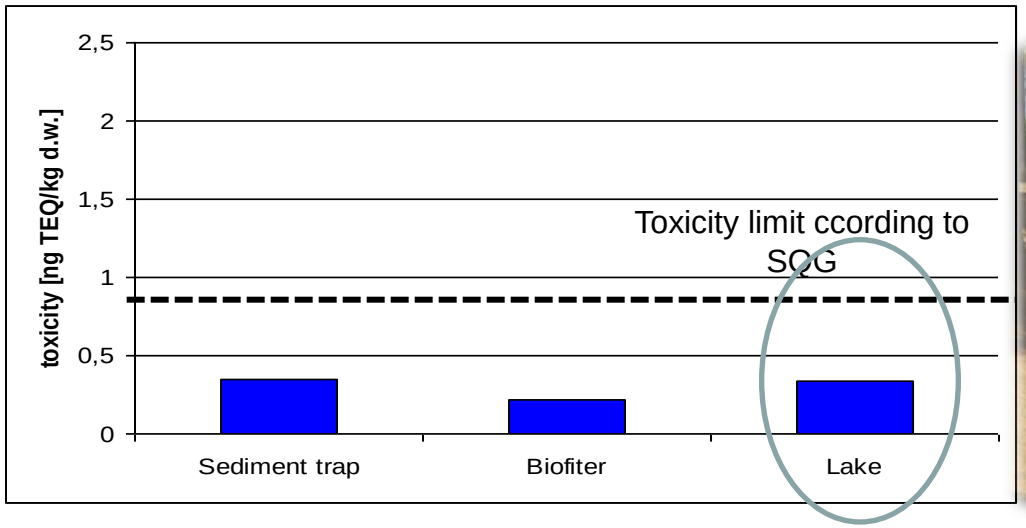
Before

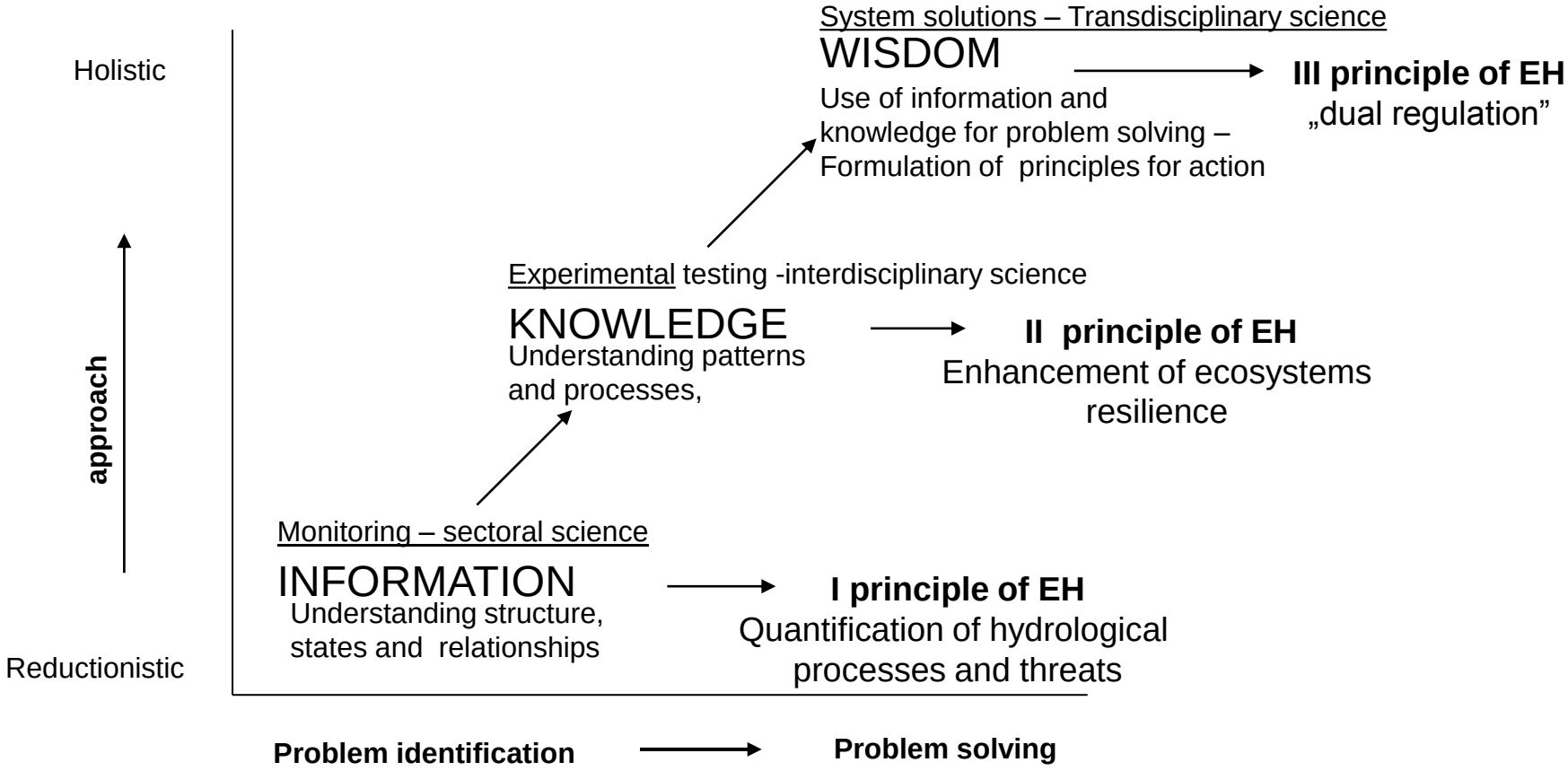


Construction of the biofiltration system

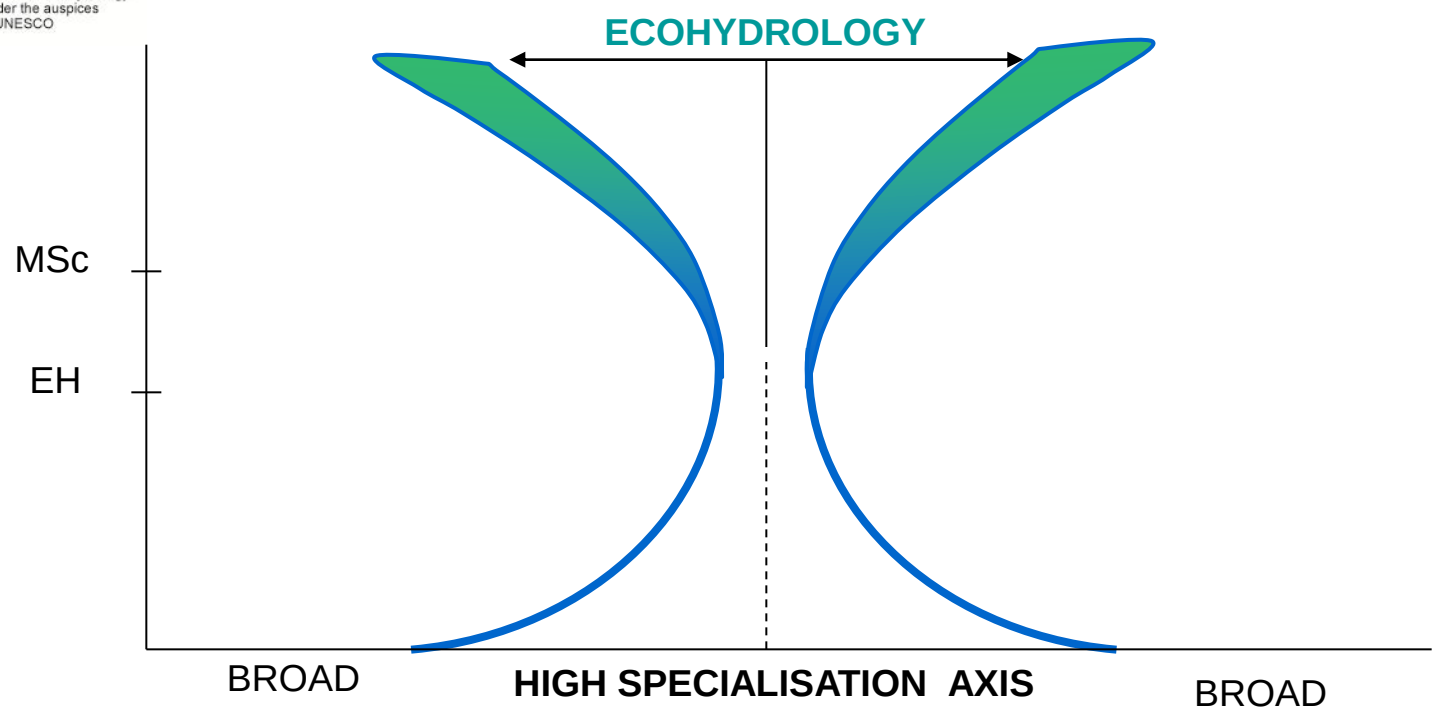
Construction of the biofiltration system

After

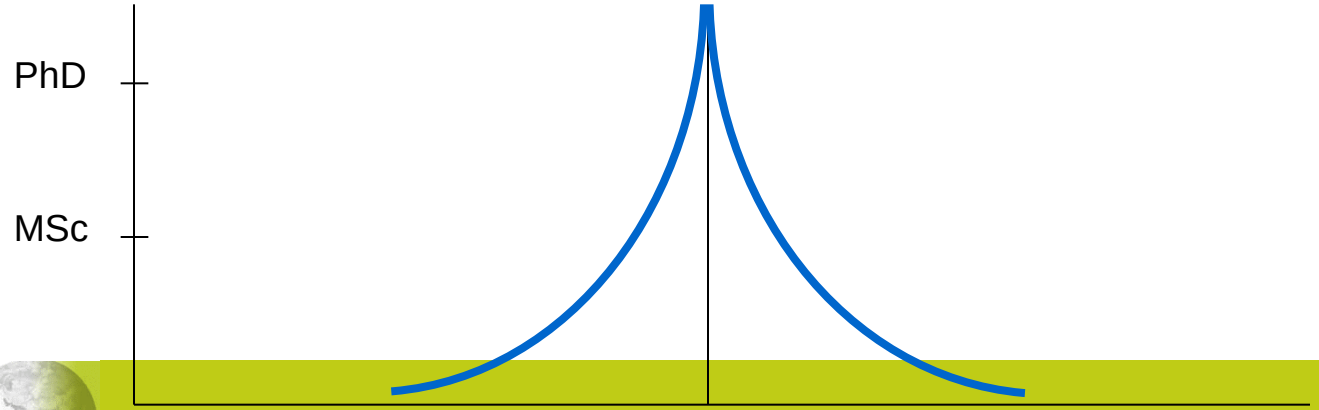




Zalewski 2011 modified



traditional education of high specialized environmental scientists



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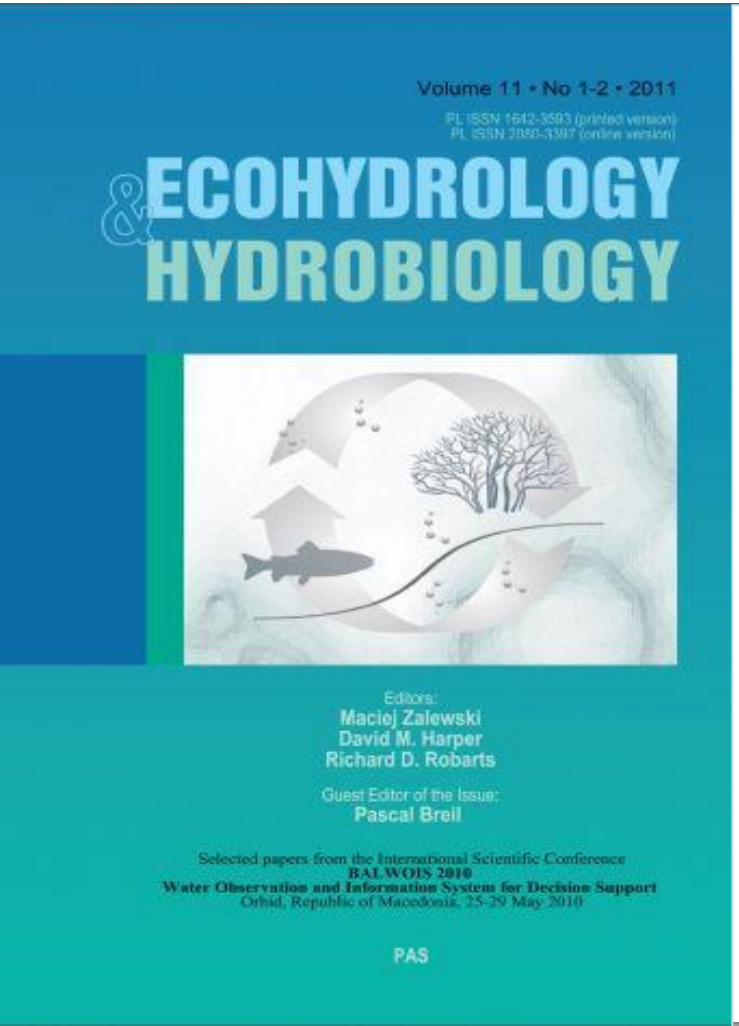

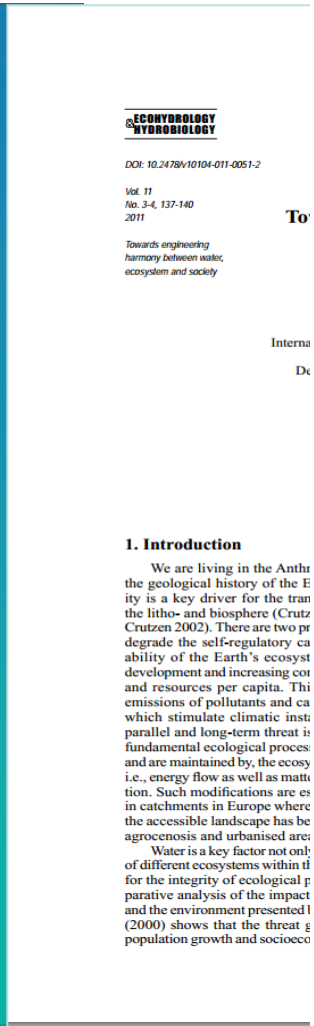

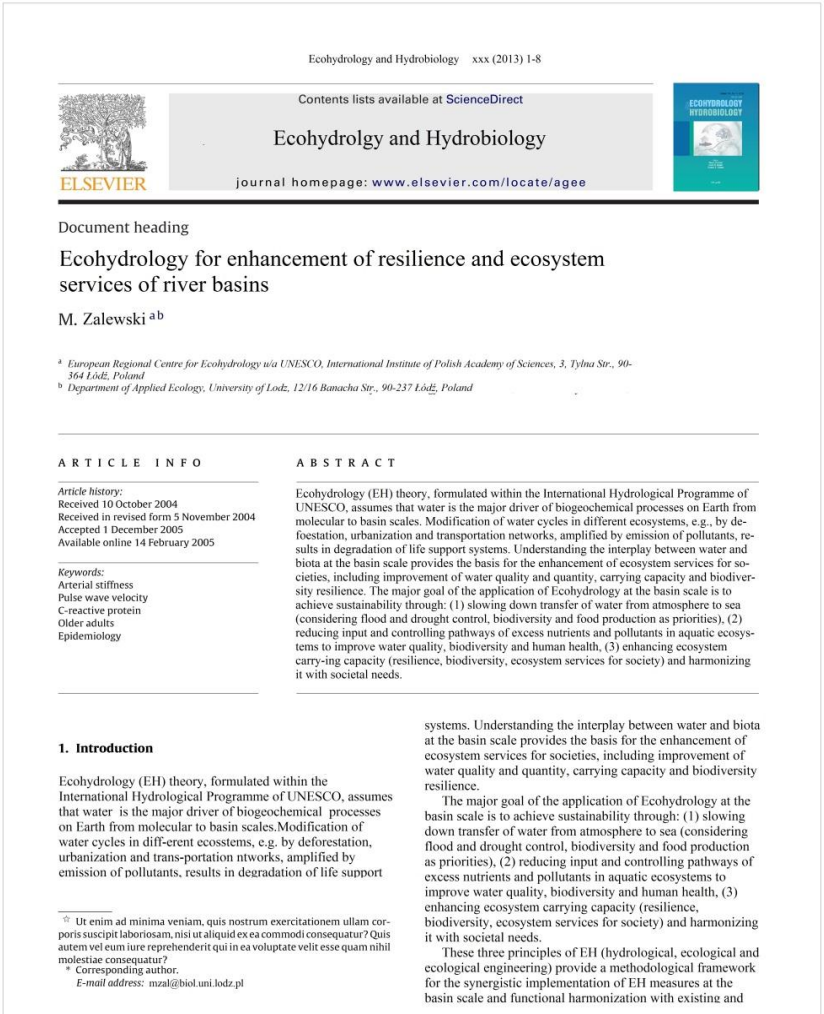

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