United Nations Educational, Scientific and Cultural Organization

ERCE European Regional Centre for Ecohydrology Under the auspices of UNESCO

PAN POLSKA AKADEMIA NAUK

FACULTY OF BIOLOGY AND ENVIRONMENTAL PROTECTION

VERITAS ET LIBERTAS UNIVERSITAS LODZIENSIS

Ecohydrology - Framwork for Low Costs, Advanced & Systemic Solutions for Reduction of Powerty and Inequality

MACIEJ ZALEWSKI

Director European Regional Centre for Ecohydrology PAS u/a UNESCO
Chairman of Department Applied Ecology University of Łódz
Editor in Chief Int Journal ECOHYDROLOGY& HYDROBIOLOGY Elsevier
Chairman of SAC ECOHYDROLOGY, UNESCO International Hydrological Programe

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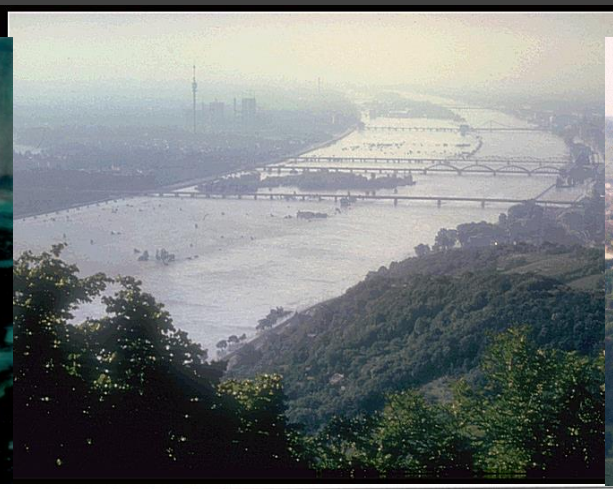
We are living in the Anthropocene Era when almost 80% of our usable ecosphere has been conditioned, converted, and consumed by humans, usually without understanding the full consequences of our actions.

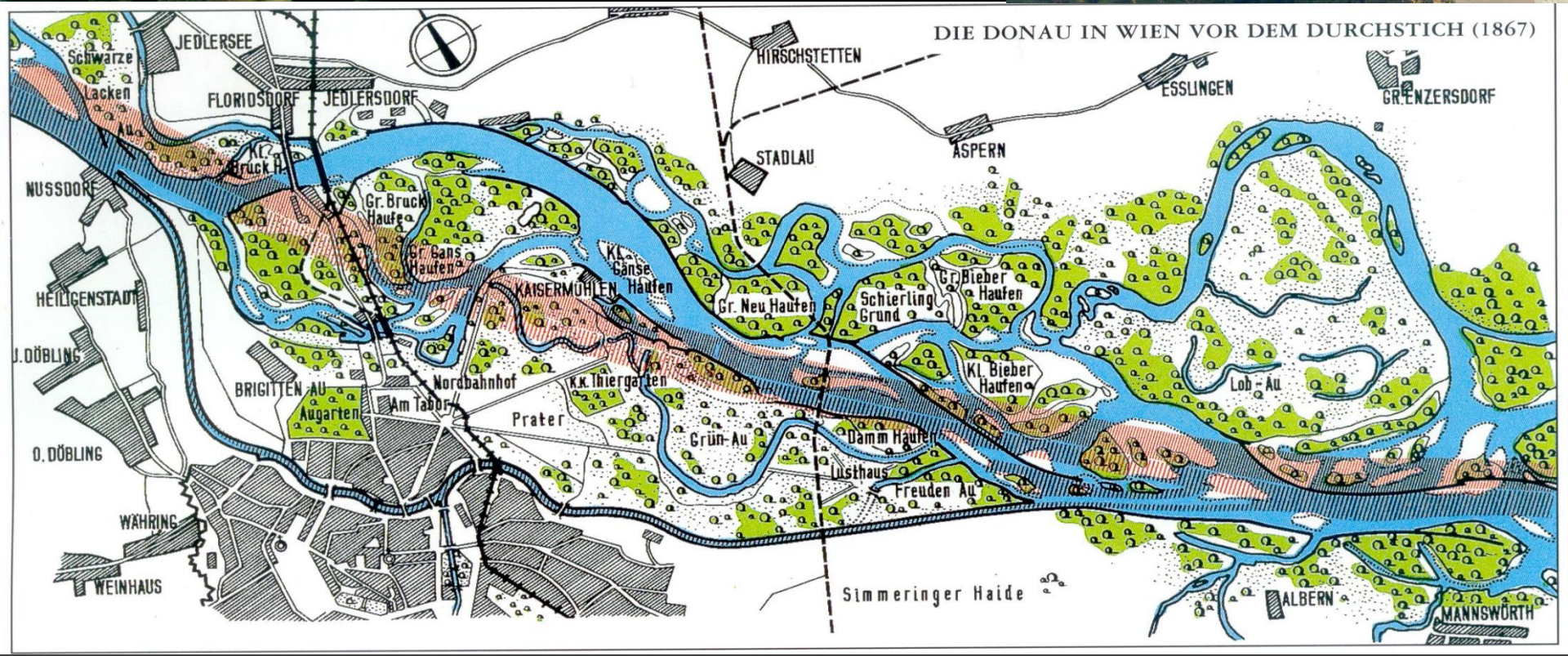
Columbus Declaration (EcoSummitt 2012)

„Legal system and politics in the range of non material values, moral and believes, changes much slower than economic processes." W.F Ogburn 2010

Earth at Night
More information available at:
http://antwrp.gsfc.nasa.gov/apod/ap020810.html

Acceleration of the water outflow from the catchment and habitats degradation
UNESCO Ecohydrology Danube Demosite (*Janauer 2010*)





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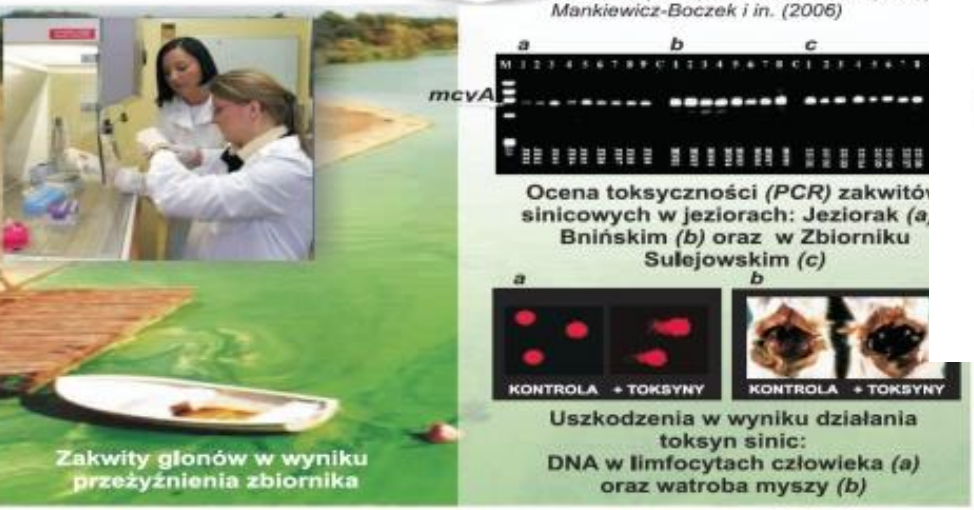
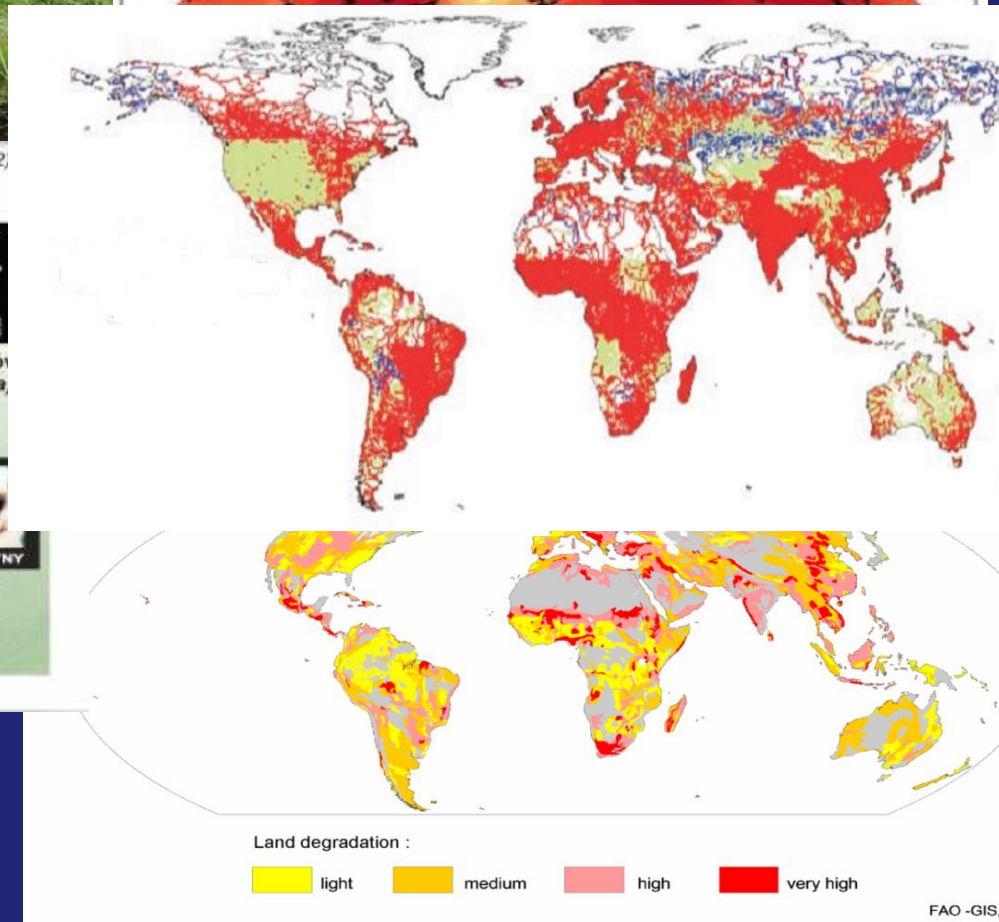
How much more warming can we expect?

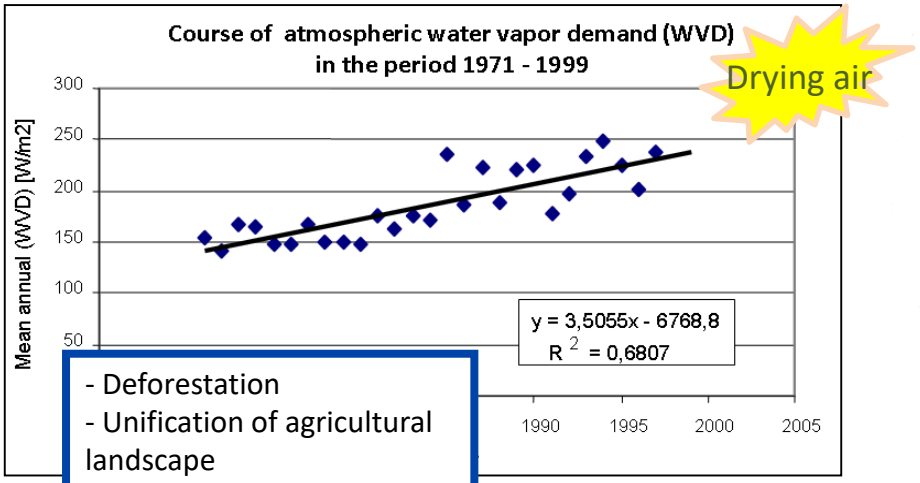
Tamperature



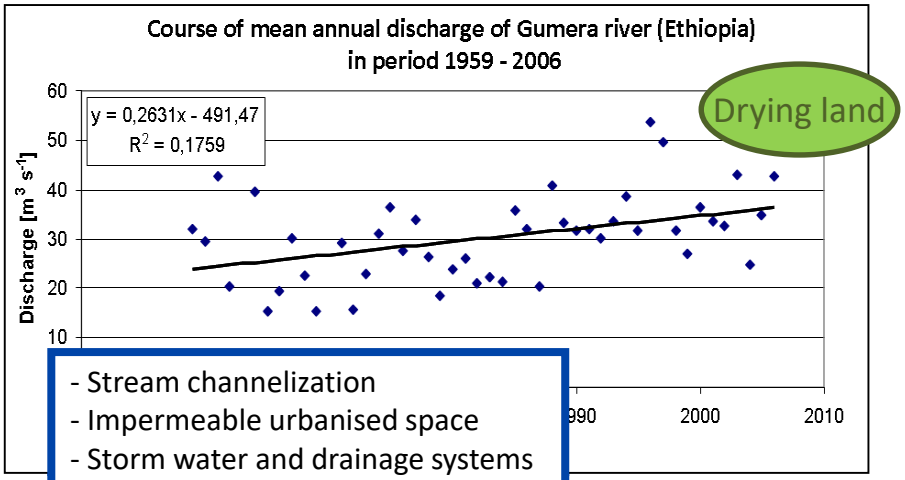


Modification of water cycle due to

Catchment's deforestation in Ethiopia



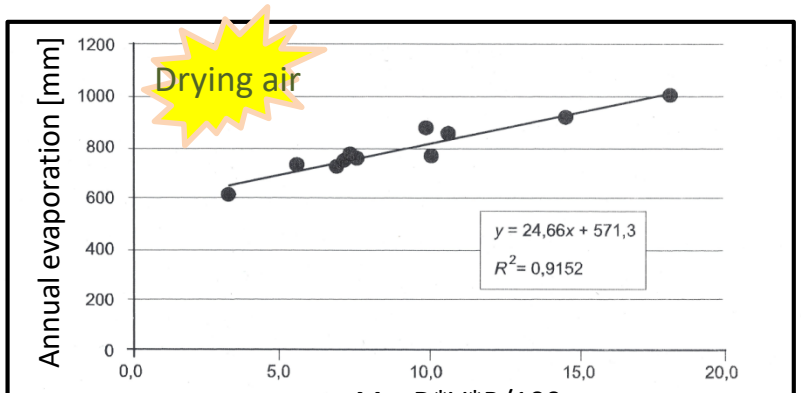
- Deforestation
- Unification of agricultural landscape



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

Kedziora 2012-2014

Climate change Warta River Poland

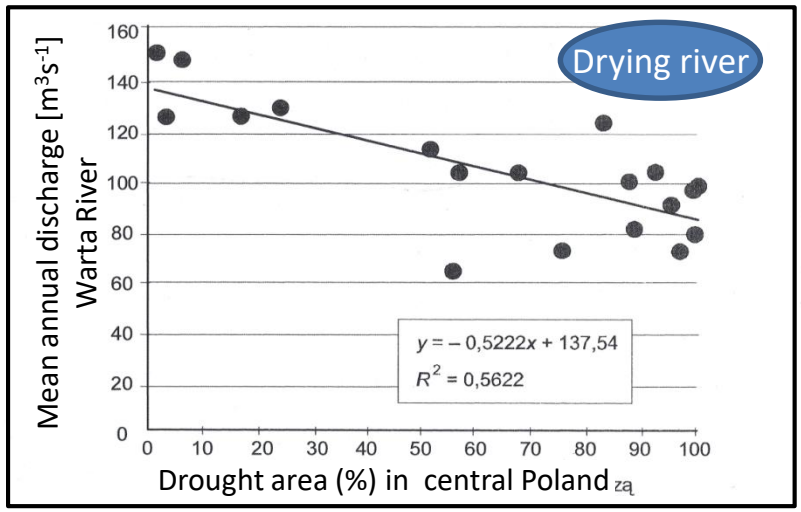


M = D*V*R/100

D – atmospheric water vapour deficit [hPa]

V – wind speed [ms^{-1}]

R – solar radiation balance [Wm^{-2}]



Terrestrial phase

Acquatic phase

- Science First

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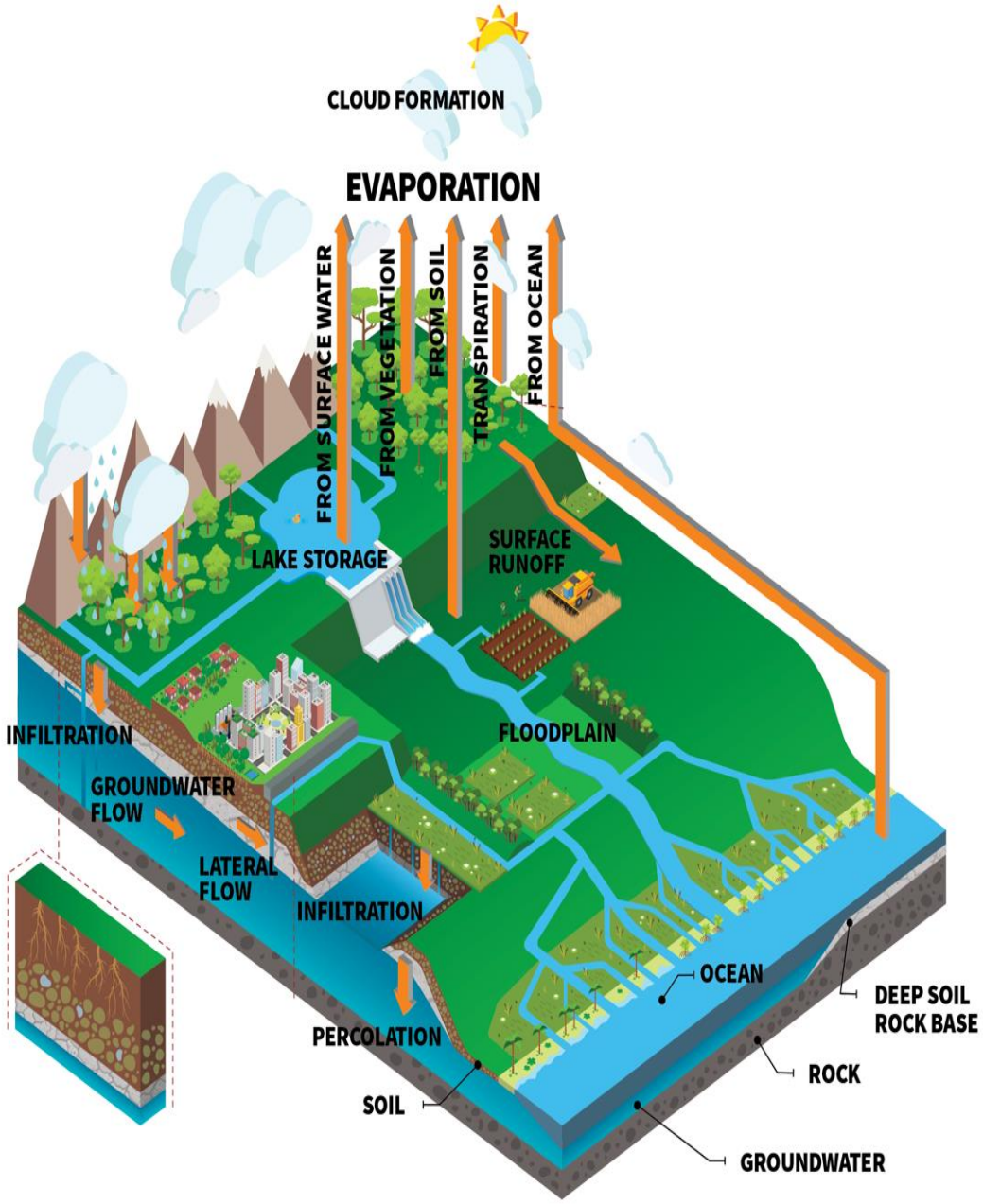
UNESCO International Hydrological Programme VIII 2014 -2021

Ecohydrology - the use the relationship between ecosystems and the water cycle as a tool for catchment managemnt

Ecological processes driven by vegetation and soils in forests, grasslands, wetlands, as well as in agricultural and urban landscapes, play a **major role** in the movement, storage and transformation of water

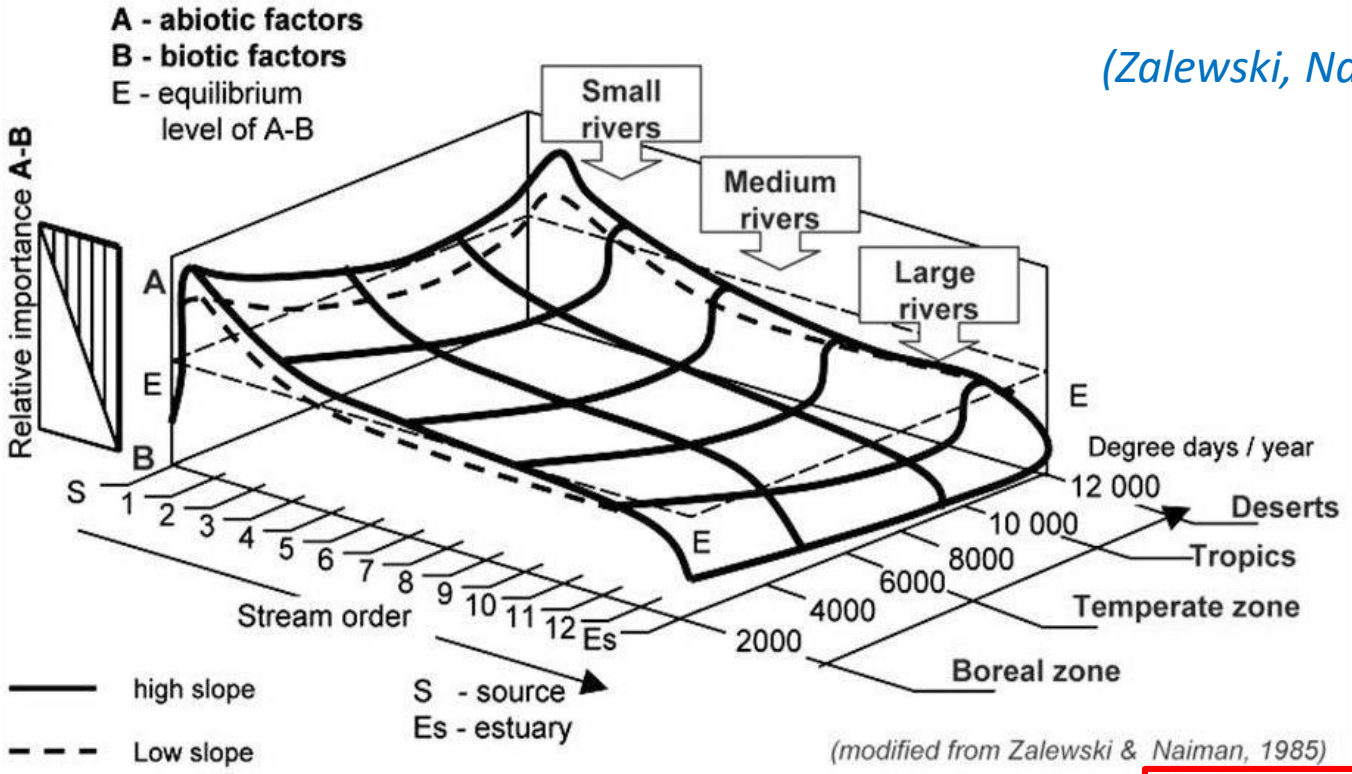


Model of hierarchy of drivers at river ecosystems as a background for regulation of ecological processes for enhancement sustainability potential

Conceptual framework for EIFAC FAO „Physical Habitat Modification and Freshwater Fisheries" and UNESCO IHP ECOHYDROLOGY

Deductive background of Ecohydrology

*(Zalewski, Naiman **1985**)*



(modified from Zalewski & Naiman, 1985)

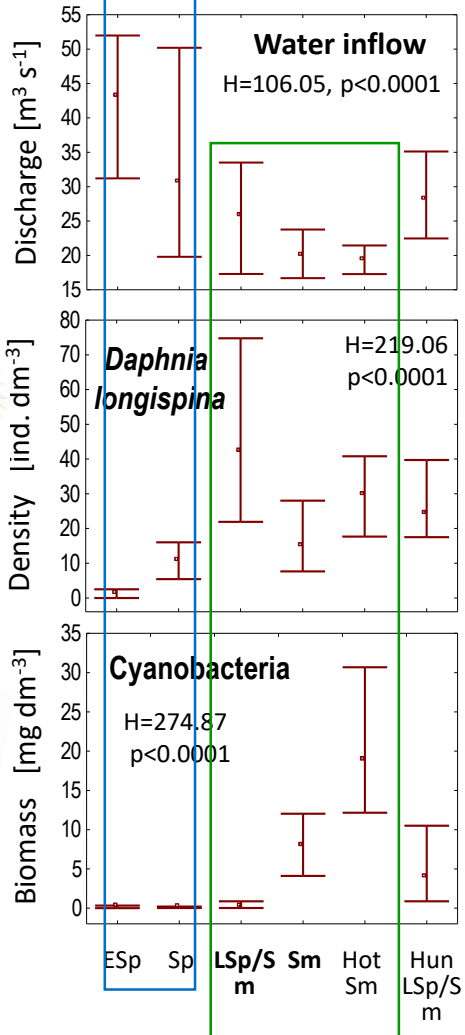
Hydrodynamics

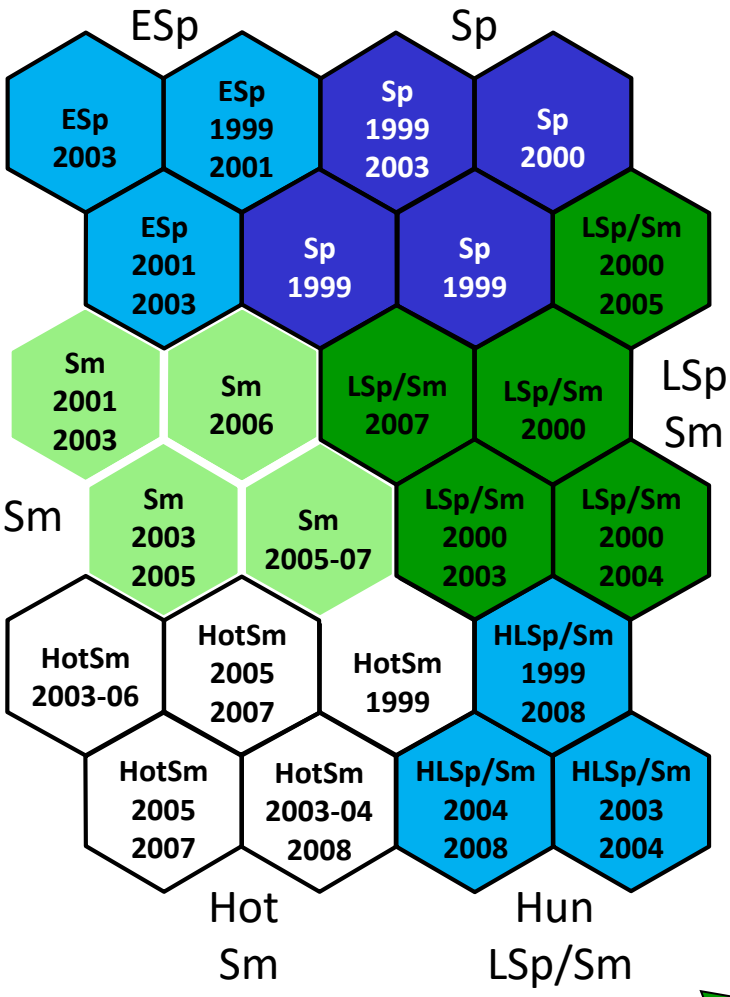
Biodiversity/Bioproductivity – species , growth, reproduction
energy gain – energy expenditure

Thermodynamics

Quantification of interactions between phytoplankton-filtering zooplankton-predatory zooplankton –juvenile Percids in pelagic zone of the Sulejow Reservoir using mathematical model

Hydrological regulation of biotoc interactions





Early spring and spring (ESp and Sp): short retention time, low temp., low density of *Daphnia*, lack of cyanobacteria.

Hydrologically unstable late spring/summer (HunLSp and Sm): low biomass of cyanobacteria

Late spring and summer (LSp/Sm): longer retention time, high density of *Daphnia* = clear water phase.

Summer (Sm) and **Hot summer** (HotSm): long retention time, high temp., high biom. of cyanobacteria

Stable hydrology - Strong biotic interactions

The 24 SOM output neurons were grouped into six sub-clusters through hierarchical cluster analysis.

Wojtal-Frankiewicz et al., 2015; PLoS ONE

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Empirical background of Ecohydrology

Hydrobiomanipulation:

regulation of trophic cascade by hydrological reg

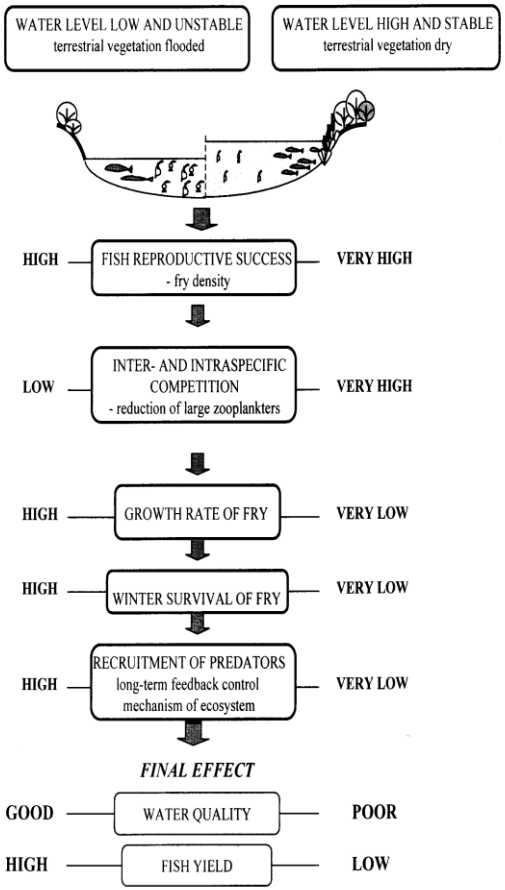
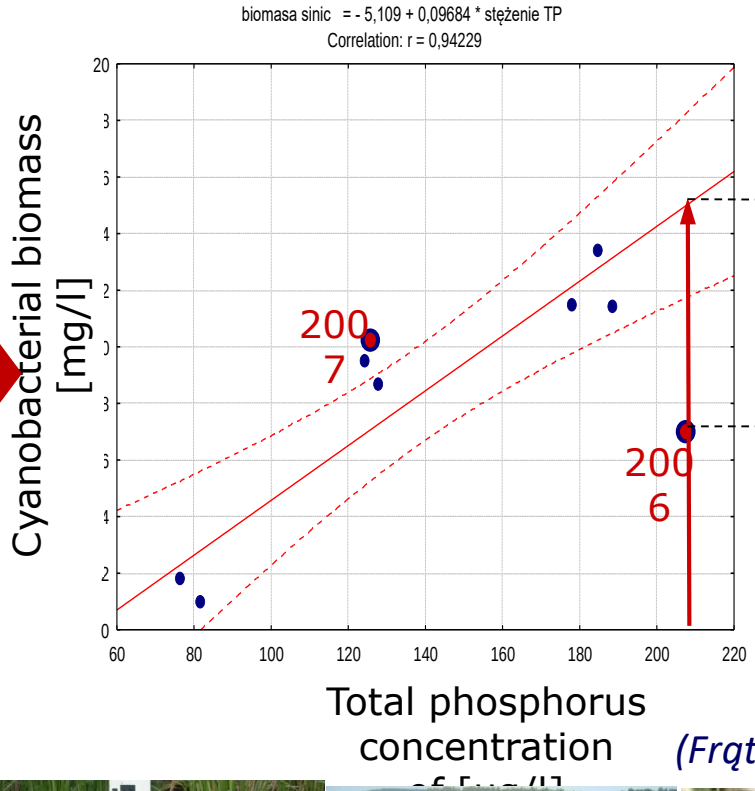
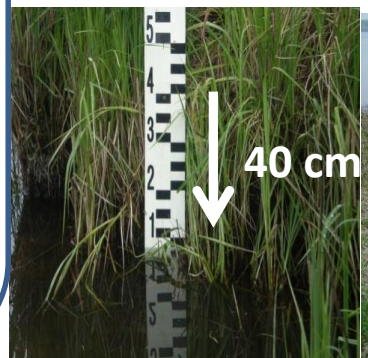


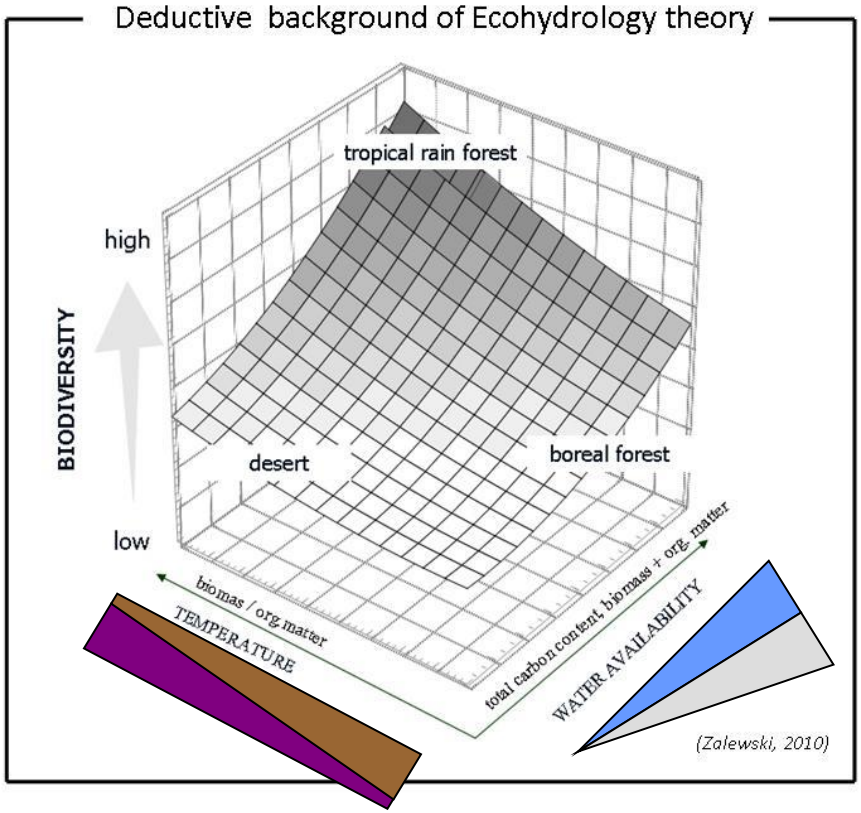
Fig. 5. Influence of flooding the shoreline on fish, plankton community structure and water quality (data from Zalewski *et al.* 1990a, b)

(Zalewski et al. 1990)



(Frątczak, Izydorczyk, Zalewski in





The deductive background of ecohydrological theory that the amount of water determines the amount of carbon accumulated in an ecosystem while temperature determines the carbon allocation between biomass and soil organic matter. The maximum biodiversity and bioproductivity is achieved at highest water availability and highest temperatures (*Zalewski 2010).*

Organizacja Narodów Zjednoczonych do Spraw Oświaty, Nauki i Kultury

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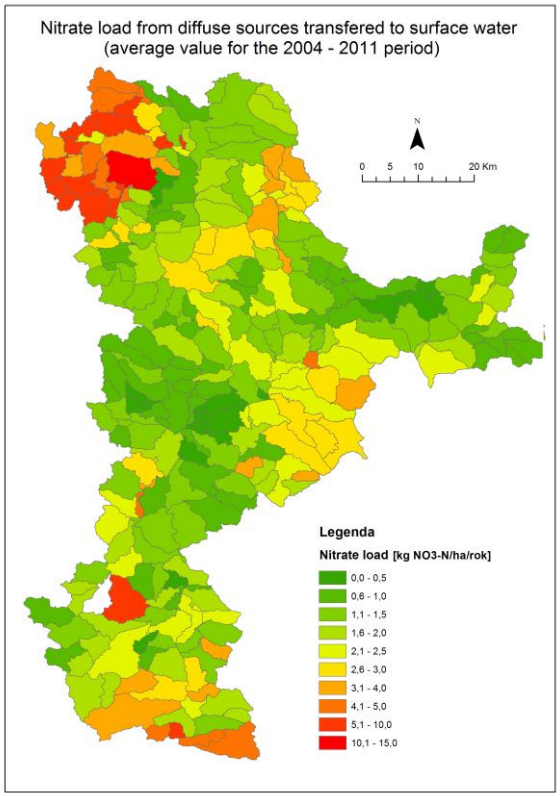
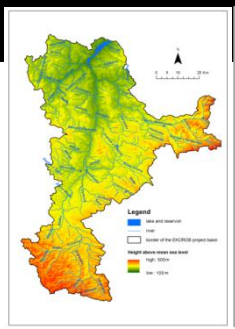
Spatial differentiation of amount of nitrogen emission in the Pilica River catchment (results form SWAT model)

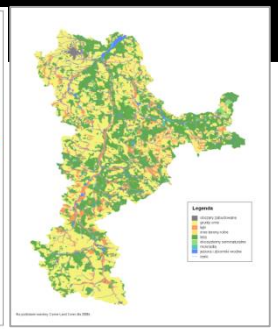


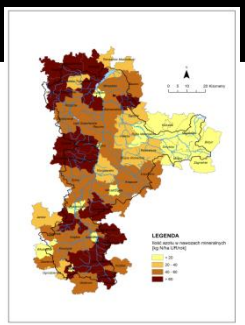
Life

NFOŚiGW

EKOROB

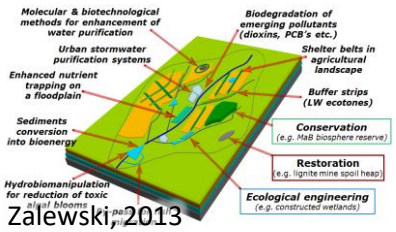




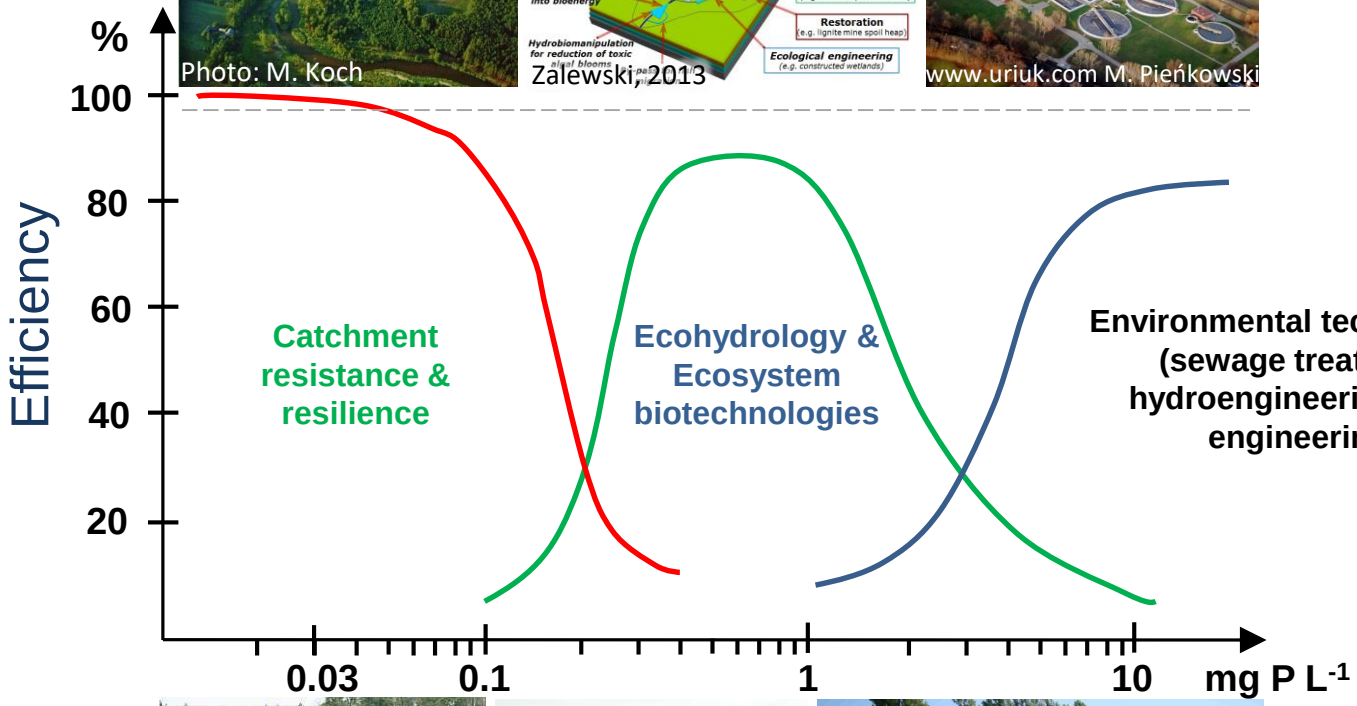


(Piniewski, Frątczak, Izydorczyk)

Ecohydrology – tool for mitigating intermediate impacts in catchment



Zalewski, 2013



Natural background

Non-point source pollution

Point-source pollution

Nutrient concentration

Zalewski 2018

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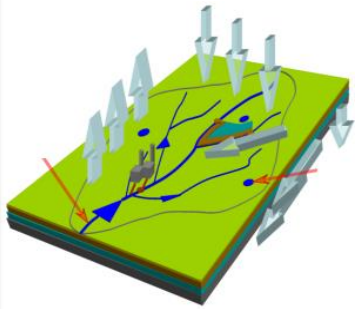
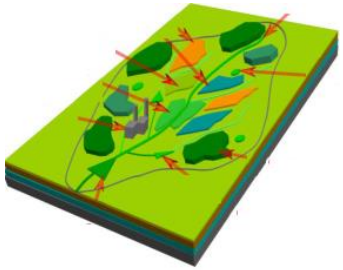
ECOHYDROLOGY – framework for implementation of NATURE BASED SOLUTIONS

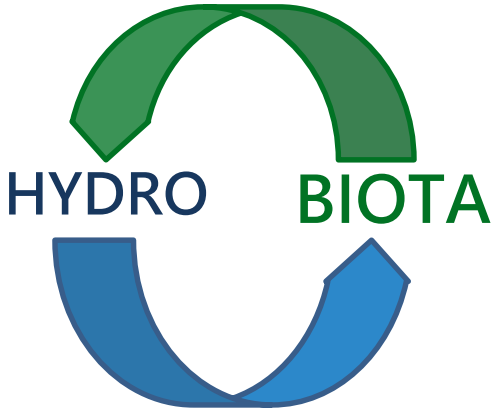
WATER CYCLE QUANTIFICATION → **ECOSYSTEMS DISTRIBUTION** → **NATURE BASED SOLUTIONS**

Ecological Engeenering

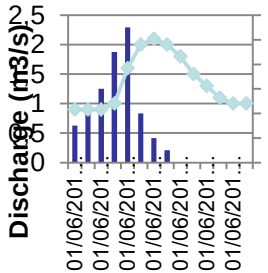




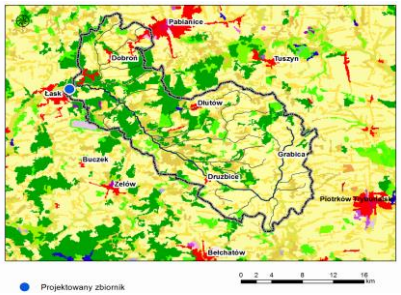
ECOHYDROLOGY



Dual regulation



e.g. rainfall-runoff model



Land cover, land use, vegetation mapping & analysis

Sequencial biofiltration systems & constructed wetlands

Zalewski, 2000; 2008; 2011; 2015

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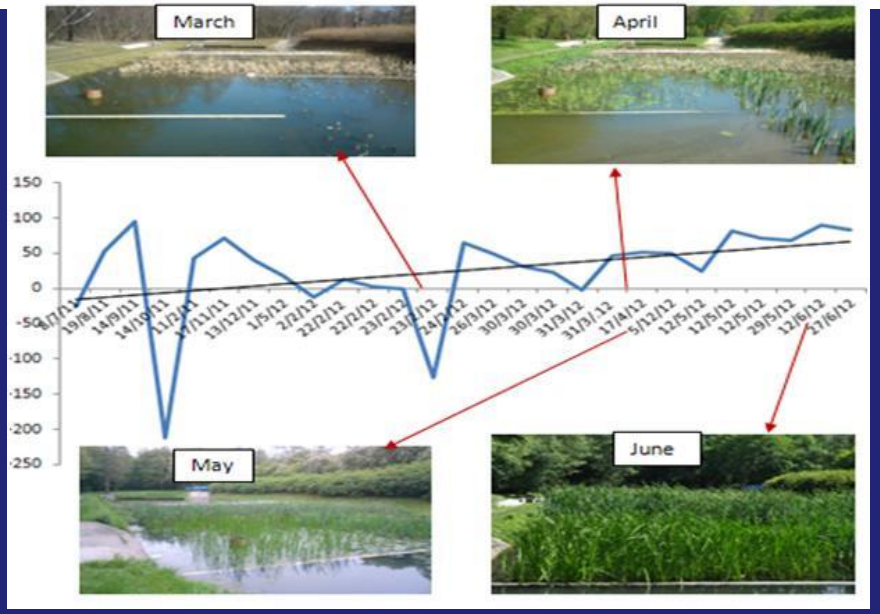
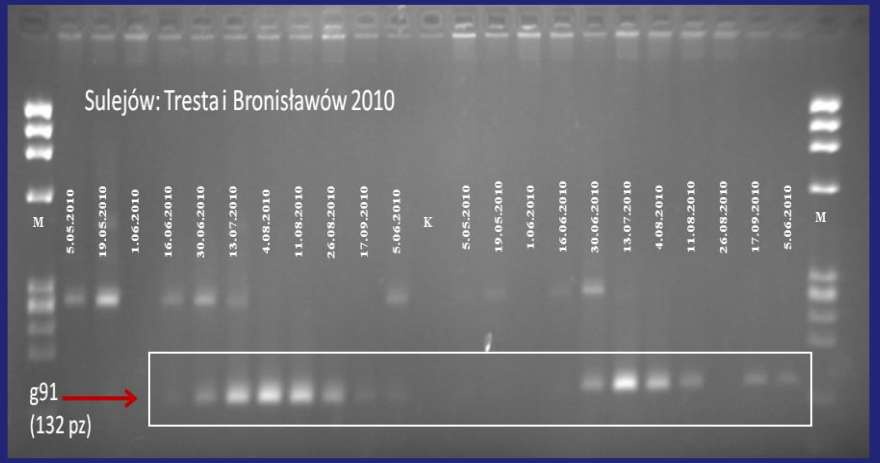
2013 17-19th September ŁÓDŹ POLAND

International Symposium Ecohydrology, Biotechnology & Engineering: Towards Harmony between the Biogeosphere and Society on the basis of Long-Term Ecosystem Research

Why Ecosystem Biotechnology ?

Because provide knowledge how to convert forms of the matter for improving water quality by using low energy methods e.g enzymes, microorganisms, plants and trophic cascade interactions.





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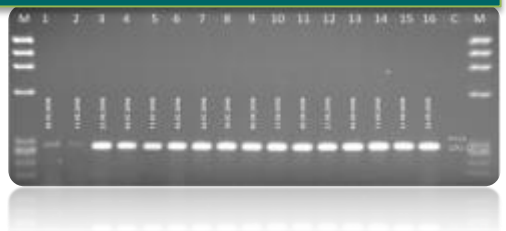
Molecular biology for Ecohydrology and NBS : methods for early warning and biotechnologies enhancement

*mcy*A gene, toxic genotype of *M aeruginosa* (291 – 297 bp)

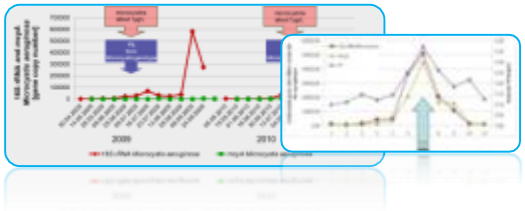


Early warning

detection of toxigenic (potentially toxic) strain of cyanobacteria

Mankiewicz-Boczek et al., Environ. Toxicol. 2006, 21: 380-387
Mankiewicz-Boczek et al., Environ, Toxicol. 2011, 26, 10-20
Mankiewicz-Boczek et al., Harmful Algae 2011, 10: 356-365
Gagała et al., Fresenius Environ. Bull 2012, 21(2): 295-303

16S rRNA *Microcystis, mcyA toxic genotype*

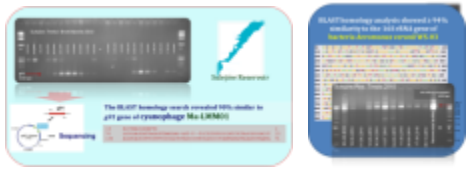


Cause-effect analysis

toxigenic cyanobacteria and physicochemicla parameters of water

Gagała et al., Microbial Ecology, 2013, DOI: 10.1007/s00248-013-0303-3

g91 ***Myoviridae*** *, 16S rRNA Aeromonas*

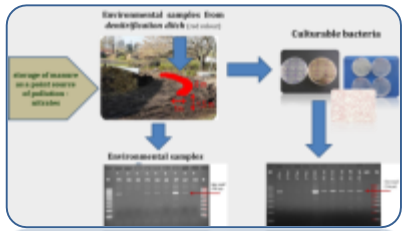


New reserach

Analisys of relationship between organisms

cyanobacteria/bacteria/cyanophages
•detection of cyanophages degrading cyanobacte cells
•detection of bacteria degrading cyanotoxins

nosZ gene, culturable bacteria, *Pseudomonas* sp.



Ecohydrological biotechnologies - process optimization

selection and implementation of bacteria in denitrifying barriers to removal of nitrate compounds

… for
regulation of processes towards:

1. **Rreversing degradation;**
2. **Development of cost efficient measures**
3. **Enhancing the carrying capacity of ecosystems**

Mankiewicz, Bednarek, Gągała-Borowska,

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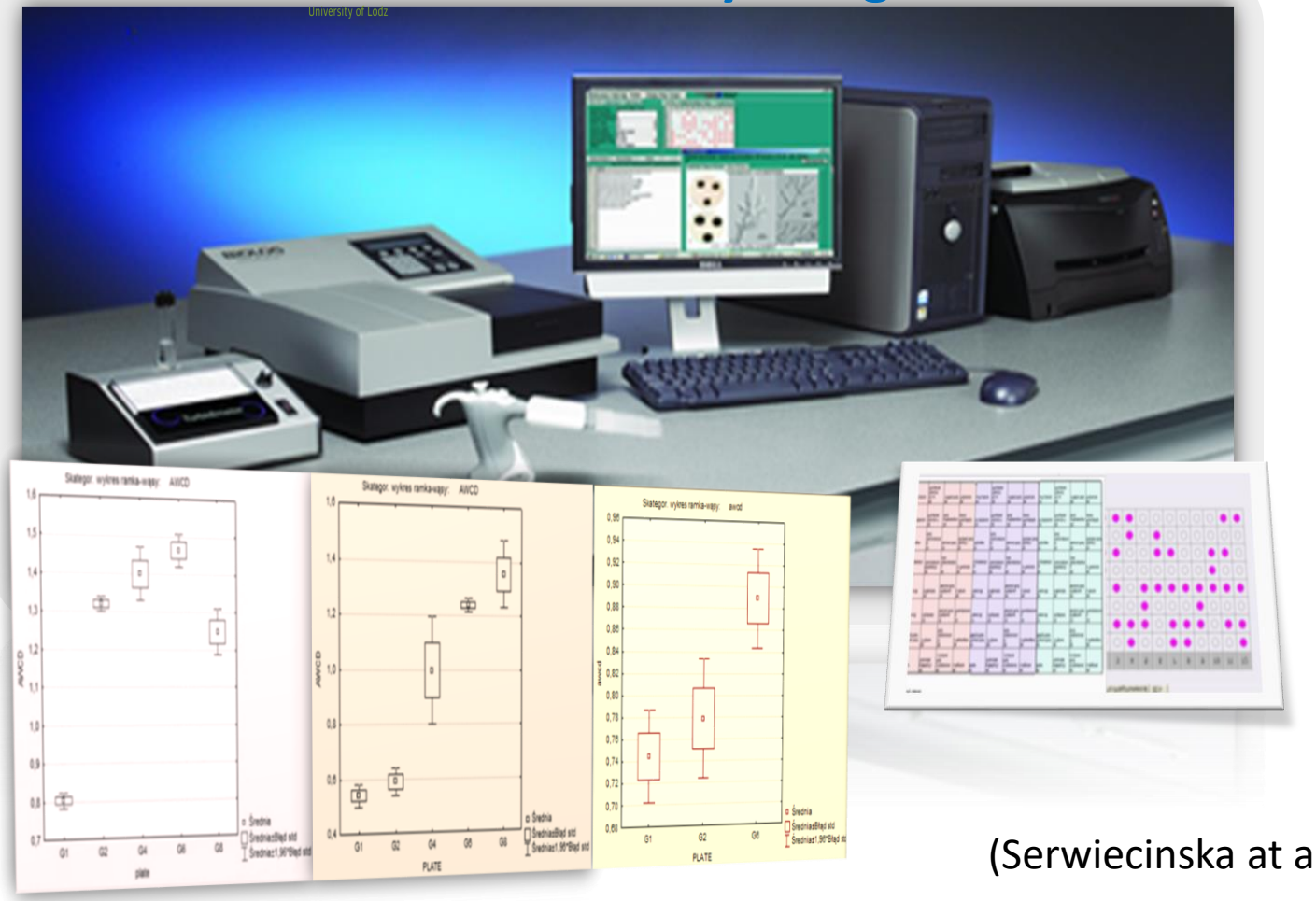
CLPP – Community-Level Physiological Profile



(Serwiecinska at al. In press)

Assessment of metabolic potential of microbial community for sole carbon utilization of the 31 different carbon sources

The National Centre for Research and Development

Gekon Generator Koncepcji Ekologicznych

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Narodowy Fundusz Ochrony Środowiska i Gospodarki Wodnej

KATEDRA EKOLOGII I OCHRONY ŚRODOWISKA UP POZNAŃ

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MIKRONATURA ŚRODOWISKO

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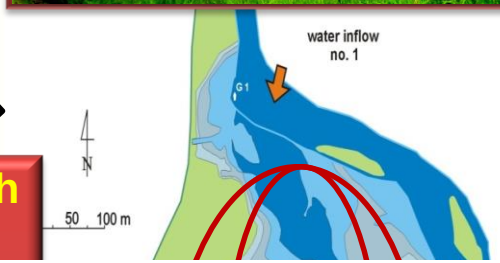
Enhancement of river floodpolain role in phosphorus acumulation

Summer phosphorus accumulation in the macrophytes biomass

26,6 ha = 255 kg P



SCENARIO

24% of area with willows

SCENARIO

48% of area with willows

ECOLOGICAL ENGINEERING 33 (2008) 15–25

available at www.sciencedirect.com

ScienceDirect

journal homepage: www.elsevier.com/locate/ecoleng

ELSEVIER

Quantification of phosphorus retention efficiency by floodplain vegetation and a management strategy for a eutrophic reservoir restoration

Edyta Kiedrzyńska[a,*], Iwona Wagner[a,b], Maciej Zalewski[a,b]

Kiedrzyńsk
retention eff

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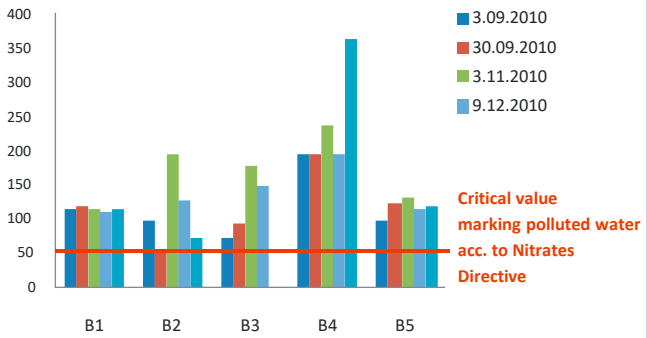
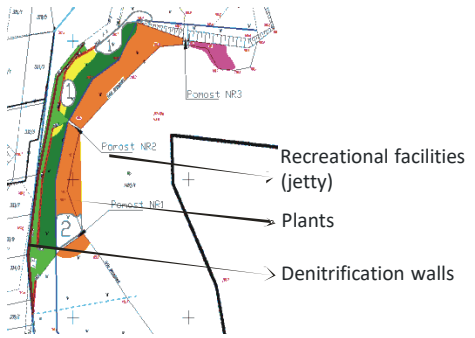
IDENTIFICATION OF PROBLEMS

DEVELOPMENT OF SOLUTIONS

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

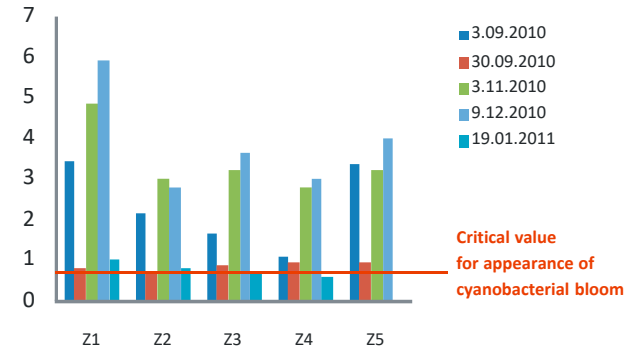
(www.geoportal.gov.pl)

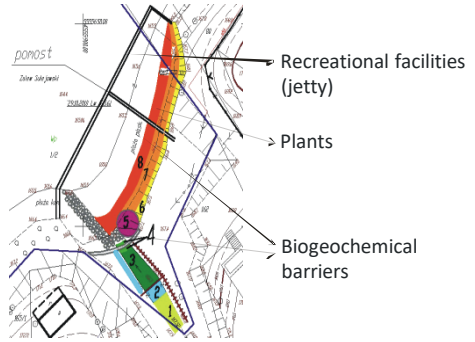




Reduction of **phosphorus** pollution from diffuse source by enhancement of plant buffering zones with biogeochemical barriers

(www.geoportal.gov.pl)





Izydorczyk Zalewski, 2011

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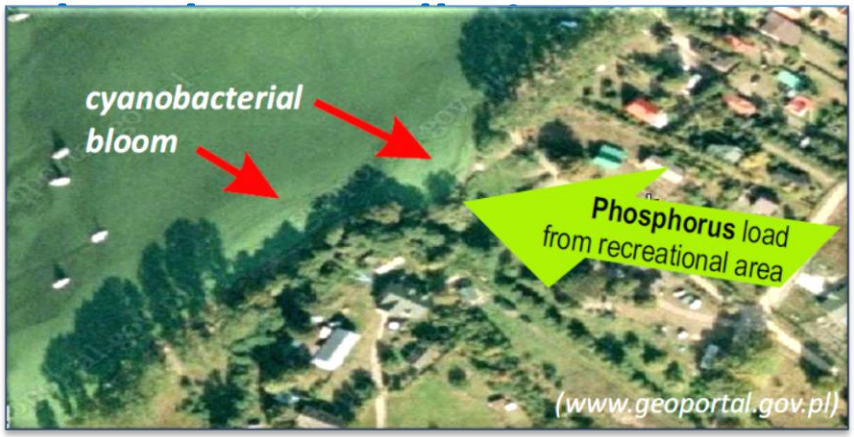
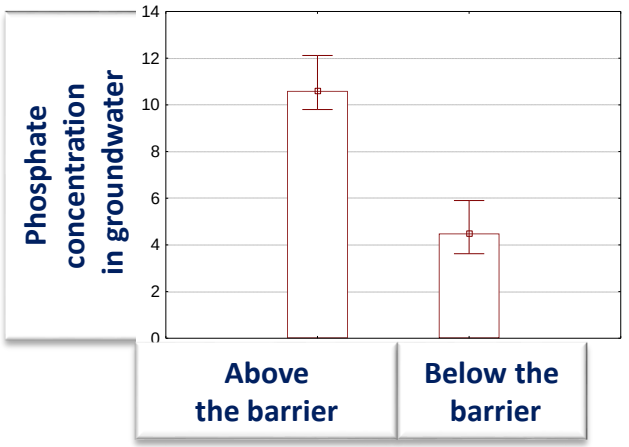
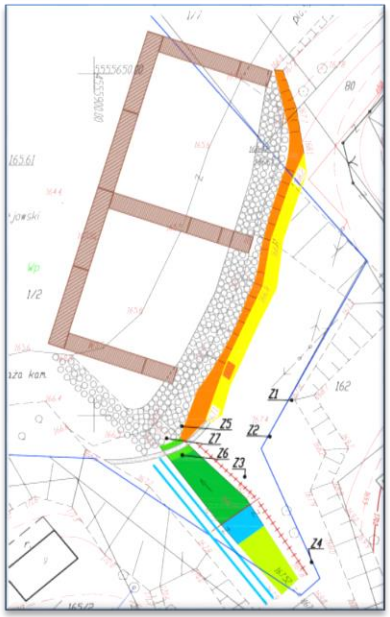
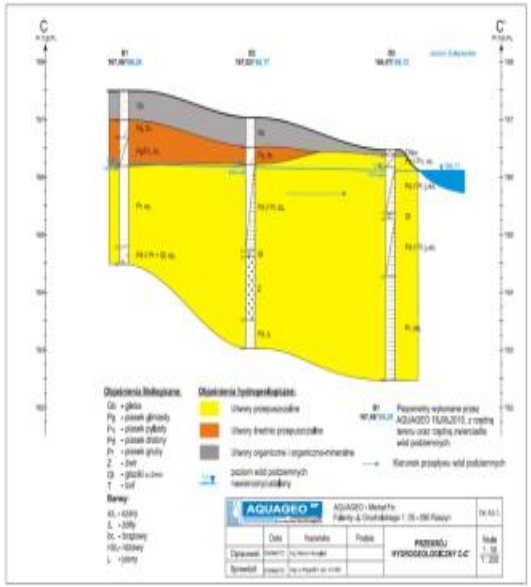
„BEST OF EC LIFE+ Project, 22 May 2018 Brussels

Highly effective buffer zones for reduction of diffuse







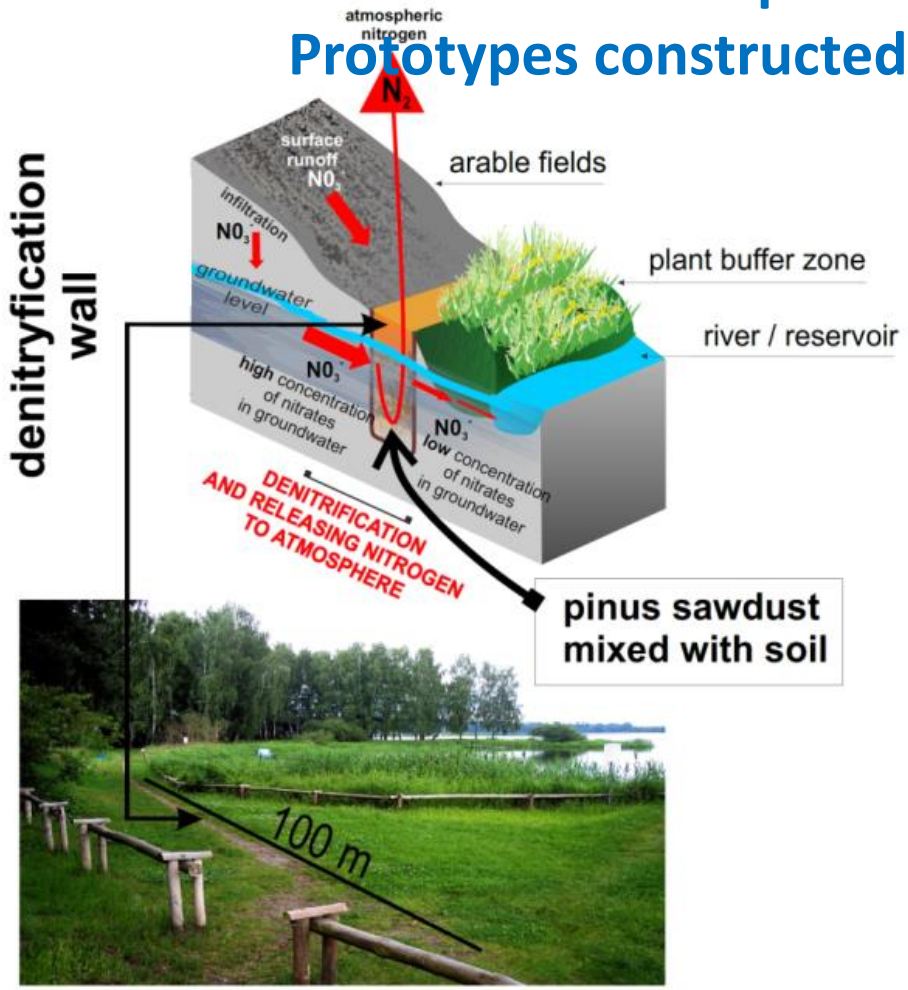


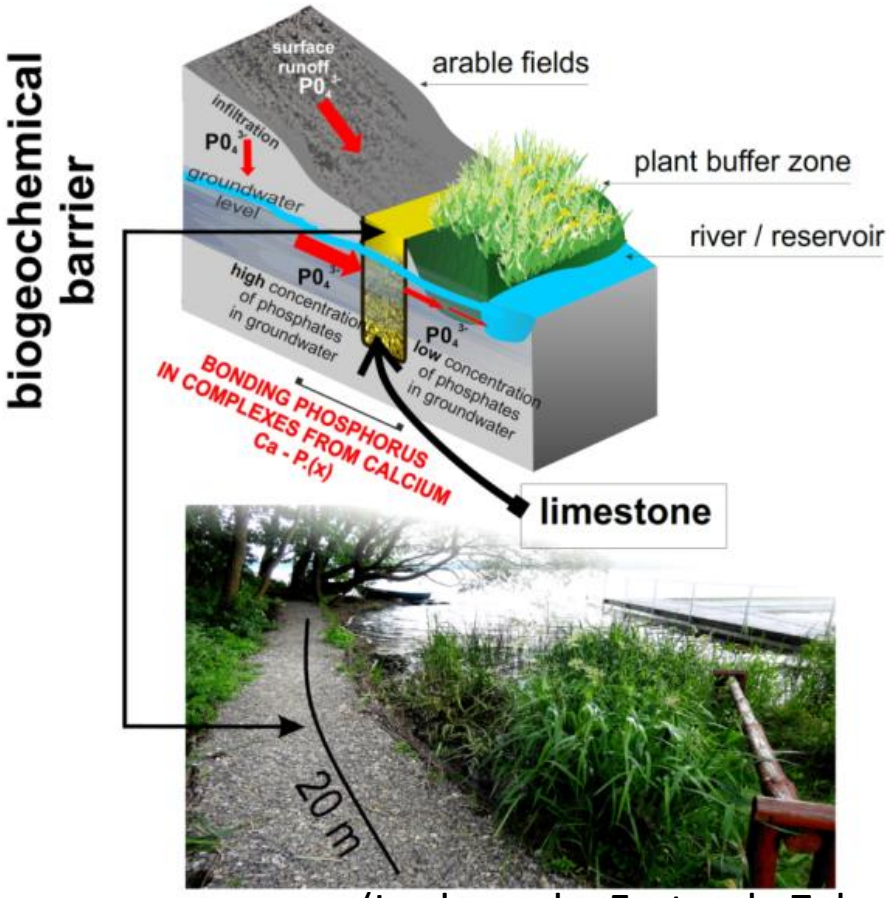
(Izydorczyk, Frątczak et al. 2013 Ecohydrology & Hydrobiology)

„BEST
EC LIFE+
Project, 2018
Brussels

Biotechnological buffering zone for reduction of non source pollution

Prototypes constructed at Sulejow Reservoir





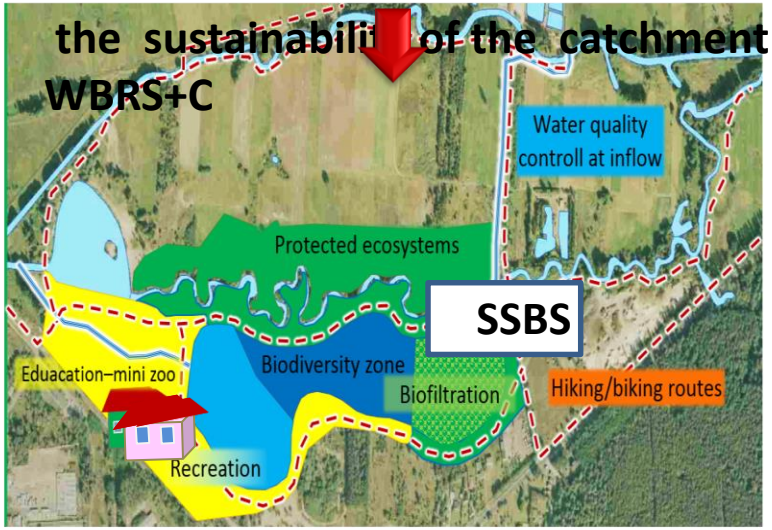
(Izydorczyk , Frątczak Zalewsl

United Nations Educational, Scientific and Cultural Organization · ERCE European Regional Centre for Ecohydrology Under the auspices of UNESCO · PAN POLISH ACADEMY of SCIENCES · UNIVERSITY OF LODZ · FACULTY OF BIOLOGY AND ENVIRONMENTAL PROTECTION University of Lodz

What the difference Ecohydrology makes in the construction of reservoirs?

The comparison the traditional Hydroengeenering design of the small reservoir and Ecohydrological Systemic solution WBSR+C for enhencemnt of the catchment sustainability

Design of the EH systemic solutions to enhence the sustainabili of the catchment WBRS+C



WBSR+C

Water · Biodiversity · Ecosystem services · Resilience · Culture/ Education

(Zalewski,Belka, Kiedrzynska 2018)

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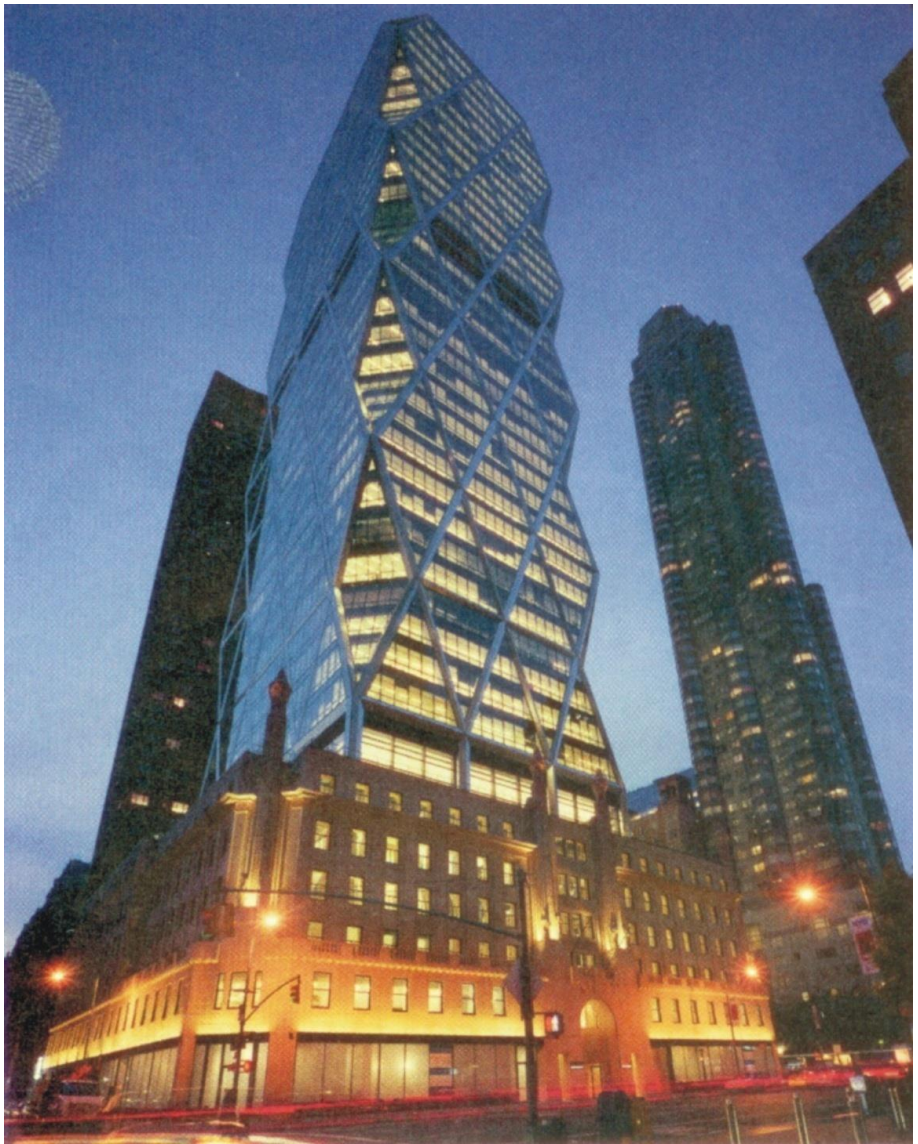
City of the future alternative scenarios

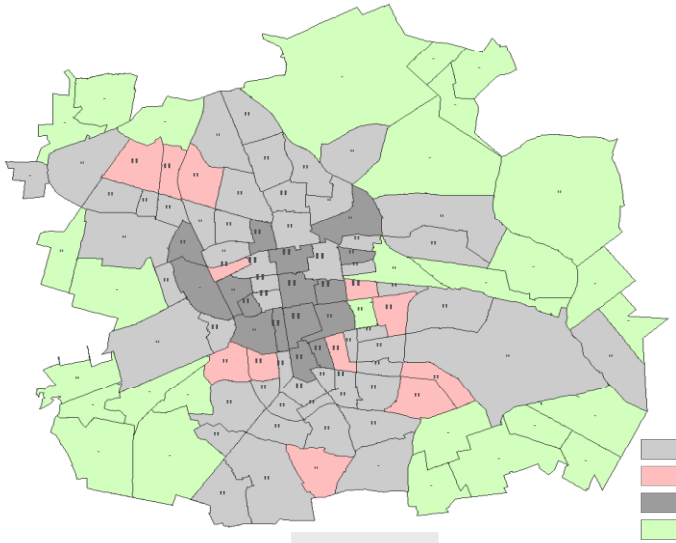


WPŁYW URBANIZACJI NA ZDROWIE
The effect of urbanisation on human helth

Organizacja Narodów Zjednoczonych do Spraw Oświaty, Nauki i Kultury

Europejskie Regionalne Centrum Ekohydrologii pod auspicjami UNESCO

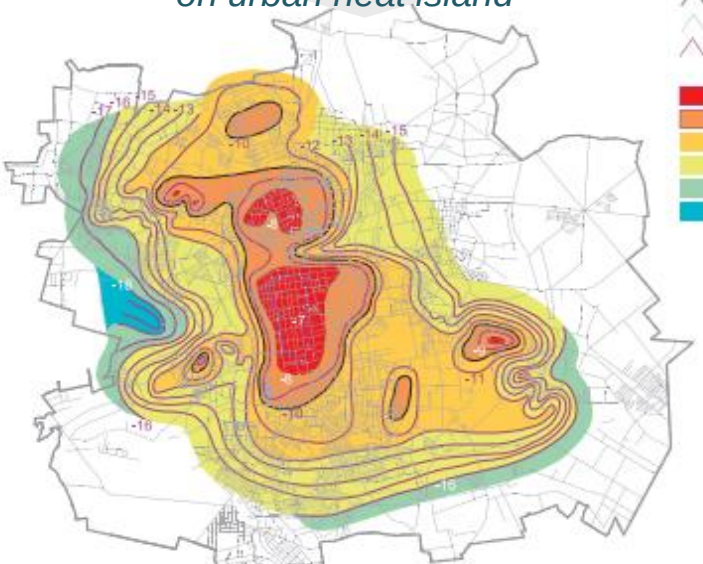
POLSKA AKADEMIA NAUK



Percentage of the urban population in the EU exposed to air pollutant concentrations above the EU and WHO reference levels (2009–2011)

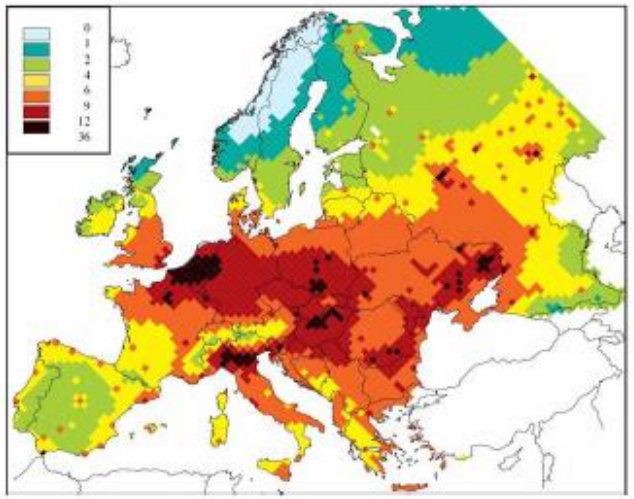
Pollutant	WHO AQG	Exposure estimate (%)
$PM_{2.5}$	Year (10)	91–96
PM_{10}	Year (20)	85–88
O_3	8-hour (100)	97–98
NO_2	Year (40)	5–13
BaP	Year (0.12)	76–94
SO_2	Day (20)	46–54
CO	8	
Pb	Y	
Benzene	Y	

Effect of land transformations on urban heat island



Life loss

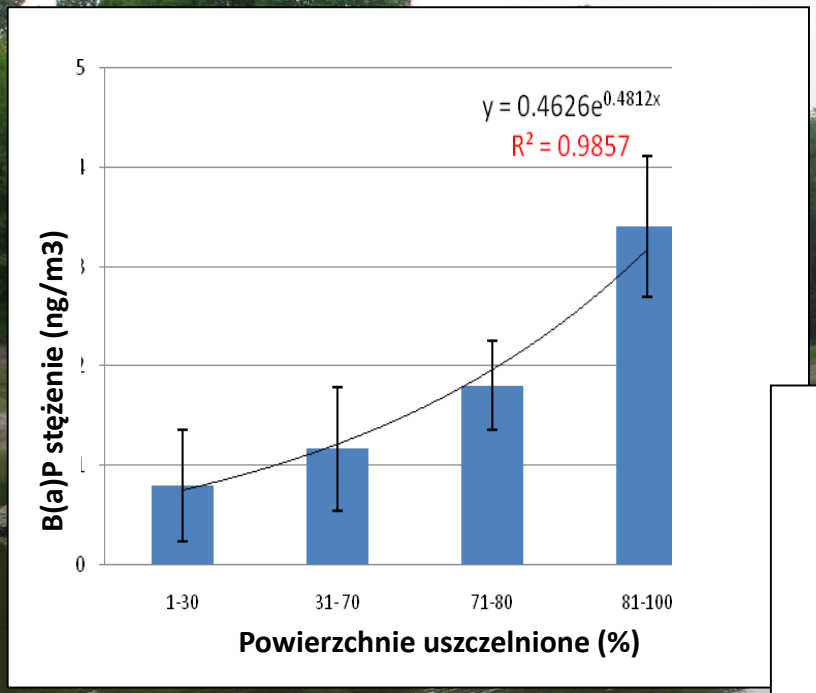
Loss in life expectancy attributable to exposure to fine particulate matter - 2000

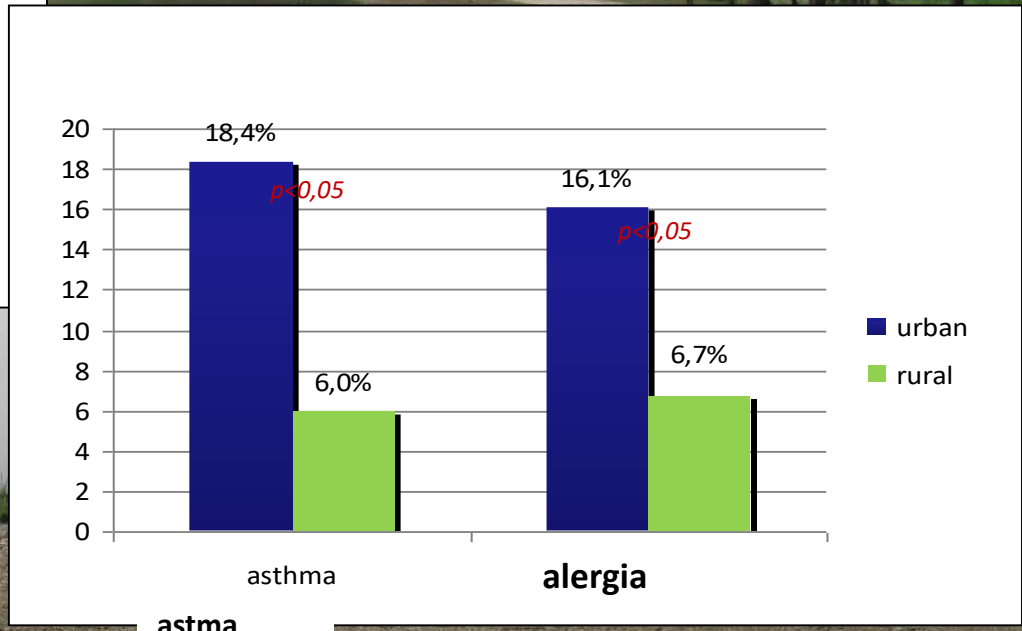


PM2.5: 8 months loss=3.6 million life yr/annual

Health cost: €189-609 billion/annum in 2020

Zbiornik Teresa





(Cuprys Lipinska at al. 2010)

(Zalewski 2012)

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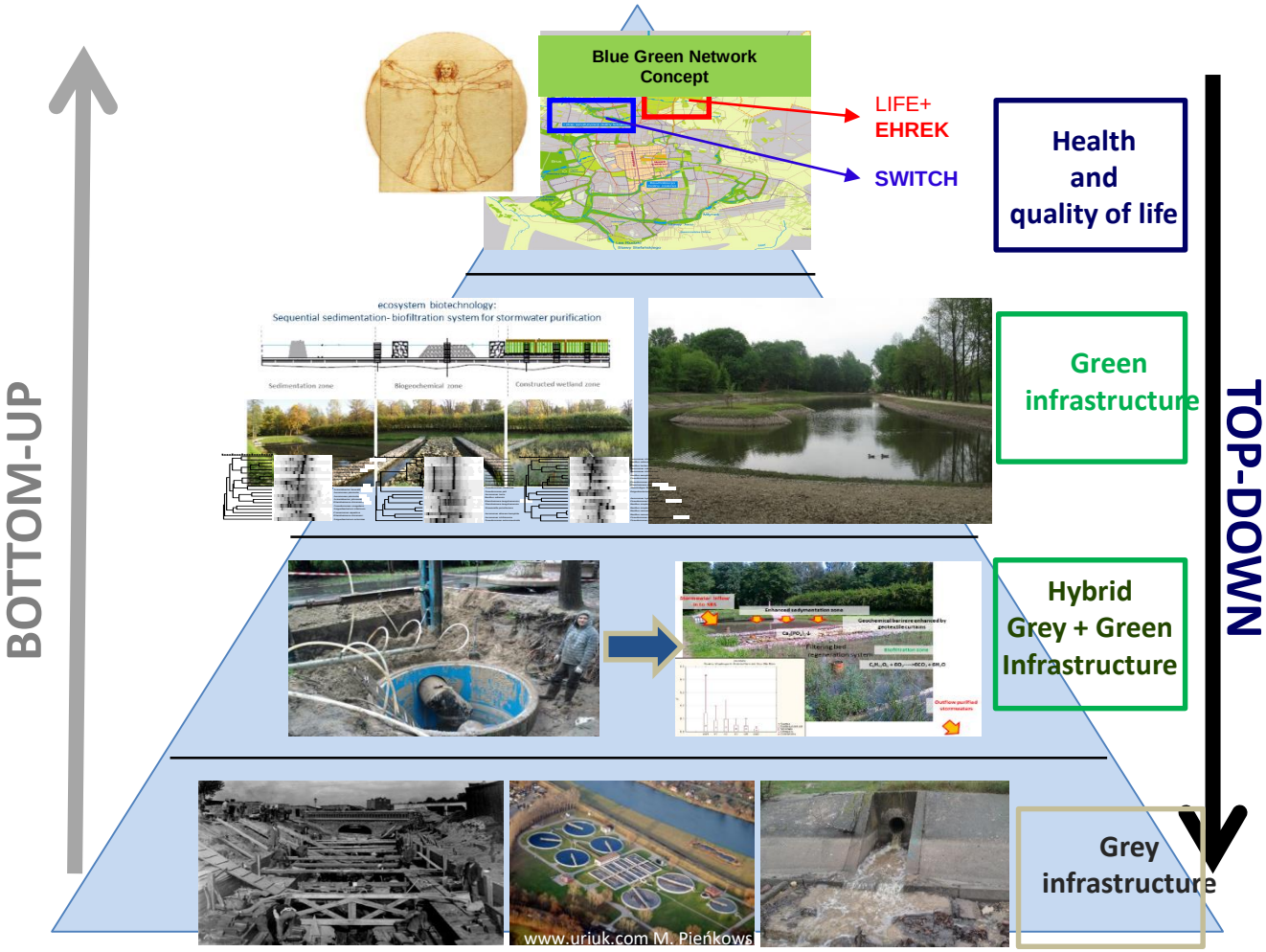
SHAPING THE FRIENDLY AND HEALTHY CITY OF THE FUTURE

(Integration of TOP-DOWN: HEALTH AND QUALITY OF LIFE BOTTOM-UP GREY, HYBRID AND GREEN INFRASTRUCTURE)

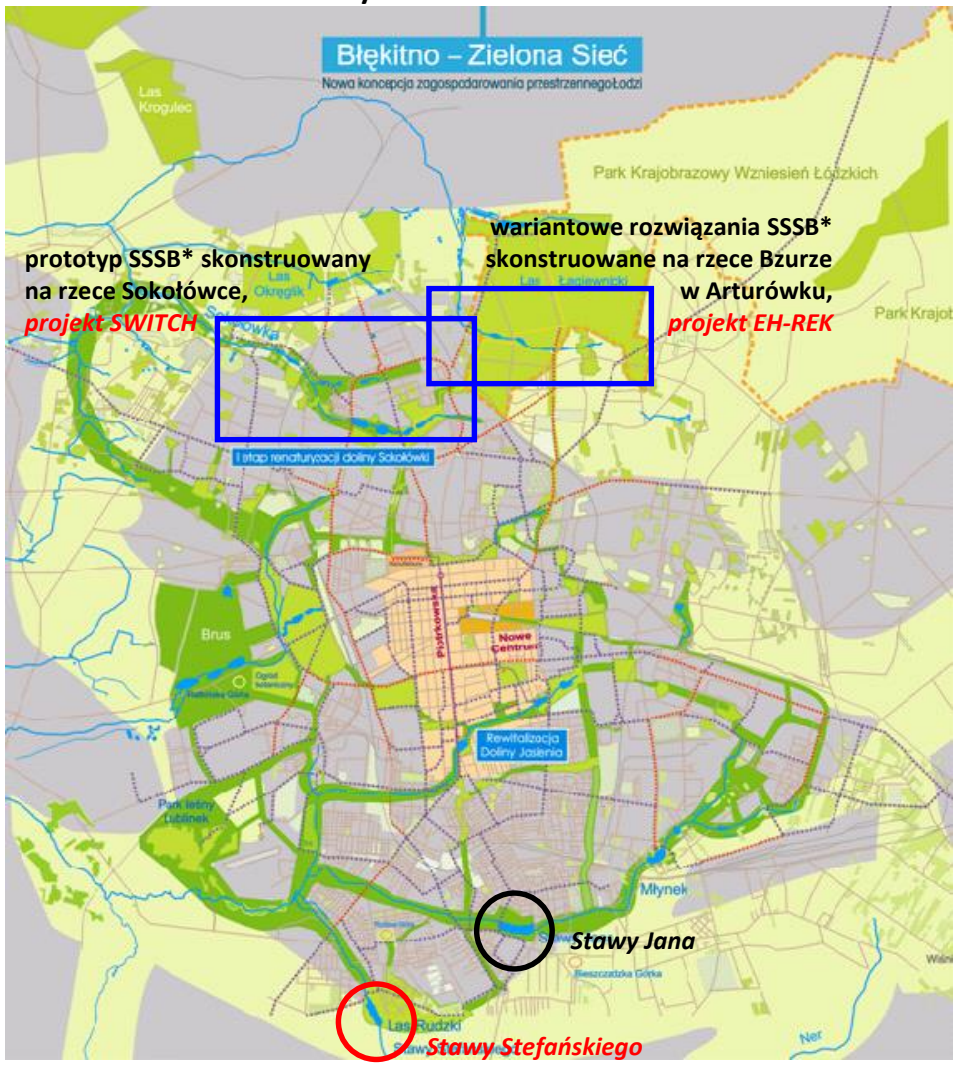


M. Zalewski
(In press)

ZAKWITY GLONÓW I TOKSYCZNYCH SINIC
w zbiornikach rekreacyjnych na terenie miasta Łodzi

LIFE08 ENV/PL/000517
www.arturowek.pl

Lodz City of Blue–Green Network



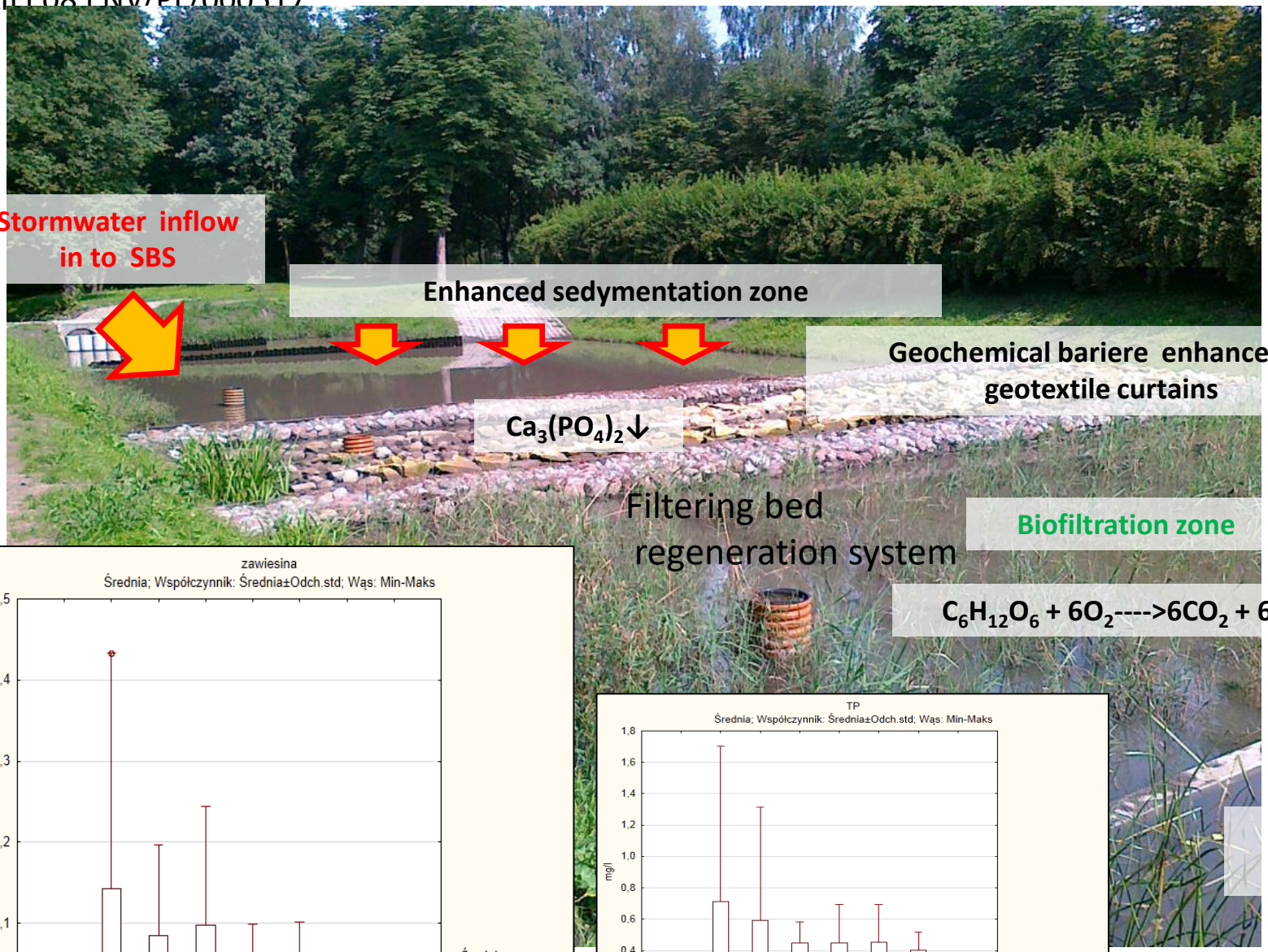
The past chalanges

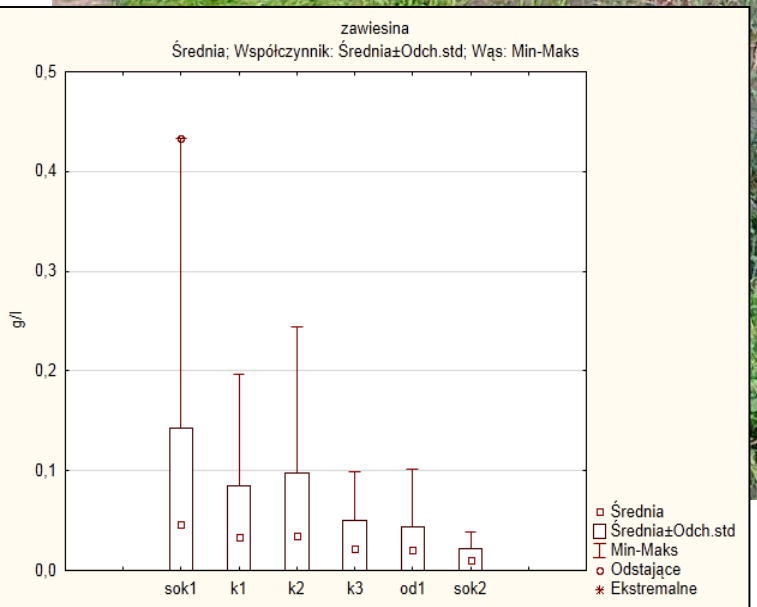
Stawy Stefańskiego, 2006

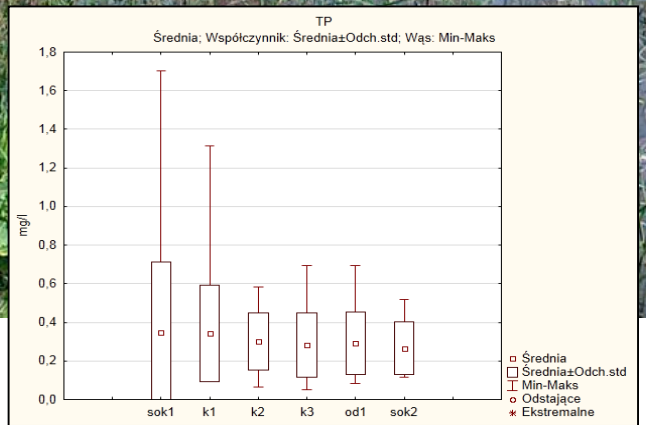
Stawy Stefańskiego, 2007

EH Sequential Sedimentary/Biofiltration System *(Zalewski 2008)*

LIFE08 ENV/PL/000517







Zbiornik na Sokolowce zkonstruowany ponizej systemu SBS

(Zalewski 2012)

Ekohydrologiczna rekultywacja zbiorników rekreacyjnych na górnej Bzurze

CITY OF LODZ

Implementation Blue - Green Network Concept LIFE+ EHREK

2010

Toxic algal blooms in reservoir at upper Bzura River catchment

Mitigation of urban stormwater impact

Green

Grey

Hybrid infrastructure

Green infrastructure

2014

Reservoir

Water quality after implementation hybrid (grey + green) infrastructure in upper Bzura River catchment (July 15, 2014)

M. Zalewski (In press)

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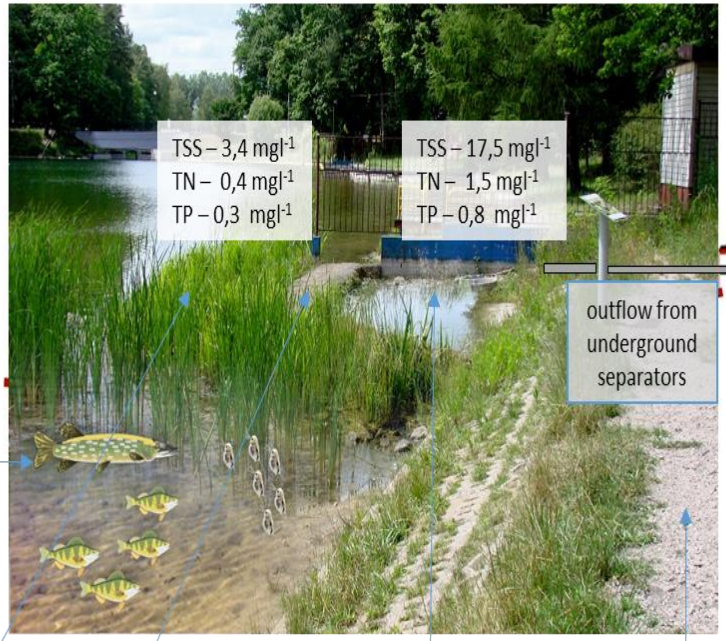
Award of European Comission
BEST OF THE BEST"
LIFE+ Project,
22 May 2018 Brussels

Integration ecohydrological biotechnologies with hydroengeenering EHREK LIFE + at Bzura River catchemnt



Stormwater from roads, roofs, parking, bicycle/walking pass

outflow from underground separators

TSS – 165,0 mgl-1
TN – 4,2 mgl-1
TP – 3,0 mgl-1

REGULATION OF BIOLOGICAL PROCESSES Enhancement of filtering zooplankton by predatory fish stocking

BIOFILTRATION ZONE Assimilation of nutrients (N, P) into plant biomass

GEOCHEMICAL BARRIER Reduction of nutrients by dolomite structure

SEDIMENTATION ZONE Reduction of suspended solids

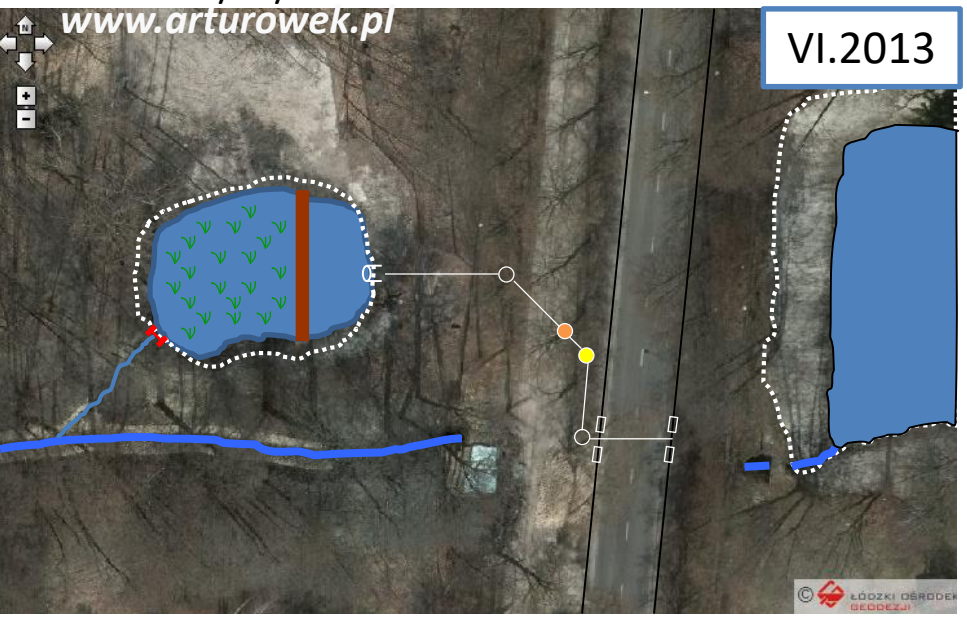
Interception of surface stormwaters by infiltration through dolomite/gravel bed

UNDERGROUND SYSTEM SEPARATORS Reduction of oil substances and suspended solids

Jurczak, Zalew

EH Sequential Sedimentary/Biofiltration System (SSBS)
Reduce up to 90% of suspended matter and nutrients

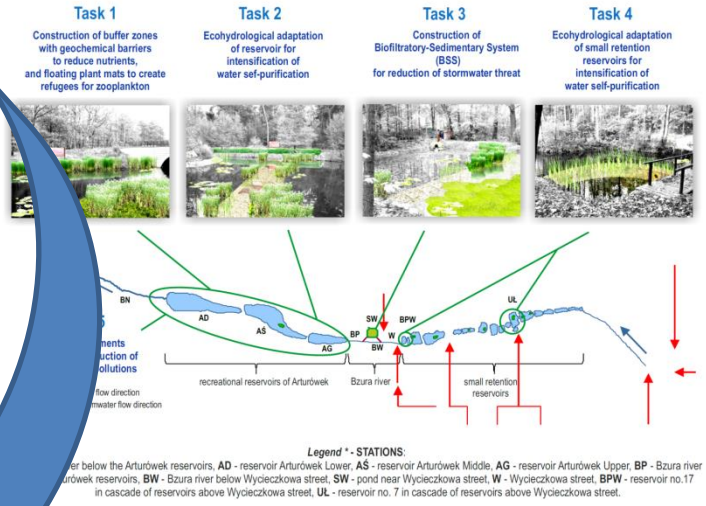
LIFE08 ENV/PL/000517



EH-REK Ekohydrologiczna rekultywacja zbiorników rekreacyjnych "Arturówek" (Łódź) jako modelowe podejście do rekultywacji zbiorników miejskich

LIFE08 ENV/PL/000517
www.arturowek.pl

The final effect construction of SSBS



Kierownik projektu: Profesor Maciej Zalewski

Koordynator projektu: Tomasz Jurczak

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EU Program LIFE, Award Ceremony

18 May Bruselss 2018

EHREK

Life

EKOROB

EHREK

The BEST of the BEST LIFE Projects

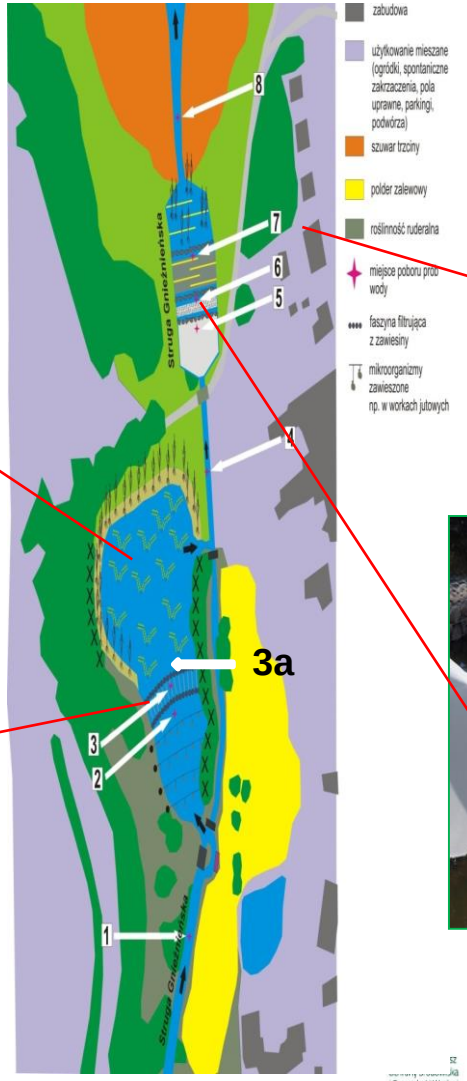
The BEST LIFE Projects

IMPLEMENTATION OF SEDIMENTATION-BIOFILTRATION SYSTEM - EH BIOTECHNOLOGY SOLUTION

"The construction and optimization of sedimentation – biofiltration system, with micro-organisms activation zone in order to reduce nutrients risks of watercourses" within the framework of the project GEKON2/03/267948/21/2016

Fot. Szklarek S.

Fot. Mikronatura i Środowisko



Fot. Mikronatura i Środowisko

Fot. Szklarek S.

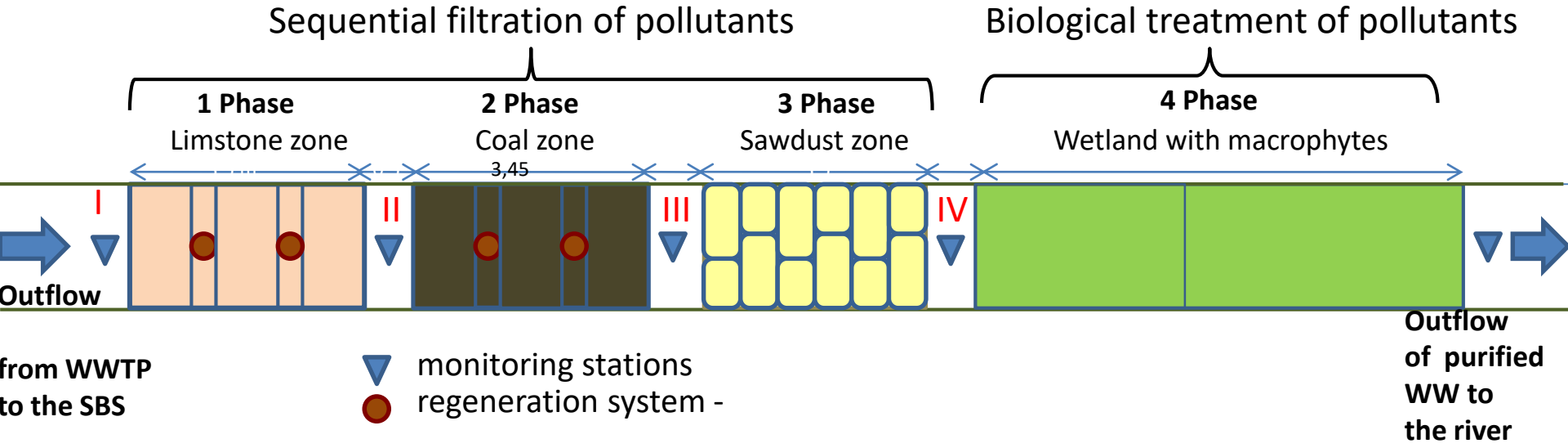
MIKRONATURA ŚRODOWISKO

Sequential Biofiltering System for improvement efficiency small WWTP

based on sequence of limestone, coal, sawdust and constructed wetlands

Mean TP reduction: 26%
Max. TP reduction 76%

Mean TN reduction: 48%
Max. TN reduction 97%



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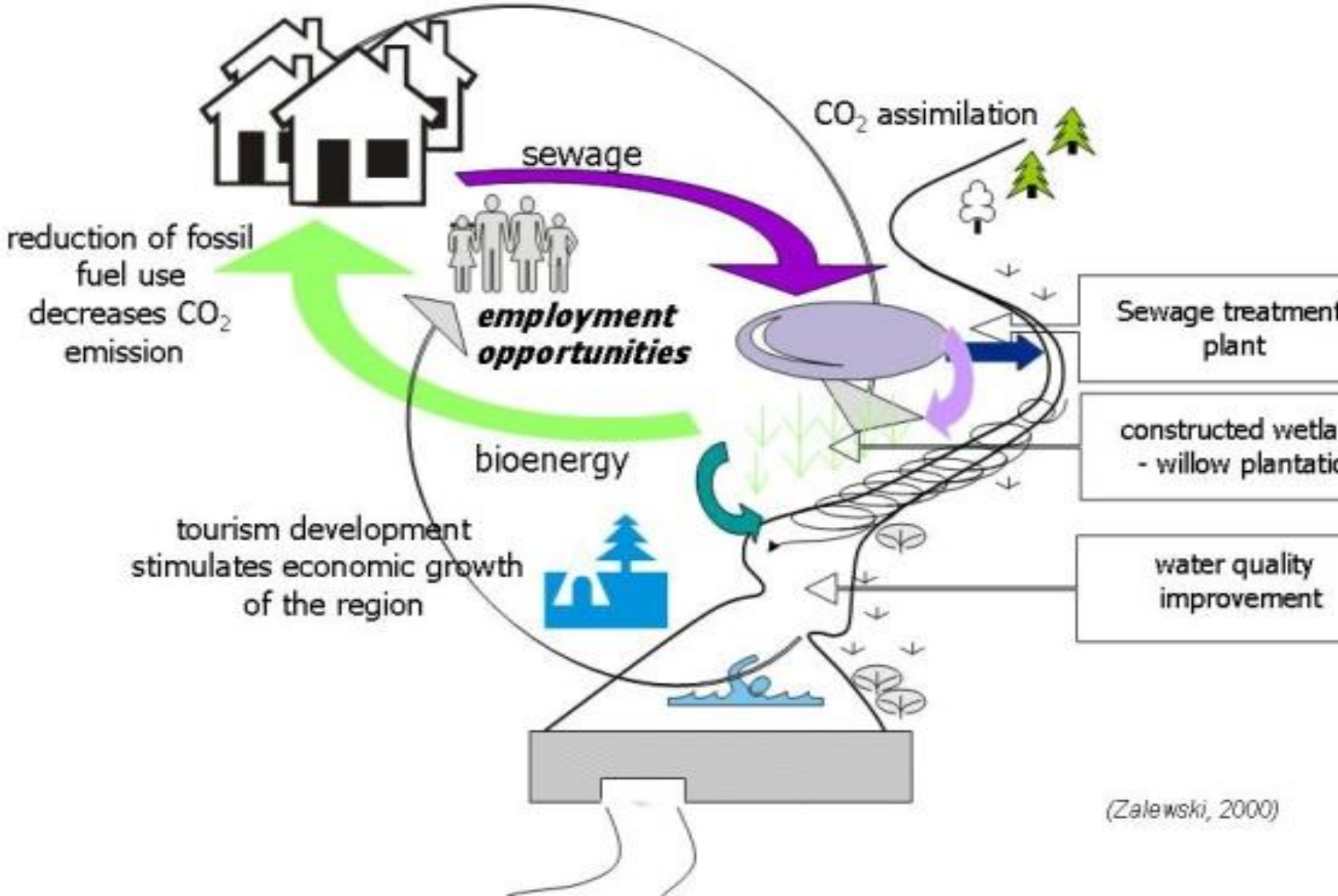
System solutions

Improvement of water quality, human health and quality of life



Ethiopia - African Centre for Ecohydrology

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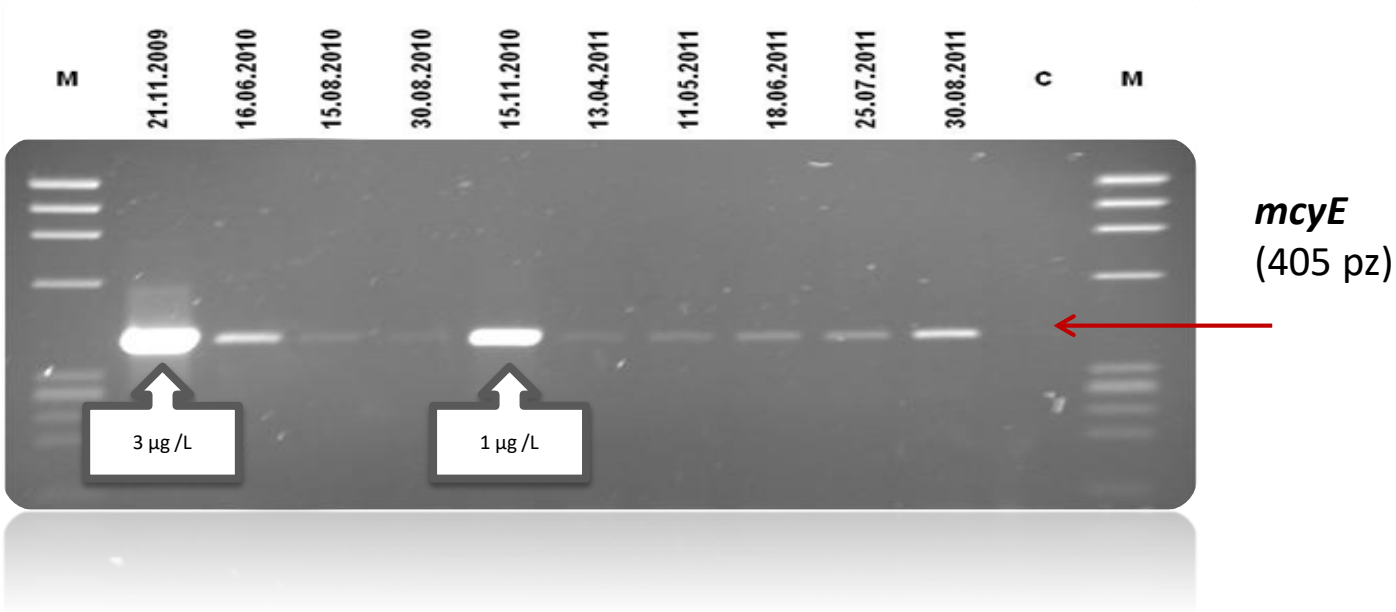
Molecular biology for EH – Early warning and quantification of toxicity Ethiopia Lake Tana

Charakterystyka występowania toksynogennych sinic wraz z oznaczeniem stężenia mikrocystyn (≥ 1 µg/L)



mcyE
(405 pz)

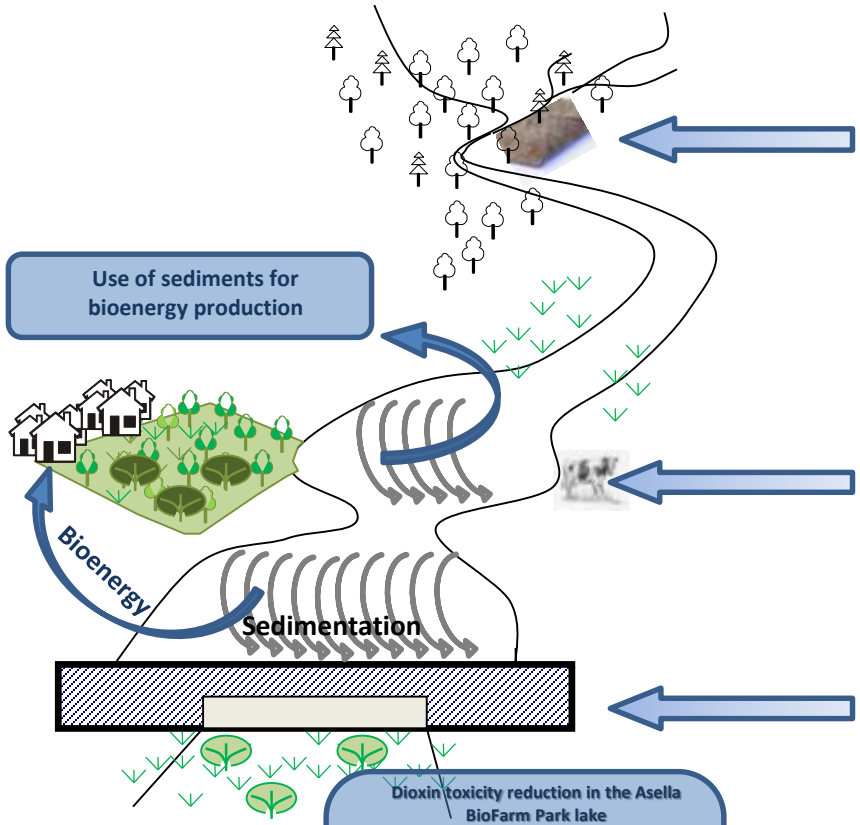
***Gągała et al., Proceedings* of 3rd Annual Conference of Ethiopian Fisheries and Aquatic Science (EFAS): Impact of climate change and pollution on tropical aquatic resources. 2011, Ethiopia, page 287-300**
Mankiewicz-Boczek , Ecohydrology and Hydrobiology, 2012, 12, 165-170

Polish aid

United Nations Educational, Scientific and Cultural Organization

ERCE European Regional Centre for Ecohydrology Under the auspices of UNESCO

Ecohydrology based systemic solutions for reduction of turbidity, toxic algal bloom and dioxin-induced toxicity in the Asalla BioFarm Park lake



Use of biodegradable geofibers for erosion controll

Stock watering site and use of manure collected at the site as a fertilizer

Construction of the sequentional biofiltration system for turbidity, eutrophication and dioxin toxicity reduction in the Asella BioFarm Park lake

Zalewski & Urbaniak

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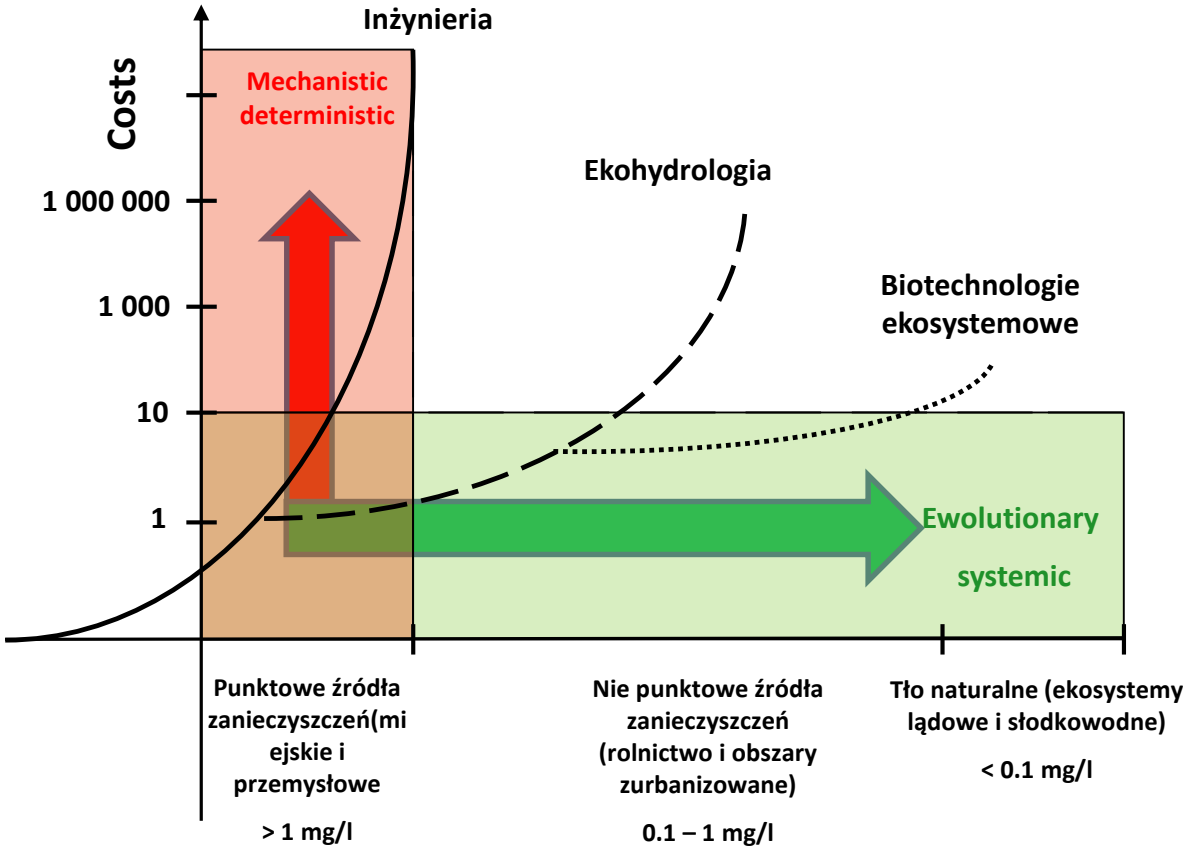
Enhencemnt of efficiency and costs reduction by integration of the ecohydrology engeenering and biotechnology



The intensity of the human impact in catchment scale expressed in phosphorus concntration

Education

Organizacja Narodów Zjednoczonych do Spraw Oświaty, Nauki i Kultury

ERCE
Europejskie Regionalne Centrum Ekohydrologii pod auspicjami UNESCO

Multi-stakeholder platform for knowledge transfer and implementation:
dialog instead of talking, building ownership and critical mass

The Lodz Learning Alliance (LA) was launched in May 2006.
The group of members is constantly growing and the LA has now a wide representation of stakeholders from the national, regional and local levels. The key partners on the City level are:

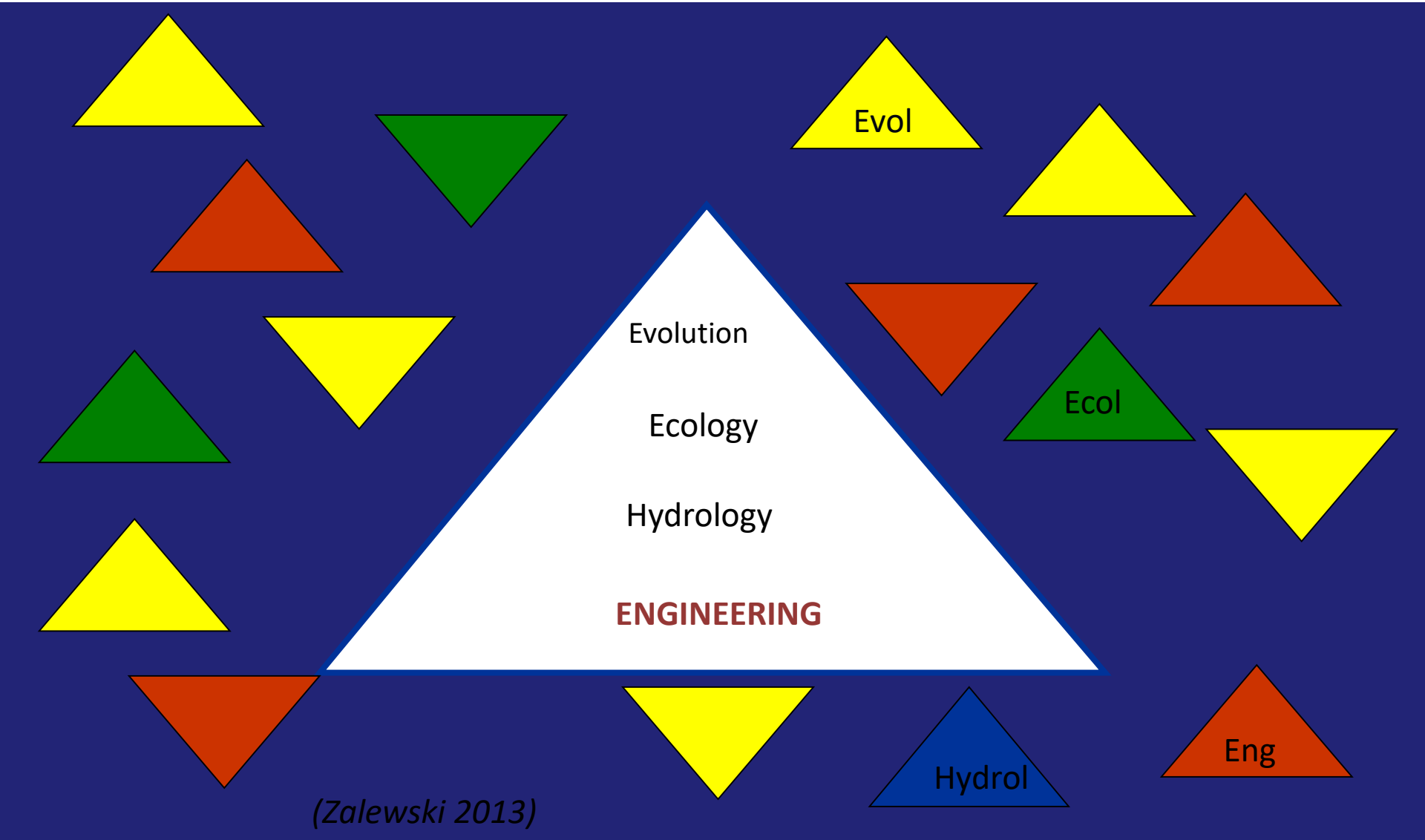
Authorities:
- City of Lodz Office
- Lodz Infrastructure Company (LSI)

Researchers:
- University of Lodz
- European Regional Centre for Ecohydrology u/a of UNESCO, PAS
- Lodz Technical University: Department of Environmental Engineering
- Nofer Institute of Occupational Medicine in Lodz

Service Providers:
- Waterworks and Sewage Systems Company (ZWiK)
- Waste Water Treatment Plant (GOS)

- *improving communication between the different organizations and to provide a cross-institutional platform to share information and discuss water issues*
- *Improving picture of how everything is working together*
- *addressing the issues in an integrated way*
- *creating independent space for discussion, sharing experience and transfer of know-how*

Integration of the knowledge



(Zalewski 2013)

Understanding the evolution of paradigms and necessity systemic solutions based on integrative sustainability science

United Nations Educational, Scientific and Cultural Organization

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Process-oriented thinking

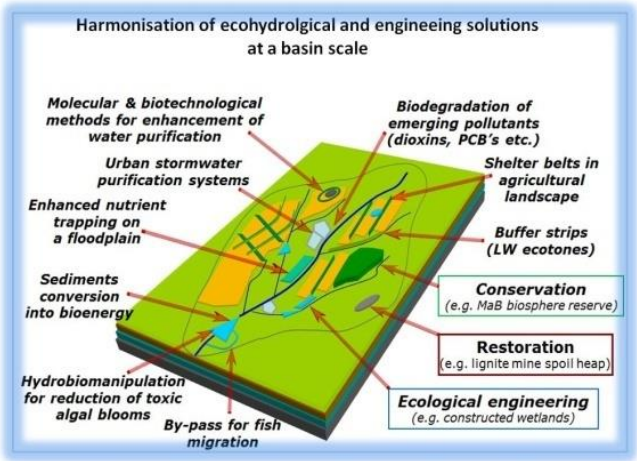
Structure-oriented thinking

	CONSERVATION	RESTORATION	ECOLOGICAL ENGINEERING	ECOHYDROLOGY
Goal	Maintaining bidiversity and the natural character of ecosystems	Reversing degradation of the structure of ecosystems	'Design of ecosystems for the mutual benefit of humans and nature' (Mitsch 1992)	Reglation of water-biota interplay for the enhancement of ecosystem potential and its harmonisation with society needs
Unit	Ecosystem ↓ Population ↓ UNESCO MaB Bisphere Reserve	Ecosystem patch ↓ Ecosystems	'Functional ecosystem'	Catchment's hydrological mezocycle
Status	**MAINTAINING** 'status quo'	**ENHANCEMENT** of secondary succession processes at terrestrial ecosystems or reversing eutrophication in aquatic ecosystems	**SHAPING** of the functions of ecosystem	**REGULATION** of water-biota interplay for sustainable catchment and coastal zones

Białowieża National Park

Recultivated spoil heap of Bełchatów Mine

Constructed ec
Olentangy Rive
Research Park,



Zalewski, M. 2013. Ecohydrology: process-oriented thinking towards sustainable river basins. Ecoh

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Ecohydrology for desirable sustainable future of „SPACESHIP EARTH'

Holistic

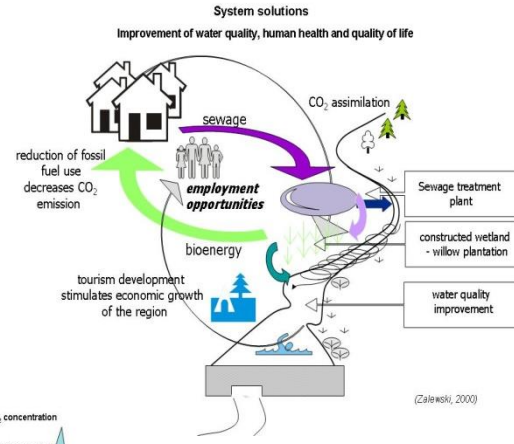
approach

Reductionistic

System solutions – Transdisciplinary science

WISDOM

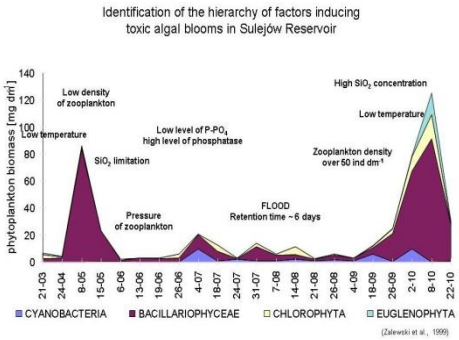
Use of information and knowledge for problem solving – Formulation of principles for action



Experimental testing -interdisciplinary science

KNOWLEDGE

Theory for understanding patterns and processes,



Monitoring – sectoral science

INFORMATION

Understanding structure, states and relationships

Problem identification → **Problem solving**

(Zalewski 2014)

United Nations
Educational, Scientific and
Cultural Organization

ERCE
European Regional
Centre for Ecohydrology
Under the auspices
of UNESCO

Thank you

The inspiring cooperation of my colleagues from
ERCE PAS u/a UNESCO, Department of Applied Ecology, UŁ
UNESCO Division of Water Sciences and IHP
is highly appreciated and made the introduced projects happened

United Nations Educational, Scientific and Cultural Organization

European Regional Centre for Ecohydrology Under the auspices of UNESCO

POLISH ACADEMY of SCIENCES

UNIVERSITY OF LODZ

FACULTY OF BIOLOGY AND ENVIRONMENTAL PROTECTION
University of Lodz

Evolution of relations between Man & Environment

Believe in unlimited nature potential

Conquest of nature

Industrial Era

Exploitation of nature

Recognition of structure of nature *(Linnaeus)* Consciousness of decline of biodiversity

Protection of nature

Increasing number of evidences of the decline of cultural and aesthetic values of nature

Restoration of ecology

Increasing consciousness of the decline of ecosystem services

Regulation of environmental processes toward harmonization of ecosystem potential and social needs - WBSRC e.g ECOHYDROLOGY & NBS

(Zalewski 2011)

United Nations Educational, Scientific and Cultural Organization · European Regional Centre for Ecohydrology Under the auspices of UNESCO · POLISH ACADEMY of SCIENCES · UNIVERSITY OF LODZ · FACULTY OF BIOLOGY AND ENVIRONMENTAL PROTECTION University of Lodz

From the Ecohydrology - use of ecosystem properties

...nagement tool to Nature Based Solutions...

ELSEVIER

ECOLOGICAL ENGINEERING

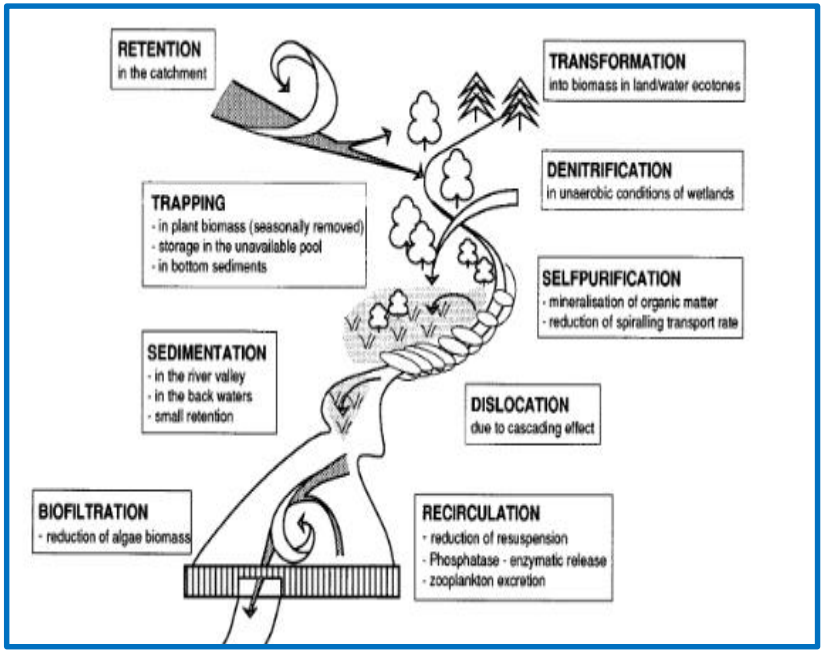
Ecological Engineering 16 (2000) 1–8

www.elsevier.com/locate/ecoleng

Guest editorial

Ecohydrology — the scientific background to use ecosystem properties as management tools toward sustainability of water resources

Maciej Zalewski



United Nations World Water Development Report (WWDR) 2018

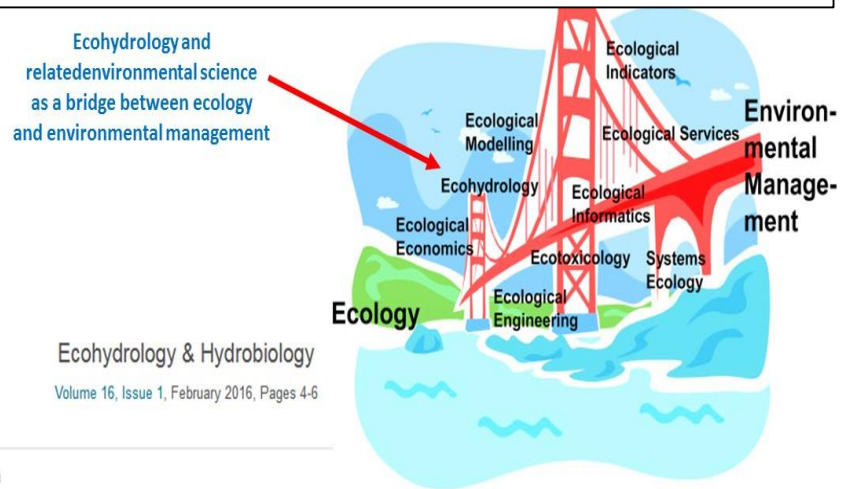
"NATURE BASED SOLUTIONS FOR WATER"

PROPOSAL/REVIEW/BACKGROUND PAPER

Background information and suggested key sectors and relevant issues to be covered in the report

I. NATURE-BASED SOLUTIONS AND THE GLOBAL POLICY AGENDA

The dialogue on water and environment has shifted over recent years from trade-offs between water use for human needs and the environment towards how the environment can be managed to support water management objectives (Figure 1). This has resulted in significant uptake of attention to environment/ecosystems/biodiversity in the water agenda.



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Ecohydrology & Hydrobiology

Volume 16, Issue 1, February 2016, Pages 4-6

Short Communication

Ecohydrology as an important concept and tool in environmental management

Sven Erik Jørgensen