# ECOHYDROLOGY

## the scientific framework for the use of water/biota interplay for mitigation of intermediate and diffuse impacts at freshwater ecosystems

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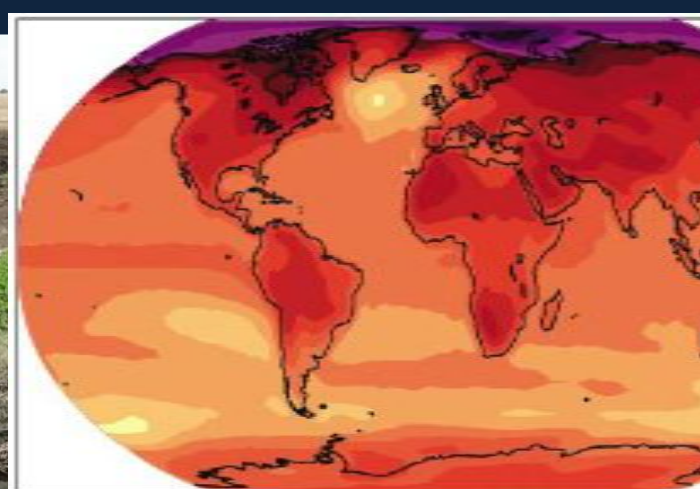
# The forecast of water resources limitation in 2025

*What we have done with climate, water and nutrients cycles?*

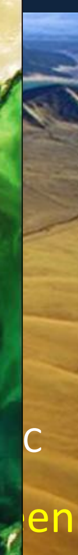
1/ Water - acceleration of the outflow to the seas from the agricultural and urbanized land, water overexploatation

2/ Carbon and nutrients - loss of organic carbon in catchments (soil and biomass) through degradation and unification of landscape (incl. land-water ecotones)

3/ Above two processes reduce resilience of ecosystems and biological productivity, and increase load of the nutrients and pollutants in to aquatic ecosystems where they generate siltation and secondary pollution



Volga Delta
(June 11, 2005, photo: Jeff Schmaltz)



C

Lack of profound understanding of ecological proces ... en
agriculture & environmental / wate

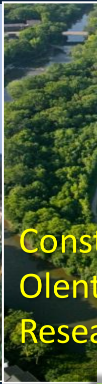
# Key approaches in environmental sciences towards sustainability

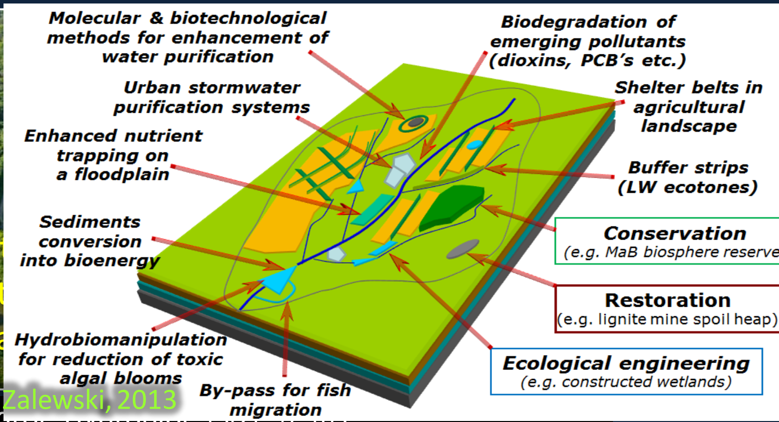
## Process-oriented thinking

## Structure-oriented thinking

| | CONSERVATION |
|---|---|
| Goal | Maintaining bidiversity and the natural character of ecosystems |
| Unit | Ecosystem ↓ Population ↓ UNESCO MaB Bisphere Reserve |
| Status | MAINTAINING 'status quo' |






Zalewski, M. 2013. Ecohydrology: process-oriented thinking towards sustainable river basins. Ecohydrol. Hydrobiol. 13(2), 97-103.

# ECOHYDROLOGY: integrative effort

**The use of biota to control hydrology and hydrology to control biota in basin scale** (Zalewski et al., 1997)

**Control of ecological processes in river basin to enhance absorbing capacity against human impact** (Zalewski, 2000)

**Instream processes-ecohydraulics**
(Leclerc et al. 1996)

**Constructed wetlands & mathematical modelling**
(Mitsch, 1993; Jorgensen, 1996

**Hydrodynamics as a forcing function into phytoplankton dynamics in reservoir**
(Straskraba & Tundisi, 1999)

**Urban Ecohydrology**
(Wagner, Zalewski, 2009)

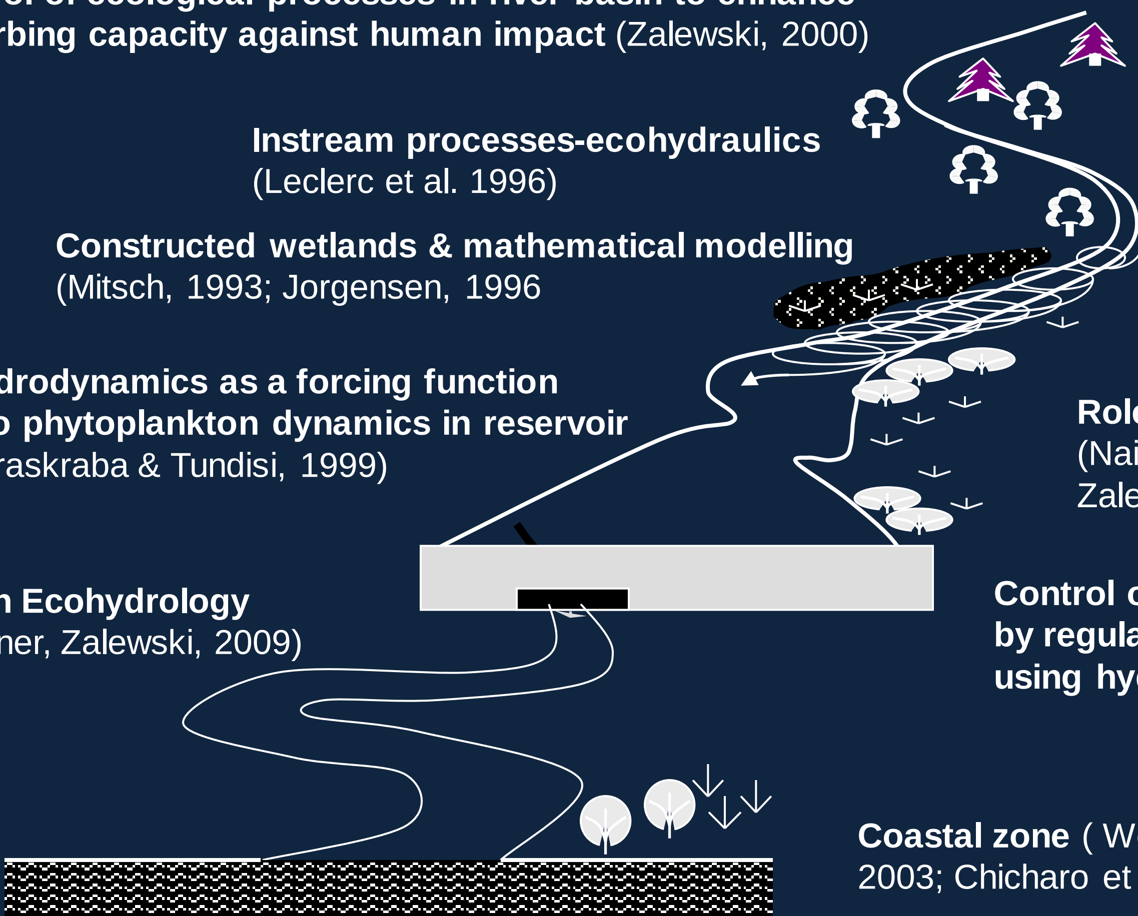
**Climate-Water-Landcover**
(Rodrigues-Iturbe, 2000
Vorosmarty & Meybeck, 1999)

**Water-plant-soil interactions**
(Baird & Wilby, 1999)

**Four dimensional nature of ecosystem**
(Ward, 1989)

**Role of land/water ecotones**
(Naiman & Decamps, 1990;Schiemer, Zalewski & Thorpe, 1995)

**Control of symptoms of eutrophication by regulation of trophic cascade using hydrology** (Zalewski et al., 1990)



**Coastal zone** ( Wolanski, 2003; Chicharo et al., 2001)

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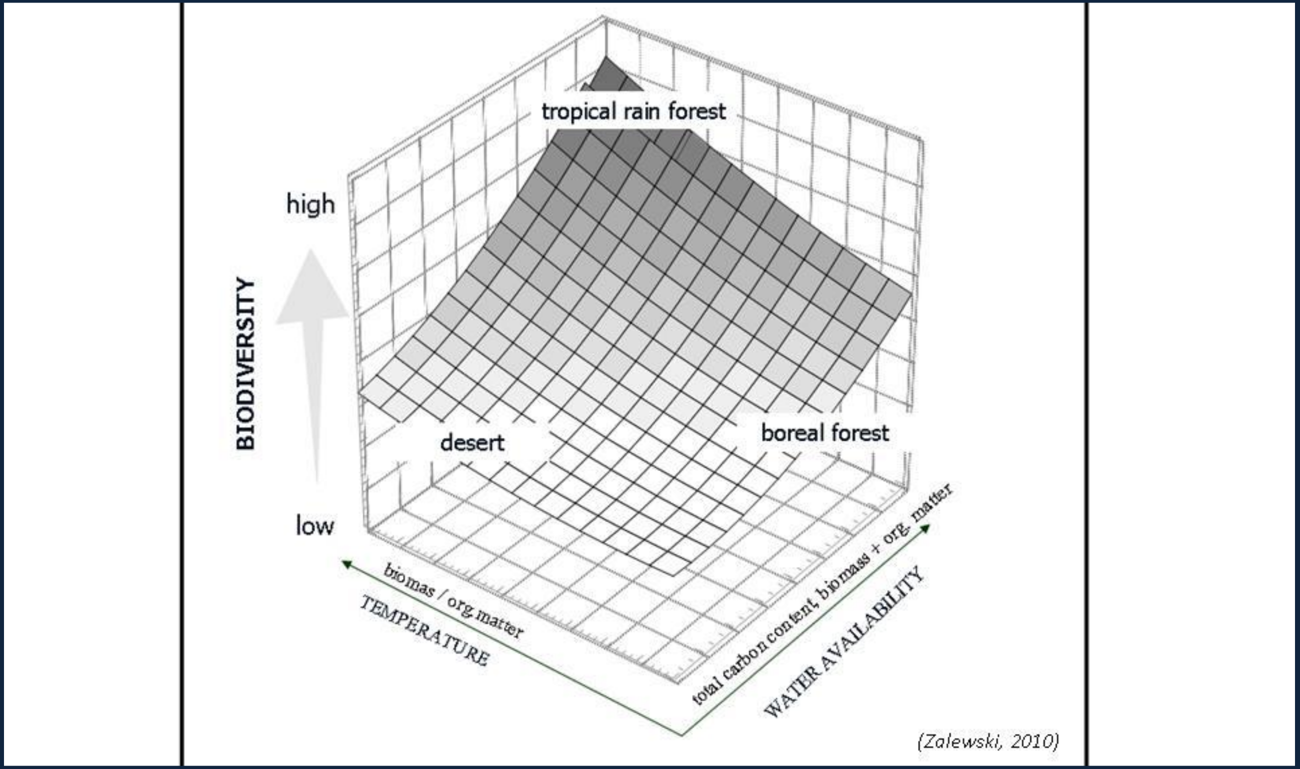
# Ecological background for ecohydrology

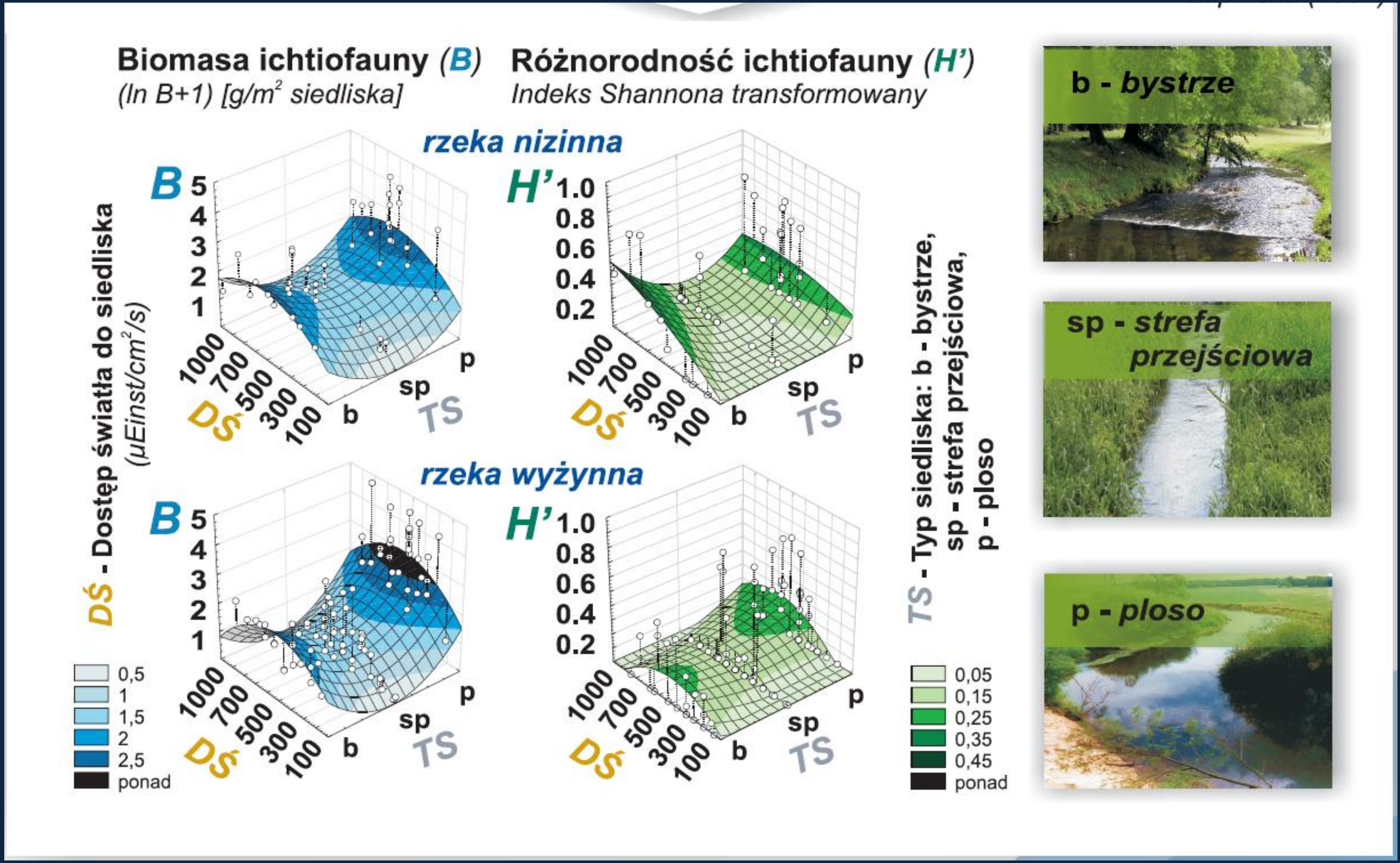
## Model of hierarchy of biota regulatory factors: biodiversity




**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)*

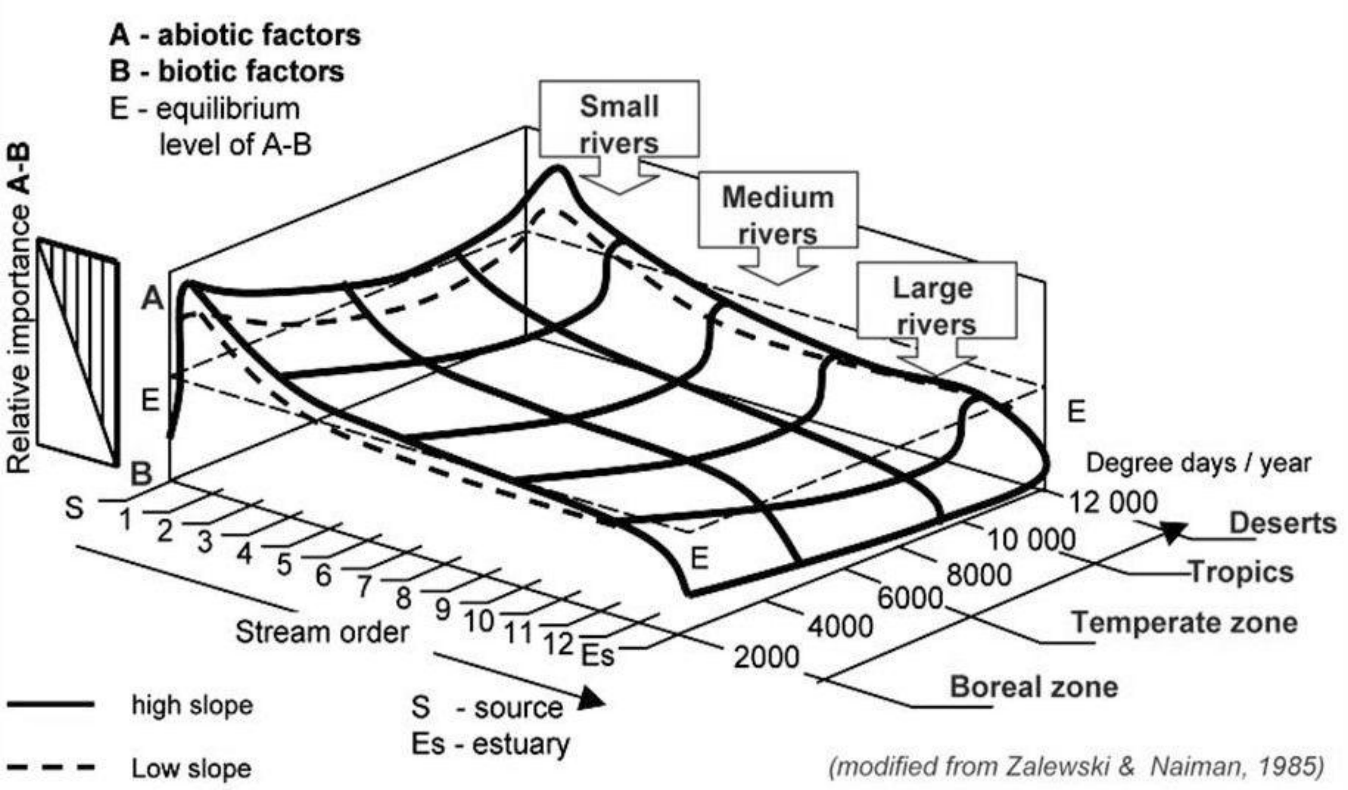
# Empirical models of the role of stream channel and riparian ecotone structure for fish biomass and diversity enhancement (in natural stream & stream renaturisation)




(Łapinska , Zalewski 2006)

# Ecological background for ecohydrology

## Model of hierarchy of abiotic – biotic regulation : spatial dimension




**Explaining changes in the hierarchy of factors which determine the structure and dynamics of riverine fish communities at different geographic zones.** *Zalewski & Naiman, 1985*

# Ecological background for ecohydrology

## Model of hierarchy of abiotic – biotic temporal regulation : temporal dimension

**WINTER**

| | PÓŁROCZE: **zimowe (XI - IV)** | | | | | |
|---|---|---|---|---|---|---|
| | PPO4 | DP | TP | TSM | MSM | OSM |
| ΔQ | 0,436 | 0,540 | 0,425 | 0,628 | 0,581 | 0,478 |
| Q_1 | 0,406 | 0,622 | | 0,648 | 0,482 | 0,685 |
| Q_3 | | 0,576 | | 0,580 | 0,412 | 0,644 |
| Q_7 | | 0,477 | | 0,476 | | 0,574 |
| Q_30 | | 0,496 | | | | 0,496 |
| T_1 | | | | | | 0,401 |
| T_3 | | | | | | 0,448 |
| T_7 | | | | | | 0,429 |
| P_1 | | | | | | |
| P_3 | | | | | | |
| P_7 | | | | | | |
| PS | -0,445 | -0,498 | | -0,670 | -0,447 | -0,785 |

| | PÓŁROCZE: **zimowe (XI - IV)** | | | | | |
|---|---|---|---|---|---|---|
| | PPO4 | DP | TP | TSM | MSM | OSM |
| ΔQ | 0,355 | 0,442 | 0,459 | 0,488 | 0,500 | |
| Q_1 | | | | | | -0,360 |
| Q_3 | | | | | | -0,454 |
| Q_7 | | | -0,299 | -0,617 | -0,490 | -0,609 |
| Q_30 | -0,456 | -0,573 | -0,522 | -0,770 | -0,732 | -0,425 |
| T_1 | | | | | | |
| T_3 | | | | | | |
| T_7 | | | | | | |
| P_1 | | | | | | -0,371 |
| P_3 | 0,294 | 0,374 | 0,506 | 0,524 | 0,517 | |
| P_7 | | | | | | |
| PS | | | | | | |

HYDROLOGICAL FACTORS

TEMPERATURE

PRECIPITATION

**SUMMER**

| | PÓŁROCZE: **letnie (V-X)** | | | | | |
|---|---|---|---|---|---|---|
| | PPO4 | DP | TP | TSM | MSM | OSM |
| ΔQ | | | | | | |
| Q_1 | | | | 0,488 | 0,343 | 0,574 |
| Q_3 | | | | 0,453 | | 0,575 |
| Q_7 | 0,316 | | | 0,440 | | 0,487 |
| Q_30 | 0,406 | 0,399 | | 0,369 | | 0,404 |
| T_1 | | 0,538 | 0,359 | 0,377 | | |
| T_3 | | 0,423 | | 0,349 | | |
| T_7 | | 0,430 | | 0,366 | 0,347 | |
| P_1 | | | | | | |
| P_3 | | | | | | |
| P_7 | | | | | | |

| | PÓŁROCZE: **letnie (V-X)** | | | | | |
|---|---|---|---|---|---|---|
| | PPO4 | DP | TP | TSM | MSM | OSM |
| ΔQ | | | | 0,691 | 0,528 | 0,551 |
| Q_1 | | | | | | |
| Q_3 | | | | | | |
| Q_7 | | | | -0,550 | -0,559 | |
| Q_30 | | | | | | |
| T_1 | 0,482 | 0,548 | | | | |
| T_3 | 0,594 | | | | | |
| T_7 | 0,604 | 0,581 | 0,470 | | | |
| P_1 | | | | | | |
| P_3 | | | 0,522 | | | |
| P_7 | | | | 0,685 | 0,449 | 0,610 |

HYDROLOGICAL FACTORS

TEMPERATURE

PRECIPITATION

(Wagner, 2001)

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# Ecological background for ecohydrology

## Model of hierarchy of abiotic – biotic temporal regulation : temporal dimension

BIOTIC STRUCTURE OF A RIVER BED AND FLOODPLAIN
IS EFFICIENT TOOL IN NUTRIENTS & POLLUTANTS PROCESSING

**WINTER**

**WINTER**

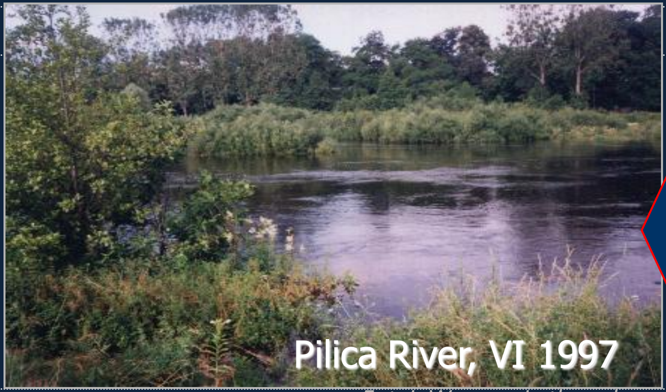
**PHYSICAL PROCESSES OF P TRANSPORT FROM A CATCHMENT**

HYDROLOGICAL FACTORS – Hydrochem. & Fluid phisics

**SUMMER**

**SUMMER**

**PROCESSING OF P VIA BIOTIC STRUCTURES OF A RIVER VALLEY**




*Fot. I. Wagner-Łotkowska*

TEMPERATURE- Biota metabolic activities

(Wagner, 2001)

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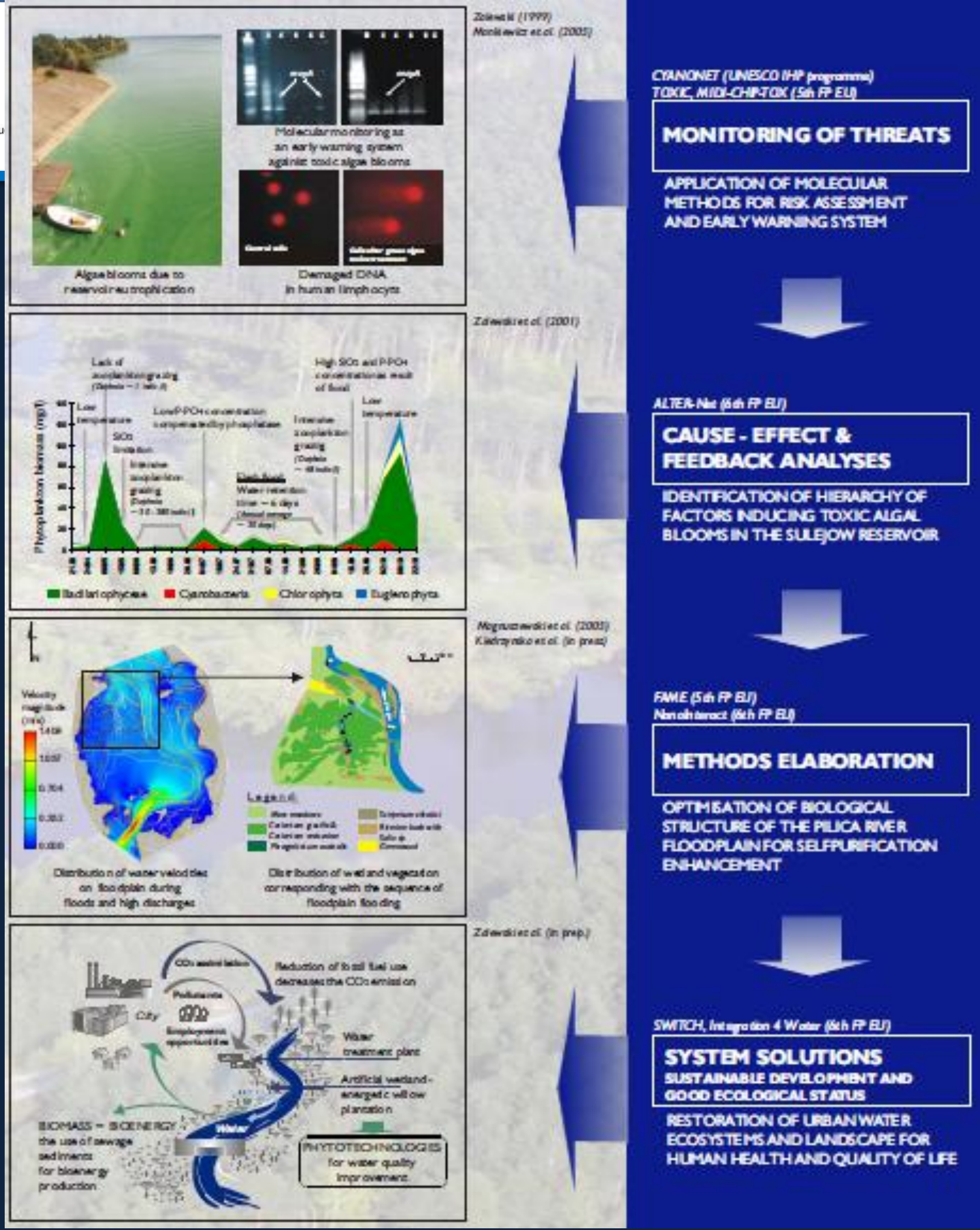
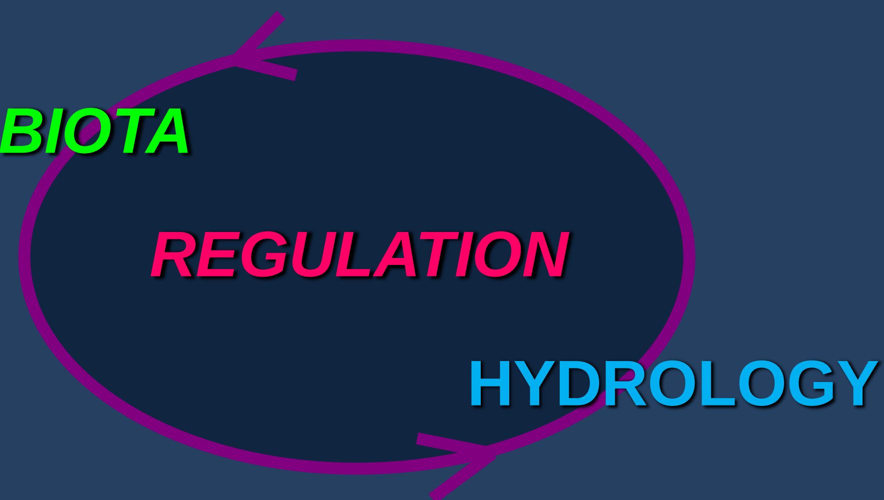
# EH methodological framework



# EH methodological framework

**DUAL REGULATION**
Regulation of biota by controling hydrology and regulation of hydrology by shaping biota




**HARMONIZATION**
of ecohydrological measures with necessary hydrotechnical infrastructure

**INTEGRATION**
of various regulations acting in a synergistic way to stabilize and improve the quality of water resources

# ECOHYDROLOGY

## examples of mitigation of intermediate and diffuse impacts

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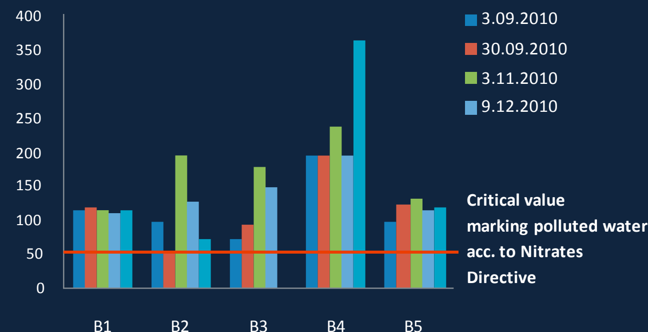
# ECOTONE ZONES: LIFE+ EKOROB project

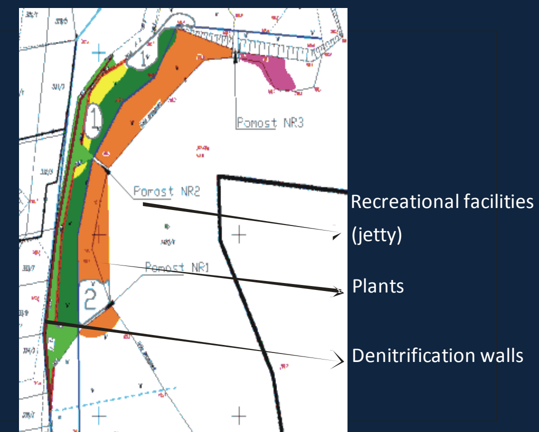
## IDENTIFICATION OF PROBLEMS

## DEVELOPMENT OF SOLUTIONS

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

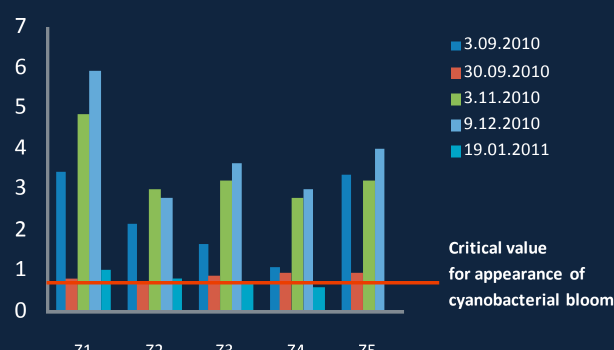

(www.geoportal.gov.pl)

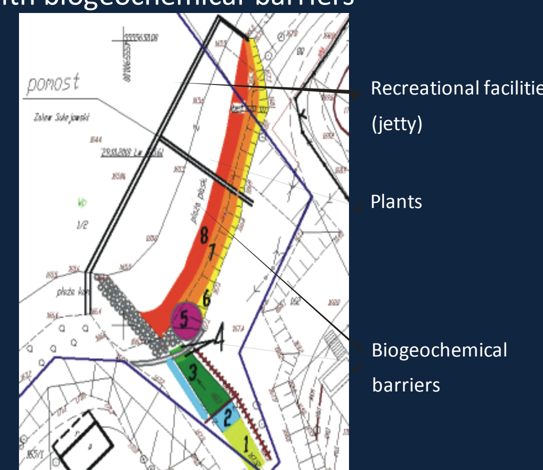



Reduction of **phosphorus** pollution from diffuse source by enhancement of plant buffering zones with biogeochemical barriers


(www.geoportal.gov.pl)




Izydorczyk Zalewski, 2011

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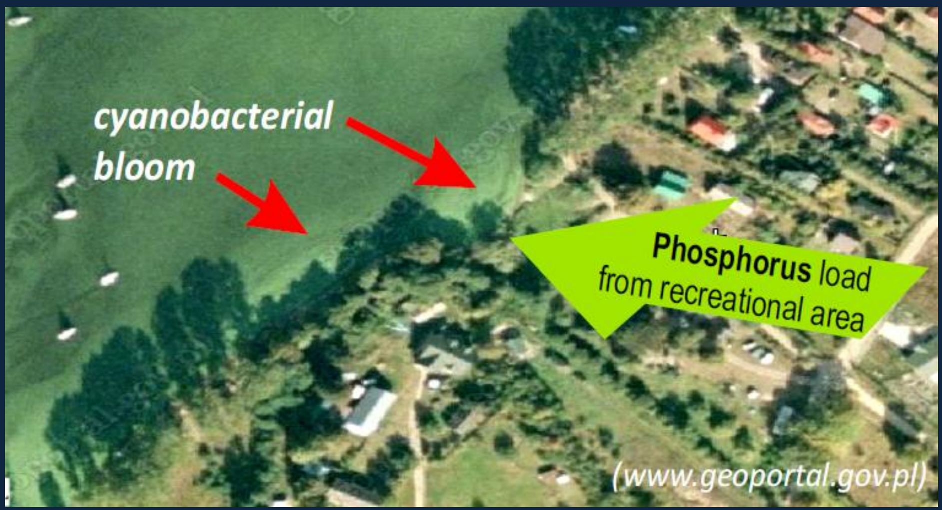
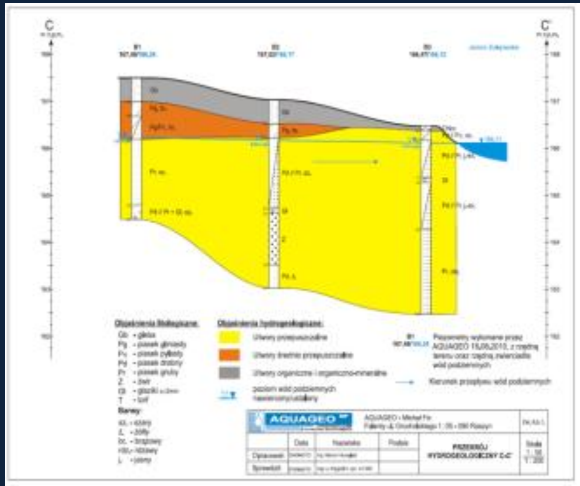
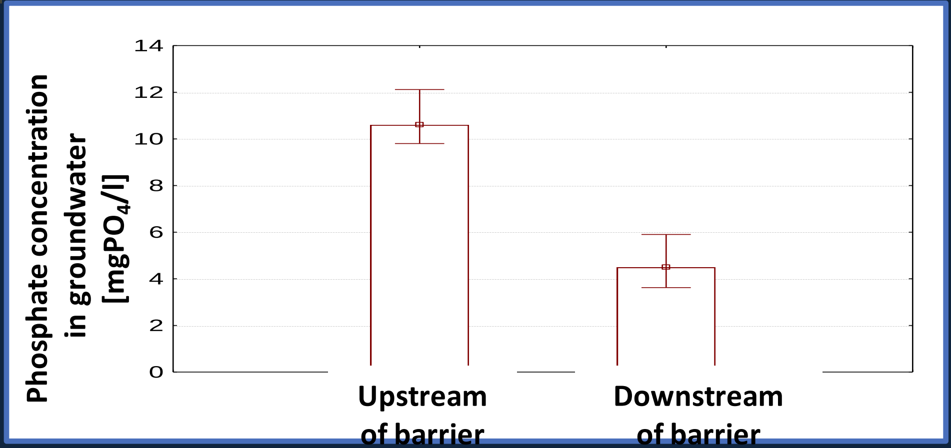
# Biogeochemical limestone-based barriers to enhance phosphorus reduction in buffer zone

Life · NFOŚiGW · EKOROB






*(Izydorczyk et al. Ecohydrology & Hydrobiology 2013)*

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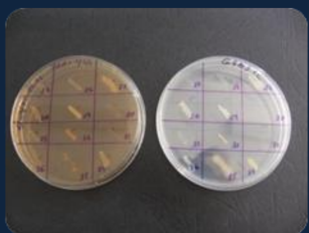
# APPLICATION OF MICROBIAL ACTIVATORS – DENITRIFYING BACTERIA

main objective:

acceleration of activation of the denitrifying ditch and increasing its capacity



Bacterial genes active in denitrification

$2NO_3^-$ → $2NO_2^-$ → $2NO$ → $N_2O$ → $N_2$

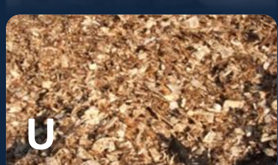
nitrite reductase *nirS* or *nirK*

nitric oxide reductase *cnorB* or *qnorB*

nitric oxide reductase ***nosZ***

complete process

## Detection of bacterial strains from ditch with coal (J) and ditch with sawdust (U)


Amplification of ***nosZ gene***


*(Bednarek A., Zalewski M., Mankiewicz-Boczek J. 2014*
*Denitrification ditches as a bioremediation tool for the removal of the nitrogen pollution and protection of groundwater in rural area.)*

# Sequential Biofiltering System for improvement efficiency small WWTP

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

Mean TP reduction: 26%

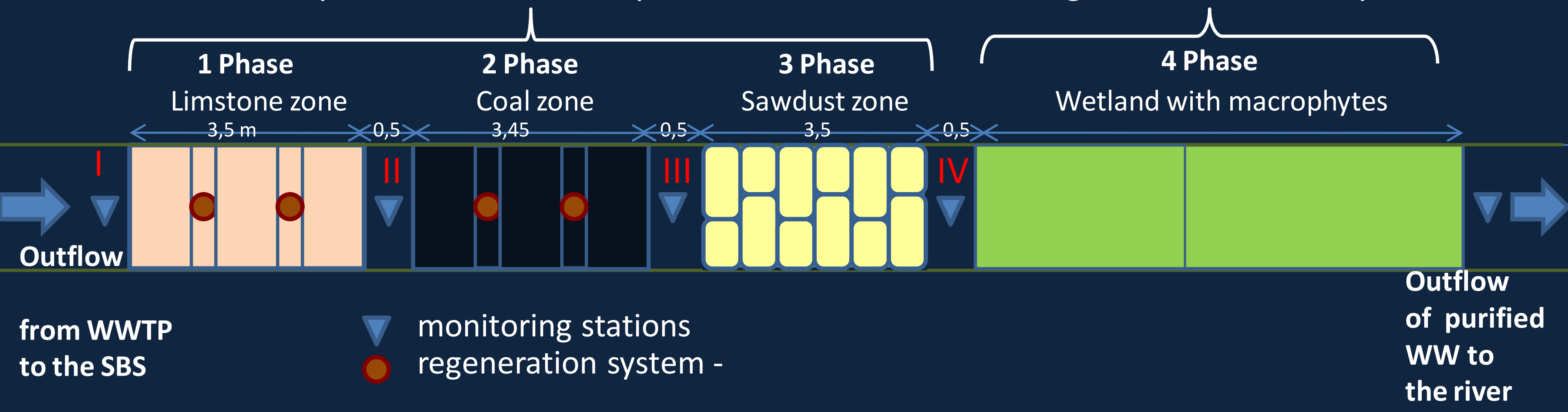
Max. TP reduction 76%

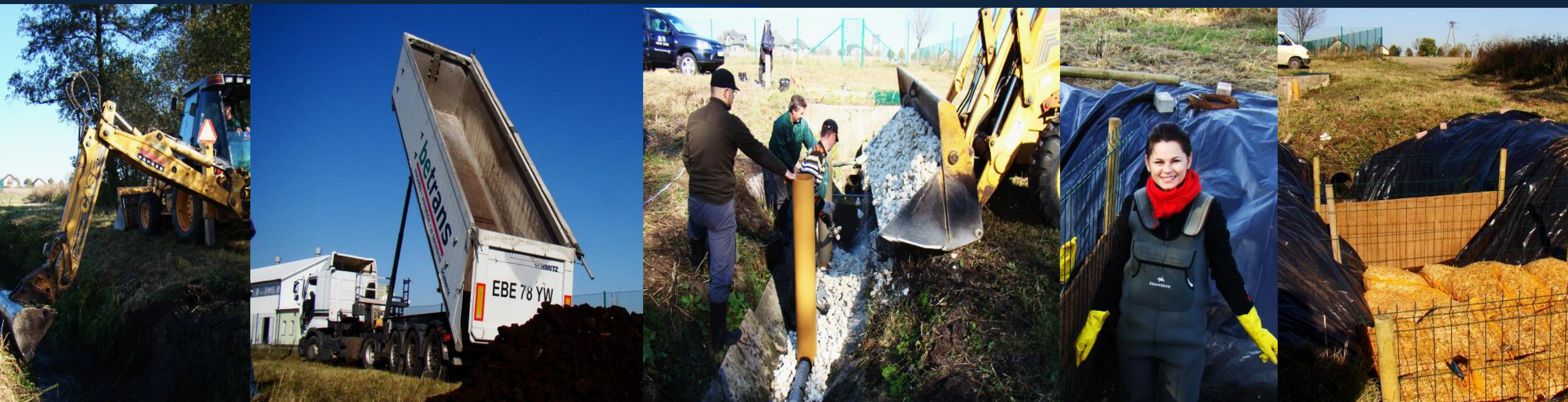
Mean TN reduction: 48%

Max. TN reduction 97%

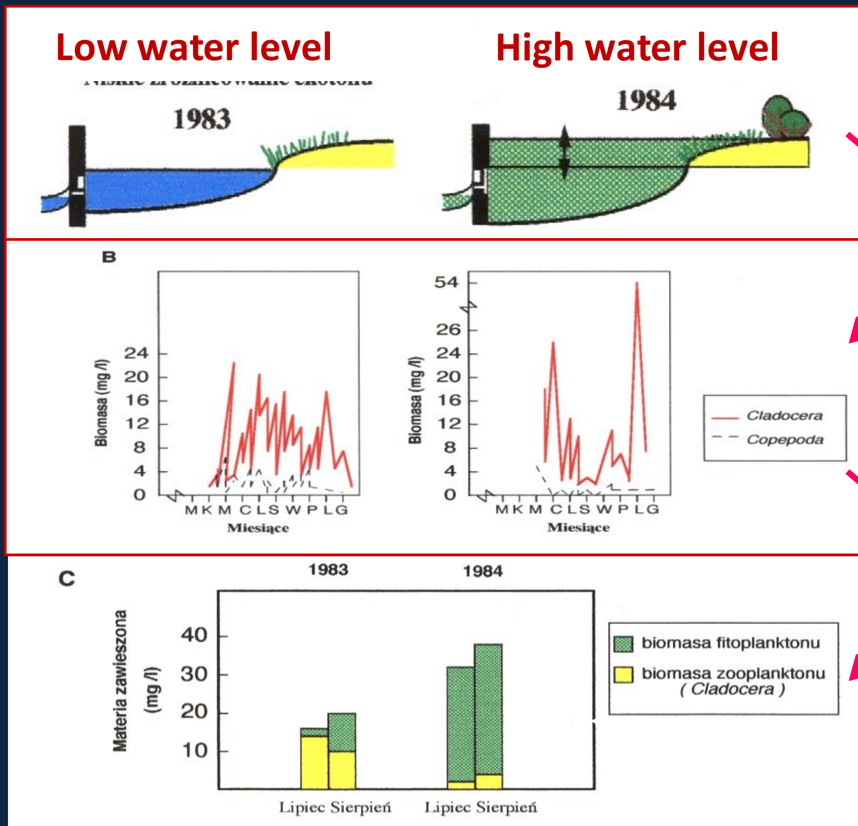
Sequential filtration of pollutants

Biological treatment of pollutants



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

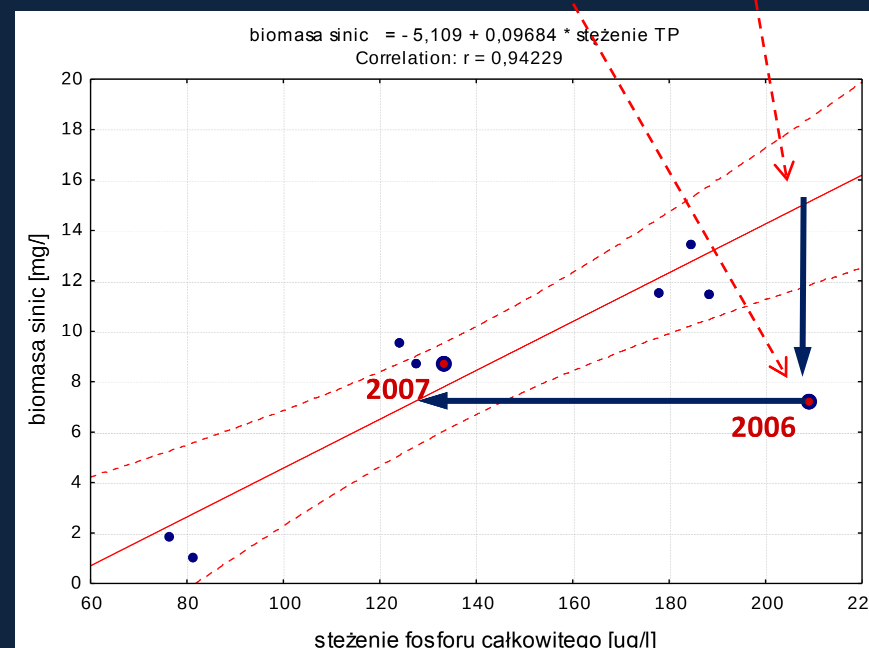



NO toxic algal bloom

Toxic algal bloom

Model predicted biomass
**15.7 mg/l**

Observed biomass
(effect of hydrobiomanipulation)
**7.1 mg/l**




*Zalewski et al..1990; zydorczyk 2010*

*Zalewski et al. 1990*

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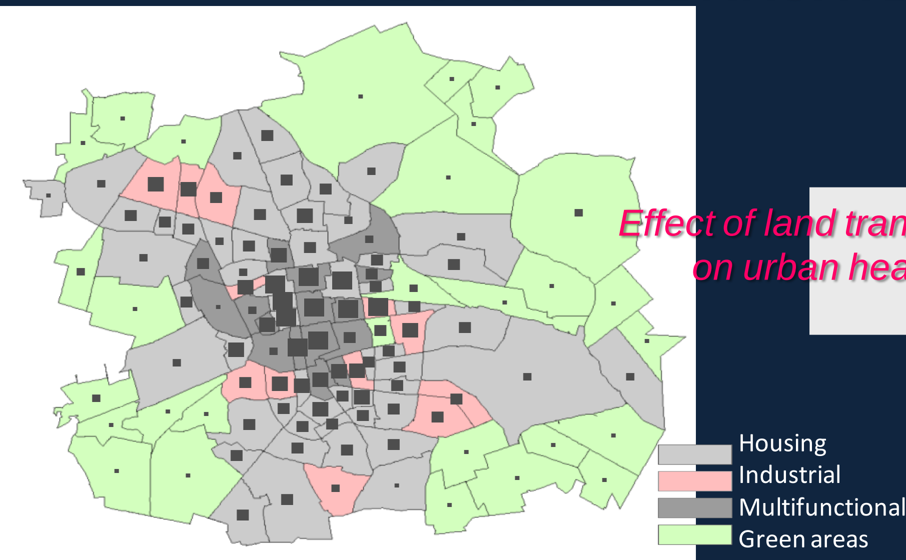
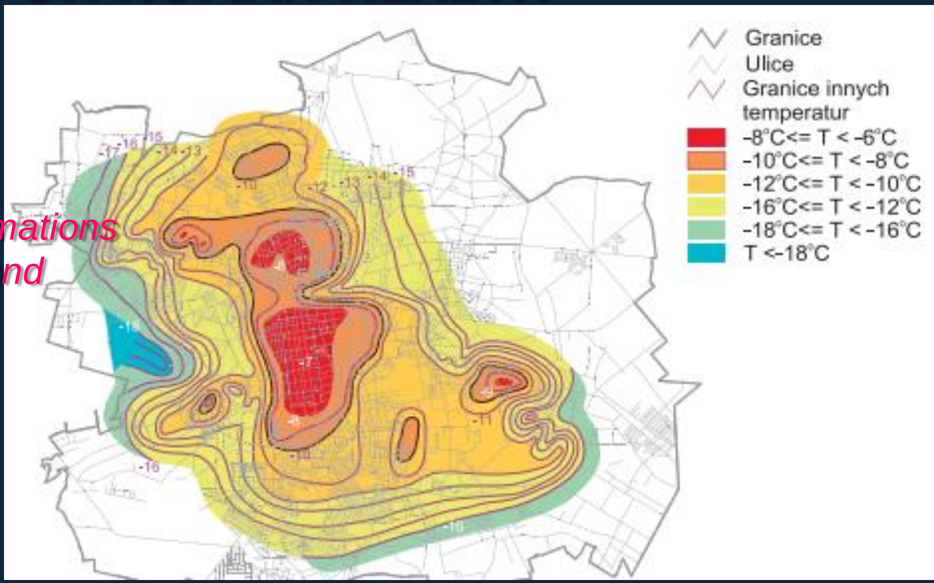
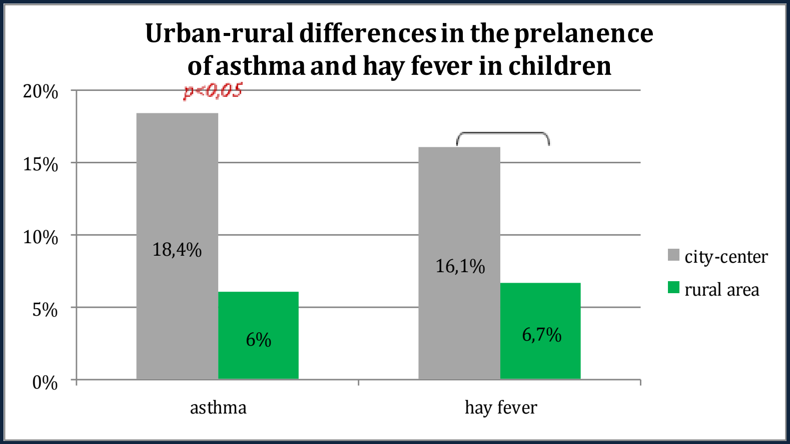
# EFFECT OF URBANSATION ON HUMAN HEALTH

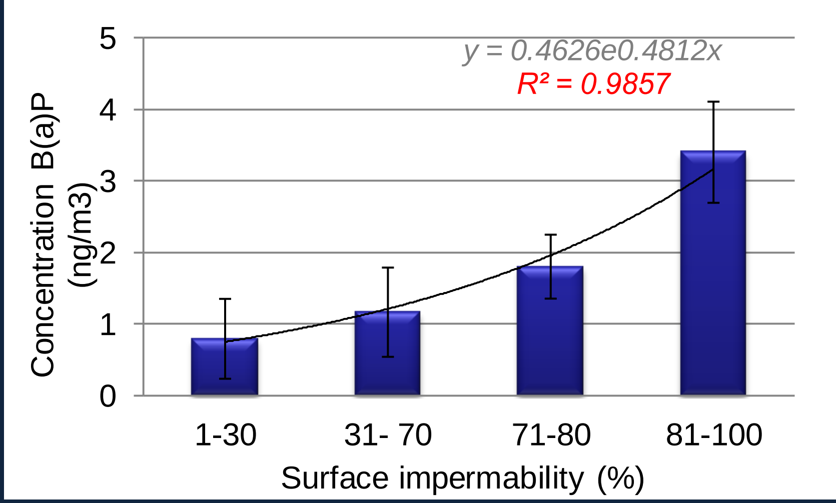



*Effect of land transformations on urban heat island*




## Co-operation with Lodz Medical University



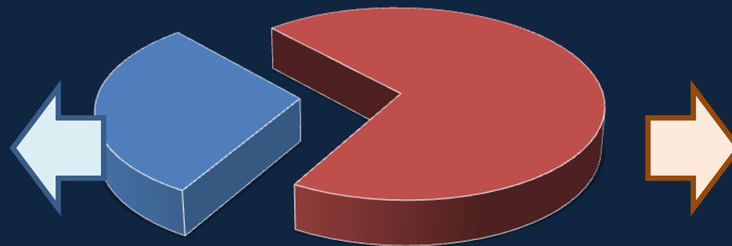

*Kupryś –Lipinska et al. Urban-rural differences in the prevalence of atopic diseases in Lodz province (Poland). EAACI 2004*

# Europe is getting old… how to be more fit and healthy?

## Human health agents

Genetics
20%

Medical Care
10%

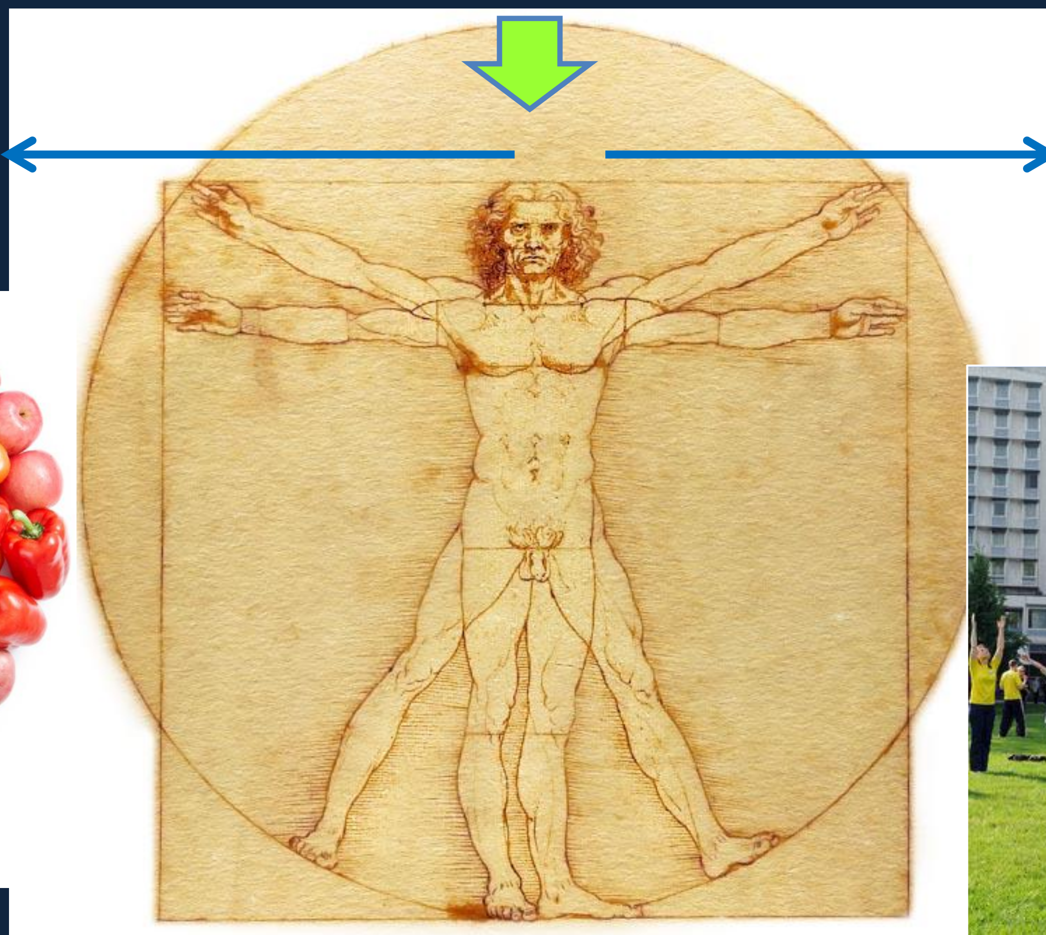


Environment
20%

Life style
50%

Consious eating
20%

Daily activity
80%



*Zalewski, 2012*

## BLUE-GREEN NETWORK CONCEPT:
new basis for restorative sustainable development of Lodz


- quality of life and health of inhabitants;
- better environment management at lower costs;
- sustainable city redevelopment and revitalisation of cultural heritage;
- city attractiveness and attracting capital, professionals and creative individuals;
- increase of urban system flexibility and adaptation to Global Climate Change.

*Grant of the City Mayor (Ed.VII.4346/G-19/2009 z 12.08.2009*

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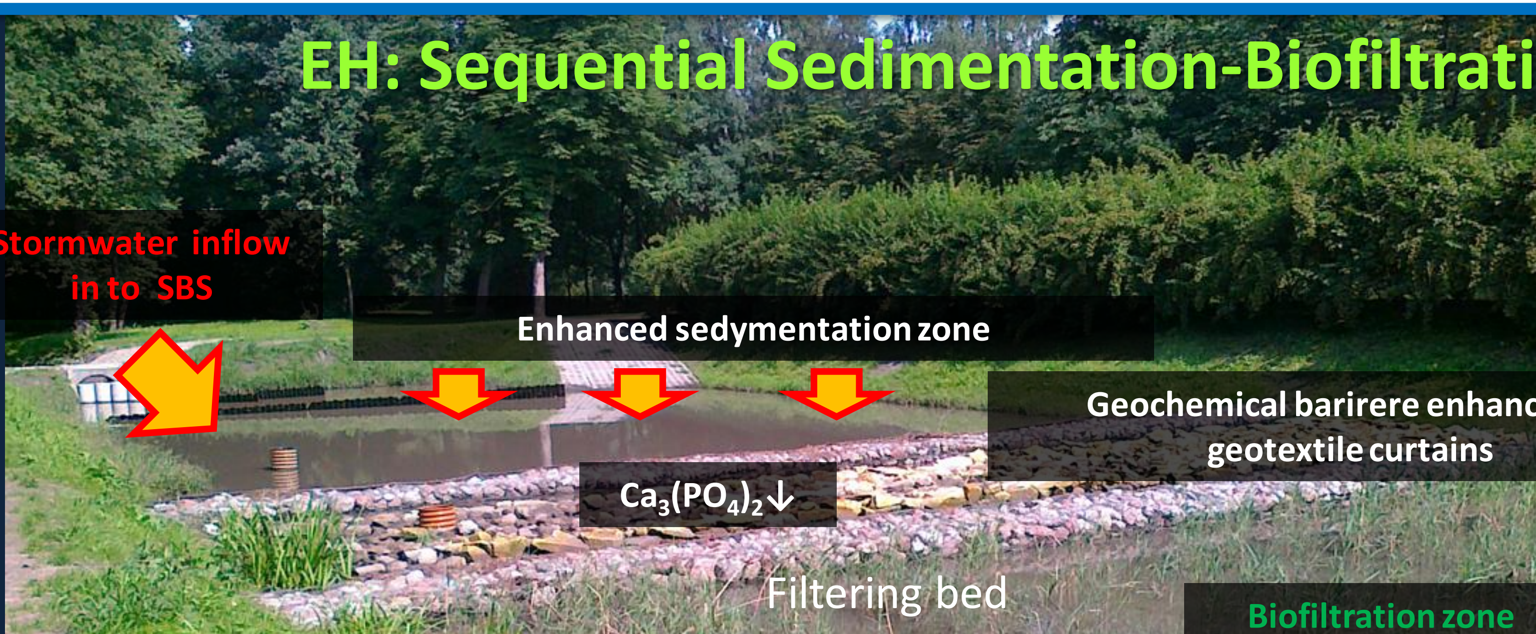
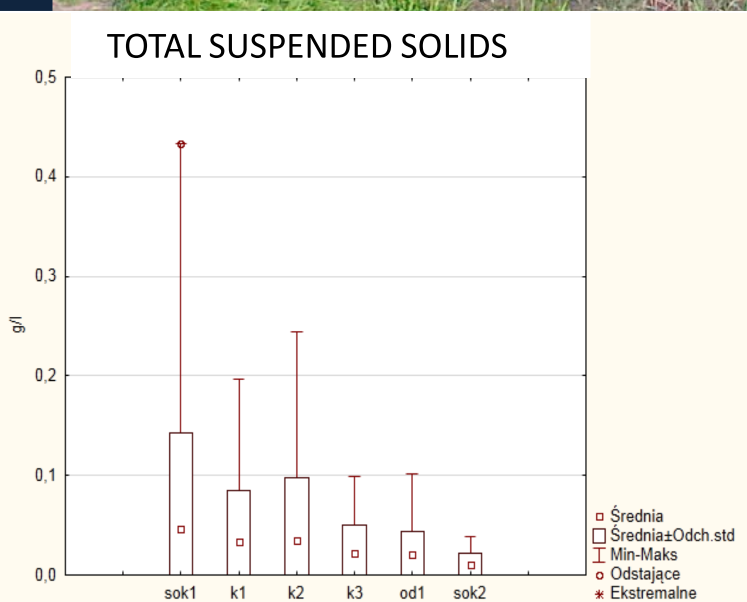
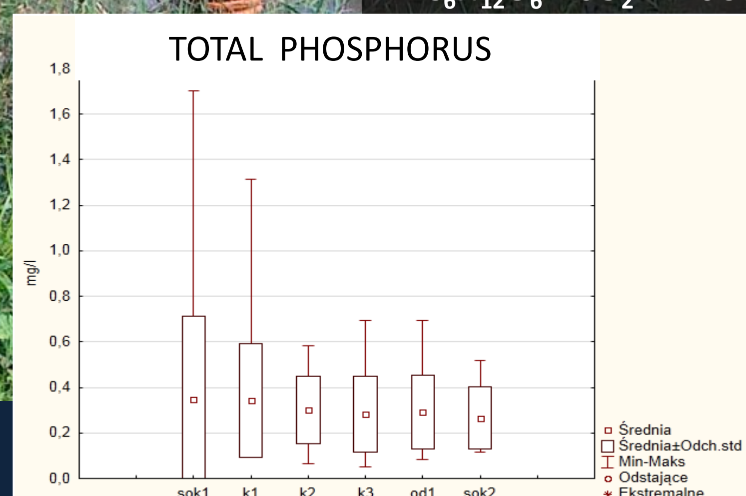
# EH: Sequential Sedimentation-Biofiltration System

*(Zalewski 2008)*



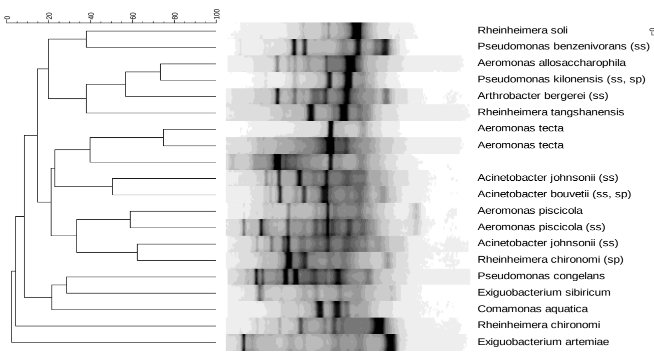



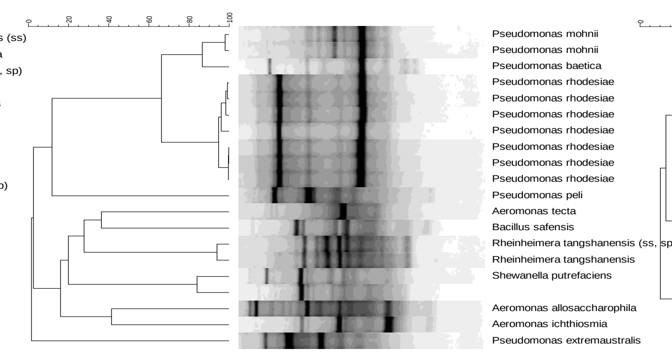



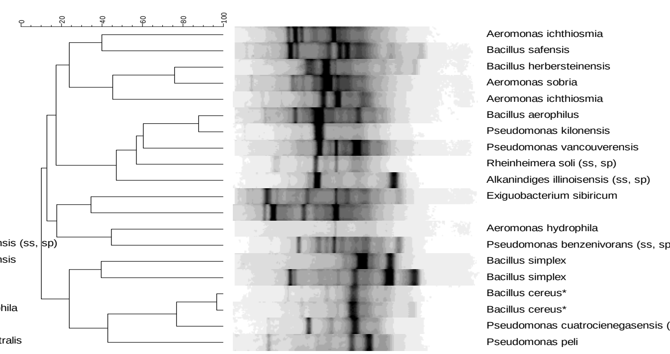
# Molecular biology for ecohydrological biotechnologies

- 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**





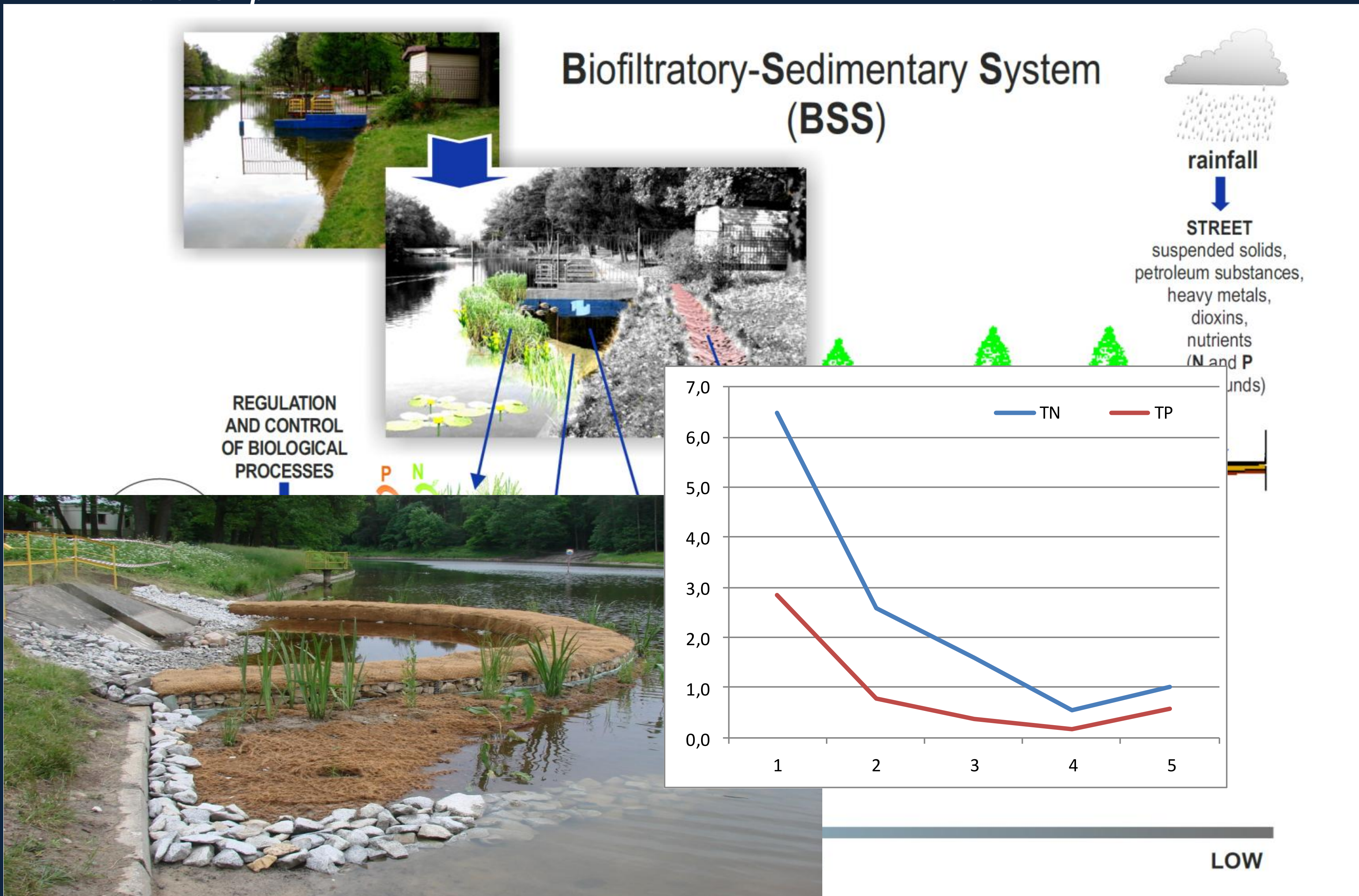


**Sequentional Biofiltration System for urban storm water purification**

*(Zalewski M., Wagner I., Fratczak W., Mankiewicz-Boczek J., Parniewski P. 2012. Blue-Green City for compensating Globar Climate Change. The Parliament Magazine – Politics, Policy and People )*

# ECOHYDROLOGY – harmonisation of hydrological and biological solutions for the freshwater ecosystem improvement

LIFE08 ENV/PL/000517
*www.arturowek.pl*



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

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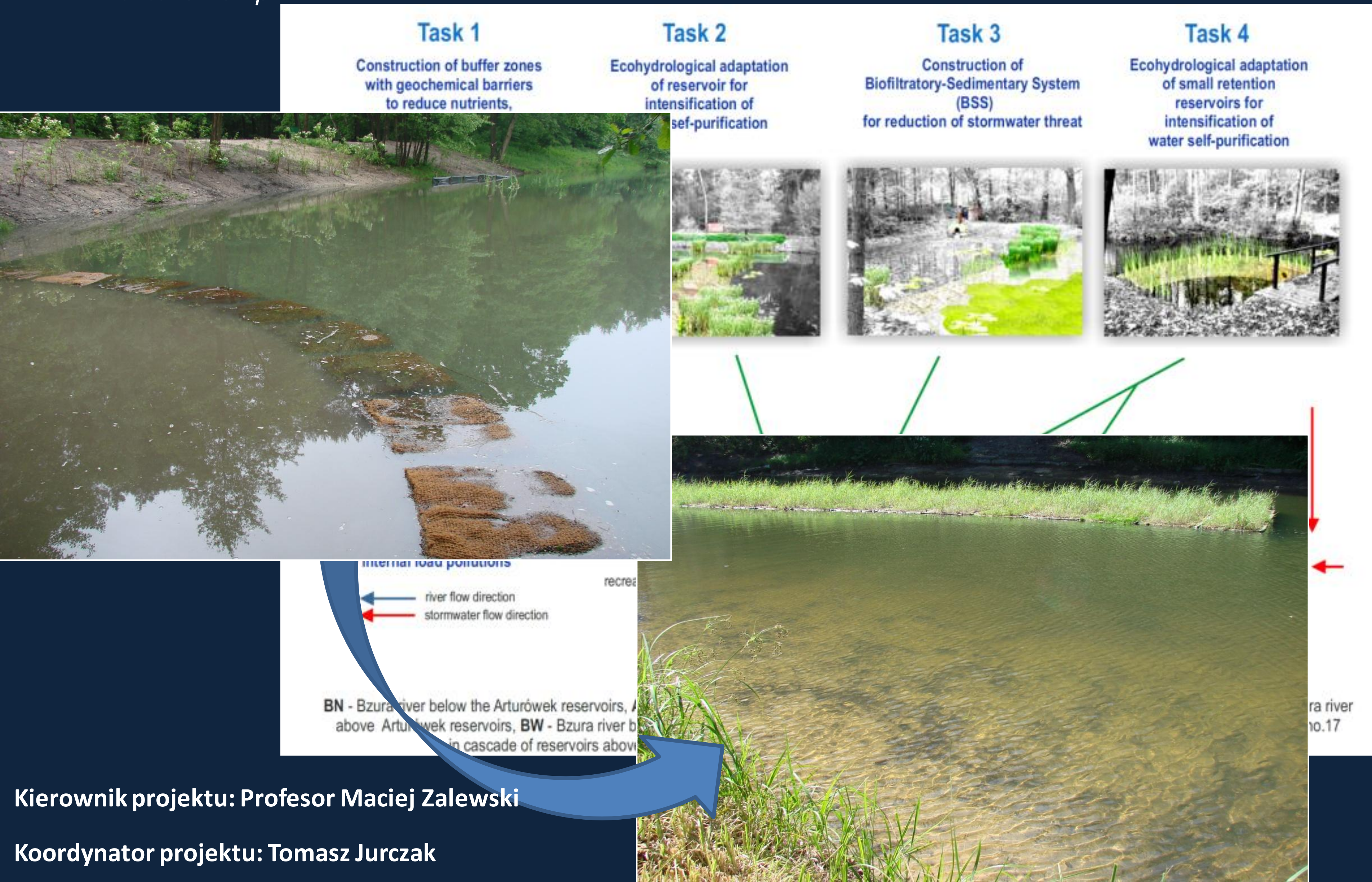
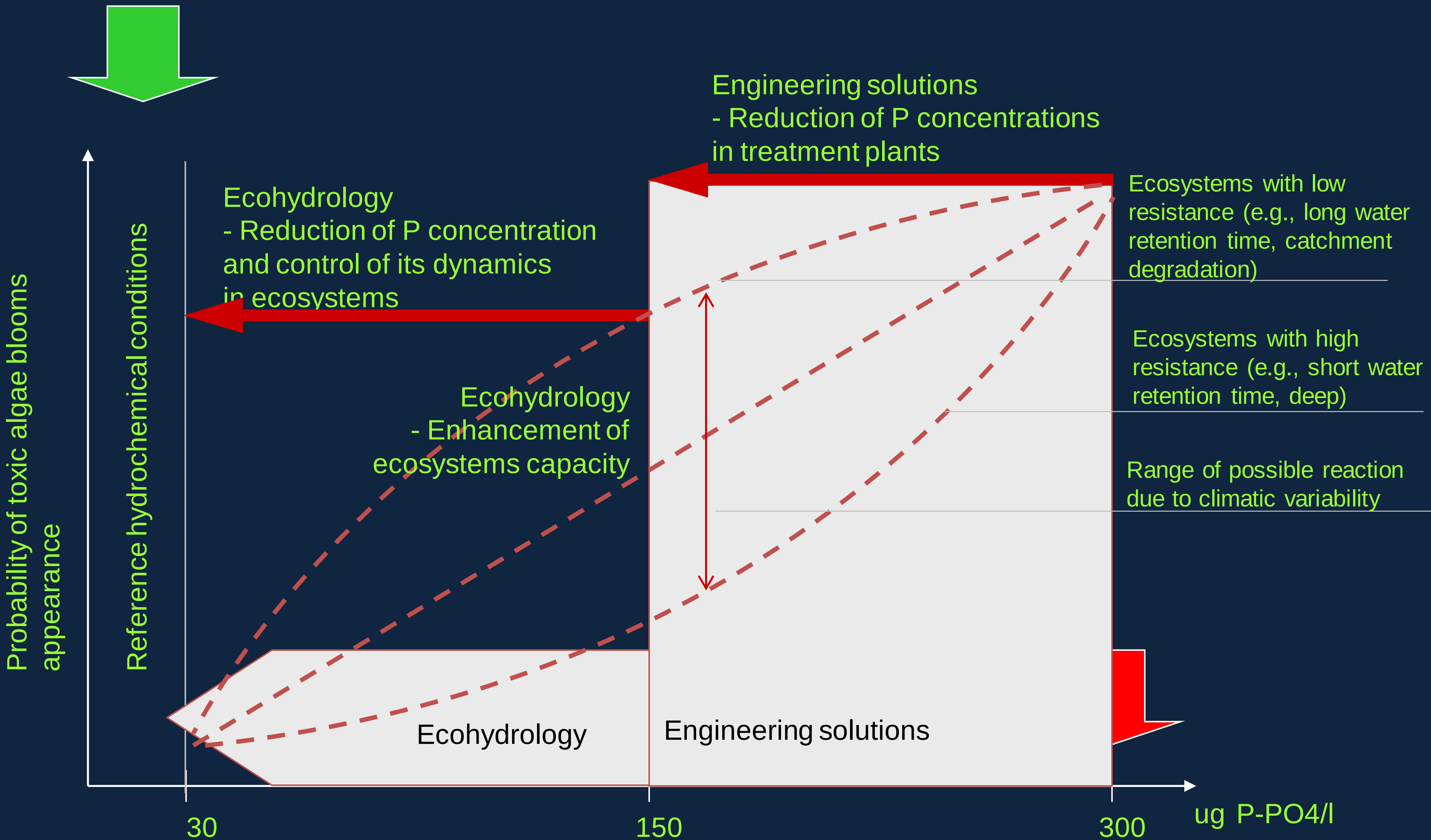



**Kierownik projektu: Profesor Maciej Zalewski**

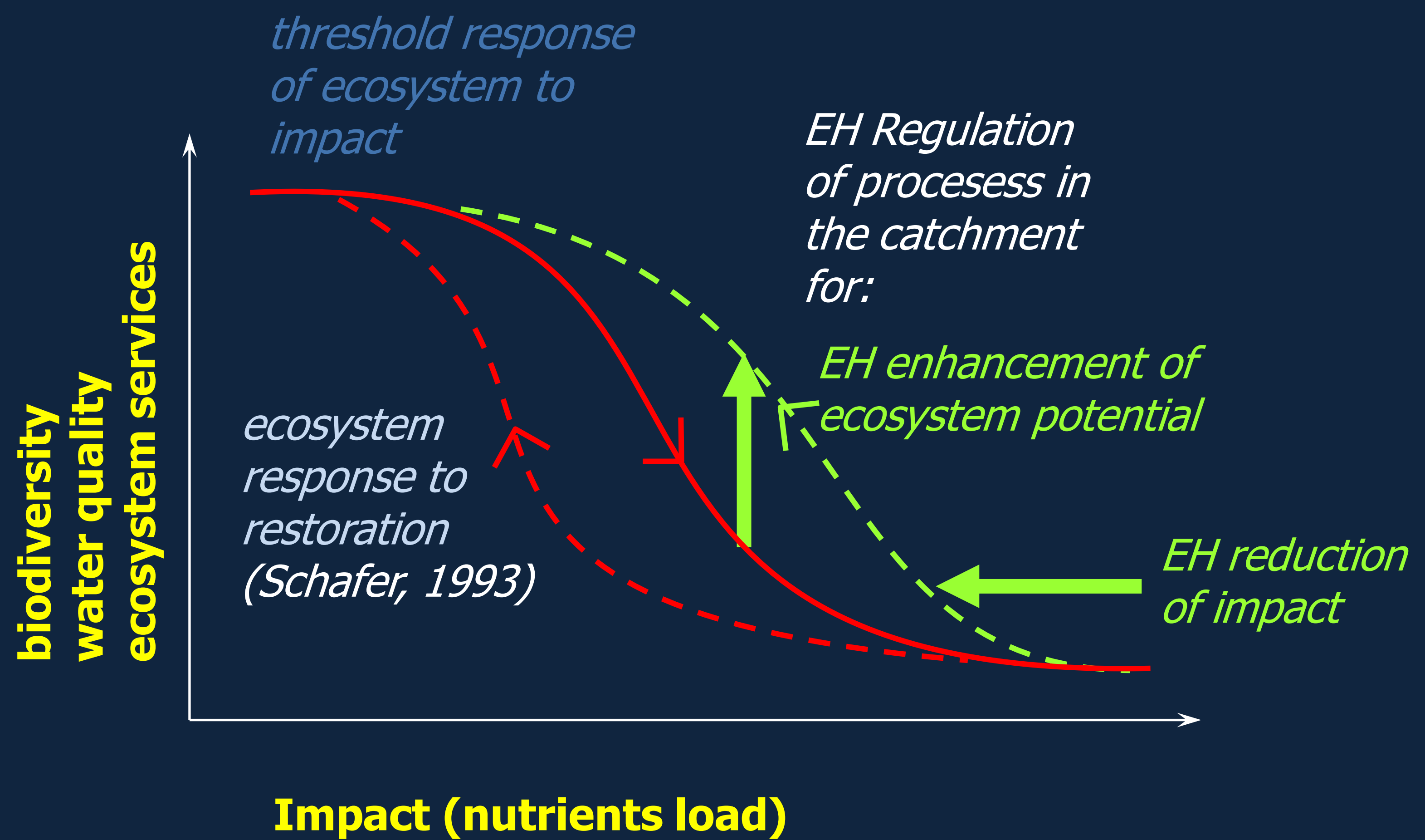
**Koordynator projektu: Tomasz Jurczak**

# Harmonization of technical and ecological solutions for eutrophication reduction




*(Zalewski)*

# Effect of Restoration vs. Ecohydrological regulation of processess at the catchment scale




*The concept of EH sustainability threshold* Zalewski 2011

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# ECOHYDROLOGY for Sustainable Developments Goals

**2.** End hunger , achieve food security… and promote sustainable agriculture

**4.** Ensure quality education and promote life long learning opportunities for all

**11.** Make cities and human settlements inclusive safe, resilient and sustainable

**13.** ….combat climate change and its impacts

**15.** Protect, restore and promote sustainable use of terrestrial ecosystems, sustainably mange forests, combat desertification and halt and reverse land degradation and halt biodiversity loss

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Water in the post-2015 development agenda and sustainable development goals

**Discussion paper**

Proposed water-related Sustainable Developm

| | UNESCO-IHP |
|---|---|
| | Ensure water security for sustainable development |
| *Water and sanitation* | By 2030, achieve universal access to safe drinking water and sanitation for all |
| *Water-use efficiency and sustainable use of water resources* | By 2030, reduce the water use in agricultural irrigation by 20%, industrial water use by 20% and domestic water use by 15% and increase water productivity by 50% in all sectors, by adopting the water demand management approach, less water demanding crops, water saving technologies and increasing the safe reuse of wastewater |
| *IWRM and water governance* | By 2030, increase by 50% the number of countries that have adopted and implemented policies and programmes for the public registration of water rights based on the IWRM approach |
| *Water quality and wastewater management* | By 2030, reduce water pollution from main sources at the country level by 30%, by increasing wastewater collection and treatment in cities to at least 80%, increasing industrial wastewater treatment to at least 95% and by taking measures to reduce pollutants at the source |
| *Water-related disasters* | By 2030, reduce the loss of human life and property from water-related disasters by 50%, by improving the resilience of nations |


# UNESCO International Hydrological Programme phase VIII: 2014 -2021

*Focal area 5.1 - **Hydrological dimension of a catchment**– identification of potential threats and opportunities for a sustainable development*

*Focal area 5.2 - **Shaping of the catchment ecological structure** for ecosystem potential enhancement – **biological productivity and biodiversity***

*Focal area 5.3 - **Ecohydrology system solution and ecological engineering** for the enhancement of water and ecosystem resilience and **ecosystem services***

*Focal area 5.4 - **Urban Ecohydrology** – storm water purification and retention in the city landscape, potential for improvement of health and quality of life*

*Focal area 5.5 - Ecohydrological regulation for sustaining and restoring **continental to coastal connectivity and ecosystem functioning***

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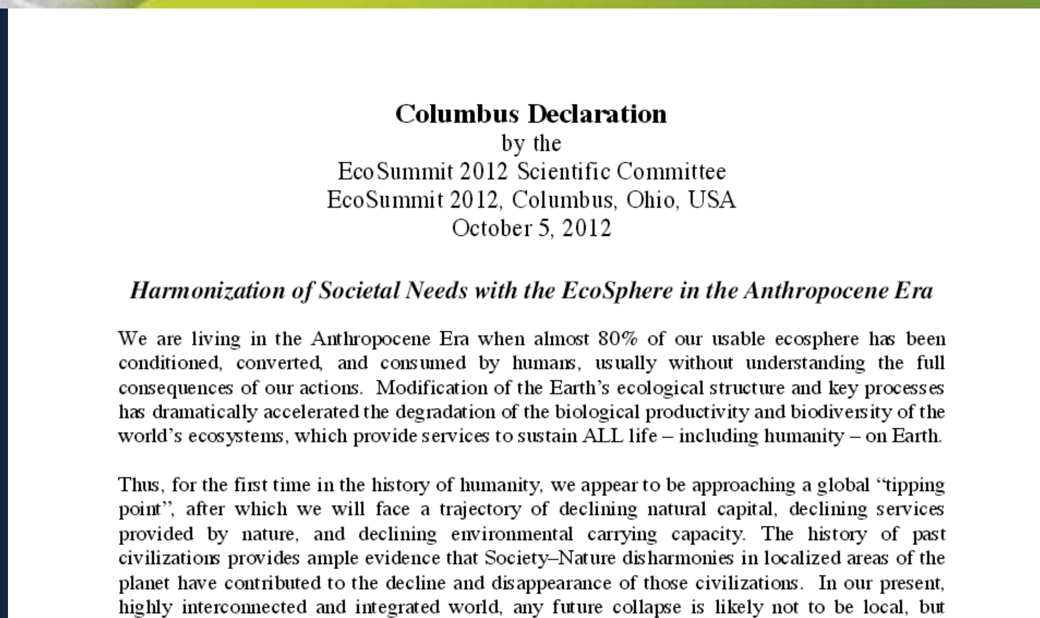

**Columbus Declaration**
by the
EcoSummit 2012 Scientific Committee
EcoSummit 2012, Columbus, Ohio, USA
October 5, 2012

***Harmonization of Societal Needs with the EcoSphere in the Anthropocene Era***

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. Modification of the Earth's ecological structure and key processes has dramatically accelerated the degradation of the biological productivity and biodiversity of the world's ecosystems, which provide services to sustain ALL life – including humanity – on Earth.

Thus, for the first time in the history of humanity, we appear to be approaching a global "tipping point", after which we will face a trajectory of declining natural capital, declining services provided by nature, and declining environmental carrying capacity. The history of past civilizations provides ample evidence that Society–Nature disharmonies in localized areas of the planet have contributed to the decline and disappearance of those civilizations. In our present, highly interconnected and integrated world, any future collapse is likely not to be local, but

**Special session on Ecohydrology -4th International Ecosummit (Columbus, Ohio, USA, 2012).**

Columbus **Declaration:**
**"Harmonization of Societal Needs with the EcoSphere in the Anthropocene Era"**


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The inspiring cooperation with 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

**Maciej Zalewski**