Catchment - based water management in agricultural area

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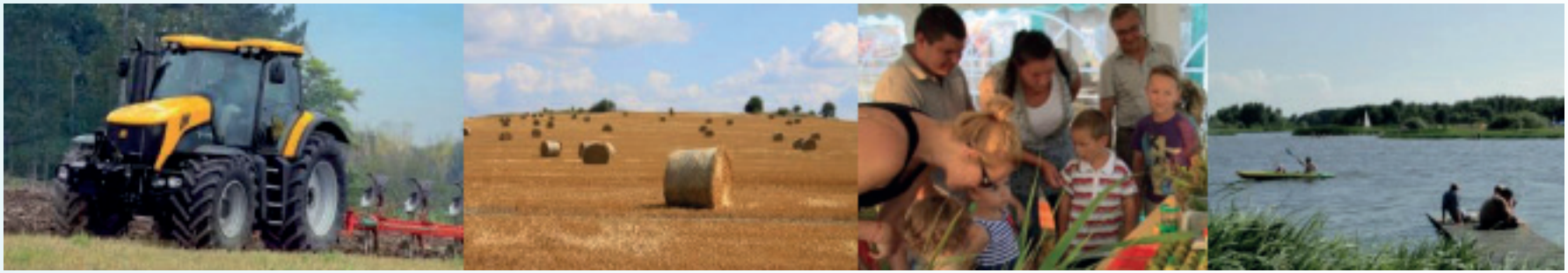
Water management in agricultural areas should take into account the two-way relationship between rural development and the quantity and quality of water resources, and should be catchment-based



Catchment (river basin, drainage basin):

an area of land from which all surface water runoff
is conveyed through a system of streams, rivers
and canals to a selected point in the course
of the watercourse (e.g., an estuary to an upstream river).
A watershed runs between two drainage basins.

Surface water:

The part of precipitation water that
does not infiltrate into the soil and does not evaporate
flows over the land surface in the direction of the slope,
gradually accumulating and forming surface water
(streams, rivers, lakes, artificial reservoirs).

Groundwater:

during percolation, or infiltration, rainwater encounters
an impermeable substrate (e.g., clay, silt),
causing all soil pores to fill and forming an aquifer.
Groundwater includes shallow and deep groundwater.

Natural processes:

1. **Precipitation** in various forms (rain, snow, hail)
2. **Evapotranspiration** is the sum of water **evaporation** from e.g. the soil and water bodies surface and **transpiration** by plant (the movement of water within a plant and the subsequent exit of water as vapor through stomata in its leaves in vascular plants)
3. **Surface runoff** (overland flow) is the flow of water occurring on the ground surface
4. **Infiltration** delivers water from the surface into the soil and plant rooting zone
5. **Percolation** moves water through the soil profile to replenish ground water supplies
6. **Subsurface flow** is the flow of water beneath earth's surface

Water cycle in agricultural basin

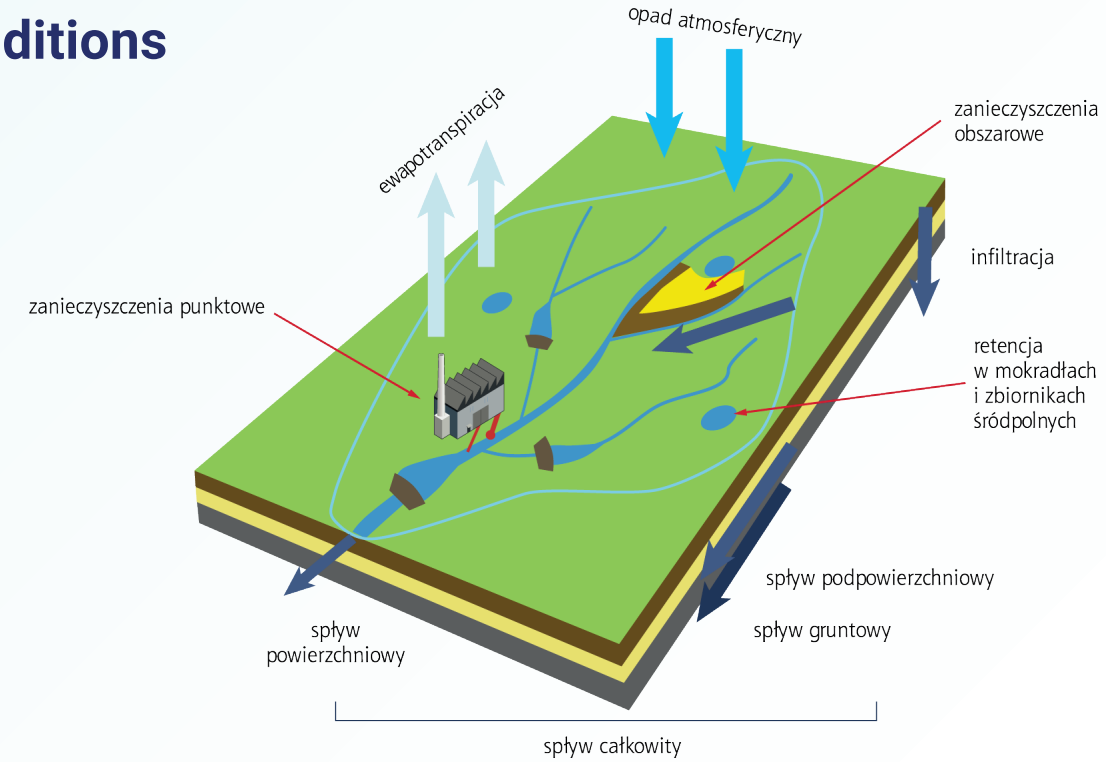
Artificial processes:

7. **Irrigation**: artificial applying controlled amounts of water
8. **Drainage**: artificial removal of a surface's water and sub-surface water

Quantification of hydrological processes and mapping of pressure sources in the catchment scale - the basis for water management

The starting point for water management in a catchment should be the quantification of hydrological processes, i.e. the quantitative description of abiotic processes and conditions in a catchment:

- Amount of precipitation and evaporation,
- Identification of groundwater and surface water pollution
- Sources of these pollutants: point sources (e.g. sewage discharge) and area sources (e.g. nutrient loads entering the water from agricultural areas).



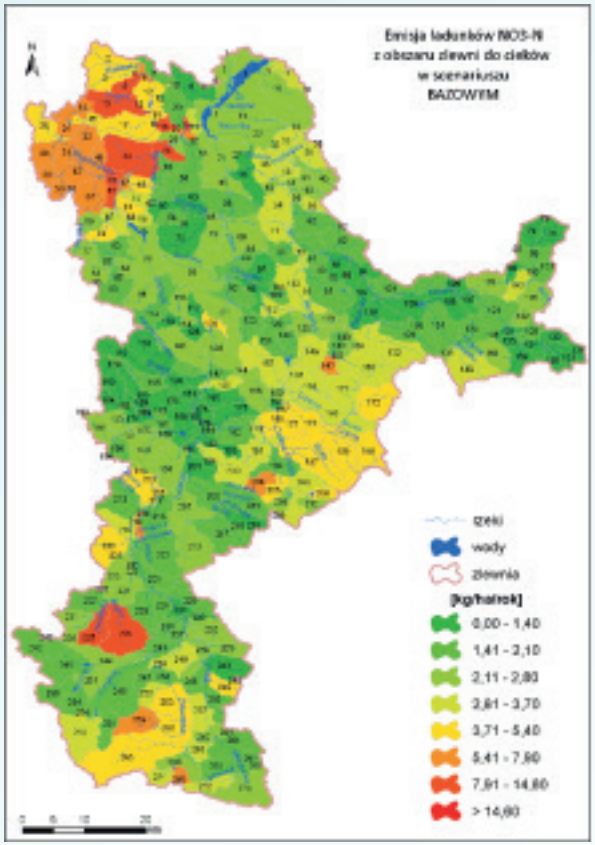
Source | Źródło: Zalewski M. 2019. Ekohydrologia. PWN

Fertiliser management as a potential source of water pollution

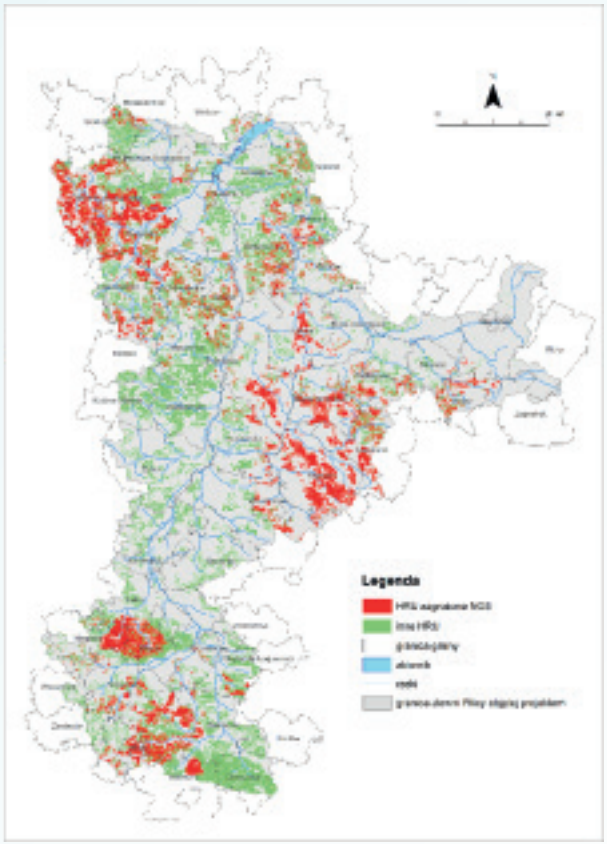
Nutrient	Nutrient sources on agricultural land (inflow)	Nutrient leaving pathways from agricultural land (outflow)	Threats to water
Nitrogen (N)	Natural fertilizers Mineral fertilisers Crop residues Soil organic matter Precipitation Assimilation by bacteria	Uptake by plants and with the harvest removed Infiltration Surface runoff Denitrification Emission of ammonia and nitrogen oxides into the atmosphere	Very good water solubility: leaching into groundwater or drainage systems can contaminate them
Posphorus (P)	Natural fertilisers Mineral fertilisers Phosphorus in rocks (apatite) Crop residues Soil organic matter	Harvesting Surface runoff combined with soil erosion Infiltration - limited	Forms complexes with soil: may move with surface runoff to surface waters and contribute to their eutrophication Not very mobile - may cause local accumulation in soil. In case of saturation of soil complexes with phosphorus, there may be a release to waters

Spatial variation of nitrate emissions from non-point sources in the Pilica river catchment

Nitrate emission



Arable land with the highest nitrate emission



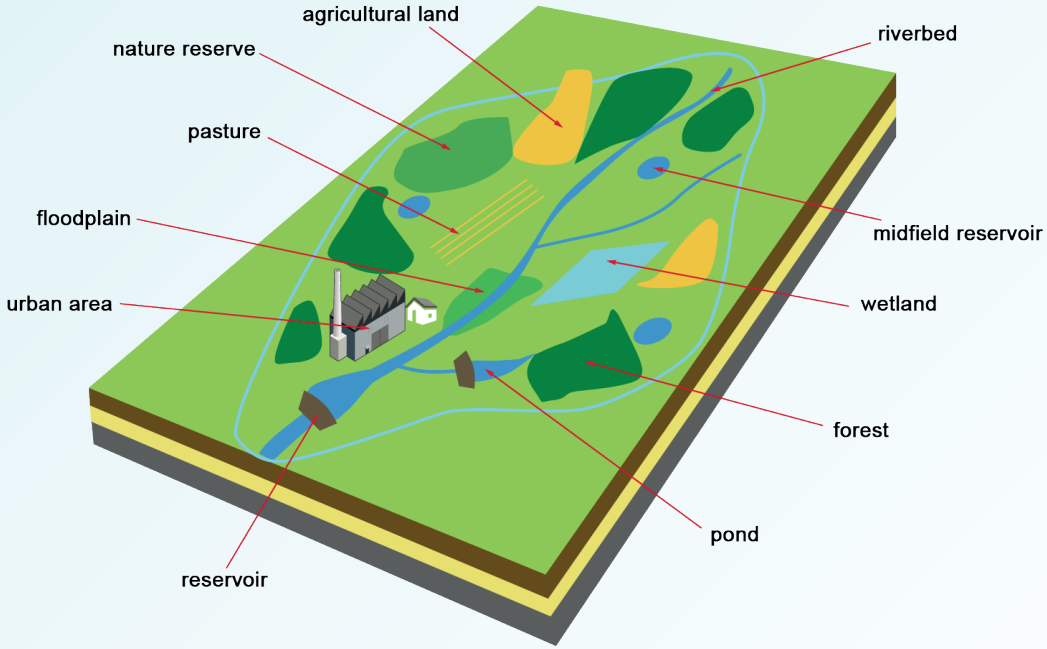
The SWAT (Soil & Water Assessment Tool) model was used (1) to estimate N&P emission, and (2) to identify priority areas in the catchment.

The identified priority areas represent only: about 6.6% of the area of the analysed Pilica river catchment and 16.3% of the area of arable land located within the catchment.

It was confirmed that the SWAT model can be used to identify areas where implementation of mitigation measures should be prioritized.

Source | Źródło: Piniewski et al. 2008, Izydorczyk et al. 2019

Next step: Analysis of the spatial distribution of ecosystems

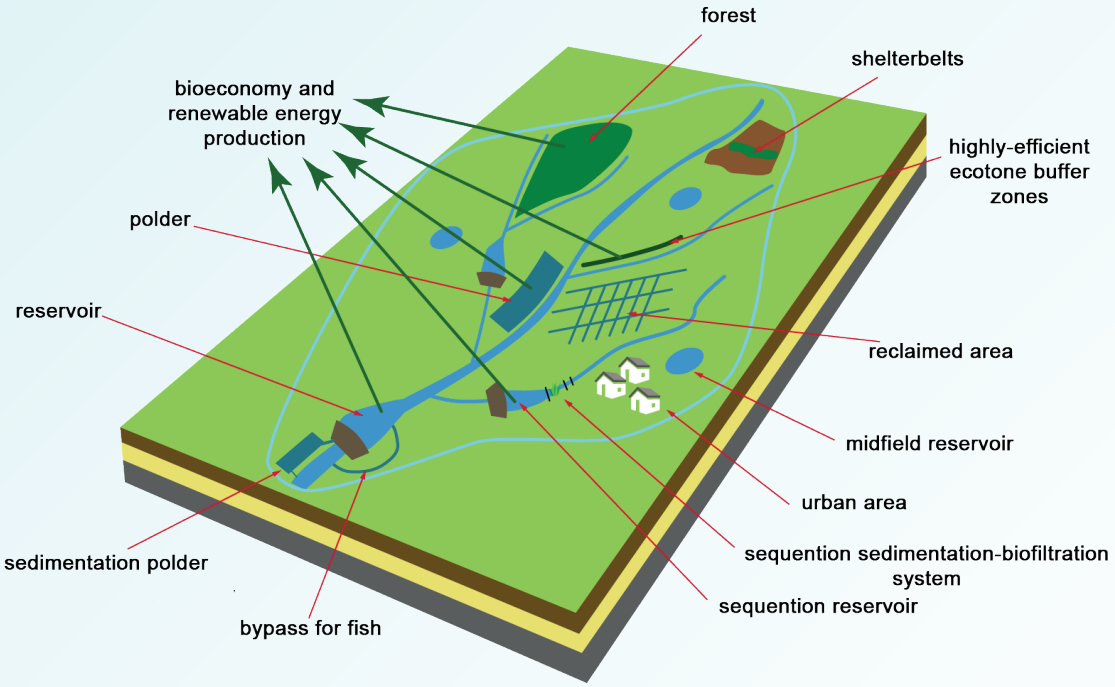


Goal: how to increase the potential of an ecosystem to respond flexibly to pressure?

- Analyze the spatial distribution of ecosystems in need of protection (e.g. national parks) and various forms of human use, including degraded ecosystems, whose potential can be increased by applying ecohydrological methods
- Understand the evolutionary link between biocenosis and the hydrological cycle
- Quantify ecological processes and link them to the hydrological cycle

Source | Źródło: Zalewski M. 2019. Ekohydrologia. PWN

Finally, use ecological processes as tools to regulate water resources



Selection of appropriate measures including nature-based solution, especially emphasis on "dual regulation" - regulation of water cycle by shaping biota and regulating biotic processes and vice versa, enhancing biota by regulating hydrology.

The selection of tools should be chosen according to the identified problems/threats and should be optimally located in the catchment scale.

It is the hydrological principle of ecohydrology (Zalewski 2002)

Source | Źródło: Zalewski M. 2019. Ekohydrologia. PWN

How to get the right quantity and quality of water for agricultural production?

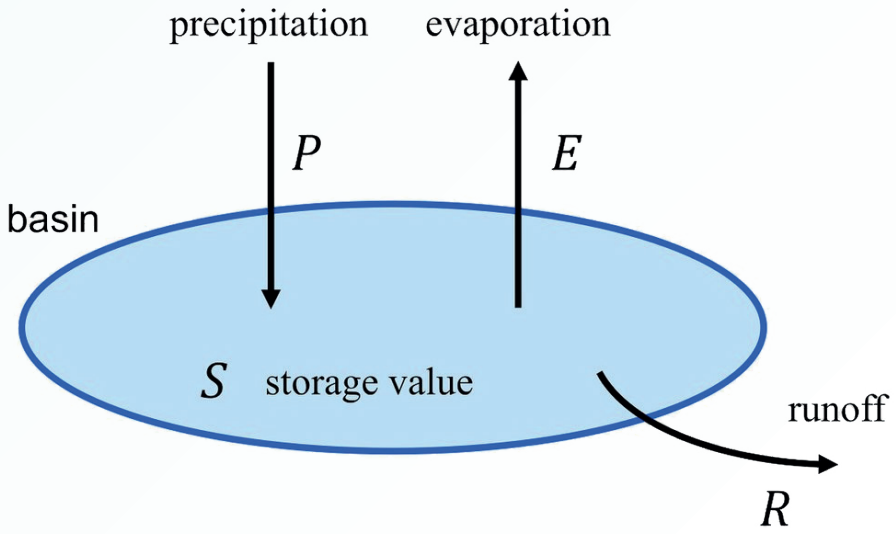
- to storage as much water as possible and for as long as possible, with proper water allocation in the catchment (water retention).
- as much water as possible should pass from the soil to the atmosphere through the plants (more transpiration then evaportation and runoff)
- slowing down the runoff reduces losses of fertilizer substances and intensifies the process of water self purification

General water balance at the catchment scale

P = ET + H + ΔR

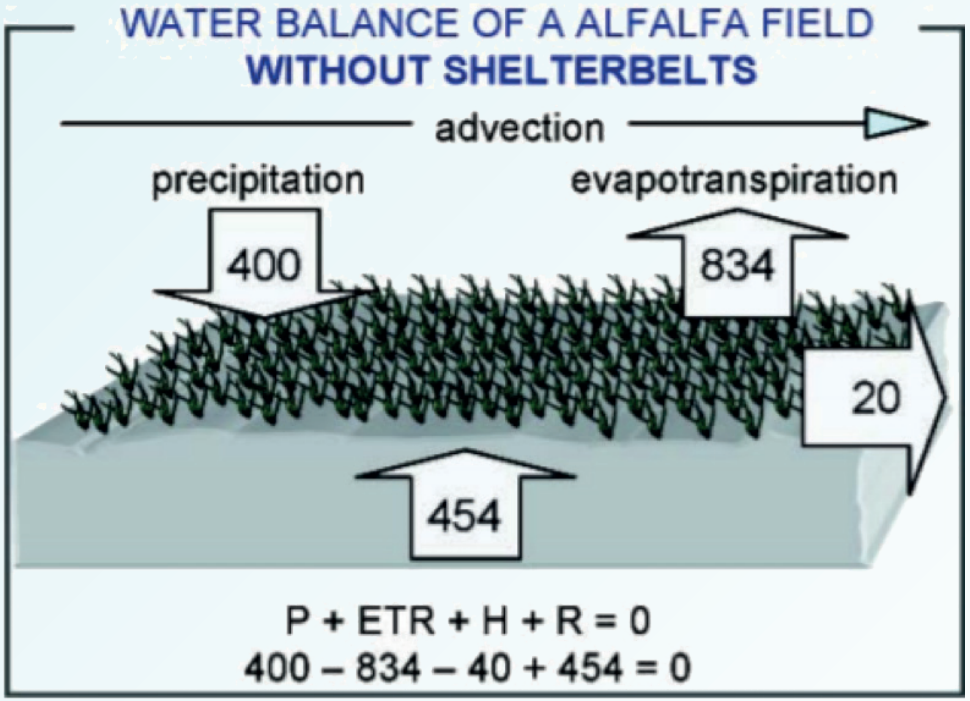
Precipitation = evapotranspiration + runoff
+ the change in retention

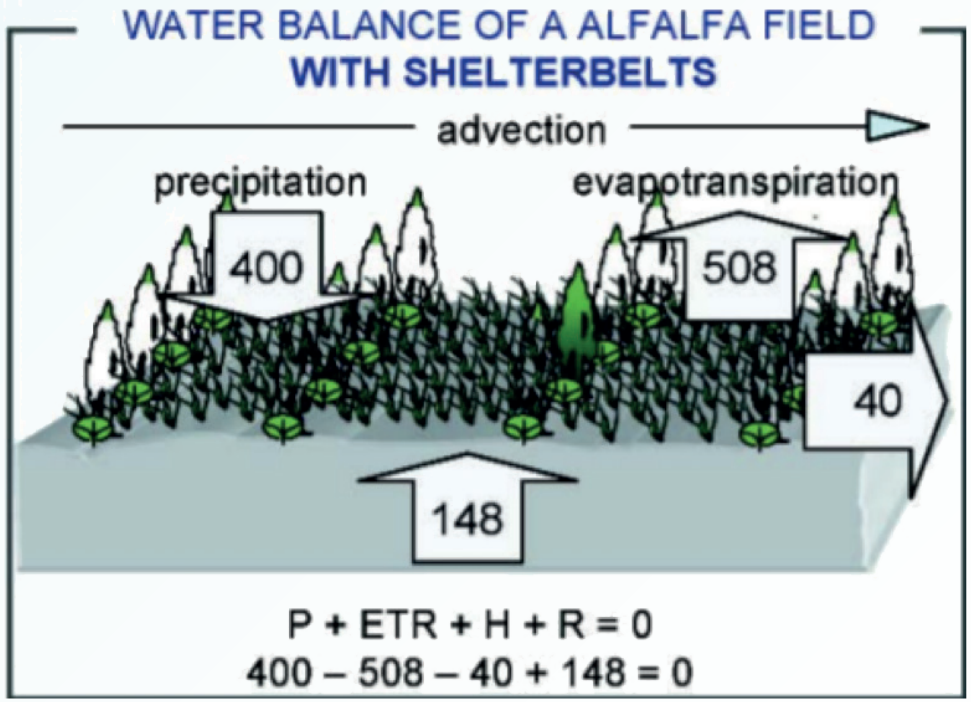
Where:
Retention: water storage in soil,
surface water or the bedrock (groundwater)



Source | Kedziora 2008. Podstawy agro-meteorologii

Landscaping helps to reduce evapotranspiration

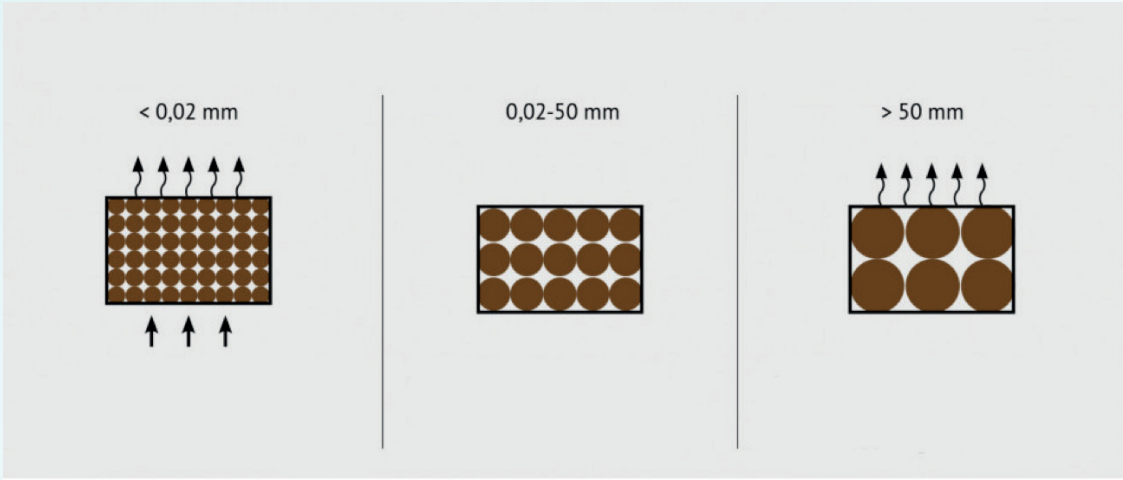




Source | Kedziora 2004

Correct size of soil aggregates reduces evaporation

Effect of soil aggregate size on soil drying



Too small of soil aggregates. Intensive waterlogging to the soil surface accelerates evaporation.

Optimum size of soil agrgregate - optimum evaporation

Too large soil aggregates. Air movement causes water evaporation and soil drying

Soil that has not been treated after a crop has been harvested evaporates very quickly, so it is important to stop the water seeping to the soil surface as soon as possible.

The soil capillaries, which carry moisture from the deeper layers of the soil upwards, must be broken.

Water losses through this process during hot, sunny days can be as high as 80 litres per square metre per day.

Source | Tyszka 2018. Jak zatrzymać wodę w glebie? https://www.farmer.pl/produkcja-roslinna/jak-zatrzymac-wode-w-glebie,79824.html

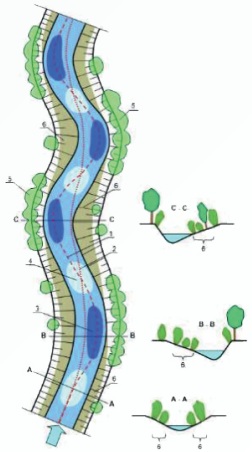
Controlled drainage to increase water retention in soil and reduce the amount of potentially leached nutrients

- modernization of drainage wells in order to make it possible to control water level and adjust it to prevailing weather conditions
- reconstruction, modernization and construction of damming devices: gates, steps, stone and wooden damming facilities on drainage ditches and watercourses located on meliorated grasslands and arable lands;

Use of good practices in water maintenance that support natural hydromorphological and ecological processes

- increased water outflow
- drainage of groundwater
- reduced self-purification
- destruction of habitats
- low biodiversity

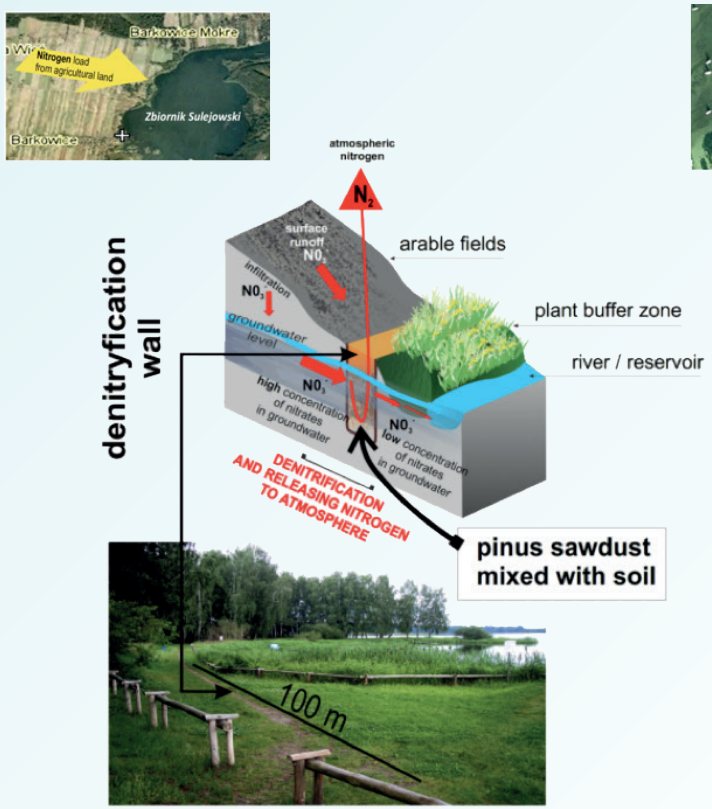
- diverse microhabitats
- biodiversity
- self-purification
- higher groundwater level in the valley
- drought alleviation
- landscape attractiveness

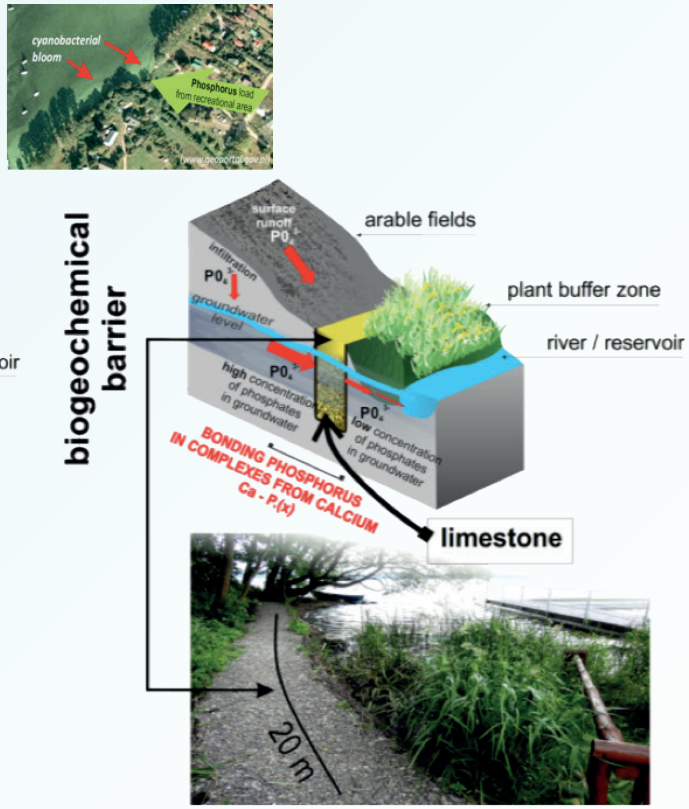


Rysunek 39. Stymulacja krętości i urozmaicenia koryta za pomocą zróżnicowanego wykaszania i usuwania roślin, w tym usuwania drzew i krzewów, z dna oraz brzegów śródlądowych wód powierzchniowych.
Oznaczenia: 1 – linia nurtu w korycie wód średnich i niskich, 2 – linia nurtu przepływu wód wielkich, 3 - przegłębienie dna koryta na łuku (plaso), 4 – wypłycenie dna koryta na przejściu nurtowym (bystrze), 5 – strefa roślinności stabilizującej skarpę na brzegu wklęsłym, 6 – strefa wykaszania roślinności brzegowej (usuwania drzew i krzewów).
Źródło: Prus i in. (2018)

Source | https://www.wody.gov.pl/images/Aktualnosci/foto/renaturyzacjaKPRWP/Podrecznik_renaturyzacji.pdf

Highly effective ecotone zones for reduction of non-point nitrogen and phosphorus pollution from shallow groundwater





Plant buffer zones along the reservoir further enhanced with:

A. Sawdust-based denitrification wall for increased nitrogen reduction

B. Biogeochemical limestone - based barriers to enhance phosphorus reduction

Source | Izydorczyk et al. 2013, Izydorczyk et al. 2015, Frątczak et al. 2019

How to increased water and nutrient retention?

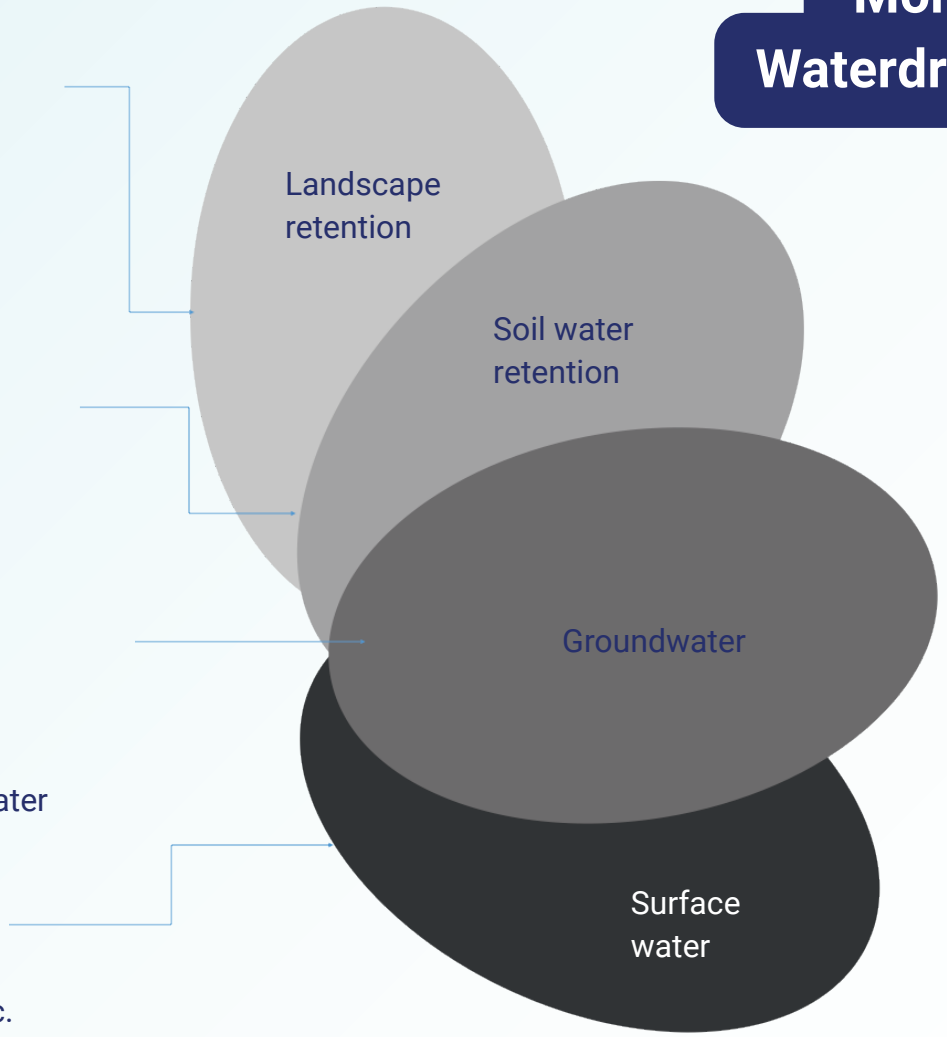
- Layout of arable fields, grasslands, forests, ecological grounds, ponds
- Afforestation, creation of protective belts, tree plantings, bushes, creation of furrows and terraces
- Increasing the area of wetlands, peat bogs, swamps

Water management in the soil profile: improving soil structure, liming, correct agrotechnics, appropriate crop rotation, increasing the content of organic matter in the soil, regulation of drainage networks

- Reduction of surface runoff
- Increasing the permeability of soils
- Anti-erosion, phytomelioration and agromelioration measures
- Regulating runoff from the drainage network
- Infiltration ponds and wells, including for rainwater collection from impervious surfaces

- Small water reservoirs
- Regulation of outflow from small ponds
- Collecting water in drainage ditches, canals, etc.
- Retention of runoff from drainage systems
- Increasing valley retention

More in the following Waterdrive presentations



Effective water management at the agriculture catchment scale as a tool to achieve the goals of the Farm to Fork Strategy

The use of pesticides in agriculture contributes to pollution of soil, water and air.
The Commision will take actions to:
- Reduce by 50% the use and risk of chemical pesticides by 2030
- Reduce by 50% the use of more hazardous pesticides by 2030

The excess of nutrints in the environment is a major source of air, soil and water pollution, negatively impacting biodiversity and climate.
The Commission will act to:
- Reduce nutrient losses by the least 50%, whicle ensuring no deterioration on soil fertility
- Reduce fertilizer use by at leaset 20% by 2030

Antimicronial resistance linked to the use of antimicrobials in animal and human health leads to an estimated 33,000 human deaths in the EU each year. The Commission will reduce by 50% the sales of antimicrobials for farmed animals and in aquaculture by 2030

Organic farming is an environmentally-freindly practice that need to be futher developed. The Commision will boost the devlopment of EU organic farming area with the ain to achieve 25% of total farmland under oragnic farming by 2030

https://ec.europa.eu/commission/presscorner/detail/pl/fs_20_908

https://ec.europa.eu/info/strategy/priorities-2019-2024/european-green-deal/actions-being-taken-eu/farm-fork_pl

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