BIOLAWEB

Belgrade, April 2023

Introduction to Bioindication

- part 1 -

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Note:

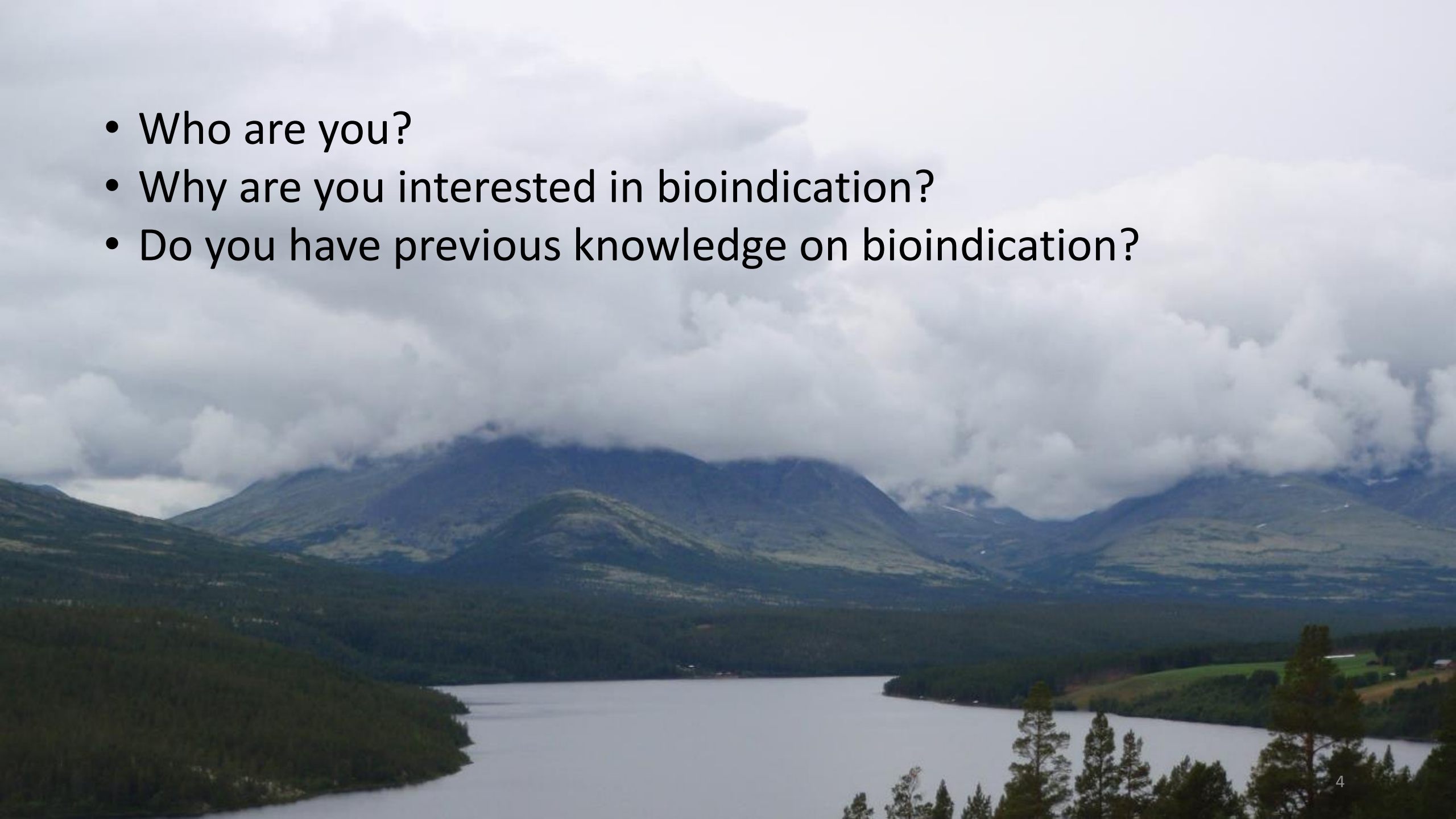
This presentation is part of a course that has been given in April/May 2023 in Belgrade. To avoid any potential issues with respect to copyright, however, the version which is publicly available has been modified. Specifically, some illustrations were removed.

For this reason, layout and design may appear somewhat “empty”.
The course content has not been changed, however.

Susanne Schneider

- studied biology/freshwater ecology in Munich (Germany)
- since 2007 at the Norwegian Institute for Water Research, Oslo
- since 2014: adjunct professor at the Norwegian University for Life Sciences, Ås
- «freshwater ecologist», but have been working a lot with bioindication and the Water Framework Directive

- The trophic index of macrophytes TIM (Germany, pre-WFD, eutrophication, macrophytes)
- Reference index for lakes (Germany, WFD, general deviation from reference status, macrophytes)
- Reference index for rivers (Germany, WFD, general deviation from reference status, macrophytes)
- Acidification index periphyton AIP (Norway, WFD, acidification, benthic algae)
- Periphyton index of trophic status PIT (Norway, WFD, eutrophication, benthic algae)
- Balkan macrophyte index BMI (Balkan, WFD, eutrophication, macrophytes)



- Who are you?
- Why are you interested in bioindication?
- Do you have previous knowledge on bioindication?

Pollutants enter rivers and lakes from **many** point and nonpoint sources.

- City streets
- Rural homes
- Suburban development
- Wastewater treatment plan
- Cropland
- Animal feedlot
- Factory
- …

These point and nonpoint sources emit **very many** different pollutants (chemicals) into rivers and lakes.

- Toxins
- Organics
- Oil
- Acid precipitation
- Sediment
- Nutrients
- Pesticides
- Microplastics
- …

So: What should we target? For which stressor can we use bioindicators?

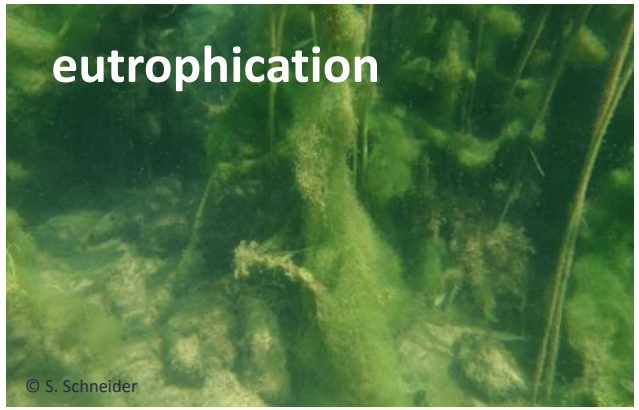
picture of a highly polluted aquatic ecosystem which is affected by multiple stressors

⇒ Note down these two questions
⇒ discuss for 5 min in breakout groups

So: What should we target? For which stressor can we use bioindicators?

=> For pretty much ANY stressor that is IMPORTANT for the environment!

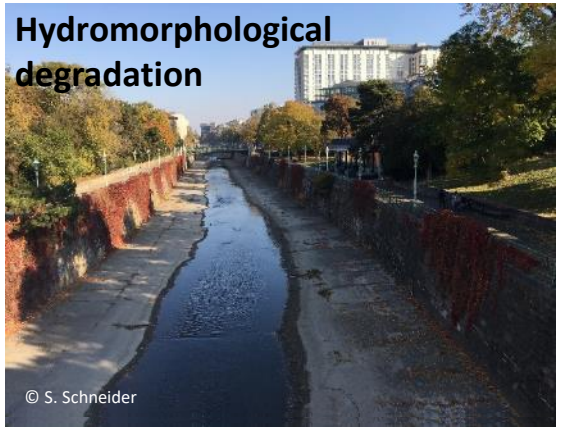
Commonly targeted stressors include …



sewage pollution

acidification

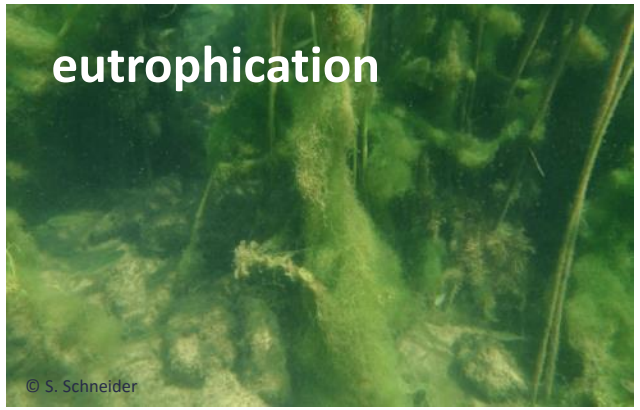
But we could also develop indicators for …



salinization

… and many more.

But why do we need bioindication?



can be measured as
nutrient concentrations

TABLE 11.1 Major forms of nitrogen and phosphorus found in natural waters (after Meybeck 1982). Nitrogen also is present as dissolved N_2 gas (not shown).

Nitrogen		
Dissolved Inorganic Nitrogen	Total Dissolved Nitrogen	Total Nitrogen
NO_3^- nitrate		
NO_2^- nitrite		
NH_4^+ ammonium		
Dissolved Organic Nitrogen		
Particulate Organic Nitrogen		
Phosphorus		
Dissolved Inorganic Phosphorus (PO_4^{-3} orthophosphate or soluble reactive phosphorus)	Total Dissolved Phosphorus	Total Phosphorus
Dissolved Organic Phosphorus	Total Organic Phosphorus	
Particulate Organic Phosphorus		
Particulate Inorganic Phosphorus		

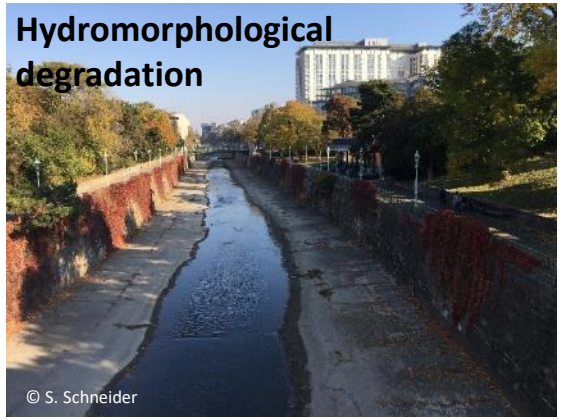
sewage pollution

can be measured as
COD, BOD, TOC

- COD (Chemical Oxygen Demand)
- BOD (Biochemical Oxygen Demand)
- TOC (Total Organic Carbon)

acidification → can be measured as **pH**

salinization → can be measured as **salinity**



→ can be **mapped visually**

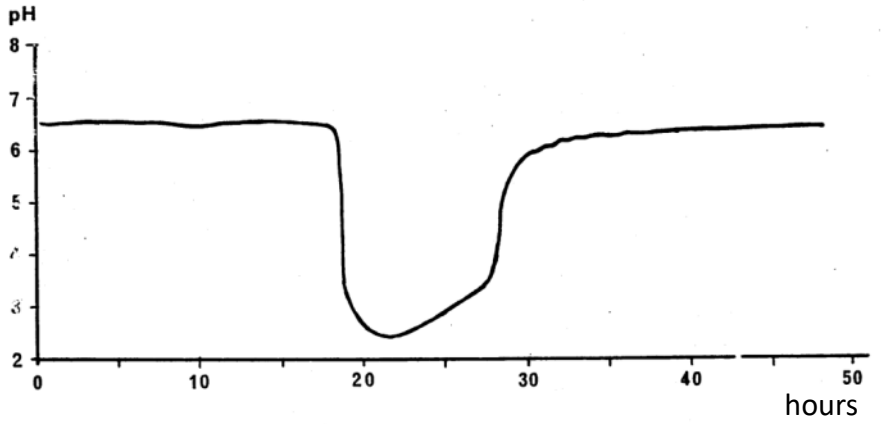
So: Why do we need bioindication?

=> discuss for 5 min in breakout groups


Coffee Break

Why do we need bioindication?

- Detect short-term releases and earlier events



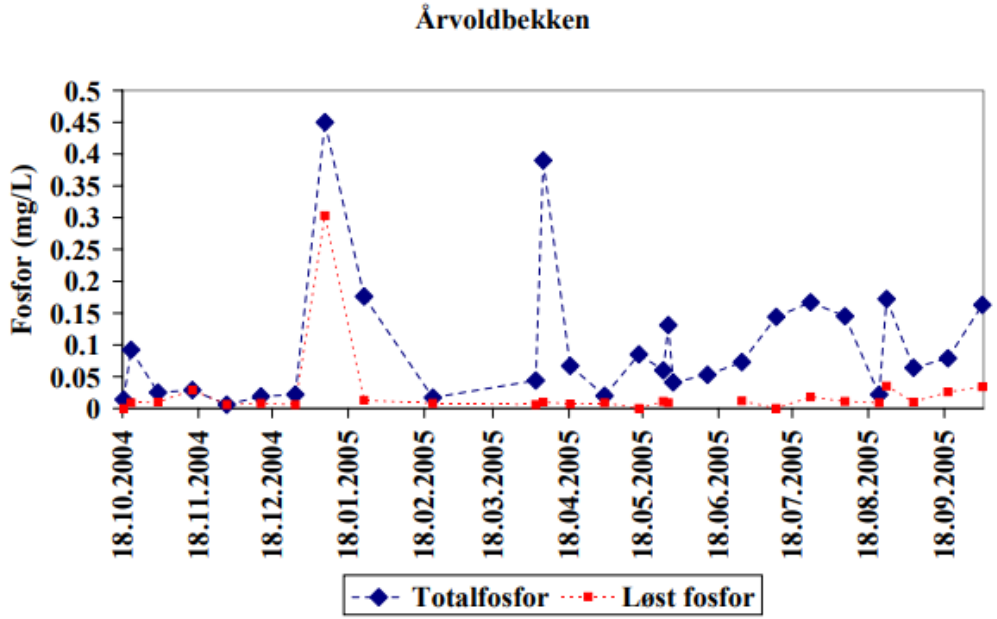
pH in a stream in Oslo, before, during and after a spill of sulfuric acid

Picture of a spill into a river

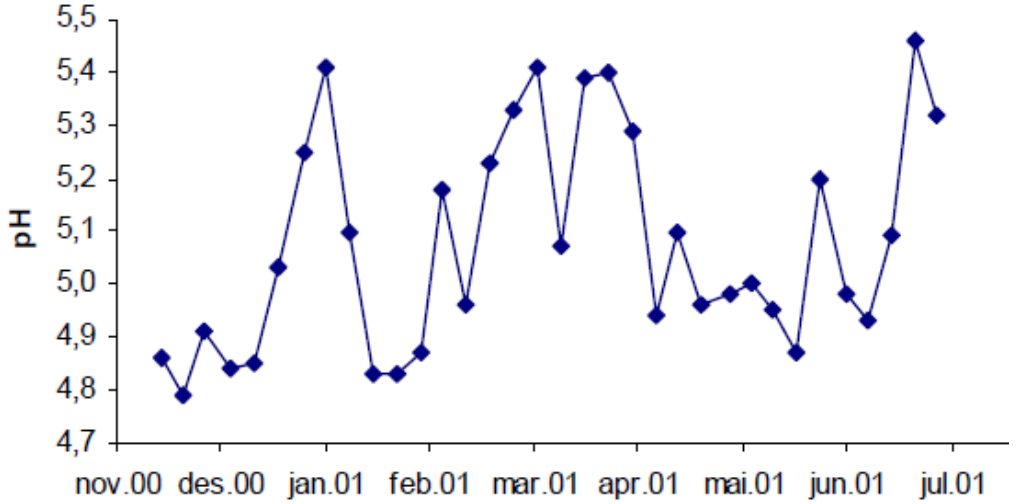
What will happen to water chemistry when you switch off the effluent?

Why do we need bioindication?

- Show less “random” variation; integrate over time



Monthly measurements of TotP and DRP in the Årvoldbekken stream (Norway)



Weekly measurements of pH in the Dåsåna stream (Norway)

Why do we need bioindication?

How do we normally notice that something is wrong in a river or lake?

- Water quality has **biological aspects** (ecosystem)

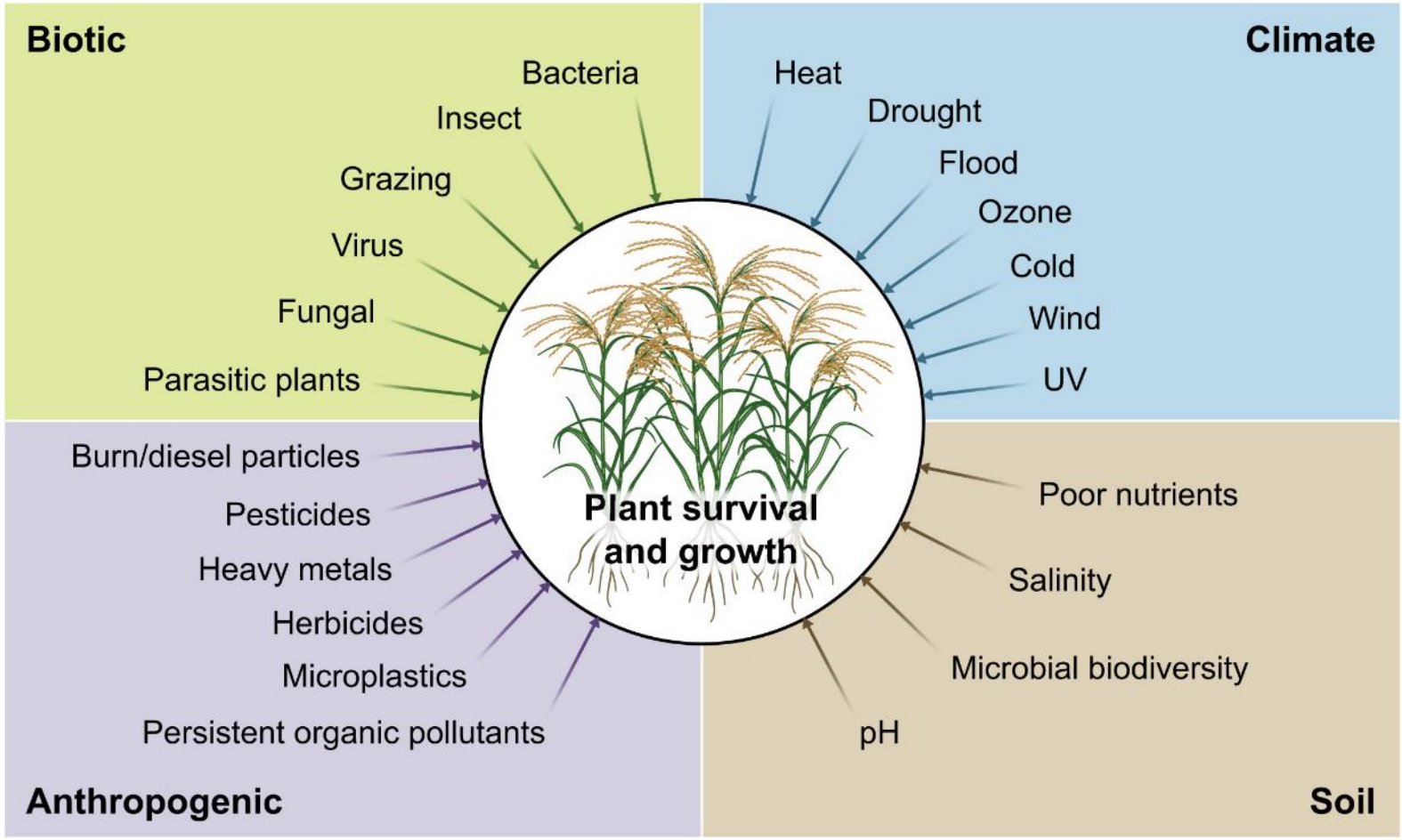
Pictures of cyanobacterial blooms, and of fish kill

Low pH or high phosphorus concentrations are only perceived as «a problem» if they also involve a change in biology: fish kills, mass developments of macrophytes, cyanobacterial blooms, etc.

Why do we need bioindication?

- Register a wide variety of pollutants

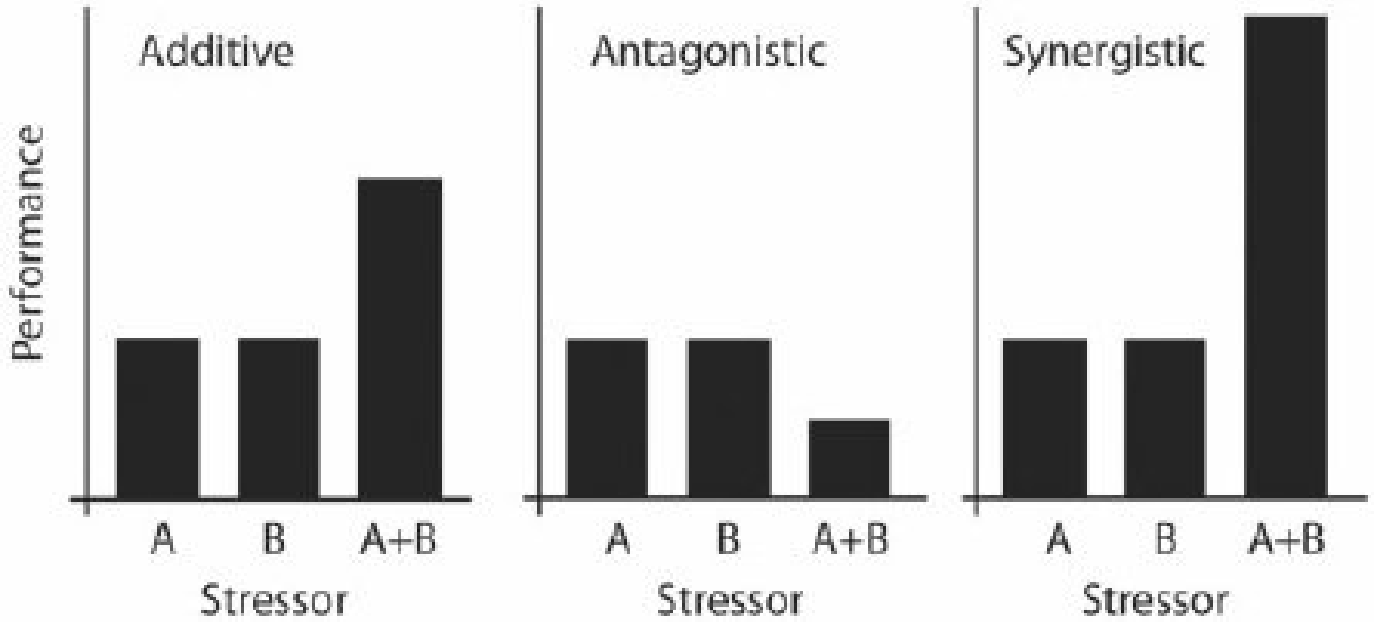
Organisms living in a river or lake are affected by many stressors. It is unrealistic that we can monitor them ALL chemically. But we can check if the biota are healthy, and only if they are NOT healthy we must search for the cause of the degradation.



Zandalinas and Mittler (2022)

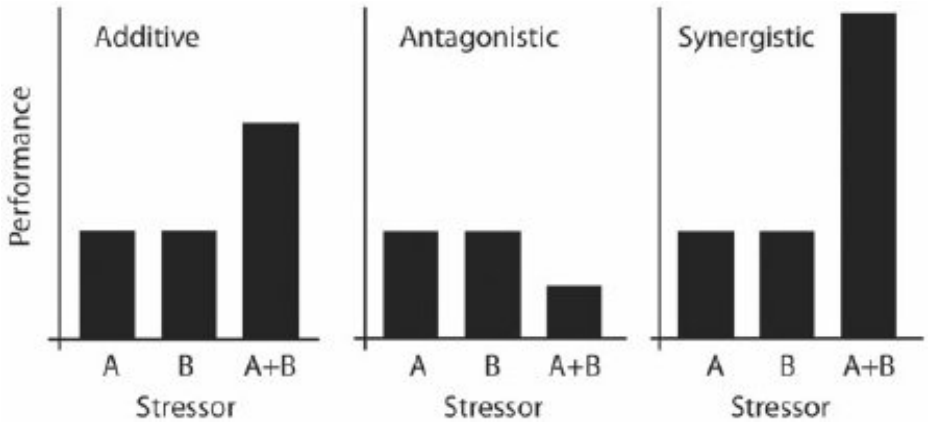
Why do we need bioindication?

- multiple stressors: synergistic and antagonistic effects



Synergistic effects: each single stressor can be below the accepted threshold, but combined they may have a serious effect on the biota. This can only be monitored by looking directly at the biota.

Multiple stressors



Additive and synergistic effects: Ecosystem managers and conservationists may tackle each stressor individually, starting preferably with the dominant one to achieve the best management effect.

In the presence of **antagonistic stressor interactions**, however, this may lead to unexpected results: if a stressor A is being mitigated that antagonistically interacts with another stressor B, the mitigation measure of A may unleash the (formerly) hidden effect of B. This is why understanding stressor interactions is not only of academic concern, but a crucial prerequisite for ecosystem management and conservation.

coffee break

★★★★★

Most rivers and lakes are inhabited by very many different species. Which species group should we select for bioindication?

Pictures illustrating different organism groups living in freshwater

=> discuss for 5 min in breakout groups

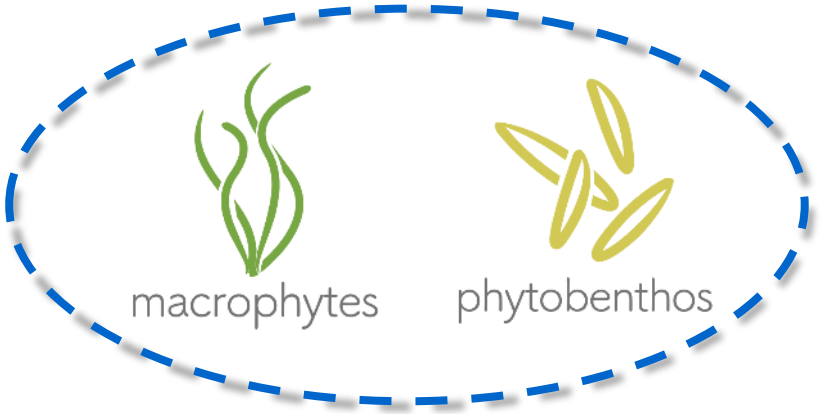
Which species group should we select for bioindication?

The «quick and dirty» answer: the WFD demands assessment of

fishes

phytoplankton

macro-invertebrates



Pictograms from freshwaterecology.info

Which species group should we select for bioindication?

But: the choice of indicator group also must make sense!

Good indicator ability	Provide measurable response (sensitive to the stressor)
	Response reflects the whole population/community/ecosystem
	Responds in proportion to the degree of contamination/degradation
Abundant and common	Adequate local population density (rare species are not optimal)
	Common, including distribution within area of question
	Relatively stable despite moderate climatic and environmental variability
Well-studied	Ecology and life-history well understood
	Taxonomically well documented and stable
	Easy and cheap to survey

Assignment of seminar papers

Katsiapi et al. (2016). Assessing ecological water quality of freshwaters: PhyCoI—a new phytoplankton community Index. Ecological Informatics 31, 22–29.

Brabcova´ et al. (2017). Diatoms in water quality assessment: to count or not to count them? Hydrobiologia 795, 113–127.

Kahlert et al. (2021). Same same, but different: The response of diatoms to environmental gradients in Fennoscandian streams and lakes – barcodes, traits and microscope data compared. Ecological Indicators 130, 108088.

Kelly et al. (2016). RAPPER: A new method for rapid assessment of macroalgae as a complement to diatom-based assessments of ecological status. Science of the Total Environment 568 (2016) 536–545.

Søndergaard et al. (2010). Submerged macrophytes as indicators of the ecological quality of lakes. Freshwater Biology 55, 893–908.

Labat and Thiebaut (2023). A new trophic index (TIM2S) to evaluate trophic alteration of small shallow lakes: a predictive reference-based approach. Hydrobiologia 850, 519–536.

Clarke et al. (2003). RIVPACS models for predicting the expected macroinvertebrate fauna and assessing the ecological quality of rivers. Ecological Modelling 160, 219-233.

Golfieri et al. (2016). Odonates as indicators of the ecological integrity of the river corridor: Development and application of the Odonate River Index (ORI) in northern Italy. Ecological Indicators 61, 234–247.

Poikane et al. (2016). Benthic algal assessment of ecological status in European lakes and rivers: Challenges and opportunities. Science of the Total Environment 568, 603–613.

Szczepocka and Żelazna-Wieczorek (2018). Diatom biomonitoring – scientific foundations, commonly discussed issues and frequently made errors. Oceanological and Hydrobiological Studies 47, 313 – 325.

Seminar: good and «bad» indices

Goal:

- To learn about examples for different indices
- **To discuss** advantages and disadvantages with certain indices

How?

1) Each course participant presents one paper **(max 20 minutes presentation)**
2) Please end each presentation with a few points **what you like and what you did not like** with the presented index
3) After each presentation we will together discuss what is good and «not so good» with each index
4) This means that each participant should **read at least the abstract of all presented papers** (but present only one paper)

Good luck!

See you May 3, in Belgrade

Acknowledgement

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