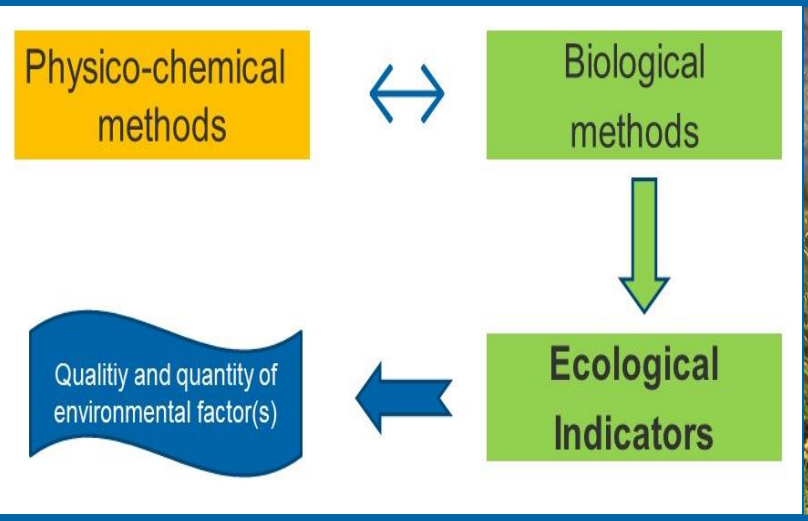
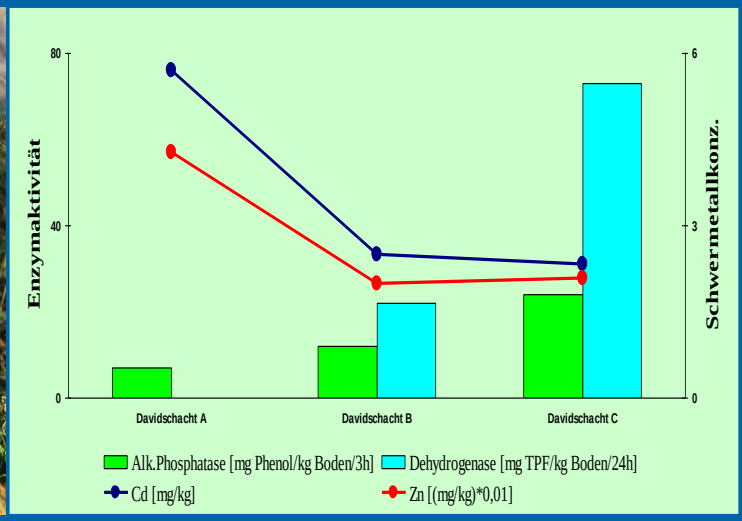
TECHNISCHE UNIVERSITÄT
BERGAKADEMIE FREIBERG
Die Ressourcenuniversität. Seit 1765.

DAAD
Deutscher Akademischer Austauschdienst
German Academic Exchange Service

National Technical University
DNIPRO POLYTECHNIC
1899

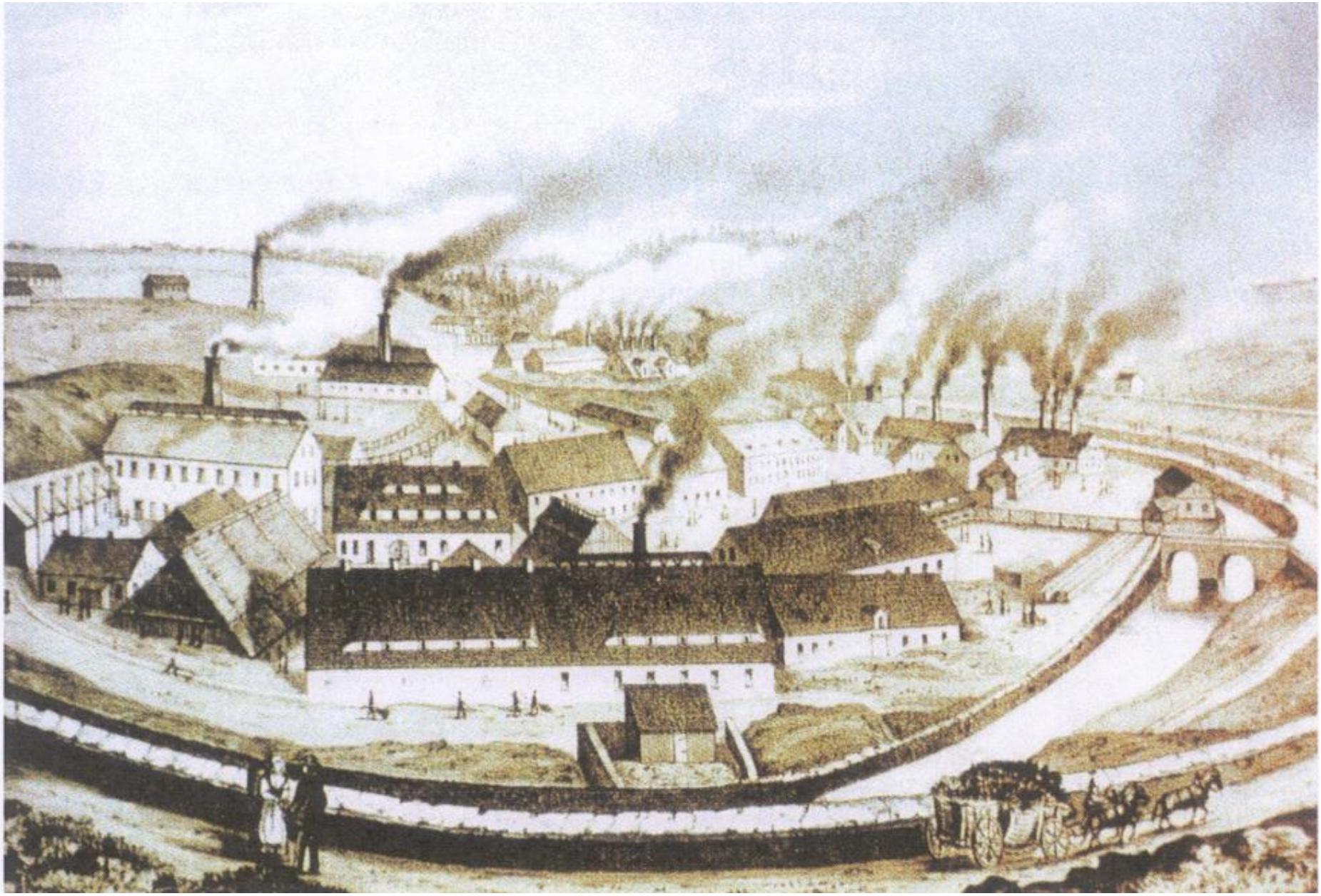
BASIC ECOLOGICAL INDICATORS for (post-)mining landscapes





“EcoMining” Training Week 06.-10.09.2021

Hermann Heilmeier, TU Bergakademie Freiberg



Muldenhütten (Freiberg, Saxony, East Germany)

Hohe Esse Halsbrücke (Freiberg, Saxony, East Germany)

→ **Need for monitoring environmental quality!**

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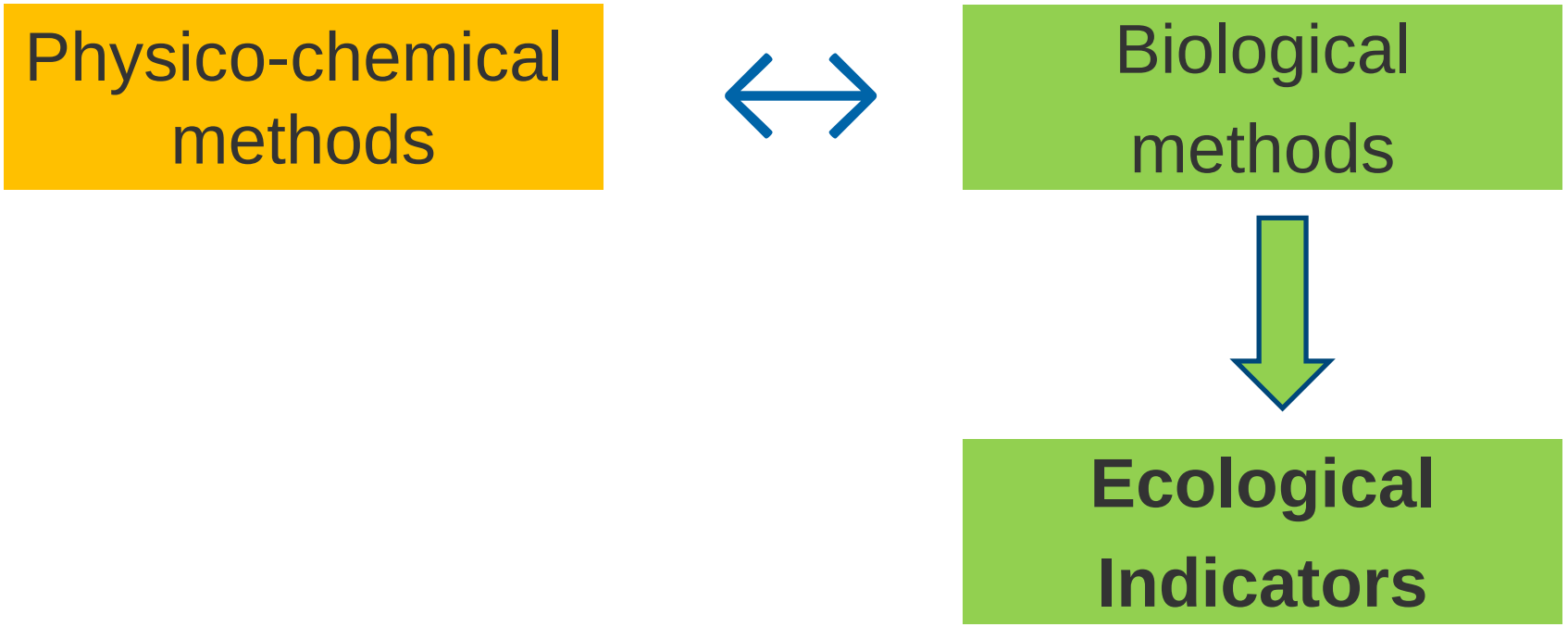
Physico-chemical methods ↔ Biological methods

→ Need for monitoring environmental quality!



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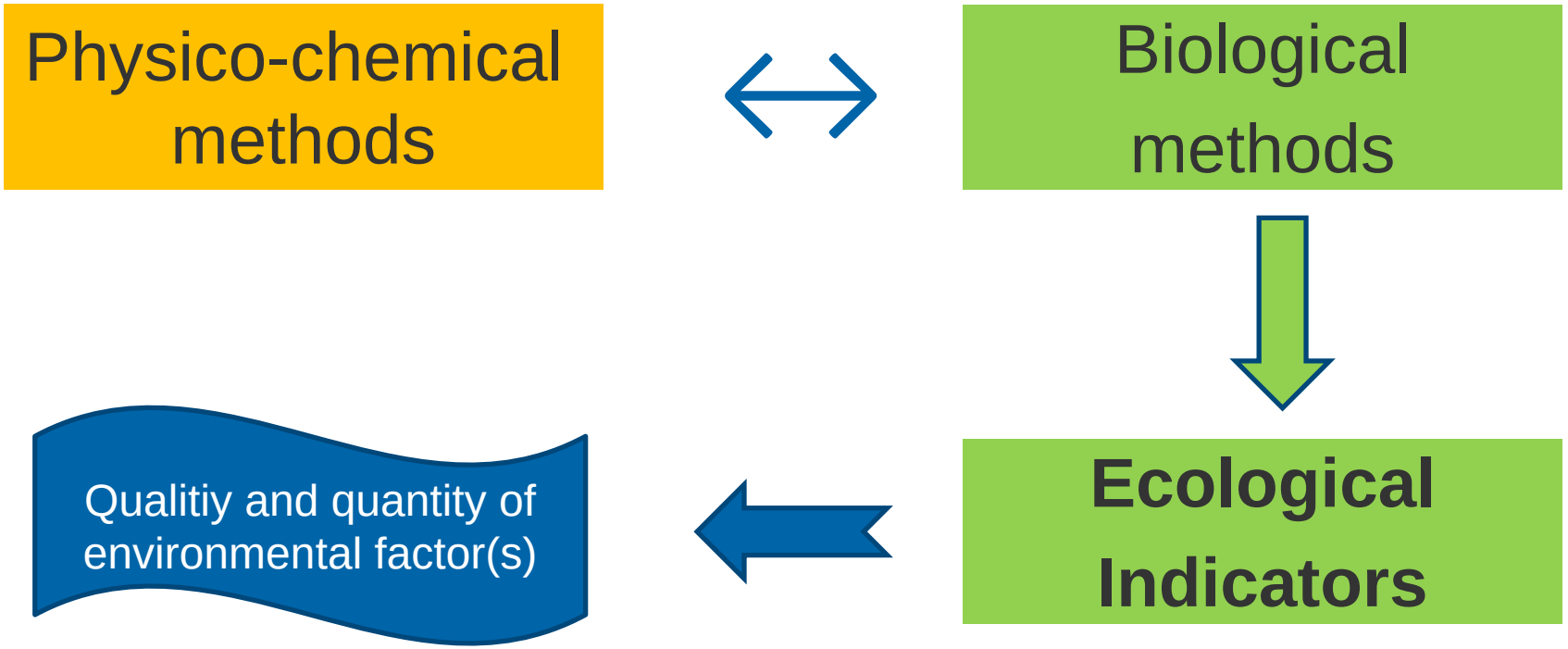


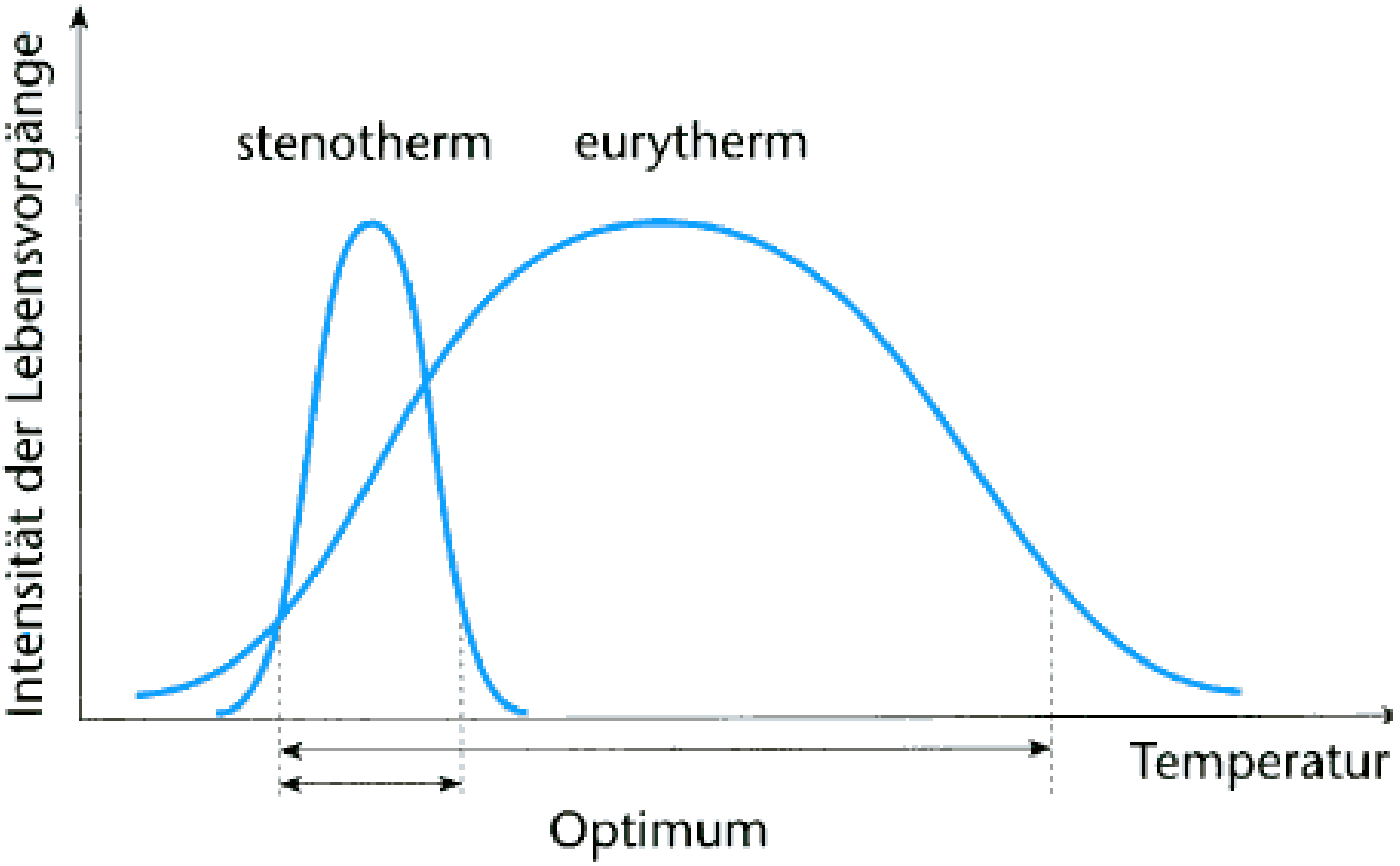
Biological / ecological indicator:

Organism (or part of it / assembly = community, ecosystem)

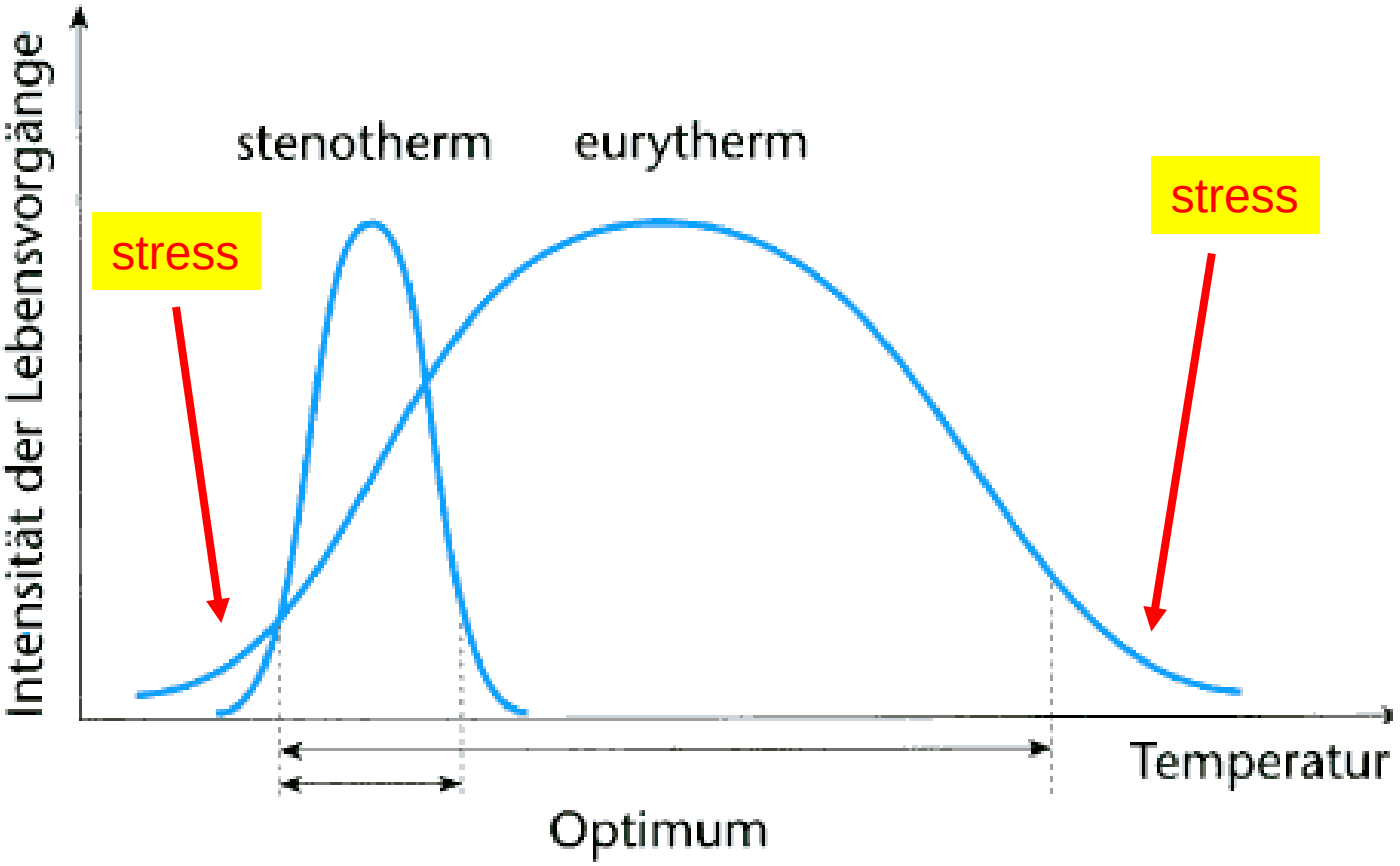
which points to (anthropogenic) environmental stress

by presence / absence or characteristic responses

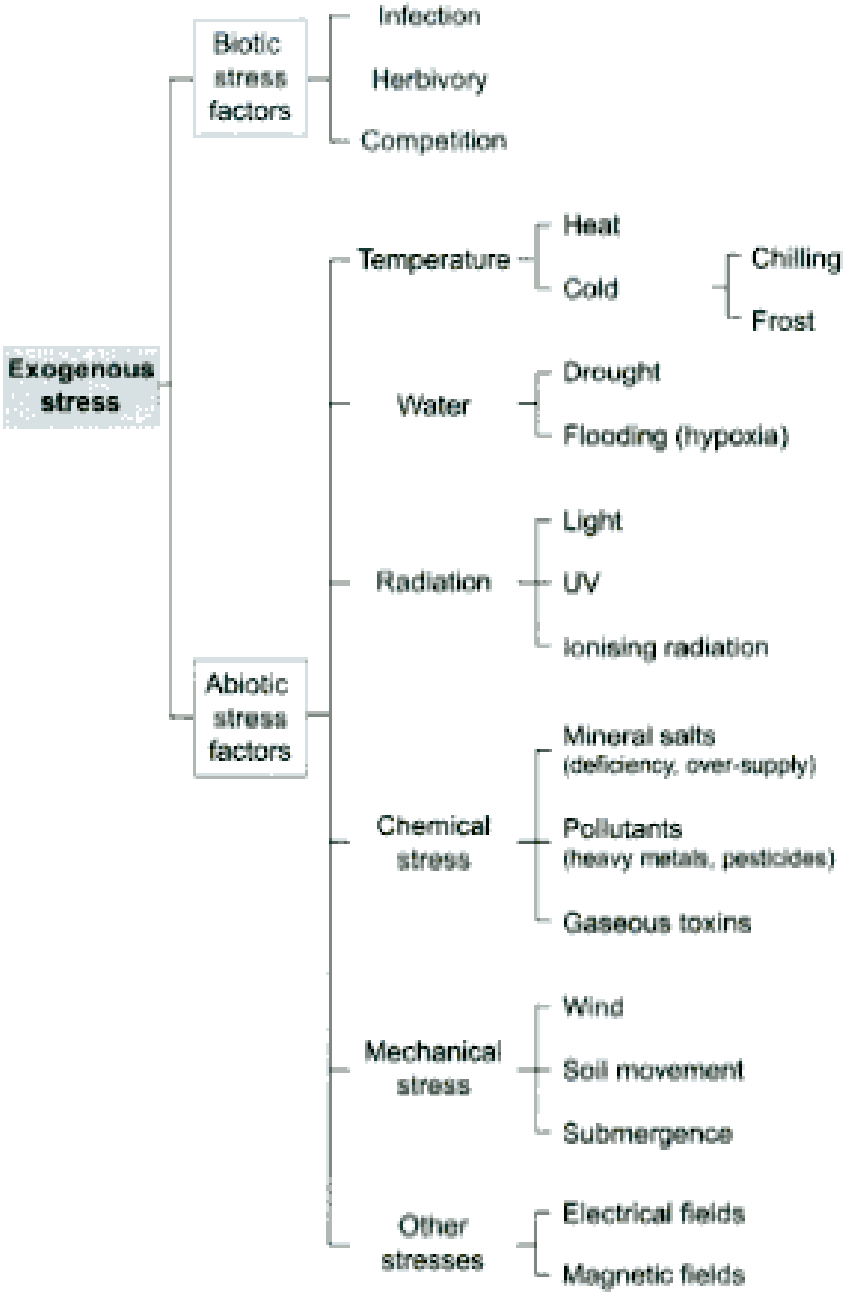
Species response / tolerance curve



Species response / tolerance curve

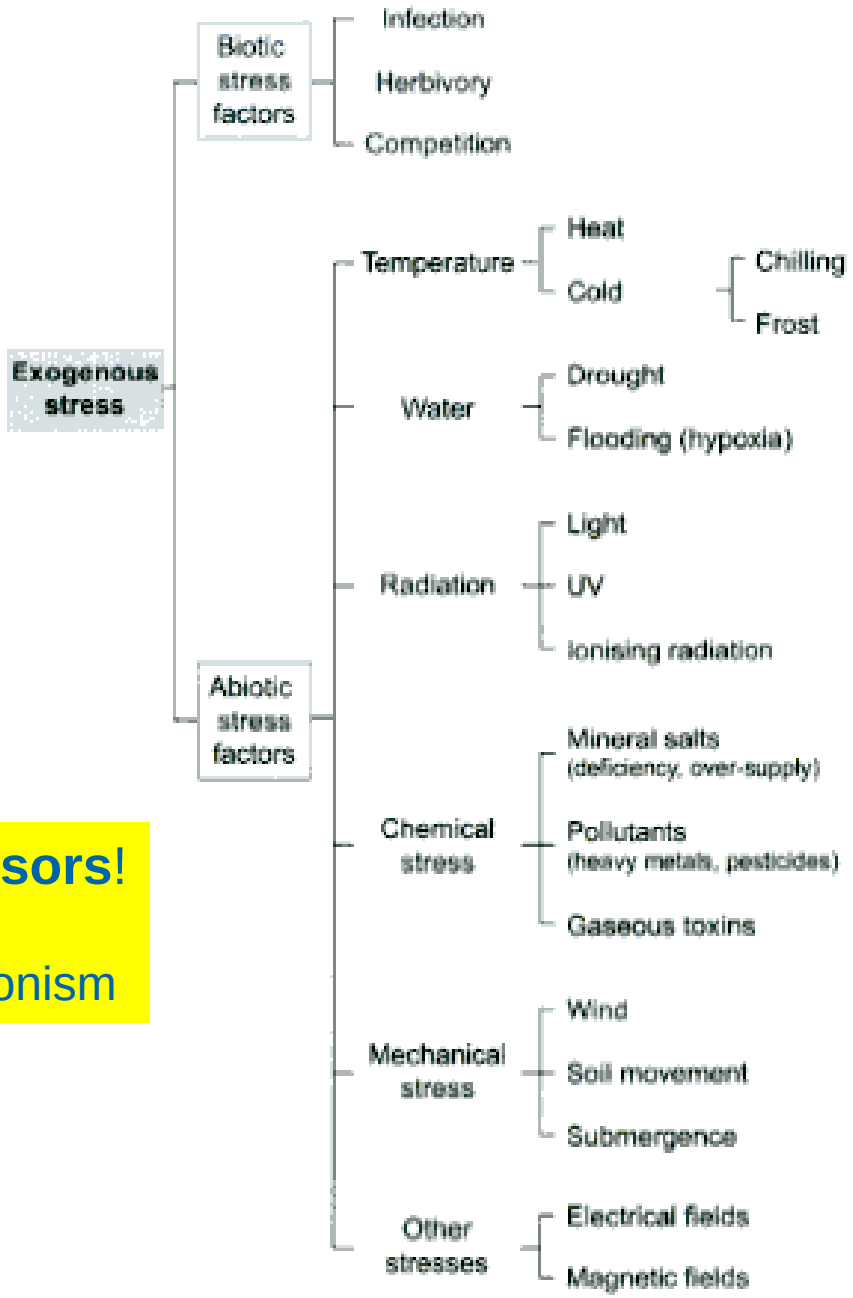


Stressors



Schulze et al. (2005)

Stressors



interaction of stressors!

→ synergism & antagonism

Schulze et al. (2005)

Stress response of an ecological indicator depends on

- State of nutrition and health
- Age
- Sex
- Metabolic activity
- Body size and weight
- Behaviour, e.g. feeding
- Genetics (resistence, resilience)
- Reproductive activity
- …

→ pre-disposition of organisms!

→ variability within populations!

Different levels of bioindication

- Macromolecules
- Cells
- Organs
- **Organisms**
- Populations
- Communities
- Ecosystems

Levels of responses

1. Biochemical and physiological responses
2. Anatomical, morphological and biorhythmic responses
3. Floristic and faunistic responses
4. Community changes
5. Ecosystem changes
6. Landscape changes

Requirements

1. Fast and easy to record / perform (bio- / ecological tests)
2. Sufficiently accurate und reproducible results
3. Objects for bioindication should be
    - abundant (large numbers)
    - widely distributed
    - longlived
    - sufficiently large
    - easy to identify
    - all-year-round active / accessible
4. Low error margins (<20%)

Types of Ecological Indicators

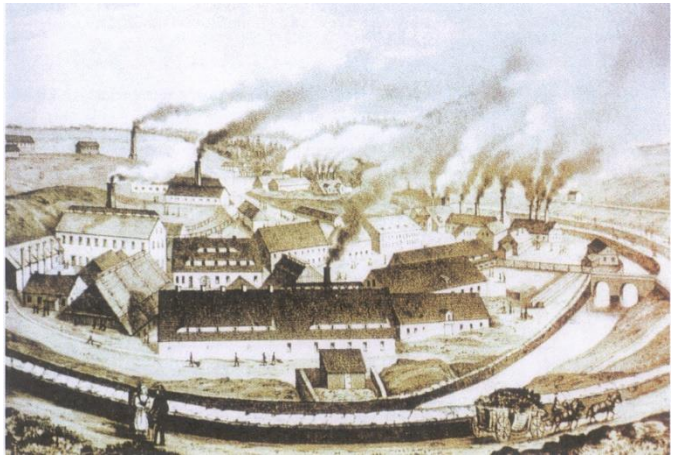
1. Indicator organisms (Presence / absence – abundance / vitality)
2. Response Indicators (organismic performance at different levels)

Terrestrial Indicator Organisms

1. Lichens
2. Plants

Lichens as bioindicators of air pollution

Lecanora muralis as an epilithic biomonitor for airborne trace metals



https://www.visitthereach.org

Lichens as bioindicators of air pollution

absorb contaminants (heavy metals, SO_2) over their entire surface (no cuticle)

advantages:

- high sensitivity
- long life-span
- wide range of distribution and habitat conditions
- low seasonal variability in physiological activities

but:

- slow response
- confounding effect of microclimate
- buffering effects caused by substrates

Heavy metals and trace elements

- concentration of heavy metals and trace elements in lichen thalli directly correlated with those in environment
- correlation between chlorophyll damage and concentration of several elements in lichens,

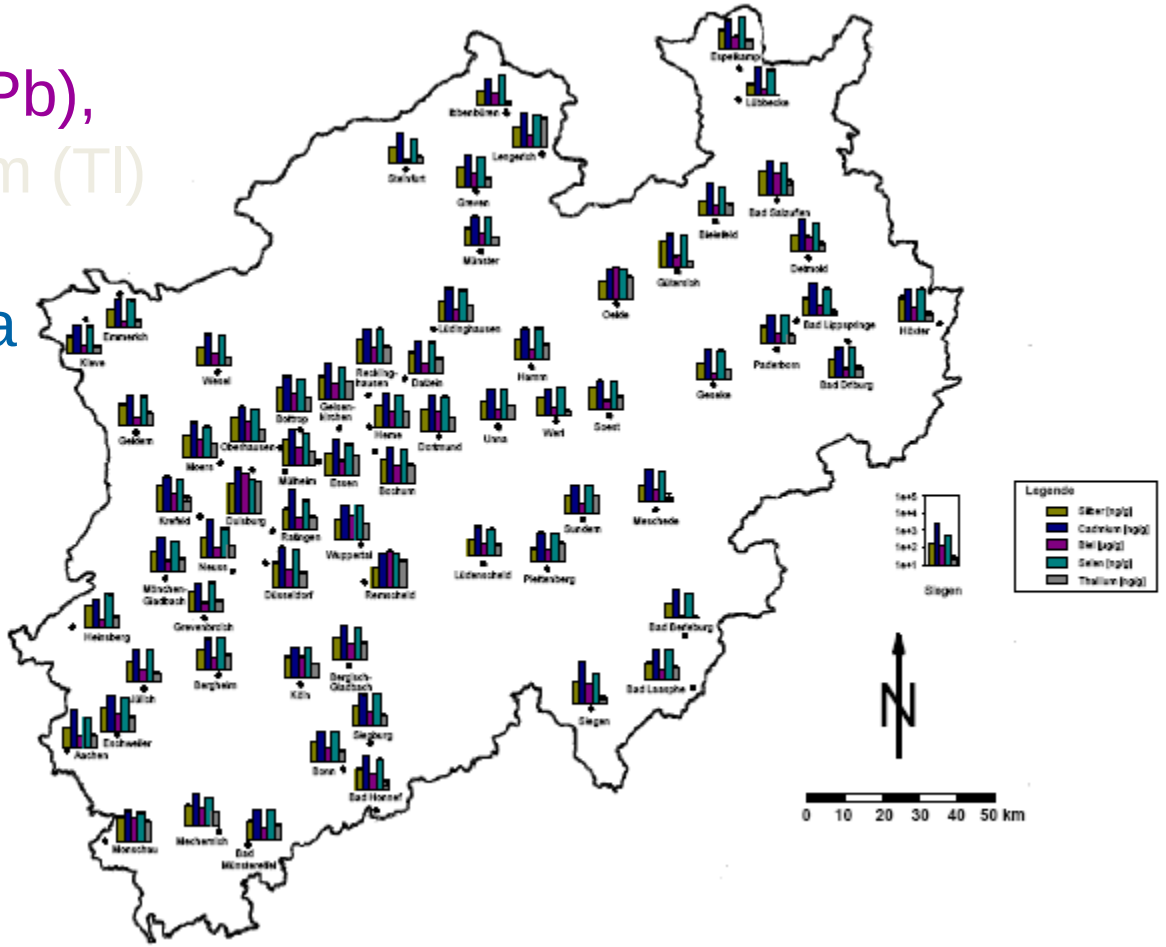
  e. g. Cr, Fe, Mn, Ni, Pb and B

– importance of climatic factors for bioaccumulation of heavy metals, especially wind direction

Northrhine-
Westphalia

Lecanora muralis as an epilithic biomonitor for airborne trace elements

Content of silver (Ag), cadmium (Cd), lead (Pb), selenium (Se), thallium (Tl) in lichen thalli from Northrhine-Westphalia



Lambrecht (2001)

Plants as bioindicators of soil quality

Types of plant bioindicators

- indigenous organisms → “passive” biomonitors
  → spatial distribution of bioavailable pollutants
  (e.g. heavy metal resistant / accumulating plants)

Festuca ovina

Calluna vulgaris (**excluder**)

Silene vulgaris

Minuartia verna

(accumulators)

Heavy metal accumulators on mine spoils

Armeria maritima

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Levels of responses

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Soil enzymes as biomonitors for soil pollution

soil pollution

→ effects on size, composition and activity of soil microbial community,

e.g. soil respiration
cellulose decay
litter decomposition
nitrogen mineralization
soil enzyme activities

(https://www.researchgate.net/publication/284111276_Enzymes_in_Soil,
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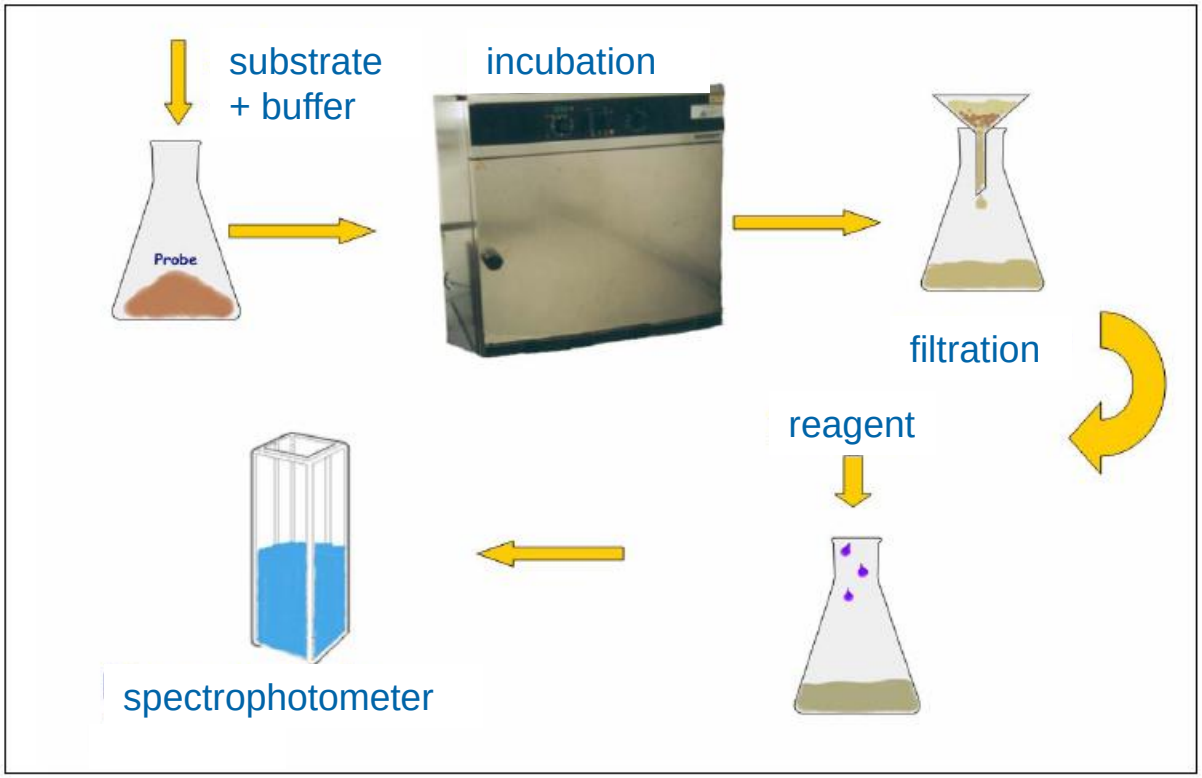
Effect of trace metals on soil enzyme activities





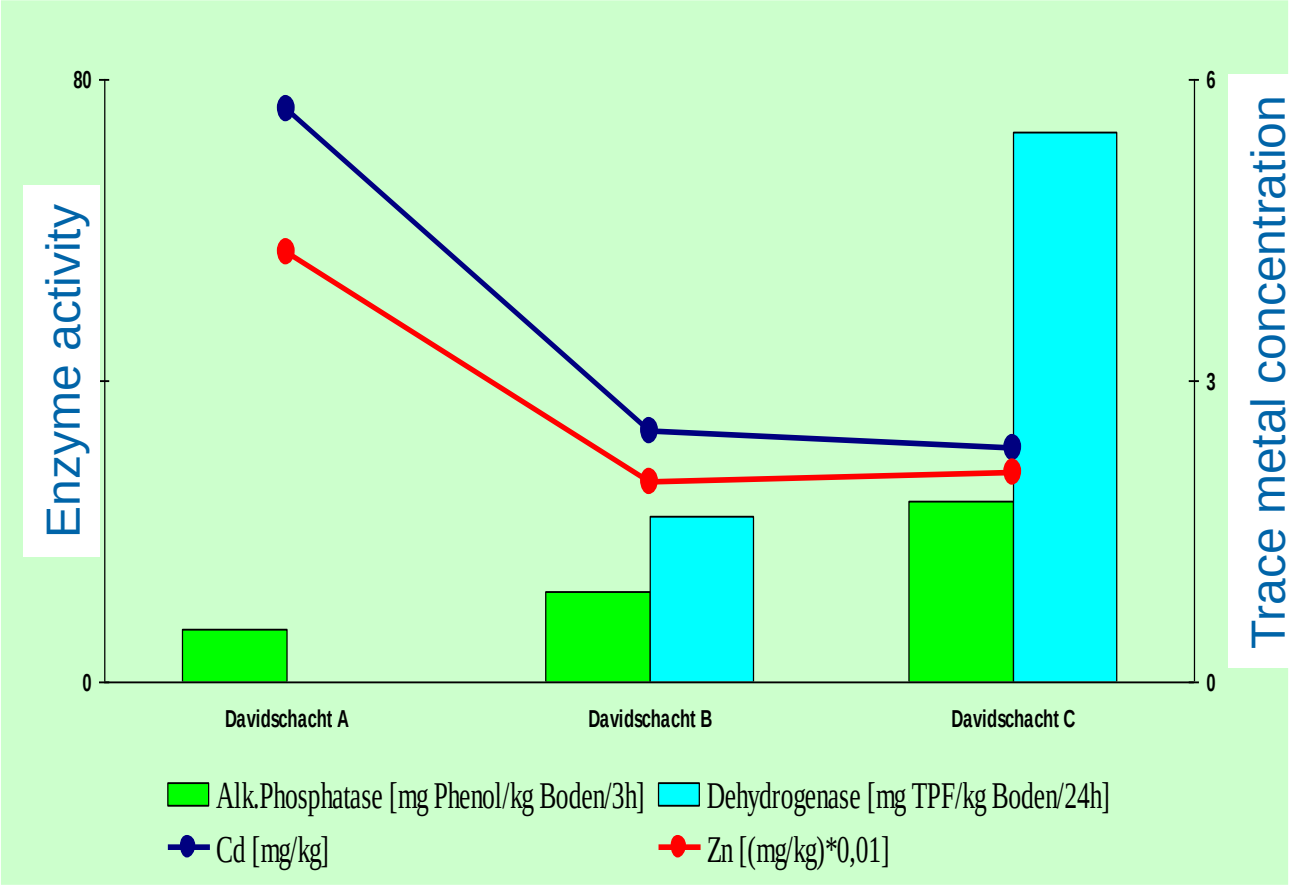
	Aue (floodplain of Mulde river)	Lichtloch	Davidschacht	Rauchblöße
As (mg/kg): 0.1	0.05	5.6	n.d.	4.1
Pb (mg/kg): 91	36.8	36.8	340	1800
Cd (mg/kg): 13.8	6.8	2.3	5.7	2.6
Zn (mg/kg) : 662	270	90	427	38

Determination of enzyme activities in soil samples



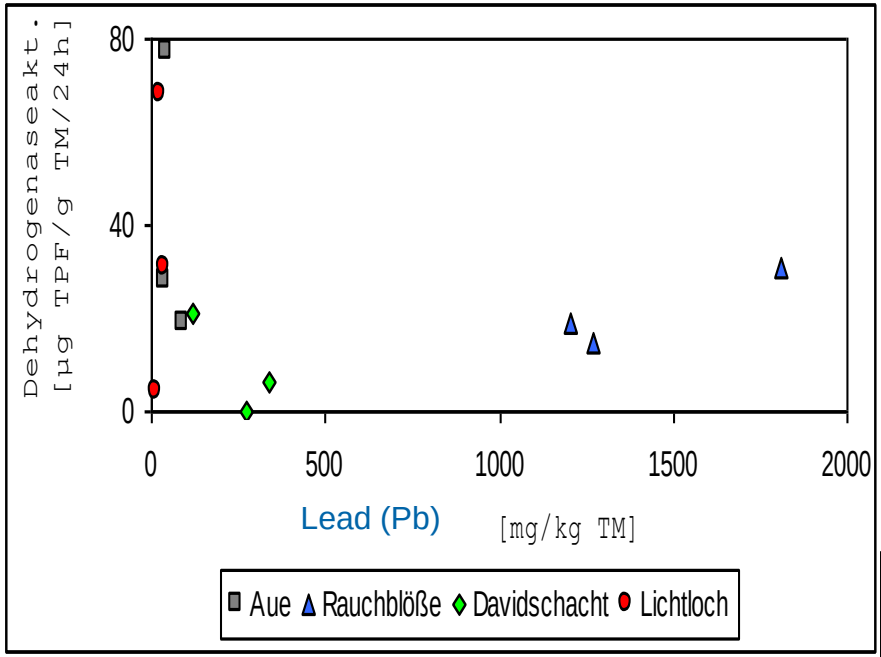
Huhle (2004)

Mining deposits

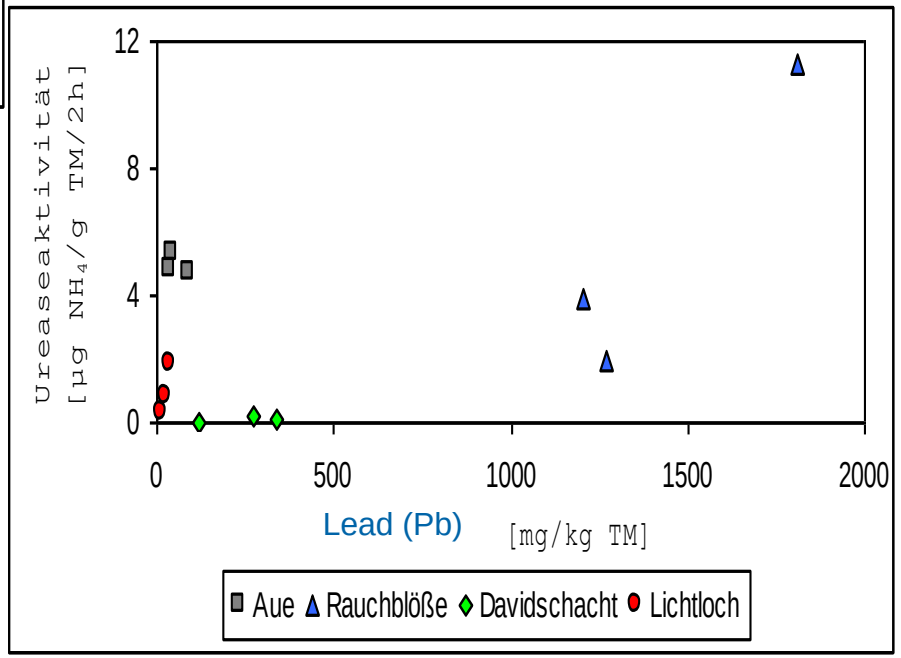


Hofmann (2006)

Dehydrogenase



Urease



Hofmann (2006)

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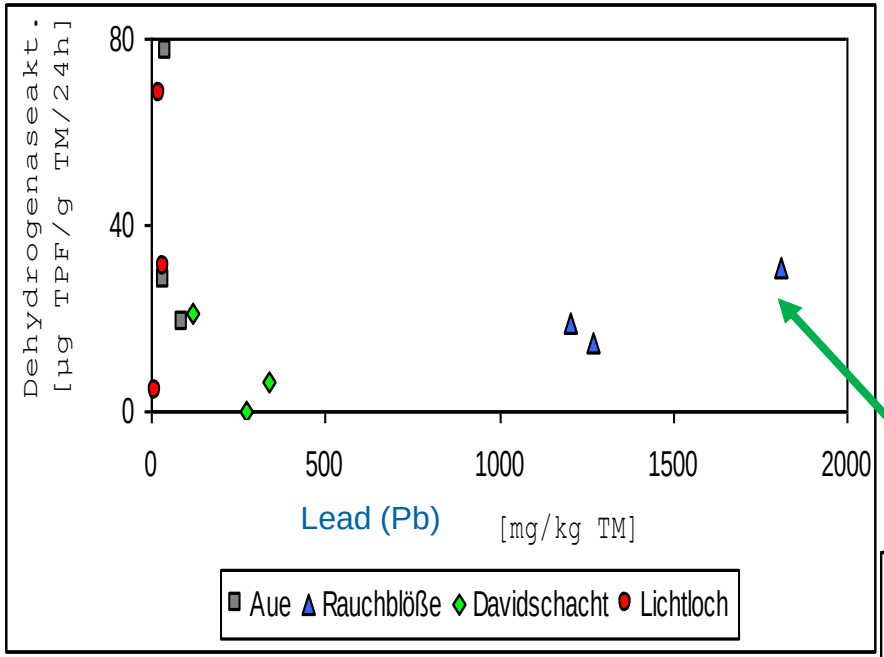
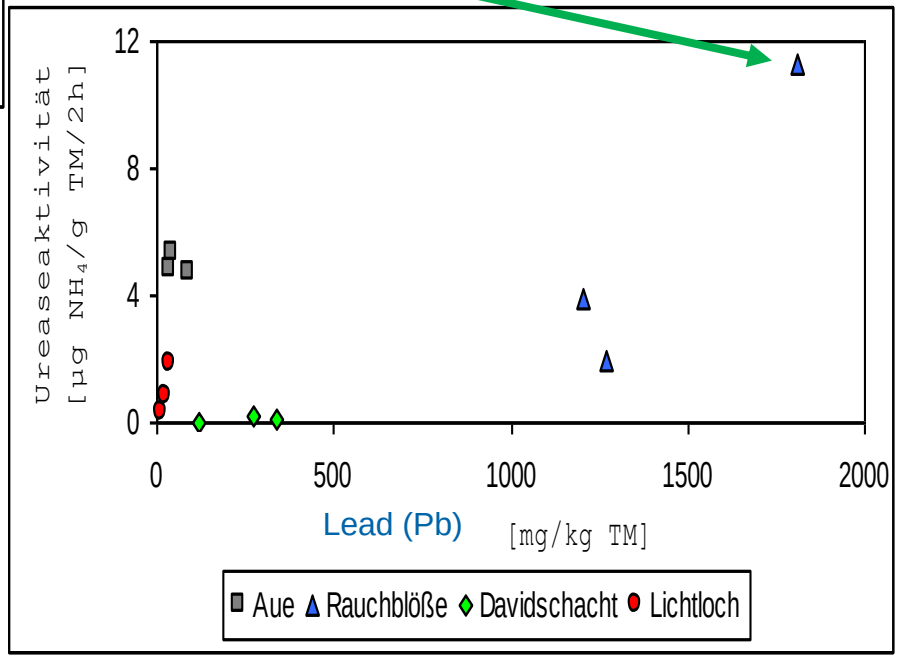


Soil organic matter

Urease



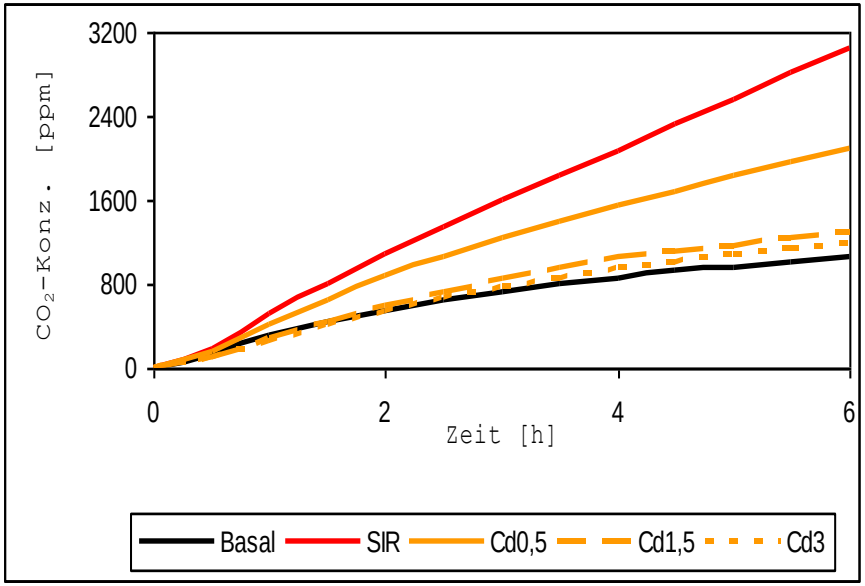
Hofmann (2006)

Soil respiration

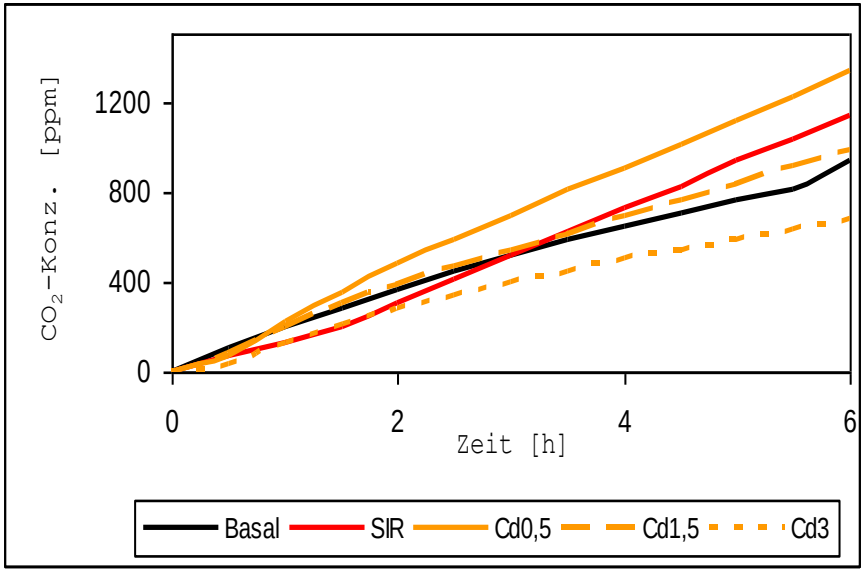
Hofmann (2006)

Soil respiration

Reference site (arable field)



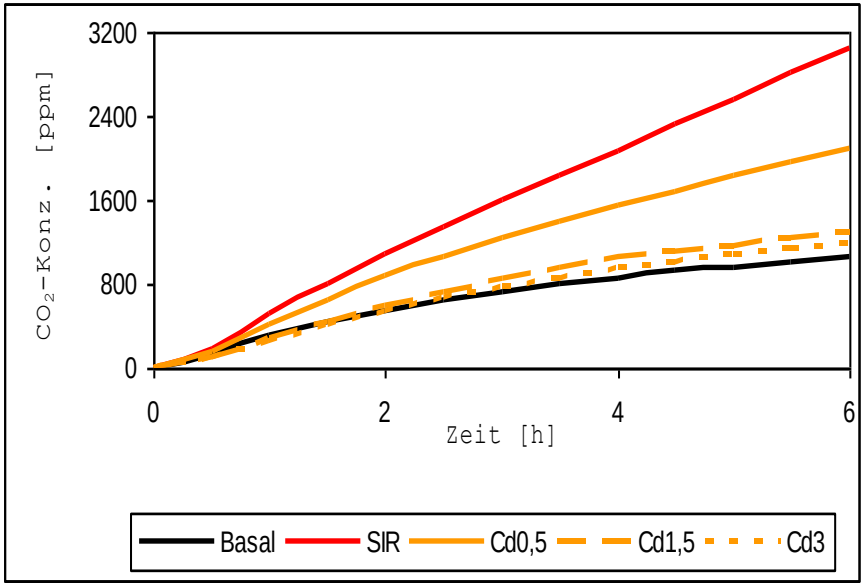
Contaminated site (mining dump)



Hofmann (2006)

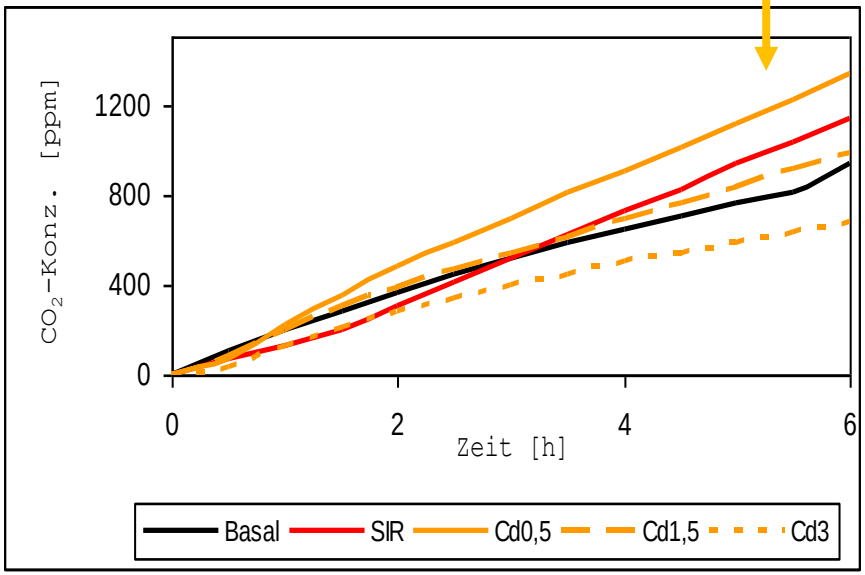
Soil respiration

Reference site (arable field)



increased tolerance
due to adaptation

Contaminated site (mining dump)



Hofmann (2006)

Succession in post-mining landscapes: Soil quality

Tagebau
Nochten

Succession in post-mining landscapes: Soil quality

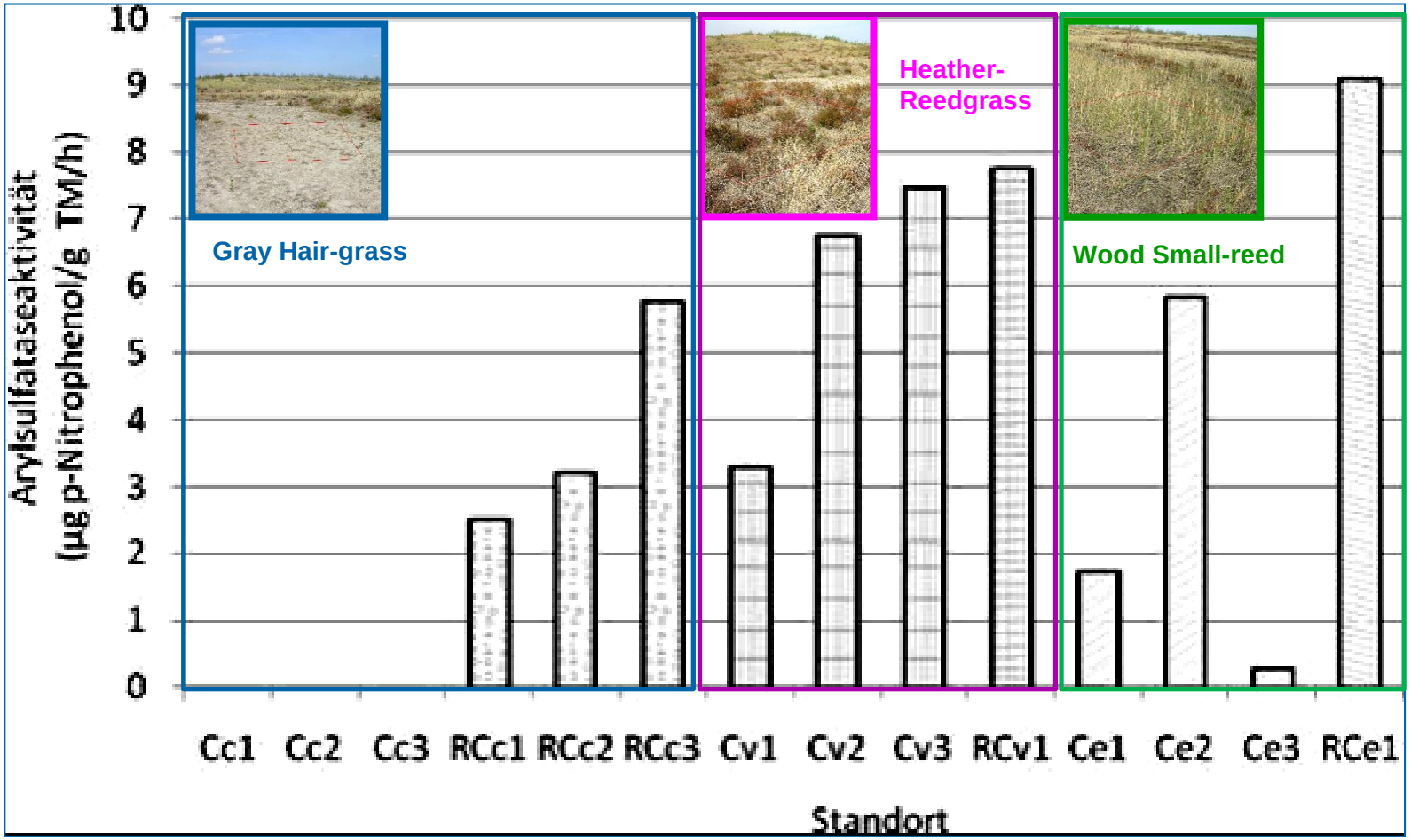
Gray Hair-grass:
sparsely populated by
Corynephorus canescens

Heather-Reedgrass:

Mixture of *Calluna vulgaris*
and *Calamagrostis epigejos*

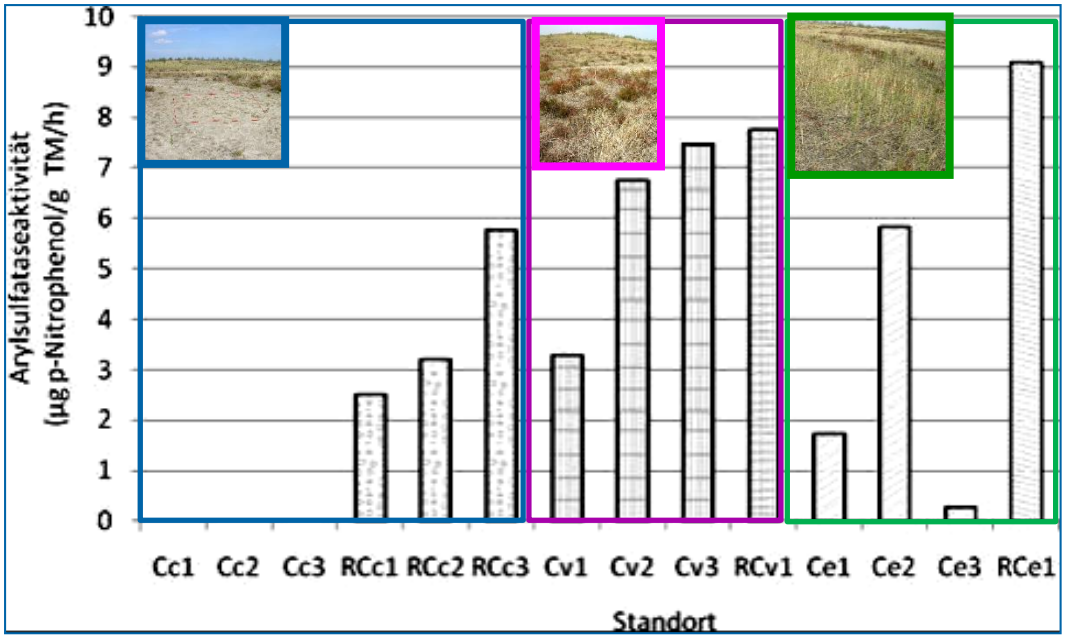
Wood Small-reed:
densely populated by
Calamagrostis epigejos

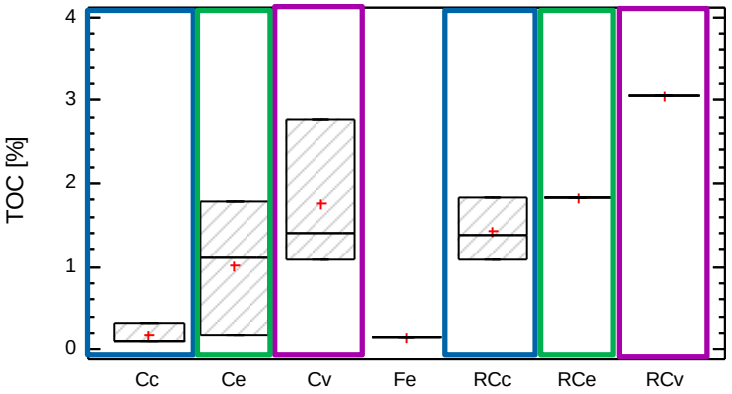
Succession in post-mining landscapes: Soil quality



Mahns & Ritter (2009)

Succession in post-mining landscapes: Soil quality





Soil organic matter

Mahns & Ritter (2009)

Take-home messages

1. Ecological indicators are cheap, usually abundant and widely distributed instruments for assessing environmental quality.

   Nevertheless, a number of biological factors determines pre-disposition of organisms and variability of their responses.
2. The tolerance curve of a species determines its suitability as an ecological indicator.
3. (Post-)Mining landscapes are characterized by a variety interacting environmental stressors.
4. Individual organisms act (i) through pre-/absence or abundance & vitality or (ii) as response indicators by their performance at different levels of biological organization.
5. Sessile terrestrial organisms (e.g. lichens and plants) are effective indicators for air and soil quality.
6. Soil enzyme and soil microbial activities can be sensitive indicators of environmental pollution, depending on other soil properties.
7. Soil quality changes during succession e.g in restoration projects in the post-mining landscape can be mirrored by activity of soil enzymes as dependent on content of soil organic matter.

Review questions

1. Which physico-chemical methods for assessing environmental quality do you know?
2. How do physico-chemical and biological methods for assessing environmental quality differ? What are advantages and disadvantages for both of them?
3. What makes it easy to work with organisms as biological indicators? Which properties must an organism have to act as an indicator? What do you have to consider when using an organism as an ecological indicator?
4. Which type of response to an environmental factor (tolerance curve) would you expect for a suitable ecological indicator? Why?
5. Which type of stressors do you expect in a (post-)mining landscape? Which types of interactions may be synergistic, which antagonistic?
6. How would you tackle the problem of variability within populations in an ecological study of environmental indication?

Review questions (cont.)

7. When trying to elucidate mechanisms (i.e. causes for the damaging effects e.g. of a pollutant), would you go from the level of an organism to lower or to higher levels of biological organization?
8. Which of the requirements of an ecological indicator may be difficult to fulfil in a stressful or polluted environment?
9. What is the advantage of using sessile organisms for ecological indicators for air and soil quality?
10. What soil properties my determine the effectiveness of soil enzymes for bioindication?
11. Individuals (plants, animals, microbes) from stressful and / or polluted sites may show increased tolerance to stressors and pollutants. How can you set up an experiment to test their quality as ecological indicators?
12. *Armeria maritima* and *Minuartia verna* have a rather narrow ecological niche and are occurring in much fewer habitat types compared to *Calluna vulgaris* (heather) and *Calamagrostis epegejos* (wood small-reed). Which of the two types of plants would you prefer as an ecological indicator?


Glück Auf!