Towards type-specific nutrient standards for lakes in Flanders (lower Belgium)

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Nutrient standards today

	general	special
TP (mg.l^{-1} P)	always < 1, average < 0.3	< 0.3 (drinking)
MRP (mg.l^{-1} P)	always < 0.05	-
ammonium (mg.l^{-1} N)	always < 5, average < 1	< 0.78 (fish) < 3.1 (drinking)
Kjeldahl-N (mg.l^{-1} N)	always < 6	≤ 3 (drinking)
ammonia (mg.l^{-1} N)	always < 0.2	< 0.021 (fish)
NO_3^+ + NO_2^+ (mg.l^{-1} N)	always < 10	-
NO_3^+ (mg.l^{-1} N)	-	< 11.3 (drinking)
NO_2^+ (mg.l^{-1} N)	-	≤ 0.009 (fish)

- avoid most severe problems
- little relevance to ‘good status’
- not type specific

Contents

Some approaches, not finalized standards…

- Reference conditions without references…
- Historical nutrient concentrations and G/M
- Some preliminary observations from field data on tentative standards suggested by BQEs phytobenthos and macrophytes

Typology (simplified)

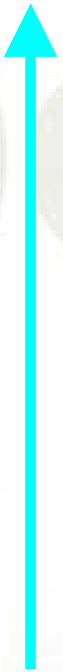
shallow alkaline waters
- strongly mineralised - Ai
- moderately mineralised - Ami

rich clayey and loamy soils, rivers

stratified alkaline waters – Aw

circumneutral waters (stratified or mixed)
- well buffered – Cb
- poorly buffered - Czb

poor sandy soils



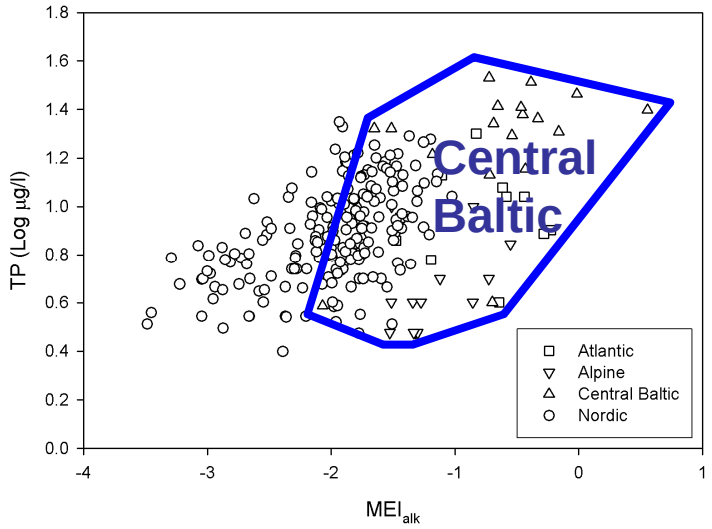
nutrients

higher background

low background

Reference conditions for nutrients?

- very few spatial references nor useful instrumental records; insufficient knowledge on type-specific natural variability of nutrient conditions
- option: apply ‘general’ models to regional water types



Cardoso et al. 2007: deep & shallow

L-CB ref. lakes	MLR-models, ()= SE
humic	log[TP] = 1,65(0,01) – 0,08(0,02)log(altitude) – 0,13(0,04)log(depth) + 0,24(0,03)log(alkalinity)
non-humic	log[TP] = 1,49(0,01) – 0,08(0,02)log(altitude) – 0,13(0,04)log(depth) + 0,24(0,03)log(alkalinity)

- considerable scatter
- generally larger lakes than ‘target’ water bodies in Flanders

Application to site observations

• alkaline and circumneutral types; alkalinity-effect predominant

observed ranges for relevant variables:

type	nr.	altitude (m)	est. average depth range (m)	obs. alkalinity range (mmol.l^{-1})
Ai*	36	2-40	0,5-3	0.99-4.50
Ami*	83	2-100	0,5-3	0.28-3.04
Aw	21	2-40	2-9	0.40-2.60
Cb	10	10-50	0.75-1.5	0.18-1.30
Czb*	23	10-65	0.5-1.5	0.00-0.40

* sometimes humic

- reference: range of median values for highest, resp. lowest depth
- high/good: range of 'maximized' TP estimates by using coefficients + or – 2 SE (to allow for natural variation at high status)

Resulting values

type	reference range	reference	high/good range	high/good
Ai	33-36	35	48	50
Ami	27-29	30	41-43	40
Aw	20-23	20	37-39	35
Cb	19-21	20	29-30	30
Czb	15-16	15	22-23	20

- reference values:
  min. 27 µg l^{-1}, max. 36 µg l^{-1} non-stratified alkaline waters,
  min. 20 µg l^{-1}, max. 23 µg l^{-1} stratified alkaline waters,
  min. 15 µg l^{-1}, max. 21 µg l^{-1} circumneutral waters,
  (averages May-November)
- H/G always < 50 µg l^{-1}
- lower value of H/G range as more precautionary value
- proposal for standard: rounded to nearest 5

Good status?

- ecosystem and biotic responses to increased nutrient loading:
  - different among indicators
  - highly conditional
  - lags will occur
  - tresholds (if any) occur over broad ranges
  - more obvious tresholds reflect less than moderate quality (clear/turbid, lack of macrophytes, predominance of lemnids, oxygen depletion,…)
  - only WFD quality elements?
  - relation to regional typology?
- an alternative starting point may be useful…

Paleolimnology for clues on Good/Moderate?

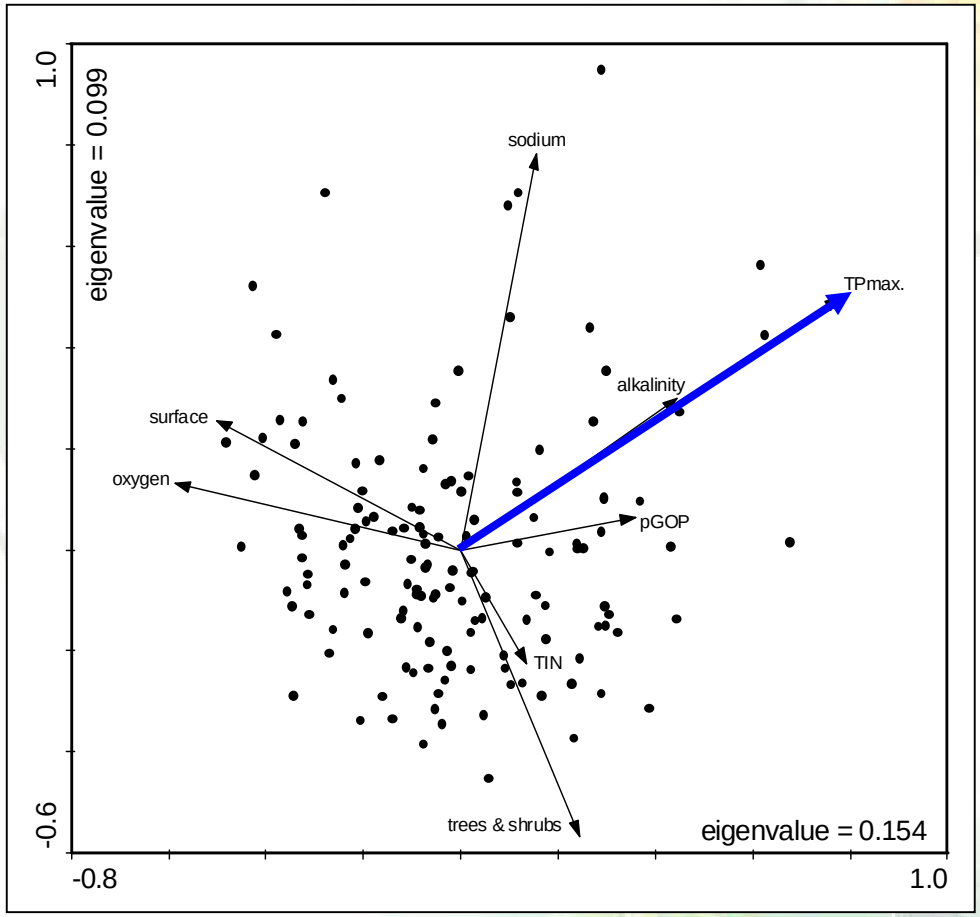
Needed:

1. a historical period for which can be assumed that nutrient loading did not compromise ≈ good status of most water bodies:
   - pre-World War II times may be appropriate

2. a method to estimate former nutrient conditions,
   incl. type-specific and regional variability among water bodies

Epiphytic diatoms in non-acid waters

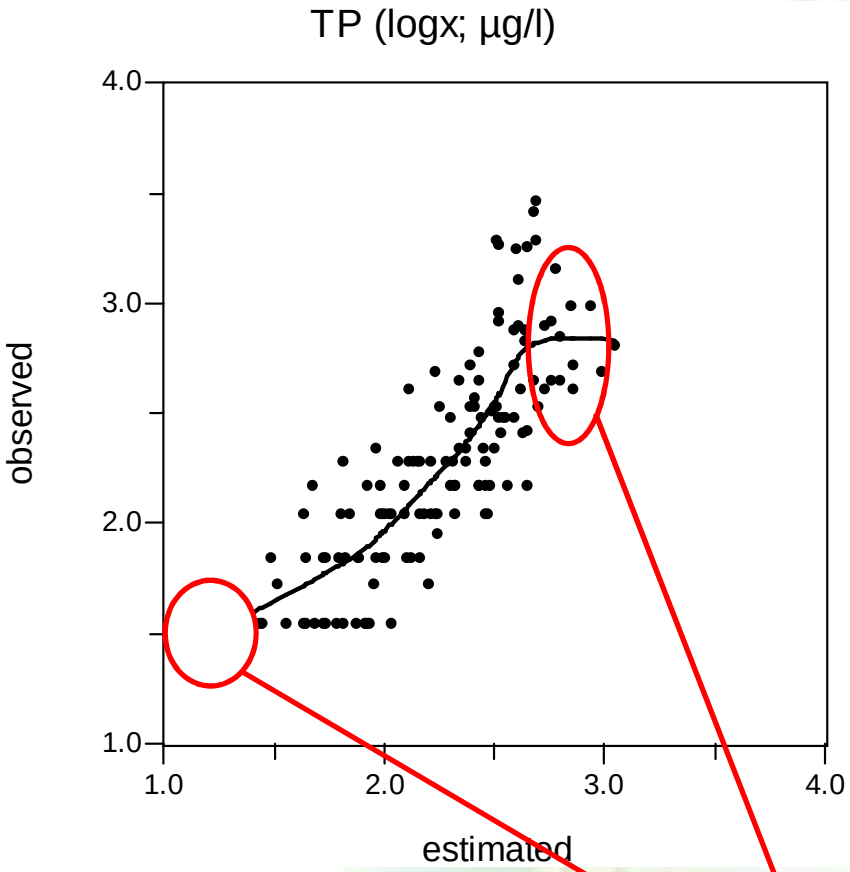
N=137, median pH ≥ 6.5

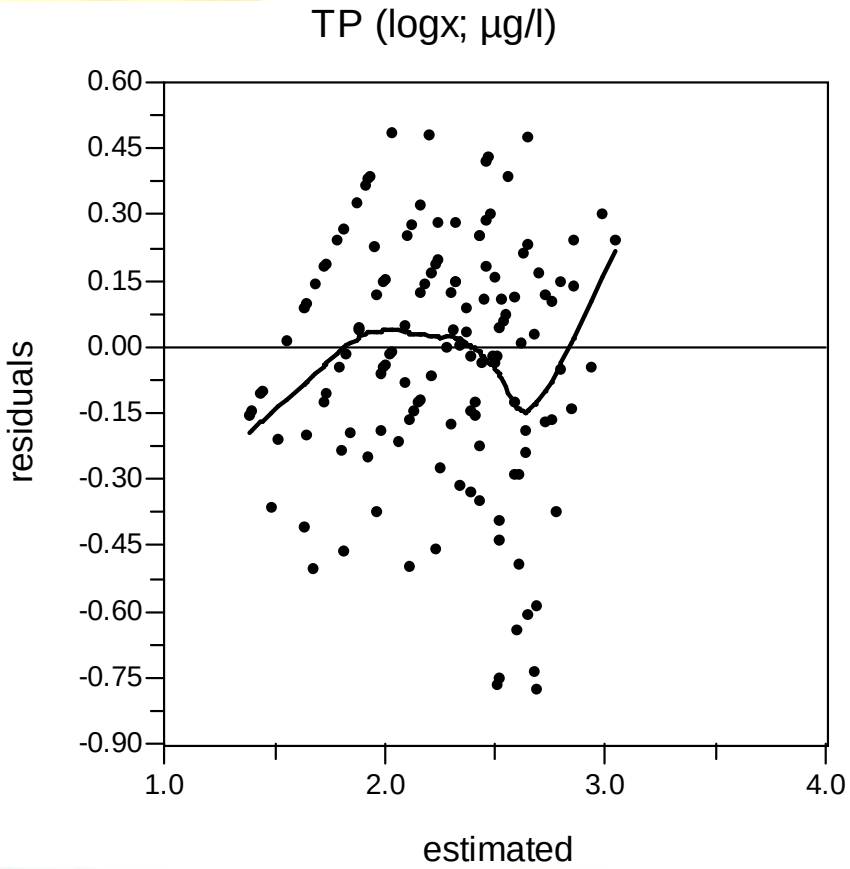


marginal and unique effects (constrained & partial constrained CCAs)

% of species variation	
pGOP (phytopl. prod.)	**2.1 / 2.5**
$TP_{max.}$ (TP_{median})	**3.3 / 2.2) (3.0 /1.9)**
alkalinity	**2.3 / 2.1**
oxygen saturation	**2.1 / 1.5**
sodium	**2.0 / 1.4**
TIN	**1.2 / 1.3**

Calibration model for TP from epiphytic diatoms





- $r^2_{jack.}$ = 0.66
- RMSEP = 0.278 log TP units, 12.3 % range

- moderate precision;
- limited to values 70-500 µg l^{-1}

Estimation of historical type-specific TP values

epiphytic diatom communities on macrophytes from 1850-1940

type	nr.	90th percentile all estimates – 1 RMSEP	tentative G/M value
Ai	27	107	105
Ami	75	72	70
Cb + Czb	16	< 70	-

necessary to stay precautionary (lags,…)

- no analogues for stratified waters
- no useful value for circumneutral waters
- G/M = median H/G range + (median H/G range – reference)

  Aw: 55 µg l^{-1}

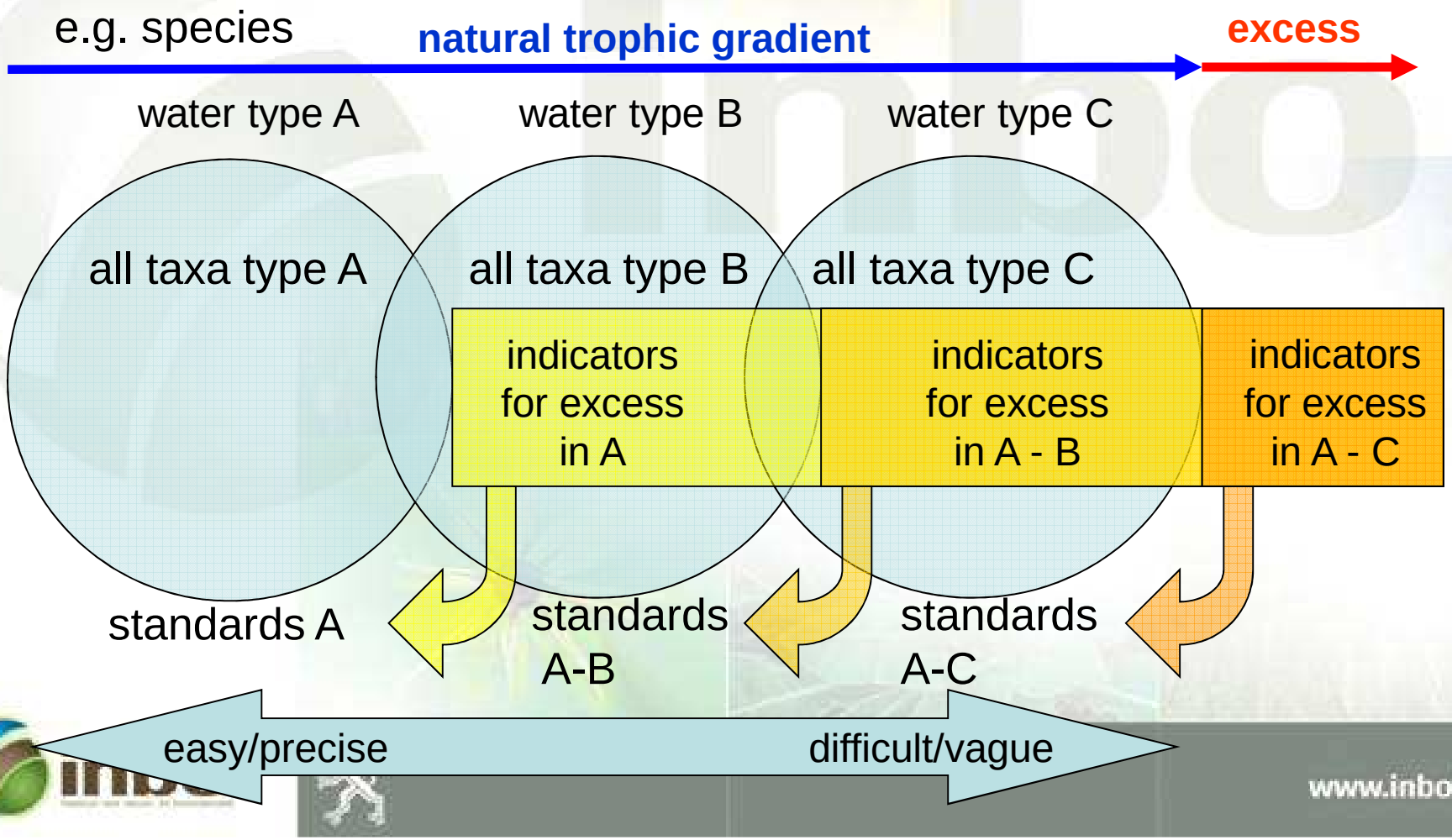
  Cb: 40 µg l^{-1}

  Czb: 30 µg l^{-1}

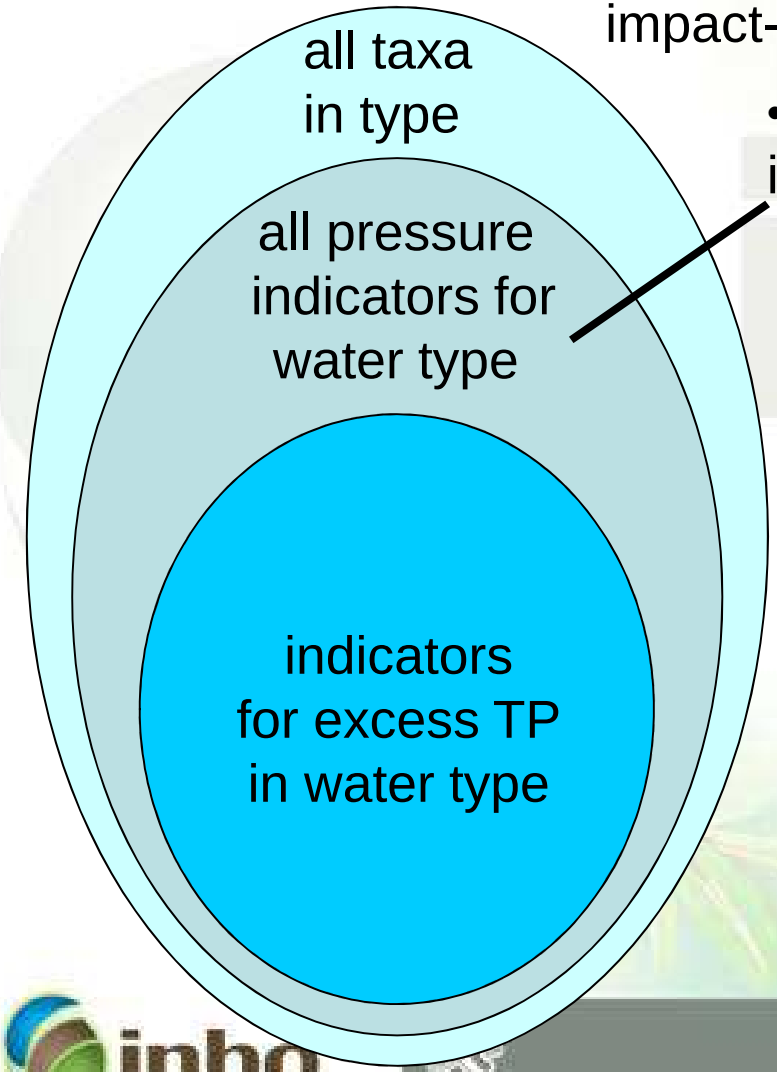
Next step: confront tentative values with nutrient response of indicators …

on a type-specific basis:

- range of natural nutrient conditions
- range of relevant nutrient indicators



Avoid spurious relations… only nutrient response



- e.g. phytobenthos EQR uses proportions of all impact-sensitive and impact-associated diatom taxa
- eliminate taxa considered in EQR but indifferent to TP or relation to TP indetermine

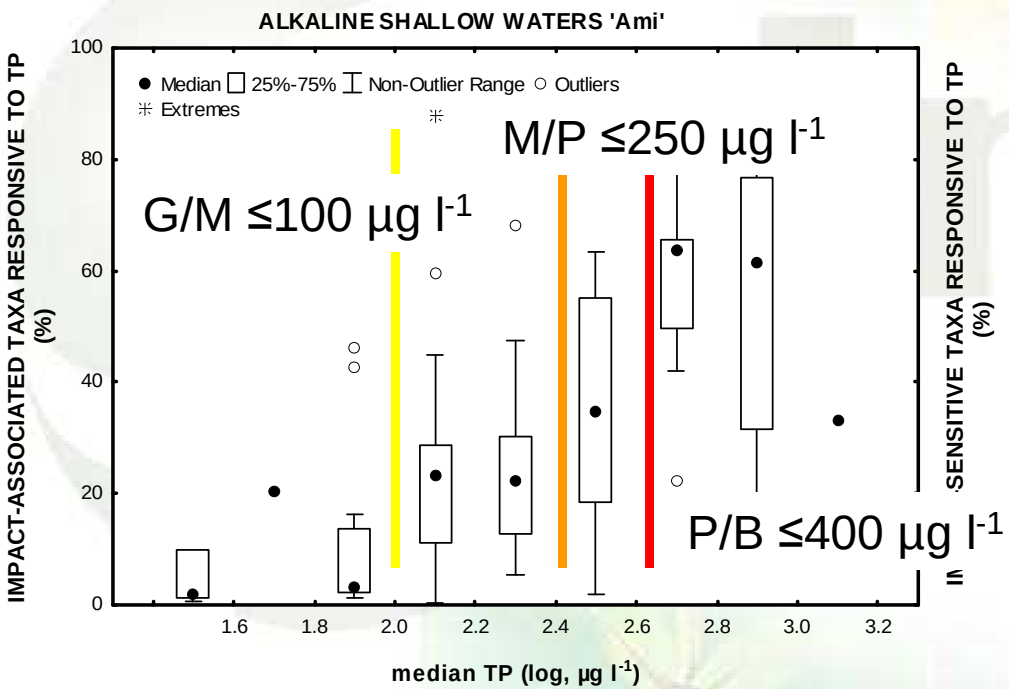
Response of taxa (HOF) to TP (log-transformed) in non-acid waters.

149 taxa	%
I – no response	20.1
II - monotonic	19.5
III - monotonic, plateau	1.3
IV - symmetric unimodal	37.6
V - skewed unimodal	21.5

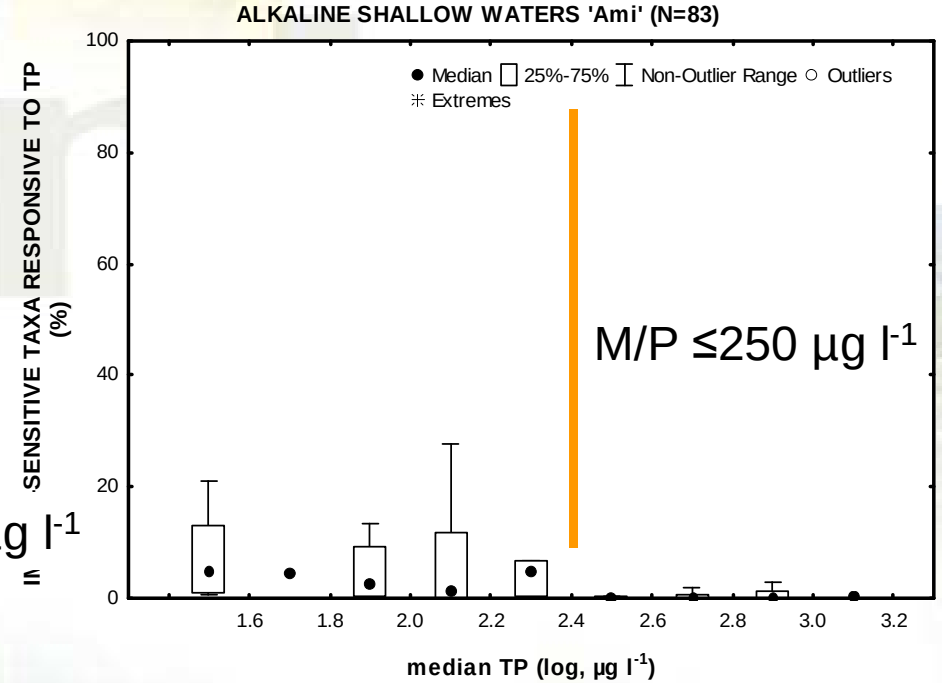
Proportions of type-specific indicator diatoms responsive to TP

- shallow, alkaline, moderately mineralized waters (Ami)

impact-associated taxa



impact-sensitive taxa

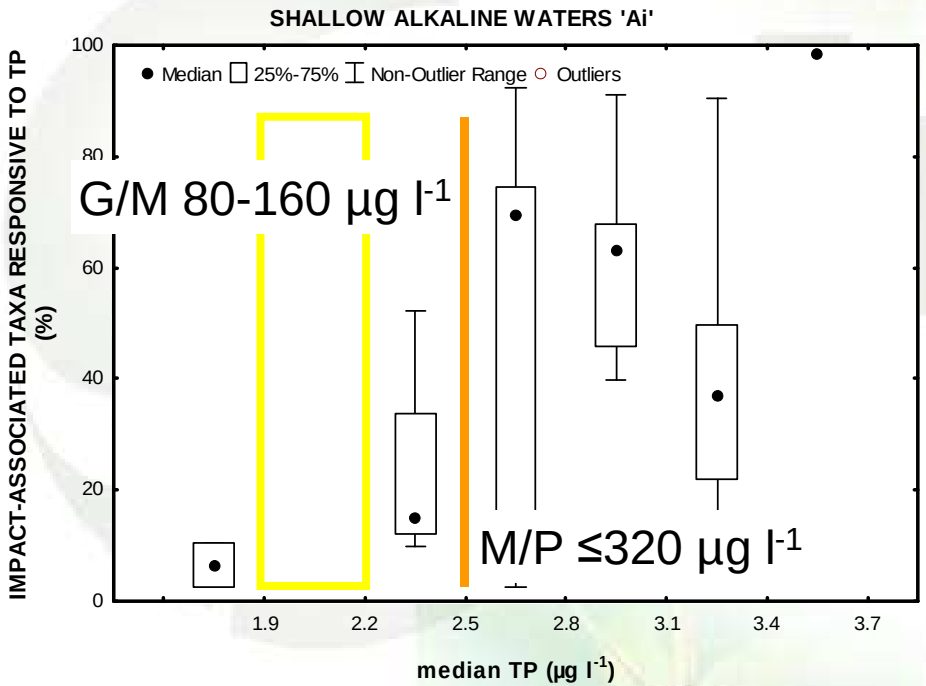


- G/M reasonably consistent with historical G/M of 70 µg l^{-1}
- suggested M/P ≤ 250 µg l^{-1} TP
- suggested P/B ≤ 400 µg l^{-1} TP

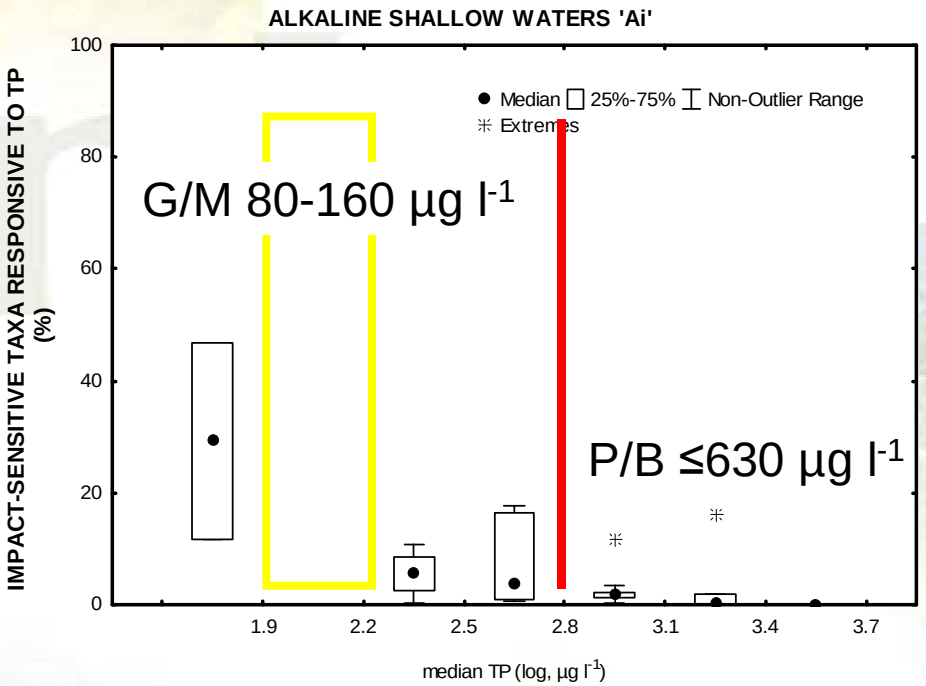
Proportions of type-specific indicator diatoms responsive to TP

- shallow, alkaline, strongly mineralized waters (Ai)

impact-associated taxa



impact-sensitive taxa



- suggested G/M consistent with historical G/M of 105 µg l^{-1}; more data needed
- apparent M/P higher than for Ami: consistent with typological expectations
- perhaps indication of possible P/B at ≤ 630 µg l^{-1}

Indicators not considered in EQRs…

e.g. *number* of submerged macrophyte taxa in a water body

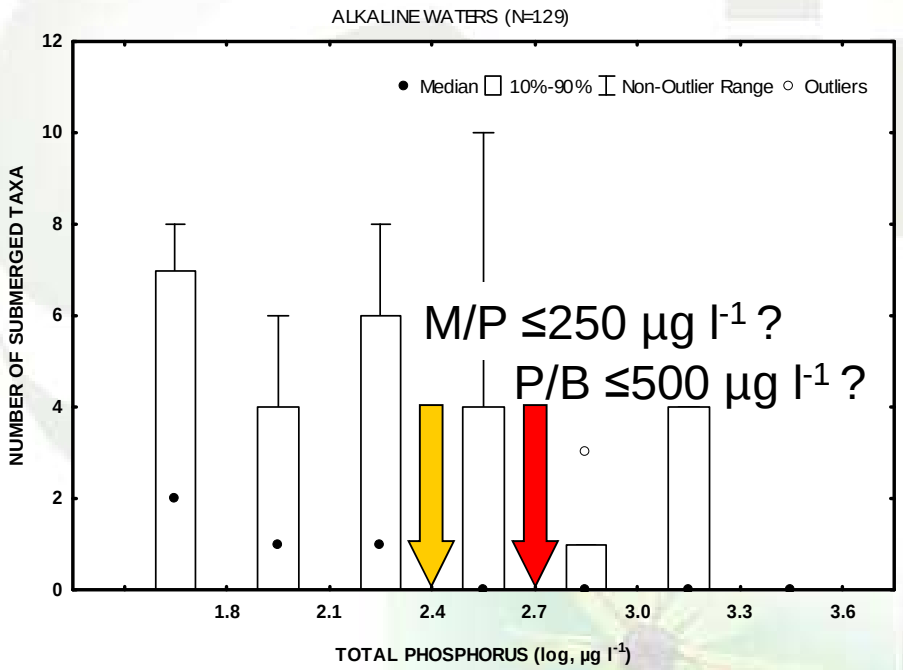
(not used as such in macrophyte EQR)

- 60 shallow lakes UK & Poland (James *et al.* 2005)
- negative relation to winter nitrate/total nitrogen & (less important) winter TP
- ‘good’ ≤ 1-2 mg.l-1 winter nitrate-N

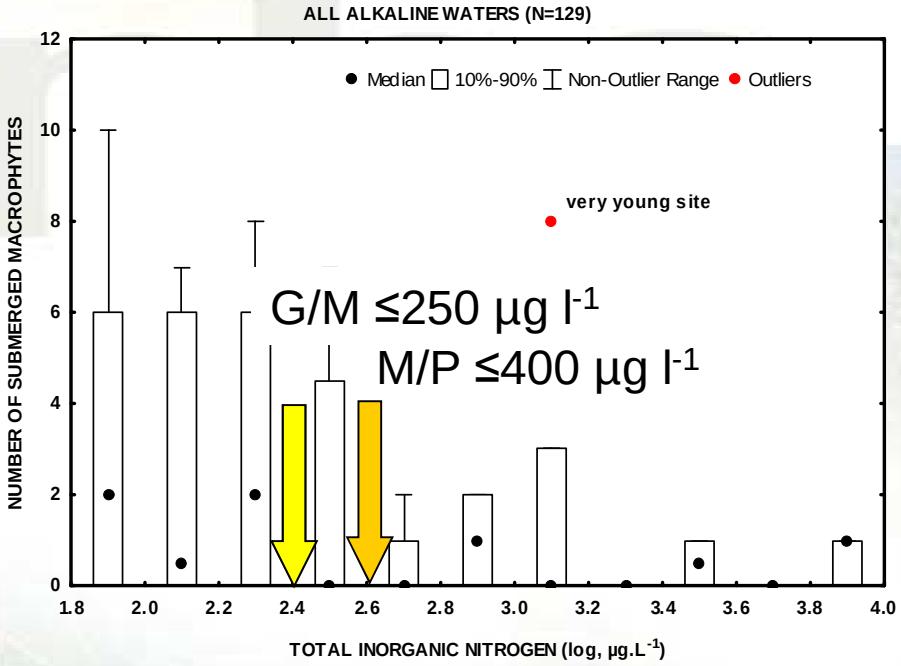
Number of submerged taxa in In Flanders

- 129 alkaline waters: GLZ : 3 significant variables
- gross oxygen production (phytopl.) > TP > total inorganic nitrogen
  (all median values spring-autumn; no improvement with maxima)

TP



TIN

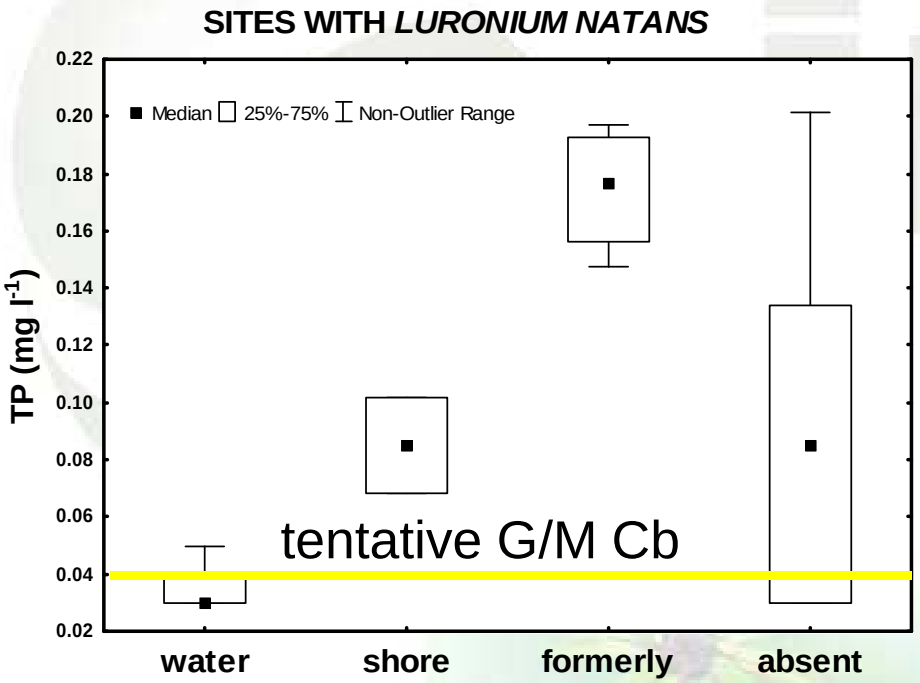


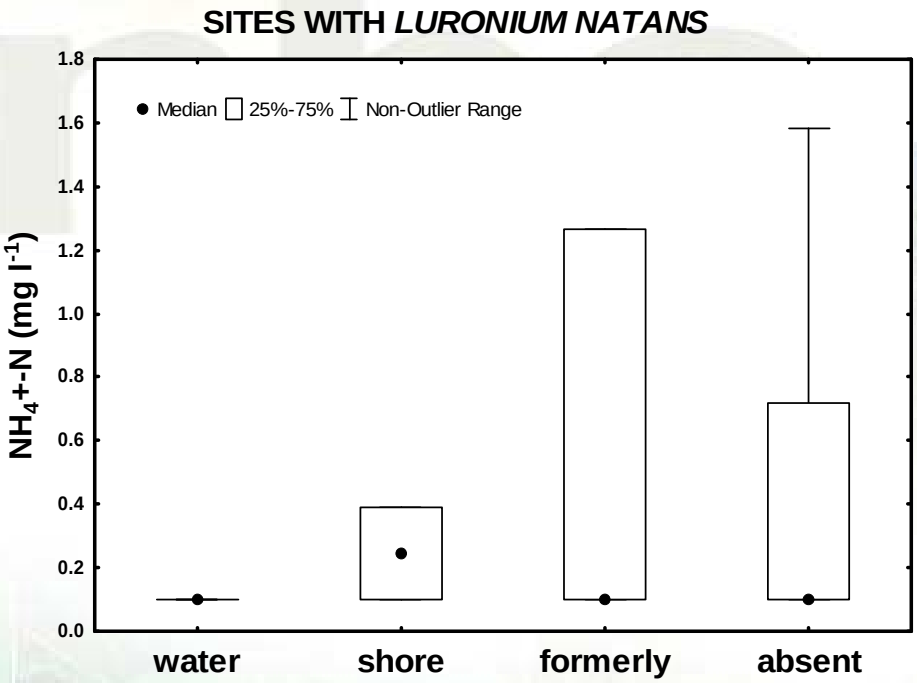
- suggests TP boundaries similar to diatoms
- suggests considerably lower TIN boundaries than 1-2 mg l^{-1}

Indicators not considered in EQRs…

requirements N2000 habitats & species

e.g. Luronium at 41 sites in Asbroek-Langdonken





Conclusions, if any…

data!

- typological consistency is important
- screening different biological indicators → check consistency with historical/model data
- only type-specific indicators are suited to set type-specific nutrient standards
- EQRs should be multi-stressor related; not necessarily best option to set nutrient standards (if they are – are they good EQRs?)
- expand scope of possible indicators
- similar data types in different regional data sets may not yield similar standards → **proceed towards general GIG-wide standards, or keep to regional patterns?**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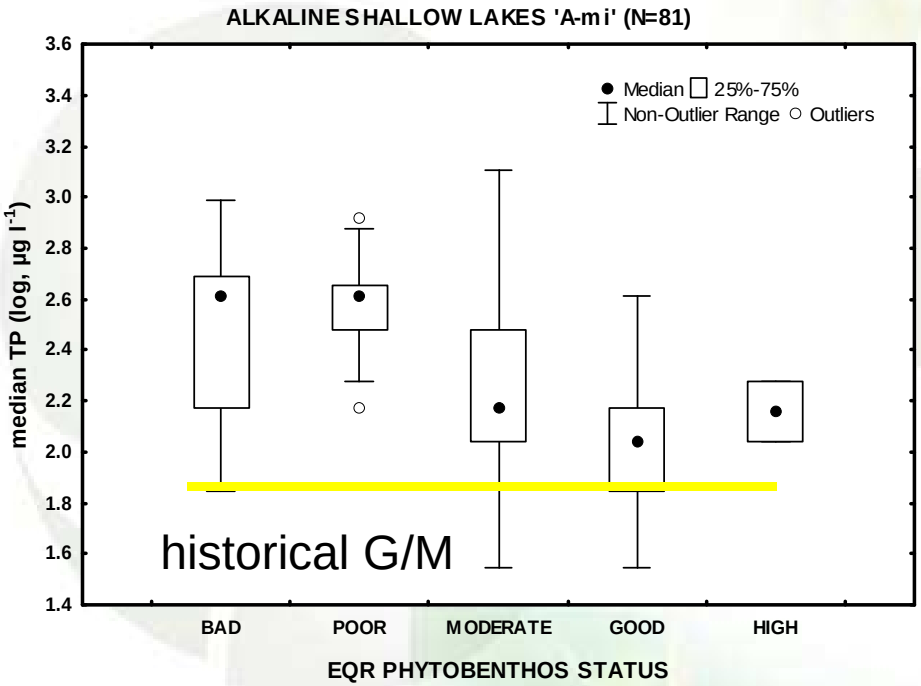
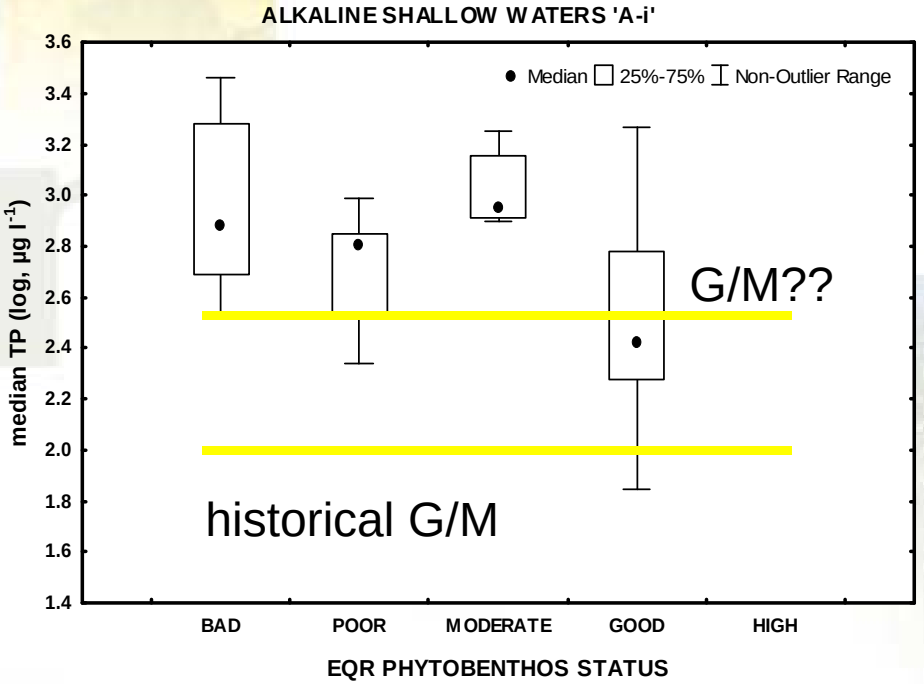
If we had used EQRs to set nutrient standards?





- boundaries not evident
- inconsistent with historical G/M of 70 µg l^{-1}

- type Ai G/M ≈ 320 µg l^{-1}; vague
- inconsistent with historical G/M of 105 µg l^{-1}

Relations to EQRs

Phytoplankton (chl a & cyanobacteria): no relation to TP (data BIOMAN)