

Experiências de restauração de lagos da Holanda: o que funciona e o que não funciona

02-08-2019, Miquel (Mike) Lürling

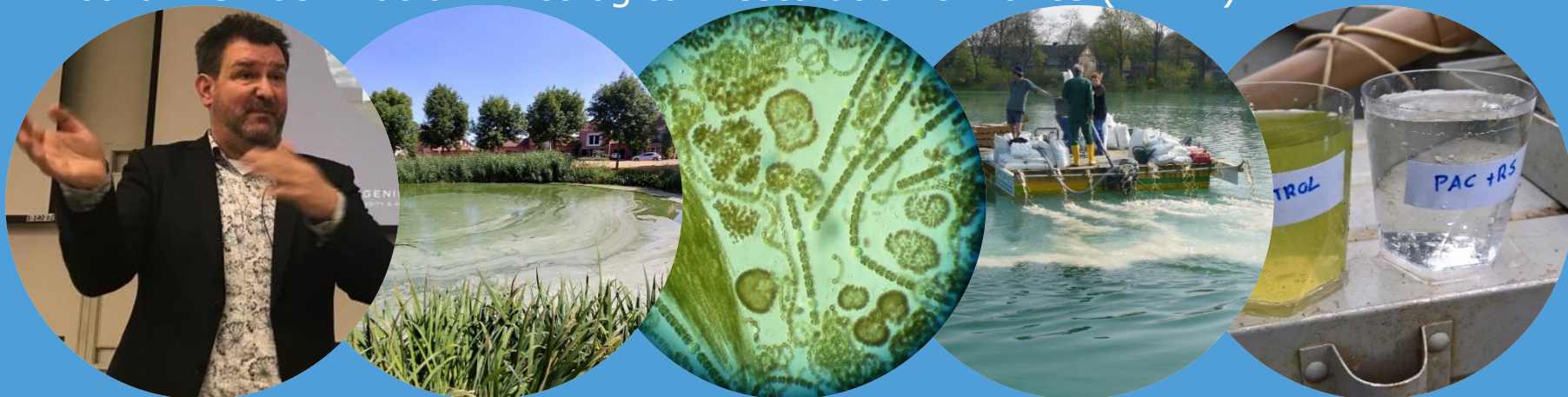
Wageningen University, Aquatic Ecology & Water Quality Management Group

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Chairman Lake Restoration Work Group (Int'l Limnology Society, SIL)

Board member Platform Ecological Restoration of Lakes (PEHM)



Eutrophication = no.1 water quality issue in the Netherlands

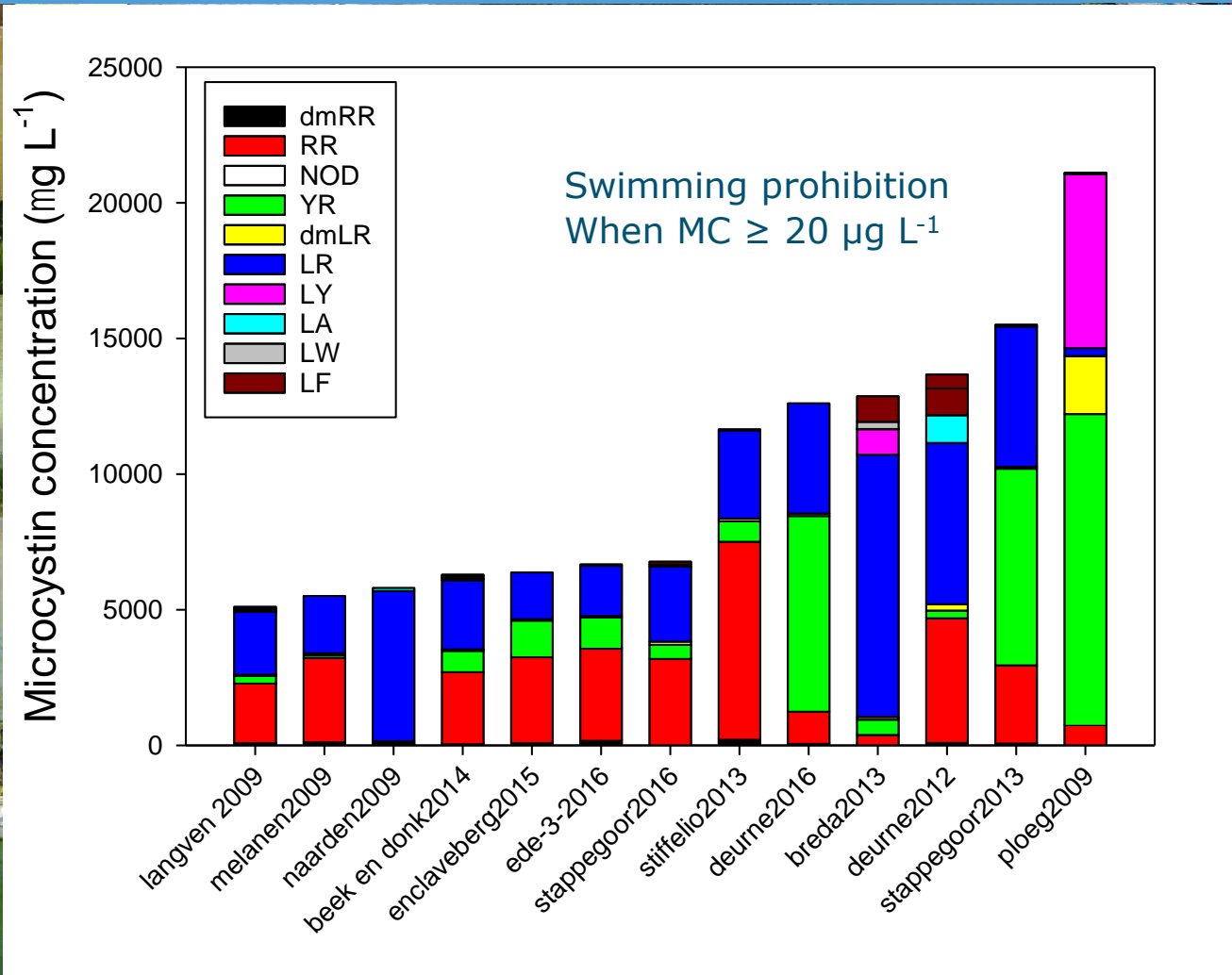
- Cyanobacterial bloom in the river Meuse



Pictures made by Rijkswaterstaat Zuid-Nederland – August 2018

- Cyanobacterial blooms in many surface waters

No.1 water quality issue in the Netherlands



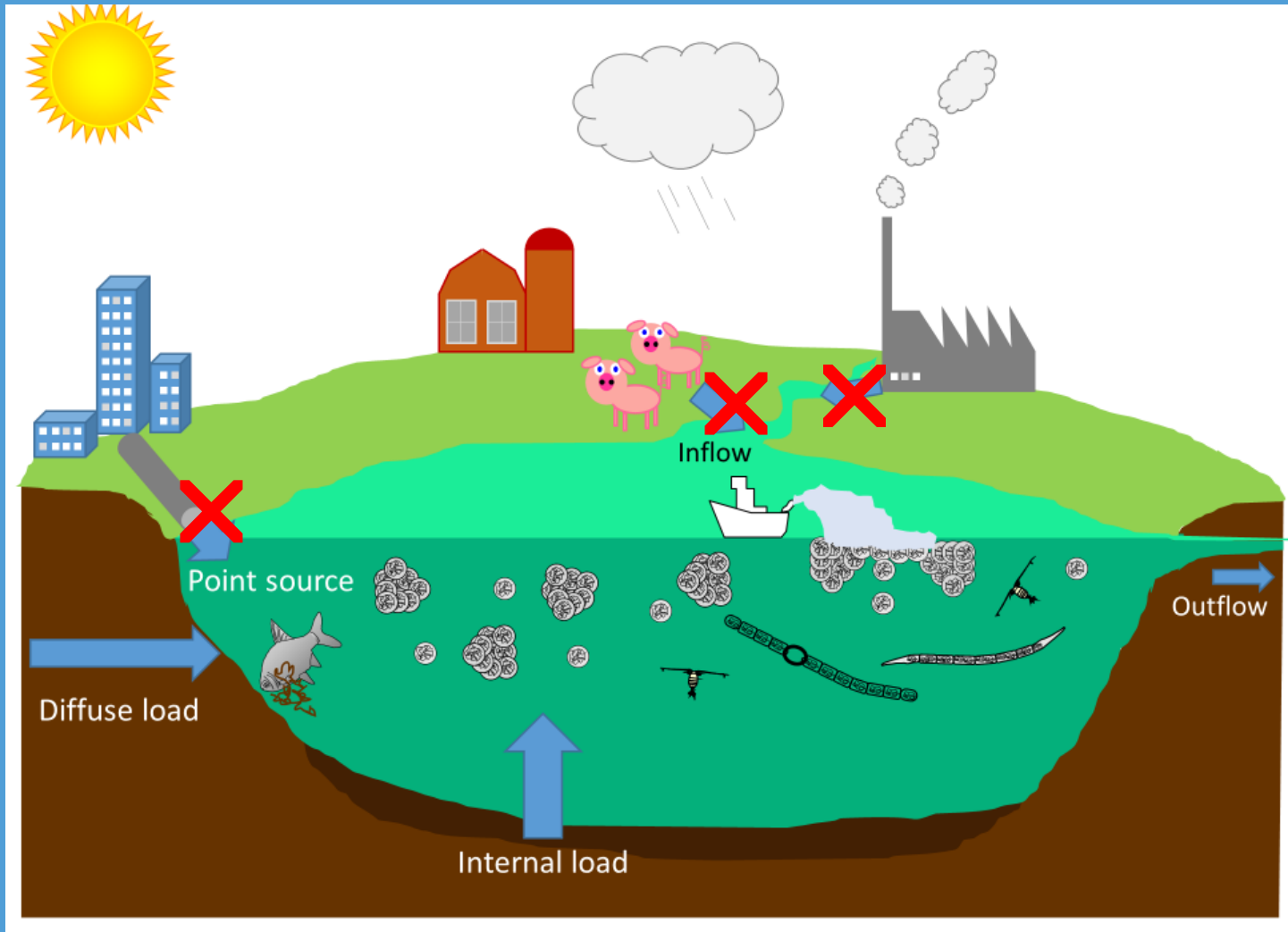
Somethings need to be done, but what?

■ Measures:

- Public oriented
 - Information, awareness, warnings
- Effect oriented
 - Reduce nuisance, fighting symptoms
- Source oriented
 - Reducing nutrient inputs
 - Tackling internal loading

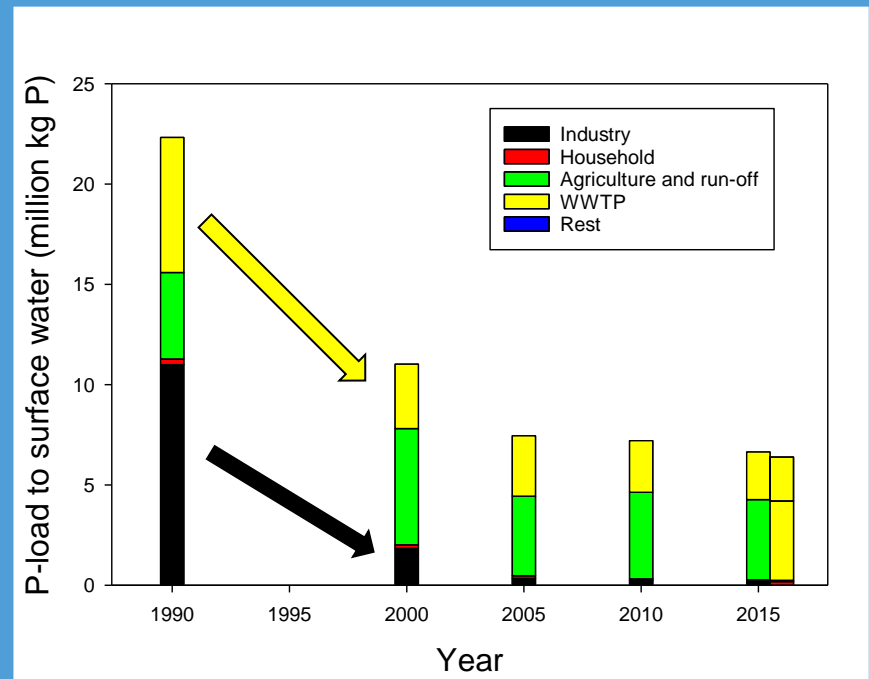
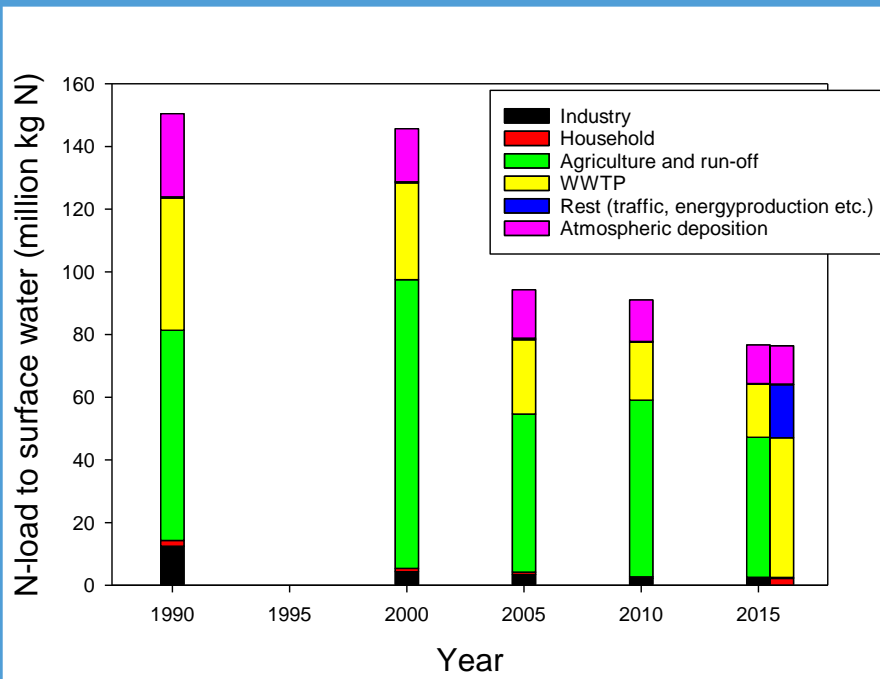


Source oriented: reduce the external load



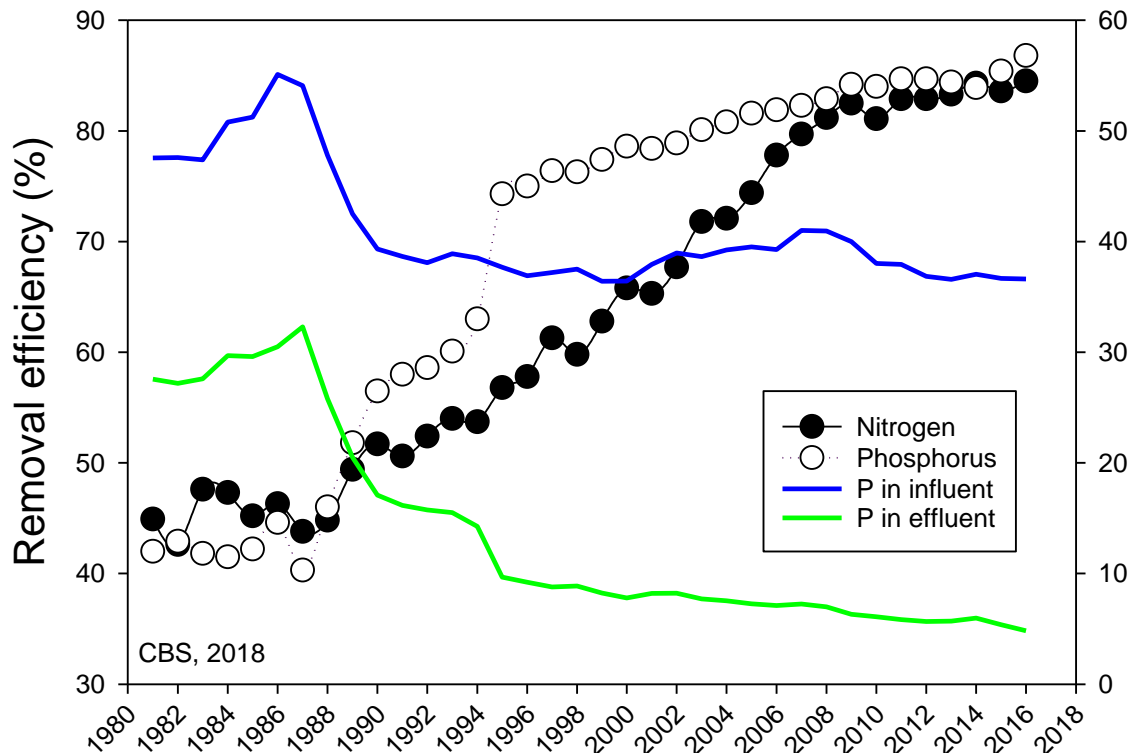
Source oriented measures in Netherlands

- Point source pollution is being tackled:
 - Drastic reduction P load from industry
 - Strong reduction P load from WWTP



The Netherlands has world leading WWT

- Point source nutrient pollution has been tackled



CBS, 2018

Water Resources

Explore how countries perform on each of the issues included in the EPI. Select countries using the chart below each country, view the issue rank, score, and trendlines for the issue and indicator(s).

OVERVIEW



2. Netherlands

ISSUE RANK & COUNTRY
OUT OF 178 COUNTRIES

98.82

ISSUE SCORE
OUT OF 100

WASTEWATER TREATMENT
98.82

INDICATOR SCORE
OUT OF 100

RAW DATA TREND
PERCENTAGE



Science of The Total Environment
Volumes 640–641, 1 November 2018, Pages 1489-1499



Impact of industrial waste water treatment plants on Dutch surface waters and drinking water sources

Annemarie P. van Wezel^{a, b, c, d}, Floris van den Hurk^a, Rosa M.A. Sjerps^a, Erwin M. Meijers^e, Erwin W.M. Roex^f, Thomas L. ter Laak^a

**Wastewater management
roadmap towards 2030**
A sustainable approach to the collection and treatment of wastewater in the Netherlands



Legacies and diffuse loads remain an issue



COMMISSION STAFF WORKING DOCUMENT

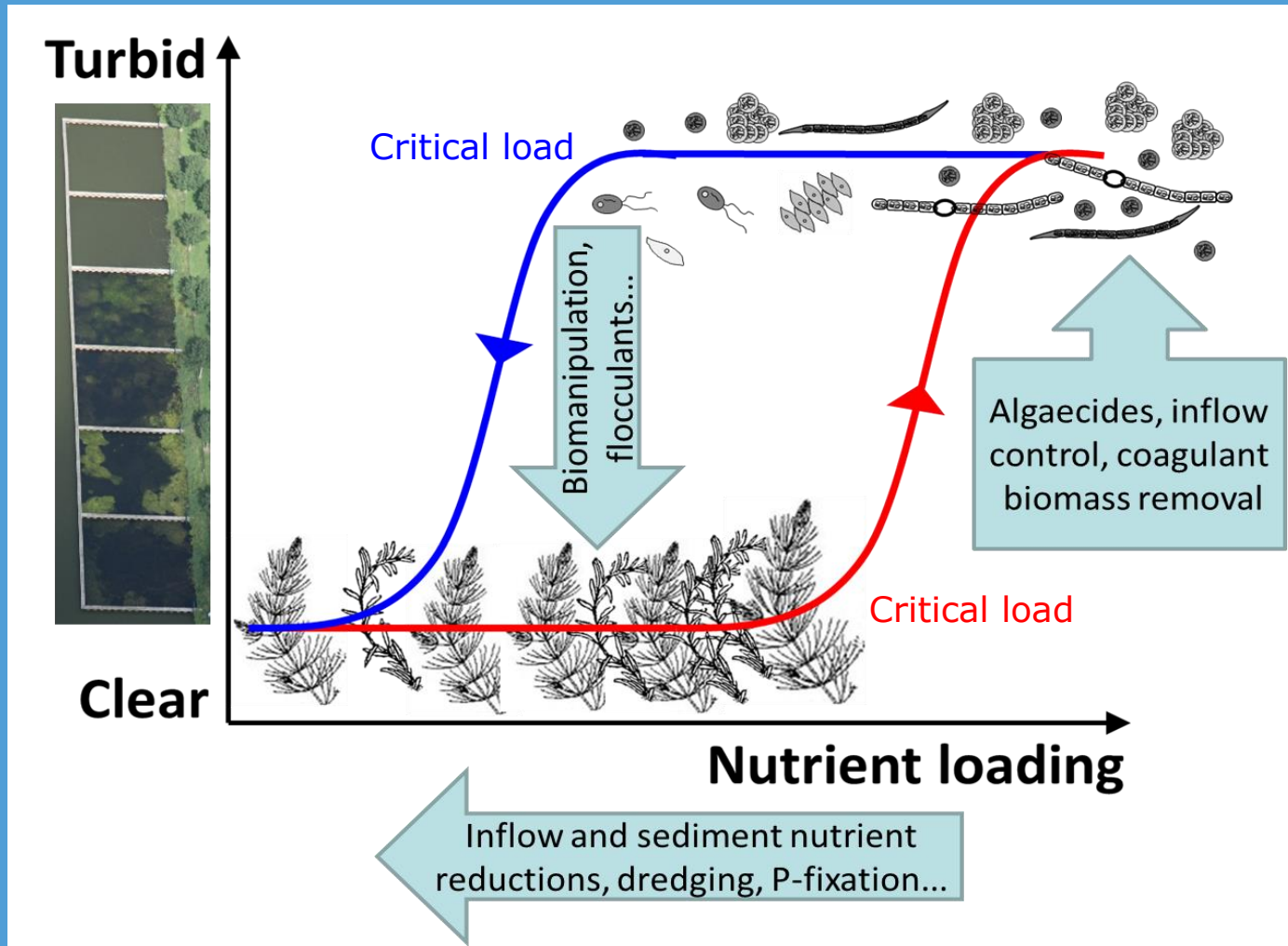
The EU Environmental Implementation Review Country Report - THE NETHERLANDS



almost all (99%) of the water bodies are still subject to significant pressures. In all the four RBDs the basic measures were not enough to meet the Water Framework Directive objectives of ecological quality of surface waters in rivers and lakes. Roughly half of rivers, drainage ditches and lakes have too high concentrations of nitrogen and phosphates as a result of over-fertilization in agricultural areas⁸⁵.

The main pressure on the Dutch surface waters is diffuse pollution⁸⁶ that affects 90% of water bodies

More action needed: in-lake interventions

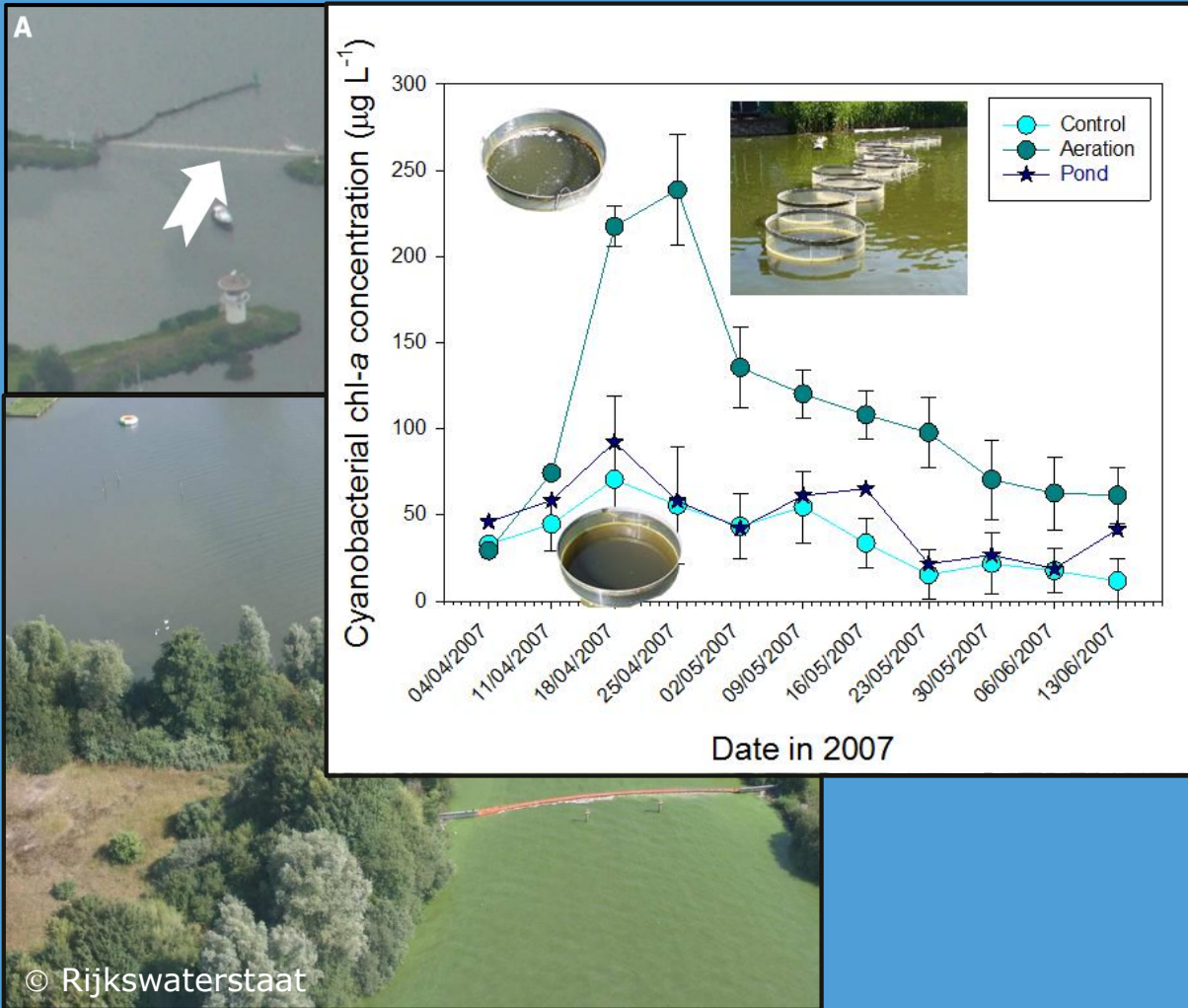


Effect oriented measures (in-lake actions)

- Numerous measures proposed and applied:
 - 💧 **Physical:** Aeration/water movement, ultrasound, jets, bubble screen, dam, floating screen...
 - 💧 **Chemical:** Algaecides, H_2O_2 , coagulants, P-fixatives...
 - 💧 **Biological:** Barley straw, *Dreissena*, EM "effective micro-organisms", Golden algae, plant extracts, filter-feeding fish...
- Some are promising, others come with dubious claims and without proper scientific testing



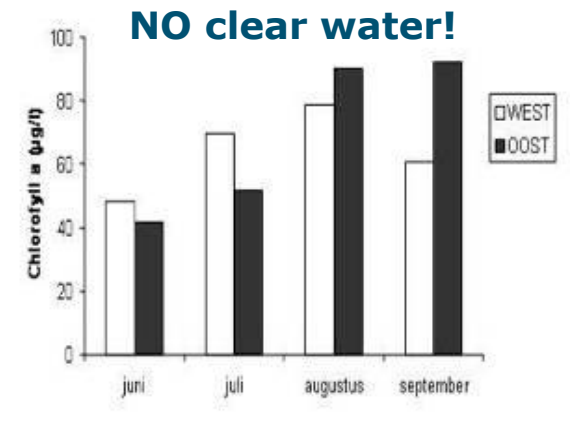
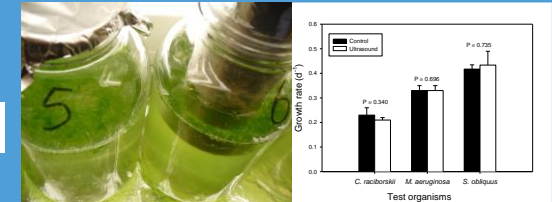
Physical methods



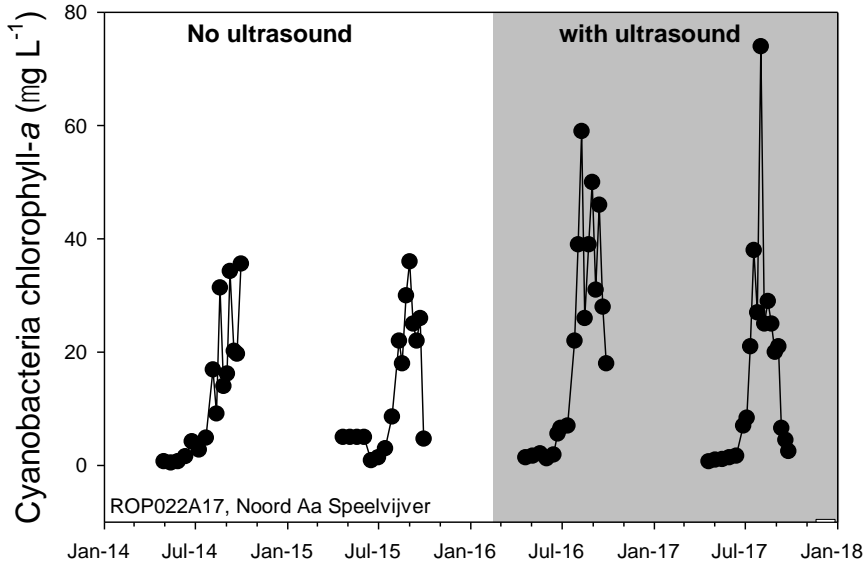
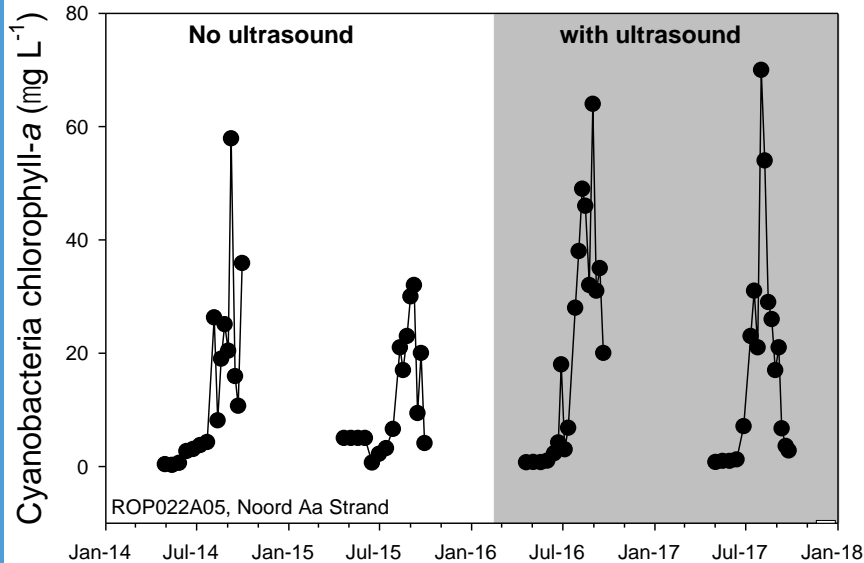
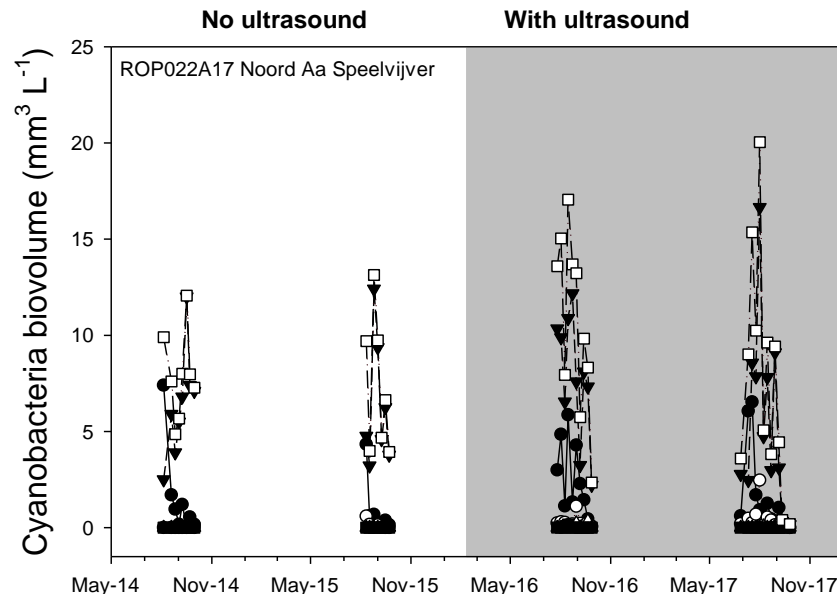
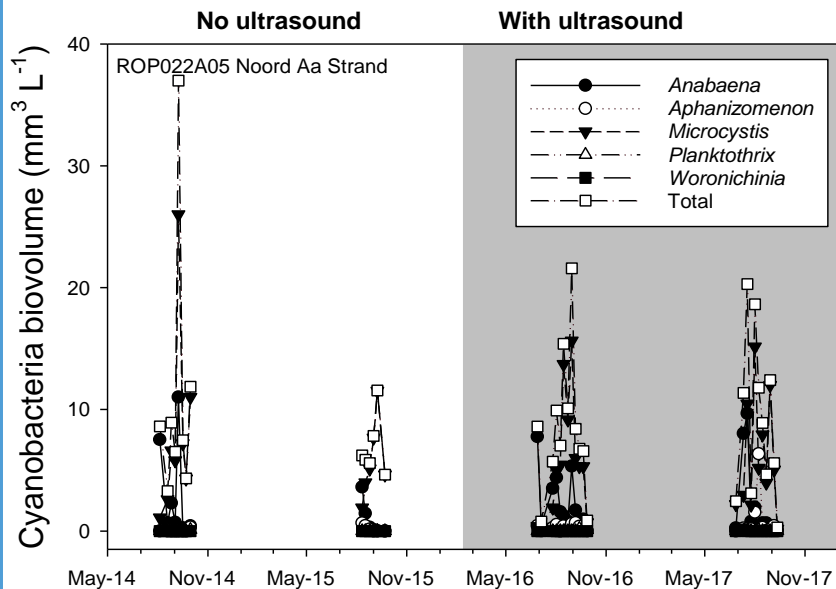
Physical methods – low energy ultrasound

- High energy ultrasound will kill everything at high energy costs, but low water penetration depth
- Low frequency, low energy ultrasound heavily promoted
- No proof of control in laboratory
- No proof in field trials

WATER RESEARCH 66 (2014) 361–373

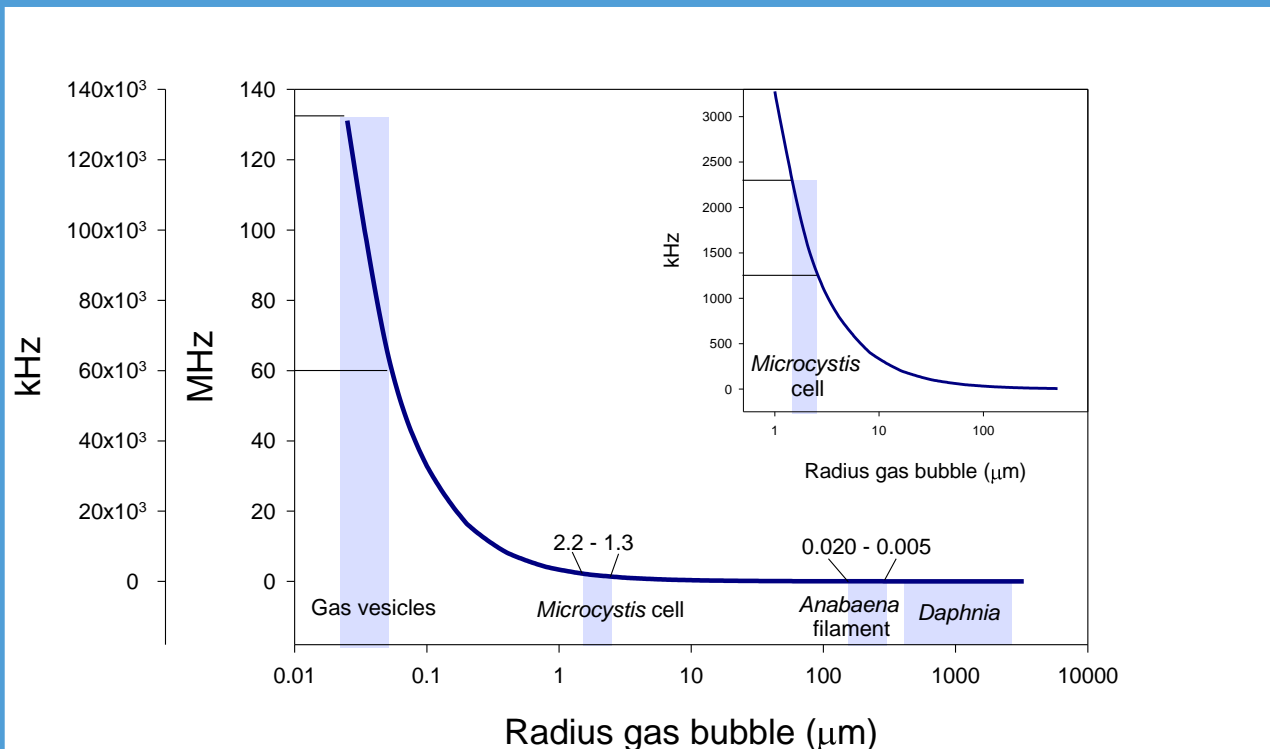


Kardinaal *et al.*, 2008: Ultrasound could **NOT** prevent cyanoblooms and surface scums



Physical methods – low energy ultrasound

Ultrasound is promoted with lots of “**anecdotal evidence**”, but experiments and independent monitoring show it, physics explains it: Low energy, low frequencies ultrasound **cannot** eliminate cyanobacteria



Resonance frequency can be calculated:

$$f_0 = \frac{1}{2\pi} \sqrt{\left(\frac{3\gamma}{R_0^2 \rho} \left(p_0 + \frac{2\sigma}{R_0} + \frac{2\chi}{R_0} \right) - \left(\frac{2\sigma + 6\chi}{R_0^3 \rho} \right) \right)}$$

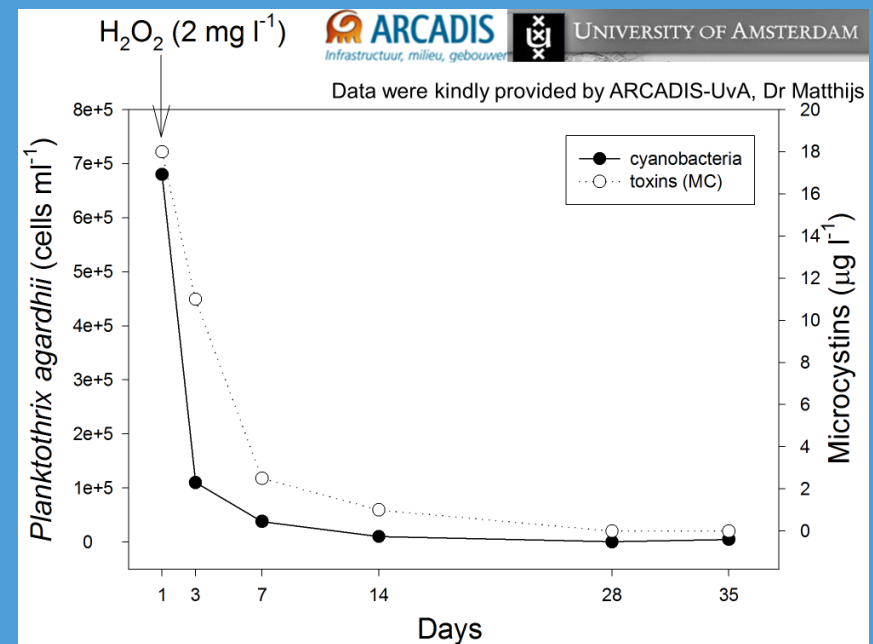
Chemical methods

- Algaecides, coagulants and P-fixatives are most common
- Intended effect: decimating/removing cyano-biomass



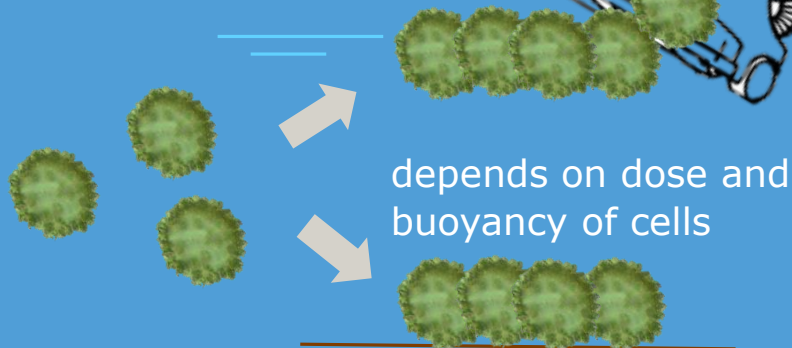
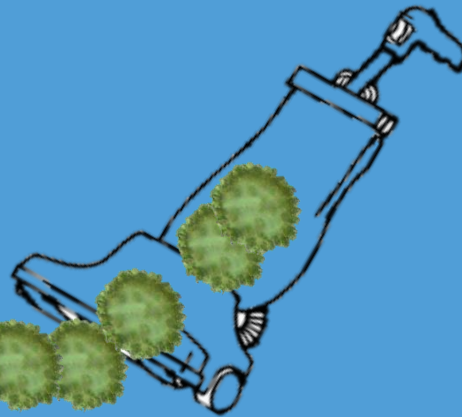
Chemical methods – hydrogen peroxide

- Cyanobacteria are more sensitive than eukaryotes to H_2O_2
- Intensively used in The Netherlands
- Efficacy is variable (none, few weeks, whole season)



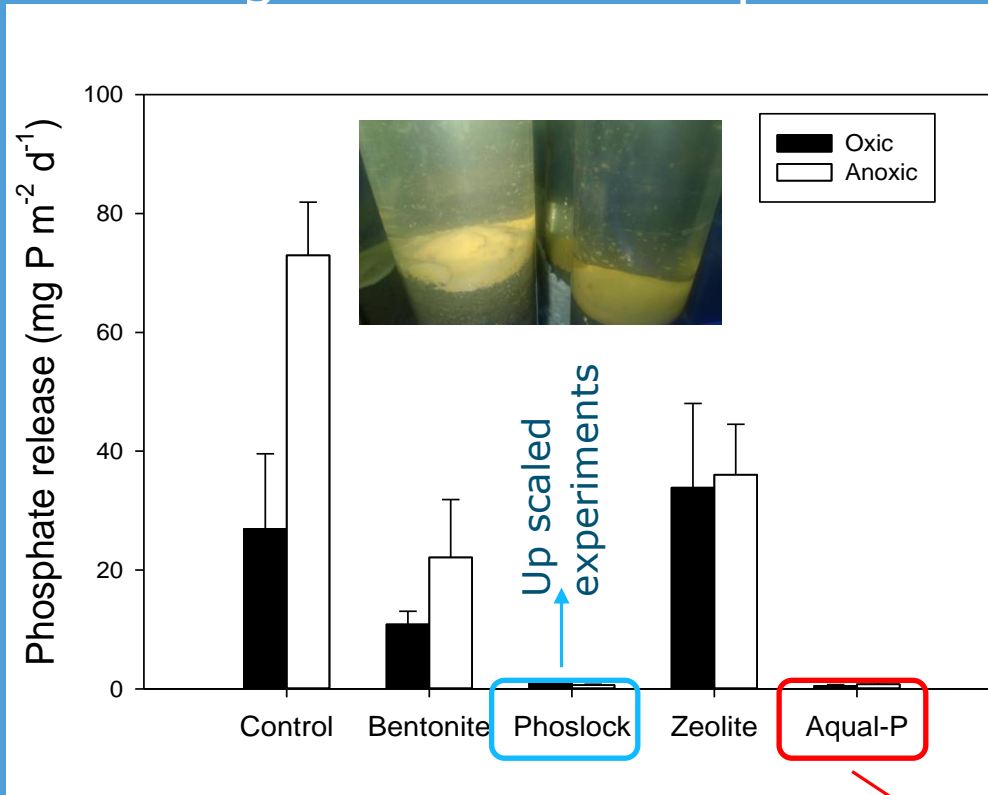
Chemical methods - Coagulants

- Inorganic – alum, polyaluminium chloride, ferric chloride
- Organic – chitosan, polyacrylamides, *Moringa* extract...
- Combined with ballast (soil, modified clay)



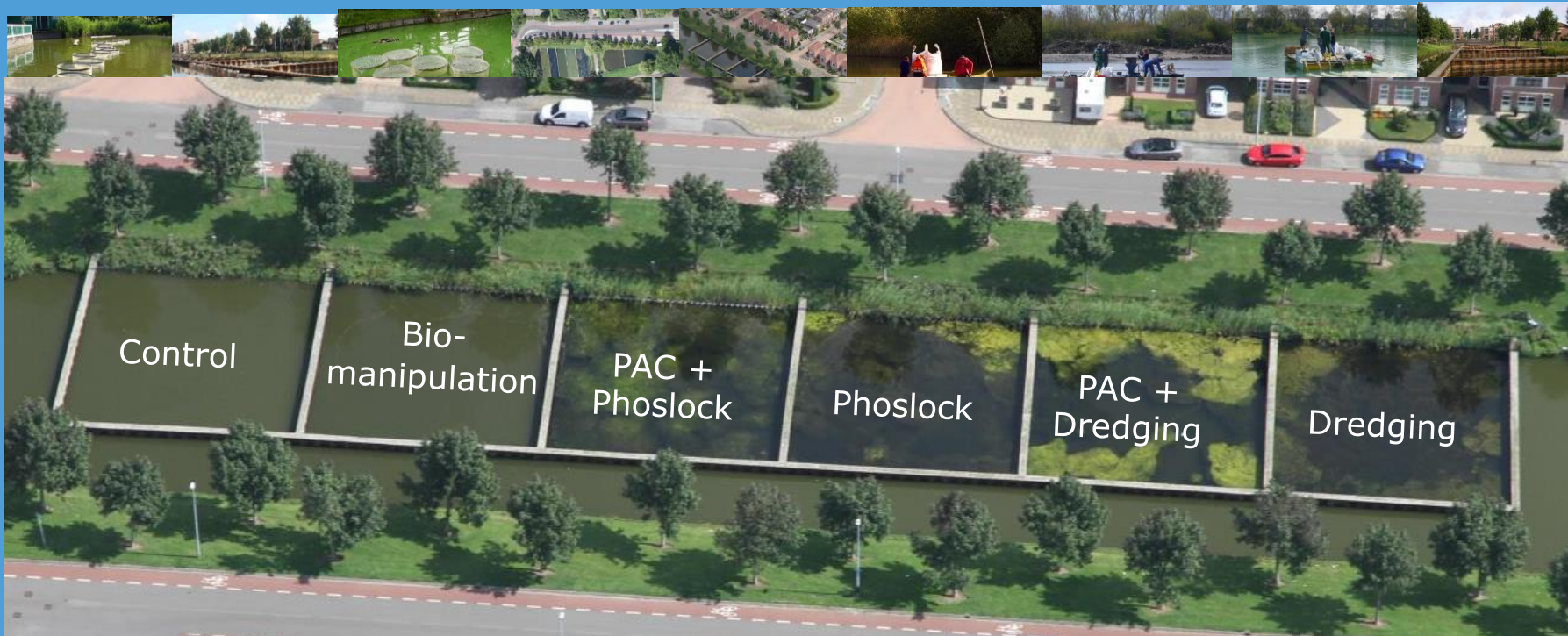
Chemical methods - Phosphate-fixatives

■ Testing numerous compounds



Was not available for further testing, but is now!

Field experiments in the Netherlands



Pond Eindhoven	0.7	Compartments	9/2009 – 9/2011	1.13 kg/m ²
Pond Eindhoven	0.7	Enclosures	Aug – Sep 2010	1.3 kg/m ²
Pond Heesch	0.16	Enclosures	Jul – Sep 2009	0.3 kg/m ²
Kleine Melanen	4	Enclosures	Mar – Jun 2010	0.3 kg/m ²
Kleine Melanen	4	Field	Aug – Oct 2010	16.6 ton Phoslock [®]
Grootte Melanen	4.8	Field	19/20 Apr 2016 20 Apr 2016	13.7 ton Phoslock [®] 4 ton PAC

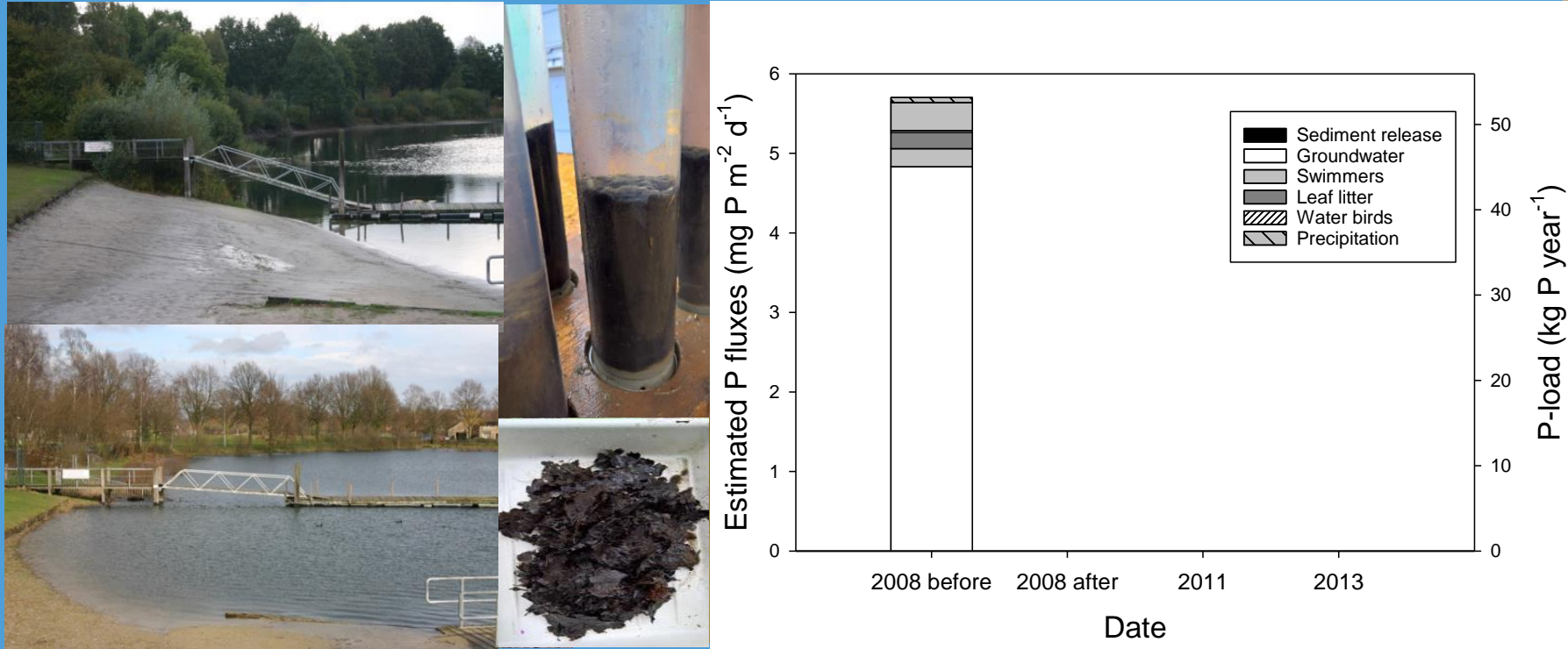
Lake Rauwbraken – official bathing site



Lake Rauwbraken

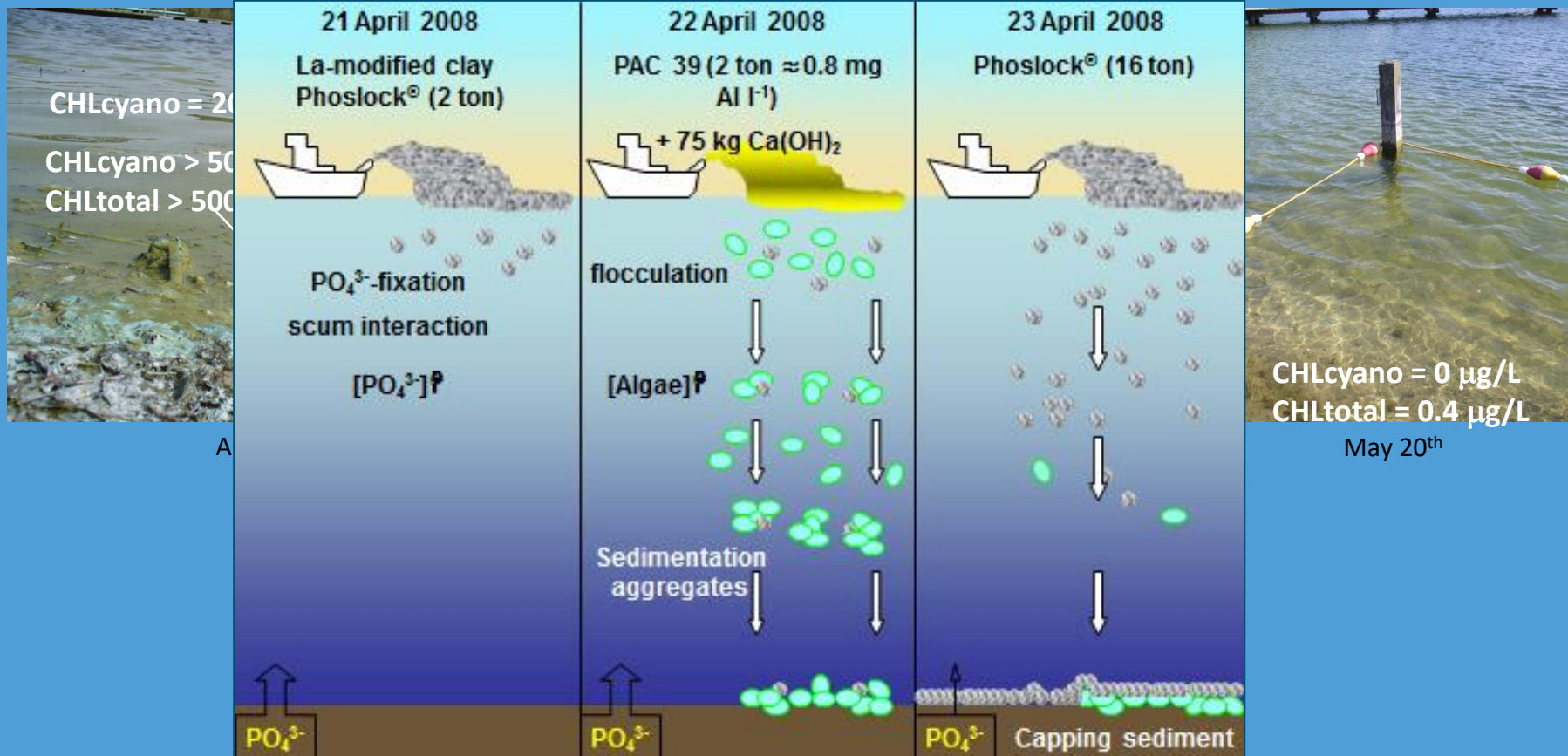
Water: No inflow, no outflow, precipitation, evaporation, groundwater

P: P in precipitation, P in groundwater, P from leaf litter, P from birds, P from bathers, P from sediment...

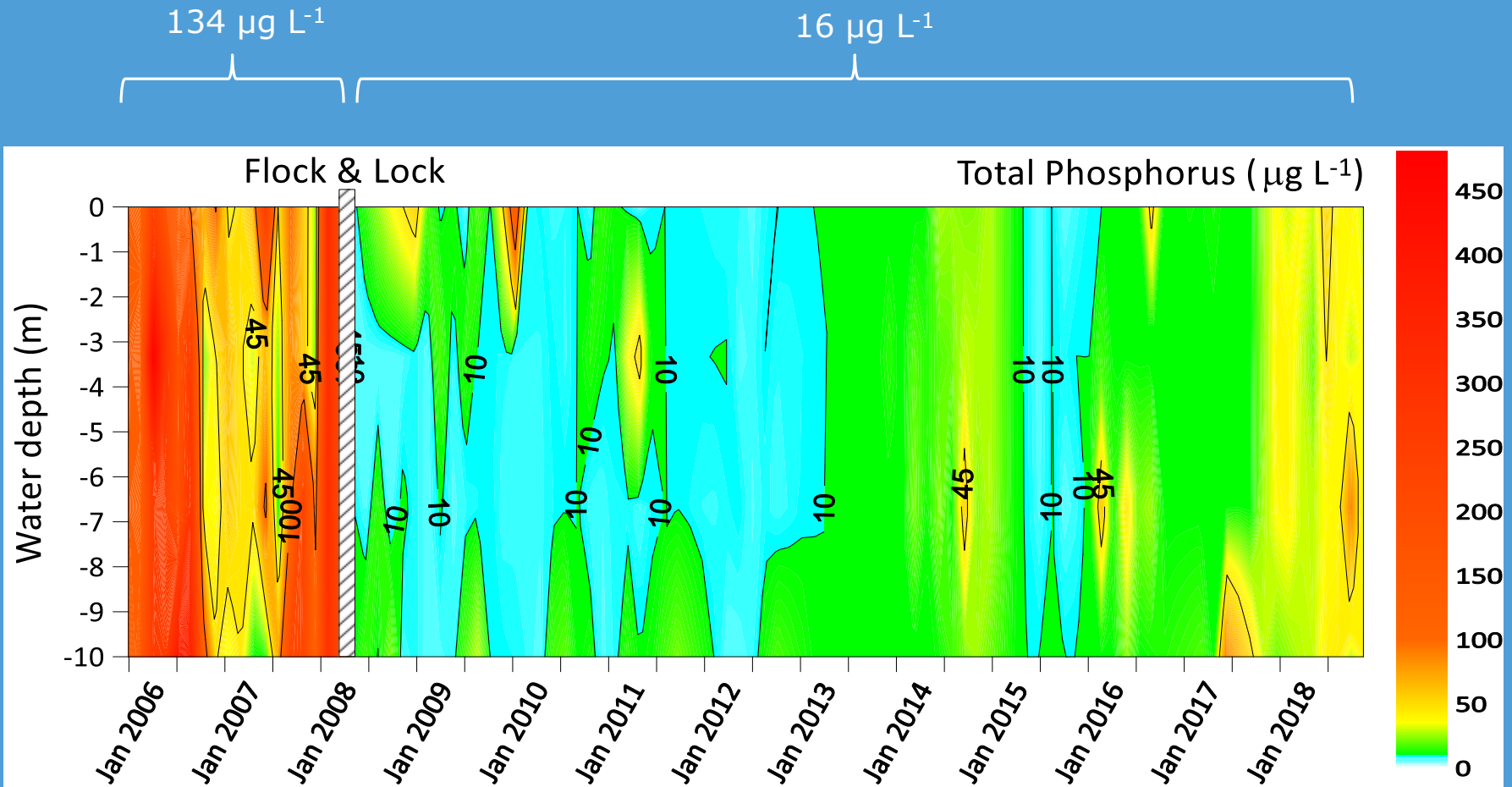


Combined coagulant + P-fixative addition

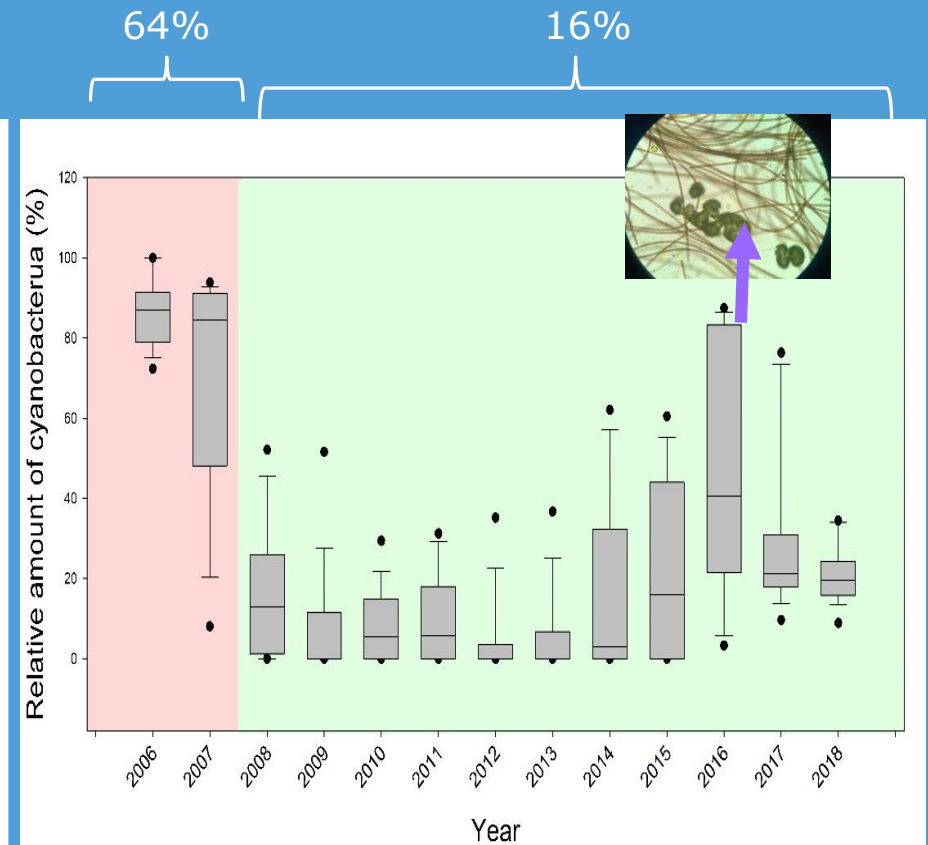
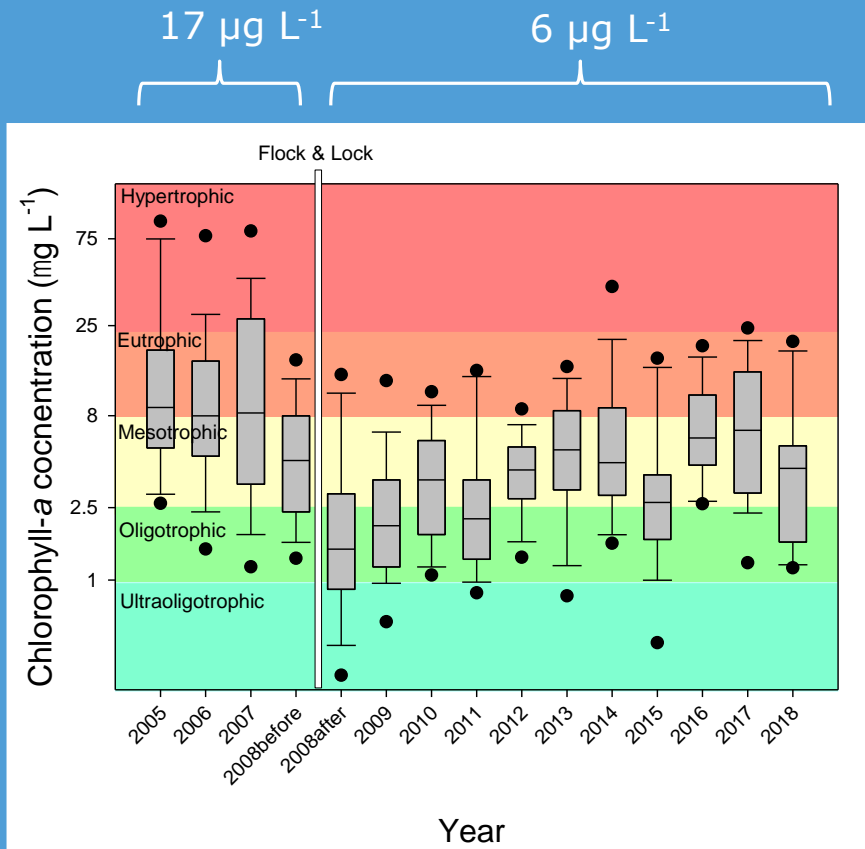
- Immediate removal of cyanobacteria and reduction internal P release



Lake Rauwbraken – Total Phosphorus

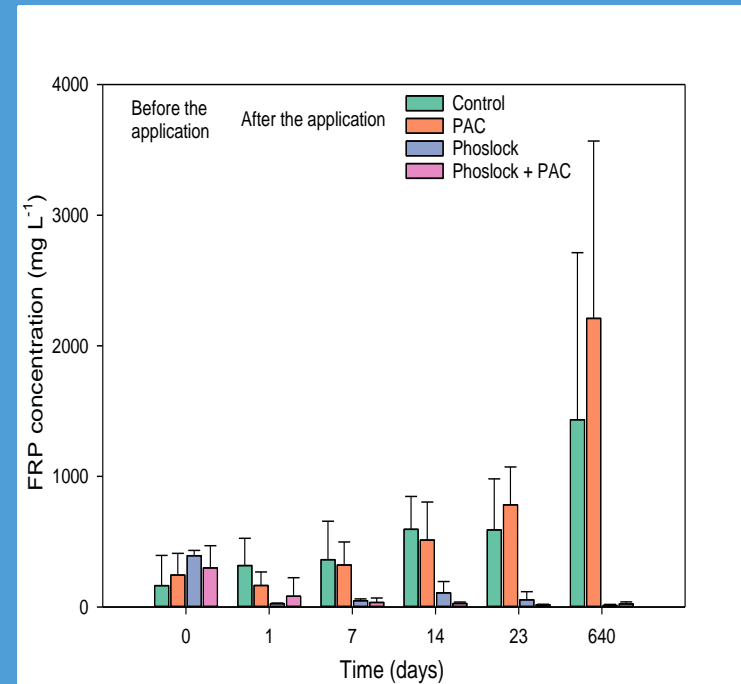
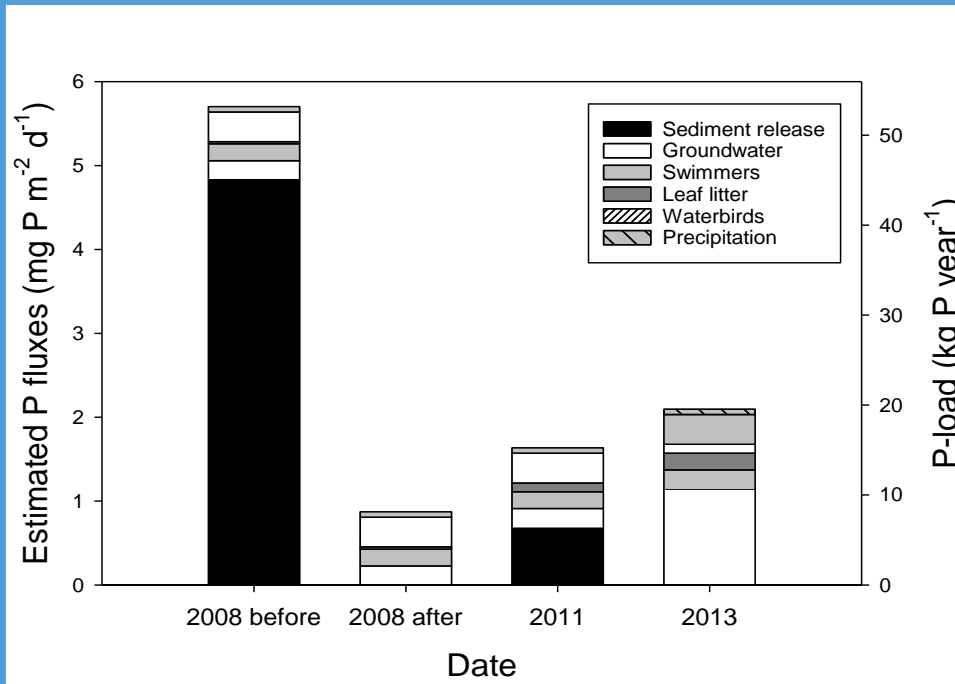


Lake Rauwbraken



Lake Rauwbraken

- Repeated interventions are inevitable = maintenance
Application costed € 50.000,-, i.e. ~ € 4.500,- per season



- Lake Rauwbraken is not unique for NL, diffuse pollution is everywhere

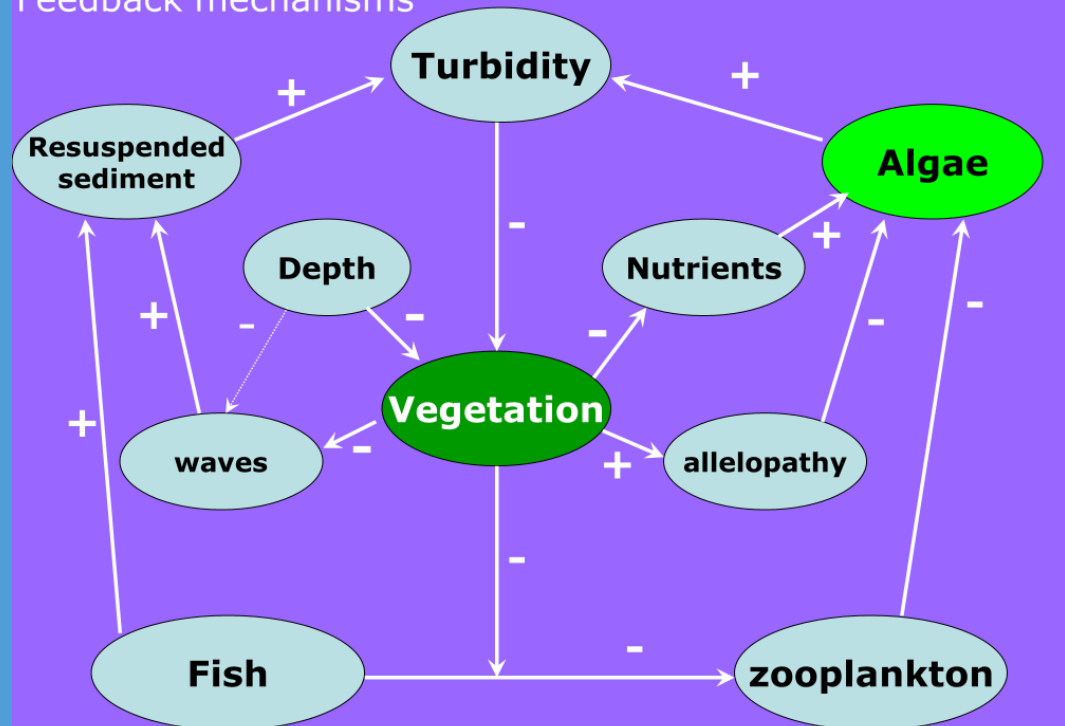
Biological methods

■ Biomanipulation:

Many attempts failed (Gulati et al 2008)



Feedback mechanisms

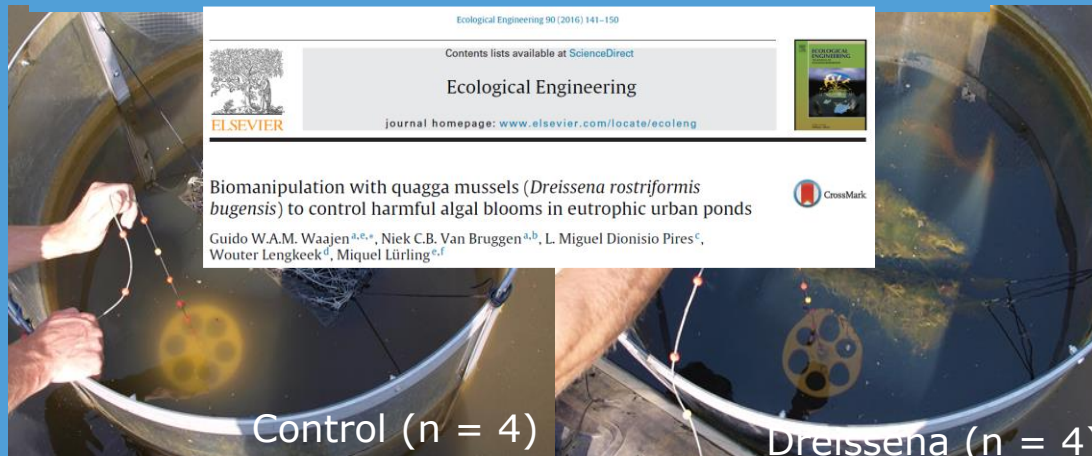
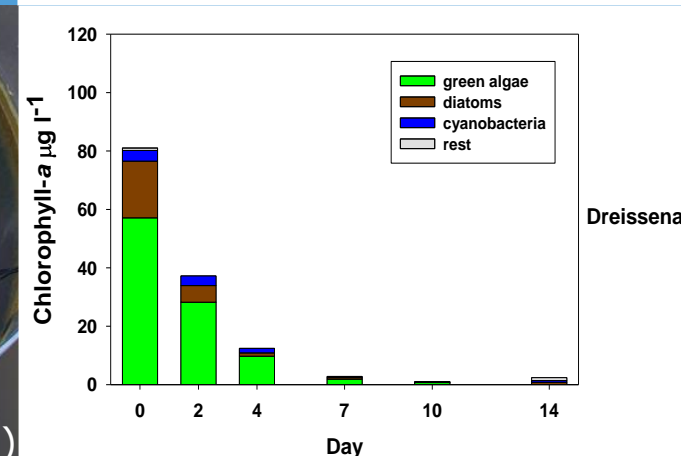
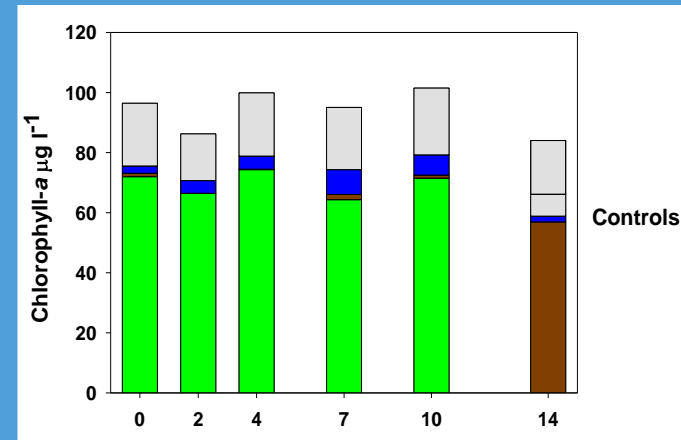


Scheffer et al., 1993

Biological methods - Zebra mussels

- Filtering could reduce phytoplankton biomass

Experiment with 1600 crates of dreissenids placed in 1.1 ha urban pond (Linievijver Breda) failed, because mussels didn't reproduce and died in three years time.



1000-faces of "Effective Micro-organisms"

They come in many formulations, but are they as 'effective' as claimed?



EM-A
suspension



EM-mudballs



ACF32



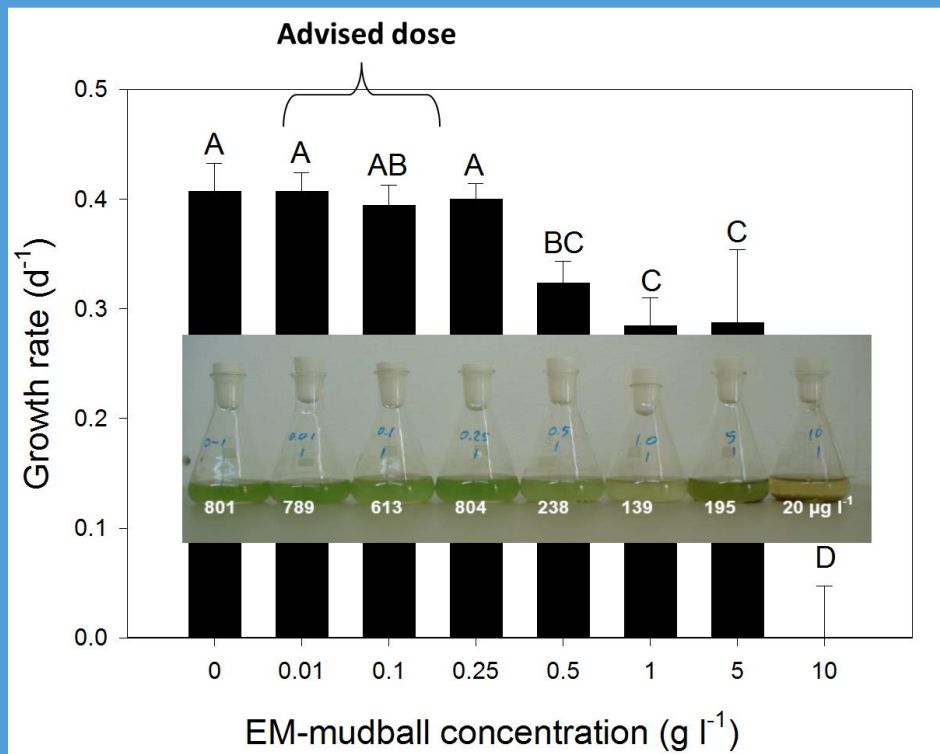
Poco



CBX

“Effective microbes” are not effective

- Do not remove or permanently fix P
- Are on menu grazers → Green soups remain



Lakes & Reservoirs: Research and Management 2009 14: 353–363

Mitigating cyanobacterial blooms: how effective are ‘effective microorganisms’?

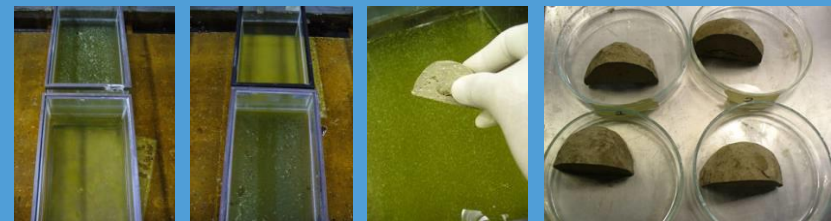
Miquel Lurling,^{1*} Yora Tolman^{1,2} and Marieke Euwe^{1,3}

Hydrobiologia (2010) 646:133–143
DOI 10.1007/s10750-010-0173-3

SHALLOW LAKES

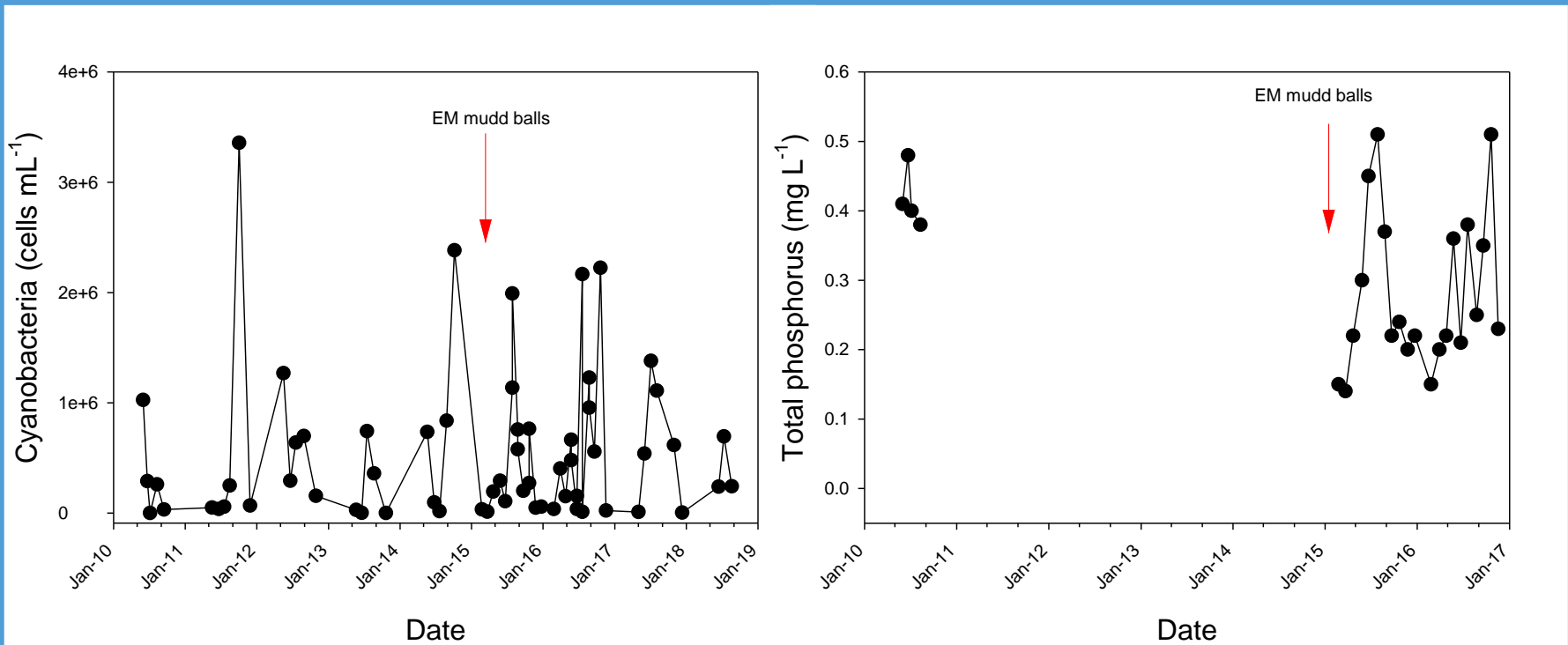
Cyanobacteria blooms cannot be controlled by Effective Microorganisms (EM[®]) from mud- or Bokashi-balls

Miquel Lurling · Yora Tolman ·
Frank van Oosterhout



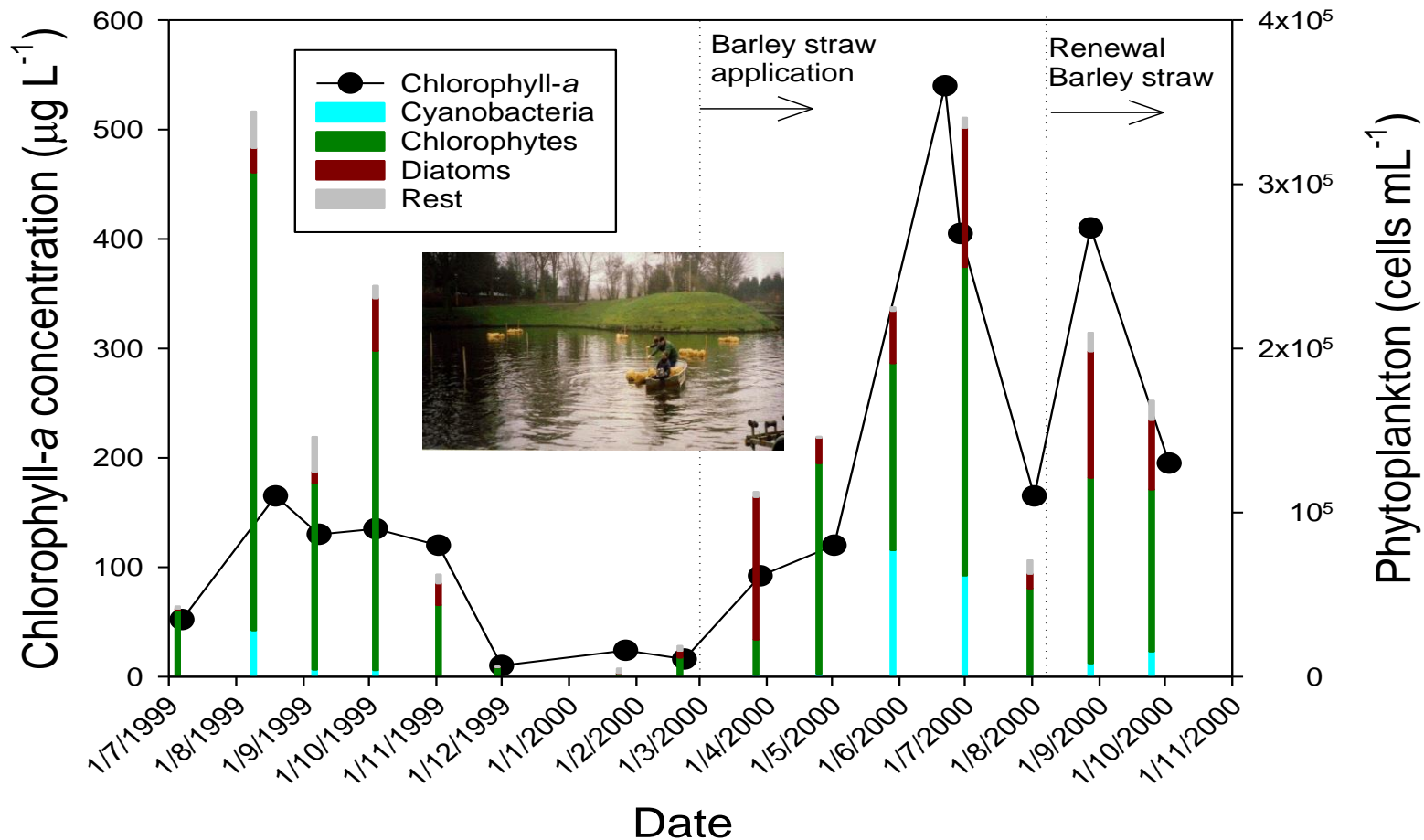
Field experiment – RWA De Dommel

- 30-01-2015: 500 EM mudd balls in pond
- No effect on water quality variables: blooms persisted



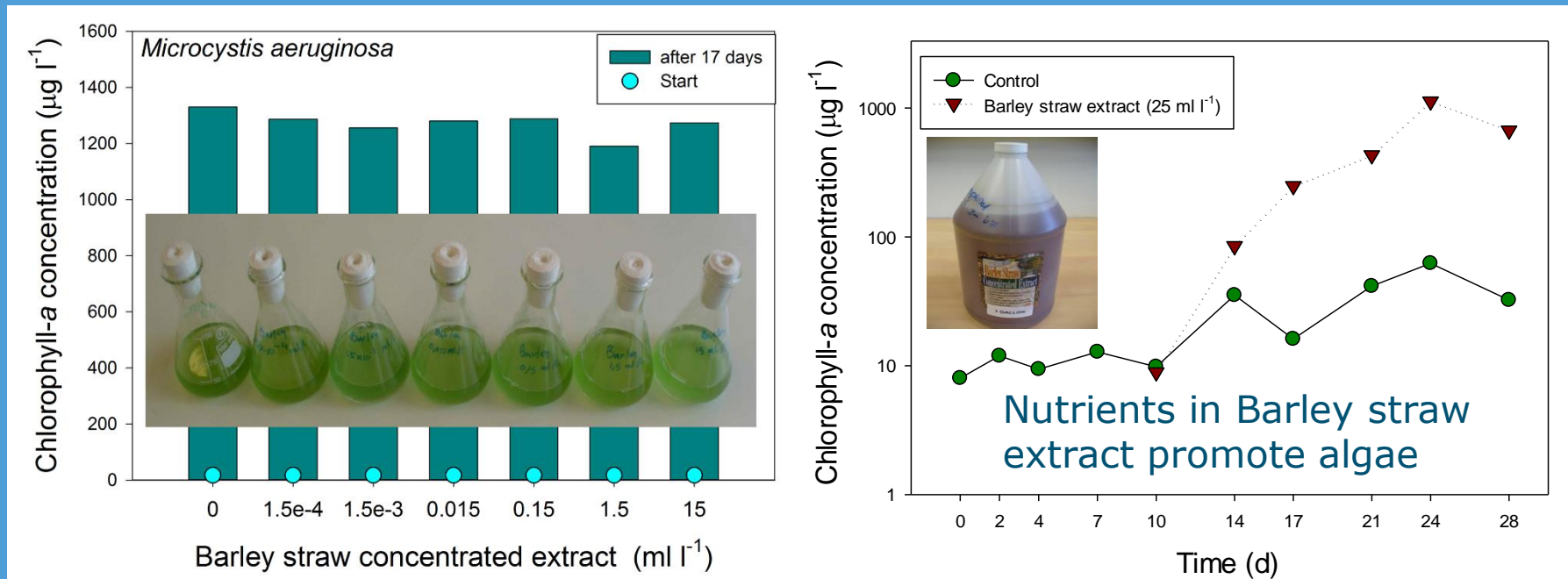
Biological methods - Barley straw

Field experiment with barley: **NO** success



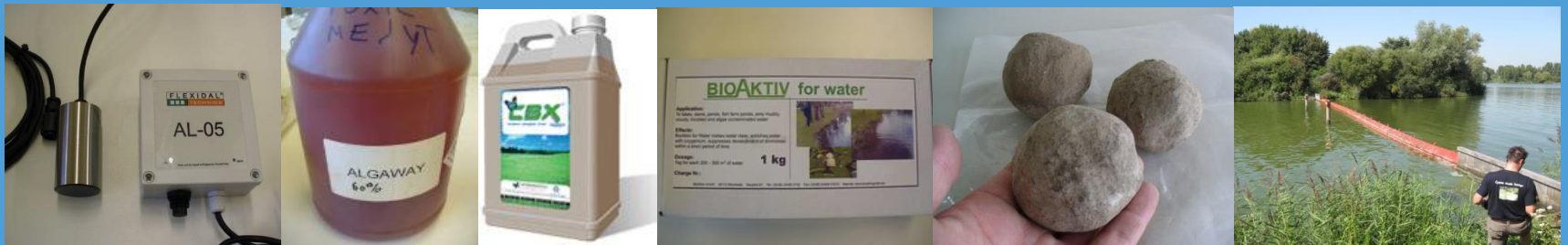
Biological methods - Barley straw extract

- No growth reduction in nutrient rich medium, even growth stimulation in less enriched conditions
- Nutrients in extract !



Road to hell is paved with good intentions: Better not put your money on these

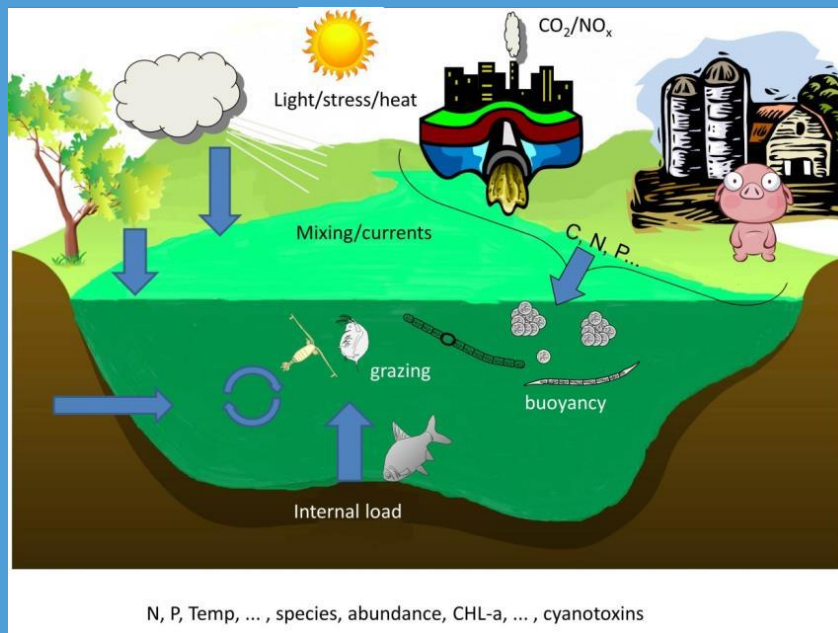
- Ultrasound
- Surface aerators, oil screens, bubble screens...
- 'Effective- micro-organisms', mud balls...
- Barley straw
- Plant/tree extracts
- Things that can be toxic
- Anything copy-pasted without a proper diagnosis of your identified problem



There is NO silver bullet: each lake is unique

Mitigation should always start with a system analysis

- Water- and nutrient fluxes
 - Biological make-up
 - Functions (C/B-analysis)
- } = diagnosis → **measures**



EUTROPHICATION

no.203.078 From Weber until now - Since 1907

In-lake measures are inevitable

Legacies delay recovery

Nutrients accumulated in lake beds may delay recovery for many decades, scientists say.

Diffuse loads

Are extremely problematic. Overly enriched soils keep on leaching nutrients, and particularly phosphorus, to groundwater and surface water. A recent study by Goyette and co-workers in the journal Nature Geosciences revealed it might take 100 to 2000 years!

Investments

Large upfront investments are needed in third world countries and countries in transition to tackle pint sources. WWTP should be built.

To bridge the time between their effectiveness in-lake actions are the single solution to bring relief to people fully relying on the polluted waters.

System analysis

The actions should be based on a thorough understanding of the problem in each individual lake, according to the scientist.

Lake Groote Melanen – The Netherlands

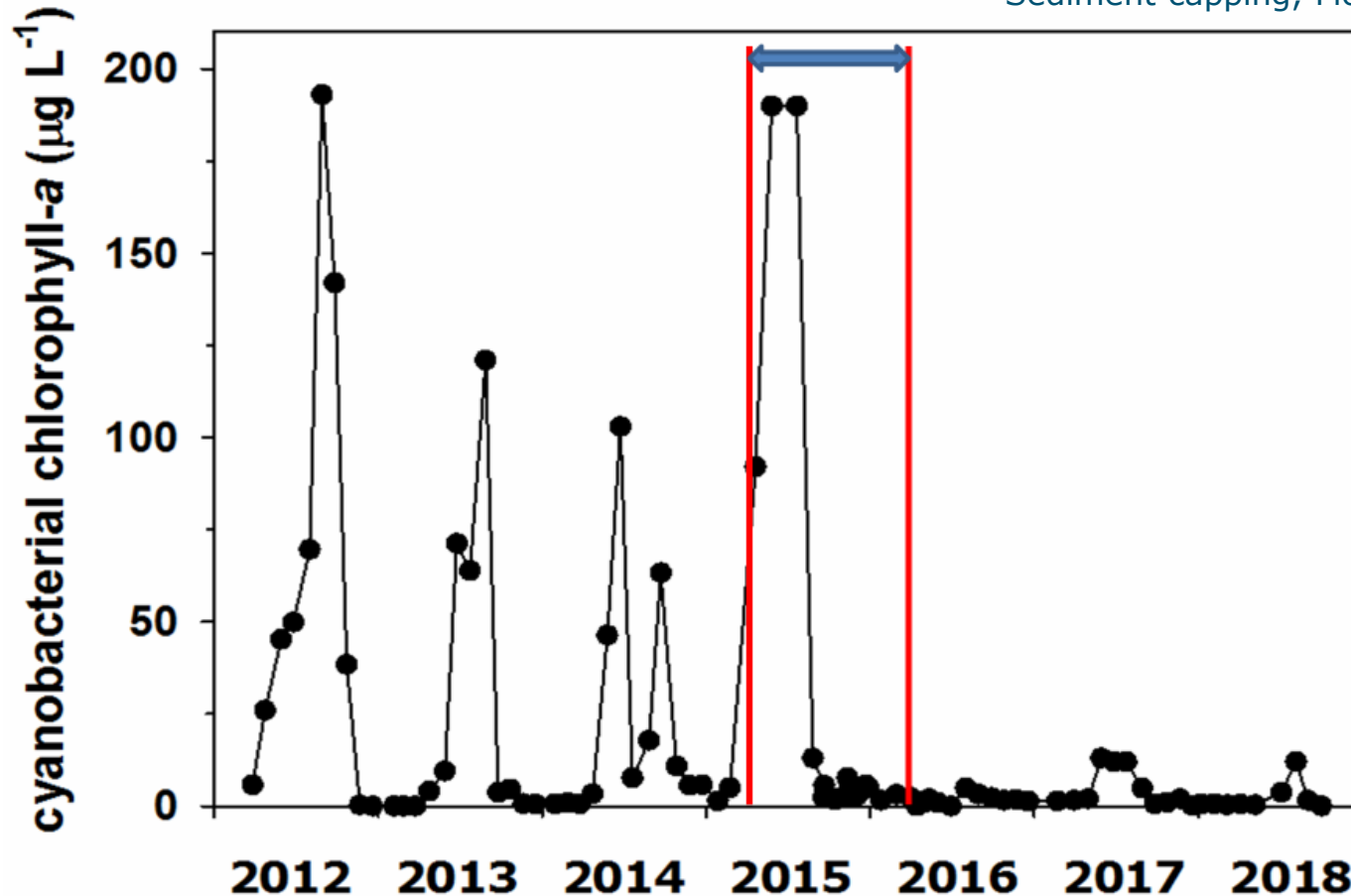
Dr Guido Waajen – Water Authority Brabantse Delta

- Example of diagnosis driven lake restoration:
 - External P-load > critical P-load (inflow from 2 streams is main P source)
 - High internal load from sediment (0.7 m mud on organic rich peat and sand)
 - Fish 268 kg ha⁻¹ dominated by carp (78%)
- Measures:
 - Fish removal
 - Diversion stream
 - Dredging, capping sediment
 - Flock & Lock



Groote Melanen

Fish removal, external P-load↓
Dredging+reconstruction
Sediment capping, Flock & Lock



Lake restoration research in Netherlands

**Experiments on various scales were done
Testing efficacy and side effects ...**



Lake restoration: system analysis is crucial

- In-lake measures are inevitable (legacies, diffuse pollution)
- Repeated interventions are often unavoidable
- Many doubtful “magic solutions”:
 - ultrasound
 - “effective microbes”
 - plant extracts, barley, oil screens, surface mixers...
- Targeting cyanobacteria directly:
 - algaecides, peroxide
 - coagulants (harvest or sink)
- Targeting phosphate = removing fuel for blooms
 - La-bentonite is a very powerful P-fixative



Thank you!



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