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Mitigation of pressures on water bodies by nutrient retention from agricultural drainage effluents using purification ponds

Jörg Steidl
Thomas Kalettka, Volker Ehlert, Joachim Quast & Jürgen Augustin

Leibniz Centre for Agricultural Landscape Research (ZALF), Müncheberg,
Institute of Landscape Hydrology
Institute of Landscape Matter Dynamics

jsteidl@zalf.de

Outline

- **Pressures** on waters from agricultural drainage
- **Purification Ponds -** objectives, installations
- **Methods** to determine the purification effects
- **Budgets** of purification effects
- **Processes** of purification
- **Summary & Conclusions**

Pressures on water bodies
from agricultural drainage effluents

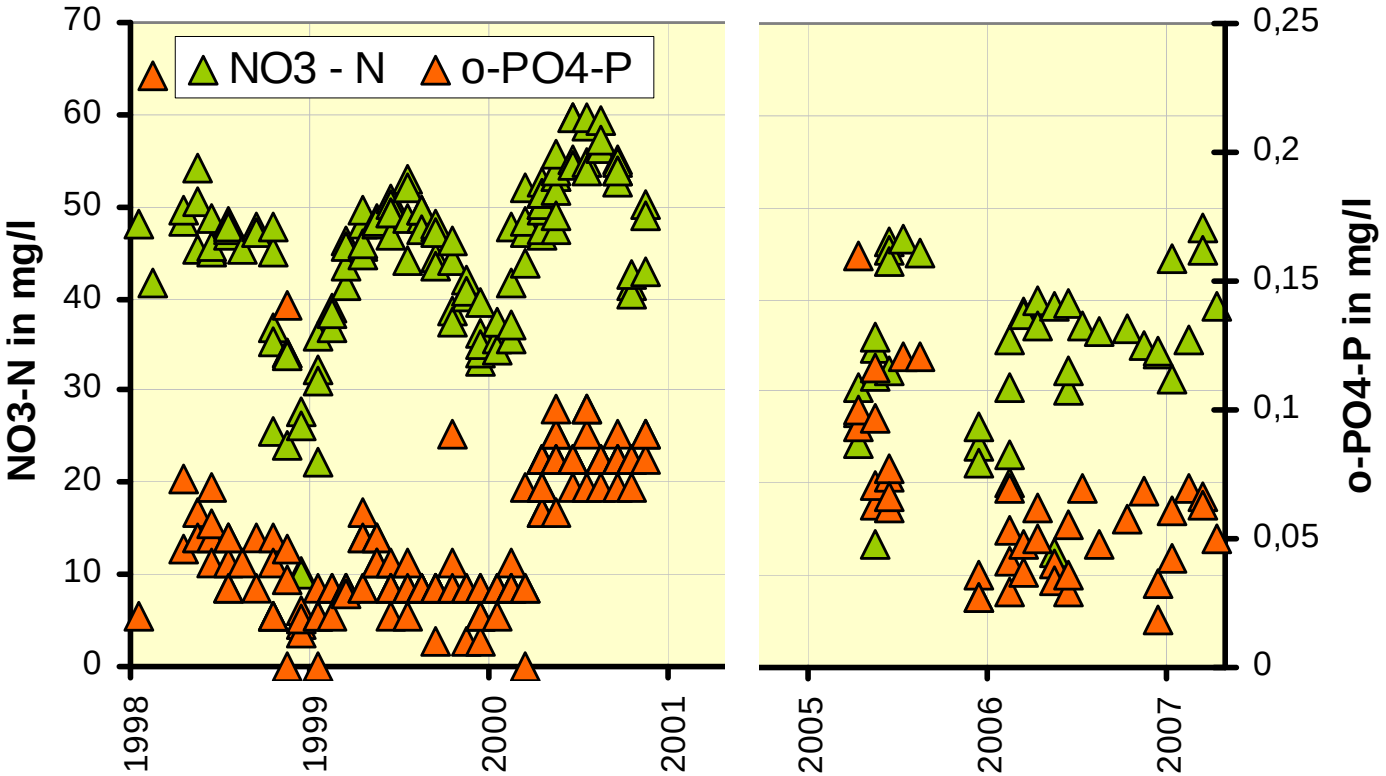
Agricultural drainage systems:

- ⇨ regulate the soil water on waterlogged sites and improve their farming conditions
- ⇨ accelerate the originally strongly damped runoff processes
- ⇨ are coupled with high nutrient entries towards the receiving waters

Pressures on water bodies

from agricultural drainage effluents

Measured nutrient concentrations in an outflow of a tile drain



Pressures on water bodies
from agricultural drainage effluents

Agricultural Drainage Systems

- ⇨ regulate the soil water on waterlogged sites and improve their farming conditions
- ⇨ accelerate the originally strongly damped runoff processes
- ⇨ are coupled with high nutrient entries towards the receiving waters
- ⇨ nearly half of the nitrogen entries (45 %) towards waters of the German Baltic Sea catchment is coming from drainage *(MEWES, 2004)*

Pressures on water bodies

from agricultural drainage effluents

- ⇨ **actual objectives for the water quality are declared in the**
  - European Water Frame Directive
  - Convention on the Protection of the Marine Environment of the Baltic Sea Area (HELCOM)
- ⇨ **more than 2 million hectares tile drainage systems exist in Germany and used for improvement the farming conditions**
- ⇨ **ecological and economical conflicts occur especially in catchments with a high agricultural drainage portion and with shortcomings in achieving the water quality objectives**

Purification Ponds
objectives

Reduction of nutrient entries from agricultural drainage systems towards receiving waters by enhancement of

- water retention,
- sedimentation processes,
- nutrient accumulation in biomass and
- biogeochemical transformation processes

with a possible long residence time.

Purification Ponds

objectives

⇨ using natural depressions or slopes (combined with embankments) for a environmentally adapted installation

Purification Ponds

pilot installations

objectives

⇨ investigate the effects on the reduction of nutrient entries from agricultural drainage systems towards receiving waters

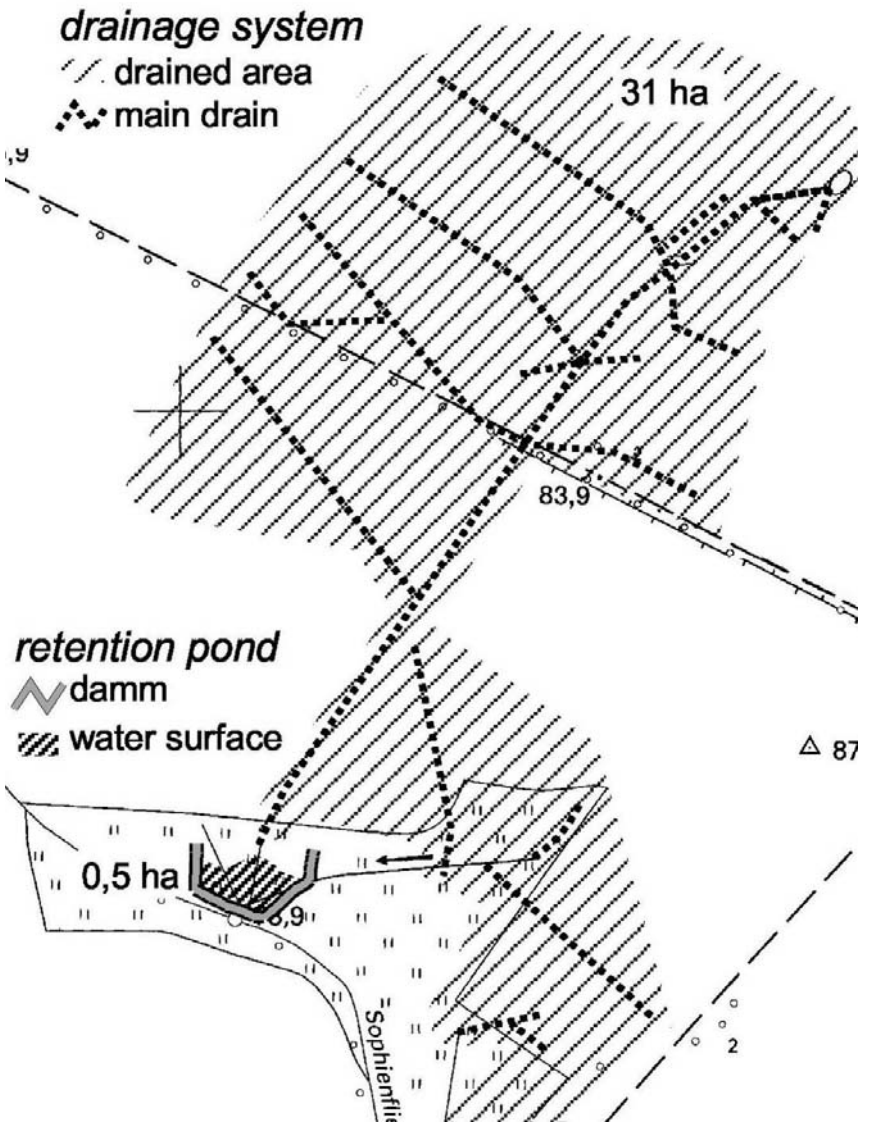
⇨ providing evidence for the functioning of pilot ponds

Purification Ponds

pilot installations

Main drain and gauging weir

Pond outlet and gauging weir



Purification Ponds

pilot installations

Physical Characteristics of the Pilot Ponds

pond		I	II	III
drained area	ha	31	185	5
drainage system		regular	checked	regular
surface area	m^2	4320	1653	614
volume	m^3	705	429	293
surface area/ drained area	m^2/ha	139	9	123
maximum depth	m	0,8	0,7	1,1
mean depth	m	0,2	0,2	0,5
shore length/ surface area	m^{-1}	0,1	0,1	0,2

Methods

to determine the purification effects

inflow from drainage syteme

precipitation

evapo-

outflow from pond

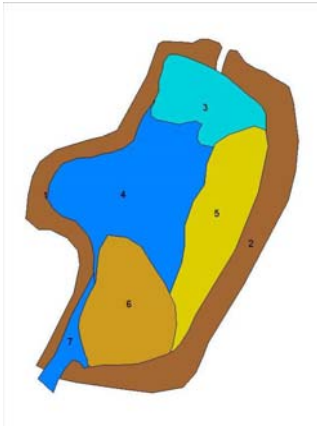
gauging channel water sampler

meteorological station

sediment trap

sediment sampler

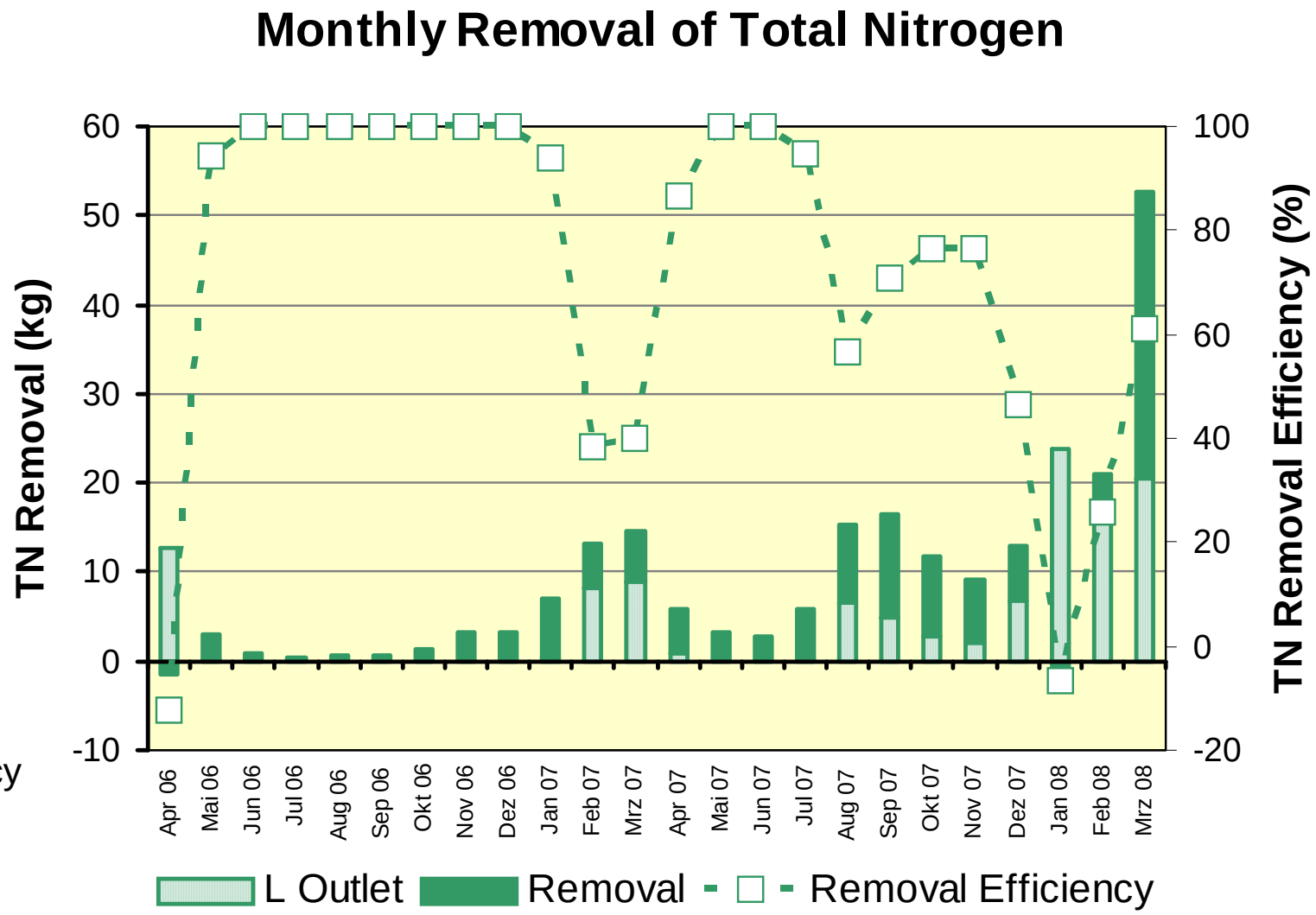
dialysis sampler



vegetation analyses

Budgets of purification effects

pilot pond III



Removal

$$R_M = L_{Inlet} - L_{Outlet}$$

Removal Efficiency

$$R_{eff} = \frac{R_M}{L_{Inlet}}$$

Processes of purification


I


II

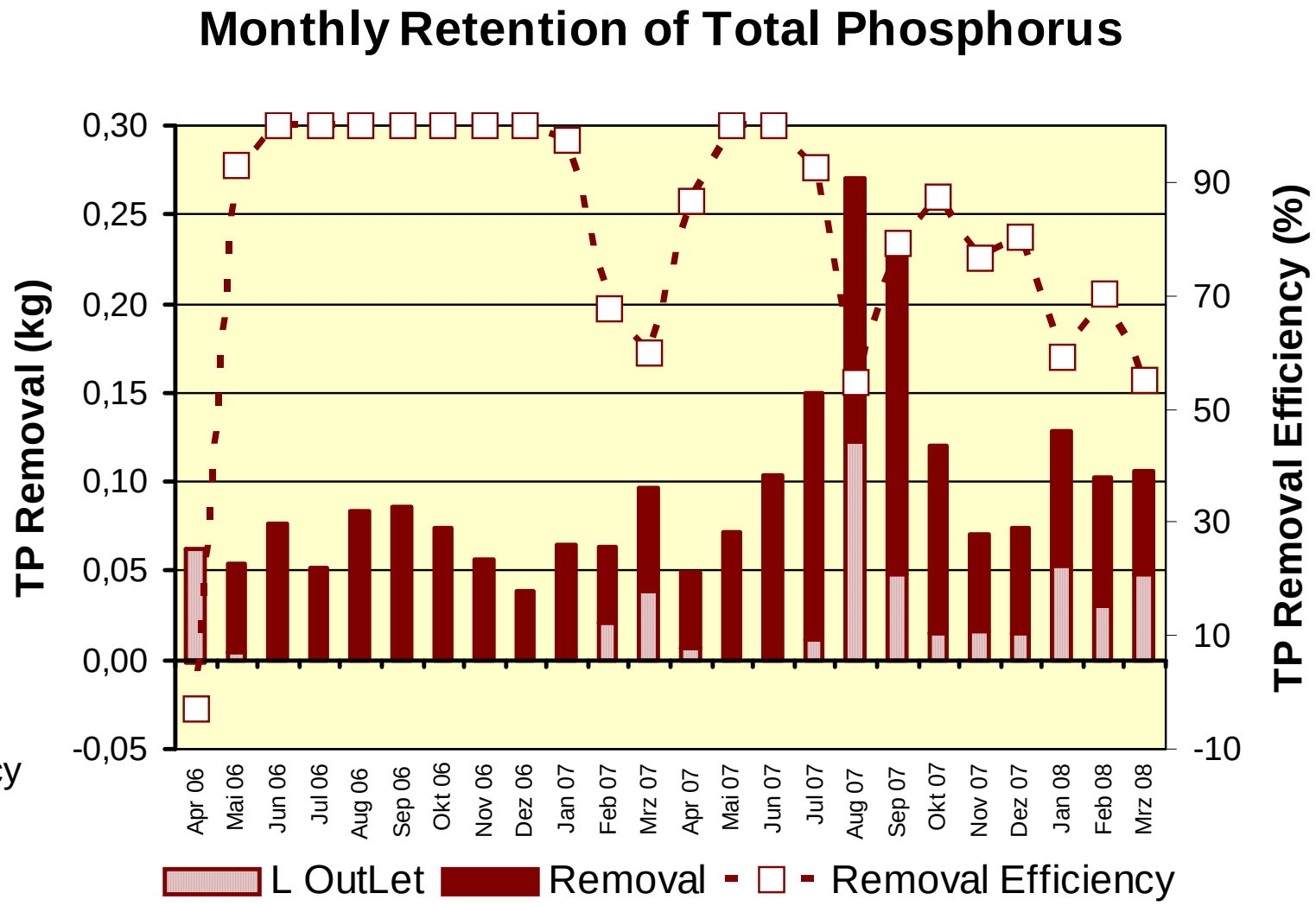

III

Nitrogen Removal by Accumulation and Denitrification in the Ponds

pond	process	
	storage in above-ground **biomass** of macrophytes	**denitrification**
	max. N in kg	kg a^{-1}
I	112,5	17,1
II	10,4	0,9
III	1,7	10,8

Budgets of purification effects

pilot pond III



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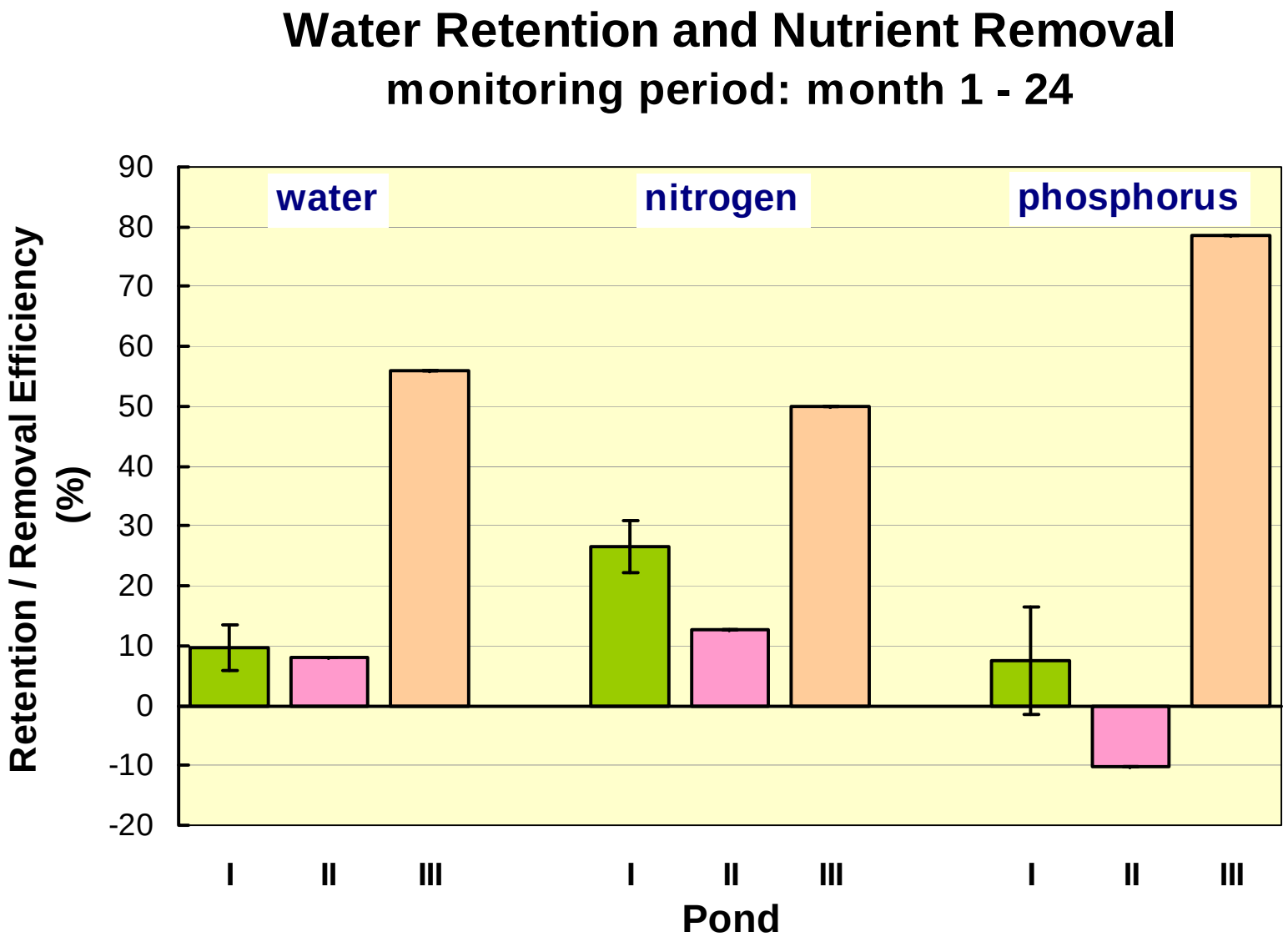
Budgets of purification effects



Summary

- Over the whole investigation period the pilot ponds impacted the pressures on the water bodies from the agricultural drainage systems by
  - runoff reduction by 8 - 56 %
  - nitrogen load reduction by 13 – 50 % and
  - phosphorus load reduction by 7 - 78 %
    (exception: increase by 13 %. in pond II)
- The pilot ponds could be placed environmentally adapted between drainage outlets and downstream receiving waters without harmful effects on the agricultural drainage systems.

Conclusions

- The principle of purification ponds is appropriate for the reduction of nutrient entries from agricultural drain systems towards the receiving waters.

- The findings from the monitoring of the removal processes in the pilot ponds provide essential basics for guide lines on an effective installation and operation of purification ponds.

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Thank you!

Pressures on water bodies

from agricultural drainage effluents

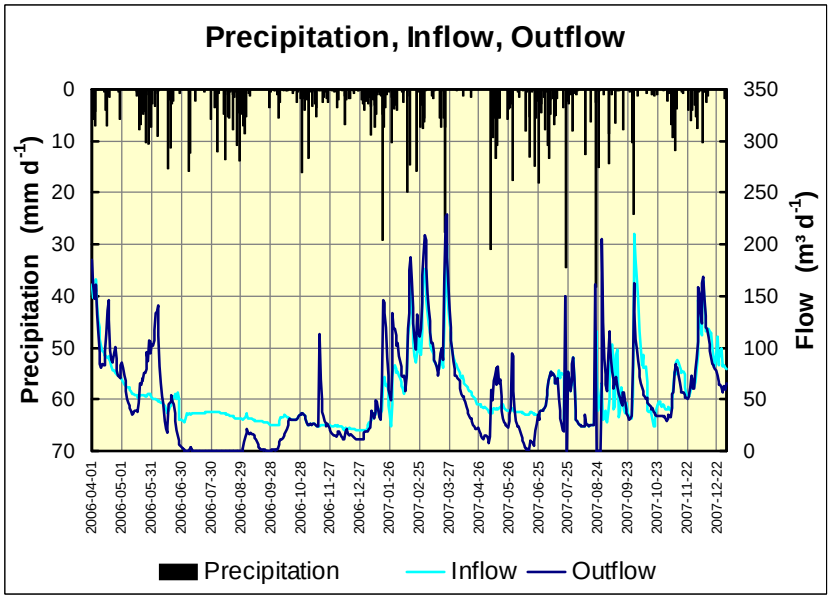
Estimated nitrogen entries from drainage into waters of German Baltic Sea catchment (1992-1997)

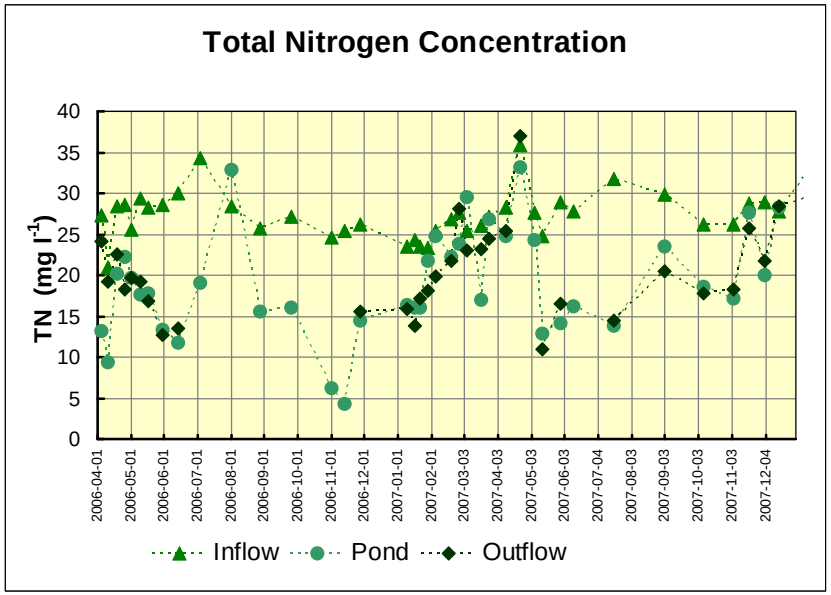
catchment	Nitrogen (tN/year) from drainage	total	portion from drainage
1 coast Vorpommern	1950	4609	42%
2 coast Schleswig-Holstein	1860	7500	25%
3 Warnow	1949	3708	53%
4 Peene	1780	2844	63%
5 Tollense	1257	2232	56%
6 Uecker	1011	1646	61%
7 coast Mecklenburg	1687	4111	41%
8 Recknitz	769	1235	62%
9 Trave 2	169	1283	13%
10 Zarow	385	622	62%
11 Trebel	810	1444	56%
12 Randow	238	366	65%
13 Trave	173	1291	13%
14 Stepenitz	1225	2009	61%
15 Schwentine 2	55	795	7%
16 Barthe	337	572	59%
17 Schwentine	36	497	7%
18 Ryck	200	337	59%
19 Wallensteingraben	159	358,8	44%
sum	**16049**	**37459**	**45%**

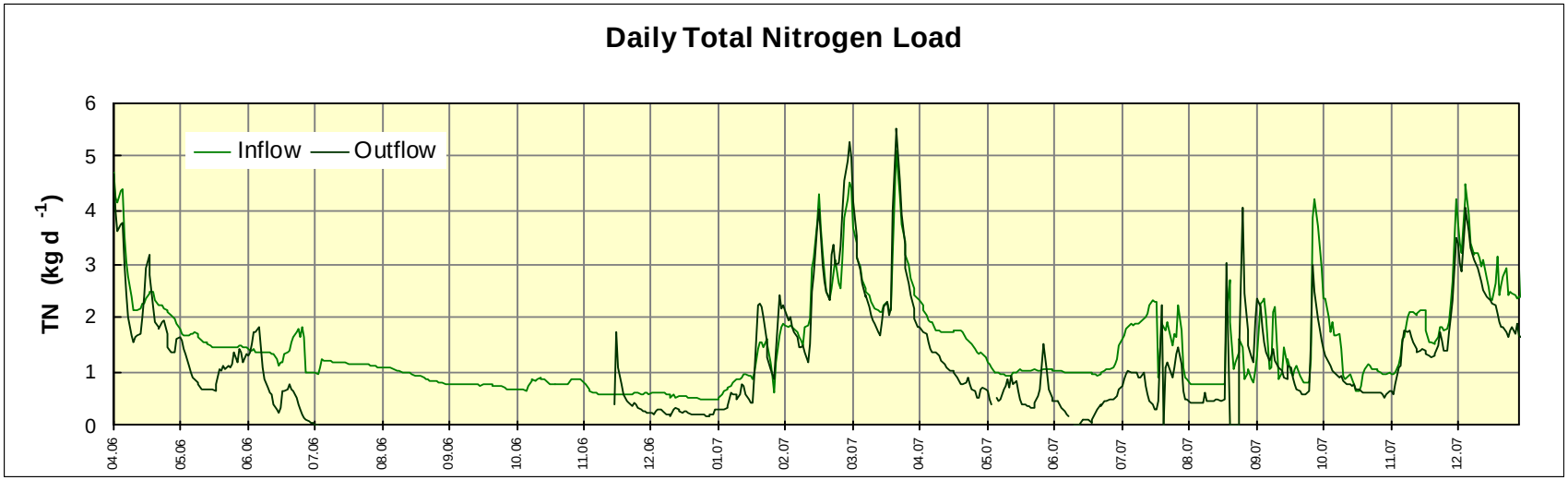
source:
MEWES (2004)

Methods

to determine the purification effects

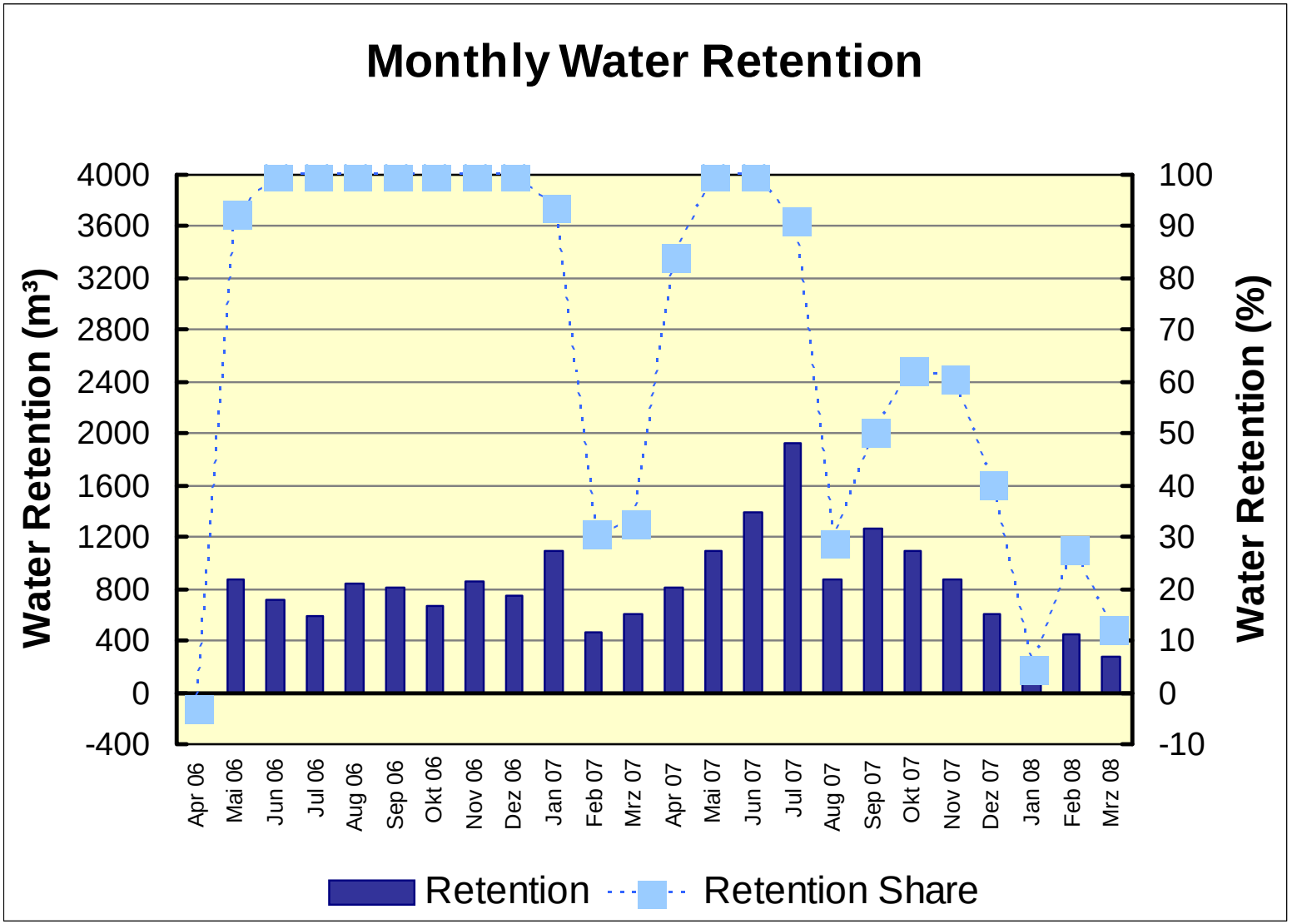






Budgets of purification effects

pilot pond III



Water Retention

$$R_W = Q_{Inlet} - Q_{Outlet}$$