Optimització del funcionament de dos filtres verds i monitorització de la seva eficiència (accions B3 i C3)

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RECERCA I TECNOLOGIA AGROALIMENTÀRIES

EBRO ADMICLIM
LIFE 13 ENV/ES/001182

Life

Generalitat de Catalunya
Departament d'Agricultura, Ramaderia i Pesca

The Ebro Delta is a strongly humanized wetland area

- Around **70% of the delta plain has been converted from wetlands to rice fields** (ca. 20,000 Ha), mostly during the XX century.

- The **hydrology is completely modified by rice cultivation**, leading to a fresher delta with higher river water and nutrient inputs in summer (May-Oct.).

- Dam construction in the lower Ebro river (60’s) caused the **retention of 99% of the original sediment load**, leading to coastal erosion.

- Irrigation and other water uses in the river basin have lead to a **reduction of 40% in the river runoff**.

- The remaining **natural wetlands (9,000 Ha) still are a remarkable biodiversity hotspot**, but are small in size, fragmented and affected by hydrological alterations.

- **Constructed wetlands are being built in order to improve water quality from rice field drainage** before reaching shallow coastal waters.

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Rice fields: the good and the bad

- Besides providing food, **Ebro Delta rice fields are outstanding in terms of ecosystem services they can potentially provide**.

- **We investigate how to optimize their ecosystem services:** increase C sequestration, reduce GHG emissions, remove nutrients and pollutants, increase soil accretion, control salinity, etc.

- However, during some periods **inputs of nutrients and pesticides affect the ecological quality of surrounding wetlands and adjacent coastal waters**, and constructed wetlands are a good tool to mitigate those impacts.

- He we show **results concerning the efficiency of real scale constructed wetlands** in the Ebro Delta in terms of several ecosystem services.

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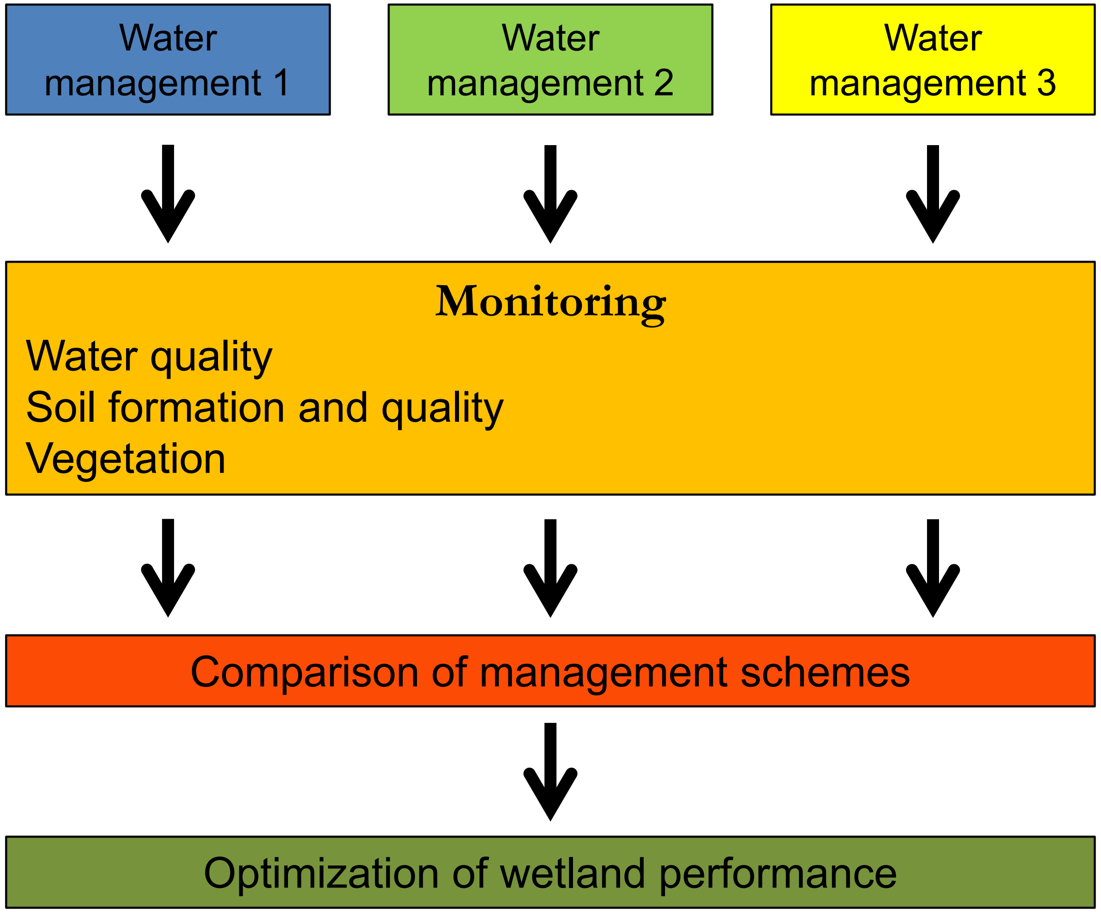
Location and general features





Main goals of the pilot action



- The main goal was to **optimize the functioning of the constructed wetlands** in terms of water quality and other ecosystem services, as a function of water level and turnover.
- However, **real conditions (ecological, economic, social, etc.) made things more complicated**…the control of the hydrology was far from "perfect".
- We decided to change the analytical methods **from a factorial approach to a multivariate one**: extract information from the complexity in space and time.

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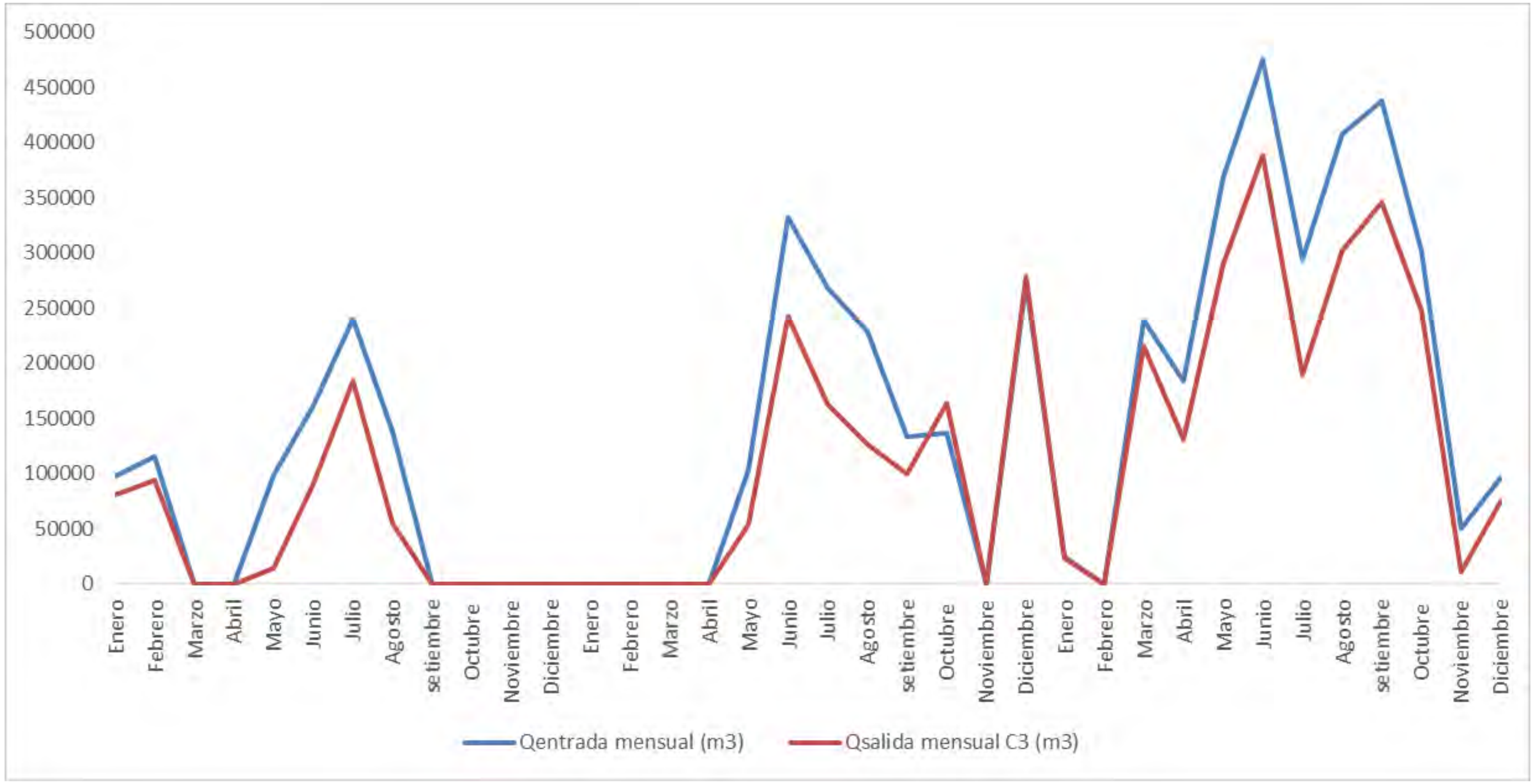
Water management



Water management of the South constructed wetland along the 3 year period of the pilot action. A large variability of water inputs along the year is observed. The variability at daily time-scale was also very high (pumping only at night).

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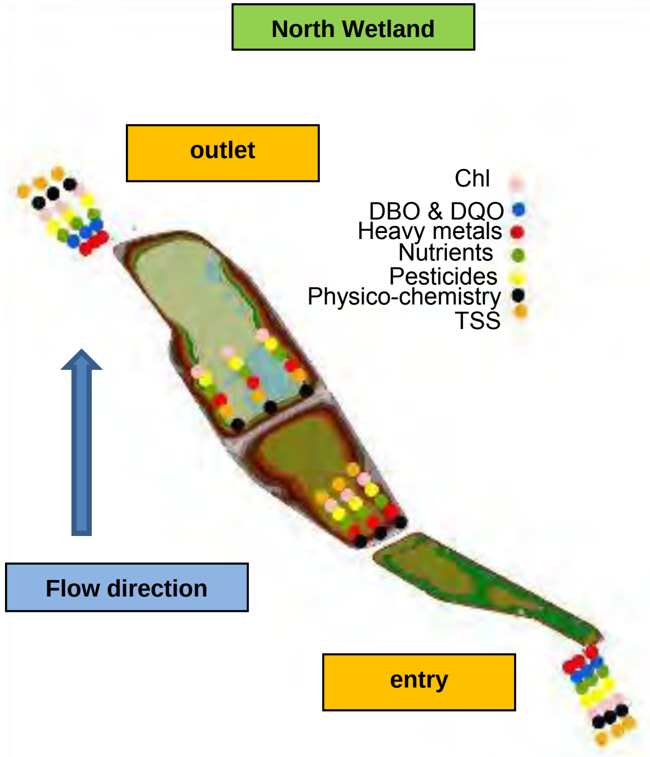
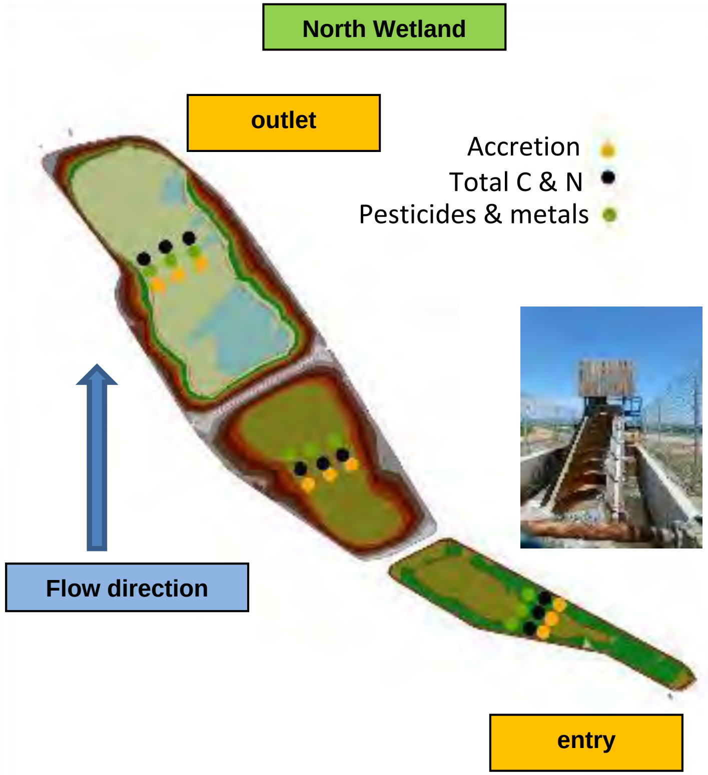
Monitoring program of the constructed wetlands

WATER



Variable	Sampling frequency
Chl	Quarterly
DBO / DQO	Monthly
Heavy metals	Quarterly
Nutrients	Monthly
Pesticides	Quarterly
Physico-chemistry	Monthly
Suspended sediments	Monthly

SOIL



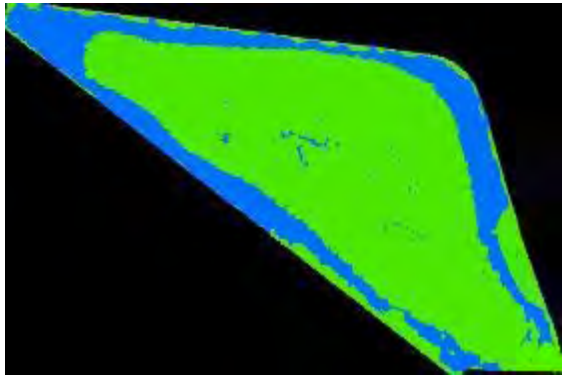
Variable	Sampling frequency
Accretion	start/end
Total C	start/end
Total N	start/end
Pesticides	start/end
Heavy metals	start/end

Monitoring changes in vegetation cover

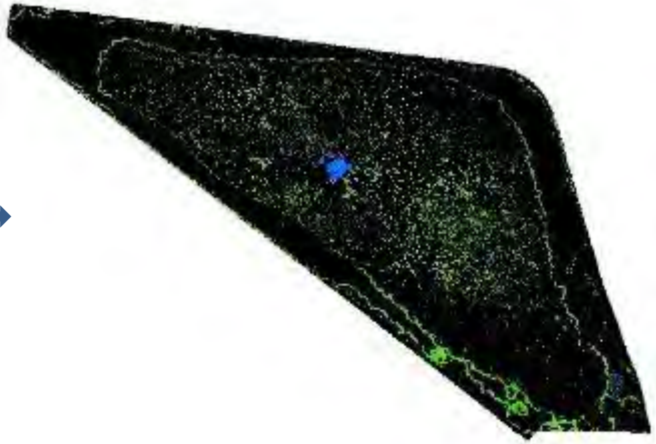
Vegetation cover was obtained from NDVI (normalized vegetation index) by using satellite images and ArcGIS.

Combining images

Obtention of NDVI

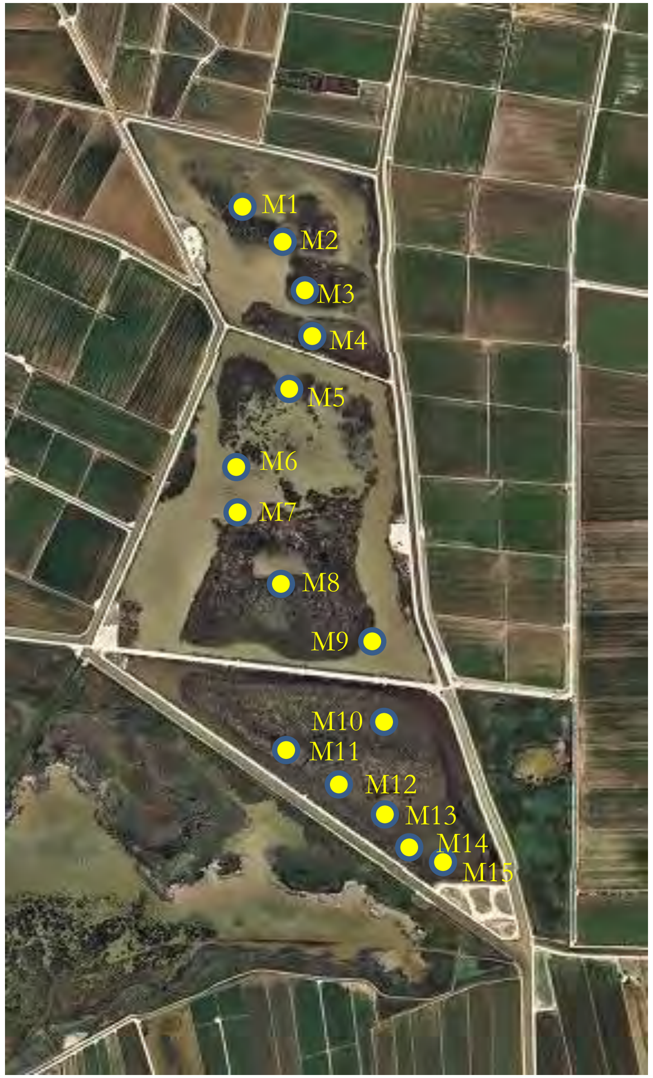


Vegetated area and open water



Observed differences

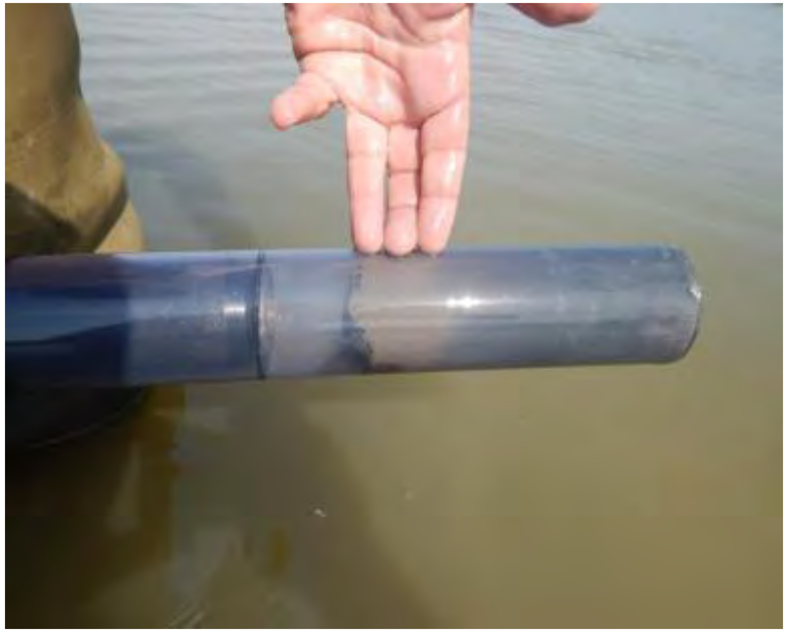
Monitoring vegetation biomass



South

North

Monitoring soil accretion, elevation change & carbon sequestration



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Results: North constructed wetland

Variable	Entrada (Media ± SE (n))	Salida (Media ± SE (n))		
	NE	NM	NF	NS
Altura del agua m	0,43 ± 0,02 (45)	0,57 ± 0,01 (45)	0,50 ± 0,02 (45)	0,62 ± 0,02 (45)
Temperatura ºC	22,7 ± 0,5 (39)	23,0 ± 0,6 (39)	22,7 ± 0,6 (39)	23,6 ± 0,6 (39)
pH s.u.	7,67 ± 0,03 (39)	7,31 ± 0,03 (39)	7,33 ± 0,03 (39)	7,42 ± 0,04 (39)
OD mgl^{-1}	6,1 ± 0,2 (39)	1,9 ± 0,2 (39)	3,0 ± 0,3 (39)	2,7 ± 0,3 (39)
ORP mV	103,8 ± 11,3 (39)	46,4± 16,4 (39)	60,7 ± 15,7 (39)	74,2 ± 14,8 (39)
EC$\mu S^{-1}cm^{-1}$	2023 ± 65 (39)	2053 ± 35 (39)	3345 ± 441 (39)	5496 ± 765 (39)
Boro	0,31 ± 0,1 (18)	0,17 ± 0,02 (18)	0,295 ± 0,053 (18)	0,33 ± 0,04 (18)
Manganeso	88,1 ± 11,9 (18)	121,44 ± 21,77 (18)	137,72 ± 31,34 (18)	92,94 ± 25,47(18)
Hierro	327,4 ± 42,8 (18)	204,78 ± 34,23 (18)	237,72 ± 50,36 (18)	178,94 ± 33,61 (18)
Arsénico	6,8 ± 0,7 (18)	6,21 ± 0,59 (18)	6,22 ± 0,48 (18)	9,82 ± 1,15 (18)
Estroncio	2413,5 ± 280,9 (18)	1931,22 ± 62,93 (18)	2270,5 ± 144,5 (18)	2337 ± 232,4 (18)
Clorofila Total	58,2 ± 21,6 (18)	17,05 ± 3,97 (18)	13,19 ± 3,70 (18)	16,96 ± 2,72 (18)
Clorofila a	44,5 ± 16,41 (18)	13,60 ± 3,14 (18)	10,66 ± 2,85 (18)	12,82 ± 2,10 (18)
Solidos Supendidos Totales mgl^{-1}	28,6 ± 7,5 (45)	6,9 ± 0,8 (45)	8,9 ± 1,29 (45)	8,90 ± 0,95 (45)
Oxadiazon μgl^{-1}	1,30 ± 0,11 (18)	0,70 ± 0,06 (18)	0,42 ± 0,09 (18)	0,12 ± 0,25 (18)
$N\text{-}NO_3^{-2}$ mgl^{-1}	0,1389 ±0,0141 (45)	0,0239 ± 0,0046 (45)	0,1485 ± 0,0015 (45)	0,0160 ± 0,0020 (45)
$N\text{-}NO_2^{-}$ mgl^{-1}	0,1648 ± 0,0049 (45)	0,0011 ± 0,0002 (45)	0,0011 ± 0,0002 (45)	0,0009 ± 0,0001 (45)
$N\text{-}NH_4^{+}$ mgl^{-1}	0,2234 ± 0,0452 (45)	0,0290 ± 0,0002 (45)	0,0420 ± 0,0111 (45)	0,0944 ± 0,0300 (45)
$P\text{-}PO_4^{-3}$ mgl^{-1}	0,0130 ± 0,0013 (45)	0,0246 ± 0,0052 (45)	0,0249 ± 0,0056 (45)	0,0083 ± 0,0011 (45)
$Si\text{-}SiO_2$ mgl^{-1}	1,9359 ± 0,1088 (45)	1,9371 ± 0,1376 (45)	1,7742 ± 0,1182 (45)	1,5512 ± 0,1392 (45)

- High efficiency in nutrient removal, chlorophyll and suspended solids
- Lower efficiency in metal removal
- Little information about pesticide removal
- High rates of soil accretion and carbon sequestration (results not shown)

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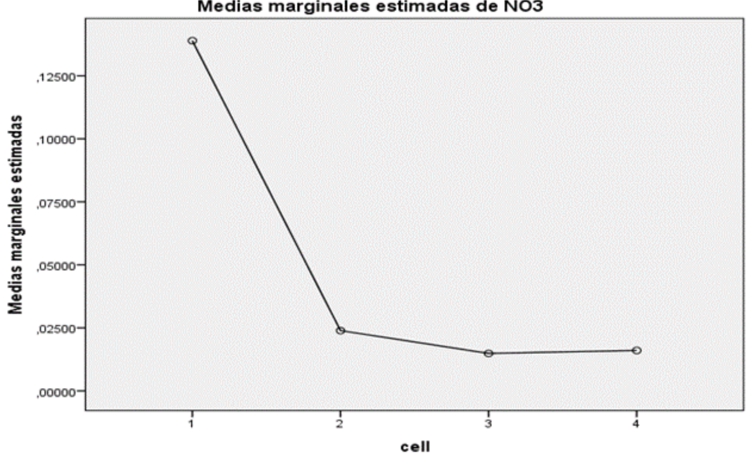
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Medias marginales estimadas
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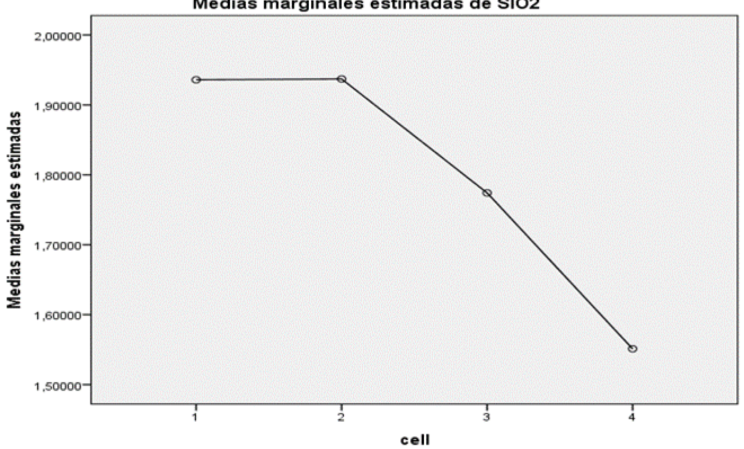
,02500
,05000
,07500
,10000
,12500
1
2
3
4
cell


Medias marginales estimadas de SiO2
Medias marginales estimadas
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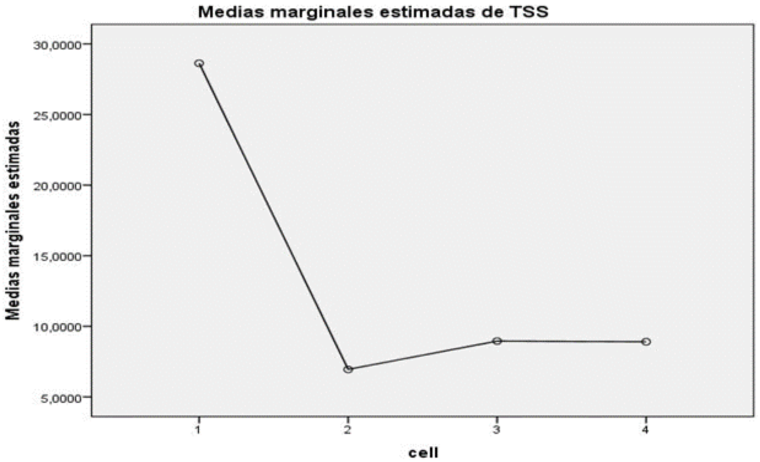
1,80000
1,90000
2,00000
1
2
3
4
cell


Medias marginales estimadas de TSS
Medias marginales estimadas
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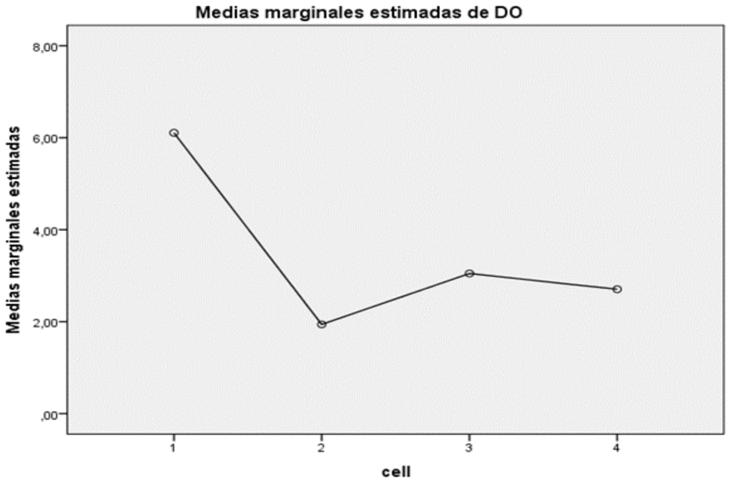
15,0000
20,0000
25,0000
30,0000
1
2
3
4
cell


Medias marginales estimadas de DO
Medias marginales estimadas
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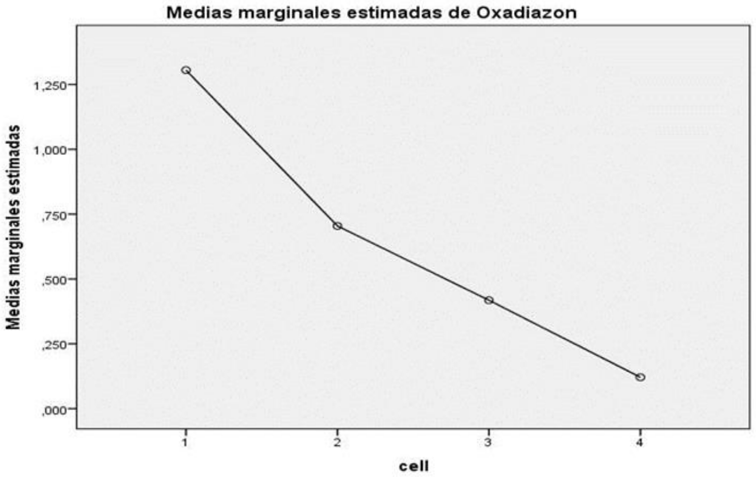
8,00
1
2
3
4
cell


Medias marginales estimadas de Oxadiazon
Medias marginales estimadas
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,250
,500
,750
1,000
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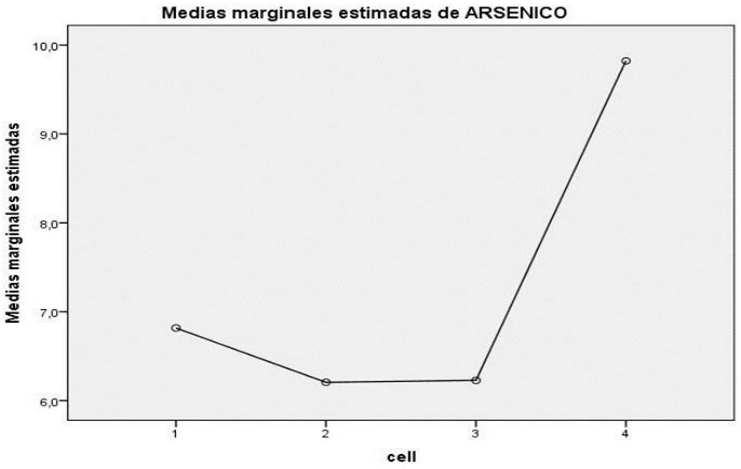
1
2
3
4
cell


Medias marginales estimadas de ARSENICO
Medias marginales estimadas
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7,0
8,0
9,0
10,0
1
2
3
4
cell

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Results: nutrient removal efficiency

North wetland

	% Efficiency NO_3	% Efficiency NO_2	% Efficiency NH_4	% Efficiency PO_4	% Efficiency SiO_2
2015					
C1	81.25±3.5	86.71±1.3	80.08±2.7	12.45±14.6	26.99±2.6
C2	57.55±10.5	41.05±6.9	36.12±20.7	56.25±6.46	39.91±5.3
C3	55.17±10.7	63.66±6.3	55.80±13.2	74.21±3.8	72.30±8.5
Total	96.59±0.8	97.25±0.6	96.16±1.3	90.95±1.8	88.03±3.6
2016					
C1	77.86±9.5	88.38±3.2	65.62±10.4		16.20±20.7
C2	28.89±33.7	12.22±20.1	-36.72±17.6	22.23±19.7	25.35±11.9
C3	9.66±25.2	25.09±16.0	-58.28±27.2	48.87±33.5	36.15±25.3
Total	93.89±1.6	92.76±3.1	25.52±22.6	49.38±17.9	67.27±12.7
2017					
C1	87.96±4.7	95.27±9.1	85.15±9.2	55.19±7.8	14.18±9.9
C2	24.40±17.3	-4.50±32.1	-56.03±32.1	-50.39±61.0	23.03±8.7
C3	13.85±13.1	23.57±20.0	10.82±20.0	19.77±17.7	-4.33±26.5
Total	82.29±9.4	95.82±5.2	89.35±5.2	63.72±11.3	38.78±10.8
TOTAL	**90.92±3.9**	**95.28±1.9**	**70.34±9.7**	**68.02±10.4**	**64.69±8.9**

South wetland

	% Efficiency NO_3	% Efficiency NO_2	% Efficiency NH_4	% Efficiency PO_4	% Efficiency SiO_2
2015					
C1	71.21±6.8	72.69±10.0	84.10±4.9	50.84±5.9	15.11±1.9
C2	59.39±13.8	55.93±6.1	-43.10±71.2	27.30±11.0	57.15±12.0
C3	-48.08±42.6	-4.85±±31.0	-71.08±49.9	48.05±10.6	10.70±15.8
Total	85.79±7.1	89.844.4	63.34±	78.36±8.0	69.40±9.8
2016					
C1	74.00±9.3	80.79±5.5	74.33±10.7	50.44±11.8	-8.67±16.1
C2	31.19±16.8	46.82±13.3	23.81±20.5	20.28±12.6	41.70±10.8
C3	-8.70±22.5	-56.70±63.6	-7.06±19.	9.37±21.4	36.96±9.0
Total	75.6315.8	79.66±9.6	84.27±5.3	76.04±5.9	61.27±7.9
2017					
C1	69.96±23.3	87.93±3.0	33.47±13.8	65.08±9.8	-8.23±14.8
C2	47.55±16.7	33.51±19.1	68.26±8.5	25.40±14.1	28.33±6.3
C3	19.46±18.3	28.89±8.4	28.82±9.5	17.30±2.9	31.38±7.3
Total	92.18±5.7	95.79±1.3	87.61±2.9	81.56±3.7	47.36±8.3
TOTAL	**84.53±4.8**	**88.43±4.7**	**78.41±7.6**	**78.65±1.6**	**59.34±6.4**

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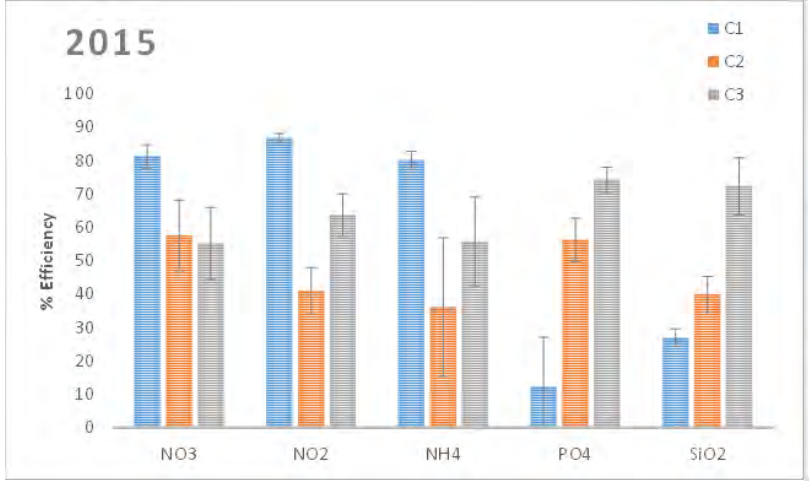
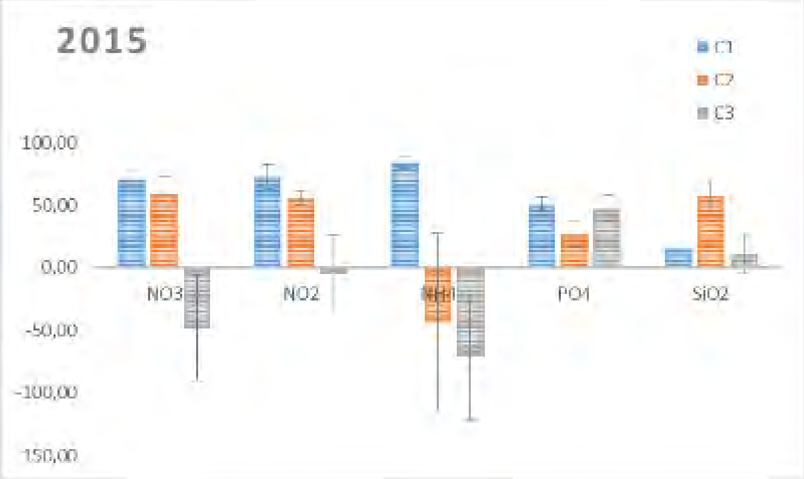
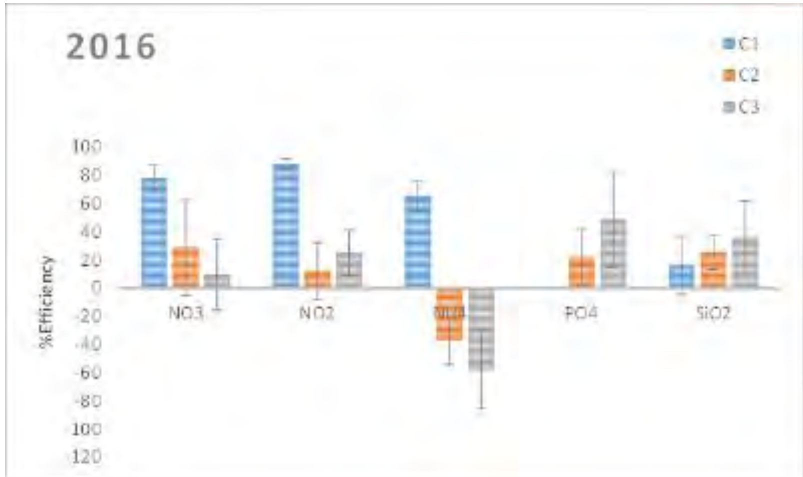
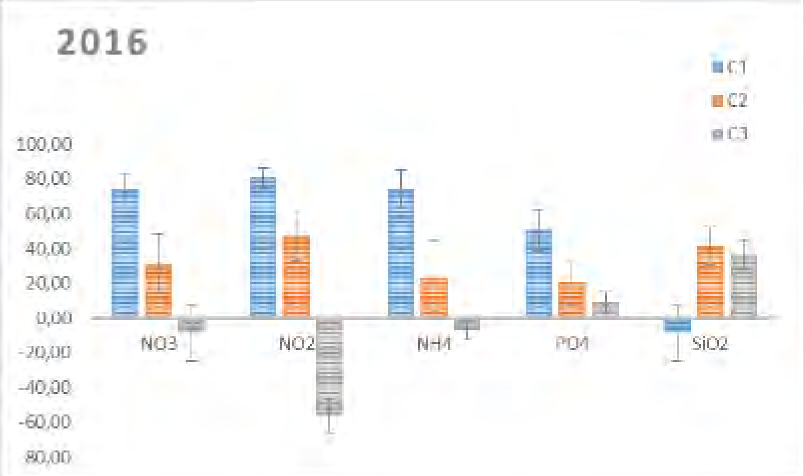

2015
C1
C2
C3
% Efficiency
100
90
80
70
60
50
40
30
20
10
0
NO3
NO2
NH4
PO4
SiO2


2015
C1
C2
C3
100,00
50,00
0,00
-50,00
-100,00
-150,00
NO3
NO2
PO4
SiO2


2016
C1
C2
C3
%Efficiency
100
80
60
40
20
0
-20
-40
-60
-80
NO3
NO2
PO4
SiO2


2016
C1
C2
C3
100,00
80,00
60,00
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-20,00
-40,00
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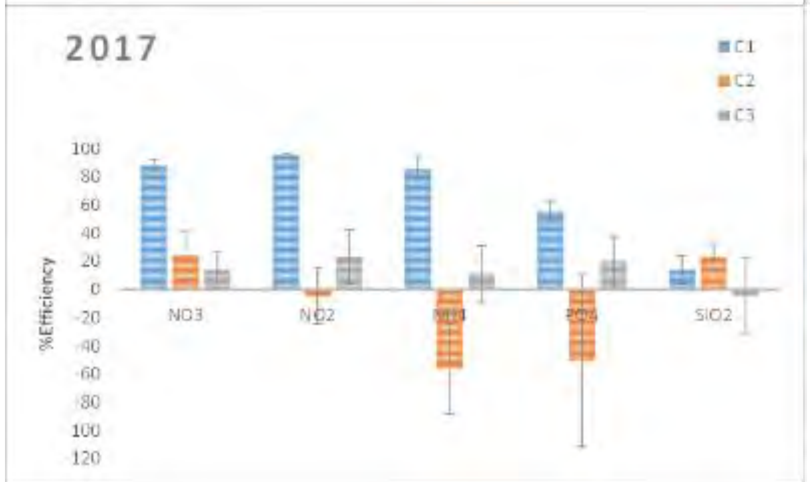
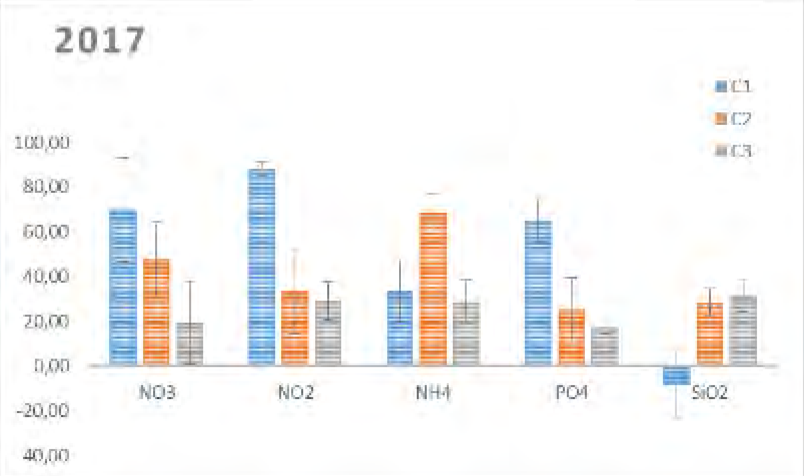
NO3
NO2
NH4
PO4
SiO2


2017
C1
C2
C3
%Efficiency
100
80
60
40
20
0
-20
-40
-60
-80
NO3
NO2
SiO2


2017
C1
C2
C3
100,00
80,00
60,00
40,00
20,00
0,00
-20,00
NO3
NO2
NH4
PO4
SiO2

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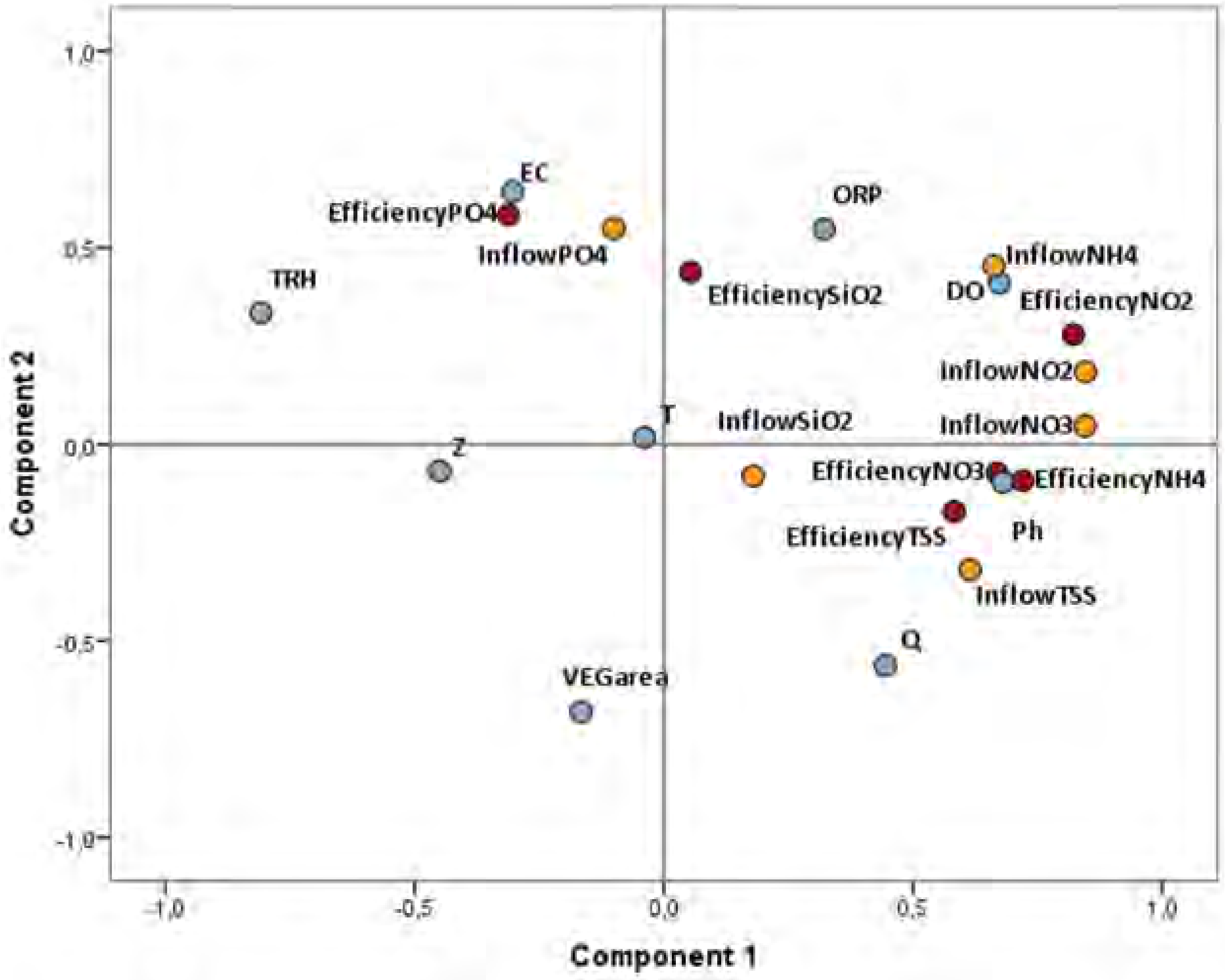
Results: Principal Component Analysis (North)



- **First axis related to N and TSS and second to P and Si**. Explained variance: 46%
- **N, P and TSS removal efficiency related to load**, but not clear for Si.
- **pH (directly) and water depth (inversely) related to N and TSS** removal efficiency.
- **Marsh vegetation cover inversely related to P and Si** removal efficiency.

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Results: multivariate analysis (North)

Dependent variable	Significant variables	Adjusted R^2
Efficiency NO_2	Inflow concentration NO_2 Ph	0.612
Efficiency NO_3	Inflow concentration NO_3 Ph	0.476
Efficiency NH_4	Ph Inflow concentration NH_4 Electrical Conductivity	0.452
Efficiency PO_4	TRH Inflow concentration PO_4	0.325
Efficiency SiO_2	-	-
Efficiency TSS	Inflow concentration TSS	0.543

Results of the stepwise regression (forward) concerning removal efficiency ($p<0.05$).

- As expected, **removal rates depend on load and also pH**. Silica goes its own way (?).

- **The space&time to remove N and TSS was smaller than P and Si**. Turnover (TRH) was only significant for PO_4 removal rate. Turnover rate was low in general (ca. 1 month).

- Complexity in terms of hydrological functioning, ecogeomorphic conditions, operational constraints, etc., prevented the initial goal to compare "standard" management schemes.

- **A multivariate approach with exhaustive data across space and time is necessary to disentangle the complexity of real scale constructed wetlands.**

- The key question is: **how to optimize the different ecosystem services?**

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