Integrated Multitrophic Aquaculture: Ecological intensification of freshwater ponds

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Cooperation in Fisheries, Aquaculture and Seafood Processing

Context

Multi goals for aquaculture :

- **Aquaculture products more and more required**
- **To Produce in systems environmentally friendly**
- **Sustainable systems and less dependent in exogenous resources**

How answer to fish production increase and limit impacts on environment at the same time?

That's the work scope of the IMTA effect project and of this work

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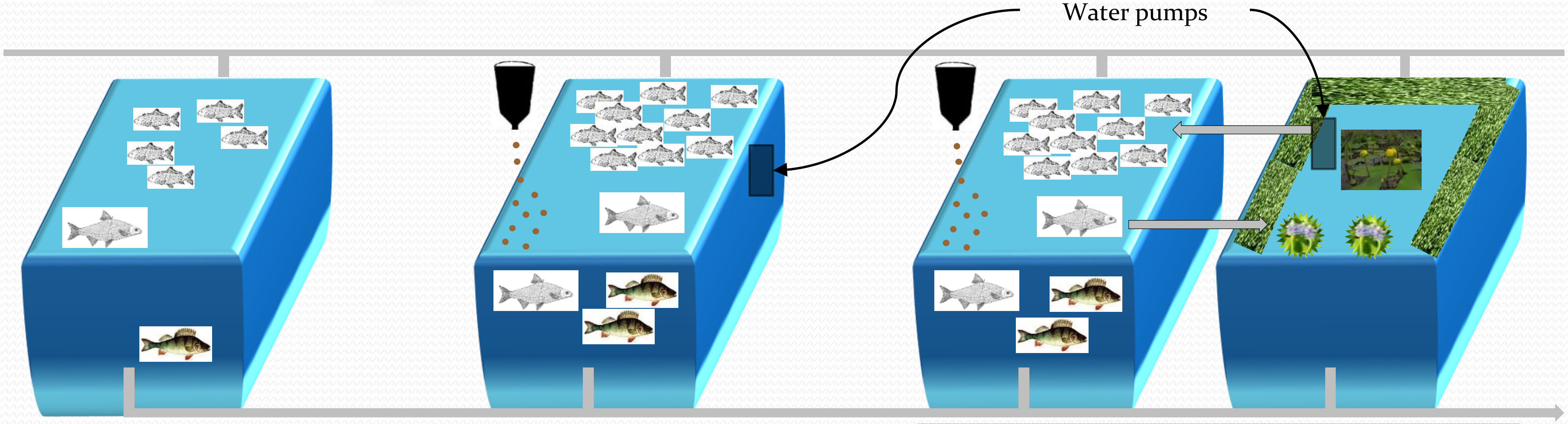
Experimental design



“Extensive” treatment	
330 carp	50 kg/ha
30 roach	20 kg/ha
5 perch	1 kg/ha

“Semi-Intensive” fed treatment	
660 carp	100 kg/ha
60 roach	40 kg/ha
10 perch	2 kg/ha

“coupled” fed treatment	
660 carp	50 kg/ha
60 roach	20 kg/ha
10 perch	1 kg/ha

Macrophytes introduced :
Watercress (*Nasturtium officinale*)
Water lily (*Nuphar lutea*)
Manna grass (*Glyceria aquatic*)
Pickerel weed (*Pondeteria cordata*)

Polyculture :

- **Fingerlings of common Carp, target species, wide diet, burrowing behavior and ability to keep nutrients available for phytoplankton and macrophyte**
- **Adults of Roach, wide diet, use entire water column**
- **Only male of Perch, carnivorous diet, to limit fry, crayfish and tadepole**

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Experimental design

- Experimentation lasted from March to December
- Ponds were filled with water from the nearby watershed river, 3 weeks before the beginning and during the experiment to counteract evaporation

- At stocking and harvesting fish were weighed and counted
- Quantity of pellets was daily recorded and supplied on the basis of 2.8% live weight

- Water quality :
  - Weekly, recorded for t°, pH, [O_2], %O_2, water transparency, conductivity,
  - Monthly, analyzed for Nitrogen and Phosphorus compounds,
- Chlorophyll : fluorometer analyzer (Phyto-PAM®),
- Nutrient budget for N and P

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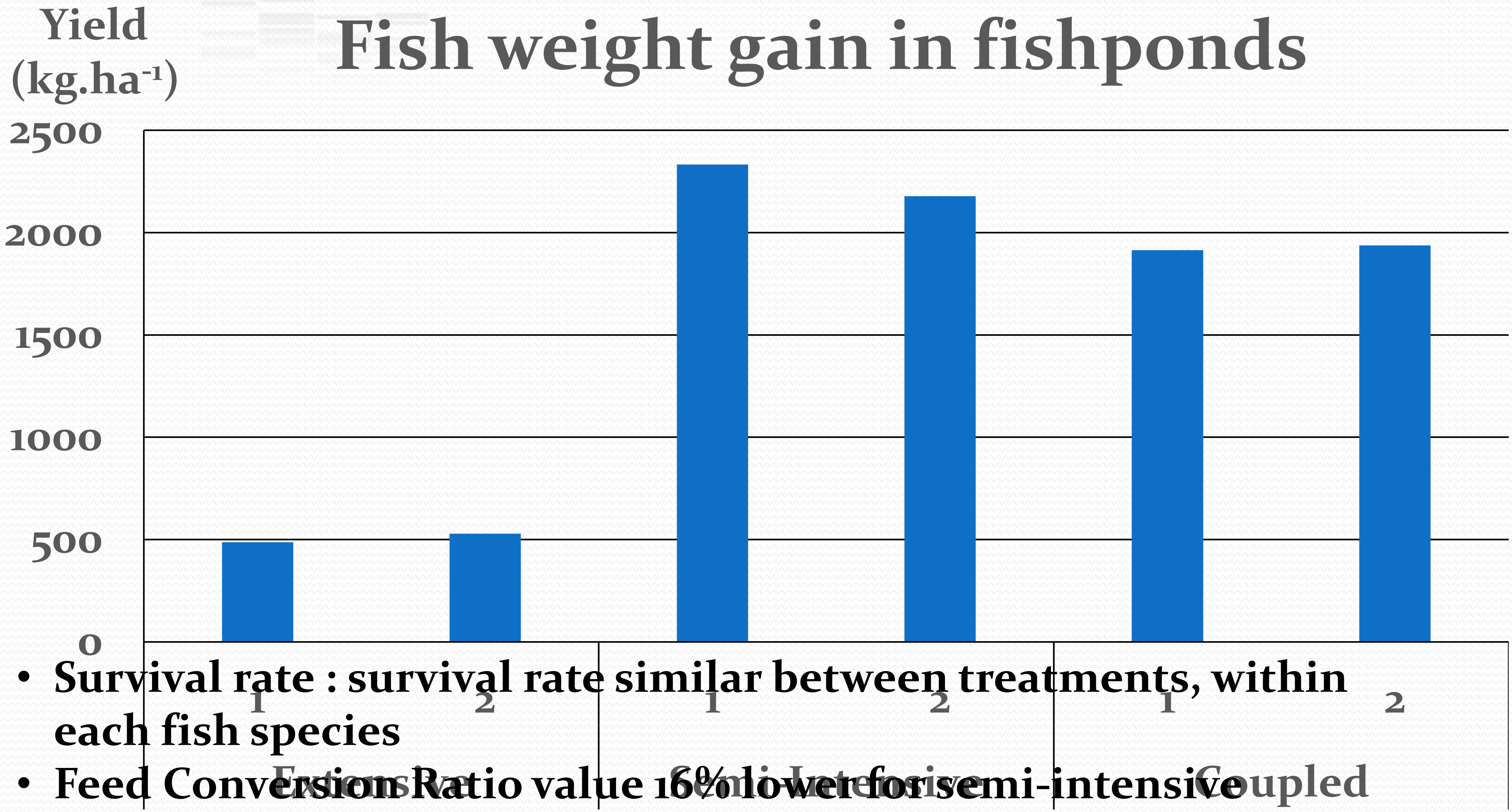
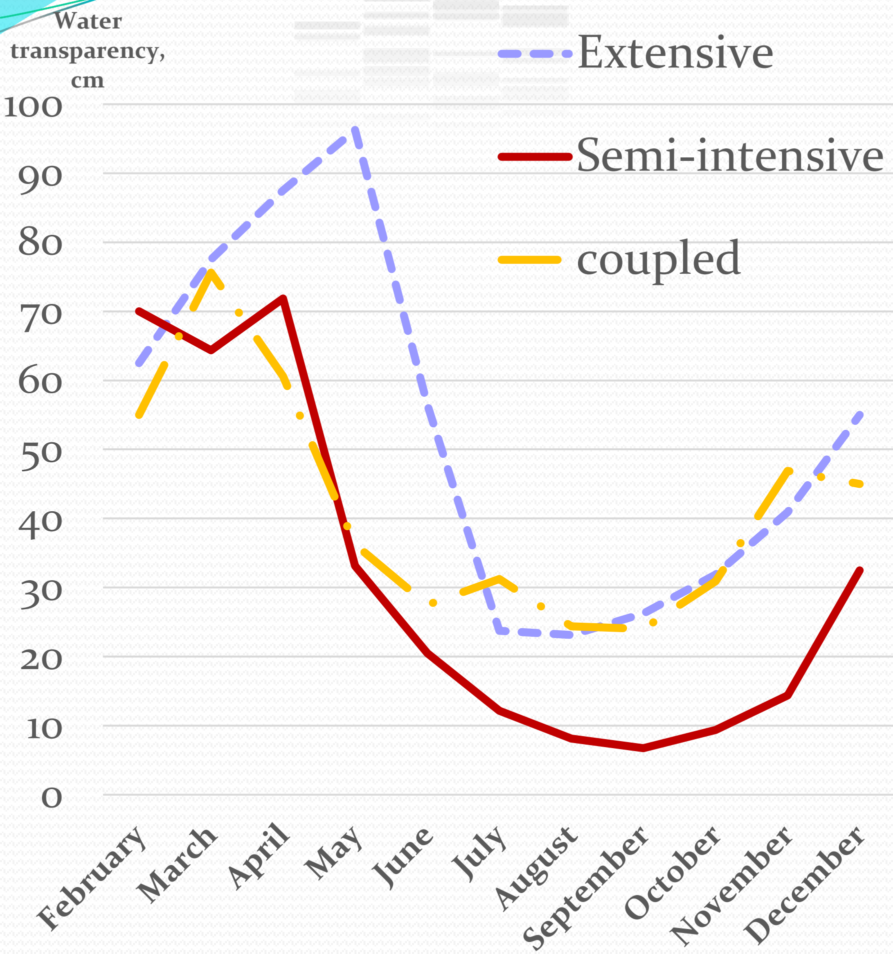
Fish weight gain in fishponds

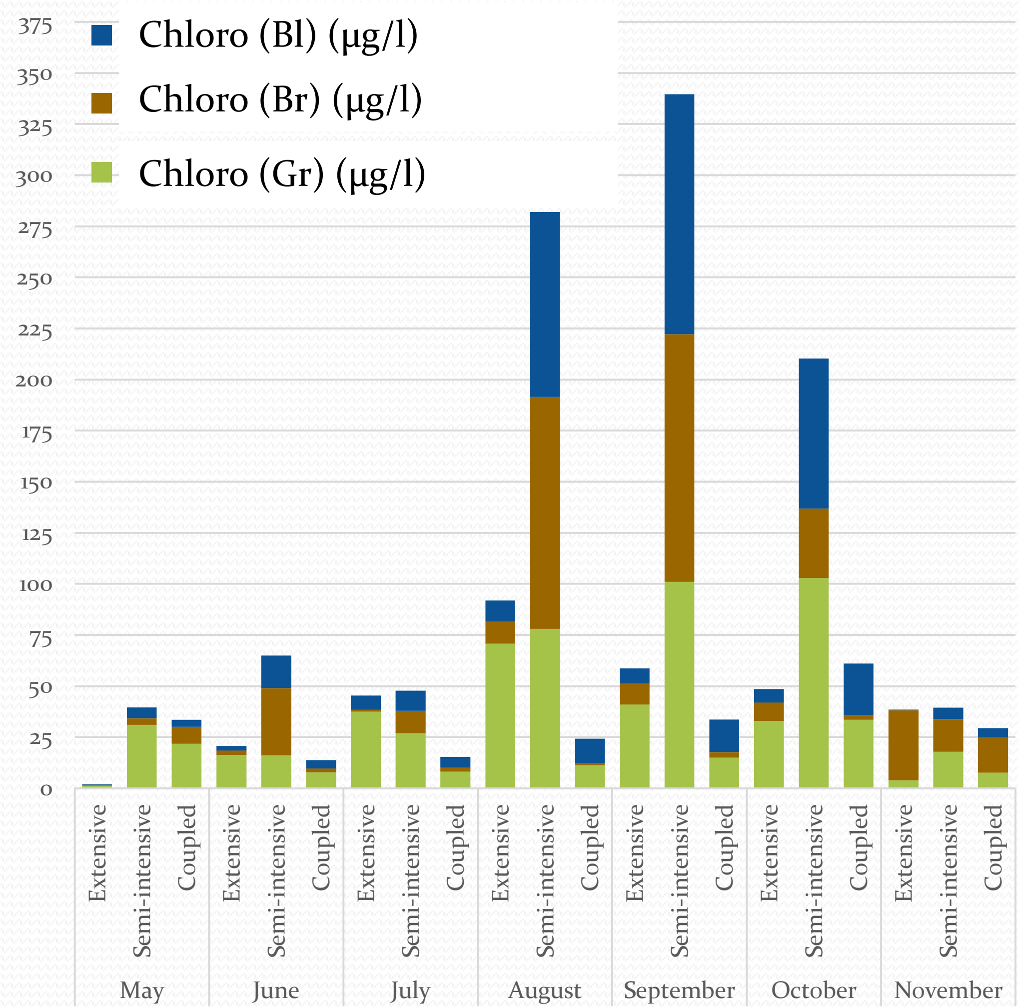


- Survival rate : survival rate similar between treatments, within each fish species
- Feed Conversion Ratio value 16% lower for semi-intensive treatment than for coupled treatment

Water transparency



Chlorophyll concentrations



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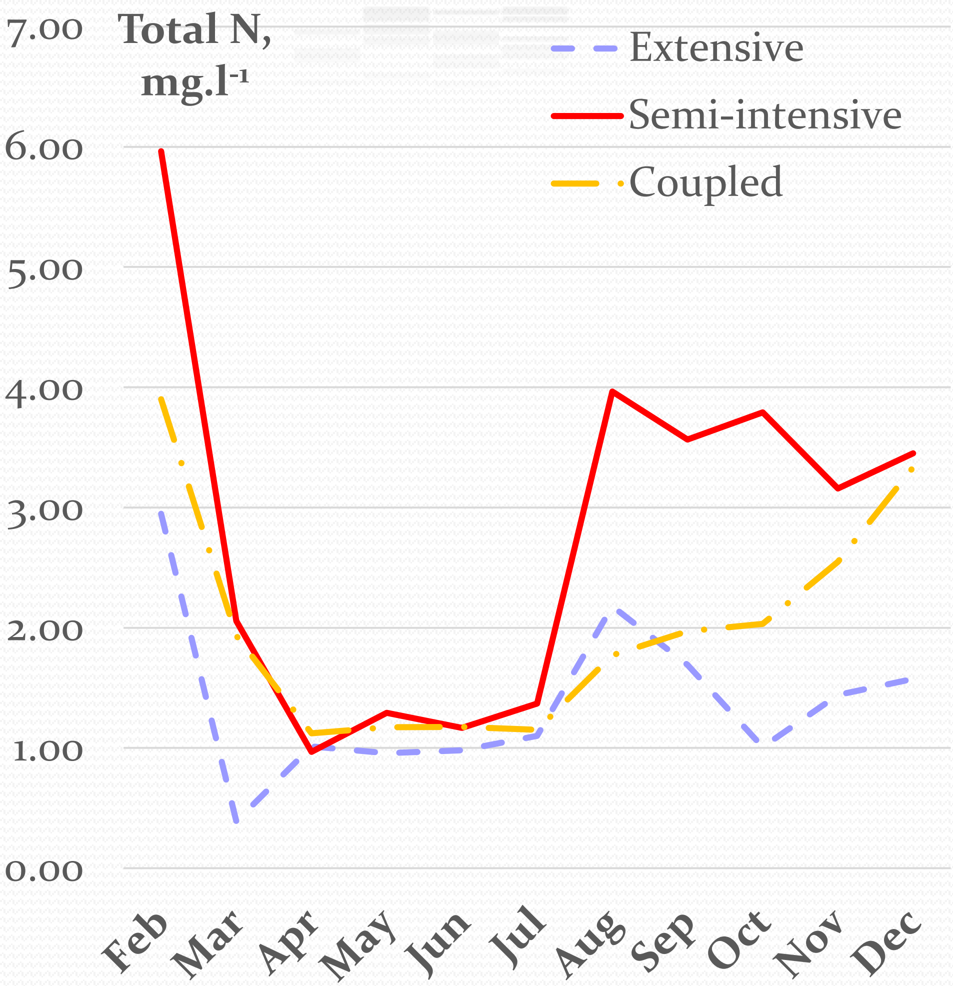
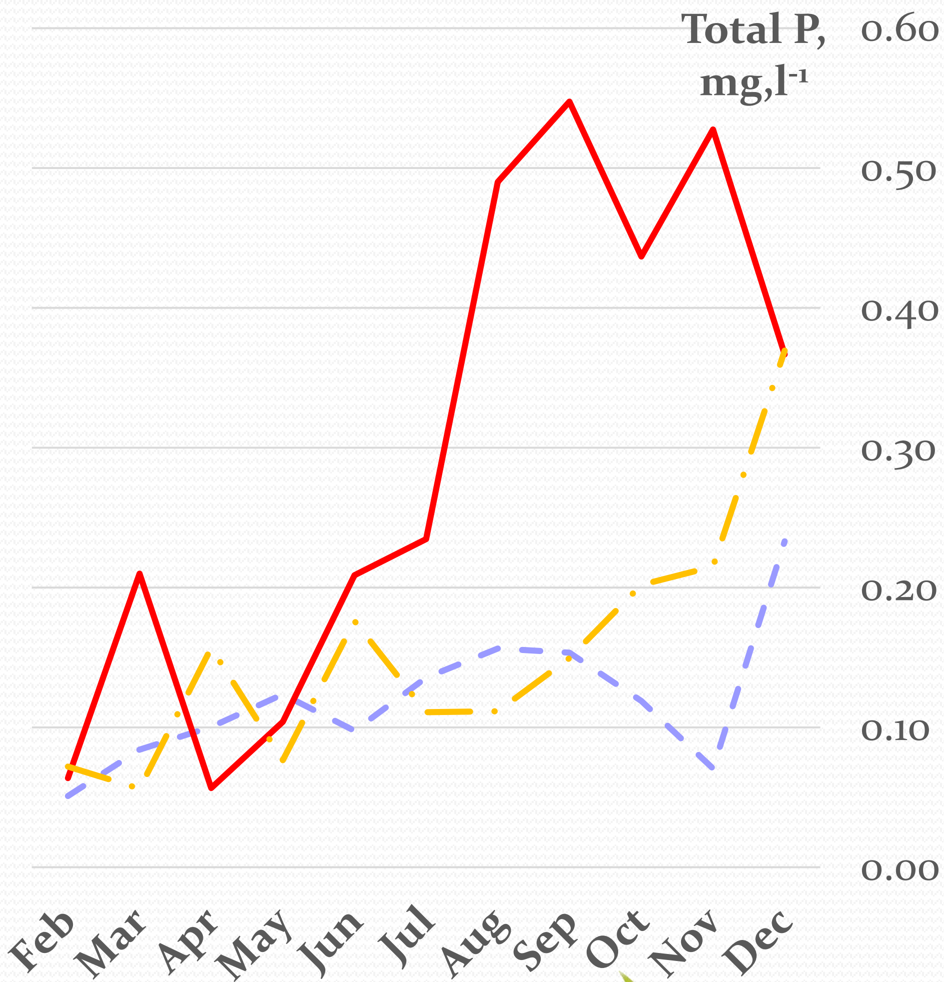
Evolution of N and P in water





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Mass balance for N

	Extensive 1	Extensive 2	Semi-intensive 1	Semi-intensive 2	Coupled 1 fish	Coupled 1 plants	Coupled 2 fish	Coupled 2 plants
N Inputs, g								
fish	108	82	164	165	161	0	160	0
feed	0	0	608	608	608	0	608	0
water	2104	2497	2527	2426	1155	1781	1930	2480
N Outputs, g								
fish	642	648	2628	2451	2173	8	2168	53
Proportion of N input recovered in fish biomass gain	25%	23%	79%	75%	57%		41%	
Water	490	605	1118	1034	1369	1192	544	798
Unaccounted for	1079	1325	-448	-287	-1036		1615	

- **No treatment well balanced**
- **But, in every treatments, N quantity in outlet water<inlet water,**
- **N input (from feed and water) was used more efficiently for fish biomass production in semi-intensive treatment**

⇨ Feed seemed improving trophic web production but in a less extent in coupled treatment

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Mass balance for P

	Extensive 1	Extensive 2	Semi-intensive 1	Semi-intensive 2	Coupled 1 fish	Coupled 1 plants	Coupled 2 fish	Coupled 2 plants
P inputs, g								
fish	27	19	38	39	38	0	38	0
feed	0	0	151	151	151	0	151	0
water	50	68	30	33	31	84	28	92
P outputs, g								
fish	147	145	578	535	477	2	477	14
Proportion of P input recovered in fish biomass gain	241%	184%	297%	270%	166%		167%	
water	66	98	135	91	136	137	24	119
Unaccounted for	-137	-155	-493	-403	-447		-325	

- **P outputs > P inputs in every treatments**
- **P quantity in outlet water > inlet water, in every treatments ⇨ role of senescence of plants?**
- **Proportion of P input recovered in fish biomass gain >100% ⇨ a large part of phosphorus came from environment … sediments**

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Conclusion

- **Feed clearly improved fish production**
- **In coupled treatment:**
  - ➢ **Phytoplankton development was limited to the benefit of Macrophytes**
  - ➢ **As a possible consequence, fish growth was limited too**
  - ➢ **Water concentration in N and P was buffered during the period observed**

⇨ coupled treatment improved fish production compared to extensive treatment and improved water quality compared to semi-intensive treatment

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Perspectives

- **Further investigations need to be carried out to :**
  - **well balance nutrient budget: sediments dynamic, macrophytes yield, gas emission**
  - **Evaluate potential of coupled ponds to support biodiversity and to produce plants of market value**

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