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Preliminary results of a floating wetland system in carp breeding

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Abstract

Aquaculture allows fish cultivation under controlled conditions and it is often considered as a sustainable solution that determines economic development while safeguarding environmental resources. Furthermore, over the past few decades wetland systems have been used for water treatment as they can break down pollutants through the interaction between plants, soil and microorganisms. For this reason, a trial was conducted at the University of Padova (Italy), combining these two systems. It took place in the North of Italy from 21/07/2011 to 18/11/2011. Two tanks were set up for aquaculture, both connected to a mechanical/biological filtration system, but only one with the inclusion of Tech-IA, a floating mat that allows herbaceous plants to float on the water surface, carrying out their purifying function without the aid of a substrate. About 30 kg of carp (*Cyprinus carpio*) were released in each tank. Several parameters were measured during the trial to assess ~~the~~ water quality and each carp was weighed at the end. The results obtained by the tank with Tech-IA showed better water quality data and a faster carp growth rate.

Key words: aquaculture, carp, floating mats

1 Introduction

Nowadays 42% of the fish consumed worldwide, 66 million tons, comes from aquaculture (FAO, 2014), which is a fish production system under controlled or semi-controlled conditions. Its characteristics differ according to: tank size, species grown, production intensity, number of species, salinity and temperature (Frankic and Hershner, 2003). It is generally considered the evolution of fishing because it combines protection of environmental and biological resources in a determined area and sustainable economic development. In fact it is an example of human activities aimed at controlled production by taking care of the different life cycle phases, optimizing production quality and quantity. It is consequently seen as a sustainable solution that determines economic development while safeguarding environmental resources (Mipaaf, 2014). In this context of sustainability the concept of phytodepuration was also introduced to control the pollution originated by fish farms. Over the past few decades floating wetland systems have been used for water treatment as they can break down pollutants through the interaction between plants, soil and microorganisms (Headley and Tanner, 2006). To obtain some initial information on the potential of floating wetlands installed directly in aquaculture tanks, two tanks for rearing fish were set up at the University of Padova, one with the inclusion of Tech-IA elements: floating mats already used in aquaculture wastewater (De Stefani et al., 2011). The aim of the study was to assess the water quality and carp growth rate in the two systems.

2 Materials and method

2.1 System layout and carp breeding

The trial was carried out at the "Lucio Toniolo" experimental farm of the University of Padova, in Legnaro, near Padova. An indoor pilot carp breeding plant was set up (Figure 1), composed of two tanks, tank V and NV, (4 x 2 x 0.7 m), both filled with 4.8 m³ of water and connected to a mechanical and biological filtration system to remove suspended solids and convert nitrogen catabolites (ammonium and nitrite) in water to nitrate.

In May 2011 30 kg of carp (*C. carpio communis* and *C. carpio specularis*) were released in each tank. The tanks had a shelter on the bottom, to provide refuge for the fishes and a grid on the top, to avoid carp jumping out. Carp were given a daily dose of feed (protein 24.4%, fat 3.7%, fibre 2.6%) corresponding to 1% of their body weight and their health was periodically checked by a veterinarian.

In July 2011, after levelling the initial water parameters in both tanks, eight Tech –IA floating mats were positioned in tank V. This structure allows herbaceous plants to float on the surface of the water, doing their purifying function without the aid of a substrate. In this system the $N\text{-}NO_3$ absorption by plant roots was particularly important because a high concentration of nitrate nitrogen is dangerous to fish in aquaculture (Losordo et al., 1998), so a daily replacement of 5-10% of the water volume is needed. Four equal-sized plants of 8 species were transplanted in each Tech –IA (Figure 1 and Table 1).

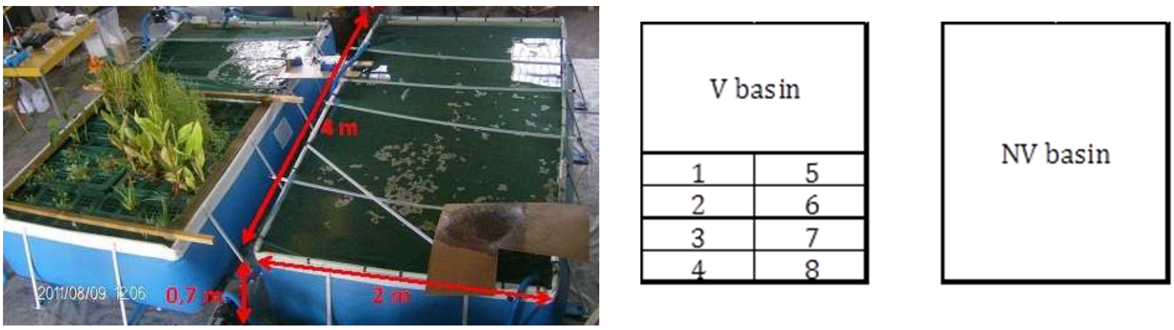

Figure 1: Photo and layout of the system with dimensions. Numbers refer to Table 1

Table 1: Species transplanted in Tech-IA floating mats.

Tech-IA	Species
1	*Scirpus paludosus* A. Nelson
2	*Thalia dealbata* Roscoe
3	*Oenanthe javanica* (Blume) DC var. *Flamingo*

4	*Caltha palustris* L.
5	*Iris laevigata* Fisch
6	*Canna indica* L. var. *Pretoria*
7	*Mentha aquatica* L.
8	*Juncus effusus* L. var. *Spiralis*

2.2 Monitoring activity

Monitoring started on 21st ~~of~~ July 2011 and ended on 18th November 2011. Three times a week the following parameters were analysed: temperature (T) and electrical conductivity (EC) with the multiparameter HQD40 (Hach Lange, USA), pH with pH Meter HI 9212 (Delta OHM, Italy), dissolved oxygen (DO) with HI 9143 (Hanna Instruments, Italy), nitrate nitrogen ($N\text{-}NO_3$) and ammonium nitrogen ($N\text{-}NH_4$) with photometer HI 83215 (Hanna Instruments, Italy), nitrite nitrogen ($N\text{-}NO_2$) with photometer HI 93707 (Hanna Instruments, Italy), and turbidity with a portable turbidimeter (Hanna Instruments, Italy). During the trial the water in the tanks was replaced, due to the high temperature reached by the water in August and in order to reset the biochemical equilibrium in the tanks in September, according to Table 2. Each carp was weighed at the end of the experiment.

Table 2: Water replacement during the trial

Day	**Water replacement (%)**
24/08	50
25/08	20
26/08	40
30/08	10
20/09	33
27/09	50
30/09	50

3 Results

3.1 Water quality

During the trial the mean value of T was 26 °C in both tanks, with peaks of 32 °C in August. However, the water replacements slightly reduced it from September (Figure 2).

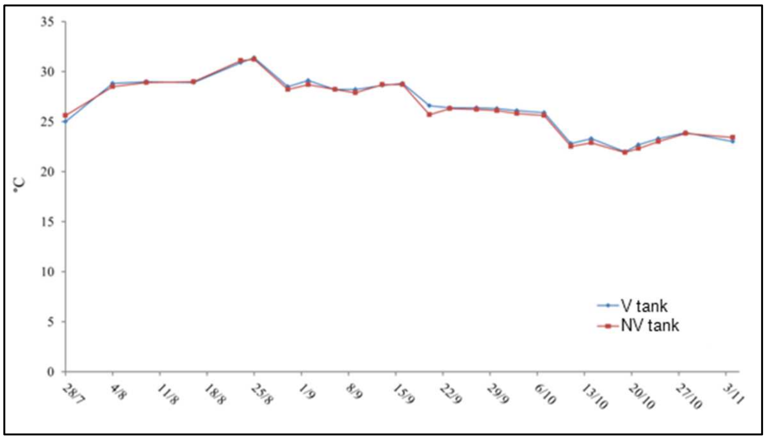

Figure 2: T values during the trial.

The EC had been almost the same in both tanks since the beginning of the experiment but from the end of September it became lower in V, due to the fact that plants could adsorb solute and decrease EC (
Figure 3). pH remained stable at around 7 during the trial while the DO values varied between 4 and 7.5 mg/L but were always higher than 60% of the saturated values as recommended for closed circuit recirculating systems (Losordo et al., 1998) (data not shown).

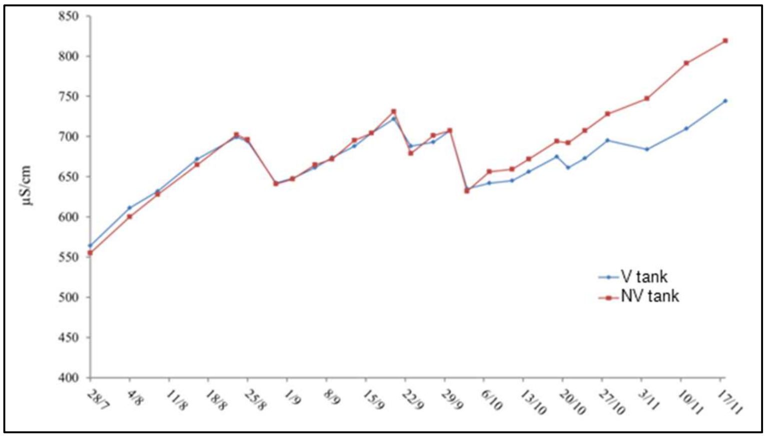

Figure 3: EC values during the trial.

Initially V showed higher $N\text{-}NO_3$ values than NV (24.2 and 19.2 mg/L, respectively). When the water exceeded 50 mg/L, even if this value would not affect fishes, water replacements to mitigate the T were started. Thus both tanks then had the same EC values but, from 26th October until the end of the trial, values were lower in the one with plants. In effect the lower T allowed ~~a~~ better plant growth and activity that translated into higher $N\text{-}NO_3$ absorption (
Figure 4).

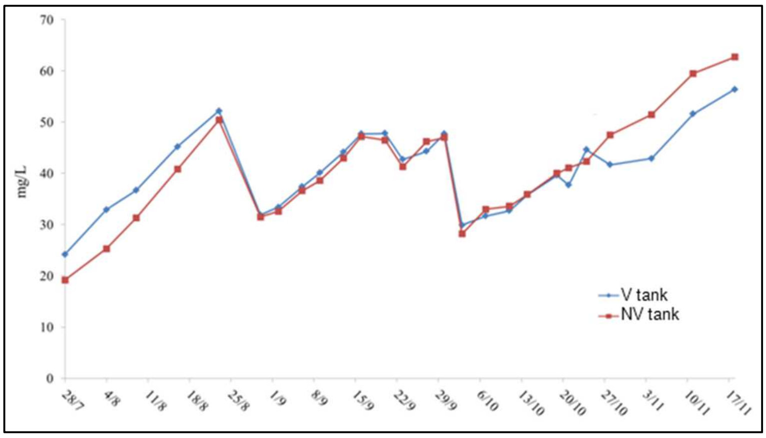

Figure 4: N-NO_3 values during the trial.

N-NH_4 is a dangerous nitrogen form for carp. During the trial its trend was very fluctuating in both tanks but it was generally higher in NV, which reached 0.5 mg/L (Figure 5). N-NO_2 values were lower than 1 mg/L for both tanks (data not shown).

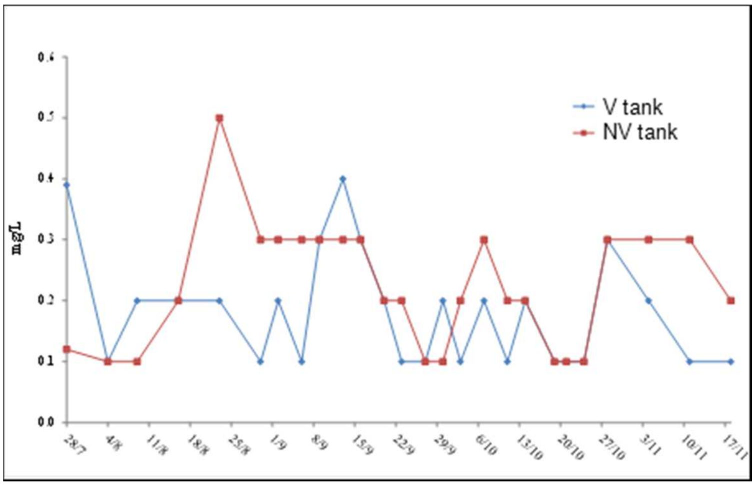

Figure 5: N-NH_4 values during the trial

Turbidity was measured to assess the suspended solids quantity (uneaten feed, faeces and algae). The plants, with their roots, contributed to the water clarification, giving lower values during the entire trial: mean values of 3 and 6 for V and NV, respectively (Figure 6).

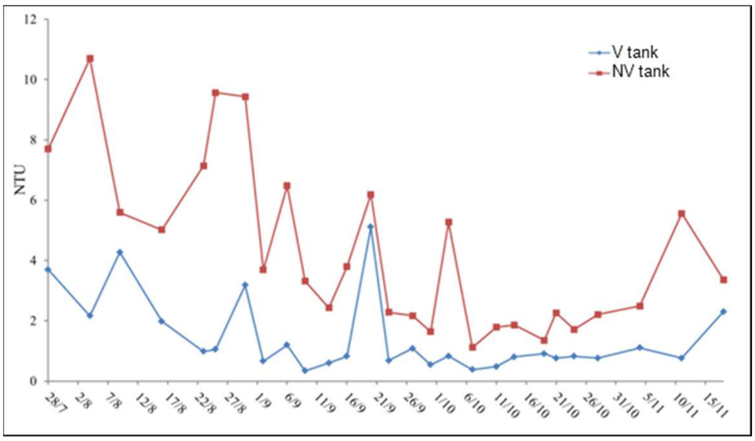

Figure 6: turbidity values during the trial

3.2 Carp

An increase in mean fish weight was observed from July to November, especially in tank V (Table 3). The mean daily growth rate was also much higher in the latter, specifically triple and double for *C. carpio communis* and *C. carpio specularis.* In addition, the carp in tank V reproduced, providing around 100 fry. Indeed it is known that the eggs are adhesive and are usually attached to aquatic plants and at water temperature higher than 18-19 °C larvae hatch after 5-6 days (Billard, 1999).

Table 3: Fish characteristics from the beginning (21/07/2011) to the end (18/11/2011) of the trial

Characteristics	**tank V**		**tank NV**	
	C. carpio communis	***C. carpio specularis***	***C. carpio communis***	***C. carpio specularis***
Fish weight at 21/07/2011 (kg) (mean± s.d.)	1.32 (± 0.50)	1.88 (± 0.30)	1.64 (± 0.35)	1.50 (± 0.65)
Fish weight at 18/11/2011 (kg) (mean± s.d.)	1.75 (± 0.75)	2.52 (± 0.31)	1.70 (± 0.36)	1.82 (± 0.86)
Mean daily growth rate (g/d)	4.8	7.7	1.3	3.5

4 Conclusions

Before stating the conclusions it is worth stressing that the pilot plant was indoors, which means that plants could not fully play their role in phytodepuration, due to the reduced light, lower air volume for transpiration and high temperatures in August. Those factors negatively influenced the plants settlement and growth. Nevertheless at the end of the trial the tank with Tech-IA floating mats showed better results, in terms of water quality and carp growth. Turbidity was lower as were both nitrogen forms, even if less evidently, and carp had a faster growth rate where plants were placed in the tank. This means that using Tech-IA floating mats might lead to a better quality of life for fish by providing a suitable habitat for breeding. From these results, it appears necessary to extend the validation of floating mats to a full-scale plant.

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