AQUAPONICS SYSTEM, A SOLUTION TO LIMIT NUTRIENT RELEASE BY FISH FARMING ?

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INTRODUCTION

In terrestrial agriculture, the use of manure as fertilizer is a sustainable way to provide nutrient to plants. Similarly, aquaponics is an integrated aquaculture system in which fish farming and soilless culture are combined to recycle nutrient. As dissolved nutrient generally released in wastewater from fish culture is recovered into edible plants thus Aquaponics System (AS) can be considered as a sustainable production system (Graber & Junge, 2009). AS is historically set up as a Recirculating Aquaculture System (RAS) for fish rearing connected to a Hydroponic System (HS) for crop cultivation, sparing use of water (Love et al., 2014). The aim of this study was to assess AS efficiency in fish waste treatment, through a nutrient budget of total Nitrogen (TN) and total Phosphorus (TP), in an operational farm.

MATERIAL AND METHODS

The experiment lasted 52 days inside a single greenhouse. A total of 1001 common carp (*Cyprinus carpio*) (mean weight = 647 g) were stocked to reach a rearing fish density in accordance with usual commercial fish farming densities, and fed with commercial pelleted feed (32% crude protein, 9% crude fat and 1% phosphorus of the fresh weight). Pelleted feed was delivered at a mean ration of 1.1 kg feed/100 kg fish biomass. For the HS compartment, four culture areas of 4.8 m² each were composed of bed raft (volume = 550 l) covered by floating rafts (extruded polystyrene foam) set at a density of 16 seedlings/m². Lettuce oak leaf and Batavia were set up in equal numbers at a four leaves stage. Water was continuously running through the bed raft (under the floating rafts) at a flow rate of 1 m^3/h, then went back to a common tank. From this common tank, water was distributed between the HS, the RAS and the discharge wastewater. In the RAS, water from the 4 fish rearing tanks (3.7 m^3 each) was continuously running through the entire system. A rotary drum filter with a mesh of 60 µm catched the solid particles from water and sent them into a settling tank to concentrate them into sludge. Sludge was then transferred to a second tank in which flocculating agent was added, then sent into a water permeable geotextile bag. At the exit of the drum filter, filtered water entered into the common tank in which new water was added at a 6% water exchange rate per day. In the RAS, water was pumped from this common tank through a UV filter until it reached a moving bed biofilm reactor (MBBR) and finally closed the loop by return flow to the rearing tanks.

Total Nitrogen (TN) and Total Phosphorus (TP) concentrations were analysed, at the beginning and at the end of the experiment, in lettuce, sediment, leachate from sludge and water. Water samples were collected from the tap water, the common tank and the discharge waste water. TN and TP concentrations were measured using spectrophotometry, (ISO 5663:1984 and ISO 6878:2004 respectively). In pelleted feed and lettuce, TN content was determined using an Elementar Vario Pyrocube elemental analyzer (Elementar, Langenselbold, Germany). TP content was determined by the molybdate-blue/ascorbic acid method at 820 nm after mineralization and acid digestion (AFNOR, 1992). In fish, TN and TP contents were estimated according to literature available (Schreckenbach, Knosche, & Ebert, 2001). Volumes and quantities of all these compartments were recorded in order to calculate a nutrient budget for N and P.

RESULTS AND DISCUSSION

Pelleted feed and stocked fish (tab. 1) were the most important inputs in N and P, equivalent to 92.5% and 96.9% of the TN and TP input respectively. N was mainly released from AS through the outlet water whereas P was mainly released through the sediment. The N budget was not well balanced as 24.5% of TN input was not recovered. N gaseous emissions might explain this result (Ru et al., 2017). The N retention rate in fish and lettuce biomass gain represented 18.7% and 0.6% of N delivered by the formulated feed respectively. The P retention rate in fish and lettuce biomass gain represented 19.9% and 0.7% of TP delivered by the formulated feed respectively. As P is a conservative element and according to uncertainties of measurement and sampling, we consider that the nutrient budget for this element is well balanced. Indeed, 6.6% of P input was not recovered.

Table 1: quantities of nitrogen and phosphorus, inputs and outputs, in the different compartments of the aquaponics system used for nutrient balance calculation of nitrogen and phosphorus.

	Nutrient (g)	
Compartments	Nitrogen	Phosphorus
Inputs		
Feed	25 047	4 403
Stocked fish	16 613	3 108
Circulating water at beginning	2 592	213
Inlet water	496	5
Lettuce seedlings	21	2
Outputs		
Harvested fish	21 292	3 984
Outlet water	7 549	975
Circulating water at end	2 427	324
Sediment	2 076	1 741
Harvested lettuce	174	32
Leachate	254	166
Unaccounted: Input-Output	10 997	509

Conclusion

Considering the very low N and P uptake by plants, we can conclude that AS ability to recover nutrients in plant biomass is limited. Nevertheless, it seems necessary to reconsider the design of the AS in order to maximize the bioremediation potential through optimization of the plants/fish ratio.

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