Nitrogen and Phosphorus Fate in Fishponds: Use of the Nutrient Budget

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Abstract

Aquaculture is expected to simultaneously increase its production and decrease its environmental impacts while developing a path to sustainability. In this context, the IMTA-Effect project (European Union funding) studies environmental perspectives of Integrated Multi-Trophic Aquaculture (IMTA), especially its ability to use available resources from the environment. To this end, nutrient budgets of IMTA were calculated. Nutrient budgets account for inputs and outputs of nutrients, such as nitrogen (N) and phosphorus (P), from each compartment considered in the system studied, during the production cycle.

An initial study, performed in 500 m² fishponds, compared two systems of fish polyculture (common carp-roach-perch): a fed semi-intensive system vs. a non-fed extensive system. Nutrient budgets were calculated for N and P by accounting for feed, fish and water as inputs, and fish and water as outputs. Results of the two systems indicated that none of the nutrient budgets was balanced: outlet water contained less N than inlet water, while the opposite was observed for P. N retained in fish biomass growth represented 77% of N input (feed + water) for the semi-intensive system vs. 24% for the extensive one (nutrients only in water input), while P retained in fish biomass growth was more than 100% for both systems. This result highlighted the importance of sediment, especially as a P source, and its importance to fishpond food webs. It also raised the question of the fate of N, as shown in a previous study (Jaeger et al. 2018). Thus, sediment must be included when calculating nutrient budgets.

To balance nutrient budgets, an additional study was performed in 12 mesocosms (mimicking a simplified fishpond ecosystem in tanks) of 10 m^3. Sediment (300 l) was collected from a drained fishpond and placed into each mesocosm. Two treatments were compared: fed-fish polyculture (common carp-roach-black bass) and a non-fish treatment (only plants grew). Results showed balanced nutrient budgets for P but not for N. More than 95% of total inputs of N and 85% of P were measured in the sediment; the quantities of N and P used for fish biomass growth were larger than those in feed and water inputs. This study highlighted that most nutrients in fishponds lie in the sediment. Fish and plant biomass growth together retained no more than 5% of the total N or P in the system.

Unbalanced N nutrient budgets clearly indicate loss of N to the atmosphere. Fishpond sediment is a major source of nutrients that indirectly benefits fish growth through the food web. Nonetheless, even though carp contributed most to nutrient availability in the water column, especially for phytoplankton, only a small percentage of nutrients was retained in fish biomass at the end of the production cycle. Increasing use of nutrients in the sediment is a potential path to increasing overall fishpond productivity by increasing production through the food web.

Jaeger, C., Aubin, J. (2018). Ecological intensification in multi-trophic aquaculture ponds: an experimental approach. Aquatic Living Resources. 31, 36.