Conservation of Aquaculture Wastewater and Nutrients through Vegetable Crop Production

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Global aquaculture production has expanded at an average annual rate of 6.2% during 2000-2012, with world aquaculture production of 66.7 million tons in 2012, outpacing world population growth rate of 1.6%. According to Food and Agriculture Organization (FAO), aquaculture is estimated to supply 62% of the world's fish for human consumption by 2030. However, aquaculture produces huge volumes of wastewater containing nitrogen (N) and phosphorus (P), considered to be environmental pollutants, leading to eutrophication of water bodies. Therefore, effective management of aquaculture effluents is critical to protect natural water bodies while conserving water resources for agricultural production.

Aquaponics is a highly integrated system that recycles more than 98% of the water (Al-Hafedh et al., 2008), and therefore, dramatically reduces discharge of aquaculture wastewaters to the environment, with greater potential for profitability by simultaneously producing two cash crops, fish and plant crops (Azizah et al., 2010). The addition of feed is the main source of nutrient input and indirect production of pollutants in aquaculture-generated wastewaters. About 50-80% N and 10-50% P from fish feed are lost to the environment through aquaculture wastewater (Schneider et al., 2005). While some nutrients in aquaculture wastewaters can be toxic to fish in high concentrations, the nutrient-rich waters can benefit plant growth. Different plant species have different capacities of nutrient removal and utilization, thus directly influencing nutrient levels in aquaponics wastewaters. However, few studies have systematically investigated the effects of plant species on the performance of an aquaponic system.

This study was conducted to evaluate the role of plant species in N and P removal from wastewater effluents in an aquaponic system. Three vegetable crops were assessed in their ability to remove N and P from aquaculture effluents, including two leafy vegetables (lettuce and basil) and one fruity vegetable (cherry tomato). Seeds were germinated in a soilless medium, and uniform seedlings were transplanted into a hydroponic grow bed at their optimum planting density. Water samples from the fish tank, biofilter system and grow bed were taken every other day, and the concentrations of total ammonia-N (TAN), nitrite-N (NO_2-N), nitrate-N (NO_3-N), and phosphate-P (PO_4-P) were determined using a DR900 Colorimeter (HACH, Loveland, CO, USA). The dissolved oxygen (DO), pH, temperature, and electrical conductivity (EC) of waters in the fish tank and grow bed were measured *in situ* daily using a portable meter kit (HQ40d, HACH) and were maintained within acceptable levels for all test crops. Daily N and P removal efficiencies were monitored for one

Figure 1. Aquaponic systems in the Purdue Horticulture greenhouse complex.

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month production period. The results show that plant species differ in their ability to remove N and P from aquaculture effluents (Table 1), which appeared to be associated with their growth characteristics (data not shown). N was more effectively removed from aquaculture effluents compared to P (Figure 2). There were no significant differences in daily removal efficiency of N and P among plant species. The removal efficiency of N varied over time, which may be associated with the biomass production pattern of each vegetable crop (Table 1).

The present study demonstrates that plant species play a critical role in N and P removal and conservation from aquaculture wastewaters. Depending on the plant species and production stage, N and P removal efficiencies and characteristics can be varied. We will further elucidate water and nutrient removal and recovery from aquaculture wastewaters as affected by biomass production of different plant species.

Table 1. Estimated N (nitrate) removal capacity of plant species in aquaponics at 1, 2 and 4 weeks after transplanting. N levels from aquaculture system were compared with effluents from aquaponics systems.

Plant species	Estimated N removal (%)		
	1 week	2 weeks	4 weeks
Lettuce	87.3	79.2	82.4
Basil	13.3	63.9	87.3
Tomato	50.5	30.3	84.4

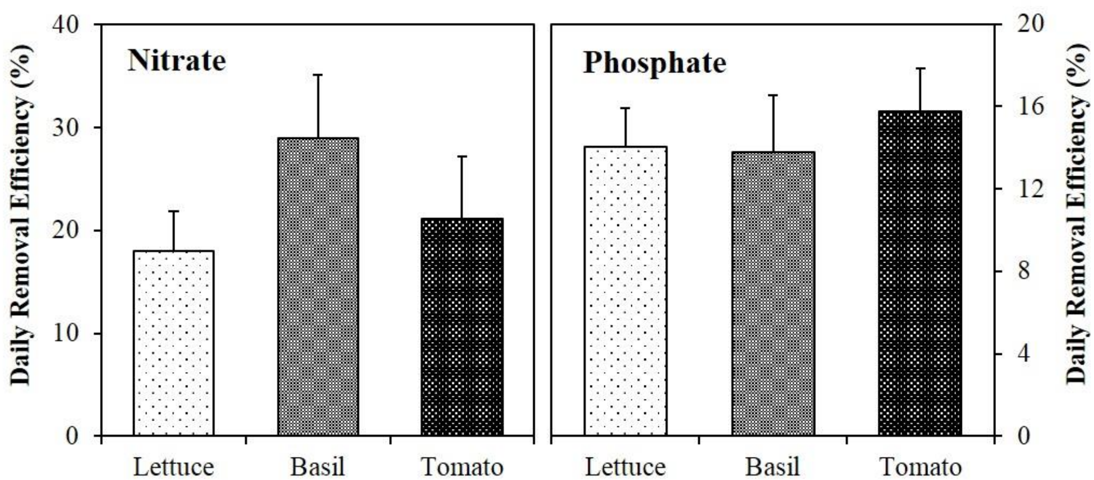

Figure 2. Daily removal efficiency (%) of nitrate-N and phosphate-P from aquaculture wastewater as affected by the production of lettuce, basil or tomato in aquaponic system.

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