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Le Corps professoral de

Gembloux Agro-Bio Tech - Université de Liège vous prie

de lui faire l'honneur d'assister à la défense publique de la dissertation originale que

Monsieur DELAIDE Boris,

Titulaire d'un diplôme de master bioingénieur : chimie et bioindustries, à finalité spécialisée,

présentera en vue de l'obtention du grade et du diplôme de

DOCTEUR EN SCIENCES AGRONOMIQUES ET INGENIERIE BIOLOGIQUE,

le 24 novembre 2017, à 16 heures précises (personne ne sera admis après cette heure),

en l'auditorium PhV (Physiologie Végétale, bât. 48),

Avenue Maréchal Juin, 13, à 5030 GEMBLOUX.

Cette dissertation originale a pour titre :

« A study on the mineral elements available in aquaponics, their impact on lettuce productivity and the potential improvement of their availability ».

Le jury est composé comme suit :

Présidente : Prof. M.-L. FAUCONNIER, Présidente du Département AGROBIOCHEM,
Membres : Prof. H. JIJAKLI (Promoteur), Prof. S. MASSART, Prof. H. SOYEURT, Prof. M. EMERENCIANO (Udesc, Brésil), Prof. P. BLEYAERT (Inagro).

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Summary

Aquaponics is an integrated farming concept that combines fish and hydroponic plant production in a recirculating water system. This innovative technique has the potential to reduce the impact of fish and plant production on the environment by namely closing the nutrient loop. Indeed, the nutrients leaving the fish part are used to grow hydroponic plants.

This thesis focused on the mineral elements available in aquaponics to grow plant. The thesis started by deepening the aquaponic concept and highlighted that the mineral elements available for plants growth in solution were lower concentrated than in hydroponics and assumed that an important parts of the nutrients input were unavailable and lost out of the aquaponic system via sludge spillage. This leaded to the necessity to determine the consistency of the plant growth and to what proportion the mineral elements were recycled in aquaponic systems. A solution to improve the recycling of these elements and increase their availability was also studied in this thesis. Therefore, the performances of a one loop aquaponic system named the plant and fish farming box (PAFF Box), in terms of yields of fish and plant, energy and water consumption, and mineral elements mass balances were studied. The mineral nutritive elements were also characterised. For experimentation convenience, lettuce was taken as a model plant. To determine if aquaponics can assure consistent plant growth compared to conventional systems, lettuce growth has been compared between a one loop aquaponic solution, a hydroponic solution and a complemented aquaponic solution in deep water systems in controlled conditions. The latest allowed studying also the growth when nutrient concentrations are increased in the aquaponic solution. The potential of improvement of nutrient recycling for increasing their availability to plant by sludge digestion onsite was studied. Therefore, the mineralisation performance of sludge has been explored in simple aerobic and anaerobic reactors and in up-flow anaerobic sludge blanket reactors (UASB).

In the term of this work, it appeared that aquaponics consumed and discharged less water to produce fish and plant but required more energy than conventional farming systems. The lettuce showed similar growth performance between aquaponic and hydroponic solution but significantly higher growth (i.e. 39% fresh mass increase) in complemented aquaponic solution. This indicated that lower mineral elements concentrations did not impact negatively plant growth and that an increase of concentrations improved growth compared to conventional hydroponics. Also the microorganisms and dissolved organic matter may play an important role for promoting plant roots and shoots growth in aquaponics. Mineral elements mass balances analysis showed that an important part of the elements were accumulating in sludge and lost by water and sludge spillage. However, the sludge digestion onsite showed promising results to recover these elements in available form for plants. It would allow reducing environmental footprints by limiting the nutrients loss and recycle even more water. Regarding these results an implementation of the one loop aquaponic system was suggested as a hybrid decoupled aquaponic system that would limit water and nutrients discharge and improve plant growth.