魚菜共生系統動態模擬之溫室、營養鹽及水份循環分析研究

Study on the Dynamic Simulation of Aquaponics Systems: Analysis of Greenhouse, Nutrient, and Water Cycling

國立台灣大學生物環境系統工程學系

碩士生	教授	博士後研究員
許勝喆	余化龍	陳以容
Sheng-Che Hsu	Hwa-Lung Yu	Yi-Ron Chen

摘要

魚菜共生系統是一種創新的可持續農業技術，它將水產養殖與水培植物栽培結合在一個循環系統中。這種系統的主要目的是實現資源的最大化利用和環境影響的最小化。在魚菜共生系統中，魚類的排泄物提供了豐富的營養物，這些營養物經過微生物的作用轉化為植物所需的形式，供植物吸收，從而清淨水質，有利於魚類生長。這種循環不僅節省了肥料和水的使用，還能減少對外界環境的污染。此系統可以根據不同的場地、氣候條件以及所種植和養殖的物種，調整水分、二氧化碳濃度和熱量等關鍵參數，以最低的資源投入達到最高的產量效益。

本研究基於 INAPRO 魚菜共生動態模型的研究，以 VENSIM 軟體進行魚菜共生動態系統的建置及分析，致力於發展一套切合實際情況的架構，以便清楚了解實行魚菜共生時的各項可控參數以及最終生產情況。

當前的挑戰包括不同的魚類和植物種類對養分、水分以及熱量的需求都不依，且在生命週期中的不同階段也會有所差異。若欲使模型更為精確，則需配合現場的實測，透過實驗得到經驗參數，並了解模擬中可能出現的問題及缺陷。

模型將會依據溫室系統、營養鹽和廢棄物的循環以及魚類產量等為框架，以各個小單元的輸入及輸出建構，最終尋找相關點串連這些單元並以系統動力模型呈現，以支持此項技術在未來的發展。

關鍵詞：魚菜共生、水產養殖工程、系統動力學、資源循環利用、溫室調控

Abstract

Aquaponics is an innovative and sustainable agricultural technology that combines aquaculture with hydroponic plant cultivation in a recirculating system. The main goal of this system is to maximize resource use and minimize environmental impact. In aquaponics, the waste produced by fish provides a rich source of nutrients that are converted by microbes into a form that plants can absorb, thereby purifying the water and promoting fish growth. This cycle not only saves on fertilizer and water usage but also reduces pollution to the external environment. The system can be adjusted according to different site conditions, climates, and the species being cultivated and raised, tweaking key parameters such as moisture, carbon dioxide concentration, and heat to achieve the highest yield with the lowest resource input.

This study builds upon the INAPRO aquaponics dynamic model, using VENSIM software to develop and analyze the dynamic system of aquaponics. It aims to develop a framework that aligns with practical situations to clearly understand the controllable parameters and final production outcomes when implementing aquaponics.

Current challenges include the varying needs of different fish and plant species for nutrients, water, and heat, especially at different stages of their life cycles. To enhance the accuracy of the model, it is necessary to complement it with on-site measurements, obtain empirical parameters through experiments, and identify potential issues and shortcomings in the simulations.

The model will be based on the greenhouse system, nutrient cycling, waste management, and fish yield. It will be constructed using inputs and outputs from individual sub-units, ultimately connecting these units with a systems dynamics model to support the future development of this technology.

Keywords: Aquaponics, Aquacultural engineering, System dynamics, Resource Recycling, Greenhouse climate control