魚菜共生循環系統動態模擬模型建構

Construction of dynamic simulation model of aquaponics circulation system

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在全球沙漠化及氣候變遷的影響下，需要創新的農業方法來確保糧食的安全。在這個前提下，「魚菜共生」已被認為是一種農業方法，透過養分和排泄物循環再利用，可以幫助實現永續發展目標。但有一個已知的缺點，即必須在植物和魚類的最佳生長條件之外做出折衷，才能在相同的環境條件下生產作物和魚類。「魚菜共生」系統設計中最重要的原則是，系統可以在營養鹽負荷和養分之間保持平衡。因此，確定魚與植物的比例已成為平衡系統最常用的設計方法。然而，由於每種植物和魚類都有不同的營養需求，這些需求也取決於生長階段/生命週期和外部因素，因此該比例的準確性是複雜的、依賴於系統的，並且通常透過經驗數據。而研究的系統設計越多，就可以更準確地估計魚與植物的比例，以便更有效地管理營養鹽的分流和產量。儘管具體的計算可能適用於特定的系統設置，但採用這種做法來調整或平衡全新的設計而不進行實驗評估可能會出現問題。本研究擬以系統動力學模型用於設計和進一步優化「魚菜共生」系統，透過各個子系統的異質條件及其對養分累積的影響並根據模型的結果解決設計缺陷，提出可獨立控制的單獨水循環系統的設計理論方法，並與現有的魚菜共生農場實地量測水質參數比較模型模擬與現場實測的差異性。

關鍵字

中文：魚菜共生、水產養殖工程、系統動力學

Abstract

Due to the impact of global desertification and climate change, innovative agricultural methods are needed to ensure food security. In this context, "aquaponics" has been recognized as an agricultural method that can help achieve sustainable development goals through the recycling of nutrients and waste. However, there is a known drawback: a compromise must be made between the optimal growth conditions for plants and fish to produce crops and fish under the same environmental conditions.

The most important principle in the design of aquaponics systems is that the system can maintain a balance between nutrient load and nutrients. Therefore, determining the ratio of fish to plants has become the most commonly used design method to balance the system. However, since each plant and fish has different nutritional needs, which also depend on the growth stage/life cycle and external factors, the accuracy of this ratio is complex, system-dependent, and often based on empirical data. The more system designs are studied, the more accurately the ratio of fish to plants can be estimated to more effectively manage nutrient distribution and yield. Although specific calculations may apply to particular system setups, adopting this approach to adjust or balance entirely new designs without experimental evaluation may pose issues. This study intends to use a system dynamics model to design and further optimize aquaponics systems. By analyzing the heterogeneous conditions of various subsystems and their impact on nutrient accumulation, the study aims to address design flaws based on the model's results. It proposes a theoretical design method for independently controllable single water circulation systems and compares the differences between model simulations and on-site measurements of water quality parameters at an existing aquaponics farm.

英文： Aquaponics, Aquacultural Engineering, System Dynamics