Project Title: Automatic Nitrogen and pH Regulation in a Recirculating Aquaponic System

Abstract: This research proposes a system-dynamics and control-theoretic approach for water-quality management of a recirculating aquaponic system (RAS). The goal is to compensate for imperfections in RAS design, simplify the regulation of dissolved nitrogen, so as to lower the technical entry barrier faced by operators.

Research Objective

Sub-systems in a RAS are intimately connected by water. In particular, water quality depends on the efficiency of nitrification, i.e. conversion of ammonia to nitrite, to nitrate, as this directly affects the health of the fish and the nutrient available to the plants. Nitrification is affected by feed, flow rate, dissolved oxygen, pH level and even temperature. In order to automate its regulation by means of flow and feed control, data-driven modeling and control are viable solutions.

Research Methodology

- Architecture: Small-scale (6m²) RAS, variable DC motor, pH & conductivity monitoring system, microcontroller, network connectivity.
- Analysis: Correlation between nitrate concentration and pH and conductivity.

Nitrification

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\begin{align*}
\text{NH}_3 + 1.5 \text{ O}_2 + \text{AO bacteria} & \rightarrow \text{NO}_2^- + \text{H}_2\text{O} + \text{H}^+ \\
\text{NO}_2^- + \text{CO}_2 + 0.5 \text{ O}_2 + \text{NO bacteria} & \rightarrow \text{NO}_3^- \\
\text{NH}_3 + \text{O}_2 & \rightarrow \text{NO}_2^- + 3\text{H}^+ + 2\text{e}^- \\
\text{NO}_2^- + \text{H}_2\text{O} & \rightarrow \text{NO}_3^- + 2\text{H}^+ + 2\text{e}^-
\end{align*}
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Outcome

- Completed: system setup, conditioning, nitrification initiation.
- Completed: fish dynamics model (Simulink).
- In progress: data collection and analysis.
- In progress: model and control law design.

References


