Institute for Food and Environmental Research (ILU)

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AutoPro: An automated bioprocess for the cultivation of the microalgae *Galdieria sulphuraria* for improved utilization of aquacultural sidestreams

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Background

In 2021, Vietnam's aquacultures produced 3.3 M t fish, 1 M t shrimps and 0.5 M t other species, with residuals being usually emitted to the environment. The use of macroalgae and autotrophic microalga to produce food and fodder in free water and aquaculture has a tradition in Vietnam, while heterotrophic algae cultivation is widely unknown.

Even though the cultivation of *G. sulphuraria* on various organic residues has been proofed, an industrial implementation, which allows a decentralized utilization, has not been achieved. The reasons are uncertain yield forecasts and challenging process control when organic residues are hydrolyzed and the hydrolysate is applied as complex nutrient source.

The project aims at overcoming associated challenges and implementing this approach to steer aquacultures towards resource efficiency.

To manage and control the process performance with organic residuals, AutoPro addresses the development of a process model in form of a digital twin and a real-time operating system for a decentralized process.

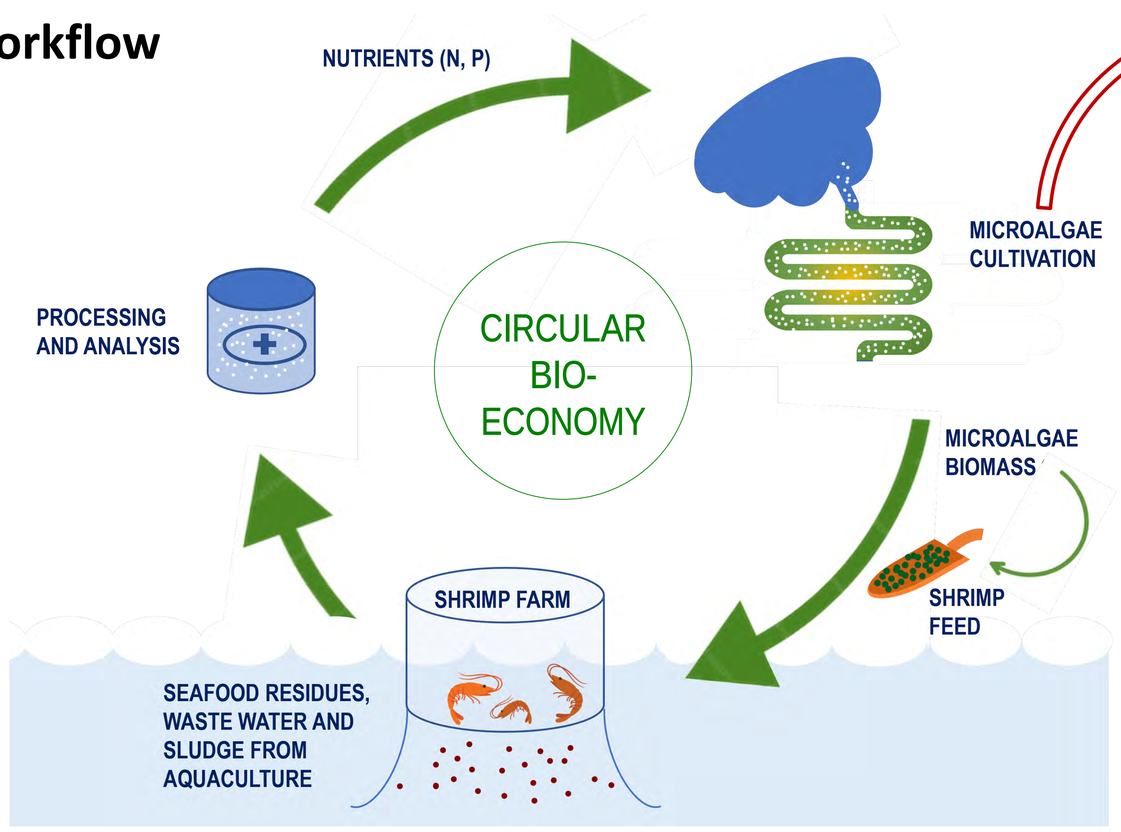
Main objectives

1) Developing a process model (digital twin) and automated process control for the cultivation of *G. sulphuraria.*

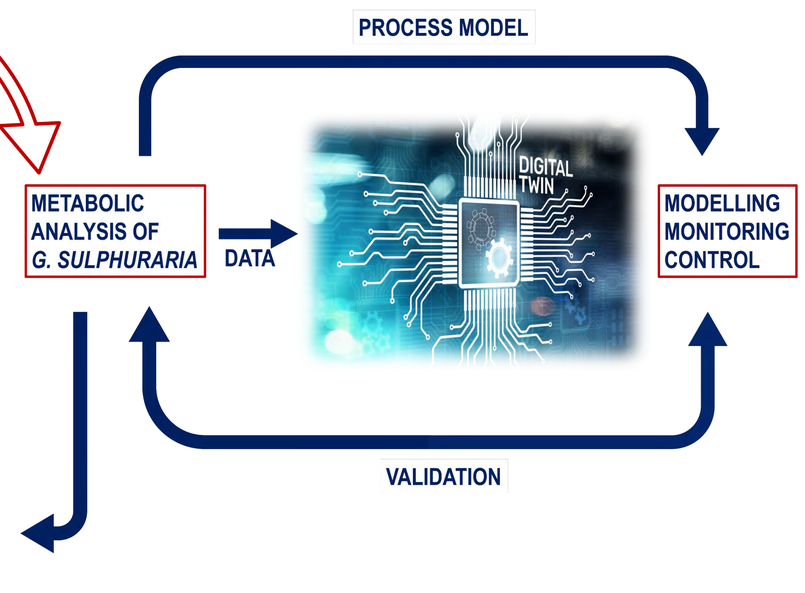
2) Developing on that basis options for circular resource flows and scale-up strategies in Vietnamese and German aquaculture.

3) Setting up a long-term research and development cooperation amongst the involved parties from Vietnam and Germany.

Workflow



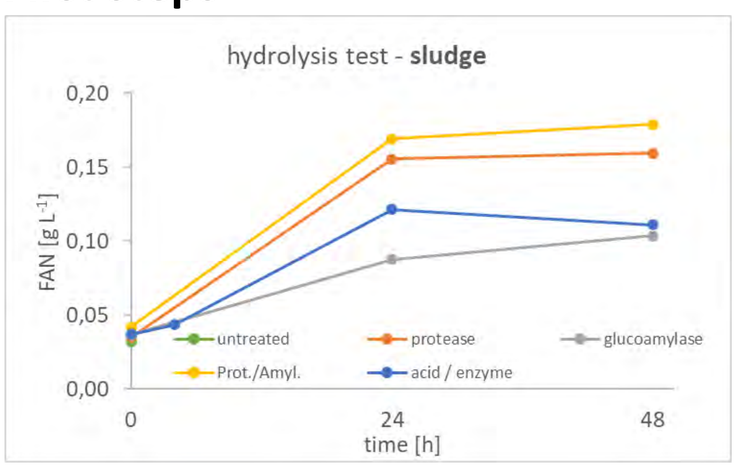
Aquacultural residues to be used in AutoPro are unused feed material as well as wet and solid organic sidestreams appearing at aquacultures in Vietnam, but also in emerging enterprises in Germany. In AutoPro the formed protein rich algal biomass will be applied as feed for shrimps, and thus an on-site circular biomass and nutrient management is created.



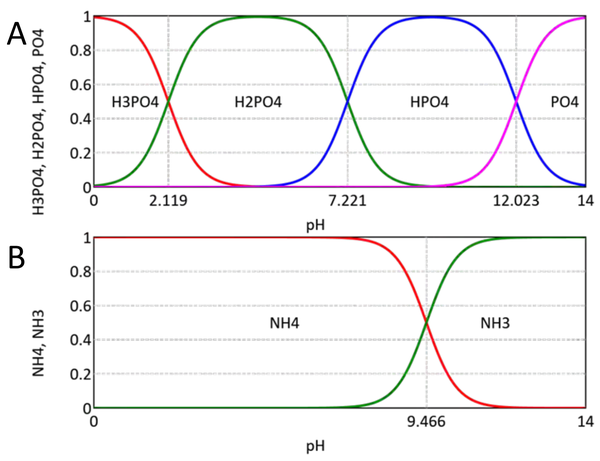
A mathematical model describing substrates-related changes in the biochemistry of *G. sulphuraria* will be developed. Based on data from metabolic analysis of both substrates used and biomass gained, the model's structure will contain all essential fractions (biomass, liquids, chemicals), kinetics (growth, respiration, enzymatic reactions) and stoichiometric dependencies to describe the process under varying operational conditions and production targets.

The model will be iteratively validated by comparism with experimental data, which will improve both the model and the cultivation process.

First steps



Test of different hydrolysation conditions: The FAN concentration in sludge samples after different hydrolytic treatments is shown. Sludge obtained from the ground of a shrimps farm was adjusted to (orange) pH3 and incubated with 2mL/L protease at 60 °C, adjusted to (grey) pH 4 and incubated with glucoamylase at 65 °C or adjusted to (yellow) pH3,5 and incubated with both aforementioned enzymes at 60 °C. One sample (blue) underwent acidic hydrolysis with 1 % H_2SO_4 for 4 h at 90 °C before both enzymes were added. For comparison, a sludge sample that was pH-adjusted to 3 and heated up to 60 °C, without further acidic or enzymatic treatment, was measured (green). Samples for FAN-measurement according to the ninhydrin-method were taken after24 and 48 h.



Ionisation state of nutrients: pH-dependencies of the ionisations states of nutrients A) phosphorus and B) nitrogen are shown as calculated from model parameters. Both are essential nutrients and need to be bio-available. At pH2, *Galdieria* can directly take up ammonium and also dihydrogen phosphate ions which are metabolized as ortho-phosphate intracellularly, are available.

Partners involved

Institute for Food and Environmental Reasearch

Institute for Automation und Communication

- Institute for Circular Economy Development (ICED)
- University of Technology, Key lab of Advanced Waste Treatment Technology

Master Program in Water Technology, Reuse & Management

R&D department, Group Aquaculture/Biotechnolgy

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