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WATER TREATMENT TOPOLOGY OPTIMIZATION IN RECIRCULATING AQUACULTURE

Land-based fish farming with integrated mechanical and biological water treatment is a rapidly expanding practice with many benefits over traditional farming, such as

- ✚ Reduced emissions to water
- ✚ UV and/or ozone can replace antibiotics
- ✚ No risk of escapes
- ✚ Control over temperature, pH, salinity...

The biological treatment is used to convert the toxic ammonia excreted by fish to nitrate. The bioreactors are a significant investment and a design with minimal volume is desired.

By virtue of their closed-loop nature, these special bioreactor systems unfortunately behave in a complex and sometimes unintuitive fashion...

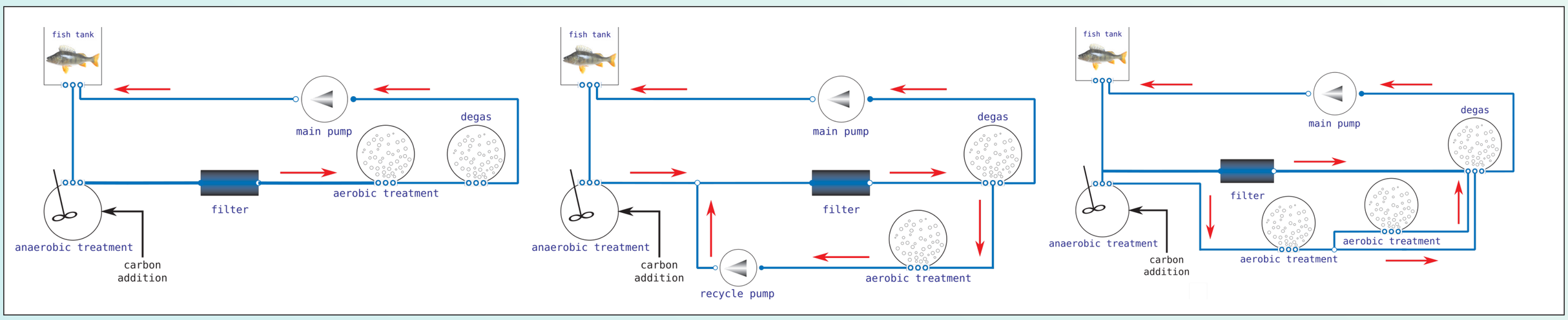

Figure 1: Different water treatment topologies in a RAS. Left: single loop treatment. Middle: partial recycling with treatment in side loop. Right: three-way split flow. Anaerobic treatment is often not present in existing systems.

Most volume-efficient topology?

The literature contains many water treatment system designs, but no comparative studies have investigated which configuration or topology that is the most effective. Nonlinear dynamics and large uncertainties makes analysis difficult, while experiments are made infeasible by high costs and extremely slow dynamics (months or years).

Optimal design

To make the best **comparison of topologies**, each configuration should be optimally sized and operated. Using a simulation model of a complete recirculating aquaculture system, built in Modelica, together with a **genetic optimization** algorithm we compared the performance of each topology under **optimal design** conditions using the same cost function for each.

Results

Simulations of recirculating aquaculture systems have revealed several tendencies, some of which are quite surprising:

- Several small reactors in series perform *worse* than one large (!)

- The feasibility of anaerobic treatment is highly dependent on the farming conditions (fish species & oxygen saturation)

- Unintuitive mechanisms may be significant for ammonia removal

- Carbon dosing controller may destabilize (simulated) system

- Systems possibly have multiple equilibria

- A quantitative comparison is WIP

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