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Modeling in Aquaponics system

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1 Introduction

With the increasing population on the planet, the consumption of food follows the similar trend. Nutrition demands are responsible for the soil exhaustion and sea replenish. The recent green and blue revolutions offered greenhouses, hydroponic, extensive aquaculture, and biotechnology. On the apex of the rediscovered approaches is the combination of hydroponics and aquaculture, the aquaponics.

Usually, the aquaponics system consist of three biological subsystems: a) aquaculture, the fish population; b) sludge digestion, the bacterial modification of the fish waste; and c) the plants, consuming the nutrients flow from the bacteria. Our laboratory was involved the EU Cost Aquaponic hub with the measurement, modeling, optimization, maintenance, sustainability, management, alelopathy, and accumulation effects[Urban et al. (2017)].

There is a huge focus on the plants, what nutrients are required [Nozzi et al. (2018)], models of photosynthesis, metabolic cycles, and growth. Many information are already available from the agriculture, systems biology, and biophysics. The nitrification process is considered as the current bottleneck, together with the diseases, of the aquaponics systems. The ammonia from the fish, which is toxic form them in high concentration, is processed by the nitrification bacteria to nontoxic composition nitrate. Such more compounds are involved in the fish waste, extensive research uses multiple bacterias in bioreactors to optimize the process of remineralization of the sludge.However, everything begins with the fish. The plants could consume only what bacteria produces. The bacteria have to deal with the fish output. The fish excrements are depended on two issues: the fish metabolism, and fish diet. There, the metabolism is a complex reaction to the fish size, age, sex, species, temperature, oxygen, activity, etc.

2 Results and discussion

To model the system, it is necessary to understand it, and to measure it. Therefore, we developed and licenced an IoT approach based system Aquasheriff online water monitoring, to measure the basic water parameters (pH, temperature, electrical conductivity, dissolved oxygen, oxidative-reduction potential)[Barta et al. (2018)].

The basic and additional environmental conditions (spectrophotometry, ammonia, nitrate) are regularly performed and protocolized in the bioWes system for data and metadata management. The behaviour of the fish is also required, to correlate the fish speed, depth, and movement with the environmental conditions. We have two biomonitoring systems: 5dviewer, single camera aquarium and five mirrors, and infrared monitoring using MS Kinnect.

The model of the fish feeding periods and its propagation to the level of amonia was modeled using Matlab Simulink. The positive feedback of amonia is given by the fish metabolism, the negative is represented by the nitrification bacteria.

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$$\frac{dM}{dt} = KM(t) = \kappa CM(t), \tag{1}$$

$$\frac{dC}{dt} = -\alpha \frac{dM}{dt} + \frac{dF}{dt}, \tag{2}$$

$$\frac{dF}{dt} = \frac{1}{D} * \frac{dQ}{dt} * \frac{dU}{dt} - \frac{dC}{dt}, \tag{3}$$

where M is mass of fish, C is concentration of fish food (ff), F is one dose of ff, D is constant, Q is daily dose of ff and U is input. The general problem in aquaponics is in huge gap between the theoretical simplicity, and practical achievements. On the theoretical issues, the current models, especially of fish behaviour and metabolism are based on average values. However, the fish shoal has a distributions, and this distributions evolve in time. The propagation of the metabolism and therefore excrements production, nitrification process, and plants growth, all have its own probability distribution. There, the Bayesian approach has to be applied, since the probabilities are conditional. To achieve the stochastical description of the fish metabolism, the multi-agent modeling will be applied, where individual fish with simple rules cooperate inside the 'sworm' in the NetLogo environment.

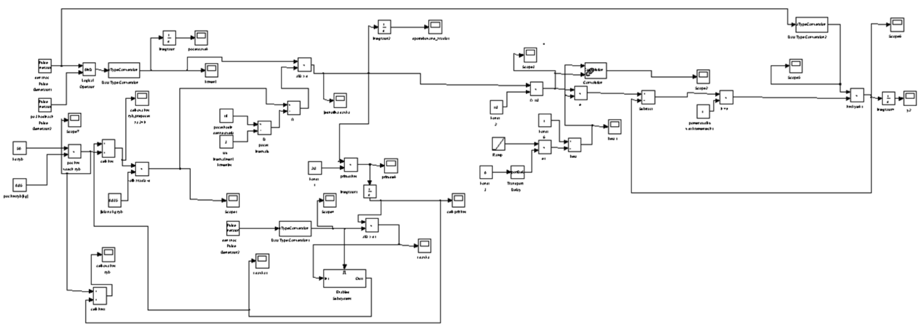

Figure 1: Simulink model of aquaponics.

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