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Ecoponics

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Design of Breen aquaponics

The design of Breen aquaponics system is based on the optimization of the overall production capacity. It needs to fit well to the relatively cold climate in the Basque Country, in the north of Spain.

The central cleaning system consists of 4 tanks (R1-R4) through which the water flows. The solids are separated from the water and the ammonia is nitrified to nitrate so the water reaches optimum conditions for the cultivation of fish.

The water is pumped to all the culture tanks through the recirculation pump, B1. The tanks have overflows and pick-up tubes from which the water head back to the central cleaning system.

The rearing/culture tanks (H1-H4) have a height of water for cultivation of 1m, with 20cm of security at the top, All tanks have a system of radiant floor heating to control the temperature of the water. Through the PVC pipe of 40mm in diameter, a water flow of 250l/h to each tank is regulated. Fig. 1 shows the rearing tanks (white tanks H1-H4) and the cleaning system (black tanks R1-R4) and Fig. 2 shows the schematic hatchery design.

Figure 1. Culture Tanks (H1-H4) and the four compartment cleaning system (R1-R4).

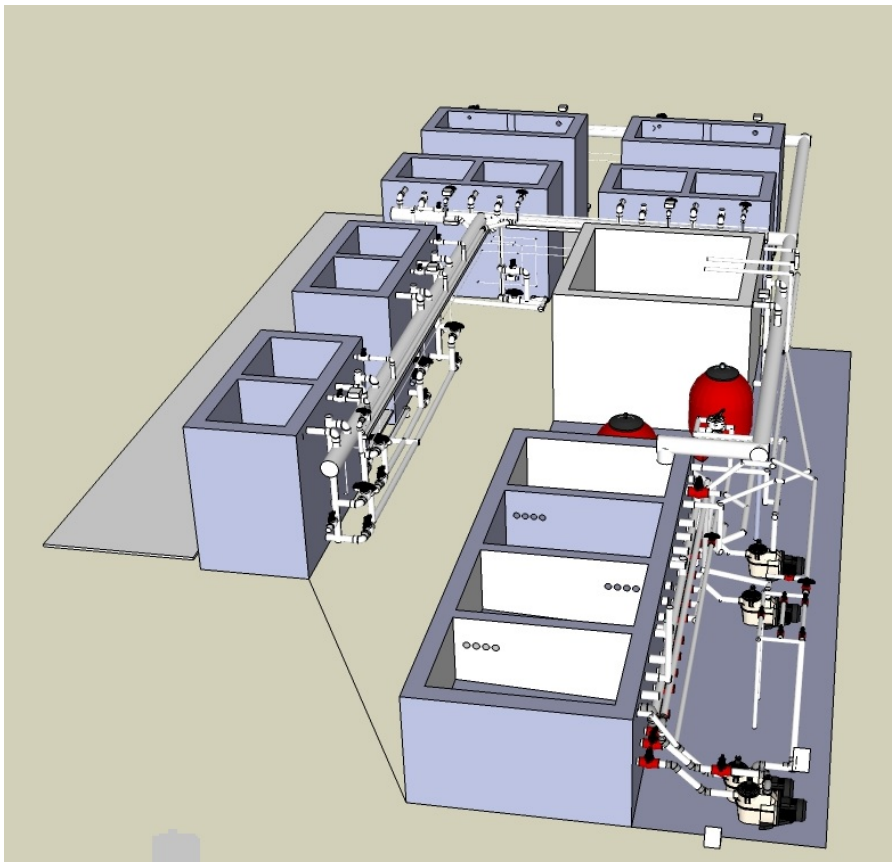

Figure 2. Hatchery design.

From the sump tank R4, the filtered and nitrified water is pumped to the plant system. The plants uses the nitrates in the water and the cleansed water is then pumped through a recovery system to the R4 tank again where it is mixed with the water from the fish tanks, see Fig. 3.

Figure 3. Plant cultivation (left) and recovery system (right).

Automatic control

The process control system is performed by a PLC, a programmable control system, Profilux3. The Profilux system can control activation and deactivation of pumps, lights and automatic feeding. Thus, it controls the pumps, the photoperiod and the use of feed per tank.

The system is connected to an expansion box where the monitoring probes are connected to. They remain submerged in the water continuously measuring the parameters of water, pH, dissolved oxygen, temperature, electrical conductivity and redox. Also, the expansion box allows the management and control of water levels, volumes of water, flow and temperature and relative humidity of the air.

For the management of alarms, the Profilux has an SMS module, which enables to receive in the scheduled mobiles, notices, alerts and alarms generated in the system, as well as the parameters of the water on demand.

Figure 4. The Profilux expansion box (left) and the Profilux SMS, above and Profilux 3, below (right).

Minimizing risks in the system of production

-Water parameters

In order to maintain optimum environmental conditions for the cultivation of tilapia, the main critical parameters are kept within the following limits: ammonium (<1.5 mg/l), nitrate (<150mg/l), pH (6-8) and the temperature (22ºC - 30ºC). Keeping the values within these limits minimizing the risks of stress in the cultivation.

In addition to the parameters that are managed with the Profilux system Breen controls ammonium and nitrate levels in the water to obtain a uniform balance between the growth of fish and plants. These parameters are measured with a spectrophotometer from Hanna Instruments, making periodic measurements twice per week.

Figure 5. Spectrophotometer from Hanna Instruments.

-Fish density and pathogen control

The quality of the cultivation also depends on the biomass density. This is kept below 50kg/m^3 for the welfare of the cultivation and production optimization.

The breeding stock were purchased from the company FishGen in UK. FishGen provides a veterinary certificate with all its exported tilapia and in addition the fish go through a quarantine process when they arrive at Breens facilities. Breen has its own hatchery for production of larvae and juveniles. This further minimizes the risk of pathogen infections.

-Feeding

Breen feeds the fish according to the levels suggested by the feed manufacturer, Biomar (see biomar.com).

Table 1. Feeding indicative (kg feed per day per 100 kg of fish) (Biomar).

			Temperature °C								
grams		**mm**	**17**	**19**	**21**	**23**	**25**	**27**	**29**	**31**	**33**
4	8	1.5	1.72	2.51	3.45	4.31	**5.22**	7.01	6.91	3.54	1.56

As an example if the temperature of the water is 25ºC, for 1000 g of 4-8 g juveniles 52.2 g of 1.5 mm pellets would be fed per day. Breen divides the daily feeding to four batches a day. Fig. 6. Shows the feeding percentage Breen uses.

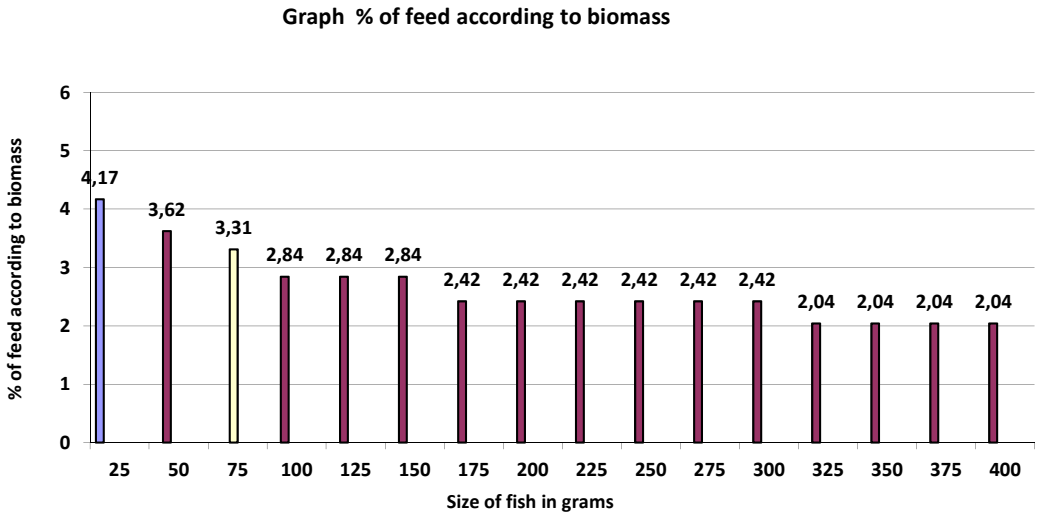

Figure 6. Feeding at Breen (% feed related to biomass).

-Watering and cleaning

The tanks have a special design so that when the stopcock is opened, in approximately 15 seconds, the sedimentation is cleaned from the tank. This operation is performed twice a day. The cleaning of tanks is done manually.

Figure 7. Stopcock system to release sedimentation.

Through all these processes and the control of these risks, it is intended to get up to a 75tons/year of fish, tilapia, and achieve a sustainable production.

Risk Analysis

-Minimize risks in the water

It is crucial to maintain good water quality, for proper growth of the fish and plants. The optimum environment for cultivation of the fish and vegetables, respectively is not the same. Thus, the environmental parameters need to be kept in a zone that is optimal for the entire production system.

The optimum values for the tilapia are:

pH : between 7 and 8
Ammonia: below 1.5 mg/l, preferably 0
Nitrates: below 150mg/l
Oxygen: above 5ppm

The vegetables need a pH between 6 and 7, ammoniums are not harmful and nitrates generally have to be above 150mg/l. The rest of the macro and micro nutrients that plants need are in sufficient quantities, thanks to the organic matter generated in the aquaculture.
The only micro nutrient that may not be in sufficient quantities, is iron, which at certain moments of the cultivation is necessary to add into the water, so that the vegetables do not have a yellowish color.

On the other hand, the bacteria need a pH between 8 and 9, for optimum nitrification.

Seeing all of this, the risks that we can find in the system may be located in 3 different processes, which are:

-The aquaculture
-The bacterial nitrification
-The plant cultivation

-Risks in the nitrification process

The process of nitrification, the conversion of ammonium to nitrate is necessary to maintain a healthy environment for the aquaculture. The nitrification releases hydrogen ions thus lowering the pH. Therefore, it is necessary to include a buffer system, adding carbonates and/or hydroxides, to stabilize the system.

-Risks related to pH

Low pH values, around 6 can cause inefficiencies in the nitrification process and stress the fish. If the nitrification is not working well the ammonium levels can rise above the maximum levels negatively affecting the growth of the fish. If the fish are not in an optimum environment, they do not eat and the feed accumulates in the mechanical filters and in the sump tank causing decreases in oxygen levels that is harmful both to the fish and the plants.

-Risks due to feeding

Optimum feeding is crucial in the system, both to maintain a balanced and healthy system and to obtain optimum growth rates. Underfeeding negatively affects the growth rate in the system whereas overfeeding directly affects the quality of the water (increasing organic load,

ammonium and lowering of oxygen) and the production costs by wasting feed. In both cases the economy is negatively affected.

-Risks due to fouling

In the intensive culture, the fish are fed 4 times a day, with an approximate daily percentage of 2% of the total biomass, (depending on the size of the fish). This means that every day there is a high input of organic matter. Suspended solids are separated by a system of mechanical filtration and decantation. However, the organic solids also adhere to all surfaces of the recirculation system. This mounting of organic matter is called "fouling".
It is very important to include effective cleaning processes and aeration in aquaponics systems to keep good water quality.

-Risks due to power outage

Power outage can cause the stop of the pumping systems, the recirculation and the aeration system. A 15 minutes power outage may cause the death of all the fish by lack of oxygen. To avoid this type of critical situations it is essential to have a generator which will provide electricity in the basic systems of oxygenation and recirculation while the general power supply is not active. Breen has a generator of 5 kW.

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