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DIY WATER FILTERING MODULE FEATURING AN AUTOMATED C&C UNIT ON REVERSED AQUAPONIC SYSTEMS

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Abstract

The goal of the project was to design and build a self-sustaining herbs production system in an applied research environment based on an ornamental aquarium as a nutrient source for plants. The solution was to setup an ornamental aquarium, which, on the next stage of the project, became part of an aquaponic system where the required herbs are grown. The novelty emerged from the specific requirements of the project, which led to a build of a reversed aquaponic system, on which the fish tank is positioned above the grow bed. Designing a new Command & Control Unit surpassed the technical issues that emerged due to the lack of conformity with a "traditional" aquaponic system. A new Water Filtering Unit was also designed in compliance with project requirements. The paper will present the general DIY ("Do It Yourself") steps to build the Command & Control and Water Filter units for a reversed aquaponic system. The Water Filter Unit build requires no special tools or skills, so anyone can replicate it. On the other hand, the Command & Control Unit requires some special skills as automation electrician, so professional help may be required in order to replicate this particular unit.

Key words: *aquarium, command & control unit, DIY, reversed aquaponic system, water filter unit.*

INTRODUCTION

An aquaponic system is a symbiotic closed-loop recycling water system that combines the best of hydroponics and aquaponics in a way to create a closed, self-sustainable, dirt-free, weed-free and chemical-free grow system for fish and plants. In such a system the wastes generated by fish such as urine, ammonia and decomposed fodder (Nicolae, 2007) are converted by nitrifying bacteria into forms that plants can accept in their nourishment processes, thus, acting as biofilters by cleaning the water before being sent back to the fish tank (Figure 1).

The Recirculation Aquaculture Systems (RAS) started in the 1950s in Japan and was introduced experimentally in Europe in the 1970s. The commercial utilization of aquaponics started in Northern Europe, especially in the Netherlands, Denmark and Germany only as early as 1980s. A special note goes to the paper on aquaponics published by Watten and Busch in 1984 (Connolly and Trebic, 2010). Today, this new innovative agriculture technology is widely adopted in countries in America, Australia and Middle East, even if different issues are still raised, such as the use of fishmeal and oil as feed ingredients. Unfortunately, the number of aquaponic implementations is still scarce in Europe.

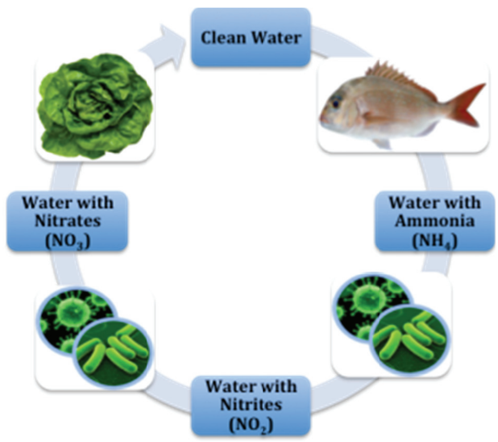

Figure 1. How aquaponic systems work

However, establishing a successful aquaponic system is less about fish and plants and more about "growing" the "good bacteria". It is so because the "good bacteria" will perform those

chemical reactions in the water in order to transform the compounds which are harmful for the fish and not usable by the plants into compounds which are harmless for the fish and usable for the plants, process known as "nitrification" (process which is part of the global nitrogen cycle). The process of luring the "good bacteria" and help it to establish viable colonies (widely known as "system cycling") is critical for any aquaponic system.
In terms of business, there are two major elements that define an aquaponic system: the fish and the plants. Fish can be grown in monoculture or in polyculture systems, based on its feeder habits: an algae feeder fish (as Tilapia), a benthic feeder fish (like Carp or Catfish), a zooplankton feeder fish (some Chinese Carp species), and so on. Natural and/or artificial food supplies may also be used. Based on the fish species and on the fish fodder, different growing scenarios will be available in order to identify which plants are most suitable to be grown on the specific water parameters sets generated by fish and fish fodder. Any existing aquarium can be easily upgraded to a self-sustaining herb production unit (Elia et al., 2014).
Regarding the fish, the most common grown species is tilapia *(Oreochromis niloticus)*. However, any species of fresh water fish can be suitable for an aquaponic system as long as a proper fish tank is prepared (dimension wise) and the required environmental conditions are met. The most common cultivated plants are green leafy plants such as lettuce, basil, parsley and mint. There also have been cultivated tomatoes, cucumbers, cabbage, kale, celery, eggplant and okra but the income obtained from the herbs is much higher and therefore those are preferred (Rakocy et al., 2006; Connolly and Trebic, 2010).
In this context, the paper present the general DIY ("Do It Yourself") steps to build the Command & Control and Water Filter units for an ornamental aquarium turned into a full fledged *reversed* aquaponic system, an implementation with the fish tank suspended one meter above the floor AND above the grow bed (Nicolae et al., 2015).

MATERIALS AND METHODS

To assess the water parameters, the following indicators were used: water temperature, pH value and nitrogen concentration (ammonia, nitrites and nitrates).
During the period of system cycling, water temperature, pH value and nitrogen concentration (NH_3/NH_4^+, NO_2^-, NO_3^-) were daily assessed. While water temperature and pH value were determined by direct observation (using a thermometer and a commercial test kit), nitrogen concentrations were determined by using spectrophotometric analysis of water probes (Hodoșan, 2014).
This method requires measuring the intensity of light as a beam of light passes through the probe, knowing that each chemical compound absorbs or transmits light over a specific and known wavelength. The concentration values of nitrites and nitrates are then determined from the benchmark curves built out of the extinctions shown by spectrophotometer. The water assessment was carried out between December 2014 – January 2015.
The aquarium was built out of tempered glass, using silicone to harden and seal the joints. A sturdy aquarium stand was also built out of metal bars to withstand a total weight of 500 kg.
The Water Filter Unit build required no special tools or skills, so anyone can replicate it. On the other hand, the Command & Control Unit required some special skills as automation electrician, so professional help may be required in order to replicate this particular unit and to avoid electrical hazards (Figure 2).

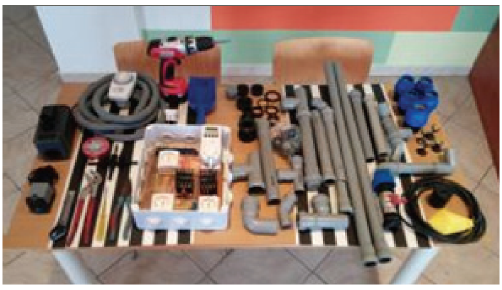

Figure 2. Tools, C&C Unit and Piping elements

RESULTS AND DISCUSSIONS

The Water Filter Unit

The Water Filter (Figure 3) is an innovative system that acts like a two levels *whirl settlement tank* AND *biofilter*.

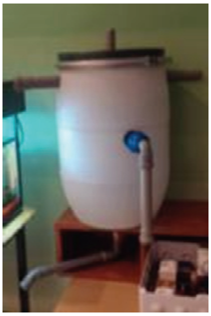

Figure 3. The Water Filter Unit

It was actually made from a 60 liters plastic barrel, provided with a custom piping system to allow water to flow in from the fish tank, flow out to the grow bed, and to collect the sediments. It also acts as housing for the biofilter, which was made out of a 12 liters plastic bucket. From the fish tank, the water with settlements is pushed by an electric pump, through a plastic hose, into the admission pipe of the Water Filter. The admission pipe release the water through a whirl system placed into the plastic bucket, located above its middle section (Figure 4).

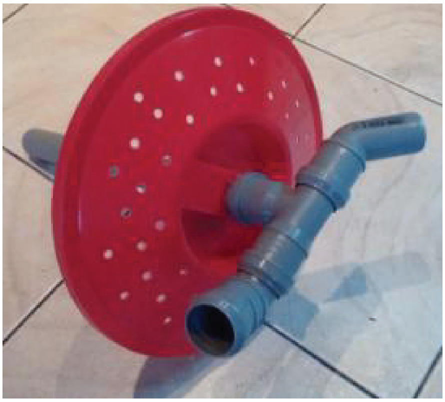

Figure 4. The Whirl System

The water (while spinning around the round body of the bucket) eventually will gravity-fill up the lower section of the bucket, then, from bottom to top, through a sieve, will fill up the whole bucket. The larger solid particles in the water sink down to the bottom of the bucket and stay there. The residual water is collected once a day (Figure 5) through a pipe going from the bottom of the bucket, through the barrel, and fitted with a tap. *The residual water makes a very good fertilizer and is not to be disposed of.*

Figure 5. The Residual Water (left probe)

The sieve at the middle of the bucket holds the layers of inert plastic bio-ribbon which the nitrogen converting bacteria affix to, acting as biofilter (Figure 6).
It is the most important part of the aquaponic system, since most of the nitrification process occurs within it.

Figure 6. The Biofilter

The biofilter is held in place by a second filter for smaller solid particles (made out of sponge), and a lid with openings to let the water flow out of the bucket. The bucket is placed 10 cm above the bottom of the barrel (to

avoid some sealing issues), centered by a shaft made out of plastic pipes (Figure 7).
Flowing out from the bucket, the water starts to fill up the barrel until its overflow level is reached. Through the overflow and by a pipe system, the water reaches the grow bed. Upon filling the grow bed, the water flows into a collector tank. In the collector tank, when the water reaches a certain "High" level, a "smart" electric drain pump starts to push the water from the collector tank to the aquarium.

Figure 7. The Biofilter, with the lid on

The drain pump only stops when a preset "Low" level is reached. The "High" and "Low" levels are determined by using a floating micro-switch which, based on its horizontal or vertical alignment, closes or opens two electric circuits.

The Command and Control Unit

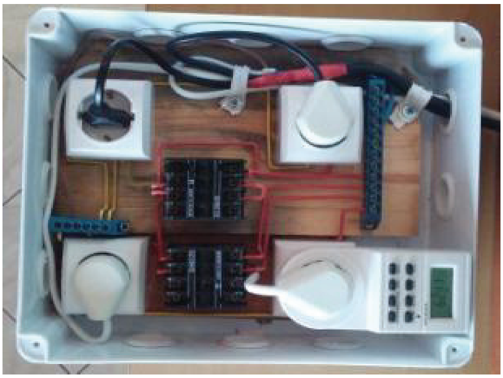

Figure 8. The Command & Control Unit

The characteristics of the C&C Unit controls (Figure 8) are:

- by means of a timer, the electric water pump placed in the fish tank;
- the electric water pump placed in the collector tank, powered according to the water level in the collector tank: as long as the water is below the "High" level, the pump is switched off. When the water reaches the "High" level, the pump starts to drain the collector tank and remains active until the water reaches the "Low" level. The "Low" level should be established is such a manner so the water pump will always be submerged.

CONCLUSIONS

The costs of such a system are very low and no special skills or tools are required. More than that, even the most expensive element of the system (the filtering unit) can be homemade.
This is a way for urban people to get closer to the nature, and, with virtually no production costs, to always have in their kitchen fresh herbs straight from the grow bed.

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