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# In-Situ Nutrient Removal From Clarias Gariepinus Hatchery by Vegetable on Floating Bed Coupled With Attached Growth Media

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**Abstract**: Aquaponics is a method of combining aquaculture and hydroponics. Aquaculture farming generates both solid and liquid waste, which comes from faeces and leftover fish feed. The accumulation of waste can lead to a deterioration in water quality, which affects the physiological processes, behaviour, growth, and mortality of fish. Thus, this study was designed to measure the water quality of the aquaponic system incorporating Ipomoea Aquatica, also known as the water spinach and Clarias Gariepinus, commercially known as the African Catfish and to observe the performance of the hybrid attached growth media on the system. The plant component was isolated from the fish rearing operation so that nutrient removal could be evaluated independently. The attached growth media were placed together in the second tank with the plant. The results obtained from the experimental data showed that the aquaponics recirculating system was able to sustain the dissolved oxygen (DO) at the average value of 6.1 mg/L, average ammonia nitrogen reading of 0.14 mg/L and pH value within 7.15 and 7.19 for inlet and outlet point, respectively. It was found that all nutrient removal in the aquaponic system and water quality were maintained within the acceptable and safe limits for the growth and survival of fish. Therefore, this study has given substantial evidence to support the claim that the aquaponics system is efficient in producing catfish and water spinach.

**Keywords**: Aquaponics system, attached growth media, nutrient removal, water quality

## 1. Introduction

Aquaponic systems are recirculating aquaculture systems that include plant production without soil. Recirculating systems are intended to raise large numbers of fish in small amounts of water by treating the water to remove toxic waste products and then reusing it. Aquacultural waste contains nitrogen (primarily in the form of ammonia and nitrate) and phosphorus (primarily in the form of phosphate), both of which are necessary nutrients for plant growth. The plants filter dissolved waste products from the system by using them as a source of nutrients, reducing the need for biological or chemical filtration for water changes and water quality management.

Aquaponic fish require good water quality conditions, which means that parameters such as dissolved oxygen, carbon dioxide, ammonia, nitrate, nitrite, and pH must be within acceptable species-specific limits. Untreated water containing ammonia discharged into the ecosystem could cause eutrophication and other environmental problems (Hu at al., 2015). It is essential requirement good water quality for aquaculture production in order to maintain and produce high-quality, profitable products, which, in turn, have an impact on human health. As a result, any change in water quality will affect the cultured species' development, growth, reproduction, and even mortality.

However, sudden changes in fish stocking density, growth rate, feeding rate, or water volume can cause rapid changes in water quality. This can be the result of a spike with breeding, and so more fish generally equates to excreting proportionally more waste means more ammonia. Therefore, to ensure maximum efficiency in the aquaponics system a biofilter is an essential part of the process. Biofilter will ensure the plants have access to the nitrates they need while the fish have the clean water they need. The limited surface area of growing media will not have enough bacteria to perform their role in the system; therefore, a biofilter is needed. Biofilters are essentially large surfaces attached to an aquaponic farm where additional bacteria can colonise and grow, increasing the efficiency of the nitrification process if it is underperforming. As a result, it will produce more healthy water for the fish and plants.

In this study, hydroponics planted with water spinach (Ipomoea Aquatica) were integrated with a recirculating aquaculture tank to regulate the water quality for intensive culture of African catfish (Clarias gariepinus). The objectives of this study are to (1) measure the water quality of the aquaponic system with water spinach (Ipomoea Aquatica) and African Catfish (Clarias Gariepinus); and (2) to observe the performance of the hybrid attached growth media on the system.

## 2. MATERIALS AND METHOD

### 2.1 Material

For this study, few equipments were used in setting up the aquaponic system and analysis. 500 gallon round open top polyplasyics containers were used for the fsh tanks, 3 hp electric horizontal single stage centrifugal pump, pH meter (YSI pH meter), reqtangular fiber glass tanks, pipping system and connector, measuring cylinder (Class A 10 mL, Pyrex), DO meter (YSI-5000), and spectrophotometer (DR2400, HACH).

### 2.2 Method

The experimental set-up was carried out at the existing fish hatchery at the Faculty of Engineering, the University of Selangor, to provide uniform conditions such as temperature, light, pH, and aeration rate throughout the growth phase. The positioning aquaponics system is an essential component that needs to be considered before deploying the unit. It is important to choose the right location for the experiment to be effective and succeed. Positioning a system in an unstable area can result in system collapse, derailed water flow, and flooding. The selection of an appropriate location, a flat, firm, and stable ground, is to be prioritised; thus, the fish hatchery at UNISEL is the most suitable place as it has a very wide and stable concrete area suitable to conduct the experiment.

Other than that, one of the vital parameters in growing crops is the amount of sunlight it receives each day. Positioning a system in a location with inadequate sunlight can lead to a delay in plant growth. Similarly, position fish tanks on a shading platform or a roof to discourage algae growth and retain consistent water temperature. Moreover, the UNISEL fish hatchery has adequate utilities, fences and accessibilities. Aquaponic units leverage air and water pumps that will require electric outlets. It is essential to protect these outlets from getting wet, and they should be built with a residual-current device to reduce the threat of electric shock. Daily routine monitoring is necessary to make sure the system is within optimal parameters. Hence, the location chosen should be regularly accessible. A secondary treatment option gaining popularity is the attached growth process where media is used to grow and maintain populations of microbes, creating a biofilm. The media were placed in the plant tank to allow the growth of film on the surface area.

### 2.3 Preliminary data of water quality

Aquaponic fish require good water quality conditions, which means that parameters such as dissolved oxygen, carbon dioxide, ammonia, nitrate, nitrite, and pH must be within acceptable limits. Sudden changes in fish stocking density, growth rate, feeding rate, or water volume can cause rapid changes in water quality, necessitating regular monitoring of those critical water parameters. Water quality is the primary environmental consideration for the welfare of fish in an aquaponic system, with the potential to significantly affect fish health. Unacceptable levels of water quality parameters affect physiology, growth rate and feed efficiency and may cause negative stimuli. Since 2007, the Department of Environment (DOE) has been observing the water quality. Based on the National Water Quality Standard (NWQS) and WQI, the Department of Environment (DOE) has classified lakes into a few classes such as class I, II, III, IV and V. To measure the quality of water and detect the water pollution, and it is one of the indicators that can be used (Table 1). Based on six significant pollutants, the WQI parameters measured which are Dissolved Oxygen (DO), Biochemical Oxygen Demand (BOD), Chemical Oxygen Demand (COD), Ammoniacal Nitrogen (AN), Total Suspended Solid (TSS) and pH. Hence, if the parameters are not within limits, it may be harmful to the fish and plants. Table 1 shows an Excerpt of the National Water Quality Standards (NWQS) for Malaysia (Kamarudin et al., 2020).

**Table 1**. Excerpt of National Water Quality Standards (NWQS) for Malaysia

| **Parameter** | **Class** | | | | | |
|---|---|---|---|---|---|---|
| | **Unit** | **I** | **II** | **III** | **IV** | **V** |
| pH | - | >7 | 6-7 | 5-6 | <5 | >5 |
| DO | mg/L | >7 | 5-7 | 3-5 | 1-3 | <1 |
| BOD | mg/L | <1 | 1-3 | 3-6 | 6-12 | >12 |
| COD | mg/L | <10 | 10-25 | 25-50 | 50-100 | >100 |
| TSS | mg/L | <25 | 25-30 | 50-150 | 150-300 | >300 |
| AN | mg/L | <0.1 | 0.1-0.3 | 0.3-0.9 | 0.9-2.7 | >2.7 |
| Water Quality Index (WQI) (%) | | <92.7 | 76.5-92.7 | 51.9-76.5 | 31.0-51.9 | >31.0 |

*Source: Department of Environment (DOE)*

### 2.4 Fish and Plant production

The combination of fish and plants in closed aquaponics will lead to improved plant growth and benefits for fish health. A general study of coupled aquaponic systems has demonstrated low levels of nutrients inside relative to hydroponic nutrient solutions. Plants do not accept under-supply or over-supply of nutrients without any effect on growth and quality, and the frequent feed input of the aquaponic system needs to be changed to plant nutrients. This can be achieved by regulating the stocking density of the fish as well as by altering the feed of the fish classified plants in aquaponics according to their nutritional criteria. In this study, a set of the aquaponic system were developed to study the growth of selected African Catfish (*Clarias Gariepinus*) and water spinach (*Ipomea Aquatica*).

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An insight into increasing the efficiency of food production which respects principles of sustainable agriculture. Catfish are an exceptionally hardy group of fish that survive large swings in DO, temperature and pH. These species are air breathers, making them suitable for aquaculture and aquaponics, as a rapid and drastic decline in DO will not result in any fish mortality. Due to high resistance to low DO levels and high levels of ammonia, catfish can be preserved at higher densities provided that sufficient mechanical filtration is carried out. Meanwhile, according to (Pamula et al.,2019), water spinach in the aquaponic system can reduce fish nitrogen wastes by up to 58% for the plant. Under that matter hence research to know the effect of density of aquaponic system in decreasing ammonia level ($NH_3$), nitrite ($NO_2$), and nitrate ($NO_3$) and its impact on feed conversion ratio and feed efficiency optimally to improve survival rate and intense African catfish growth rate.

### 2.5 Design of Aquaponic System

The systems consist of a fish rearing tank, one tank for hydroponic which also consist of the media. Pipelines will be installed to connect the fish rearing tank and hydroponic tank to recirculate the water. Water from the fish tank will then go into the plants and allow the attach growth media to function and flow out to the pond. The water from the plant will discharged a healthy water and then recycled back to the fish tank where it will be safe for the fish. A monitoring program of the aquaponics recirculation system began one week after planting in order to allow the vegetation and biofilm to be established. The monitoring was carried out for a period of three months for each plant. The water flow rate was set at a rate of 3.50 L/min. Wastewater flow rates were adjusted manually and measured using a measuring cylinder and stopwatch. Thereafter, weekly water quality analysis was performed on both the influent and effluent water from each treatment system.

Sampling points are at the outlet of the fish tank as the initial point without any treatment. Second point is on the surface (top layer of the plant area). The third sampling point is at the outlet before the water is being discharge into the drainage system and back to the lake. Water samples were tested for ammonia nitrogen, nitrite and nitrate.

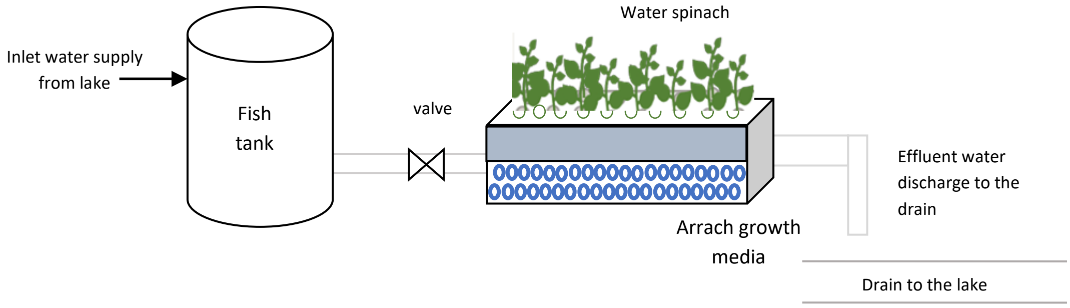


**Figure 1**. The schematic diagram of aquaponic system

## 3. RESULTS AND DISCUSSION

The key variables of interest in this study are plant growth and yield, fish growth and yield, and water quality parameters in the recirculation system. The water quality parameters of the rearing tanks in the aquaponics system were within the recommended range for aquaculture. The levels of dissolved oxygen and nitrogen waste in the system may have an impact on fish performance, as observed in this study. According to (Emerenciano et al, 2017), dissolved oxygen levels in any culture system should be more than 4 mg/L to support aquatic life's survival and development. All of the results obtained have been reported between the limits compared to the other results as obtained by Lucy, 2014 and Ekubo et al., 2011. Throughout the study, it was found that $NO^{2-}$ concentrations observed and analysed were all within the permissible limit as per (Endut et al., 2009; Azizah et al., 2016; Ayu et al., 2019). It is worth noting that the values obtained for the nitrite standard proposed by the Ornamental Aquatic Trade Association (OATA). In contrast, the limits should be less than 0.2 mg/L for a healthy fish.

Most importantly, the pH level was at an average of 7.15 for the inlet and 7.19 for the outlet after treatment. Figure 2 shows the pH monitoring throughout the observation period of twelve weeks. The pH did not fluctuate and was maintained at a steady value throughout the period of observation.

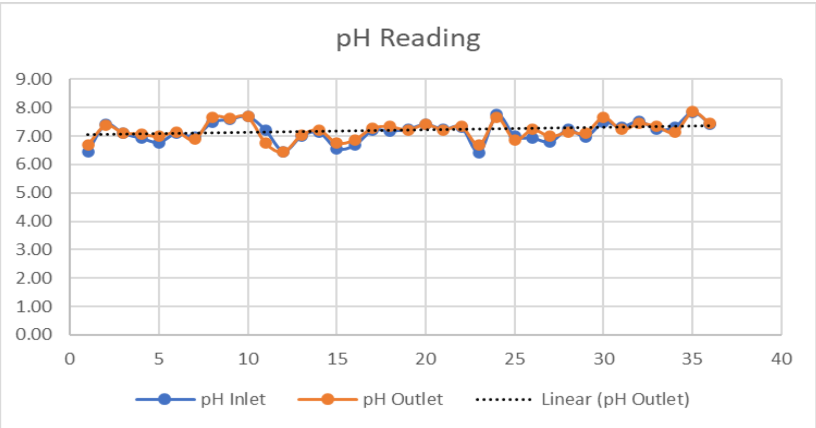


**Figure 2.** pH reading

The dossoloved oxygen of the system has also been maintain at the average of 6.7 mg/L. **Figure 3** shows the DO concentration during the experimental analysis. The value of NH3-N obtained by were within range of the limits. Plants in the aquaponics system act as biological filters, thereby absorbing nutrients such as nitrate and NH3 from the system. This, therefore, explains the adequate levels observed in the aquaponics system in the study. The above mentioned is in line with the findings observed that leafy vegetables (water spinach) significantly decrease nitrogen waste such as NH3 and $NO^{3-}$ in aquaponics system respectively. Based on the reported data, it can be concluded that water characteristics, along with nutrient availability, influenced many aspects of vegetable production, particularly final yield.Thus, showed that the fish were in a healthy state. Overall of the study, water spinach obtained high removal efficiency due to higher root surface area. Fish effluent can complement or even substitute for organic fertilizers of vegetables production. This study has given substantial evidence to support the claim that the aquaponics system is efficient in the production of catfish and water spinach.

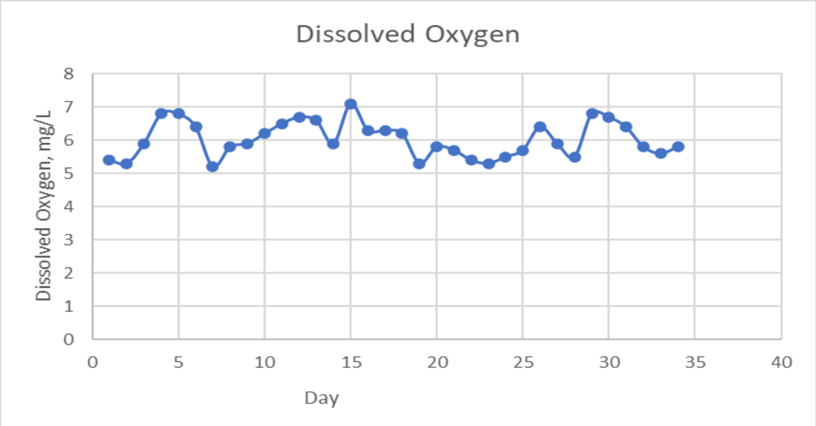


**Figure 3.** Dissolved Oxygen reading

## 4. CONCLUSION

This paper is based on the experimental analysis and an in-depth review of published aquaponics data with the goal of critically examining the outcomes of the experiments. This review has to confront the disparity in results caused by differences in production designs, particularly the areas where aquaponics was implemented, the scale of operation, sources of water supply, types of integrated (fed and extractive) species and their stocking rates, and other variables that can influence the results. However, the data obtained by the experimental study is in line with the review study.

Based on the studies and analysis data gained from the literature review and methodology, the experiment on choices of both fish and plants was successful, and objectives were achieved. The water quality of the aquaponics system after the plant treatment (spinach) shows a removal of 66.2% of removal of ammonia. With the hybrid of the growth media improves the ammonia removal by 28.6%. There is evidence of biofilm growth on the surface of the media. When the ammonia level content in the water is low, therefore it is expected can reduce the contaminants from fish ponds before the water is discharged to the lake. Meanwhile, the effects of water spinach are able to reach optimum density to absorb waste all of the nutrients. Lastly, the aquaponic will increase the survival rate and growth rate of African catfish (Clarias Gariepinus) in intensive aquaculture, as well as its effect on conversion rates and feed efficiency with the aquaponics system.

## 5. ACKNOWLEDGEMENT

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