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**Narpat Kumar**
Department of Aquaculture, College of Fisheries, Maharana Pratap University of Agriculture and Technology, Udaipur, Rajasthan, India

**SK Sharma**
Department of Aquaculture, College of Fisheries, Maharana Pratap University of Agriculture and Technology, Udaipur, Rajasthan, India

**BK Sharma**
Department of Aquaculture, College of Fisheries, Maharana Pratap University of Agriculture and Technology, Udaipur, Rajasthan, India

**ML Ojha**
Department of Aquaculture, College of Fisheries, Maharana Pratap University of Agriculture and Technology, Udaipur, Rajasthan, India

**Mansi Jain**
Department of Aquaculture, College of Fisheries, Maharana Pratap University of Agriculture and Technology, Udaipur, Rajasthan, India

**Corresponding Author:**
**Narpat Kumar**
Department of Aquaculture, College of Fisheries, Maharana Pratap University of Agriculture and Technology, Udaipur, Rajasthan, India

# Determination of water quality parameters with reference to different stocking densities and spinach (*Spinacia oleracea*) plant, grown in deep water aquaponics system

**Narpat Kumar, SK Sharma, BK Sharma, ML Ojha and Mansi Jain**

## Abstract

The present study was conducted for a period of 60 days to determine the growth performance of Common carp (*Cyprinus carpio var. communis*) fingerlings at different stocking densities and Spinach (*Spinacia oleracea*) Plant, grown in deep water aquaponic system. The experiment, was conducted with five treatments each with three replicates. A homogenous stock of fingerlings was randomly distributed in five treatment groups with stocking density of 5, 10, 15, 20 and 25 fish in T1, T2, T3, T4 and T5 respectively with addition of 10 plants in each tank. The fish was fed at 3% of their body weight. The important water quality parameters including air temperature, water temperature, pH, dissolved oxygen, electrical conductivity, total hardness, total alkalinity, ammonia, nitrate, nitrite, sodium and potassium were analyzed and average air temperature (26.175 °C), water temperature (25.5 and 27.4 °C), pH (7.4 and 8.4), dissolved oxygen (6.1 and 6.8 mg/l), electrical conductivity (152 and 163.6 ms/cm-1), total hardness (615 and 634 mg/l), total alkalinity (121 and 158 mg/l), ammonia (0.0001 and 0.0025 mg/l), nitrate (0.022 and 0.094 mg/l), nitrite (0.030 and 0.073 mg/l), orthophosphate (0.43 and 0.88 mg/l), sodium (0.612 0.872 mg/l) and potassium (0.55 and 2.23) were noted in all treatments respectively during experimental period. The result shows that all water quality parameters in all treatments were existed within the permissible for aquaculture. On the basis of these result, it also concluded that aquatic environment of deep water aquaponic system was favourable for the fish survival and plant growth.

**Keywords:** Aquaponics system, stocking density, *Cyprinus carpio*, *Spinacia oleracea*, water quality parameters

## Introduction

A record of 214 million tonnes of capture fisheries and aquaculture production were produced in 2020, including 36 million tonnes of algae and 178 million tonnes of aquatic animals, partly as a result of expansion of aquaculture, especially in Asia. The amount of (excluding algae) fish intended for human consumption was 20.2 kg per capita which is more than double of the average of 9.9 kg per capita in 1960s. According to estimates, the primary sector employed 58.5 million people. An estimated 600 million people depend partially on fisheries and aquaculture for their livelihoods, including subsistence and secondary sector workers, and their dependents. In 2020, the value of fisheries and aquaculture goods traded internationally was about 151 billion USD compare to the record high of 165 billion USD in 2018, primarily as a result of COVID-19 outbreak. Since 1961, the consumption of aquatic foods (excluding algae) has grown at an average annual rate of 3.0 per cent compared to 1.6 per cent growth rate in population. Aquatic food consumption increased from an average of 9.9 - 20.5 kg from 1960s to 2019. In 2020, it marginally decreased to 20.20 kg. Aquatic food consumption is anticipated to rise with15 per cent by 2030, reaching an average of 21.4 kg per capita, as a result of rising incomes, urbanisation, better post-harvest practices, and dietary trends (FAO-SOFIA 2022) [21].

The combined culture of fish and plant in recirculating system is known as aquaponics, and it is regarded as an inventive and environmentally friendly method of food production. Aquaponic systems are recirculating aquaculture system with hydroponically grown plants without soil (Rakocy *et al.*, 2006) [18].

Thus, aquaponics can be used to reduce environmental pollution by using aquaculture systems. When compared to other recirculating aquaculture techniques, is beneficial. Aquaponics operate on the nutrient cycle, wherein dissolved waste from the production systems is successfully converted to plant nutrients by helpful nitrifying bacteria, which plants can then use for growth. Recirculating aquaculture systems already generate substantial amount of fish waste and organic waste. But with aquaponics, the same amount of water and nutrients may be used to produce more food in the same recirculating aquaculture systems. Many authors have argued that using this technique makes it is possible to grow crops and produce fish while reducing wastes and its related environmental effects. Aquaponics has the ability to lessen environmental contamination brought on by aquaculture effluents (Hussain *et al*., 2014) [12].

Concerns over water pollution in affluent nations have increased interest in aquaponic system as a viable way to dispose of aquaculture wastes through the cultivation of high-value plants. Ammonia, the principal nitrogenous chemical produced while growing fish in a system, is harmful to fish, in connection to pH and temperature in the water column, toxicity rises even in little amounts of ammonia. Nitrosomonas bacteria, on the other hand, convert ammonia to $NO_2$ and Nitrobactor transforms nitrite into nitrate, which provides sustenance for plants. $NO_3$, in contrast, causes less damage to fish. In addition to fertilising ponds, decaying organic waste also provides a healthy habitat for growing plants that are less susceptible to disease than soil. Raft aquaponics is one method for using aquaculture sites for vegetable production and can assist to meet the increasing need for food due to the growing population (Salam *et al*., 2013) [19].

## Material and Methods

The experiment was carried out over a two-months period, in circular FRP tanks of 400-liter capacity at the wet laboratory of Department of Aquaculture, College of Fisheries, MPUAT, Udaipur. A stock of 225 common carp (*Cyprinus carpio var. communis*), from a homogenous stock fingerling were obtained. While collecting the fish seed, care was taken for their good health and infection free condition. Following a 7-day acclimatization phase in similar water tanks Healthy fingerlings of uniform size with an average body weight of 0.37±0.05 gm were distributed in five treatment groups, (variable ratios of spinach and fingerlings) with a control group: treatment-$T_1$ with 10:5 followed by $T_2$ with 10:10, treatment-$T_3$ with 10:15, $T_4$ with 10:20 and $T_5$ with 10:25. Ten healthy saplings (4 weeks old) of Spinach (*Spinacia oleracea*) were planted in styrofoam cups with cocopeat media. Water quality parameters such as Air Temperature (˚C), Water Temperature (˚C), Electrical Conductivity (µS/cm), pH, Dissolved Oxygen (mg/l), Total Alkalinity (mg/l), Total Hardness (mg/l), Ammonia (mg/l), Nitrite (mg/l), Nitrate (mg/l), Orthophosphate, Sodium (Na) (mg/l), Potassium (K) were analysed at fortnight interval in the laboratory following standard methods of American Public Health Association's Standard Procedures (2017).

## Result and Discussion

A good water quality is required in aquaculture production to produce a profitable product of high quality, which will reflect on human health by its role. Any deterioration in water quality will affect the development, growth, reproduction, or even cause the death of the cultivated species (Barker *et al.* 2009) [4]. Water temperature is the single factors responsible for ideal fish growth, plant growth and performance of nitrifying bacteria present in soil, detritus and in biofilter. Temperature in this system with acceptable limit according to Kohinoor (2000) [13] and Anita and Pooja (2013) [2] who found that the water temperature range between 18.5 to 32.9 ºC and 15-30 ºC, respectively, is the suitable for fish culture. Further it will can cause stress to fish if the water temperature <12 ºC, >35 ºC. In the present study the water temperature range between 25.3 ºC to 25.5 ºC. Which indicated a narrow deviation and was found truly suitable for fish growth and survival. pH is an important water measure which shows the water is acidic or basic. The recommended ideal pH ranges between 6 to 9 (DeLong *et al.*, 2009) [10] in tilapia culture. The highest fish biomass was produced when pH was 7.5 to 9.0 which depicted that that neutral or slightly alkaline environment was more suitable for growth of *Cyprinus carpio* according to Zou *et al.* (2016) [26]. Lower pH affects growth of fish by decreasing blood pH, oxygen carrying capacity and therefore, affect the growth of fish (Warts and Durborow, 1992) [25]. During the present study the water pH ranged from 7.4 to 8.4. Which was fairly suitable for fish growth. Electric conductivity (EC) is the index of overall ionic content present in the water. In other arguments, it is the ability to pass currents through water according to Ogbeibu and Egborge (1995) [17]. EC is a good indicator of fish production and primary productivity. Thus, it is an imperative parameters of water quality for aquaculture. Stone and Thomforde (2004) [22] reported that the electric conductivity ranged from 100-2000 µ Siemans/cm present in water has been found suitable for fish growth. During the present study, Electric conductivity ranged between 152.0 to 163.6 ms/cm and was found to be ideal for fish growth. The ideal DO (dissolve oxygen) level is most important in aquaponic system as nitrification stops at low DO according to Colt, (2006). However, nitrifying bacteria becomes incompetent a DO levels turns below 2 mg/l. Delong *et al.* (2009) [10] reported that dissolved oxygen range from 5.0 to 7.5 mg/l was found suitable for acceptable growth in tilapia. In the present study the range of dissolved oxygen in all treatments and control was 6.10 to 6.83 mg/l. which is ascertained good for fish survival and growth. Hardness is the measures of mineral content in the water. It shows the carbonate and bicarbonate of Ca and Mg ions in water. Fish absorb the calcium directly from water or food as it plays an important role in bone development, blood thickening and other metabolic reactions (Wurts, 1993) [24]. Choudhry and Sharma (2018) [9] reported a suitable range of hardness for growth of fish is between 488.56 to 530.22 mg/l while experimenting with Nile tilapia in the present study, the water hardness in control and all other treatments were found in a range from 615 to 634 mg/l. Alkalinity denotes to total amount of bases in water and is expressed in mg/l of corresponding calcium carbonate. The Total alkalinity ranges between 20.0-300 mg/l was reported suitable for aquaculture system (Buttner *et al.*, 1993) [6]. The alkalinity in aquaponic ideally range from 5.0-200 mg/l according to Eissa *et al.* (2015) [11]. However, the acceptable limit in an aquaponic system was found between 5.0-500 mg/l, according to Lawson (1995) [14]. In the present study, the ranges of Total alkalinity in all treatments and control were found in a favourable range i.e. 121.6 to 158.83 mg/l. Ammonia is the major nitrogenous excretory product of fishes and also occours from breakdown of uneaten feed. It is toxic to fish if gets accumulated in higher levels in fish production system, according to Cavalcante *et al.* (2014) [7] the optimum ranged of total ammonia in aquaponic system range between

0.17 to 3.87 mg/l in red tilapia culture. However, Nijohof and Bovendeur (1990) [15] warned ammonia level in aquaculture system should be less than 1.00 mg/l. In the present study, the ammonia levels of experimental water ranged between 0.001 to 0.0025 mg/l which is meagre and indicates good water quality management. Swann (1997) [23] founded it to be low nitrite level in aquatic system to with an acceptable limit from 0.5 mg/l. Rakocy *et al.* (2004) [18] reported 0.4 mg/l to 1.1 mg/l nitrite value suitable for okra production in aquaponic system. In accordance to these findings the nitrite values in experimental water in all treatments and control ranged between 0.030 to 0.073 mg/l. The nitrate is harmless and is the ideal form of nitrogen for growing higher plants (Rakocy *et al.* 2006) [18]. The nitrate is comparatively nontoxic to fish and has no health hazard except above 90 mg/l according to Stone and Thomforde (2004) [22]. In this aquaponic experiment, plant used the available nitrate thus low concentration was present in the water. Removal of nitrate from the system impacts the nitrification process in aquaponic system, in the present study the nitrate values of experimental water ranged between 0.022 to 0.094 mg/l. The orthophosphate is one of the important nutrients which is utilized by the plants as well as by the fish for. Bone formation along with calcium. This mineral must be supplied through diet. (Bussel *et al.*, 2013) [5]. Nuwansi *et al.* (2017) found the orthophosphate range between 0.74-1.31 mg/l in all treatment in polyculture aquaponic recirculating system. In the present study the orthophosphate ranges from 0.43 to 0.88 mg/l. Also, this an important macro nutrient for growth of plants is Potassium. It protects plant from abiotic stress as well as root development and enables the absorption of other nutrients. Fish is also absorbing potassium through gills from water. Sodium and potassium are the greatest important salts in blood of fish and are critical for normal heart, nerve and muscle function (Wurts and Durborrow, 1992) [25]. However, Low K, S, Fe and Mn have been reported in aquaponic plants that received nutrition from only from fish waste according to the Adler *et al.* (1996), Seawright *et al.* (1998) [20], Usually in aquaponic water potassium is measured 12 mg/l (Cerozi and Fitzsimmons, 2017) [8]. However, in the current study the Potassium of experimental water was ranged between 0.55 to 2.23 mg/l (as mentioned in table 1 and figure 1 to 13).

**Table 1:** Ranges of selected water quality parameters. In parentheses mean (minimum-maximum) values during the experimental period in different treatments

| **Parameters** | **Treatments** | | | | |
|---|---|---|---|---|---|
| | **T1 (Control)** | **T2** | **T3** | **T4** | **T5** |
| Air Temperature (ºc) | 24.6-27.5 (26.175) | | | | |
| Water Temperature (ºc) | 25.55-27.4 (25.5) | 25.5-27.4 (25.5) | 25.5-27.4 (25.5) | 25.3-27.4 (25.3) | 25.5-27.4 (25.5) |
| Electric Conductivity (mS/cm) | 152-161 (156.16) | 152-163.3 (157.27) | 152-163.3 (157.43) | 152-163.3 (157.80) | 152-163.6 (158.36) |
| pH | 7.4-8.3 (7.91) | 7.4-8.3 (7.85) | 7.4-8.4 (7.88) | 7.4-8.4 (7.86) | 7.4-8.4 (7.86) |
| Dissolved Oxygen (mg/l) | 6.1-6.77 (6.503) | 6.26-6.73 (6.577) | 6.26-6.76 (6.576) | 6.26-6.83 (6.562) | 6.26-6.73 (6.527) |
| Total Alkalinity (mg/l) | 121.6-140 (129.83) | 123-150 (135.25) | 124-158.3 (145.89) | 124-148.6 (136.82) | 119-151.6 (137.19) |
| Total Hardness (mg/l) | 615-633 (624.64) | 615-634 (626.05) | 615-632 (623.13) | 615-632 (625.93) | 615-633 (626.30) |
| Ammonia (mg/l) | 0.001-0.002 (0.00143) | 0.001-0.0024 (0.00169) | 0.001-0.0024 (0.00175) | 0.001-0.0024 (0.00174) | 0.001-0.0025 (0.0019) |
| Nitrite (mg/l) | 0.033-0.061 (0.047) | 0.035-0.063 (0.048) | 0.043-0.072 (0.057) | 0.030-0.061 (0.046) | 0.033-0.073 (0.051) |
| Nitrate (mg/l) | 0.022-0.081 (0.060) | 0.026-0.075 (0.052) | 0.027-0.089 (0.065) | 0.024-0.087 (0.059) | 0.027-0.094 (0.070) |
| Orthophosphate | 0.43-0.82 (0.631) | 0.44-0.84 (0.652) | 0.45-0.86 (0.682) | 0.44-0.87 (0.711) | 0.46-0.88 (0.730) |
| Sodium (Na) (mg/l) | 0.611-0.842 (0.730) | 0.613-0.853 (0.741) | 0.613-0.853 (0.786) | 0.612-0.872 (0.797) | 0.613-0.808 (0.808) |
| Potassium (K) | 0.56-1.59 (1.063) | 0.55-1.63 (1.103) | 0.56-1.81 (1.196) | 0.55-1.97 (1.271) | 0.57-2.23 (1.398) |

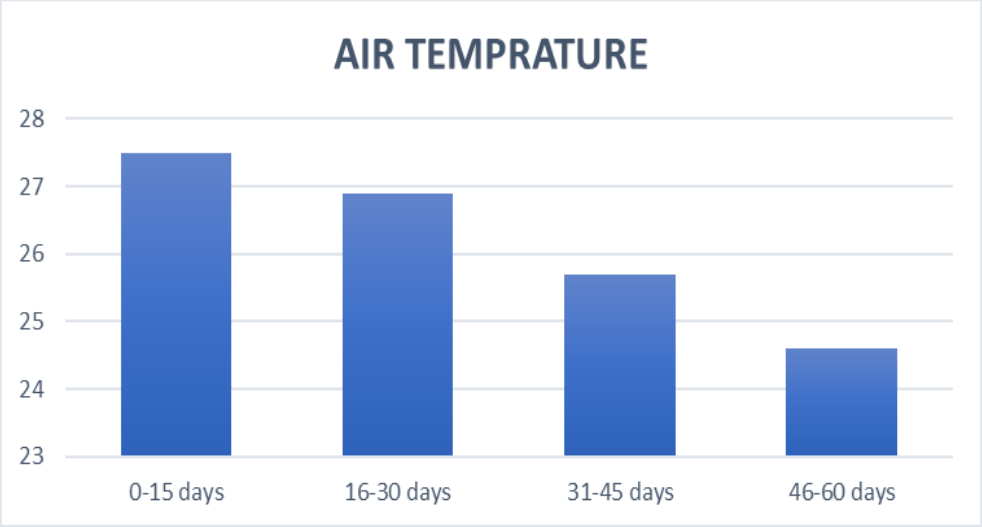

**Fig 1:** Air temperature during the experimental period in different treatments

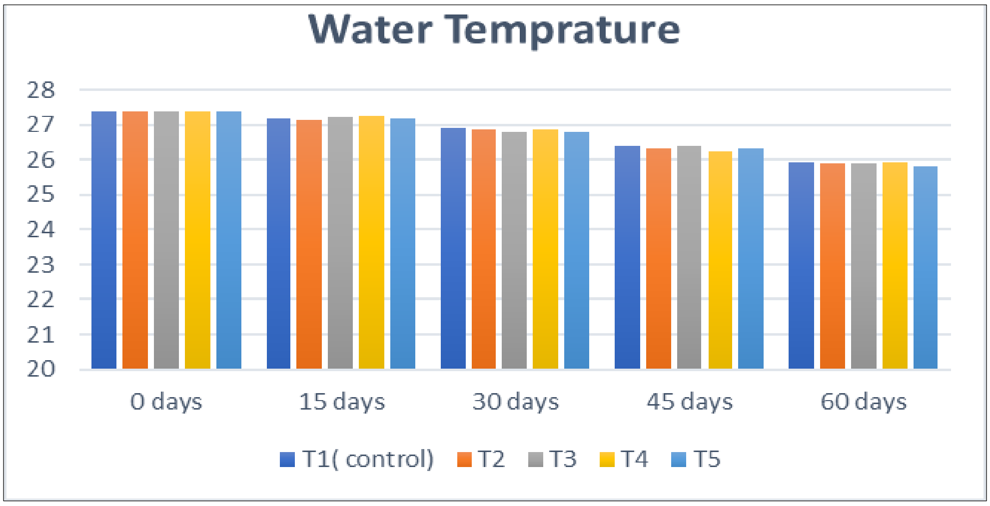

**Fig 2:** Water temperature during the experimental period in different treatment

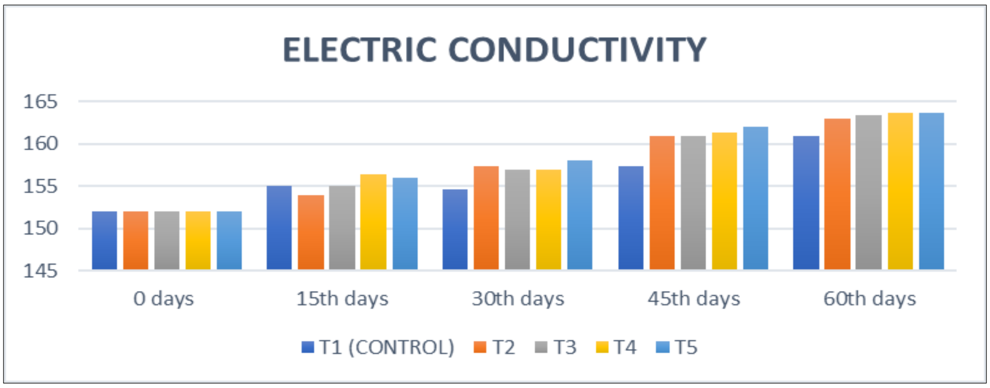

**Fig 3:** Electric conductivity during the experimental period in different treatment

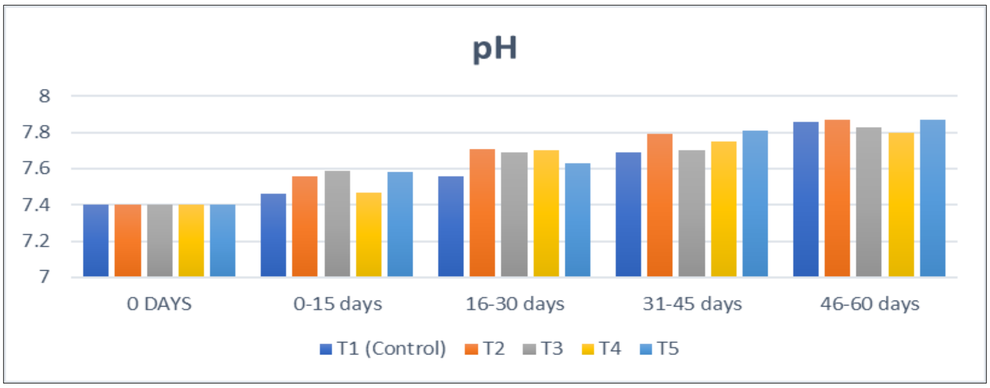

**Fig 4:** pH during the experimental period in different tanks

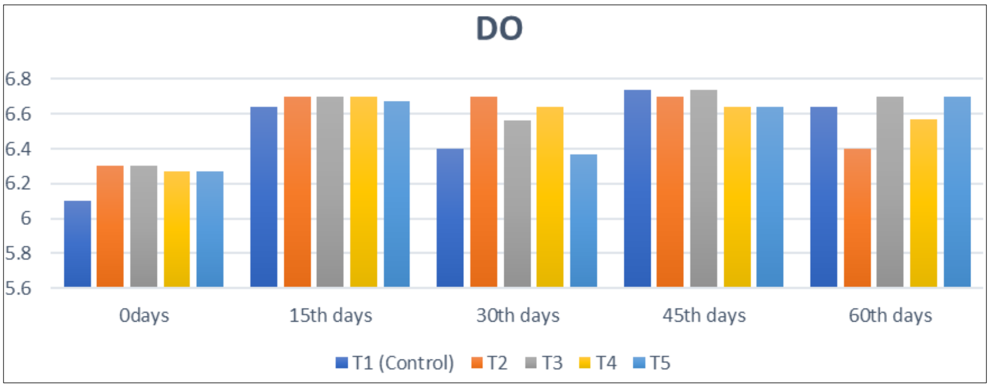

**Fig 5:** Dissolve oxygen during the experimental period in different tanks

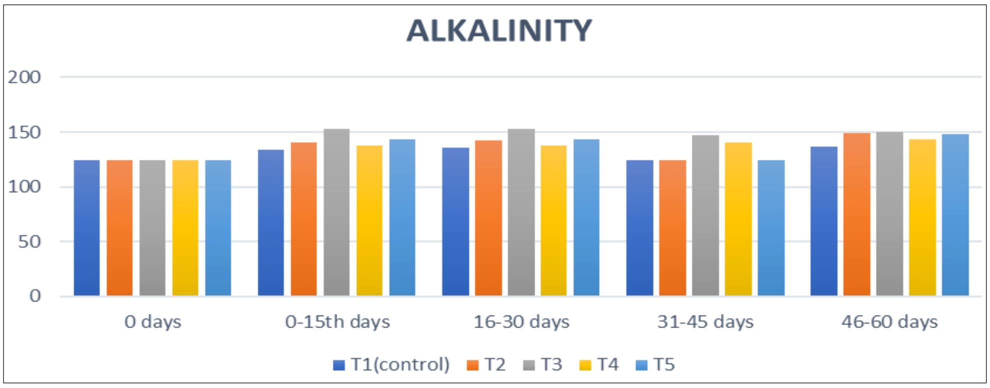

**Fig 6:** Total Alkalinity during the experimental period in different tanks

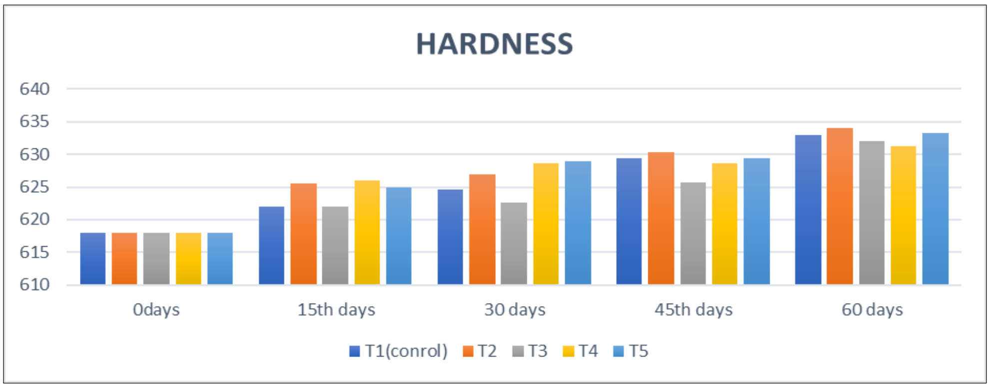

**Fig 7:** Total Hardness during the experimental period in different tanks

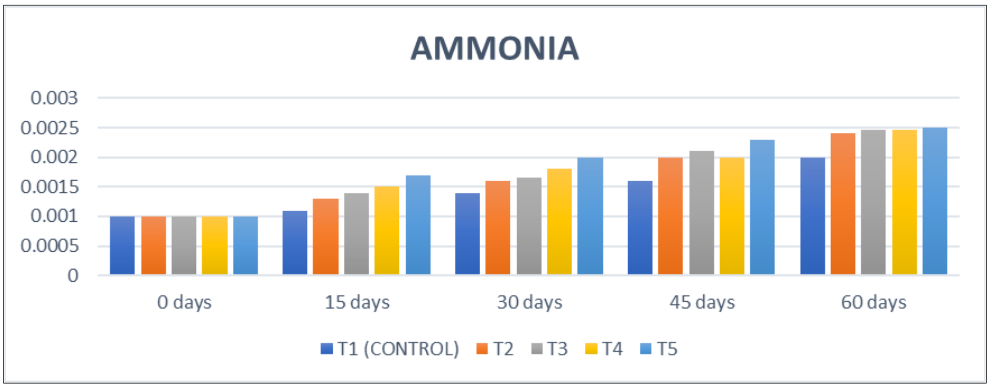

**Fig 8:** Ammonia during the experimental period in different tanks

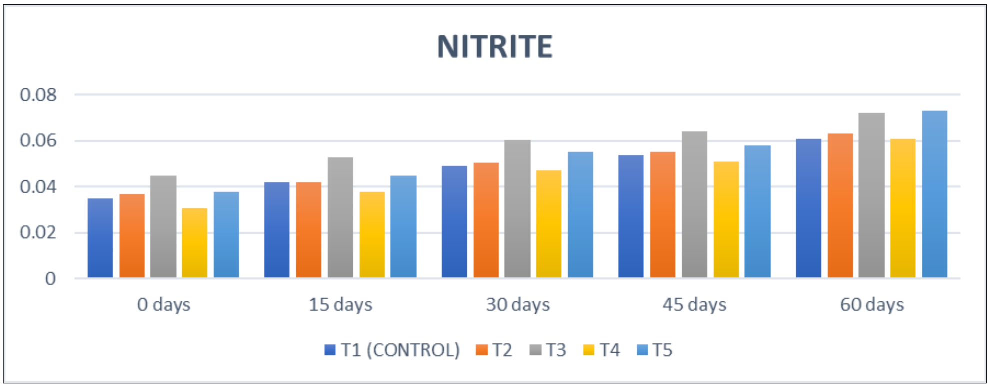

**Fig 9:** Nitrite during the experimental period in different tanks.

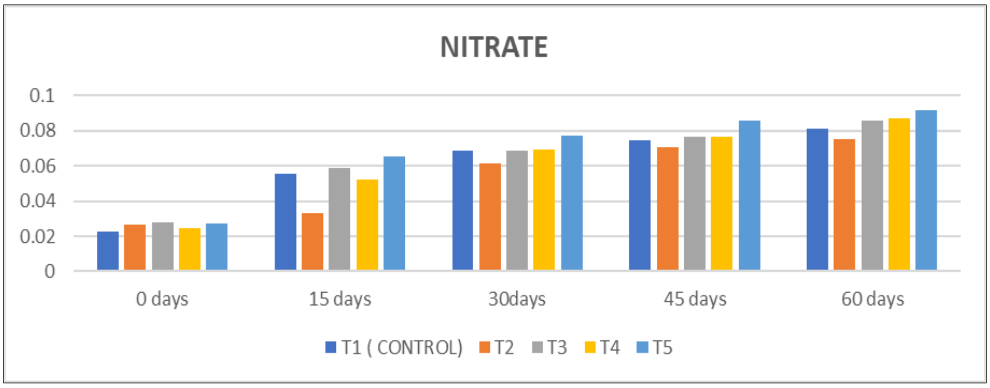

**Fig 10:** Nitrate during the experimental period in different tanks.

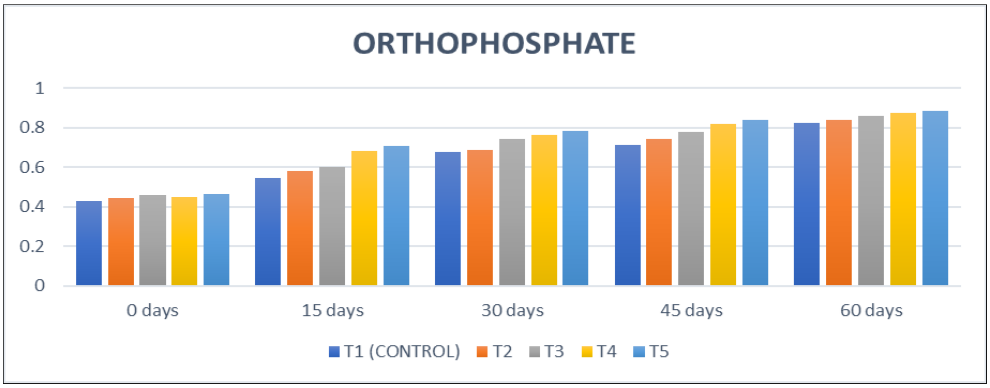

**Fig 11:** Orthophosphate during the experimental period in different tanks

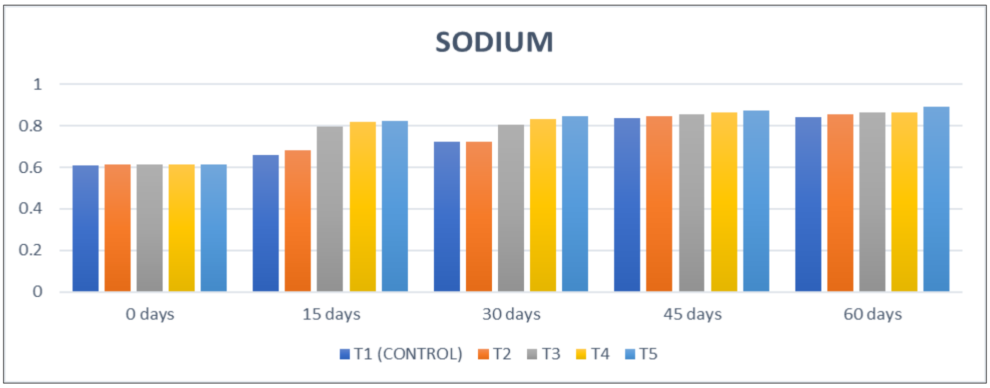

**Fig 12:** Sodium during the experimental period in different tanks

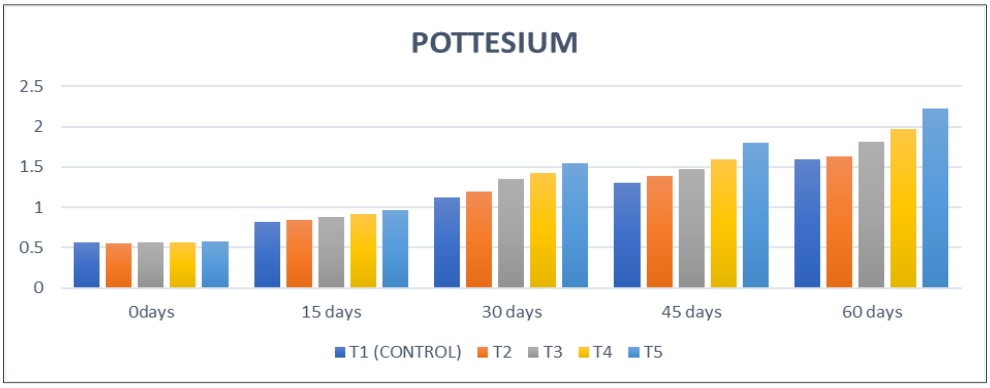

**Fig 13:** Potassium during the experimental period in different tanks

## Conclusion

The findings of the present study on water quality parameters in treatments of aquaponics system was noted optimum and it can be concluded that the aquatic environment of aquaponics system is conducive and favourable for fish and plants growth. It also can be concluded that the growing environment of an aquaponic system is favourable for bacteria for nitrification and nitrification process that help to produces the nutrients for plant growth.

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