iJRASET
International Journal For Research in Applied Science and Engineering Technology

INTERNATIONAL JOURNAL FOR RESEARCH

IN APPLIED SCIENCE & ENGINEERING TECHNOLOGY

Volume: 10 **Issue:** V **Month of publication:** May 2022

DOI: https://doi.org/10.22214/ijraset.2022.42456

International Journal for Research in Applied Science & Engineering Technology (IJRASET)
ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor: 7.538
Volume 10 Issue V May 2022- Available at www.ijraset.com

Water Quality Assessment of Low-Tech Aquaponic System Based on an Ornamental Aquarium

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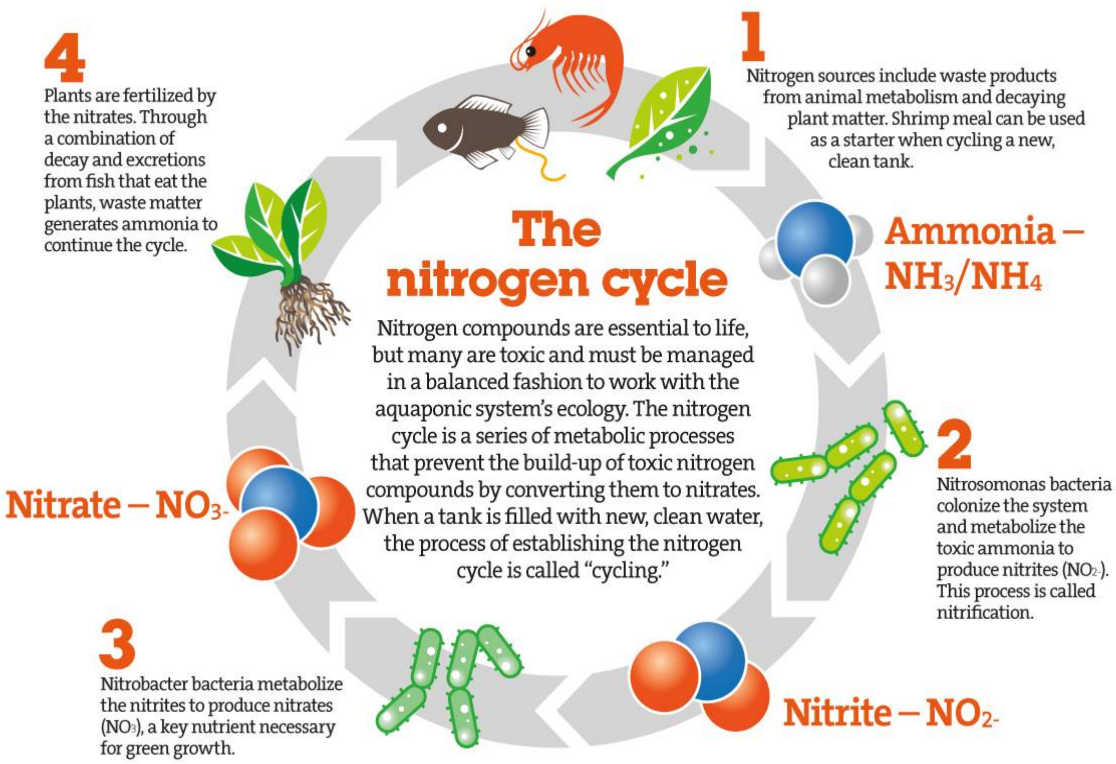
Abstract: Objective: The article presents a discussion on the aquaponics technology, including its working principles and applications in farming as well as the trends and challenges associated with its use in different areas of agriculture. Methods/statistical analysis: In this work, we discuss aquaponics, a combination of two techniques: a. 'hydroponic', which means cultivating plants/vegetables without soil, and b. 'aquaculture', which means fish farming. Aquaponics has become a popular technique because of its similarities to natural ecosystem, where the only difference is that it is a controlled system, in which the fish eats and produce ammonia, beneficial bacteria convert ammonia produced by the fish into nutrients, and the plant absorbs the natural fertilizer and the nutrients. In addition, the water carrying the ammonia and nutrients is continuously recirculated through the system. Findings: The present study was conducted to explore and find a better way to apply the aquaponics agriculture system in various agriculture industries. Findings show that this method enhances the benefits and eliminates the many drawbacks that occur in traditional soil-based agriculture. Application/improvement: This agriculture system does not depend on the soil, and no pesticide is required during the farming. This system is suitable for year-round farming and can produce high-quality vegetables at a much higher yield rate. Vegetables grow at a much faster rate using this technique, compared traditional farming techniques. Aquaponics takes place in a closed system and there is no discharge of waste into the stream. This system produces up to 30% more production compared to traditional farming using the same amount of space. This system requires less water compared to traditional farming.
Keywords: Automation, Aquaponics, Aquatic Farming, IoT, Arduino, Aquaculture

I. INTRODUCTION

The word *aquaponics* is the combination of 'aqua' and 'ponics'; aqua denotes aquaculture, where fish are raised in a controlled environment, and 'ponics' is a Latin word, which means 'to work', and cultivation is carried out in soilless media. Nowadays, population's food demand has grown manifold and indeed become a crisis, with regular agricultural farming barely meeting all the requirements, and severe problems faced by farmers, such as high cost of fertilizers, water for irrigation, land for farming, and soon. To overcome these problems a new technique called aquaponics comprising of automation and which mimics natural ecosystem has been introduced. The method is very efficient, cost-effective, inexpensive, and free of various other issues associated with traditional agriculture; this being a modern, computer-driven technique, there is enormous scope for automation and, thus, a wide range of applications in agriculture. Aquaponics combines regular agricultural methods with aquaculture. In this system, the fish cultivated eats and produces waste, which in turn is used as the perfect fertilizer for growing the required crop. Aquaponics describes the relationship between the water, aquaculture design, and nutritional values. Plants grow in watercourses and circulates the power through the bio-integration various components. Hence, these are very beneficial for the food system, and in most of the food crops obtained from the regular farming heavy-duty pesticides are used that cause serious health hazards. Thus, aquaponics is highly prescribed, and the control system of the aquaponics can be heavily automated to yield more quantity of agricultural produce or plants and vegetables.[1] The schematic diagram of the aquaponics system is shown in Figure 1.



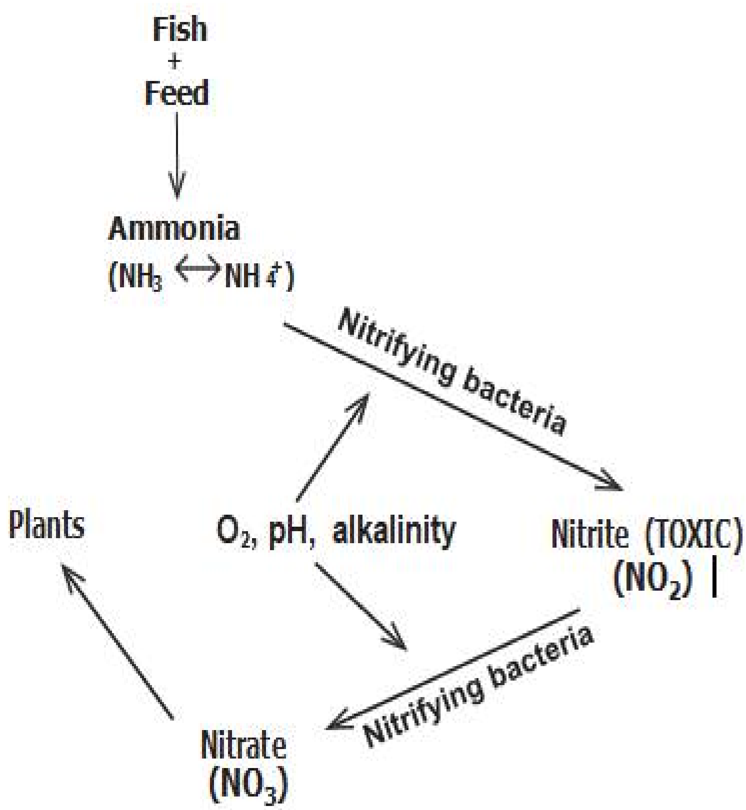


Figure 1. Schematic representation of the biofiltration process in aquaponics systems.

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II. LITERATURE SURVEY

The quality of soil and climatic condition differ in various regions. Some soils have different structures withsubstantial content clay or sand. Some soils have concrete, asphalt, and also heavy amount of chemicals and fertilizers used during cultivation, and this coupled with water erosion, wind erosion, and other natural calamitiesleads to serious health hazards to food consumers.[2]

However, these issues are resolved in aquaponics as iteliminates weeds and the system recycles the water whichis rich in nutrients. There is no toxic run-off in the system. Aquaponics uses just 10% of total water used in regular agricultural farming. Hence, it is very effective and usefulfor drought-prone areas.[3] Aquaponics uses a hydroponicssystem that consists of a. a fish tank – to house the fish and grow beds in which the plants are grown; b. a pump,to move water from the lowest part of the bed to the highest part of the bed; c. a pipe, through which water is recirculated; d. an air pump ensures adequate oxygenationof water; e. a filter tank installed removes solid wastes before water reaches the hydroponic grow bed; f. a sumptank is kept at the lowest part where water collects and the water-circulation pump is located; and g. bioreactor, which provides mechanical and biological filtration and plant root support in drained grow beds.[4]

III. TYPES OF AQUAPONICS SYSTEMS

A. Floating Raft or Deep Water Culture

Plants are grown with the pieces of Styrofoam, whichglide on the exterior of water-filled grow beds.

B. Flood and Drain

Plants are grown in an intermediate-filled grow bed.The substrate medium acts as a biological as well as mechanical filter, which helps with better maintenance ofplants cultivated.

C. Nutrient Film (NFT)

Plants are grown in pipes through which a small amount ofwater is continually flowing; water is propelled constantlyfrom the tank to the filter.[5]. The use of geothermal energy for food production in urban areas has also gained popularity, as this concept uses excavated water to heat and cool buildings. The greenhouse gases along with the combination aquaculturesystem exhibit a demand curve that is totally different from the regular heating technologies. Thus, comparedto conventional greenhouse gases and by using deep water culture grow beds, we can use thermal buffers to achieve peak loads within the prescribed limit of zone temperatures. However, given the drawback that the gradient fish tank temperature maximizes, which may kill the plants, further research is required to developthe technology and devise/implement appropriate design changes to take care of nibbling issues and make the system more robust and capable of protecting the aquaculture as well as the plants being cultivated.[6]

IV. MATERIALS AND METHODS

In a traditional mason jar aquaponics system, you'll typically use a standard mason jar, a betta fish and a plant pot in the top containing your grow medium and crop. A the classic mason jar is far too small for fish. A single betta fish needs a 2.5 gallon tank at the very minimum, which means a standard mason jar is far too small. Don't let this put you off however. There are a number of larger alternatives available on Amazon that are just as decorative and better suited for keeping a betta fish. Size (volume) If you plan to stock a fish such as a betta then you need to find a jar that can hold at least 2 to 2.5 gallons / 7.5 to 11 litres. Not only is this kinder for your fish but it will also allow you to harvest more from your crop. Size (space) The second rule of thumb to keep in mind is that your fish should be able to comfortably turn around and swim. While jars are a popular choice, we've heard of people successfully creating systems using large vases. That said, you want to avoid anything with a thin middle section. Opening: The final consideration is that the opening at the top of the container should be wide enough for a plant pot. This is why jars are a popular choice as the opening is more than capable of holding a plant pot. Choose Your Fish: When it comes to choosing fish for your setup there are a number of popular options that come with various pros and cons. Betta fish are one of the easiest creatures to keep in your jar based aquaponics system. They don't require a filter, can be kept in a relatively small tank (2 gallons / 7.5 litres) and the males are beautiful to look at. While the don't require a filter the do need the water to be full of oxygen so you'll need to change the water each week and put a real plant into the tank. You're also limited to just one fish per setup unless you're using a large tank. A Note on Goldfish While Goldfish are a great choice for larger setups, for a small jar system they are far too large and should never be used. Plants: Now for the fun part – picking what you're going to grow! Almost anything can be grown in an aquaponics system but herbs and leafy greens always grow well. For the best results you need to start the plant in soil and then transport the seedling(Spinach, Kale, Lettuce, Basil, Coriander) to your aquaponics system.[7] The plant Balsam,(Impatiens

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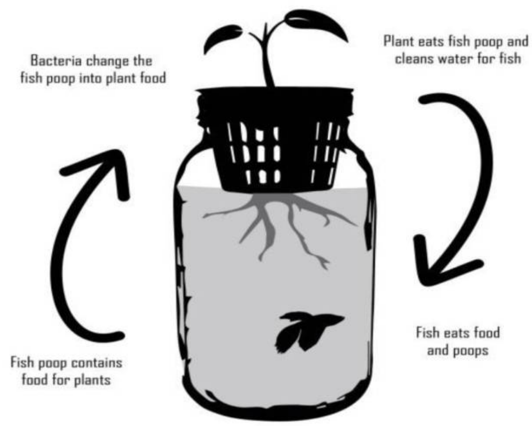
balsamina) is selected because the plant is reported to contain mainly naphthoquinones, coumarins, phenolic acids, flavonoids, anthocyanidins and steroids, which might be useful in the development of new drugs of the versatile nature to treat various diseases because of their different pharmacological activities [8]. This species, being the impatiens native of India, it is widely distributed all over the country. Impatiens balsamina is known as Rose balsam in English and as Gul Mehendi in Hindi. Locally known as balsam in Kerala belonging to the family Balsaminaceae [8]. Herbal medicines based drugs are commonly used in India. Balsam plant mixed with other herbs is popularly used in a bath after childbirth for general health. The drug made with allium cepa, locally known as onion, and fennel flower known as black cumin, is used for the treatment of joint problems and coughs. The leaves of balsam plants are used as antiarrhythmic, expectorant, antispasmodic, astringent, antigastralgic and anthelmintic [8]. The fish species selected is Pangasianodon hypophthalmus commonly known as iridescent shark. The iridescent shark has earned economic value and become the fishery practices as well as the habitats of many neighbor countries.

V. HOW TO GROW PLANTS IN MASON JAR AQUAPONICS?

In growing plants aquaponically in a mason jar, you would need a large glass jar that will serve as your fish habitat, net pots, grow medium, betta fish, plant seedling, decorative rock/gravel, air stones, and water conditioner. After completing all these items that are mostly available in Amazon and local aquaponics stores, the following procedures should be followed in setting up the system. Prepare the glass jar by ensuring that it is thoroughly cleaned. Any glass design will do as long as it can hold the size of the fish. For instance, a single betta fish usually requires 1 gallon or 3.8 litres of water. Another thing to be considered is the opening of the jar. It should be wide enough so the net pot/s can fit in the rim. Place the decorative rock or gravel at the bottom of the jar, including the air stones. Fill the jar with purified water but make sure to leave an inch of air at the top. Also, pour the water conditioner that is equal to the water volume. If the fish came from stores like Petco, you should let them acclimate first before putting it in the jar. After the mason jar is put in order, it is best to wait a week for the betta fish waste to build up before putting the plant since it will be the source of its nutrients. This is suggested if the plant was already grown in soil and will only be transferred to the container. If you are starting from seeds, you won't have to wait a week since the plant growth will take time and the fish would already be able to produce enough nitrogen through its waste. In transferring the mature plant from soil to the net pot, make sure that its roots are well cleaned so there are no soil particles that can serve as a water pollutant. You also have to be sure that the grow media is evenly spread in the net pot for the plant to absorb more nutrients and moisture. This goes the same if you are starting with seeds. After setting up the plant, put the net pots at the top of the glass jar and place it in an area where it can get natural sunlight. [8]



VI. RESULTS

The experiment was conducted for 60 days from April 1, 2018 to June 14, 2018. Four plants were grown in the hydroponic component. The leaves count was first taken on the 14^{th} day from the plantation. After 60 days the height of the plants was found on an average 24cms. It is an annual plant normally growing to 20–75 cm tall [8]. Therefore, the experimental results are similar to those achieved in earlier research, confirms that this method and combination can be effective. The number of leaves on all the four plants is counted after the periodic intervals of 7 days. At the end of 60days duration of the experiment, count of leaves on plant A1, A2, A3, and A4 was found to be 78,62,94 and 82 respectively(table1). The variations in pH, total ammonia nitrogen, total solids, nitrates, chlorides, and alkalinity were recorded. It was noted that with the change in pH and time intervals, there is a significant variation in each parameter. With decreasing pH, there is an increase in all the rest of the parameters. When water was completely replaced, the parameters show their average values similar to the values at the beginning of the first recycling of water. The biofilter was maintaining the total ammonia in the water below 1 ppm. Forthe next 15 days, the ammonia level increased to 4.3 ppm. The water was replaced in the aquaponic component on the 30^{th} day of experimentation. As a result, the pH was raised to 7.4 and total ammonia was lowered below 1 ppm. [9]

Table 1: Growth of leaves per plant

Date	No.of leaves	
	Plant A1	Plant A2
14/01/22	07	05
20/01/22	12	11
26/01/22	15	14
30/01/22	20	18
07/02/22	27	23
14/02/22	39	35
22/02/22	52	46
29/02/22	64	53
06/03/22	78	62
14/03/22	82	65

From table 2, it can be concluded that maintaining the pH ofwater is an important task in the system. The fish excreta started settling down at the bottom of the tank. The quantity was negligible and didn't cause a strong odor in the water. Also, it didn't affect the water quality as it was washed awayon the 30th day.

Table 2: Ammonia, nitrogen, nitrates and total solidsconcentration

Dates	pH	NH3 (ppm)	N (ppm)	NO3 (ppm)	K (ppm)
14/04/18	7.5	0.03	0.70	1.40	0.30
20/04/18	7.4	0.055	0.86	1.535	0.65
26/04/18	7.3	0.08	1.02	1.67	1.00
30/04/18	7.2	0.12	1.38	2.37	1.17
07/05/18	6.9	0.27	2.2	2.89	1.54
14/05/18	6.5	0.67	4.3	3.27	1.70
22/05/18	7.4	0.043	0.79	1.37	0.26
29/05/18	7.3	0.05	0.82	1.48	0.61
06/06/18	7.2	0.074	1.23	1.84	0.79

The dissolved oxygen content was recorded before and after recirculation of water through the biofilter. The records fromtable 4 show the dissolved oxygen dropped below 1 ppm before recirculation. The dissolved oxygen level increased after recirculation of aquaponic water. It was recorded more than 5 ppm after every recirculation. The recirculation periodwas kept 3 hours once after 3 days of a span. No death of thefish species observed during the gap of recirculation cycles. The biofilter worked efficiently as the growth of the plant wasmore rapid than the conventional system in practice The balsam plant growth was satisfactory with respect to height, number of leaves and flowers. The fish species namediridescent shark proved its high survival strength as the system run with less dissolved oxygen for 45 days. The fish length increased from 10cm to almost 18 cm in the span of 45 days. No death was observed out of 6 fish within the experimentation cycle. It can be concluded that in the condition of very less dissolved oxygen like 0.5 ppm, 0.2 ppmand zero ppm, varying pH values from 7.5 to 7.2, and high nitrogen levels (4.3 ppm) the iridescent sharks can survive. [10] For almost 45 days, the biofilter without maintenance, proved its efficiency of working satisfactory for longer duration. With 1000 lit of water replaced only once in 3 months, the issue of availability fresh water can be solved to some extent by implementing this system.

Recirculation done once in 3 days also benefits by reducing the demand for electricity and thereby reduces operational cost. This systemcan be effective in areas like Alwar, Jaipur, Kota and Udaipur districts where water deficiency is at its peak or water quality is alkaline free. Recycling and reuse of water to the plant and fish growth can be effective insuch districts particularly in Rajasthan.

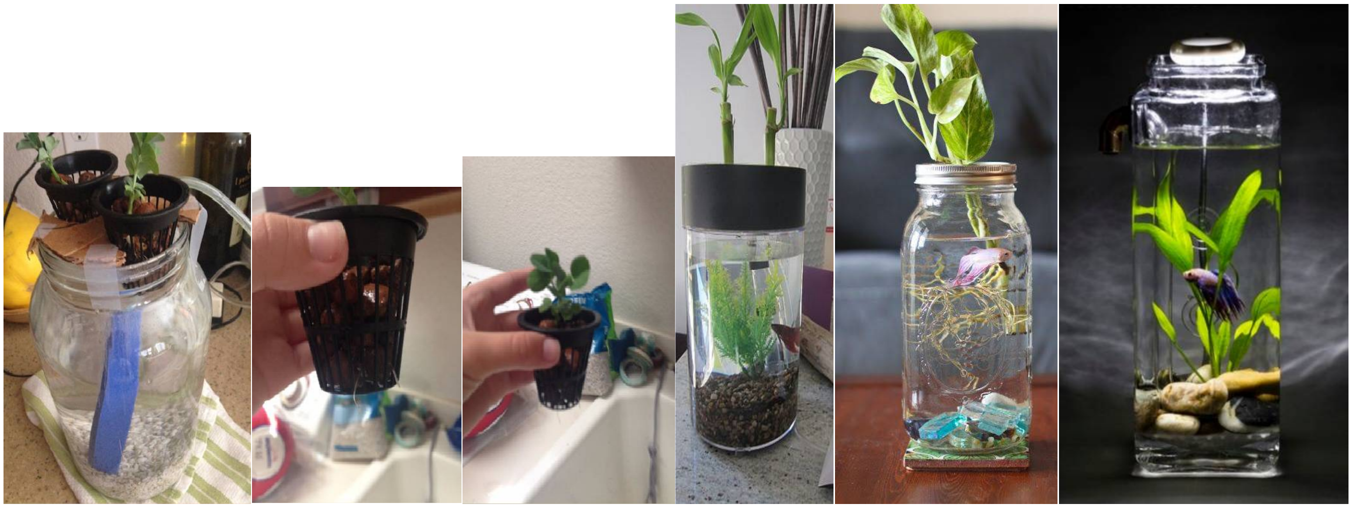


Figure 2 Shows different growth in pots with Betta fish and plants.

VII. DISCUSSION

There are some consequences with the working of biofilter as it couldn't control the rising ammonia and lowering pH of the system water. Though the pH value didn't show considerable decrease, as it dropped to 7.2 from 7.5, it still makes significant changes in TAN levels. So maintaining pH for better quality control is the scope of this experimental investigation. The removal of the solids settled at the bottom of the fish tank is another area of the future scope for this type of recirculating systems. After recirculation, the DO levels recorded around 7 ppm and were decreased below 1.5 ppm, whereas sometimes less than 0.5 ppm. An hourly investigation should be done to detect a particular time when the DO level falls below 4 ppm. The recirculation can be scheduled more accurately with respect to these records. The system needs to be tested with varying recirculation periods to examine the effects on plant growth. Specific research apart from experimenting with different filtering media is required in hydroponic cum biofilter media. There should be some innovation in further research in microbial activities involved in the aquaponic system and its optimization.

VIII. CONCLUSIONS

The main challenge in the agricultural sector is to meet the demand of the growing food crisis along at the lowest cost possible. Given the cost considerations, the method to be chosen should be simple to use, efficient, and reliable. Our findings show that aquaponics can meet all these criteria. Just with any technology, this method has very limited issues and shortcomings, but the benefits clearly outweigh the disadvantages when compared to traditional agriculture. Other advantages of this system include the generation of nutrients that help boost plant and fish growth; as a result, in this system, expensive chemicals are replaced by less expensive fish feed, whichmeans a major cost advantage in cultivation comparedto traditional farming that requires more money and also the use of harmful chemicals and fertilizers that contaminate the crop and are harmful to food consumers. This system is thus closest to the natural ecosystem. The system produces zero waste, as it doesn't require discharging water, and is more productive compared to other agricultural techniques.

REFERENCES

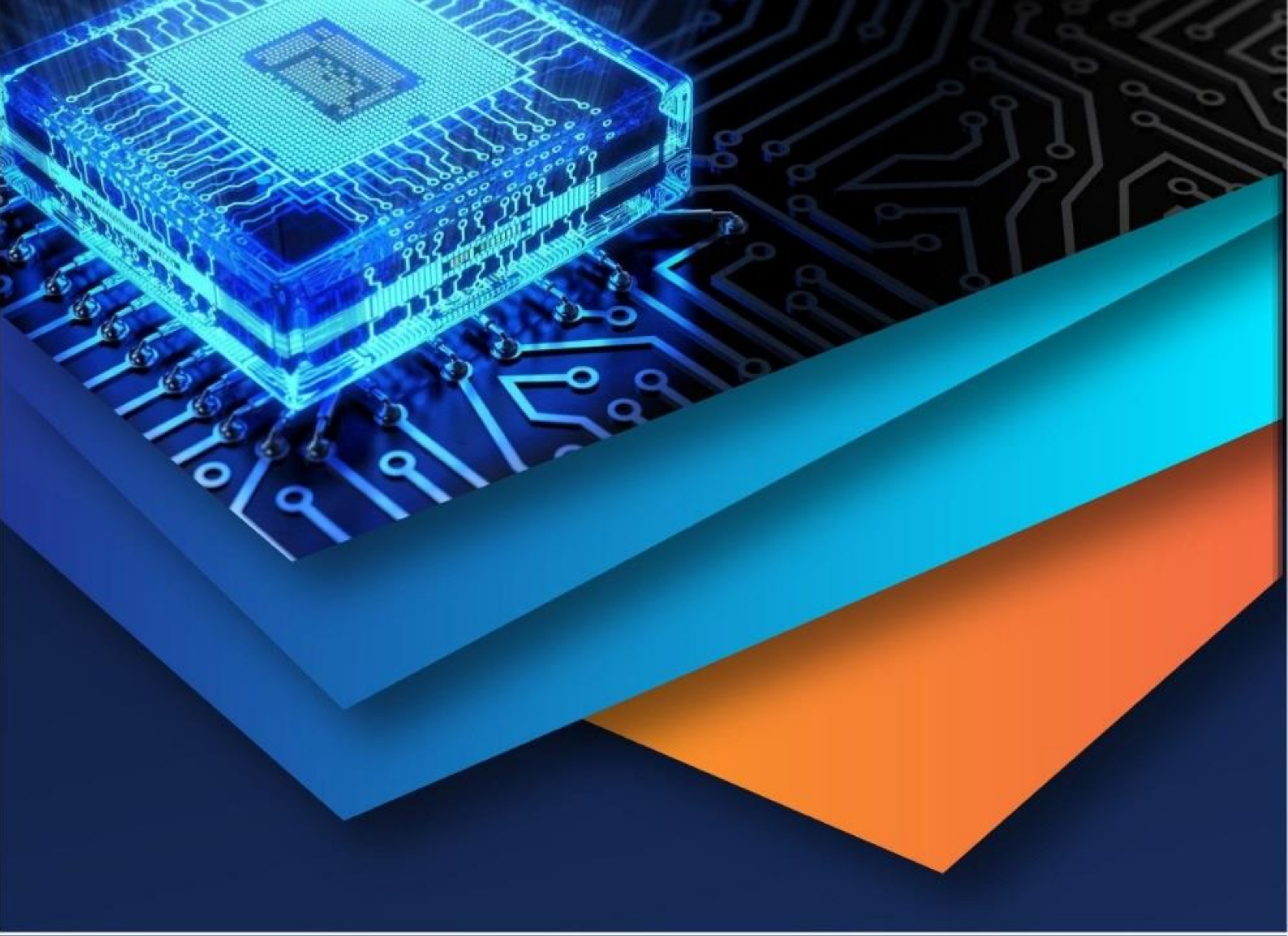
[1] Roosta HR. Interaction between water alkalinity and nutrient solution pH on the vegetative growth, chlorophyll fluorescence and leaf magnesium, iron, manganese, and zincconcentrations in lettuce. J Plant Nutr. 2011;34(5):717–31.

[2] Rakocy JE, Hargreaves JA. Nutrient accumulation in a recirculating aquaculture system integrated with hydroponic vegetable production. In: Techniques for modernaquaculture, proceedings of a conference, Sponkane; 1993.P. 148–58.

[3] Saaid MF, Yahya NAM, Noor MZH, Ali MSAM. A development of an automatic microcontroller system for Deep Water Culture (DWC). In: 2013 IEEE 9th internationalcolloquium on signal processing and its applications; 2013.P. 328–32.

[4] McMurtry MR, Sanders DC, Cure JD, Hodson RG, HaningBC, Amand ECS. Efficiency of water use of an integrated fish/vegetable co-culture system. J World Aquacult Soc. 1997;28(4):420–28

[5] Graber A, Junge R. Aquaponic systems: Nutrient recyclingfrom fish wastewater by vegetable production. Desalination.2009;246(1–3):147–56.
[6] Sikawa DC, Yakupitiyage A. The hydroponic production of lettuce (*Lactuca sativa* L) by using hybrid catfish (*Clarias microcephalus* × *C. gariepinus*) pond water: potentials andconstraints. Agric Water Manag. 2010;97(9):1317–25
[7] D. C. Love, M. S. Uhl, and L. Genello,"Energy and water use of a small-scale raft aquaponics system in Baltimore, Maryland, United States". *Aquacultural Engineering.*, 2015, vol. 68, pp. 19–27.
[8] C. I. M. Martin, "New developments in recirculating aquaculture systems in Europe : A perspective on environmental sustainability", *Aquacultural Engineering*, vol. 43, no. 3, 2010, pp. 83–93.
[9] Y. Zou, Z. Hu, J. Zhang, C. Guimbaud, and Q. Wang, "Effect of seasonal variation on nitrogen transformations in aquaponics of northernChina," *Ecol. Eng.*, vol. 94, 2016, pp. 30–36.
[10] S. Ratnoji and N.Singh, "A study of coconut shell - activated carbon for filtration and its comparison with sand filtration," *International Journal of Renewable Energy and Environmental Engineering*, ISSN 2348-0157, Vol. 02, No. 03, July 2014, pp. 201-204.



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