# *Hypaponics - Monitoring and Controlling using Internet of Things and Machine Learning*

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***Abstract*— Hypaponics is a monitoring system which takes care of integrated vertical farming. Hypaponics contains fields like Aquaponics, Agriculture and poultry. It is monitored using various sensors and the predictions are taken based on the data using Machine Learning Algorithms. These are the advantages for the farmers to decrease their water, fertilizer usage in farm and to increase their profit hence it gives multiple ways for the income. It also gives pure organic food to eat. We can also use Solar power panels for energy. This also helps the environment to lead a healthy life free from pollution. The sensors will be kept inside the hypaponics system. The detailed information about it will be noted under the hardware topic and the data from the IoT will be stored on the cloud (AWS, Microsoft Azure, Google cloud, IBM Cloud, etc) for machine learning. The organic store will be hosted where the organic products are uploaded with their cost. The consumer can check whether its organic or not by the QR code that the consumer found on their pack, where each field, product will have unique QR code in it. The farmers will also get all kind of supports from the help desk they find on the portal. The whole system is monitored 24/7 and the input to farmers are given at a regular intervals of time. The latest technologies like Internet of Things and Machine Learning are used in this project to predict the plants growth and the maintenance charges are also less. The 10% of the water is only consumed by this method while comparing with the ancient irrigation methodologies. This also saves the environment from pollution, food poisoning, diseases.**

***Keywords—Hypaponics; IoT; ML; Aquaponics; Hydroponics; Aquaculture; Poultry; Organic product; Prediction;***

## I. INTRODUCTION

The world is covered with 71% of water among that only 2.75% is freshwater, where in that only 0.3% of freshwater are found on lakes, rivers, etc remaining all are in underground. Almost 70% of fresh water are used for Agriculture, 18% for industries and 12% for household purposes. In 2050, 50% increase in agricultural production is needed to meet population needs which leads to scarcity in freshwater and also organic food. So we want a alternate way of agriculture which should give high organic food and with less water usage. By using this system only 10% of water is used for agriculture as we are doing aquaponics. The system is arranged in the way that the recycle of waste is done automatically as per the nitrogen cycle so it reduces the maintenance cost and manual cost. The product from this system is 100% organic as it has aquaponics in it. This can also be proved with the sensor data from the system that the product is developed using hypaponics.

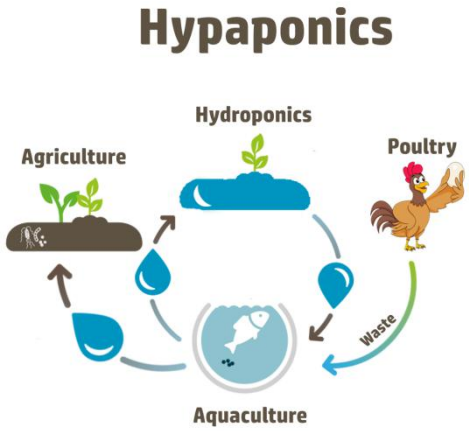


**Figure 1. Hypaponics**

The nutrients needed for plants [N,P,K, other nutrients] will be supplied through the aquaculture water after nitrification process. 10% of poultry waste will be let inside the aquaculture as input for fishes. That fish waste are then goes under nitrification process in which the ammonia is changed to nitrite and then to nitrate.

Nitrosomonas is the bacterium in many hundreds which converts Ammonia to nitrite.

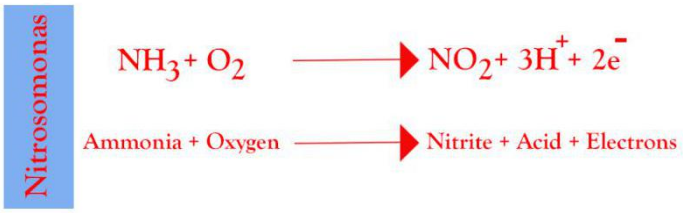


**Figure 2. Ammonia to Nitrite Conversion**

Nitrite is quite toxic which we monitor through the pH sensor and that changes nitrite to nitrate using the Nitrobacter bacteria. Nitrate is the non-toxic substance which are used by plants to grow cells. Thus this water is made to pass through the plants in the aquaponic system which absorbs the nutrients from this water. Nitrobacter in many hundreds converts the nitrite to nitrate.

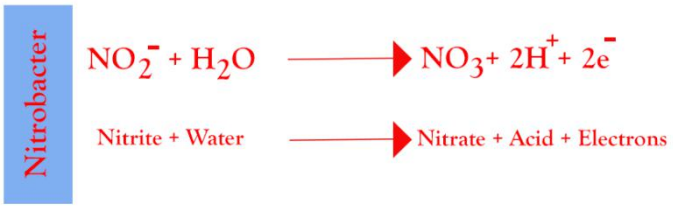


**Figure 3. Nitrite to Nitrate Conversion**

This water after nitrification process is called the Nutrient water which are used for the circulation in the aquaponics system.

## II. HYPAPONICS WORKING

***Flow charts of Hypaponics***

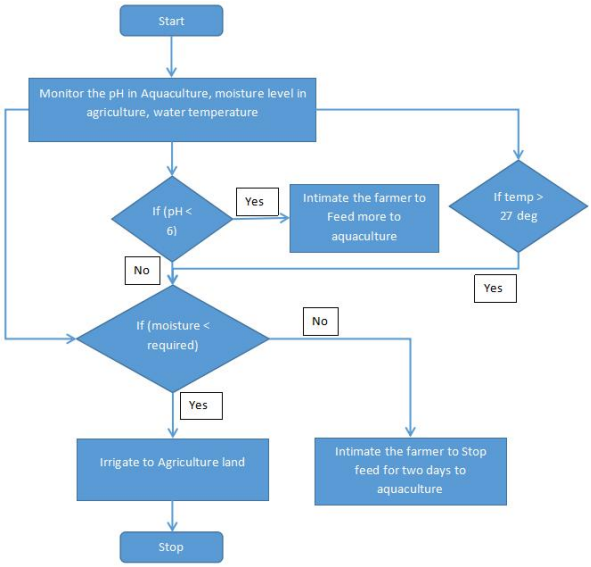


**Figure 4. Flowchart of Hypaponics (i)**

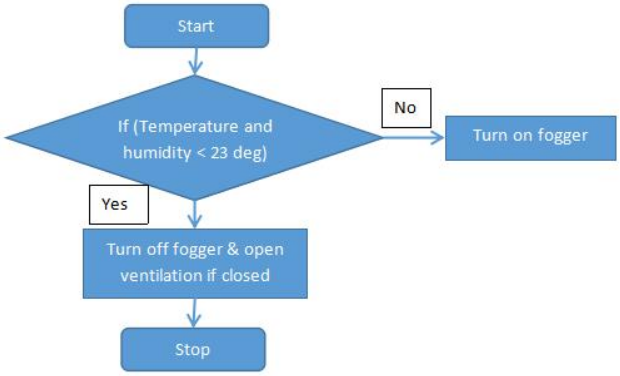


**Figure 5. Flowchart of Hypaponics (ii)**

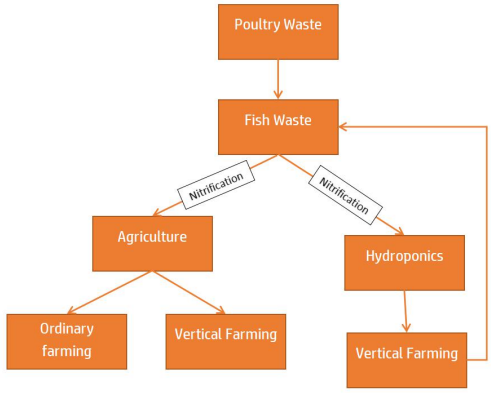


**Figure 6. Flowchart of Hypaponics (iii)**

Hypaponics - Monitoring and Controlling using Internet of Things and Machine Learning

***Hypaponics Working***

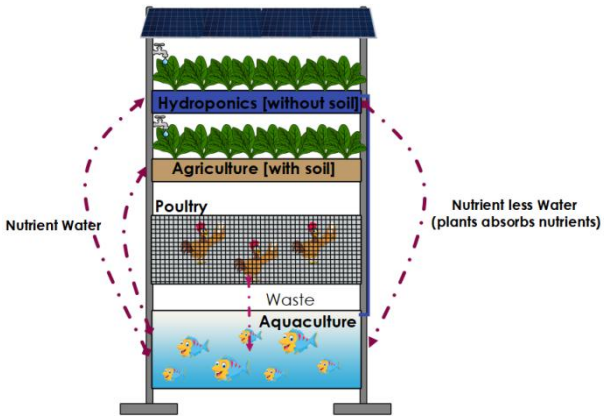


**Figure 7. Hypaponics Working**

The above are the process of hypaponics system in which the freshwater is used effectively. The nutrient water has the nutrients like Nitrogen (N), Potassium (K), Phosphorus (P), Calcium (Ca), Magnesium (Mg), Sulphur (S), Iron (Fe), Manganese (Mn), Copper (Cu), Zinc (Zn), Molybdate (Mo), Boron (B), Chlorine (Cl) where distributed equally to all plants in that system based on soil moisture sensor reading. These are monitored using the IoT with its pH value where these components affect the pH of the water.

## III. PROPOSED SYSTEM

The hardware components are chosen as per the requirements of the system. All the data are stored in the cloud and used for Machine Learning. The machine learning algorithms are used to predict the Health of the particular plant by comparing with the best system data which gives the maximum profit to the farmer. The algorithm used in this system is simple linear regression algorithm (y=mx+c).

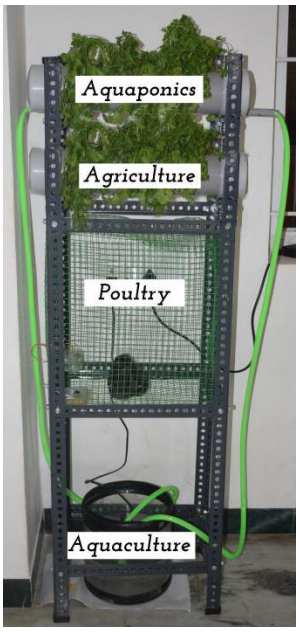


**Figure 8. Working Model**

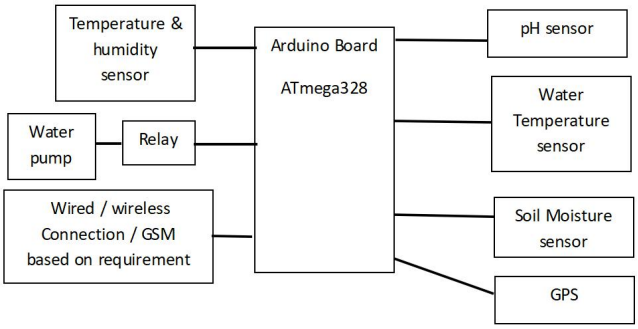


**Figure 9. Hardware Components**

The Temperature and humidity sensor is used to measure the atmospheric temperature and humidity. pH sensor is used to take the pH value from the Aquaculture to operate the water pump based on soil moisture sensor, pH sensor and water temperature reading. The data is transmitted to cloud via wired or wireless connection. This system uses the Transmission Control protocol [TCP] for wireless and User Datagram Protocol [UDP] for wired in the transport level and Hyper Text Transfer Protocol Secure [HTTPS] in application level.

For wireless communication like wifi this system has a Intrusion Detection System (IDS) which detects any intrusion happened in this system to take action to it. If any intrusion detected those details are sent to the admin of this system. This can be improved by using honeypot to catch the information about the hacker or intruder.

| Date | Time | Temperature (Celsius) | Humidity (RH) | Water Temperature (Celsius) | pH (pH) |
|---|---|---|---|---|---|
| 2018-07-17 | 2:15 PM | 25 | 50 | 25 | 7 |
| 2018-07-17 | 2:18 PM | 25 | 51 | 25 | 7 |
| 2018-07-17 | 2:21 PM | 25 | 50 | 26 | 7 |
| 2018-07-17 | 2:24 PM | 26 | 52 | 24 | 7 |
| 2018-07-17 | 2:27 PM | 25 | 53 | 25 | 7 |

**Table 1. Data inserted in the DB from Sensors**


**Figure 10. Linear regression Output for Training Set**

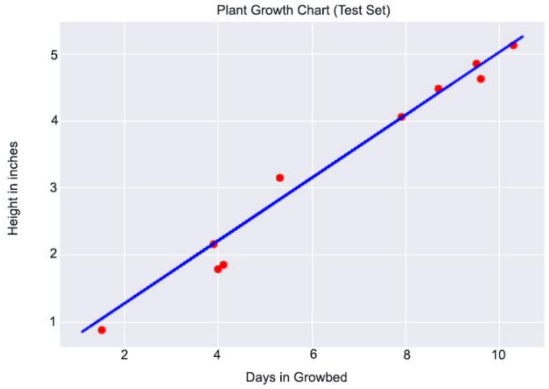


**Figure 11. Linear regression Output for Test Set**

If the height doesn't reach as we expected there may be a bit less growth rate from the expected amount which can be because of the factors like temperature, humidity, pH, water temperature in the system which are analyzed in the following graph.

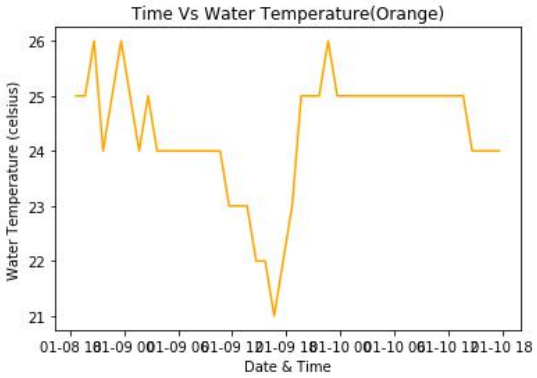


**Figure 12. Date & Time Vs Water Temperature (Celsius)**

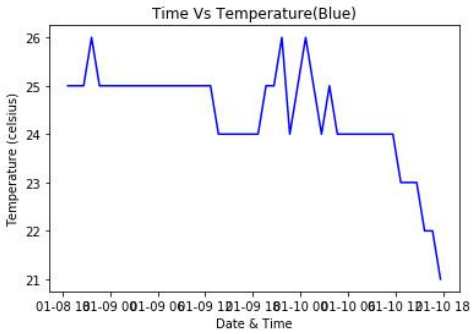


**Figure 13. Date & Time Vs Temperature (Celsius)**

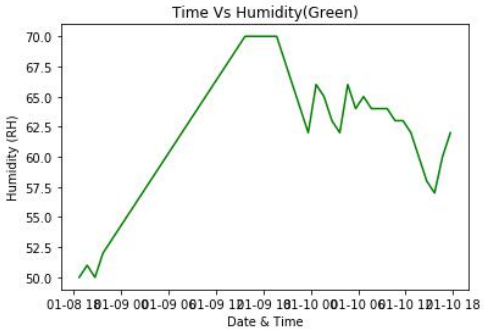


**Figure 14. Date & Time Vs Humidity (RH)**

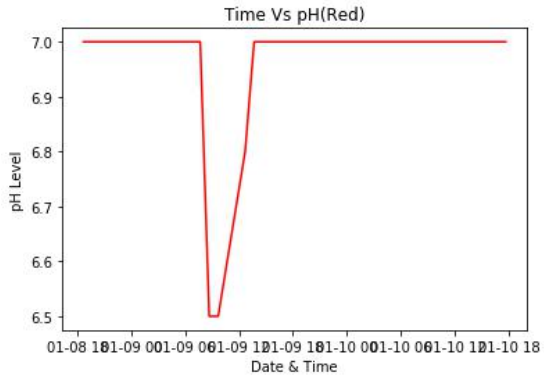


**Figure 15. Date & Time Vs pH**

The above are the data visualization from 2.15PM to 4.15PM in a day from live data(Figure 12 to 15). This system is semi automated where the maintenance person should want to input the height of the plant manually to this system. It is also used to check whether the system is working good and everything are under the correct condition if not the information is given to the admin. If everything is doing good but still there is any lack of growth, the help desk in this system is triggered automatically from this system that the system has some problem to checkout which also sends the data to the expert to analyze and help the customer.

Designed a separate website for hypaponics where all the data gets visualized and the organic market is found which the users are differentiated using their login details. Each form have different links which are given in the QR Code for the product while purchase. Where the user can also view all the visualized data to check its purity.

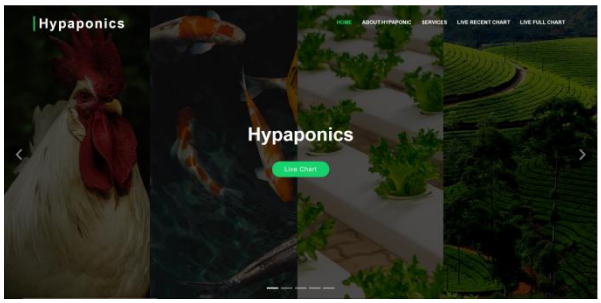


**Figure 16. Home Page**

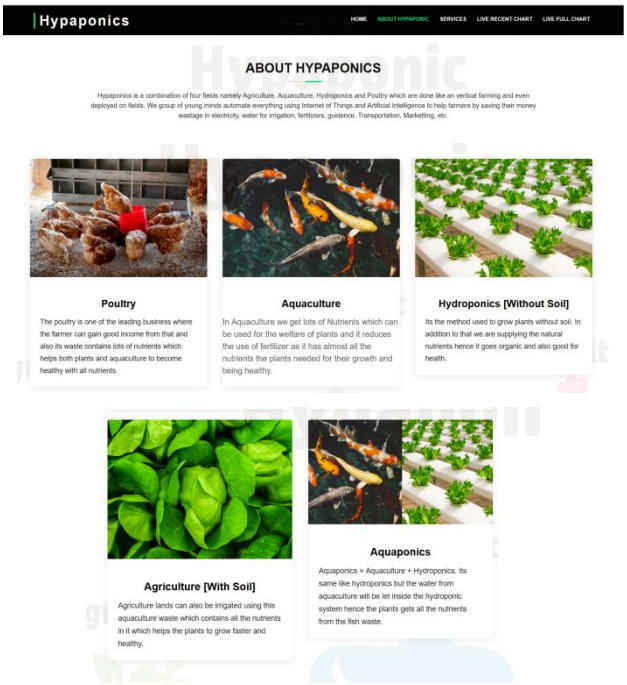


**Figure 17. About Hypaponics**

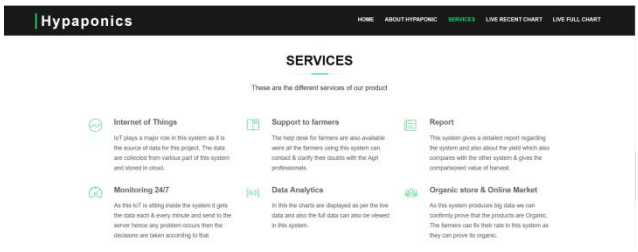


**Figure 18. Services**

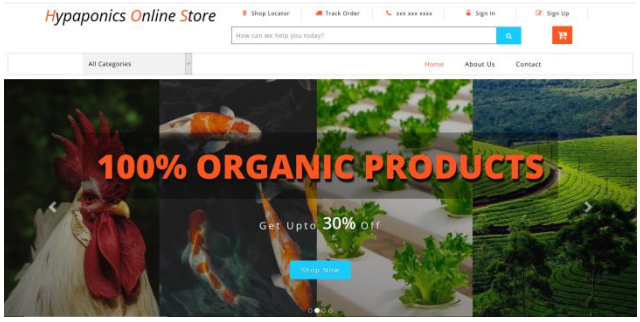


**Figure 19. Online organic Hypaponics store**

The figures (figure.16 to figure.19) are the websites made for the organic store which will be very useful for farmers. The payment is also done online. The farmers can also keep track of their sales from this market. The above mentioned figures(figure 10 to figure 15) are also in these website to monitor the system.

## IV. ADVANTAGES

- Water used for irrigation to plants will be reduced 90% as the aquaculture waste water is used and also keeps circulating in the aquaponics system.
- By this kind of vertical farming the place will be reduced and even this system can be build inside the closed environment.
- This project can also be implemented in the Integrated farm land where all the above live stocks are grown.
- This helps the farmer to produce the organic products as their result which also helps the consumer to stay healthy as they intake organic products.
- One time investment and gives the income till lifetime.
- Farmer can choose the product based on their field.
- This supports the farmers as it has help desk in it. It also helps to monitor remotely as the motor and all other things were connected through internet. The customer can operate through the webpage or the mobile app we give to them.
- Return on Investment [one square feet] Profit estimation for 120 Days based on particular crop & fish variety.

| **AGRICULTURAL LAND** | **PROFIT** | **HYPAPONICS** | **PROFIT** |
|---|---|---|---|
| MAX 2 plants<br>Eg: Coriander leaves | Rs: 10/- | MIN 8 plants<br>[vertical farming]<br>Eg: Coriander | Rs: 40/- |
| NO FISH | - | AQUACULTURE<br>Eg: Rogu, katla, Thilapia - Min 1kg | Rs: 200/- |
| NO POULTRY | - | POULTRY<br>Eg: Indian breeds - Min 1Kg | Rs: 300/- |
| **TOTAL** | **Rs: 10/-** | **TOTAL** | **Rs: 540/-** |
| **1 cent** = Rs.540 × 435.59(sq feet) = **Rs. 2,35,218/-**<br>**1 acre** = Rs.2,35,218 × 100(cents) =**Rs. 2,35,21,800/-** | | | |

- This also keeps the farmer up to date with the current market rate.
- The UI of this system will be kept simple so any person can understand easily.
- The customer will get the fresh food directly from the land even we can have a organic restaurant which uses all these products to make some delicious dishes.
- As we are growing organic, the Soil pollution will be reduced as we don't use any chemical fertilizer, pesticides.

## V. FUTURE ABRIDGMENT

This system can be further developed using Image processing to calculate the height of the plant and solar panel which could be able to turn towards the direction of sunlight can be used for powering this system. If this system got spread over the world then using the data we can analyse the climatic pattern of a particular place and suggest some crops.

## VI. CONCLUSION

Hypaponics system monitors all the fields and gives the data visualization on a webpage where it contains water temperature, atmospheric temperature and humidity, pH of the water which are major factors affecting this system and takes a decision on it. The organic store also helps farmer to have a direct contact with buyers to get a better profit rate. The crops cultivated in this method are rich in nutrients and flavour. This helps the people to create their household vegetation by themself. In future we want a effective mode of using freshwater over agriculture to avoid freshwater scarcity and also should increase the food production rate 50% extra than now. This system also helps the people to avoid diseases which are caused by food using chemical fertilizers while cultivating. It also prevents the soil pollution.

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