International Journal of Scientific Research & Engineering Trends
Volume 8, Issue 2, Mar-Apr-2022, ISSN (Online): 2395-566X

Hydroponic System Monitoring by Means of Solar Energy

M. Tech. Scholar Kanduri Navya Sri, M. Tech. Scholar Megavath Shankar
Department of ECE,
JNTUH College of Engineering,
Hyderabad, India
kandurinavyasri007@gmail.com, shankarshankar738@gmail.com

Abstract- The main idea behind this project is to develop a hydroponic system monitored by using solar energy. The hydroponic system uses water with required nutrients as a medium to grow instead of soil. For the power supply to the Arduino Uno, a microcontroller to control all sensors and for collecting and displaying the data to the users, we use solar energy. Different sensors such as propylene float water level sensor, pH sensor, and temperature sensor are used to monitor the elements, which helps users in the hydroponic system. For monitoring the system, the code was implemented by using Aurdino Software [5]. The temperature, water level, and Ph are measured and collected for further analysis.

Keywords- Hydroponic, solar, Arduino Uno, ESP32 Wi-Fi +Bluetooth, Solar Charge Controller, LDR.

I. INTRODUCTION

Hydroponics [15] is a Latin word that means "working water" and is the technique to grow plants without soil. Here as the soil is not present, water with good nutrient content acts as a major thing for providing nutrients to the plant for good growth of the plant. This system provides rapid growth with good and superior quality yields.

Generally, plants exhibit some energy for consuming the nutrients in the soil through roots when they are planted in the soil. But in nutrient film, plants do not need to exhibit any energy and this energy can be used for the overall development of the plant.

Fig 1.Hydroponic Spinach Plant.

Hydroponic systems [2][6] work by controlling various environmental conditions like temperature and pH balance and best exposure to the nutrients by maintaining the exact required conditions for plant growth. The main thing needed for the setup of a hydroponics system [14] is the knowledge of nutrients and proper pH levels essential for the sprouting of plants [7].One can use suitable techniques for hydroponic systems based on required conditions. Based on the reusability of nutrient solution, hydroponics is classified as recovery or non-recovery systems. The recovery system reuses the nutrient solution by again circulating the nutrient solution whereas the non-recovery system does not reuse the nutrient solution again.

Hydroponics has six different techniques and they are Wick, Water Culture, Ebb and Flow, Drip, N.F.T (Nutrient Film Technique) and Aeroponic.

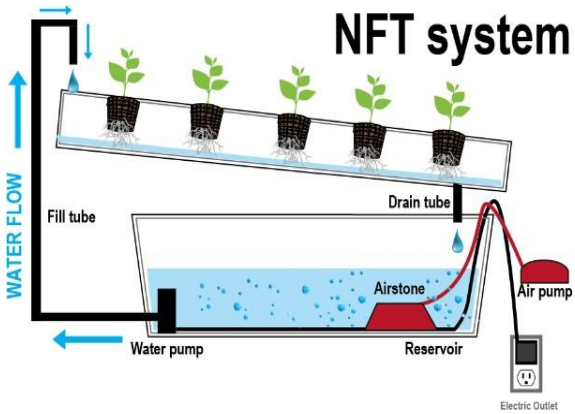


Fig 2.NFT Technique.

The Nutrient Film Technique [1] is an active recovery type hydroponic system. It consists of a constant flow of nutrient solution where the pump operates continuously. The nutrient solution is pumped into tubes by using a pump that flows over the roots of the plants and drains back into the reservoir. This process continues all over the

day. This technique is very effective and very responsive to power outages and pump failures. The roots dry out very quickly and rapidly when the flow of nutrient solution is interrupted.

II. LITERATURE REVIEW

India is the 4th largest country among the leading food-producing countries by Rahul Nalwade and Tushar Mote. Agriculture has been a part of Indian culture from the beginning of civilization. The contribution of Agriculture to the Economic growth of the country is high. Agriculture plays a vital role in economic growth compared to other grown countries.

Thus, we need an emerging technology that helps us increase food production that causes an increase in the country's economy. One such technology is to adopt new farming techniques by stepping aside traditional methods. So, it's necessary to educate the farmers to use new techniques like hydroponics that helps in getting good yield by increasing the living standards and eradicating poverty. The main of this project is to implement hydroponics using automation that reduces labour and improves the way of growing.

IOT has been the most influencing thing these days by Somchoke Ruengittinum and Sitthidech Phongsamsuan. One such example is Thailand which is trying to apply IOT in day-to-day activities. The main of the IOT is to reduce human interactions and automate things that require no labour. Hydroponics has been a new and impressive method that acts as a remedy to changing weather conditions. The main advantage of this system is that we can grow a range of crops that cannot be grown up using traditional methods.

This paper gives information on controlling different parameters like Nutrients, Temperature, Humidity, pH and electrical conductivity. The project aims to provide sufficient information to the farmers to start up with an initial setup of a hydroponic plant. The concept of IOT is used to control and monitor different parameters through an android application and to alert the users during abnormal functioning of the farm.

The advancements in technology with the combination of science has resulted in some brilliant ideas that would improve the way of agricultural practices, according to a study by P Sihombing, N A Karina, J T Tarigan and M I Syarif. In this paper, they have developed a control tool that could automatically control the flow of nutrients by using a smartphone. Arduino Uno microcontroller is used as the base of hardware part and also it can be programmed.
Various parameters like Fluid Level, Temperature and Humidity are continuously monitored using a smartphone. The temperature is measured by using an LM35 temperature sensor. The readings from the sensors are displayed on an LCD that helps the farmer control different parameters from remote areas. The main limitation is that it requires good internet speed. If internet speed is good, the controlling and monitoring happen without lags.

1. Motivation for research:
NFT hydroponics system makes a simple person grow plants with an automated system where the user can reduce the risk of lengthy setup and daily maintenance. This system helps maintain all the basic regular checks like temperature, pH levels, nutrients and water content required. It also notifies the user regarding the problems and stores data for assessment.

2. Goal of Research:
- Powered by Solar
- Low maintenance
- Ability to grow plants by hydroponics using an automated system
- Wireless alerts and update to mobile

3. Objective:
- Designing of system for conversion of solar energy to electrical energy
- To provide updates to the user using Wi-Fi module to smartphones
- To control Temperature and Humidity and regular monitorization
- Checking the pH levels of the water suitable for plant growth
- For maintaining the light intensity required

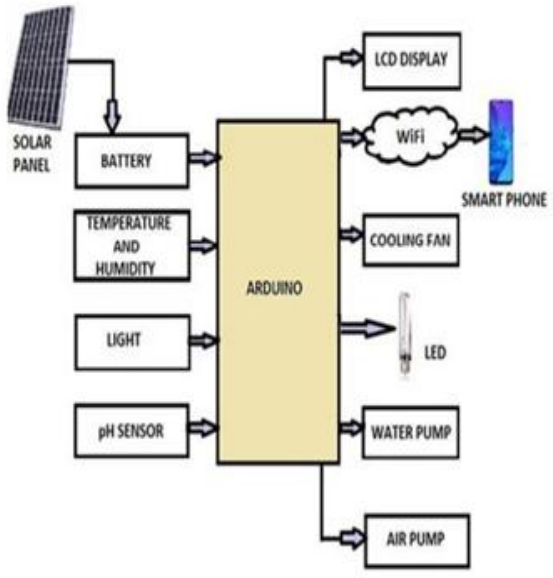


Fig 3. Block Diagram

4. Problem Statement:
The benefits of this system are that it is free from soil diseases and the crops are very consistent with faster

growth and good quality. It can be raised in any season and is inorganic and ionic form. Hydroponics is most efficient and eco-friendly than conventional farming.

III. METHODOLOGY

1. Objective 1: Designing of system for conversion of solar energy to electrical energy:
Solar panels [9] produce electricity to power up various types of equipment like fans, pumps, or light. In this model, solar panels are used to generate 8W of power to develop a 3 X 3 hydroponic system.

1.1 Working of solar panels in electricity generation:
Solar panels [8] consist of many small photovoltaic cells. Photovoltaic means the conversion of solar energy into electricity. These cells consist of semi-conductive material that conducts electricity by maintaining the electric imbalance required to create an electric field.

When sunlight falls on the semiconductor in a solar PV cell [4] the photons from light are absorbed by losing some electrons that are drifted freely in the cell. A solar cell consists of positively and negatively charged semiconductors to produce an electric field. This electric field forces the electrons to flow in one direction towards conductive metal. The flow is known as electric current where strength determines the amount of electricity produced by each cell.

High voltage damages the equipment if we connect directly. Here the 19 Volts generated solar power [12][13] damages the equipment. So, we use Solar Charge Controller or DC-DC Converter.

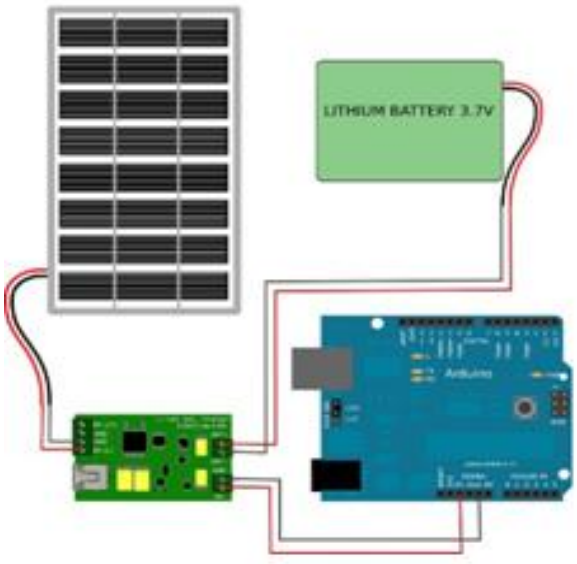


Fig 4. Solar power for Arduino board

Solar Charge Controller converts the solar panel output to 12 Volts and is used for energy transfer between battery and system based on different day conditions for continuous running of the equipment. A battery attachment is required for the proper functioning of the solar charge controller.

The board established a charger for Li-ion batteries and a DC-DC converter to supply the 5V. The Squid Bee mote includes three different inputs: 1. A couple of pin connectors for more than 6V cells, 2. A couple of pin connectors for up to 6V cells and 3. a mini-USB connector. The first connection goes through a voltage regulator to limit the output to prevent the charger from any damage caused by high voltage, and the last two links go directly to the battery charger. When it is impossible to attach a solar cell, we use a mini-USB connector to charge the battery.

To energize the battery, we use the MAX1555 charger from Maxim that operates to inputs ranging from one that bares voltages from 3.7V to 7.0V that charges the battery from a DC source and other bares voltages from 3.7V to 6.0V to carry charge from the USB. The MAX1555 provides a typical current of 280mA and a voltage of about 4.2V to the battery.

2. Objective 2: To provide updates to the user using Wi- Fi module to smartphones:
Here we use the ESP32 microcontroller that is the advanced version of ESP8266. It is a dual core 160MHz to 240MHz CPU that adds an extra CPU core, faster Wi-Fi, more GPIs. The main feature is that it comes with Bluetooth 4.2 and Bluetooth low energy, where the data transmits through a server. The reliability and hi-tech security are the unique features of ESP32.

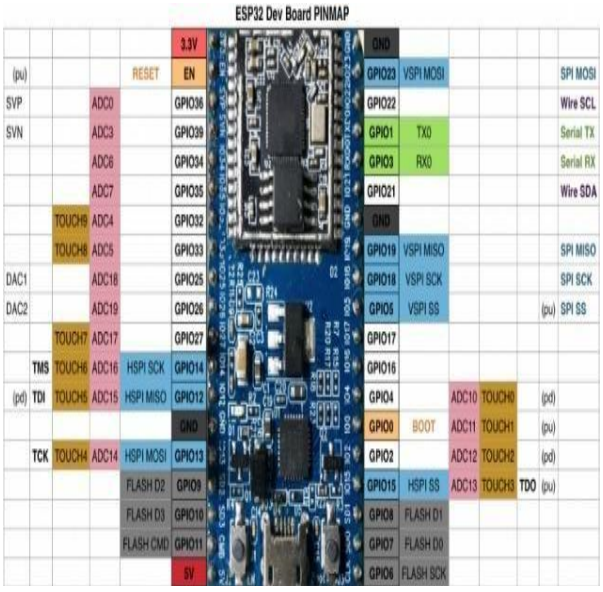


Fig 5. ESP32 Wi-Fi + Bluetooth with 36 pins.

With ESP32, we can control different types of AC and DC loads and monitor different types of analog and digital

sensors over a long-range using Wi-Fi or short-range using ESP32 built- in low energy Bluetooth module.

ESP32 Wi-Fi + Bluetooth Module is a 3.3V compatible controller board. To, connect a 5V sensor with any IO pins, bidirectional voltage conversion is used. There are two types of ESP32 boards, i.e., 36 pin version and 30 pin version. The 36-pin version of the ESP32 WIFI + Bluetooth module is bigger with a connector to connect a small 3.3V Lipo battery. Both the modules are provided with micro-USB ports.

There are so many ways to communicate between ESP32 and Arduino Uno [3]. ESP32 supports SPI, I2C and serial communication. Here both the Arduino and ESP32 supports serial communication i.e., UART (Universal Asynchronous Reception and Transmission). We use two pins i.e., Tx and Rx for the serial communication and this mode of communication are called Hardware serial communication. The Tx of Arduino connected to Rx of ESP32 and Rx of Arduino to the Tx of ESP32. To send data, we use Serial. println (). To read the data, we use Serial.readstringuntil('\r').

One can also use Digital GPIos pins for serial communication where one need to define 2 Digital pins as Tx and Rx in both micro-controllers. This mode is called as software serial mode of communication. For software serial communication, we use SoftwareSerial.h.

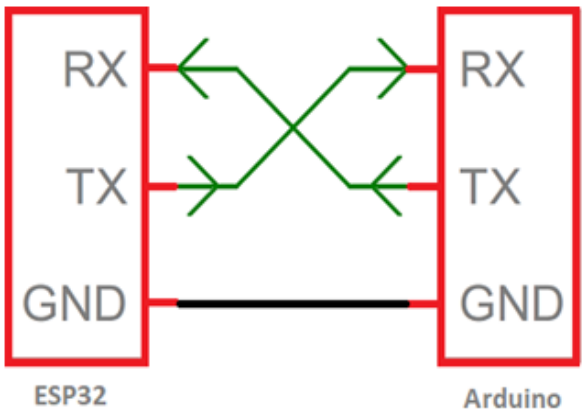
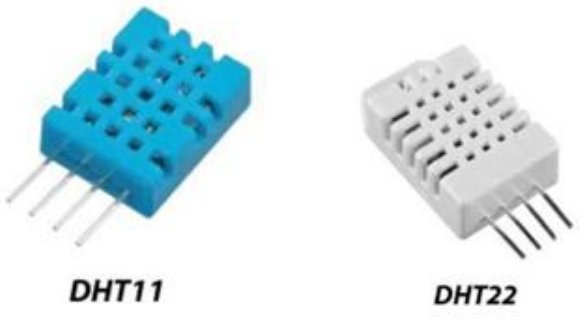


Fig 6. Connection between ESP32 and Arduino Uno Block Diagram.

3. Objective 3: To control Temperature and Humidity and regular monitorization:

Fluctuating temperature and humidity play a vital role in plant growth. If both parameters are high, the plants cannot transpire. Thus, it harms their growth. Once the roots have matured, they adapt to a higher humidity range. Hence it is mandatory to maintain temperature and humidity [10].



0 - 50°C / ± 2°C	Temperature Range	-40 - 125 °C / ± 0.5 °C
20 - 80% / ± 5%	Humidity Range	0 - 100 % / ± 2-5%
1Hz (one reading every second)	Sampling Rate	0.5 Hz (one reading every two seconds)
15.5mm x 12mm x 5.5mm	Body Size	15.1mm x 25mm x 7.7mm
3 - 5V	Operating Voltage	3 - 5V
2.5mA	Max Current During Measuring	2.5mA

Fig 7. Comparison of DHT11 and DHT22.

There are different sensors for measuring temperature and humidity. Mostly the DHT11 or the DHT22 sensors are used. The DHT22 is the more expensive version with better specifications when compared with DHT11. The sampling rate for DHt11 is 1Hz, for 0.5Hz for DHT22.

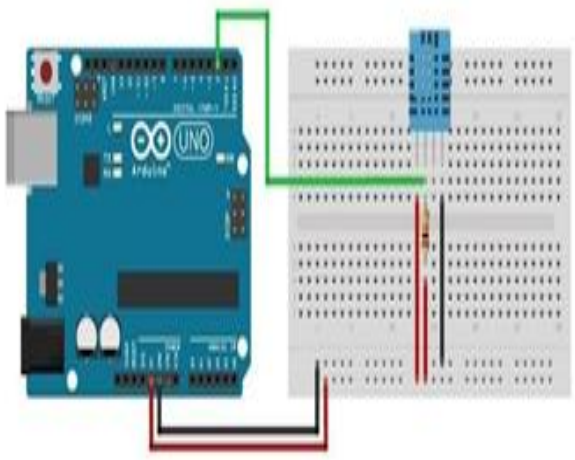


Fig 8. Connection of DHT11 to Arduino Uno

Around 18 to 32 degrees Celsius and 50% of humidity is essential for the spinach plant. Hence, we set 32 degrees Celsius as the threshold and the humidity threshold set to 50%. If the temperature is beyond 32 degrees Celsius, the fan turns ON. If the humidity level is beyond 50% pump turns ON.

4. Objective 4: Checking the pH levels of the water suitable for plant growth:

Control of pH is required not only in hydroponics but also in soil. When the pH differs, the plants lose the ability to absorb the nutrients and they have a particular pH that is optimal for their growth. Generally, most plants prefer a slightly acid growing environment with an ideal pH level between 5.5 and 7. Changing the pH levels too quickly is not a good idea. The pH scale ranges from 0 - 14, where 7 is neutral,0-6 is acidic and 8-14 is alkaline.

The required pH levels for growing spinach are 5.8-6.6. Phosphoric acid with a concentration of 81% was added to a reservoir containing water as a pH lowering buffer. After Stabilization, phosphoric hydroxide with a concentration of 50% that acts as a pH increasing buffer is added and later nutrient solution is added.

Fig 9. pH(SEN0161) sensor.

With the help of a motor, water stimulates through the pipe where the plant's roots are submerged. The pH sensor is placed in water containing pH and nutrient solution connected to an analog input of Arduino. ph sensor that senses the pH range continuously. Arduino, send the message to the owner showing the pH range and potassium hydroxide is added to raise the pH when the pH range is less (i.e., less than 5.8). When the pH is more (i.e., more than 6.6) phosphoric acid is added to lower the pH range and then later the nutrient solution is added.

5. Nutrient Solution:

The factors that play a significant role in plant growth and development are Nutrients. The nutrient solutions are composed of macro-nutrients and micro-nutrients shown in the table given below.

Light is an essential factor in plant growth. The plant growth rate and the lifetime of a plant depend on the amount of light received. Light energy is used in photosynthesis, the basic metabolic process in plants. In photosynthesis, light energy is used to convert carbon dioxide and water into sugar. There are three areas to consider while determining the effect of light on plant growth. They are intensity, duration and quality. Light intensity [11] influences the manufacture of plant food, stem length, leaf color and flowering. The plants grown in low light tends to have light green leaves. The plants grown in bright light tends to be shorter with better branches and have large, dark green leaves.

Table 1. Components of Nutrient Solution Objective 5: For maintaining the light intensity required.

Macro-nutrients		Micro-nutrients	
Nitrogen (N)	125pm	Iron (Fe)	0.94pm
Phosphorous (P)	31ppm	Manganese (Mn)	0.14pm
Potassium (K)	215pm	Boron (B)	0.16pm
Calcium (Ca)	84ppm	Copper (Cu)	0.03pm
Magnesium(M)	24ppm	Zinc (Zn)	0.13pm
Sulphur(S)	35ppm	Molybdenu m (Mo)	0.03pm

Plants can be classified according to the light energy required, such as high, medium and low light requirements. The light intensity received by an indoor plant depends on the nearness of the light source to the plant.Light intensity rapidly decreases as the distance from the light source increases.

A light-dependent resistor (LDR) or photoresistor or photocell is a light-controlled variable resistor. The resistance changes gradually when the light intensity falls due to the change in sensitivity with the wavelength of light incident on it. They are made of semiconductor materials having high resistance.

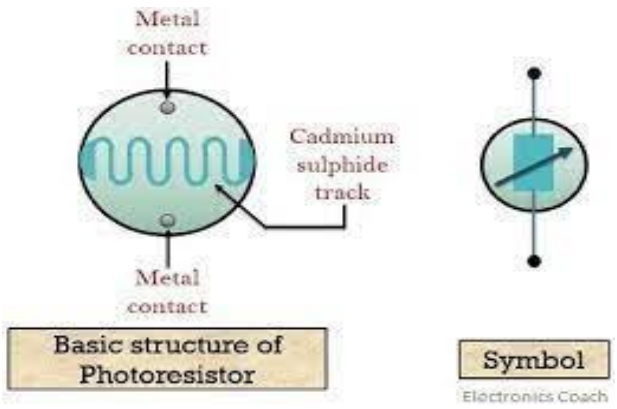


Fig 10. Basic structure of LDR.

LDR is designed to provide the maximum possible contact area with two metal films. The principle involved in the working of LDR is photo Conductivity which states that when photons fall on the materials, the electrons in the valence bond are excited to the conduction band. So, photons must have energy higher than the bandgap of the semiconductor material. As the light falls on LDR, its

resistance decreases and when it is kept in the dark its resistance is high, then the transistor turns on and led glows. LDR sensors are non-linear, light-sensitive and don't produce any electrical energy. The intensity of the light and the current increase if a constant voltage is applied.

We give a 5v power supply to the circuit. When the light falls on the LDR sensor, the resistance decreases, current flow increases by turning on the transistor and signal is given to the Arduino as input at pin 8 and we receive the output through pin 9. The flow of current from pin 9 get cancelled with the 5v power supply that is already present and led doesn't glow. When the light does not fall the LDR, output from pin 9 is zero as we don't have any input here and the led blub glow with the 5v power present.

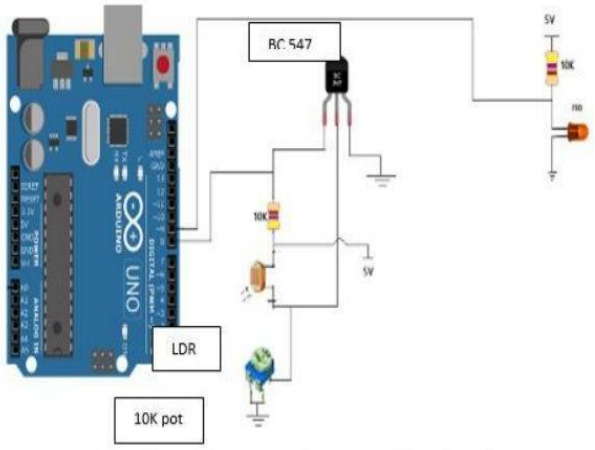


Fig 11. LDR connection to Arduino board.

6. Advantages:

6.1 Soilless Cultivation: We can grow crops without depending on the land and in places where land is limited. Hydroponics is considered a future farming technique to grow food in space for astronauts.

6.2 Space and Location Usage: Plant roots usually expand in search of oxygen and food in the soil. In Hydroponics, the roots are sunk in a yank full of oxygenated nutrient solution and directly contact with vital minerals. This makes the best usability of the present space to grow more plants and more space savings.

6.3 Climate Control: In Hydroponics, one can control the climate, temperature, humidity and light intensification. We can grow foods all year regardless of the season. Farmers can maximise their business by using this.

6.4 Water Saving Technique: In Hydroponics, only 10% of water compared to field-grown ones is utilized. Here water is recirculated. Plants take the necessary water and the remaining water that runs off will be captured and returned to the system.

6.5 Best Usage of Nutrients: Nutrients are essential for plant growth. We can have 100% control of nutrients needed by plants. They are conserved in the tank, so there are no losses of nutrients when compared to soil.

6.6 Better Growth Rate: Plants are placed in ideal conditions by providing enough nutrients that come into direct contact with root systems. There will be no loss of energy for plants in search of diluted nutrients in the soil

7. Disadvantages:

7.1 System Failure Threats: Here electricity is used to manage the whole system. So, preliminary action needed to be taken to avoid the stoppage of the system that results in plant death in several hours.

7.2 Initial Expenses: For purchasing of types of equipment like containers, lights, a pump, a timer and nutrients more money is needed. Once the system set-up is done, the cost reduces to nutrients and electricity.

IV. RESULTS AND DISCUSSION

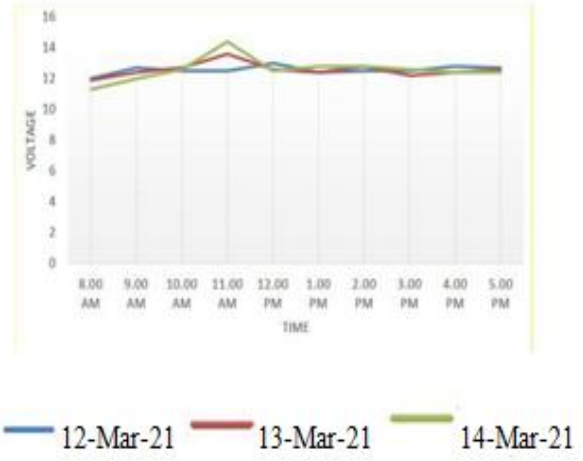


Fig 12. Graph of Voltage charging the battery.

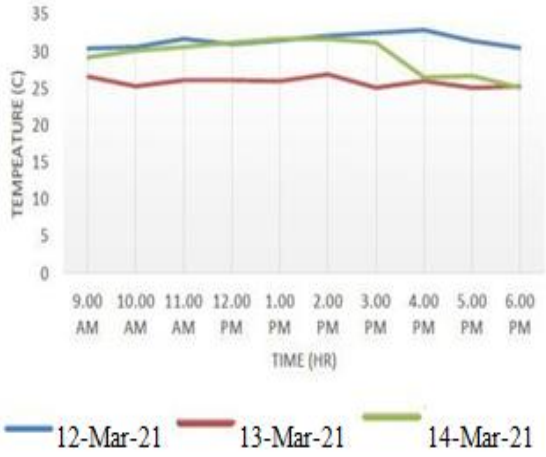


Fig 13. Graph of temperature for three days.

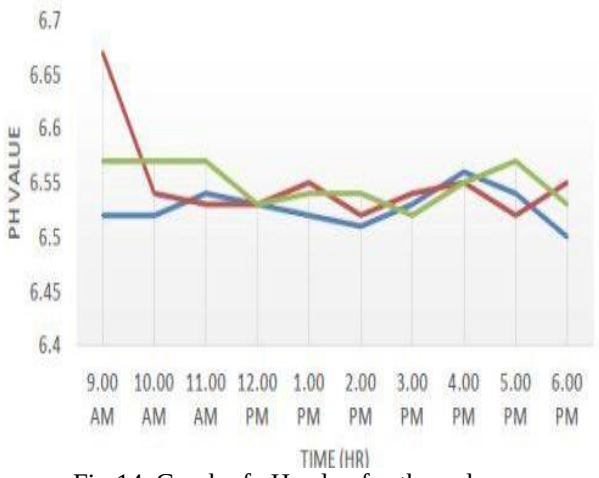


Fig 14. Graph of pH value for three days.

The results for the hydroponics monitoring system consisting of temperature, water level and pH sensor has recorded in the environment. The testing was done for three days on 12th March, 13th March and 14th March 2021 from 9.00 am to 6.00 am and data was recorded once in an hour. Based on the result, the value of temperature for three days ranges from 25 degrees Celsius to 33 degrees Celsius and the value of pH of water ranges from 6.5 to 6.57 is neutral and suitable for vegetables.

V. CONCLUSION

Solar based hydroponics monitoring system using Arduino is used to control and monitor the plant's growth. Here we use solar panels for power supply and Wi-Fi + Bluetooth module for communication purposes. This system detects and controls the different climatic conditions such as temperature, humidity, pH level and light by using different types of sensors.

It also uses less water and requires no usage of fertilizers. It provides a better yield when compared to the soil system. These sensors send results to the Arduino Uno microcontroller and an android smartphone.

ACKNOWLEDGEMENT

We would like to thank JNTUH College of Engineering, Hyderabad for motivating us to do research and development works. We are thankful to the faculty members of ECE department for support.

REFERENCES

[1] Helmy, "Nutrient film technique (NFT) hydroponics monitoring system" Journal of Applied Information and Communication Technologies, Volume 1, No. 1, 2016.
[2] Nisha Sharma, "Hydroponics as an advanced technique for vegetable production" Journal of Soil and Water Conservation, Volume 17, Issue 4, October-December 2018.
[3] P Sihombing, "Automated hydroponics nutrition plants systems using Arduino uno Microcontroller based on android," International Journal for Research in Applied Science and Engineering Technology, Volume 4, 2017.
[4] Simon Siregar, "Automation system hydroponics using smart solar plant unit," Journal of Applied Science, Jan. 2016.
[5] Kunyanuth Kularbphettong, "An automated hydroponics system based on mobile application," International Journal of Information and Education Technology, Volume 9, No. 8, August 2019.
[6] David R. Hershey, "Solution culture Hydroponics: History & inexpensive equipment" IJRASET, Volume 56, No.2, 2017.rg
[7] Nisha Sharma, "Hydroponics as an advanced technique for vegetable production," ISEC, Volume 10, 2017.
[8] Mohd Rizwan, "A review paper on electricity generation from solar energy", International Journal for Applied Science and Engineering Techonolgy, Volume 5, Issue 9, 2017.
[9] Sai Manoj Rompicherla, "Solar energy: The future," IJETT, Volume 4, Issue 6, June 2016.
[10] Jay P. Sipani, "Temperature and humidity monitoring and control system based on Arduino and SIM900A GSM shield," International Journal of Electrical, Electronics and Data Communication, Volume 5, Issue 11, Nov. 2017.
[11] Justin Shaw, "LED colour temperature and its effect on the growth of Hydroponic lettuce seedlings," The Young Researcher, Volume 2, No 1, 2018.
[12] E. Kabir, P. Kumar, S. Kumar, A. A. Adelodun, and K. H. Kim, "Solar energy: Potential and future prospects," Renew. Sustain. Energy Rev., vol. 82, no. September, pp. 894–900, 2018
[13] S. Mekhilef, S. Z. Faramarzi, R. Saidur, and Z. Salam, "The application of solar technologies for sustainable development of agricultural sector," Renew. Sustain. Energy Rev., vol. 18, pp. 583–594, 2013
[14] Zeidler, C., Schubert, D. and Vrakking, V. (2017) Vertical Farm 2.0: Designing an Economically Feasible Vertical Farm—A Combined European Endeavor for Sustainable Urban Agriculture. https://www.researchgate.net/publication/3214
[15] Sharma, N., Acharya, S., Kumar, K., Singh, N. and Chaurasia, O.P. (2019) Hydroponics as an Advanced Technique for Vegetable Production: An Overview. Journal of Soil and Water Conservation, 17,364-371. https://www.researchgate.net/publication/330080392