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Aeroponics- A step towards sustainable farming

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ABSTRACT

Aeroponic is a type of vertical farming. It is actually a process which means the cultivation of plants without the use of soil or minimal use of soil. In this method, the roots of the plant are suspended in the air and nutrients are sprayed in the nutrient chamber. This process can be done in both ways whether it be a semi-closed environment or closed environment. The circumstance is controlled and it requires a lot of care with respect to temperature, humidity, pH etc. In recent years, the Aeroponic system has been used mostly to have a pesticides free cultivation. Prediction says that in coming years Aeroponic will increase the yield and also the quality of crops grown. The set up for Aeroponic includes a proper monitoring and control system for water and nutrients distribution for utilizing the Aeroponic cultivation at its best. The monitoring system monitors the chamber's parameters such as temperature & humidity whereas control system manages actuators in delivering water and nutrients. LCD will display the details of temperature and humidity and the data will be transmitted to the computer to facilitate easier monitoring. The microcontroller will help in the automation of the regulation of actuators for the distribution of water and nutrients.

Keywords: *Aeroponic, Monitoring system, Control system, Sensor.*

1. INTRODUCTION

Aeroponics is an alternative for people with limited spaces to grow plants. It is a soilless agriculture technique and it is very similar to hydroponics. Hydroponics only uses water for the growth of plants. Whereas, in aeroponic technique plants are grown without any rooting medium. The plant roots are not supported by any soil or water. Roots are suspended in a dark chamber. Water which is rich in nutrient is sprayed on to the roots at constant intervals.

Sprinkler system is used by the Aeroponics for spraying oxygen and nutrient-rich solution on the plant roots. It contains growing chamber with a lid. Roots of the plants are suspended inside the dark chamber. There is a programmable cyclic timer which is used to trigger the high-pressure aeroponic pump to go on. It also sprays the nutrient solution from the nutrient reservoir as a fine mist in the rooting chamber. Developed root hairs help in absorbing nutrients from the moisture. There is an increment in the level of oxygen as the chamber is filled with oxygen-rich nutrient solution mist. Since the spray particles are small in size, there is negligible wastage of nutrient solution. And with an ample amount of oxygen supply, root rot is completely avoided.

Types of Aeroponics:

a. Low-pressure Units

In most of the low-pressure aeroponic gardens, roots of the plant are suspended above a reservoir of nutrient solution or a channel which is inside and is connected to a reservoir.

The nutrient solution is delivered by a low-pressure pump through jets or by ultrasonic transducers, which drips or drains the nutrients back into the reservoir. When plants grow to maturity, then the units suffer from dry sections of the root systems and thus adequate nutrient uptake is avoided. These types of units lack features to purify the nutrient solution, removal of debris and unwanted pathogens because of cost. These units are usually suitable for bench top growing. And it is also used for the demonstration of principles of aeroponics.

b. High-pressure Devices

In high-pressure aeroponic devices, mist is created by high-pressure pump(s). And it is generally used in the cultivation of high value crops. This method includes technologies for air and water purification, nutrient sterilization, low-mass polymers and pressurized nutrient delivery systems.

c. Commercial System

The commercial system has high-pressure device hardware and biological systems. Enhancements for extended plant life and crop maturation is included in the biological systems matrix.

2. EXISTING METHODS

Conventional farming techniques can bring us fruits and vegetables only seasonally also due to the usage of hybrid and dangerous methods they adversely affect our health. These large-scale systems have the main motive to overproduce for the masses that is food with less quality at higher quantities are produced. The soil on these large-scale farms suffers tremendously due to the extensive use of pesticides, fertilizers and external energy inputs. A lot of labor is required to seed, plant and pick from the fields. With water being depleted, conventional farming systems overuse surface and groundwater for irrigation and growth

3. WHY AEROPONICS?

- Less usage of energy and water than traditional agriculture.
- Maintenance requirement is less as air is used as the medium to grow plants.
- Quick and disease-free plants are obtained as the roots of the plants are exposed to air and they can easily absorb the required oxygen level. However, the roots can also be sterilized by using mist on the roots to further prevent the plant diseases.
- 100% safe and environment-friendly. They conserve water and reduces the amount of human labor involved.
- A much faster method than any other conventional means.
- Easy to clean the system and replace the old plants with the new ones.

4. OBJECTIVES

- Aeroponics can be applied on a small, medium and large scale.
- Aeroponics drastically reduces the amount of water required due to the recycled water structure put in place.
- Aeroponics reduces the cost of maintenance requirements such as fertilizer, chemicals, insect fumigation, soil, staff and more.
- Eliminate seasonal dependency due to the controlled climate within the green house. This increases profit due to lack of certain vegetable availability in the market within certain seasons.
- Increase speed of plant growth which increases the frequency of harvest as well as profit. (Growth increases between 45% and 70% in certain cases).
- Eliminate waste of vegetables during harvest caused by pathogens (algae and mold).
- Make farming easier to manage.

5. METHODOLOGY

- In our project, we implemented a smart vertical farm module in which various sensors and controllers were used to sense and control the major factors that affect the crop yield.
- We have implemented a vertical farm module based on aeroponics technology that is a soilless farming method.
- An aluminum frame of dimension 20*15*30 cm was constructed which is covered by glass on the front to give transparency.
- Inside this frame, three layers of PVC pipes were stacked horizontally to form vertical layers.
- Holes of fixed diameter were drilled at equidistant points on each pipe row where the plants are to be placed.
- The pipes were connected using solenoid valves to regulate the water flow between the pipes.
- On top of the frame, a central water tank was placed and a hole was made at its bottom to allow flow from tank to the below PVC pipe layer.
- Two separate tanks of smaller capacity compared to the main tank were placed on either side of the main tank that stores alkaline and acidic solutions.
- LED strips of blue and red light were pasted on side walls of the frame to produce a pink light which is absorbed by the plant during photosynthesis.
- On top surface, two holes were drilled to place an exhaust fan and a bulb respectively.

5.1 Architecture of Aeroponic model

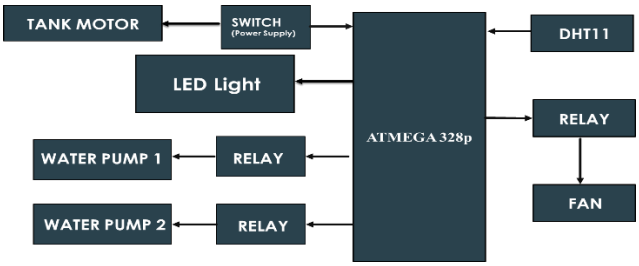

Fig: Block diagram of Aeroponic model

Block diagram of the aeroponic model is shown in the figure above. Microcontroller ATmega328p works as the soul of the model. It connects as well as controls all the other components. ATmega328 is a single chip microcontroller. It is a product of Atmel. A most common version of ATmega328 is "picoPower" ATmega328p, commonly used in projects and autonomous system.

It is a low-powered and low-cost microcontroller. Pin diagram of ATmega328p is shown below.

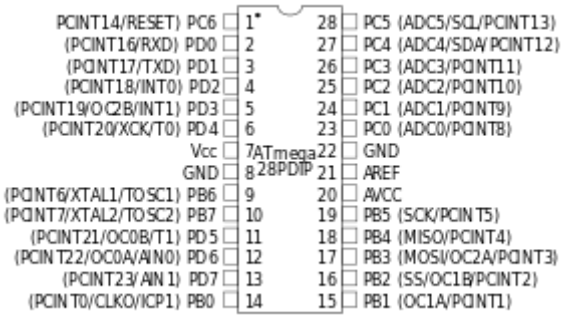

Fig: Pin diagram of ATmega328p

It is a RISC based microcontroller which has 32KB flash memory. It can read while writing. The other technical details of ATmega328p is given in the table below.

Program Memory Type	Flash
Program Memory Size (KB)	32
CPU Speed (MIPS/DMIPS)	20
SRAM Bytes	2,048
Data EEPROM/HEF (bytes)	1024
Digital Communication Periphe...	1-UART, 2-SPI, 1-I2C
Capture/Compare/PWM Periph...	1 Input Capture, 1 CCP, 6
Timers	2 x 8-bit, 1 x 16-bit
Number of Comparators	1
Temperature Range (C)	-40 to 85
Operating Voltage Range (V)	1.8 to 5.5
Pin Count	32
Low Power	Yes

5.2 Working of Aeroponic Model

The main hardware components are shown clearly in the block diagram.

ATmega328p microcontroller is used in the proposed model. The input to the microcontroller is the DHT sensor. It is a basic temperature and humidity sensor. It is a low-cost sensor and the input power of this sensor ranges between 3V and 5V. It uses a capacitive humidity sensor with a thermistor to measure the air surrounding it and then gives a digital signal on the data pin. It comes with a 10K or 4.7K resistors which are used as pull-up resistor from the data pin to VCC. It is interfaced with Arduino and instantaneous results can be obtained.

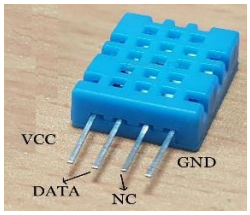

Fig: DHT11 sensor with pin details

The microcontroller is connected to three relays as shown in the block diagram. The first relay is connected to a fan. The fan helps in moderating the temperature inside the frame. The other two relays connected to the microcontroller help in controlling the water pumps. Water pumps sprinkle the nutrients which are mixed with the water to the suspended roots of the plant and thus creates a misty environment. The relay is an electromagnetic switch. It is operated by a very small electric current. It has the capability to switch on or off a large electric current. The picture of SRD relay used here is shown below.

Fig: SRD Relay

The working of the aeroponic model can be studied in more detail by the flow diagram given below.

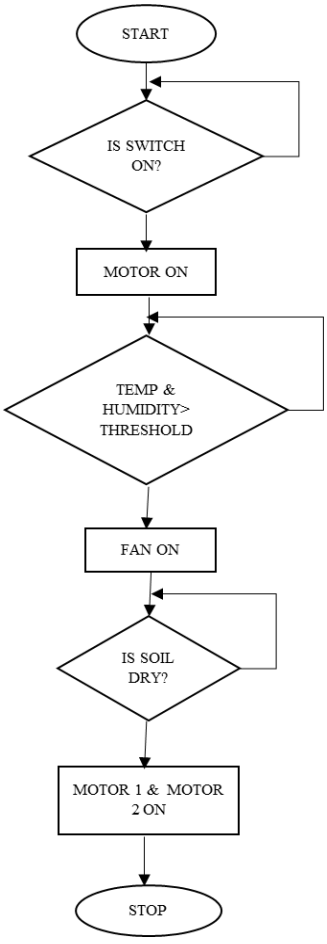

Fig: Flow diagram of the working of the aeroponic model

Based on the flow diagram a simple code is provided to control the temperature and humidity inside the frame. It can also be modified accordingly. Every plant has its unique requirements in terms of temperature, light, humidity, and nutrients. This code can be modified and thus provides the required atmospheric condition to the respective plant.

```
#include <LiquidCrystal.h>
   #include "DHT.h"
       #define DHTPIN 10
   #define DHTTYPE DHT22
   #define fan 11
       int maxHum = 60;
       int maxTemp = 40;
       DHT dht(DHTPIN, DHTTYPE);
LiquidCrystallcd(2,3,4,5,6,7);
       int water_pump1=8;
       int water_pump2=9;
       int count;
void setup()
{
  Serial.begin(9600);
  pinMode(water_pump1, OUTPUT);
  pinMode(water_pump2, OUTPUT);
  lcd.begin(16, 2);
 lcd.setCursor(3, 0);
 lcd.print("abcd");
 //delay(1000);
  dht.begin();
}
void loop()
{
delay(2000);
 float h = dht.readHumidity();
  float t = dht.readTemperature();
digitalWrite(water_pump1, HIGH);
 digitalWrite(water_pump2, HIGH);
if(h >maxHum || t >maxTemp) {
        digitalWrite(fan, HIGH);
     } else
 {
       digitalWrite(fan, LOW);
     }
lcd.clear();
```



```
lcd.setCursor(0, 0);
 lcd.print("Humidity:");
 lcd.setCursor(10, 0);
 lcd.print(h);
 lcd.setCursor(0, 1);
 lcd.print("Temperature:");
 lcd.setCursor(10, 1);
 lcd.print(t);


Serial.print("Humidity: ");
  Serial.print(h);
  Serial.print(" %\t");
  Serial.print("Temperature: ");
  Serial.print(t);
  Serial.println(" *C ");
  }
```

6. HARDWARE AND SOFTWARE COMPONENTS

Hardware:

1) 12 Volt Regulated Power Supply (7805)

2) MagLev Motor Fan

3) DHT11 Humidity & Temperature Sensor

4) LCD Display -016M002B

5) 12v DC Circulation Pump 59510-0012

6) Light Dependent Resistor

7) LM35 Precision Centigrade Temperature Sensor

8) Light Emitting Diode

9) SRD Relay Module

10) BUZZER

Software:

1) Arduino IDE

7. GROWING CORIANDER USING AEROPONIC

Coriander which is also known as Cilantro or Chinese parsley is an edible plant. It is mainly used in cooking. Its dried seeds are powdered and it is a known spice. Its grown plant is used as a garnish in most of the seeds.

For the germination of seeds, it requires very little soil and once the roots start coming, then the suspended roots are provided with the required nutrients and water. The germination of coriander seeds is shown in the picture below. These are sprayed through water sprinkler placed at the bottom of the frame.

Fig1

Fig2

Fig3

Fig1: Germination of coriander seeds
The preferred atmospheric condition for coriander plant is 40-75 degree Fahrenheit.
Fig2: The coriander plant after the 2nd week is shown in the second figure. (Height- 3.5 cm)
Fig3: The coriander plant after the 3rd week is shown in the third figure. (Height- 10cm)

8. CONCLUSION

In conclusion, aeroponics is a good method to study the growth of plants in the controlled environment. For people living in urban areas, aeroponics prove to be a good alternative for gardening and organic vegetables since they have a very limited space owing to high rise buildings. Although for conventional farmers setting up of aeroponic nursery turn out to be a costly venture however it is cheaper than acquiring large plots of farm land which does not guarantee the quality of crops. On arid lands, aeroponics provides the best alternative to growing plants effectively.

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