AQUAPONICS PRECISION : -

ELEVATING SUSTAINABILITY THROUGH INTELLIGENT CONTROL SYSTEMS

VELLORE INSTITUTE OF TECHNOLOGY-*AMARAVATI*

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ABSTRACT

- Aquaponics is a sustainable farming method that combines aquaculture (raising aquatic animals) and hydroponics (cultivating plants in water) in a symbiotic environment. This project aims to develop an Arduino-based system for monitoring and controlling key parameters in an aquaponics setup, such as water temperature, pH levels, and nutrient concentrations.

- The system consists of sensors to measure these parameters and actuators to adjust them as needed to maintain optimal conditions for both fish and plants. Data collected from the sensors is processed by the Arduino microcontroller, which then triggers actions based on predefined thresholds or user-defined settings.

- The project also includes a user interface, possibly implemented using a graphical LCD or a smartphone application, allowing users to monitor the status of their aquaponics system remotely and adjust settings as necessary

- Overall, this Arduino-based aquaponics system offers an efficient and user-friendly solution for individuals or small-scale farmers interested in sustainable agriculture practices.

INDEX

INTRODUCTION

- Aquaponics represents an innovative and sustainable approach to farming that integrates aquaculture and hydroponics, offering numerous environmental and economic benefits. By creating a symbiotic ecosystem where fish waste provides nutrients for plants, and the plants filter and purify the water for the fish, aquaponics minimize waste, water usage, and chemical inputs while maximizing productivity.

- Traditionally, aquaponic systems have been managed manually, requiring constant monitoring and adjustment of various parameters to maintain optimal conditions for both fish and plants. However, advancements in technology, particularly in microcontroller platforms like Arduino, have paved the way for automated and more efficient control systems for aquaponics.

- This project focuses on developing an Arduino-based control system for aquaponics, aiming to enhance the ease of management and productivity of aquaponic setups. By incorporating sensors to monitor key parameters such as water temperature, pH levels, and nutrient concentrations, along with actuators to regulate these parameters as needed, the system aims to create a self-regulating and sustainable environment for aquaponic farming.

- In this paper, we present the design, implementation, and evaluation of the Arduino-based aquaponics control system. We discuss the hardware and software components used in the system, the integration of sensors and actuators, and the user interface for water usage, and controlling the system. Additionally, we explore the potential benefits of such a system in terms of resource efficiency, productivity, and ease of management for aquaponic farmers.

- Through this project, we aim to contribute to the advancement of aquaponics technology, making it more accessible and practical for individuals and communities interested in sustainable agriculture practices.

BACKGROUND

- Aquaponics combines principles from aquaculture (fish farming) and hydroponics (soilless plant cultivation) to create a sustainable and efficient farming **system.**
- In 1970, **James Rackoy,** involved in designing systems that produce both plants and fish.
- The concept of aquaponics dates back centuries, with early examples found in ancient civilizations such as the Aztecs and Chinese who utilized the symbiotic relationship between fish and plants to grow food in aquatic environments.
- As the days passed, people started to use Aquaponics for their regular farming activities.

PROBLEM DEFINITION

- PROBLEM STATEMENT To develop an Aquaponics system for plants and fish.

- In aquaponics, ensuring optimal growth conditions for plants and fish is crucial for maximizing productivity and maintaining system stability. However, manual monitoring and management of various parameters such as water quality, nutrient levels, and environmental conditions can be labor-intensive and prone to errors. This poses a significant challenge, particularly in large-scale aquaponic systems where the number of plants and fish is substantial.

- THE PRIMARY PROBLEM CAN BE DEFINED AS FOLLOWS: "In aquaponics systems, the manual monitoring and management of water quality, nutrient levels, and environmental conditions are labor-intensive and error-prone, particularly in large-scale setups. The challenge is to develop an automated system that can continuously monitor and regulate key parameters to optimize plant and fish growth while ensuring system stability."

OBJECTIVES

- Design and Implementation of an Aquaponics System: Describe the process of designing and setting up the aquaponics system, including the selection of components such as tanks, grow beds, pumps, and fish species.

- Integration of Arduino Microcontroller: Detail the integration of Arduino microcontroller into the aquaponics system for monitoring and control purposes.

- Sensor Integration: Discuss the selection and integration of sensors for monitoring key parameters such as water pH, temperature, dissolved oxygen levels, and nutrient concentrations.

- Automation of Monitoring and Control: Explain how the Arduino microcontroller automates the monitoring and control of the aquaponics system, including tasks such as adjusting water flow, regulating nutrient levels, and managing lighting cycles.

- Data Logging and Analysis: Outline how the system collects and logs data from sensors over time, and discuss methods for analyzing this data to optimize system performance and detect anomalies.

- Precision Farming Techniques: Explore how precision farming techniques are applied within the aquaponics system to maximize crop yield, minimize resource usage, and maintain optimal growing conditions for plants and fish.

- Remote Monitoring and Control: Investigate options for enabling remote monitoring and control of the aquaponics system, allowing users to access real-time data and make adjustments from anywhere with an internet connection.

- Energy Efficiency and Sustainability: Evaluate the energy efficiency and sustainability benefits of the aquaponics system, including comparisons to traditional farming methods and potential environmental impacts.

- Scalability and Replicability: Discuss the scalability of the aquaponics system and its potential for replication in different settings, such as home gardens, urban farms, and commercial agricultural operations.

- Educational Outreach and Community Engagement: Consider opportunities for educational outreach and community engagement initiatives centered around aquaponics, including workshops, demonstrations, and partnerships with schools or local organizations.

- Future Development and Innovation: Propose ideas for future development and innovation, such as incorporating advanced technologies like artificial intelligence or machine learning algorithms for predictive analytics and decision support.

METHODOLOGY/PROCEDURE

1. System Design and Component Selection

- **Aquaponics System Design:** The aquaponics system was designed to incorporate a symbiotic relationship between fish and plants, utilizing fish waste as nutrient-rich water for plant growth.

- **Component Selection:** Careful consideration was given to the selection of components such as tanks, grow beds, pumps, and plumbing materials to ensure compatibility, durability, and optimal system performance.

2. Arduino Microcontroller Integration

- **Microcontroller Selection:** The Arduino microcontroller platform was chosen for its versatility, ease of use, and extensive community support.

- **Hardware Setup:** The Arduino microcontroller was interfaced with sensors, actuators, and other system components using appropriate electronic interfaces and protocols.

3. Sensor Integration and Calibration

- **Sensor Selection:** Various sensors were selected to monitor key parameters including water pH, temperature, dissolved oxygen levels, and nutrient concentrations.

- **Calibration Procedures:** Each sensor was calibrated according to manufacturer specifications to ensure accurate and reliable measurements.

4. Monitoring and Control Algorithms

- **Algorithm Development:** Custom monitoring and control algorithms were developed to regulate water flow, adjust nutrient levels, and manage environmental conditions within the aquaponics system.

- **Feedback Mechanisms**: The algorithms incorporated feedback mechanisms to dynamically respond to changing conditions and optimize system performance.

5. Automation and Remote Access

- **Automation Features:** The aquaponics system was equipped with automation features to minimize manual intervention and streamline operation.

- **Remote Access:** Remote monitoring and control capabilities were implemented to enable users to access real-time data and make adjustments remotely via a web-based interface or mobile application.

6. Testing and Validation

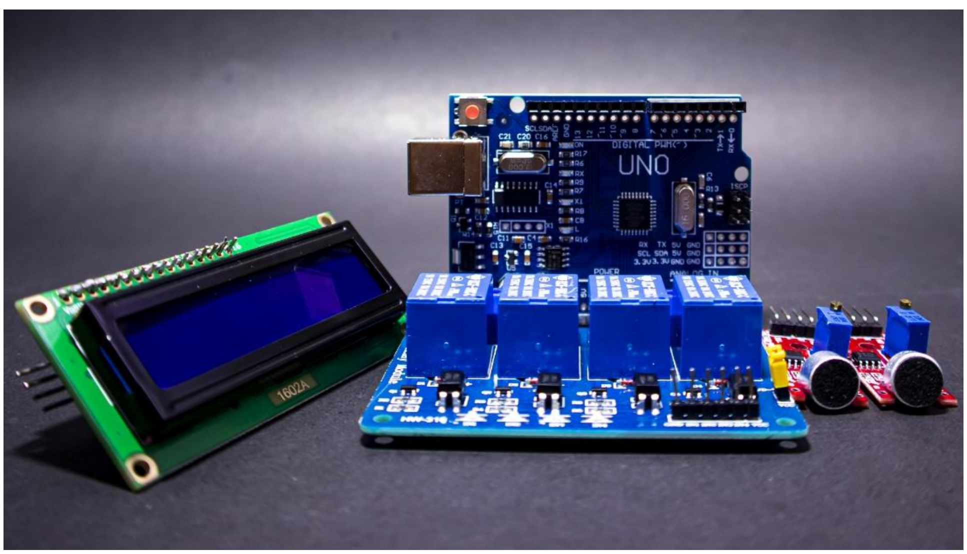
- **Performance Testing:** The system underwent rigorous performance testing under various operating conditions to validate its functionality, reliability, and efficiency.

- **Validation Criteria:** Performance metrics such as crop yield, water quality, energy consumption, and system uptime were used to assess the effectiveness of the aquaponics system.

7. Documentation and Knowledge Sharing

- **Documentation:** Comprehensive documentation was prepared, including system schematics, wiring diagrams, sensor calibration procedures, and software source code.

- **Knowledge Sharing:** Knowledge sharing initiatives, such as workshops, tutorials, and open-source contributions, were undertaken to disseminate information and foster collaboration within the aquaponics community.



Installing Dependencies for Arduino:

Arduino IDE:

- Download and install the Arduino Integrated Development Environment (IDE) from the official Arduino website.

- Visit https://www.arduino.cc/en/software to download the IDE.

Arduino Board Drivers:

- Install the necessary drivers for your Arduino board to ensure proper communication between the board and your computer depending on the board.

- Most Arduino boards, such as Arduino Uno or Arduino Nano, do not require additional drivers on most operating systems. However, for some boards like Arduino Mega, you might need to install drivers manually.

Arduino Libraries:

- Alternatively, install libraries by downloading them from the Arduino Library Manager or from GitHub and placing them in the Arduino libraries folder.

USB Cable:

- Ensure you have a compatible USB cable to connect your Arduino board to your computer.

- Most Arduino boards use a standard USB Type-A to USB Type-B or USB Type-C cable for connection.

Testing :-

Test Objective:

To verify the functionality of the water level sensor and the automated water management system in the aquaponics setup. Specifically, to ensure that:
1. When the water level drops below a certain threshold (7 in this case), the intake motor activates to bring water from an external source into the tank.
2. Regular intervals, the distribution motor activates to supply water from the tank to the plants, and the excess water drains back into the tank through the plant holders.

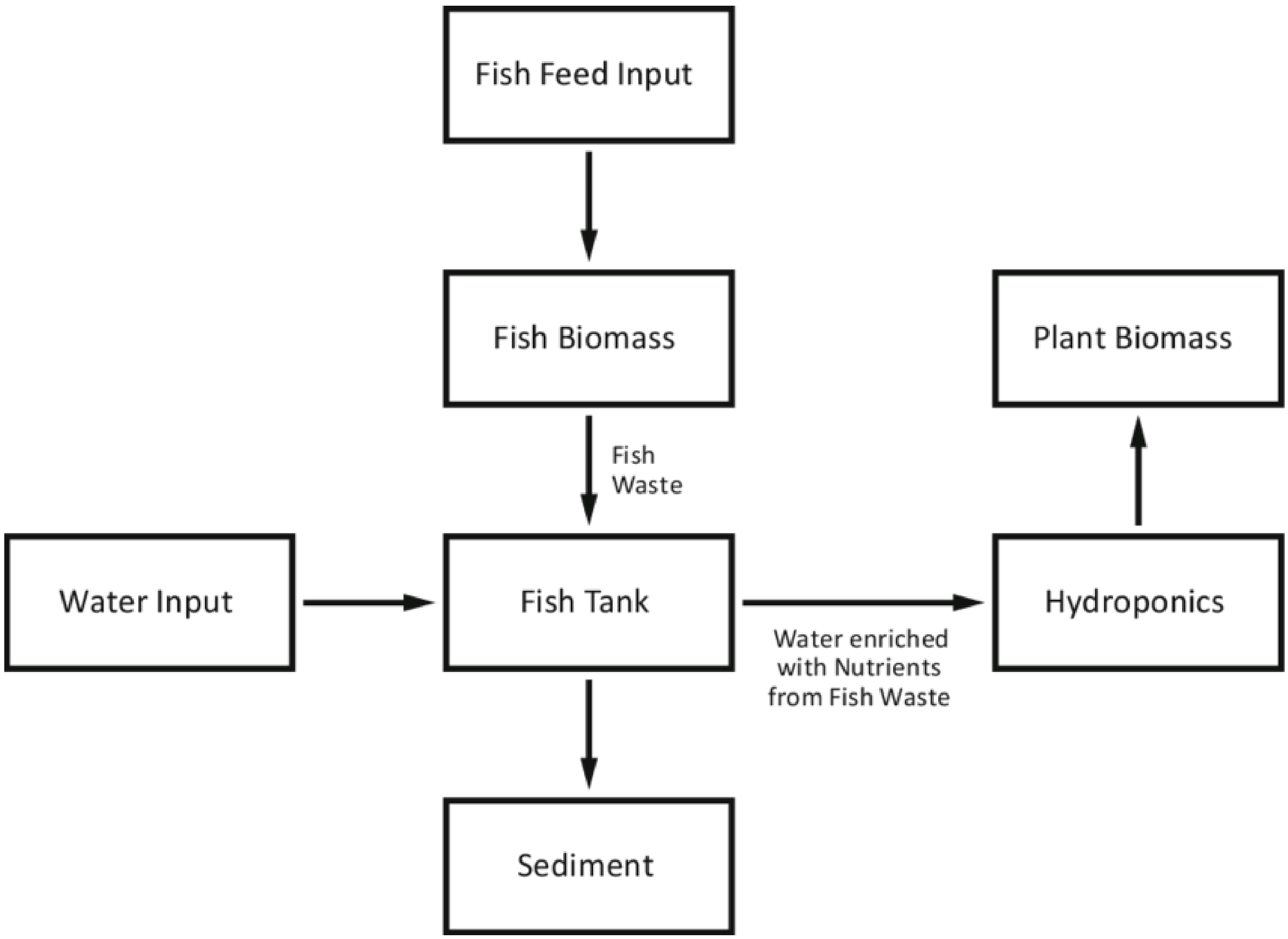
Test Setup:

1. Water level sensor installed at a suitable position inside the tank.
2. Intake motor connected to the external water source and controlled by the Arduino based on input from the water level sensor.
3. Distribution motor connected to the tank and controlled by the Arduino at regular intervals.
4. Plant holders with drain mechanisms set up to allow water flow back into the tank.

Test Results:

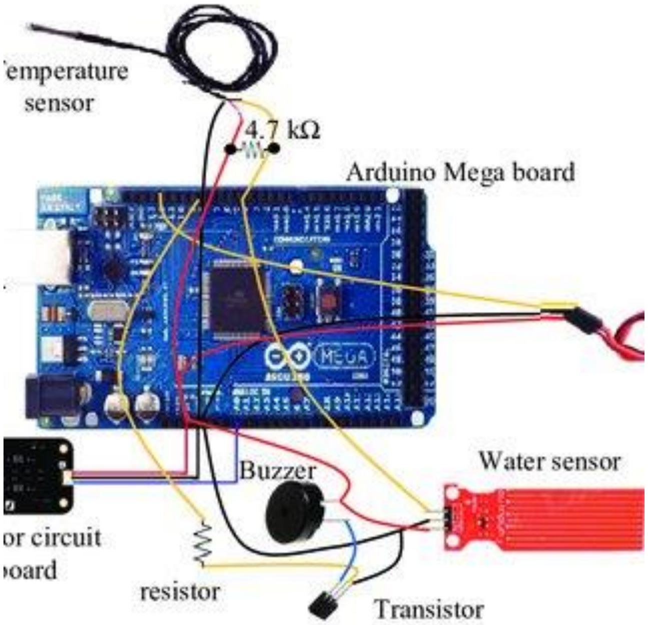
1. Water Level Sensor Activation:
   - When the water level dropped below 7, the intake motor activated promptly and started bringing water from the external source into the tank.
   - The intake motor ceased operation once the water level reached an acceptable level, preventing overflow.
2. Distribution Motor Operation:
   - At regular intervals, the distribution motor activated as expected and supplied water to the plants.
   - Excess water efficiently drained back into the tank through the plant holders, maintaining a consistent water level.
3. System Reliability:
   - Throughout the testing process, the system demonstrated consistent and reliable operation, responding appropriately to changes in water level.

Flow chart :-

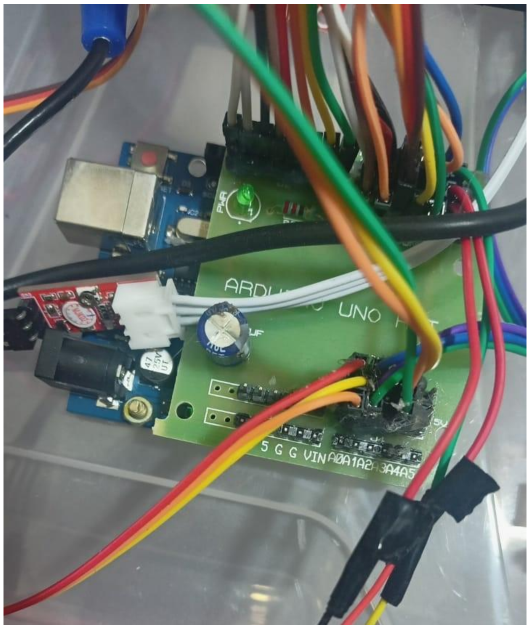


Fish Feed Input
Fish Biomass
Plant Biomass
Fish
Waste
Water Input
Fish Tank
Hydroponics
Water enriched
with Nutrients
from Fish Waste
Sediment

CIRCUIT DIAGRAM / Arduino Board :



RESULT AND DISCUSSION



CONCLUSION AND FUTURE SCOPE

- In conclusion, aquaponics presents a sustainable and efficient method for growing both fish and plants in a symbiotic environment. Despite the challenges faced, such as water quality management, disease control, and nutrient balancing, aquaponics offers numerous benefits including resource conservation, reduced environmental impact, and increased food production.

- Implementing advanced sensors, monitoring systems, and automation technologies can enhance efficiency, optimize resource utilization, and improve overall system performance.

- Continued research into optimal fish and plant species selection, nutrient management strategies, and system designs can lead to improved productivity, sustainability, and scalability of aquaponic operations.

- Increasing awareness and understanding of aquaponics through education programs, workshops, and community outreach initiatives can promote wider adoption and acceptance of this sustainable farming method.

- Expanding the commercial viability and market penetration of aquaponics products can create new opportunities for entrepreneurs, farmers, and investors, contributing to food security and economic development.

- Integrating aquaponics with urban agriculture initiatives, rooftop gardens, and indoor farming systems can help address food deserts, promote local food production, and enhance urban sustainability.

REFERENCES :-

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PROGRAMMS ELECTRONICS ACADAMY

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DRONEBOT WORKSHOP FORUMS

https://forum.dronebotworkshop.com/show-tell/arduinoponics-monitor-control-you-aquaponics-with-arduino/

MAKE:

https://makezine.com/projects/aquaponic-garden/

SETUP

https://www.instructables.com/Arduino-Based-Timer-for-Aquaponics-Pump/

PAPER JOURNAL

https://www.scribd.com/document/477972469/Smart-Aquaponics-System-Design-and-Imple

IMAGE :-

https://www.researchgate.net/figure/Example-of-a-flow-chart-in-aquaponics-only-RAS-and-HP-exchange_fig8_333936291

CODES IN APPENDIX

Aquaponics.c

```
#include <Wire.h>
#include <LiquidCrystal.h>
#include <OneWire.h>
#include <SoftwareSerial.h>
#include <Servo.h>
#include <DallasTemperature.h>
#define ONE_WIRE_BUS 2
OneWire oneWire(ONE_WIRE_BUS);
DallasTemperature sensors(&oneWire);
LiquidCrystal lcd(8,9,10,11,12,13);
const int pingPin =7; // Trigger Pin of Ultrasonic Sensor
const int echoPin =6; // Echo Pin of Ultrasonic Sensor
long duration;
int distance;
//SoftwareSerial mySerial(10,11);
const int bz=A4;
int kk=0;
Servo feed;
int ts=A0;
int ps=A1;
int is=A3;
int mp1=3;
int mp2=4;
void setup() {

   Wire.begin();
   Serial.begin(9600);
   pinMode(pingPin, OUTPUT);
pinMode(echoPin, INPUT);
  // mySerial.begin(115200);
   sensors.begin();
   lcd.begin(16, 2);
   lcd.setCursor(0,0);
   lcd.print("AQUA MNTRNG");
   feed.attach(5);
   pinMode(mp1,OUTPUT);
   pinMode(mp2,OUTPUT);
   pinMode(bz,OUTPUT);
  //  wifi_init();
   feed.write(0);
   digitalWrite(bz,0);
   digitalWrite(mp1,0);
   digitalWrite(mp2,0);
   pinMode(ts,INPUT);
   pinMode(ps,INPUT);
   pinMode(is,INPUT);
   delay(2000);
}
```

```
void loop() {
  digitalWrite(pingPin, LOW);
delayMicroseconds(2);
digitalWrite(pingPin, HIGH);
delayMicroseconds(10);
digitalWrite(pingPin, LOW);
duration = pulseIn(echoPin, HIGH);
distance= (duration/2)/29.1;
   int tbval=analogRead(ts)/20;
   int pval=analogRead(ps)/105;
   int irval=1-digitalRead(is);
   sensors.requestTemperatures();
   int tval = sensors.getTempCByIndex(0);
   digitalWrite(mp1,1);
   delay(3000);
   digitalWrite(mp1,0);
   lcd.clear();
   lcd.print("T:"+ String(tval) + " TB:"+ String(tbval) + " P:"+ String(pval));
   lcd.setCursor(0,1);
   lcd.print("IR:" + String(irval) +" L:" + String(distance));
   if(irval==1)
   {
     feed.write(0);
     delay(200);
   }
   else
   {
     digitalWrite(bz,1);
     feed.write(60);
     delay(200);
     digitalWrite(bz,0);
   }
   if(distance>7)
   {
     digitalWrite(mp2,1);
   }
   else
   {
     digitalWrite(mp2,0);
   }

   delay(300);
}
//    if(kk>25)
//    {
//      kk=0;
//
//    upload(tval,pval,tbval,irval,cval);
//}
//kk=kk+1;
//}

//
//    void wifi_init()
```

```
// {
//  mySerial.println("AT+RST");
//  delay(4000);
//  mySerial.println("AT+CWMODE=3");
//  delay(4000);
//  mySerial.print("AT+CWJAP=");
//  mySerial.write("");
//  mySerial.print("prudhvi"); // ssid/user name
//  mySerial.write("");
//  mySerial.write(',');
//  mySerial.write("");
//  mySerial.print("12345678"); //password
//  mySerial.write("");
//  mySerial.println();
//  delay(1000);
// }
//
//
//void upload(int x, int y, int z,int p ,int q) //ldr copied int to - x   and gas copied into -y
//{
//
//  String cmd = "AT+CIPSTART=\"TCP\",\"";
//  cmd += "184.106.153.149"; // api.thingspeak.com
//  cmd += "\",80";
//  mySerial.println(cmd);
//  delay(1000);
//  String getStr ="GET /update?api_key=OTCJ2EFTTX3C3S8U&field1=";
//  getStr += String(x);
//  getStr +="&field2=";
//  getStr += String(y);
//  getStr +="&field3=";
//  getStr += String(z);
//  getStr +="&field4=";
//  getStr += String(p);
//  getStr +="&field5=";
//  getStr += String(q);
//  getStr += "\r\n\r\n";
//  cmd = "AT+CIPSEND=";
//  cmd += String(getStr.length());
//  mySerial.println(cmd);
//  delay(1000);
//  mySerial.println(getStr);
//}
```

ACKNOWLEDGMENT :-

We extend our sincere appreciation to the collaborative efforts of our team in executing this project under ECS II of the curriculum. The invaluable support and resources provided by VIT – AP University have been instrumental in the realization of the Aquaponics Precision project. We also acknowledge the college's financial assistance, which enabled the reimbursement of project costs, facilitating our research and development endeavors. This experience has not only deepened our understanding of intelligent control systems and sustainable agriculture but also underscored the importance of teamwork and institutional backing in academic pursuits.