# American International University- Bangladesh (AIUB)
## Faculty of Engineering (FE)
## Department of Electrical and Electronic Engineering (EEE)

## Course Project Report Outline (Microprocessor and Embedded Systems)

1. **Download the template for report writing from the link given in TEAMS.**

2. **Title, Abstract (at least 150 words but not more than 300 words) and Keywords (3-6 keywords separated by a comma)** [3 marks]

3. **Introduction**

| | |
|---|---|
| 3.1. Background of Study and Motivation | [1 mark] |
| 3.2. Project Objectives | [1 mark] |
| 3.3. A brief Outline of the Report | [1 mark] |

4. **Literature Review** ***(At least 5 project-related published journal papers within the year 2018 to 2022)*** → **[Part under OBE assessment]** [5 marks]

5. **Methodology and Modeling**

| | |
|---|---|
| 5.1. Introduction | [1 mark] |
| 5.2. Working Principle of the Proposed Project | [1 mark] |
| 5.2.1. Process of Work | [1 mark] |
| 5.3. Description of the Components | [1 mark] |
| 5.4. Test/Experimental Setup | [2 marks] |

6. **Results and Discussions**

| | |
|---|---|
| 6.1. Simulation/Numerical Analysis | [1 mark] |
| 6.2. Measured response/Experimental Results | [1 mark] |
| 6.3. Comparison between Numerical and Experimental Results | [1 mark] |
| 6.4. Cost Analysis | [1 mark] |
| 6.5. Limitations in the Project | [1 mark] |

7. **Conclusion and Future Endeavors** [2 mark]

**References** [1 mark]

**Appendix (if any, optional)**

# American International University- Bangladesh (AIUB)
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| | | | |
|---|---|---|---|
| **Course Name:** | Microprocessor and Embedded Systems | **Course Code:** | EEE 4103 |
| **Semester:** | Spring 2023-2024 | **Section:** | Q |
| **Faculty Name:** | Niloy Goswami | | |

| | |
|---|---|
| **Capstone Project Title:** | Automatic Irrigation and Water Quality Monitoring System using Arduino Mega 2560 |
| **Project Group #:** | 01 |

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### Assessment Materials and Marks Allocation:

| COs | Assessment Materials | POIs | Marks |
|---|---|---|---|
| **CO3** | Course Project Report ***(Demonstrate a course project using microcontrollers, sensors, actuators, switches, display devices, etc. that can solve a complex engineering problem in the electrical and electronic engineering discipline through appropriate research.)*** | **P.d.1.P3** | **5** |

| COs | Excellent to Proficient [5- 4] | Good [3] | Acceptable [2] | Unacceptable [1] | No Response [0] | Secured Marks |
|---|---|---|---|---|---|---|
| **CO3 P.d.1.P3** | The outcome of the project demonstrates a course project using microcontrollers, sensors, actuators, switches, display devices, etc. that can solve a complex engineering problem in the electrical and electronic engineering discipline through appropriate research. | The outcome of the project somewhat demonstrates a course project using microcontrollers, sensors, actuators, switches, display devices, etc., and also somewhat solves a complex engineering problem in the electrical and electronic engineering discipline through some research. | The outcome of the project demonstrates a course project using microcontrollers, sensors, actuators, switches, display devices, etc. but cannot solve a complex engineering problem properly in the electrical and electronic engineering discipline through appropriate research. | The outcome of the project does not demonstrate a course project using microcontrollers, sensors, actuators, switches, display devices, etc. also could not solve a complex engineering problem in the electrical and electronic engineering discipline through appropriate research. | No Response | |
| **Comments** | | | | | **Total Marks (5)** | |

# Automatic Irrigation and Water Quality Monitoring System using Arduino Mega 2560

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***Abstract*— This report presents the design and implementation of an Automatic Irrigation and Water Quality Monitoring System utilizing an Arduino Mega 2560 R3. The system integrated soil moisture, temperature and humidity, TDS, and pH sensors to optimize irrigation and monitor water quality. It employed a 5V relay module to control a water pump, ensuring efficient water usage based on real-time sensor data. Real-time information on the TDS, pH, temperature and humidity were also displayed on the 20x4 LCD display with I2C. The project demonstrates the feasibility of such a system in agriculture and pisciculture, particularly in regions like Bangladesh where water management is crucial. However, the system faces limitations in sensor accuracy and durability. Future endeavors include enhancing sensor precision, exploring advanced environmental sensors, and integrating wireless connectivity for remote monitoring. This project contributes to the development of sustainable water management solutions, offering a promising approach to improving agricultural and pisciculture productivity and environmental conservation.**

***Keywords*— Automatic irrigation, water quality monitoring, Arduino Mega 2560 R3, sensor integration, sustainable water management.**

## I. INTRODUCTION

### A. *Background of Study and Motivation*

In the realm of agricultural innovation, the integration of Automatic Plant Watering Systems and Water Quality Monitoring Systems is paramount, particularly in nations where agriculture and pisciculture are economic cornerstones. In the fiscal years 2021-2022 of Bangladesh, agriculture contributed to around 11.50% of the total GDP [17], while the pisciculture sector added 2.43% to the national GDP; 22.14% to the agricultural GDP; and 1.05% to foreign exchange. [18] Furthermore, the agribusiness sector accounts for almost 20% of the economy. [19] This proposed project is designed to address the pressing need for efficient water management and soil health monitoring. It is observed that smart irrigation and water monitoring systems can enhance water productivity [20], reduce wastage [21], and improve crop and fish yield [22], which are important for a country where over 70% of the population relies on agriculture [23]. The reliance of the system on the Arduino Mega 2560 board and an array of sensors ensures precise control and real-time data acquisition, essential for optimizing irrigation schedules and ensuring water quality.

### B. *Project Objectives*

The primary objective of this project is to develop a system that could autonomously regulate irrigation and monitor water quality, thereby conserving water and ensuring the health of crops and aquatic life. The system was designed to be cost-effective and user-friendly, with the intention of providing farmers and fishermen with a reliable tool for managing water resources efficiently. The integration of various sensors was planned to gather comprehensive data on soil moisture, turbidity, pH levels, temperature, and humidity, which were then processed by the Arduino Mega 2560 to facilitate informed decision-making.

### C. *Outline of Report*

This report is organized into several sections to provide a comprehensive understanding of the project. The "Literature Review" section reviews relevant studies and projects related to the automatic irrigation and water quality monitoring system. The "Methodology and Modeling" section details the apparatus used, the working principle of the project, the description of the components, and the experimental setup. The "Results and Discussions" section presents the simulation results, the experimental results, a comparison between the simulated and experimental results, a cost analysis, and the limitations in the project. The "Conclusion and Future Endeavors" section summarizes the findings of the project and suggests potential future improvements. Each section is intended to provide a comprehensive understanding of the project, from the initial motivations and objectives to the final results and future directions.

## II. LITERATURE REVIEW

Several studies and projects related to automatic irrigation and water quality monitoring systems have been conducted in recent years, demonstrating the practical applications and the various implementations of this system.

In The paper by Rohith *et al.* [1] highlighted the potential of IoT in smart irrigation and farming, emphasizing how it may assist farmers in growing healthier plants. The system employed three sensors to measure humidity, moisture, and temperature, and when these dropped, the motor activated the water pump. The motor was controlled by the Arduino board, voltage regulator, and relay, while the field condition was sent to the user via a WIFI module. This automation decreased physical labor, conserved water, and power, and enabled even the elderly to engage in farming. The document was used to successfully grow a tomato plant using this paper, helping to create a better agricultural system and a more affluent country.

Vamsi Thalatam *et al.* [2] described an IoT-based smart water pollution monitoring system designed to improve the quality and safety of residential water supply. The system was made up of a wireless sensor network that monitored the pH, turbidity, and temperature of the water, as well as a cloud-based platform that processed the data and showed the results via a web or mobile interface. The study covered the design of the system, implementation, and testing in several water sources, as well as comparisons to existing approaches. The study contributes to the field of smart water management by presenting a low-cost, scalable, and user-friendly system for monitoring and alerting water pollution levels in real-time.

Taneja *et al.* [3] proposed and analyzed an autonomous irrigation system based on Arduino UNO, intending to improve plant growth while lowering water and human resource costs. The system was made up of a soil moisture sensor and a water level sensor, which monitored the water content of the soil and the water container, respectively, and an Arduino board that regulated the water pumping motor depending on the sensor data. The article detailed the design, execution, and testing of a system for potted plants, as well as a comparison to handle watering. The research advanced the subject of smart irrigation by offering a low-cost, scalable, and user-friendly method for optimizing water utilization and plant development. The research also showed that the method was feasible and successful by presenting experimental findings that indicated an increase in soil moisture and plant height. The study outlined the benefits of the system, such as automation, efficiency, and resource management.

The paper of Mayuree *et al.* [4] illustrated and evaluated an automated plant watering system to reduce irrigation labour and water usage. The system comprised of a soil moisture sensor and a water level detection sensor, which monitored the water content of the soil and the water container, respectively, and an Arduino UNO board, which operated the water pumping motor based on sensor data. The research discussed the design of the system and, implementation, as well as a comparison to manual watering. The study contributed to the field of smart irrigation by presenting a low-cost, scalable, and user-friendly method for automating the watering process while conserving water.

Kumar *et al.* [5] depicted an IoT-based water quality monitoring system designed to improve pisciculture management and water supply safety. The system was made up of a wireless sensor network that detected TDS, pH, and turbidity in water, as well as an Arduino-based platform that interpreted the data and provided notifications to users over GSM and Wi-Fi. The article discussed the design, installation, and testing of a fishpond and a water tank, as well as a comparison to manual approaches. The research advanced the subject of smart water management by presenting a low-cost, scalable, and user-friendly system for monitoring and alerting water quality in real-time. The report also proved the viability of the system and efficiency using experimental data that showed the accuracy and dependability of sensor readings and alarm messages.

In their research paper, Makhtar *et al.* [6] presented and assessed a real-time strategy for monitoring water quality indicators using Arduino Uno and Bluetooth. The system was made up of four sensors that monitored the temperature of water, pH, turbidity, and total dissolved solids (TDS), as well as a microprocessor that processed the data and presented the findings on a mobile app and an LCD screen. The report detailed the design of the system, implementation, and testing in several water samples, and compared it to manual approaches. The article also included future endeavors, such as adding more sensors, improving the user interface, and implementing wireless connectivity.

Vibhute *et al.* [7] are conducting a thorough survey encompassing a wide array of applications of image processing in agriculture. Their study explores various areas including imaging techniques, weed detection, and fruit grading, highlighting the versatility and efficacy of image processing tools in improving agricultural operations. By significantly reducing the time required for analysis compared to traditional methods, image processing is emerging as a pivotal technology in enhancing decision-making processes across various agricultural domains, ranging from vegetation measurement to irrigation management and fruit sorting.

Precision agriculture stands as a cornerstone in regions with vast populations, fertile lands, and abundant water resources. Within this realm, smart irrigation plays a pivotal role in optimizing water utilization and management to enhance agricultural productivity. Tephila *et al.* [8] introduce an innovative IoT-based smart irrigation system designed to harness available water resources efficiently. Their system incorporates a sophisticated management device that automates irrigation timing to mitigate issues such as under-irrigation and over-irrigation, thereby optimizing water consumption and distribution. By leveraging open-source clouds, fusion centers, sinks, and field-deployed sensors, the system enables tailored smart irrigation practices that align with specific agricultural requirements. Experimental results demonstrate significant energy savings of up to thirty percent compared to existing methodologies, alongside offering enhanced network stability. Furthermore, the system's adaptability allows seamless integration across various irrigation models, rendering it suitable for deployment in diverse agricultural landscapes.

The advent of the Internet of Things (IoT) is ushering in a new era of agricultural innovation, empowering farmers with a diverse range of strategies to tackle challenges such as weather variability, soil fertility, and crop monitoring. Jain [9] delves into the pivotal role of IoT in revolutionizing agriculture, emphasizing its capability to deliver accurate and practical farming solutions. IoT technologies facilitate real-time monitoring of crucial factors such as weather conditions, temperature variations, soil moisture levels, and crop conditions. By harnessing remote sensor properties, IoT development can substantially reduce operational costs and enhance productivity, thereby driving improvements in agricultural practices.

The critical importance of ensuring safe access to water cannot be overstated, as it constitutes a fundamental human right and a prerequisite for survival. However, challenges such as contamination, leakages, and pilferage often plague water distribution systems, compromising water quality and availability. Omambia *et al.* [10] propose an innovative system leveraging IoT and machine learning to monitor water quality and address issues related to pilferage and wastage. By leveraging machine learning algorithms for decision-making, their system offers a promising solution to these challenges, ensuring safe water access for consumers while minimizing resource wastage.

Fish production holds significant economic importance in the agricultural sector, but modernizing fish ponds entails substantial investment and operating costs. Ya'acob *et al.* [11] propose a water quality monitoring system harnessing IoT technology to address these challenges effectively. Their system integrates ultrasonic sensors for fish detection and pH and temperature sensors for assessing water quality parameters. By centralizing control using NodeMCU ESP8266 as the central controller and utilizing the Blynk application for notifications, their system enables real-time monitoring of water quality and fish presence. Consequently, it reduces operating costs and enhances efficiency in fish farming operations.

The escalating global water pollution crisis necessitates the implementation of efficient water quality monitoring systems to safeguard water resources and public health. Konde and Deosarkar [12] introduce a novel reconfigurable sensor interface device for real-time water quality monitoring using IoT technology. Their system leverages field programmable array (FPGA) design boards programmed with VHDL and sensors to monitor critical parameters such as water pH, turbidity, humidity, carbon dioxide levels, and water temperature in parallel real-time bases, facilitating efficient monitoring of water quality parameters.

Automation technology emerges as a transformative force in agriculture, particularly in irrigation systems. Akter *et al.* [13] develop an automatic irrigation system based on sensor-based systems, designed to enhance irrigation efficiency and minimize water wastage. By integrating sensor technology with microcontrollers, relays, DC motors, and batteries, their system detects soil moisture levels and regulates irrigation accordingly, ultimately saving time, energy, and water resources.

To sum it up, it can be said that the reviewed literature highlighted the increasing interest in smart irrigation systems that integrate IoT technologies, image processing methods, and Arduino-based water quality monitoring systems. These studies are significant in advancing precision agriculture, sustainable water management, and water quality assessment by providing valuable insights into the design, implementation, and performance of integrated systems. Efficient water usage, crop monitoring, and water quality monitoring are some of the benefits of these systems.

## III. Methodology and Modeling

### A. *Introduction*

An integrated approach was employed in the development of this project that combined the functionalities of an automatic plant watering system with a water quality testing and monitoring system. The central processing unit of the system was an Arduino Mega 2560 that coordinated the operations of various sensors and modules. The irrigation mechanism comprised a capacitive soil moisture sensor, a relay module, and a water pump, while turbidity, pH, temperature, and humidity sensors were utilized to assess water quality. The Arduino Mega 2560 was programmed with the necessary code and control logic, and it processed the sensor inputs to manage the watering system and monitor water quality parameters. The sensor readings were displayed on a 20x4 LCD display with an I2C interface, providing real-time feedback on the status of the system. The hardware components were systematically arranged on a breadboard, and the interconnections were facilitated by male-to-male, male-to-female, and hard jumper wires as needed. The water pump was powered by a 9V battery, This integration aimed to enhance the efficiency of irrigation practices while ensuring the maintenance of optimal water quality standards for agricultural purposes.

### B. *Working Principle of the Proposed Project*

The working principle of the project was founded on the integration of sensor-based data acquisition with automated control mechanisms. The capacitive soil moisture sensor continuously monitored soil moisture levels, and the relay module was engaged to activate the water pump when moisture levels fell below a predefined threshold, ensuring optimal soil hydration. Water quality was simultaneously assessed through readings obtained from the turbidity sensor, pH sensor, and temperature and humidity sensor. The turbidity of the water was determined by measuring the light transmission and scattering rate, while the pH value was calculated using a standard curve method that was refined by a calibration process. Temperature and humidity data were gathered to provide additional environmental context to the water quality metrics. The control logic was executed by the Arduino Mega 2560, which processed the inputs of these sensors. Real-time monitoring and immediate response to the changing conditions of the soil and water were facilitated by the 20x4 LCD screen, creating a self-regulating system capable of maintaining the health of the plants and the integrity of the water resource.

*1) Process of Work:* The Arduino Mega 2560 was initially programmed to interface with the various sensors and the relay module. The capacitive soil moisture sensor was calibrated to detect the moisture level threshold, triggering the relay to operate the water pump accordingly. The data from the turbidity sensor were converted into NTU units (Nephelometric Turbidity Unit), indicating the clarity of the water, while the output from the pH sensor was processed to yield the acidity levels of the water. Temperature and humidity were recorded to provide a comprehensive environmental profile. The parameters were then displayed on the LCD screen, offering an intuitive visualization of the status of the system. The state of the realy was controlled based on the soil moisture readings, activating the water pump when necessary to maintain the desired moisture levels. This automated process was repeated at regular intervals, ensuring consistent monitoring and optimal irrigation without manual intervention.

### *C. Description of the Components*

The following components were used to practically implement the project:

*1) Arduino Mega 2560:* The Arduino Mega 2560 served as the central processing unit for the project. It was selected for its extensive range of input/output pins, which allowed for the connection of the multiple sensors and actuators required. The robust processing capabilities and large memory space of the board were utilized to handle the complex data processing and storage requirements of the system.

Fig. 1. Arduino Mega 2560 R3.

*2) 5V Relay Module:* The high-power circuit of the water pump was controlled using a low-power signal from the Arduino Mega 2560 through the utilization of the 5V Relay Module, which served as an electrically operated switch. Safe and effective switching operations were ensured by the module, which also isolated the microcontroller from the power circuit of the pump.

Fig. 2. 5V Relay Module

*3) Water Pump:* The supply of water to the plants was facilitated by the Water Pump which played an integral role in the irrigation part of this project. The activation was carried out by the relay module in response to the readings of the soil moisture sensor. The flow rate of the pump was deemed suitable for the irrigation requirements of the project, ensuring efficient distribution of water.

Fig. 3. Water Pump

*4) Pipe:* The tube was utilized to channel water from the pump to the plants, owing to its durability and compatibility with the water pump, providing a dependable means for water delivery.

Fig. 4. Pipe

*5) Capacitive Soil Moisture Sensor:* The volumetric water content in the soil was measured using the Capacitive Soil Moisture Sensor. The capacitive technology of the sensor was utilized, which provided an accurate and reliable measurement of soil moisture. Furthermore, the corrosion-resistant feature of the capacitive technology made it an ideal alternative to resistive sensors for long-term use.

Fig. 5. Capacitive Soil Moisture Sensor.

*6) Breadboard:* A Breadboard was utilized as the foundation for implementing the circuit, allowing for a solderless construction and making the process of testing and modifying the project both convenient and efficient.

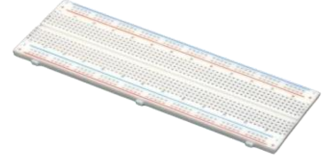

Fig. 6. Breadboard.

*7) Jumper Wires:* The connections between the Arduino Mega 2560, sensors, relay module, and LCD display were established using male-to-male, male-to-female, and hard jumper wires. A flexible and organized layout on the breadboard was facilitated by these wires.

Fig. 7. Jumper Wires.

*8) 20x4 LCD Display with I2C:* The sensor readings and system status were displayed using the 20x4 LCD Display, which was equipped with an I2C interface. The number of pins required for connection was reduced by the I2C interface, simplifying the wiring and conserving valuable I/O pins on the Arduino Mega 2560.

Fig. 8. 20x4 LCD Display with I2C.

*9) Turbidity (TDS) Sensor with module:* Valuable data on water quality was provided by the Turbidity Sensor, which was utilized to measure water clarity for irrigation and pisciculture, ensuring that clean water was received by the plants and fishes.

Fig. 9. TDS Sensor with module.

*10) DHT11:* The environmental temperature and humidity conditions were monitored by adding the DHT11 Temperature and Humidity Sensor. The performance of the system was optimized by using the data provided by the sensor to improve the irrigation and water quality.

Fig. 10. DHT11.

*11) pH Sensor Module:* The pH Sensor Module was critical for assessing the acidity or alkalinity of the water. The health of plants and fish was dependent on this information, as nutrient availability is significantly impacted by pH levels.

Fig. 11. pH Sensor Module.

*12) 9V Battery with Battery Clip:* A 9V battery was mainly used as the power source for the water pump.

Fig. 12. 9V Battery with clip.

### D. Experimental Setup

The experimental setup of the project was carried out as follows:

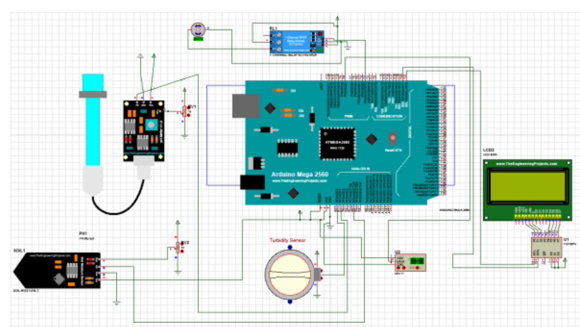

Fig. 13. Experimental Setup in Proteus

*1) Step 1:* The experimental setup was established by initially connecting the Arduino Mega 2560 board to a power supply, either through a 9V battery or a PC/laptop via a USB cable. The common $V_{IN}$ and GND pins of the pH Sensor Module, Soil Moisture Sensor, TDS Sensor, DHT11, 5V Relay Module, and the 20x4 LCD display with I2C were interconnected using the requisite jumper wires. These connections were routed to the breadboard, ensuring a common power and ground distribution with the 5V and GND pin slots of the Arduino Mega 2560 board. [14][15][16]

*2) Step 2:* Subsequently, the SDA and SCL pins of the I2C interface from the 20x4 LCD display were interfaced with the corresponding SDA and SCL pins on the Arduino Mega 2560, ensuring proper functionality of the display. The data pin of the

DHT11 sensor was linked to the digital pin slot 8 on the Arduino board.

3) *Step 3:* The analog output pins ($A_o$) of the TDS Sensor, pH Sensor, and Soil Moisture Sensor were connected to the analog pin slots A0, A1, and A6 of the Arduino Mega 2560 board respectively. The input pin of the 5V relay module was connected to the digital pin slot 3 of the Arduino board. The water pump was integrated into the system by connecting one end to the Normally Open (NO) pin of the relay module and the other end to the negative terminal of the 9V battery. The Common (C) pin of the relay module was connected to the positive terminal of the battery. [14][15][16]

4) *Step 4:* Following the hardware setup, the necessary code was composed in the Arduino Integrated Development Environment (IDE) and subsequently uploaded to the Arduino Mega 2560 board. Calibration of the sensors was performed by adjusting their built-in potentiometers to align with standard values.

5) *Step 5:* For the practical implementation, the Soil Moisture Sensor was inserted into a container filled with dry soil, while the pH, TDS sensors, and the water pump were installed in water within a separate container. The experimental outcomes were observed and recorded.

## IV. RESULTS AND DISCUSSIONS

### *A. Simulation*

The simulation of this project was precisely conducted using Proteus 8.16 Professional. In the simulated environment, the integration of the components, including the Arduino Mega 2560, relay module, water pump, and various sensors, was validated. The responsiveness of the capacitive soil moisture sensor to varying soil moisture levels was observed, triggering the relay module to activate or deactivate the water pump accordingly. Concurrently, the turbidity sensor module provided real-time water quality data by measuring the turbidity levels, which were displayed alongside pH values obtained from the pH sensor module, and the temperature and humidity readings were accurately captured by the DHT11 sensor; all of which were exhibited on the 20x4 LCD display with I2C interface. The simulation confirmed the capability of the system to autonomously regulate irrigation while continuously monitoring water quality parameters, thereby demonstrating the potential effectiveness of the project in practical applications of irrigation and pisciculture.

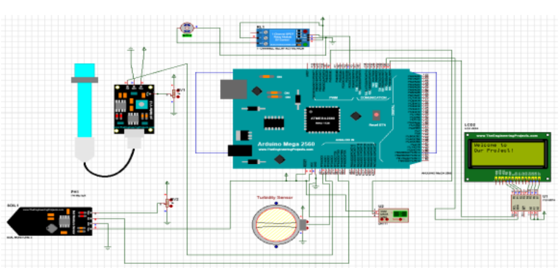

Fig. 14. Simulation of the starting screen in the 20x4 LCD display in Proteus 8.16 Professional.

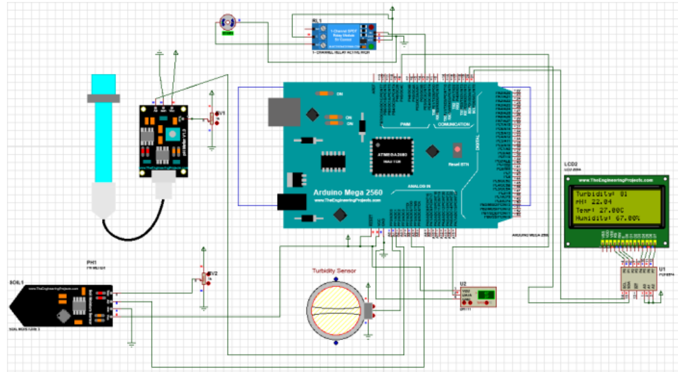

Fig. 15. Sensor values being shown on the 20x4 LCD display along with running motor in Proteus 8.16 Professional simulation.

### *B. Experimental Results*

The experimental results of this project demonstrated the efficiency of the system in a real-world setting. Upon deployment, the Arduino Mega 2560 effectively coordinated the operation of the water pump through the relay module based on the data from the capacitive soil moisture sensor. The system maintained optimal soil moisture levels, ensuring efficient water usage. The turbidity sensor module accurately detected the clarity of the water, and the pH sensor module provided precise pH measurements, which were crucial for assessing water quality. The temperature and humidity sensor, DHT11, supplied consistent atmospheric condition readings. All sensor data were dynamically displayed on the 20x4 LCD display with I2C, allowing for immediate observation. The performance of the system in automatically adjusting irrigation in response to soil moisture and providing real-time water quality monitoring validated its potential as a sustainable solution for precision agriculture and pisciculture. [14][15][16]

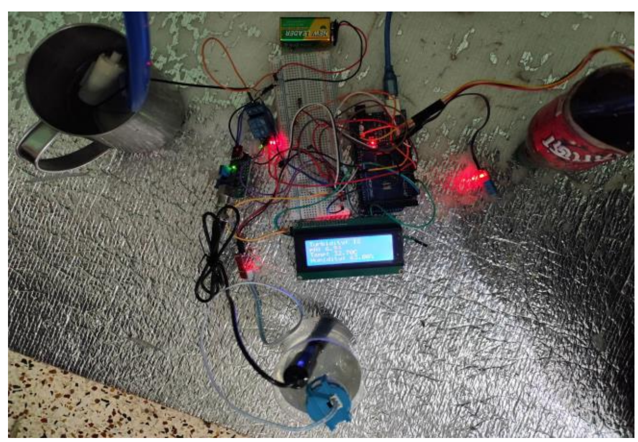

Fig. 16. Practical demonstration of the project.

### *C. Comparison between Simulated and Experimental Results*

The following table depicts a comparison between the simulated and experimental results of this project:

TABLE I
COMPARISON BETWEEN SIMULATED AND EXPERIMENTAL RESULTS

| Apparatus | Simulated Results | Experimental Results |
|---|---|---|
| 20x4 LCD with I2C | Turned ON | Turned ON |
| DHT11 | Temperature: 27°C Humidity: 67.00% | Temperature: 32.70°C Humidity: 63.00% |
| TDS Sensor | 81 | 16 |
| pH | 22.04 | 6.34 |
| 5V Relay Module | Turned ON | Turned ON |
| Water Pump | Turned ON | Turned ON |

In the above table of comparison between the simulated and experimental results, it can be seen that the 20x4 LCD with I2C consistently turned ON in both simulated and experimental conditions, affirming the reliability of the display system. The DHT11 sensor recorded a simulated temperature of 27°C and humidity of 67.00%, while the experimental results showed a slightly elevated temperature of 32.70°C and a marginally reduced humidity of 63.00%, indicating minor variances likely due to environmental factors. The TDS Sensor revealed a greater disparity, with a simulated value of 81 compared to an experimental reading of 16, suggesting the need for calibration adjustments. A significant deviation was observed in the pH module, reporting a simulated pH level of 22.04 against an experimental value of 6.34, which aligns more closely with typical aqueous solutions. Both the 5V Relay Module and the Water Pump demonstrated consistent functionality by turning ON as expected in both testing scenarios. This comparative analysis underscores the importance of real-world calibration and highlights the robustness of the system in practical conditions.

### D. *Cost Analysis*

A detailed cost analysis of the project considering each component is given in the following table:

TABLE II
COST ANALYSIS

| Apparatus | Quantity | Cost |
|---|---|---|
| Arduino Mega 2560 R3 | 1 | Tk. 1980 |
| 5V Relay Module | 1 | Tk. 85 |
| Water Pump | 1 | Tk. 160 |
| Pipe | 1 | Tk. 60 |
| Capacitive Soil Moisture Sensor | 1 | Tk. 286 |
| Jumper Wires | 20 | Tk.180 |
| Breadboard | 1 | Tk. 150 |
| 20x4 LCD with I2C | 1 | Tk. 550 |
| TDS Sensor with module | 1 | Tk. 966 |
| DHT11 | 1 | Tk. 175 |
| pH Sensor Module | 1 | Tk. 2200 |
| 9V Battery with Battery Clip | 1 | Tk.96 |
| | | **Total =** Tk. 6888 |

It can be seen that the total cost of the project was Tk. 6888. This cost is feasible considering the functionality provided by the project.

### E. *Limitations in the Project*

The project encountered several limitations that were identified during its course. Firstly, the capacitive soil moisture sensor faced challenges in providing consistent readings across different soil types, which affected the precision of the irrigation system. Additionally, while the soil moisture sensor does stop the water pump when it is submerged in wet soil, it turns on immediately after taking it out, indicating the need for a more precise sensor. Secondly, the turbidity sensor exhibited a degree of sensitivity to ambient light, leading to variations in water quality readings. The pH sensor module required frequent calibration to maintain accuracy, reflecting a limitation in the long-term stability of the sensor. Additionally, the 5V relay module and water pump were tested under controlled conditions, and their durability under continuous operation remains to be assessed. The DHT11 sensor, while functional, offered limited accuracy and range, suggesting the potential for improved environmental monitoring with more advanced sensors. These limitations underscore the necessity for further refinement and testing to enhance the robustness and reliability of the system in diverse agricultural environments.

## V. CONCLUSION AND FUTURE ENDEAVORS

### A. *Conclusion*

In conclusion, it can be said that this project, “Automatic Irrigation and Water Quality Monitoring System using Arduino Mega 2560” was successfully completed. The integration of the automatic plant watering system with the water quality monitoring system was achieved using a variety of sensors interfaced with an Arduino Mega 2560 board. The capacitive soil moisture sensor, relay module, and water pump formed the core of the irrigation system, ensuring optimal soil moisture levels were maintained. Concurrently, the water quality was meticulously monitored using turbidity, pH, temperature, and humidity sensors (DHT11). Data from these sensors were displayed on a 20x4 LCD screen, providing real-time feedback on the status of the system. The reliability and efficiency of the system were validated through a series of tests conducted in a simulated environment using Proteus 8.16 Professional.

The total cost of the project was Tk. 6888, making it a cost-effective project for a digital counter. However, the project also identified several limitations, including the need for calibration adjustments for the TDS Sensor and the pH Sensor Module, and the potential for improved environmental monitoring with more advanced sensors including a more advanced soil moisture sensor. These limitations provide areas for improvement in future iterations of the project.

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### B. *Future Endeavors*

The successful completion of this project has laid a solid foundation for future advancements in the field of automated agricultural and pisciculture systems. Opportunities for enhancement were identified, particularly in the realms of energy efficiency and remote monitoring capabilities. The incorporation of solar panels to power the system was considered, which would significantly reduce the dependency on conventional power sources and promote sustainability. Furthermore, the integration of wireless communication modules, such as Wi-Fi or GSM, and other IoT devices was contemplated to enable remote data access and control, allowing users to monitor and manage the system from any location. These potential upgrades were deemed to be instrumental in evolving the project into a more versatile and eco-friendly solution, capable of meeting the increasing demands of modern agriculture and pisciculture.

## APPENDIX

TestCode3 | Arduino IDE 2.3.2

File Edit Sketch Tools Help

Arduino Mega or Mega 2...

TestCode3.ino

```
#include <Wire.h>
#include <LiquidCrystal_I2C.h>
#include <DHT.h>

// Define pin assignments
#define relayPin 3
#define soilMoisturePin A6
#define turbidityPin A0
#define pHsensorPin A1
float calibration_value = 21.34 + 0.7;
unsigned long int avgValue;
int buf[10], temp;
#define DHTPin 8

// Initialize LCD display
LiquidCrystal_I2C lcd(0x27, 20, 4);

// Initialize DHT sensor
DHT dht(DHTPin, DHT11);

void setup() {
  pinMode(relayPin, OUTPUT);
  pinMode(soilMoisturePin, INPUT);
  pinMode(turbidityPin, INPUT);
  pinMode(pHsensorPin, INPUT);

  lcd.init();
  lcd.backlight();

  dht.begin();

  lcd.clear();
  lcd.print("Welcome to");
```

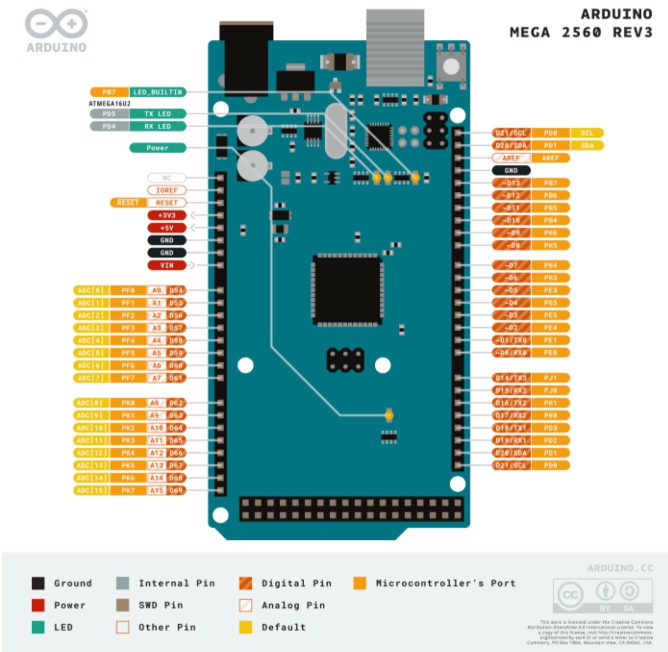
TestCode3 | Arduino IDE 2.3.2

File Edit Sketch Tools Help

Arduino Mega or Mega 2...

TestCode3.ino

```
  lcd.setCursor(0, 1);
  lcd.print("Our Project!");
  delay(2000);
  lcd.clear();
}

void loop() {
  //Read soil moisture
  int soilMoisture = digitalRead(soilMoisturePin);

  // Read TDS sensor and calculate turbidity
  int turbidityRaw = analogRead(turbidityPin);
  int ntu = map(turbidityRaw, 0, 750, 100, 0);

  // Read pH sensor and calculate pH value
  for(int i = 0; i < 10; i++) {
    buf[i] = analogRead(pHsensorPin);
    delay(10);
  }
  for(int i = 0; i < 9; i++) {
    for(int j = i + 1; j < 10; j++) {
      if(buf[i] > buf[j]) {
        temp = buf[i];
        buf[i] = buf[j];
        buf[j] = temp;
      }
    }
  }
  avgValue = 0;
  for(int i = 2; i < 8; i++) avgValue += buf[i];

  float phValue = (float)avgValue * 5.0 / 1024 / 6;
  phValue = -5.70 * phValue + calibration_value;

  // Read temperature and humidity from DHT11 sensor
  float temperature = dht.readTemperature();
  float humidity = dht.readHumidity();

  // Display sensor values on LCD
  lcd.setCursor(0, 0);
  lcd.print("Turbidity: ");
  lcd.print(ntu);
  lcd.print("  ");

  lcd.setCursor(0, 1);
  lcd.print("pH: ");
  lcd.print(phValue, 2);
  lcd.print("  ");

  // Display temperature and humidity
  lcd.setCursor(0, 2);
  lcd.print("Temp: ");
  lcd.print(temperature);
  lcd.print("C");

  lcd.setCursor(0, 3);
  lcd.print("Humidity: ");
  lcd.print(humidity);
  lcd.print("%");

  // Control water pump based on soil moisture
  if (soilMoisture == HIGH) {
    digitalWrite(relayPin, LOW); // Turn off water pump
  } else {
    digitalWrite(relayPin, HIGH); // Turn on water pump
  }

  delay(1000);
}
```





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