KWAME NKRUMAH UNIVERSITY OF SCIENCE AND TECHNOLOGY

COLLEGE OF ENGINEERING

DEPARTMENT OF COMPUTER ENGINEERING

MICROCONTROLLER-BASED WATER LEVEL CONTROLLER WITH AUTO-CUTOFF AND PURITY CHECKER

Project submitted in partial fulfillment for a Degree in Bachelor of Science (BSc.) in Computer Engineering.

By

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DECLARATION

We hereby declare that this project report is based on our original work except for citations and quotations that have been duly acknowledged. We also declare that it has not been previously and concurrently submitted for any other degree or award at KNUST or other institutions.

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(Project Supervisor)

DEDICATION

We dedicate this project to our supervisor in appreciation of her excellent leadership and assistance during this project. May the Lord God Almighty generously recompense her.

We also dedicate our project to everyone who understands the need to safeguard and conserve water, the most valuable resource on the planet. We hope this effort will serve as a reminder of how important it is for us all to encourage sustainable lifestyles and preserve the environment for future generations.

ACKNOWLEDGEMENT

We thank the Lord God Almighty for seeing us through and providing strength towards the goals of this project.

We would like to offer our sincere appreciation to everyone who helped us with this endeavor. We would like to express our gratitude to our supervisor for her direction, inspiration, and insightful criticism.

We would like to express our profound gratitude to the staff and professors at Kwame Nkrumah University of Science and Technology for providing us with the tools and facilities we needed to complete this project. We are also appreciative of our family and friends' unfailing support and inspiration.

Last but not least, we would like to thank everyone who has worked in the area of water conservation and sustainability for their efforts. Their devotion and dedication have and will continue to motivate us to make a difference in the world.

TABLE OF CONTENTS

DECLARATION 1
DEDICATION 2
ACKNOWLEDGEMENT 3
TABLE OF CONTENTS 4
LIST OF FIGURES 6
LIST OF ABBREVIATIONS 7
ABSTRACT 8
CHAPTER ONE: INTRODUCTION 9
1.1 BACKGROUND OF STUDY 9
1.2 PROBLEM IDENTIFICATION 9
1.3 OBJECTIVES 11
1.3.1 General Objectives 11
1.3.2 Specific Objectives 11
1.4 SCOPE OF STUDY 12
1.5 SIGNIFICANCE OF STUDY 12
CHAPTER TWO: LITERATURE REVIEW 14
2.1 INTRODUCTION 14
2.2 OVERVIEW OF EXISTING SYSTEMS 14
2.2.1 Presentation on Water Level Detector 14
2.2.2 Water Level Monitoring and Management of Dams Using IoT 16
2.2.3 Automatic Water Level Controller with Short Messaging (SMS) Notification 18
2.2.4 A Microcontroller-Based Water Level Indicator using Radio Frequency (RF) Technology and Ultrasonic Sensor 20
2.2.5 Automated Water Level Monitoring System using Arduino and GSM Module 22
2.2.6 Automatic Water Level Indicator and Controller using Arduino 24
CHAPTER THREE: METHODOLOGY 26
3.1 INTRODUCTION 26
3.2 SYSTEMATIC ARCHITECTURE 26
3.3 FLOWCHART 26
3.4 HARDWARE REQUIREMENTS 29
3.4.1 ATMEGA328 MICROCONTROLLER 29
3.4.2 ULTRASONIC SENSOR 29
3.4.3 TRANSISTOR 30
3.4.4 RESISTORS 30
3.4.5 JUMPER WIRES 31
3.4.6 CAPACITOR 31
3.4.7 pH SENSOR 32
3.4.8 TDS(TOTAL DISSOLVED SOLIDS) METER 32
3.5 SYSTEM SCHEMATIC 34

3.6 SOFTWARE DEVELOPMENT LIFE CYCLE..35
3.6.1 PLANNING AND REQUIREMENTS ANALYSIS..35
3.6.2 DEFINING REQUIREMENTS.. 35
3.6.3 DESIGN.. 36
3.6.4 BUILDING AND DEVELOPING THE PRODUCT.. 36
3.6.5 TESTING AND INTEGRATION.. 36
3.6.6 DEPLOYMENT AND MAINTENANCE...36
3.7 SOFTWARE DEVELOPMENT MODELS...37
3.7.1 AGILE MODEL DEVELOPMENT.. 37
3.7.2 USER FUNCTIONALITIES..38
3.7.3 ALGORITHM FOR USER FUNCTIONALITIES...38
3.7.4 PLATFORM DEPENDENCIES AND LANGUAGES.. 38
3.8 SOFTWARE ARCHITECTURE..40
CHAPTER FOUR: TESTING AND EVALUATION..43
4.1 INTRODUCTION...43
4.1.1 TESTING AND EVALUATION..43
4.1.2 FUNCTIONAL TESTING..44
4.1.3 OPERATIONAL TESTING..44
4.1.4 ACCURACY AND PRECISION..44
4.1.5 USER EXPERIENCE TESTING..44
4.1.6 EVALUATION OF WEB INTEGRATION... 45
4.2 PHYSICAL DESIGN..45
4.3 USER INTERFACE.. 46
CHAPTER FIVE: CONCLUSION AND RECOMMENDATIONS.................................49
5.1 CONCLUSION.. 49
5.2 CHALLENGES..49
5.3 RECOMMENDATION.. 50
REFERENCES...51

LIST OF FIGURES

1.1 Container overflow in legacy homestel hostel …….……………………… 10
2.1 Schematic of solution proposed by Bhushan Kumbhalkar…………………… 15
2.2 Flowchart of the implementation ……………………………………………. 16
2.3 Schematic of collection of nodes …………………………………………….. 17
2.4 Schematic of each node ……………………………………………………. 17
2.5 Flowchart of System ……………………………………………………….. 19
2.6 Prototype of the system ……………………………………………………..… 19
2.7 Flowchart description of the transmitter system ……………………………… 21
2.8 Completely implemented design ……………………………………………… 21
2.9 Circuit diagram of connected components ……………………………………. 22
2.10 Hardware Setup …………………………………………………………….. 23
2.11 Interface Of flutter application ………………………………………………... 23
2.12 Block diagram representation …………………………………………………. 24
2.13 Finished product displaying water level 1 …………………………………….. 25
2.14 Finished product displaying water level 6 …………………………………….. 25
3.1 Block diagram of product ……………………………………………………. 26
3.2 Flowchart of product ………………………………………………………… 28
3.3 ATmega328 microcontroller…………………………………………………… 29
3.4 Ultrasonic Sensor …………………………………………………………… 30
3.5 Transistor …………………………………………………………………… … 30
3.6 Resistors ……………………………………………………………………….. 30
3.7 Jumper Wires………………………………………………………………… 31
3.8 Capacitor ……………………………………………………………………….. 31
3.9 pH Sensor ……………………………………………………………………. 32
3.10 TDS Sensor ……………………………………………………………….. 33
3.11 ESP 32 ….………………………………………………………………… 33
3.12 Schematic of system ………………………………………………………. 35
3.13 SDLC phases ………………………………………………………………… 37
3.14 Frontend Architecture Flowchart ……………………………………………. 41
3.15 Backend Architecture Flowchart …………………………………………….. 42
4.1 Working System ……………………………………………………………… 45
4.2 Login page……………………………………………………………………. 46
4.3 ph value chart ………………………………………………………………… 47
4.4 Total Dissolved value chart …………………………………………………… 47
4.5 FAQ page ……………………………………………………………………… 48

LIST OF ABBREVIATIONS

LED………. Light Emitting Diode

WHO …….. World Health Organization

UNICEF ….. United Nations International Children's Emergency Fund

NRW ………Non-Revenue Water

IoT ……….. Internet of Things

SMS ……….Short Messaging Service

GSM ……… Global System for Mobile communication

RF …………Radio Frequency

LCD ……….Liquid-Crystal Display

SWLM …….Smart Water Level Monitoring

pH …………Potential Hydrogen

NPN ……….Negative-Positive-Negative

PNP ………. Positive-Negative-Positive

VCC ……… Voltage Common Collector

GND ……… Ground

SDLC …….. Software Development Life Cycle

TDS……….. Total Dissolved Solids

ABSTRACT

The goal of this project is to create a microcontroller-based water level controller with an auto-cutoff and a purity checker. The gadget is made to manage water level and ensure its purity by switching off the water supply once the target level is attained and displaying the purity level on a web application. To provide the needed functionality, the project uses a microcontroller, ATMega328P, sensors, transistors, jumper wires, resistors, ESP 32, capacitor, heat sink, jumper wires, water pump and a diode. This project report starts with an introduction, followed by a literature review. The outcome could be described as an effective water level controller that has auto-cut-off functionality and a purity checker whereby the purity levels are displayed in a responsive web application to clients or users. It may be implemented in homes, workplaces, and enterprises. The concept offers a reliable and affordable way to assess the purity and control the amount of water in a water reservoir.

CHAPTER ONE: INTRODUCTION

1.1 BACKGROUND OF STUDY

Water is a valuable resource that is essential to sustaining human life. The world's water supplies are under a lot of stress because of the expanding population and increasing industrialization. To ensure that water resources are available for future generations, it is crucial to manage them effectively and efficiently.

Controlling water levels and ensuring its purity are two essential components of water management. Water is frequently kept in tanks for storage in homes and businesses, and it is important to keep the water level within a certain range. If this isn't done, water could be wasted or the water storage system could be harmed. In order to prevent health risks, it is also crucial to guarantee that the water is pure.

Formerly, water level control and purity testing were done manually, which was labor-intensive and ineffective. However, thanks to technological advancements, it is now possible to use sensors and microcontrollers to automate these procedures.

The goal of this project is to design and create a microcontroller-based water level controller with auto-cutoff functionality and a purity checker. The apparatus will make sure that the water is clean and that the level is kept within a predetermined range. This project is a step in the direction of effective water management and conservation.

1.2 PROBLEM IDENTIFICATION

In addition to being a basic need and human right, access to adequate, safe water supply has significant positive effects on people's health and finances. Lack of access to water causes a variety of issues, including illness and death. Water is a finite resource that is necessary for the survival of people and other living things. Despite its significance, a significant amount of this finite resource is lost every day, mainly as a result of wastage due to inadequate metering. Most households and businesses do not have mechanisms in place to ensure that water stored in tanks and reservoirs remains at acceptable levels.

A major issue for utility companies in Africa is unaccounted water. Developing nations lose an estimated 45 million cubic metres (45 billion litres) of water every day. This amount is enough to provide for roughly 200 million people. The overall yearly cost of non-revenue water (NRW) to water companies globally is estimated to be $14 billion, according to a 2006 World Bank analysis. Apparent losses in 2015 were calculated to be 30 million cubic metres (35 billion litres).[1]

Another major issue African households face is access to clean water. According to the World Health Organization's (WHO) strategy for 2018–2025, inadequate water, sanitation and hygiene have caused 842,000 diarrhea deaths in 2012, and deaths from several other diseases especially in Sub-Saharan Africa.[2] According to UNICEF, seventy percent of households in Ghana are at risk of drinking water that is contaminated with faecal matter. Moreover, only four percent of households treat water suitably before drinking it, and ninety-three percent of households do not treat water at all.[3]

From the above discussion, it can be deduced that wastage of water and access to clean water are problems for Ghanaian households.

Fig 1.1 Container overflow in legacy homestel

1.3 OBJECTIVES

1.3.1 General Objectives

The general objective of this project is to reduce the occurrence of water wastage as a result of people forgetting to turn off their water pumps after filling their water tanks. With the help of the auto cut-off mechanism, water would not exceed a predetermined threshold during the filling of water tanks. In addition, this project seeks to ensure the provision of clean water for consumption and other domestic uses. The purity checker included in this project would notify users with the help of the wireless module if water stored in tanks is safe for domestic use.

1.3.2 Specific Objectives

In order to achieve the above mentioned objectives, these specific objectives have been outlined:

1. To design and develop a microcontroller-based water level controller with auto-cut off and a purity checker that can be used for efficient water management.
2. To be able to transmit purity levels through a Wireless module to the user
3. To evaluate the performance of the water level controller with auto-cut off and a purity checker and compare it with traditional water management methods.
4. To demonstrate the potential of the project to contribute towards sustainable water management practices.

1.4 SCOPE OF STUDY

This project involves the design and development of a microcontroller-based water level controller with auto-cutoff and a purity checker for use in the homes. The decision to concentrate on domestic use has been made because a critical and extensive consumer base is served. Domestic households represent a significant portion of water consumers, and by specializing in this sector, the pressing needs for efficient water resource management at the household level can be directly addressed. Domestic users frequently face issues such as water waste from overflows, worries about the quality of the water, and the necessity for user-friendly solutions. A solution that specifically solves these pervasive problems can be created by focusing only on domestic applications, which will help a lot of people and homes. It is recognized that domestic users often have limited budgets compared to industrial or commercial entities. By catering to this market, the product is ensured to be affordable and accessible to a broader population, making a positive impact on water conservation and sustainability at the grassroots level.

1.5 SIGNIFICANCE OF STUDY

Water conservation: By using a water level indicator, customers may readily check the water level in their reservoirs or tanks and save water by not filling the tank to the top or overfilling it. In regions with few water supplies or where drought conditions are common, this is especially crucial.

Access to clean water is ensured through this project's purity checker function, which addresses the global problem of contaminated water by ensuring that the water being used is safe for consumption. A vital human right is to have access to clean water for drinking, but sadly, many people worldwide still do not have this opportunity. Human activities that contaminate water can cause major health issues including diarrhea, cholera, and other water-borne illnesses. By informing the user of the water's purity before use, this project, a microcontroller-based water level monitor with auto cut-off and purity checker, contributes to ensuring that everyone has access to clean drinking water. The purity checker feature of this project uses sensors to detect impurities. The system notifies the user that the water is unsafe to drink if it determines that the water quality is inadequate.

Cost- Reduction: A precious resource, water is required for numerous domestic, professional, and industrial activities. Yet, getting and utilizing water may be expensive, particularly in places with scarce water supplies or unstable water supplies.

The following are some ways that this project, a microcontroller-based water level indicator with auto cut-off and purity checker, might lower the price of using water:

1. Eliminating water waste: This project's automatic cut-off feature makes sure that the water supply is stopped once the tank is full, eliminating overflowing and water waste. Particularly in regions where the cost of water is high, this might result in considerable cost savings on water bills.
2. Cost-effectiveness of water treatment: This project's purity checker function assures that the water being used is fit for consumption, obviating the need for expensive water treatment and purification procedures. This can reduce the cost of water treatment for homes, companies, and industries.
3. Encouraging effective water use: This project's water level indicator feature makes it simpler for customers to keep track of their water usage and cut back on wasteful water use. Lower water costs may arise from improved water consumption knowledge and the encouragement of more effective water use habits.

Increasing sustainability: meeting current requirements without sacrificing the potential of future generations to satisfy their own needs is known as sustainability. In regions where natural resources, like water, are scarce and there is a great demand for them, sustainable practices are crucial. This project's water level indicator feature makes it simpler for consumers to keep track of their water usage and cut back on wasteful water use. This can help spread the word about the value of saving water resources and encourage sustainable water usage practices. Through preserving water resources, lowering water pollution, and encouraging sustainable water use practices, this project can help improve sustainability. This helps guarantee that natural resources are handled sustainably and responsibly, which can have a substantial positive impact on the environment and future generations.

This project is justified because it tackles significant social issues including water shortages, accessibility to safe water, and sustainability, while also promoting innovation and cost-cutting.

CHAPTER TWO: LITERATURE REVIEW

2.1 INTRODUCTION

Water level indicator systems with auto cut-off and purity checkers are important for ensuring the availability of clean water and preventing water wastage. The effectiveness of a microcontroller-based water level indicator system with auto cut-off and purity checker has been studied in a number of research papers. This chapter will examine a few of these research, reviewing their modes of operation, contributions and contributions, and pointing out their shortcomings.

2.2 OVERVIEW OF EXISTING SYSTEMS

2.2.1 Presentation on Water Level Detector

A project under the aforementioned title was undertaken by Bhushan Kumbhalkar in the year 2014. This project makes use of probes to detect the level of water in the tank. The probes are connected to transistors, used as switches, which are in turn connected to LEDs. When a probe comes into contact with water, a conductive path is established, and the transistor is used to turn on the connected LED. This shows the user the level of water in the container. When the tank is full, a buzzer sounds to indicate to the user that the tank has been filled. [4]

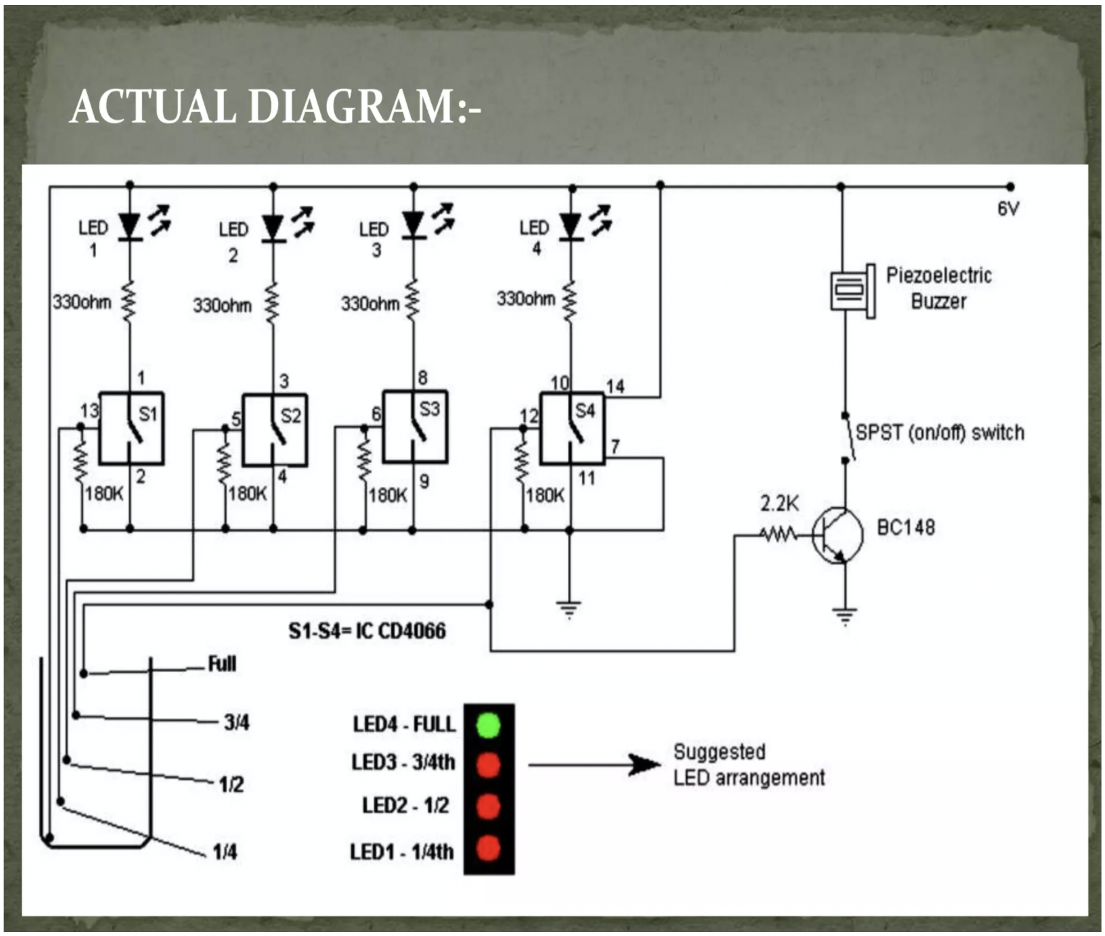

Fig 2.1 Schematic of solution as proposed by Bhushan Kumbhalkar

Strengths

- The method is simple and easy to implement.
- The proposed solution is cost effective.
- The use of probes offers better accuracy in terms of measuring water level.

Weaknesses

- Without the auto cut-off mechanism, the solution would require manual operation of the switch.
- This project does not implement the purity checker, making it difficult to determine the quality of water.
- The metal probes are prone to rusting, decreasing the quality of the water and affecting the conductivity of the probes.

2.2.2 Water Level Monitoring and Management of Dams Using IoT

A study was conducted by Phaneendra Babu and Ms. Sai Sreekar Siddula proposing a cloud based water level monitoring and management system in the year 2018. The flexibility of the network would offer control of the system from any place via access to cloud data on different types of devices. The system deals with the idea of collecting and sharing real-time information about water levels with an authorized central command center through far field communication. The authorized central command center then takes a call on whether to release the water by opening the dam gates or keep them closed. By doing so, the project aims for the operation of dams all over the country to be centralized and automated. [5]

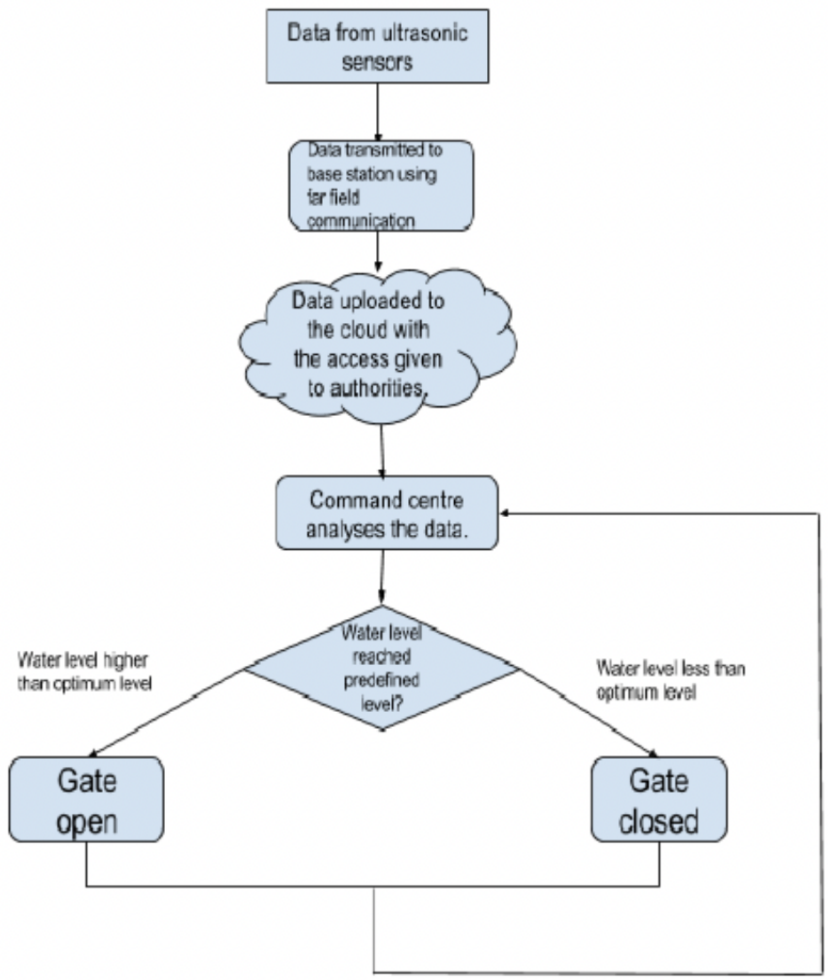

Fig 2.2 Flowchart of the Implementation

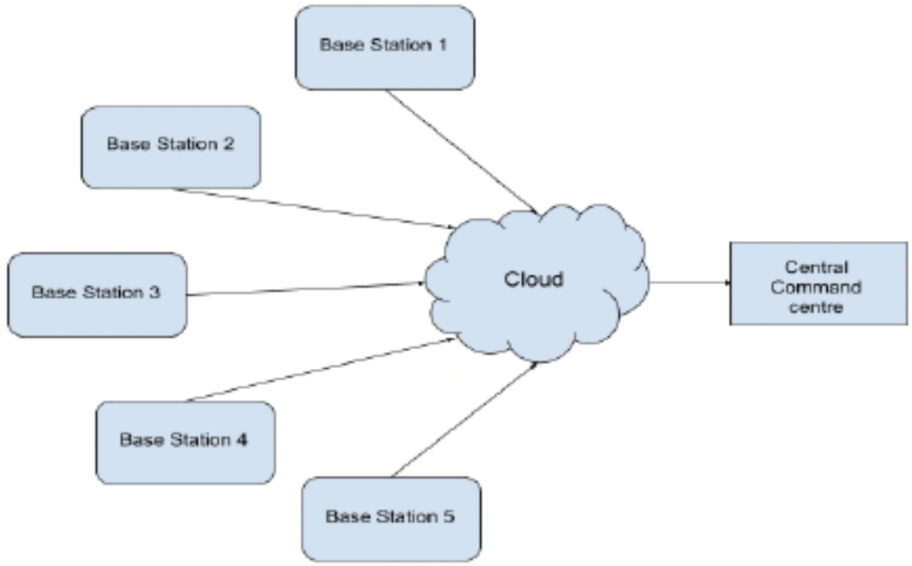

Fig. 2.3 Schematic of the Collection of Nodes

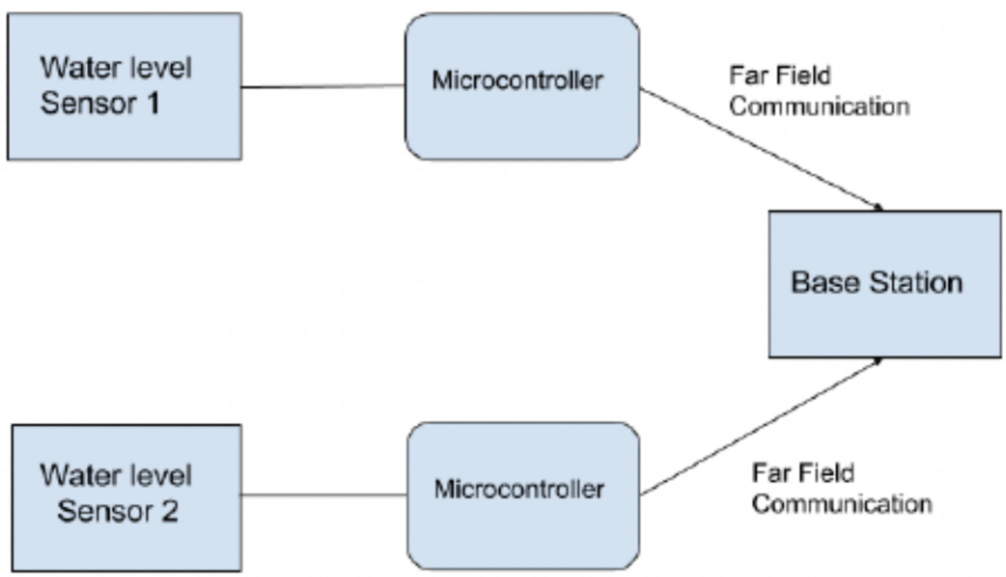

Fig 2.4 Schematic of each node

Strengths

- By eliminating physical labour, this could have a significant positive impact on research pertaining to the effective management of water at dams.
- In cases like floods, where the automated gate raising system will monitor the water levels and respond appropriately, this kind of technology is more useful.
- A simple to configure system that can protect low lying areas by resolving water distribution issues between two regions.

Limitations

- The project would incur extra cost

2.2.3 Automatic Water Level Controller with Short Messaging (SMS) Notification

The paper presents a system for an automatic water level controller with SMS notification. The project was carried out by Sanam Pudasaini, Anuj Pathak, Sukirti Dhakal and Milan Paudel in the year 2014 to assist users in load shedding based countries. The automatic water level controller is a smart system, as all processes occur automatically with continuous updates by the controller to the user via GSM. The SMS notification was added to the automatic controller system so that water can be managed by the user during load shedding. Two systems work synergistically. The program was developed in an Arduino program development environment and uploaded to the microcontroller. The water level in the system is controlled automatically. The controller operates on battery power. Whenever the system encounters an empty level or the status of load shedding, an SMS notification is sent to the user. [6]

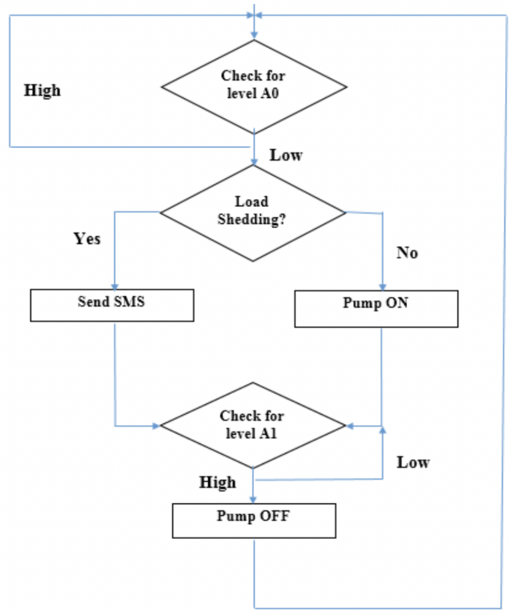

Fig 2.5 Flowchart of system

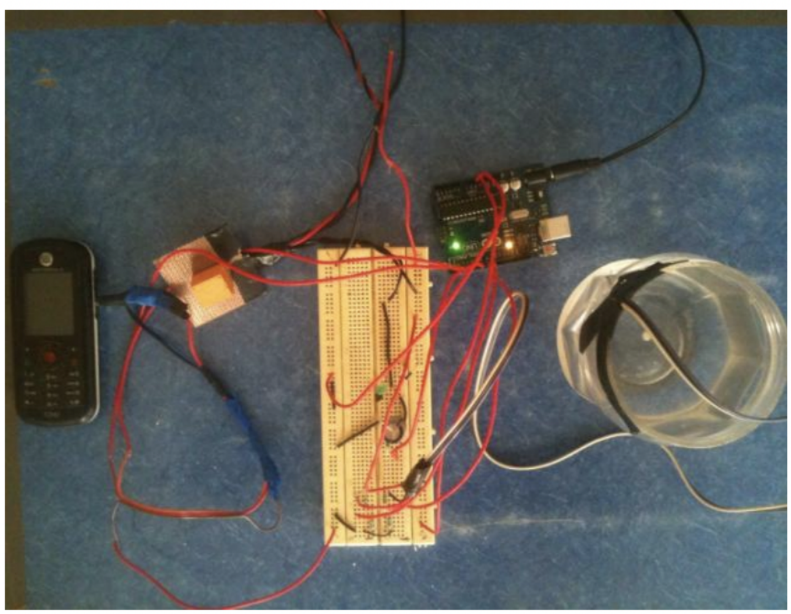

Fig 2.6 Prototype of the system

Strengths

- Water level is controlled automatically, disallowing any wastage of water and manual checking of the water level. This also provides a hassle-free experience.
- Motor overheating due to continuous usage is avoided.

Limitations

- The system would require electricity to function and power outages may affect its performance so in the case when load shedding occurs and there is a blackout, with the phone not having a proper power source, the operation can not be in operation.
- Using the GSM module, the SMS would be reliant on the network connection to send alerts. There might be delays or no message alerts if you are in an area with bad coverage.

2.2.4 A Microcontroller-Based Water Level Indicator using Radio Frequency (RF) Technology and Ultrasonic Sensor

"A microcontroller-based water level indicator using radio frequency technology and an ultrasonic sensor" by Ifeanyi Chinaeke-Ogbuka, Augustine Ajibo and Cosmas Ogbuka, published in the Journal of International Journal of Scientific & Engineering Research in 2019, presents the design and implementation of a water level indicator system that employs Arduino Uno, radio frequency (RF) technology and an ultrasonic sensor. The objective was to reduce the amount of water, energy, time and related dangers that come with the traditional designs of water level indicators. The Arduino receives the water level information from an ultrasonic sensor which when the water level reaches a certain point, automatically turns on or off the water pump. Specifically, the design provides four distinct levels of monitoring: low, medium, third-quarter and full. The level determined by the sensor is wirelessly relayed through radio frequency communication to a receiver device located some distance away from the tank, which subsequently shows the outcome on an LCD. [7]

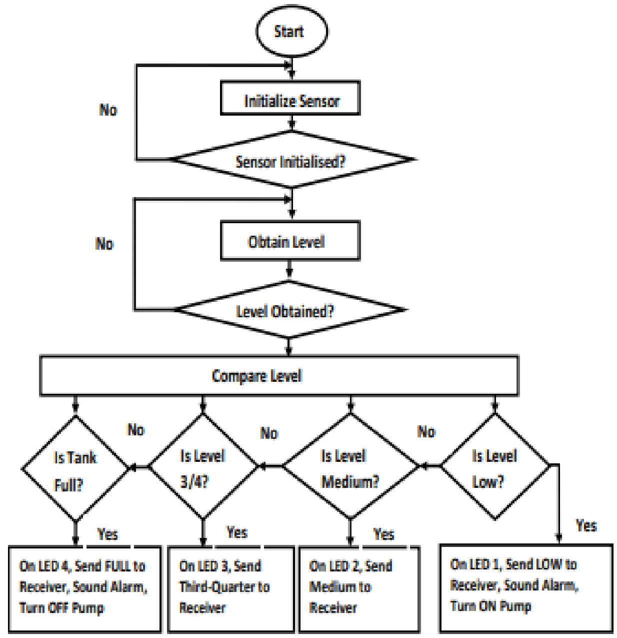

Fig 2.7 Flowchart description of the transmitter system

Fig 2.8 The completed implemented design

Strengths

- A wireless module eliminates the need for complex wiring making installation easier and faster
- The wireless module also allows the system to be scaled up or down easily, without the need for major modification to the hardware

Limitations

- Wireless module can be subject to interference from other electronic devices or environmental factors, such as radio waves or metal structures
- Wireless modules require power to transmit and receive data, which can drain battery or power supply faster than wired solutions

2.2.5 Automated Water Level Monitoring System using Arduino and GSM Module

Research conducted by Vijayalakshmi S., Smriti J. J. and Manikandan K. came up with a device that monitors water levels in tanks using an Arduino and a GSM module in the year 2023. The study sought to come up with a Smart Water Level Monitoring (SWLM) system that uses the Internet of Things (IoT) to deliver continuous water level measurement. To gauge the water levels, numerous Internet of Things (IoT) devices are interconnected. Some of these devices include ultrasonic sensors, an Arduino Uno and a GSM module. Data extracted from the sensors is sent to a mobile application created with Flutter, and the data is then saved on a platform called ThingSpeak in the cloud. According to the collected results, the suggested system would be able to evaluate the water levels and display the water level percentage in the application created with Flutter. [8]

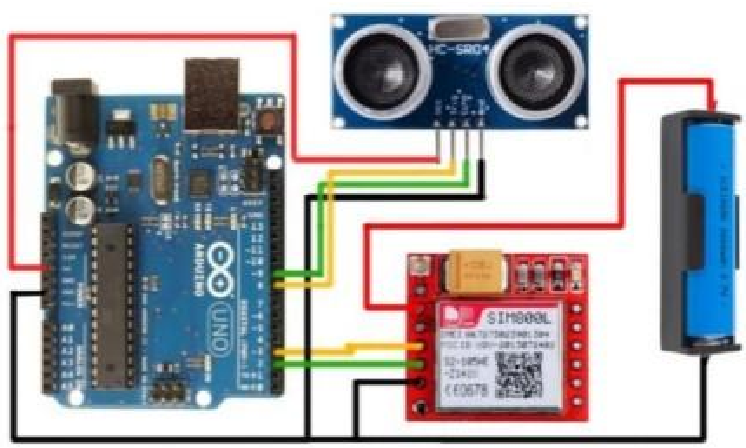

Fig 2.9 Circuit diagram of connected components

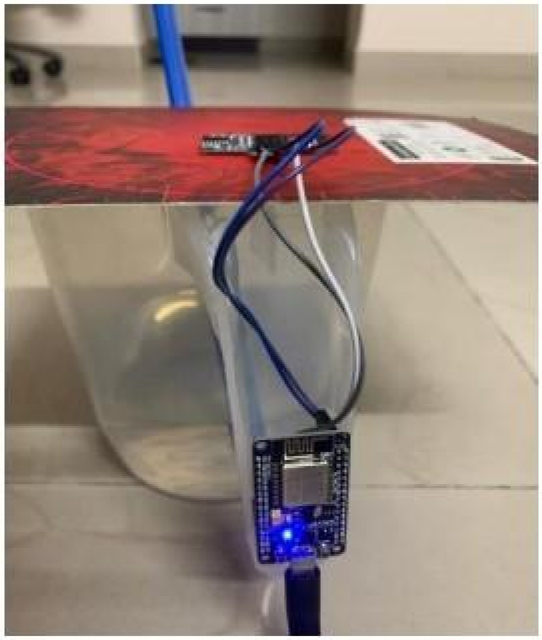

Fig 2.10 Hardware setup

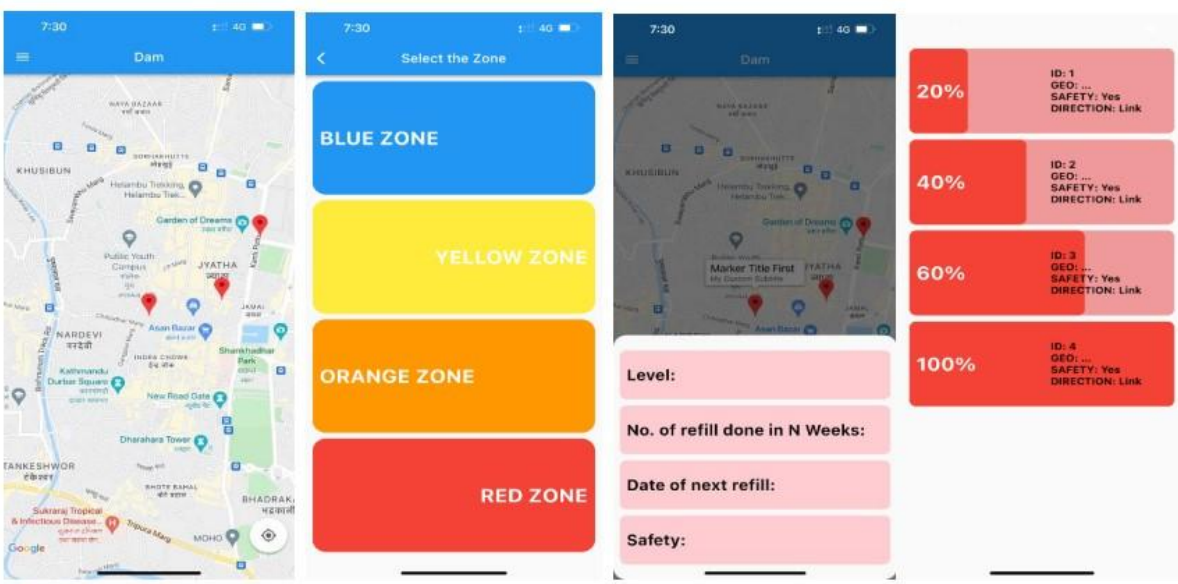

Fig 2.11 Interface of Flutter application

Strengths

- The interface of the Flutter application is user friendly.
- The final product is not bulky or cumbersome.

Limitations

- The use of the GSM module means that the product and the connected device(s) will require constant and reliable internet connectivity to operate.
- The user will still have to manually turn the tap on or turn it off.

2.2.6 Automatic Water Level Indicator and Controller using Arduino

Pooja K., Kusumavathi, Pavithra, Nishmitha and Aishwarya D. S. of the Yenepoya Institute of Technology, Moodbidri, Karnataka, India, wrote a research paper on how to implement a water level indicator using an Arduino Uno in the year 2020. Their suggested solution makes use of an Arduino Uno, an ultrasonic sensor, a seven-segment display, a relay and some connecting wires. When the circuit is powered, the ultrasonic sensor transmits a sound signal towards the bottom of the tank. The time taken for the sound signal is noted and used to determine the water level. Predetermined levels of water, each corresponding to a number, are included in the Arduino program. The level is displayed on the seven-segment display. [9]

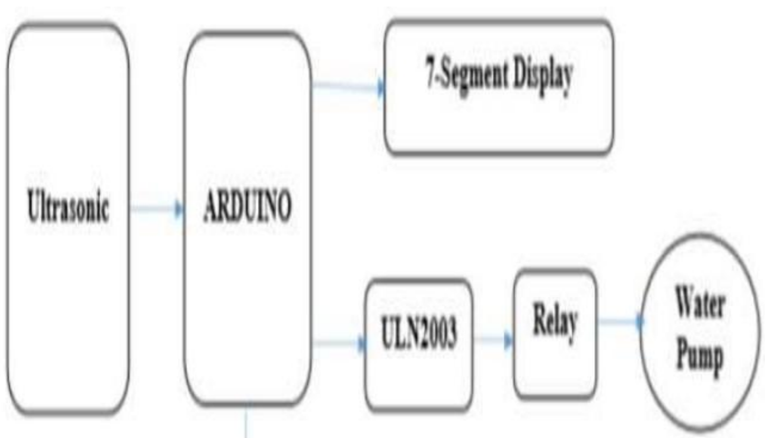

Fig 2.12 Block diagram representation of the proposed solution

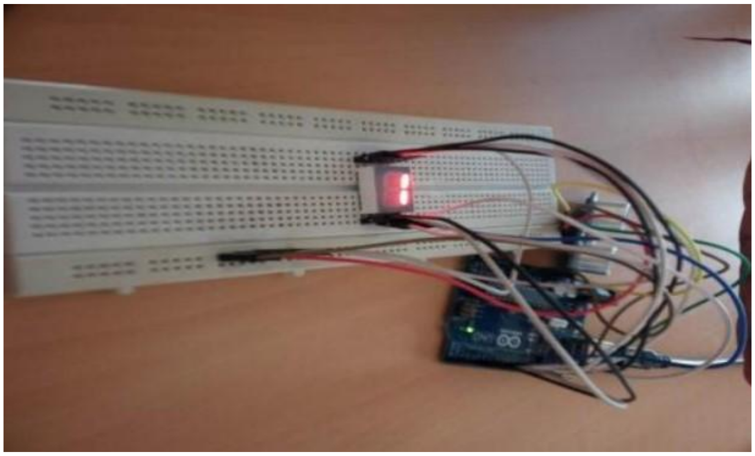

Fig 2.13 Finished product displaying water level 1

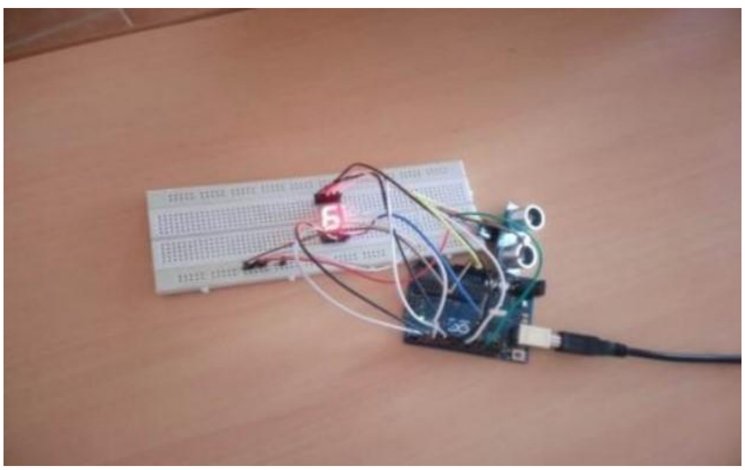

Fig 2.14 Finished product displaying water level 6

Strength

- The finished product is simple and easy to use.

Weakness

- Manual switching of the tap is required.

CHAPTER THREE: METHODOLOGY

3.1 INTRODUCTION

This chapter details the research methodology for the study. In this section, the steps to design a microcontroller-based water level indicator with auto cut-off and purity checker are outlined and the components are discussed. The method used to develop the system is explained in detail with flowcharts and schematics.

3.2 SYSTEMATIC ARCHITECTURE

Figure 3.1 demonstrates the architecture of the proposed system, including how the ATmega328 microcontroller integrates with sensors and functions as a controller.
Purity sensors, pump, relay, transistors and ESP32 are used.

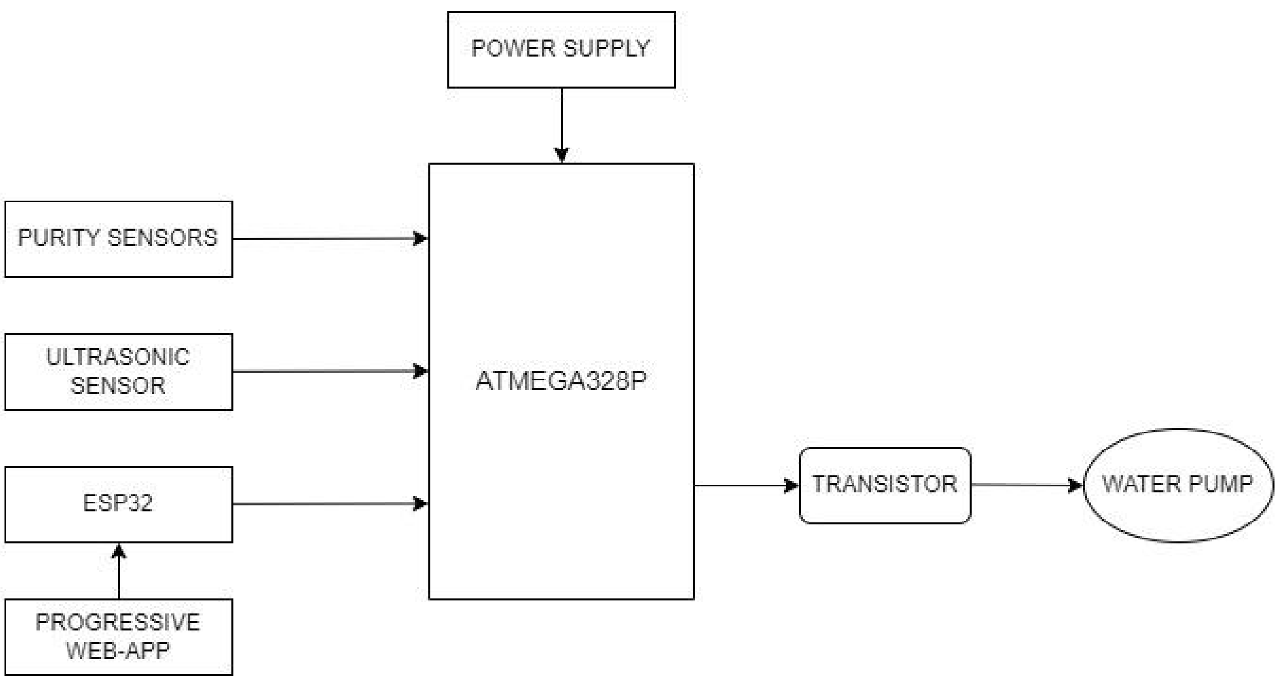

Fig 3.1 Block Diagram of Microcontroller based water level indicator with auto cut-off and purity checker.

3.3 FLOWCHART

This section presents the flowchart for a microcontroller-based water level indicator with an automatic cutoff and purity checker. The flowchart begins with the microcontroller and input/output pins being initialized. After that, a loop repeats the measurement and control operations. Using an ultrasonic sensor, the loop's initial step is to determine the water level.

The microcontroller then compares the reading of the water level with the maximum and minimum values. The microcontroller triggers the relay to turn on the pump and fill the tank if the water level is equal to or below the minimal level. The microprocessor activates the relay to shut off the pump if the water level is equal to or higher than the maximum threshold. The microcontroller waits for a certain amount of time before taking another measurement if the water falls within the required range.

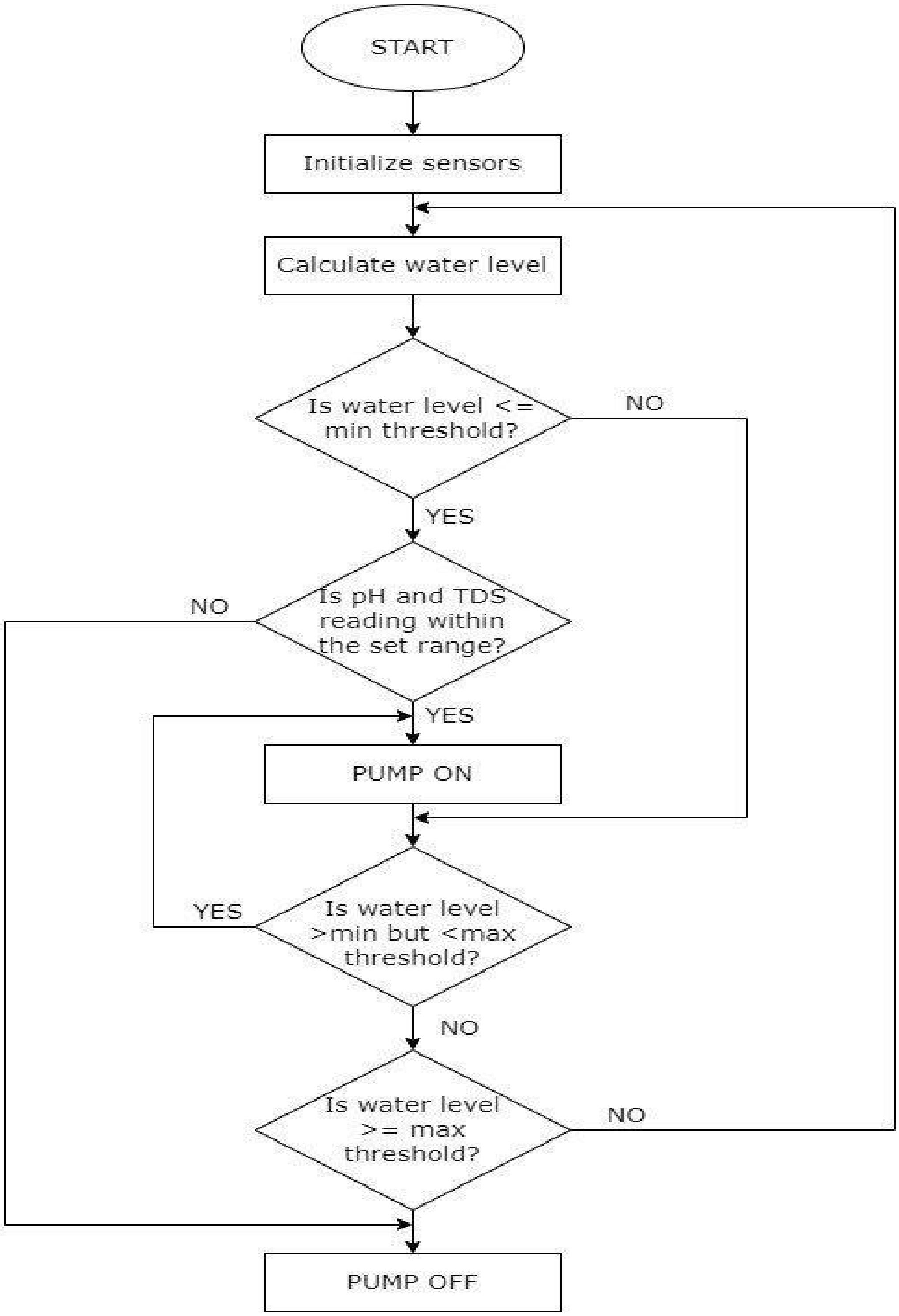

Fig 3.2 Flowchart of Microcontroller based water level indicator with auto cut-off and purity checker

3.4 HARDWARE REQUIREMENTS

3.4.1 ATMEGA328 MICROCONTROLLER

This serves as the brain of the system and is responsible for reading ultrasonic sensor data and interpreting it to determine the water level. It sends control signals to the other components of the device to ensure their proper functioning. It stores the program code, which is necessary for the program to execute.
The ATmega328 microcontroller was chosen for this particular project because:

- It is flexible.
- It proves to be cost effective, hence making the final product less costly for users.
- Its size will also make the final product portable.

Fig 3.3 ATmega328 microcontroller

3.4.2 ULTRASONIC SENSOR

The ultrasonic sensor is used for detecting distance. When the trig pin receives a HIGH signal from the microcontroller, the sensor transmits a sound wave through the air and bounces off the surface of the water and the wave is reflected to the sensor. The echo pin receives the reflected sound wave and sends it to the microcontroller which calculates the distance based on the duration the reflected signal gets back to the ultrasonic sensor.

Fig 3.4 Ultrasonic Sensor

3.4.3 TRANSISTOR

Transistors in this project will be used for both amplification and as a switch. Since the relay and other components require more current than what the output pin of the Arduino can provide, a transistor would be required to amplify the current in order for the functioning of these components. NPN transistors would be used for this project. The NPN transistor has a higher current gain than the PNP transistor, making it more suitable for this project.

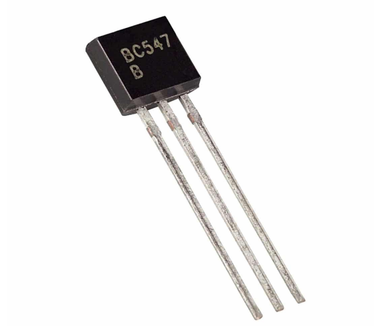

Fig 3.5 Transistor

3.4.4 RESISTORS

It acts as a current limiter, thus limiting the amount of current flowing through a device. An overflow of current would damage the device, hence the need for resistors.

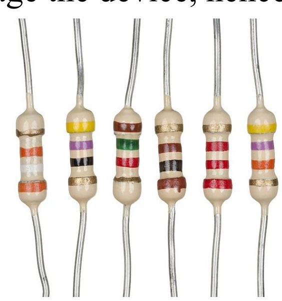

Fig 3.6 Resistors

3.4.5 JUMPER WIRES

The jumper wires provide a flexible and convenient way to create electrical connections between different components in the circuit. Jumper cables can be inserted into the female headers or pins of the various components i.e. the microcontroller, sensors, relay and Bluetooth module to create the necessary electrical connections.
Jumper cables allow for quick and easy prototyping and testing of the circuit as the connections can be easily rearranged or modified as needed. They also provide a modular and flexible approach to building the circuit, which makes it easier to troubleshoot and fix any issue which may arise.

Fig 3.7 Jumper wires

3.4.6 CAPACITOR

The capacitor acts as a filter and voltage stabilizer for the power supply. The capacitor is connected in parallel with the power, between the VCC and GND pins of the ATmega microcontroller. When the power supply voltage fluctuates, the capacitor helps to maintain a stable voltage by storing electrical charge and releasing it as needed.
In addition to the voltage stabilizer, the capacitor can also filter out high frequency noise and spikes from the power supply, which can cause interference and affect the performance of the microcontroller and other components in the circuit.

Fig 3.8 Capacitors

3.4.7 pH SENSOR

The pH sensor typically consists of a pH-sensitive electrode and a reference electrode which are immersed in the water being tested. The pH-sensitive electrode generates a voltage signal that is proportional to the pH level of the water while the reference electrode provides a stable reference voltage.

The voltage signals from the pH sensor are then processed by the ATmega microcontroller , which uses a calibration curve to convert the voltage signal into a PH reading. The pH reading is then compared to a predefined threshold value, which determines whether the water is pure or impure. The value is then transmitted wirelessly to a Bluetooth device through the Bluetooth module to the user.

The pH level of drinking water should be in the range of 6.5–8.5.

Fig 3.9 pH Sensor

3.4.8 TDS(TOTAL DISSOLVED SOLIDS) METER

TDS meters are used to determine the amount of Total Dissolved Solids (TDS) in a liquid solution. It is a useful tool for determining the concentration of dissolved compounds in water or other fluids. TDS is the total amount of inorganic salts, minerals, metals, and occasionally organic materials in a solution. The electrical conductivity of the solution is measured using the TDS meter. The presence of dissolved particles in water increases its electrical conductivity. This feature is used by the TDS meter to estimate the concentration of dissolved solids.

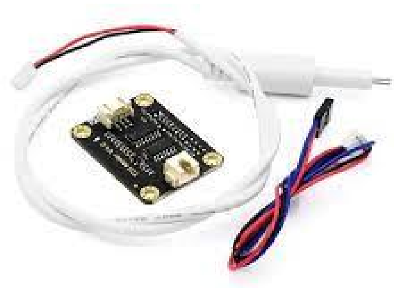

Fig 3.10 Total Dissolved Solids Sensor

3.4.9 ESP 32

The ESP32 is a versatile microcontroller that offers built-in Wi-Fi and Bluetooth capabilities, making it an ideal choice for wirelessly transmitting data between the water quality sensors and the central server or application. The wireless module allows the Atmega microcontroller to send water purity data to our server in real time. The user can then take the appropriate action to restore the water's purity such as cleaning the tank or changing the filter.

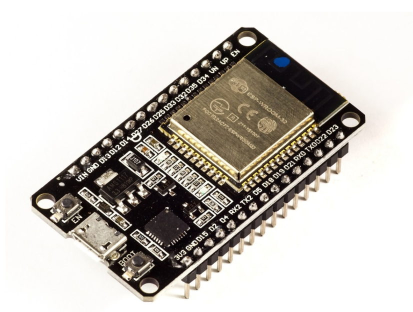

Fig 3.11 ESP32

3.5 SYSTEM SCHEMATIC

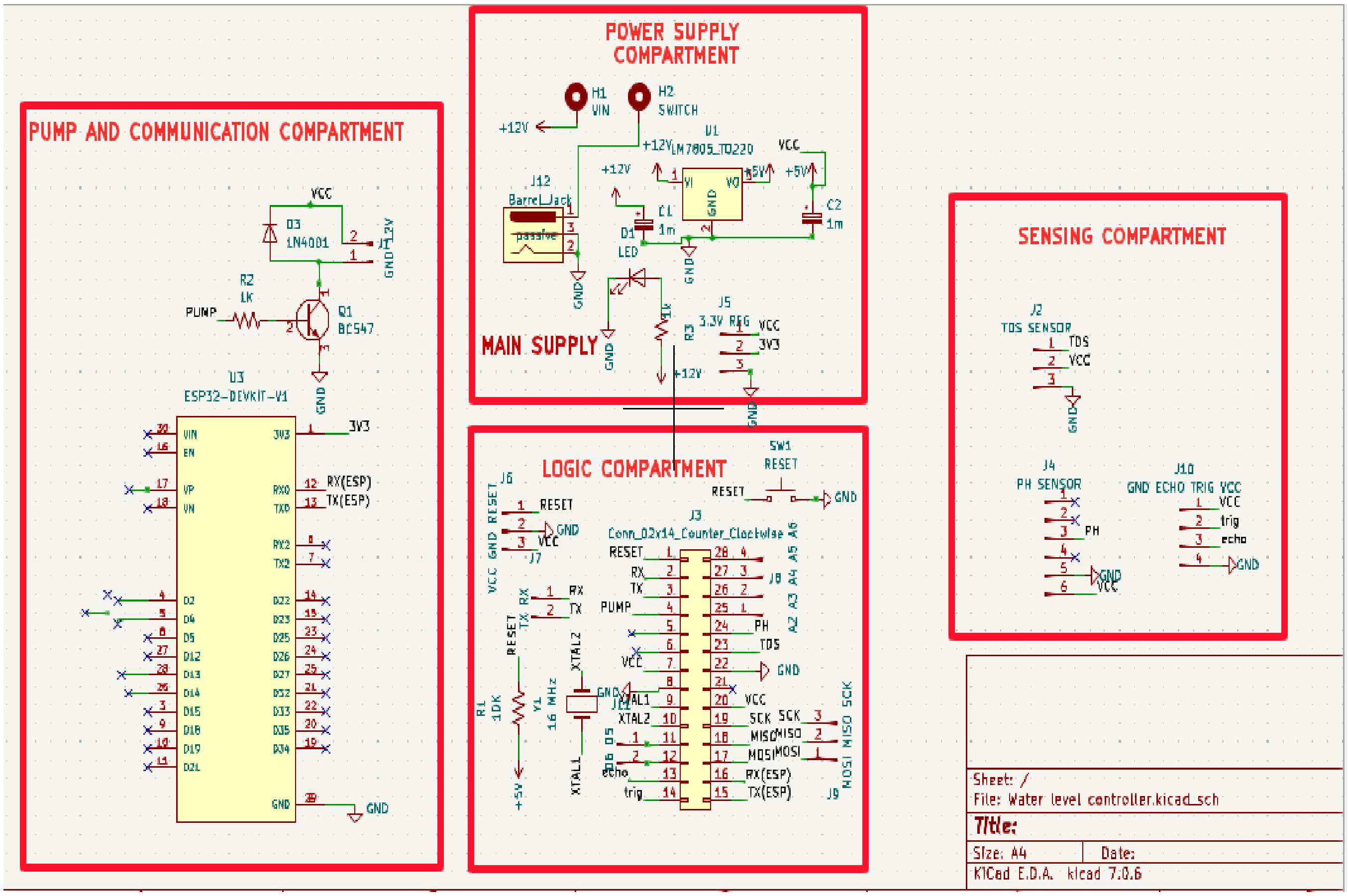

Fig 3.12 Schematic of solution

Based on the above schematic, the capacitor serves as a voltage stabilizer, which takes off any voltage variations from the power supply and hence provides a steady voltage to the microcontroller.

The ultrasonic sensor is also connected to the ATmega328, which operates based on the emission and echo of sound waves. The sensor emits high frequency waves of about 40kHz-200kHz, above human hearing when the trig pin receives a HIGH signal from the microcontroller. This sound wave travels through the air and bounces off the surface of the water and the sensor receives the reflected wave. The echo pin then receives the signal from the reflected wave. The time it takes for the sound wave to be reflected to the sensor is directly proportional to the distance between the sensor and the surface of the water.

The transistor which is also connected to the Atmega microcontroller functions as a switch thereby controlling the water pump. Due to the presence of a magnetic field in the water pump, a diode is present to shunt this high voltage spike to ground. The diode being connected parallel to the relay coil effectively short-circuits the voltage spike and therefore protects the other components.

The pH sensor and TDS sensor are responsible for checking the purity of the water and the purity level detected is being transferred to a progressive web application through a wireless module. The progressive web application displays the various readings from the purity sensors and then the user is made aware if the water available in the container is pure or impure.

3.6 SOFTWARE DEVELOPMENT LIFE CYCLE

The Software Development Life Cycle (SDLC) is a well-defined and systematic project management model. It details the various stages that brought the project idea from ideation to deployment and later maintenance. The SDLC runs through a number of stages, which are discussed below. [10]

3.6.1 PLANNING AND REQUIREMENTS ANALYSIS

As part of this, the project's stakeholders were identified, a budget was defined, and a timeline was established, along with the project's objectives, goals, and scope. In order for us to determine what the programme would be able to do and what features it would have, requirements were gathered during this stage. We created a plan for risk reduction and identified any potential dangers during this phase.

3.6.2 DEFINING REQUIREMENTS

Our project's development process includes a crucial phase called requirements definition. In this phase, we focus on the precise requirements of our project. We carefully outline both the functional and non-functional requirements, detailing the expected behaviour, functionality, and performance of the system. During this stage, it is apparently decided that the team is in agreement about the goals the system would achieve. Establishing requirements gave the project team a well-organized road map to use as we advanced through the design, development, and testing phases, finally resulting in the effective completion of our project's goals.

3.6.3 DESIGN

A significant turning point in our project occurred during the Design phase. We moved from an abstract idea of our system to detailed execution strategies. A clear picture of the system's structure was created through architectural design, highlighting the system's suitability for household settings. Subsequently, we got into the specific design of the hardware and software parts. Our system was designed with the specific needs of home water management in mind, with the help of user-friendly and dependable hardware components.

3.6.4 BUILDING AND DEVELOPING THE PRODUCT

We moved on to the Implementation phase with precise designs in hand. Here, we turned our ideas into actual objects. The precisely manufactured hardware pieces were put together and integrated for home use. To ensure its functionality in regulating water levels and checking the purity of the water, the software code was simultaneously produced and put through a thorough testing process. As a result of this stage, a functional prototype of our Microcontroller-Based Water Level Controller with Auto Cut-off and Purity Checker was created, prepared for additional testing and assessment.

3.6.5 TESTING AND INTEGRATION

We closely examined the system's performance during the testing and integration process to make sure it complied with the set objectives. While system testing evaluated the overall performance of the system, unit testing allowed us to confirm the functionality of specific system components. We were able to make adjustments to the system to make sure it was flexible enough to meet domestic needs.

3.6.6 DEPLOYMENT AND MAINTENANCE

The "Microcontroller-Based Water Level Controller with Auto Cut-off and Purity Checker" enters the Deployment and Maintenance phase as it prepares to be used in the real world and get continuing maintenance. It includes installation, user education, and ongoing system monitoring to make sure the system functions properly in home settings. In order to maintain the system's dependability and relevance for domestic users, it also places a strong emphasis on long-term maintenance, including updates and improvements.

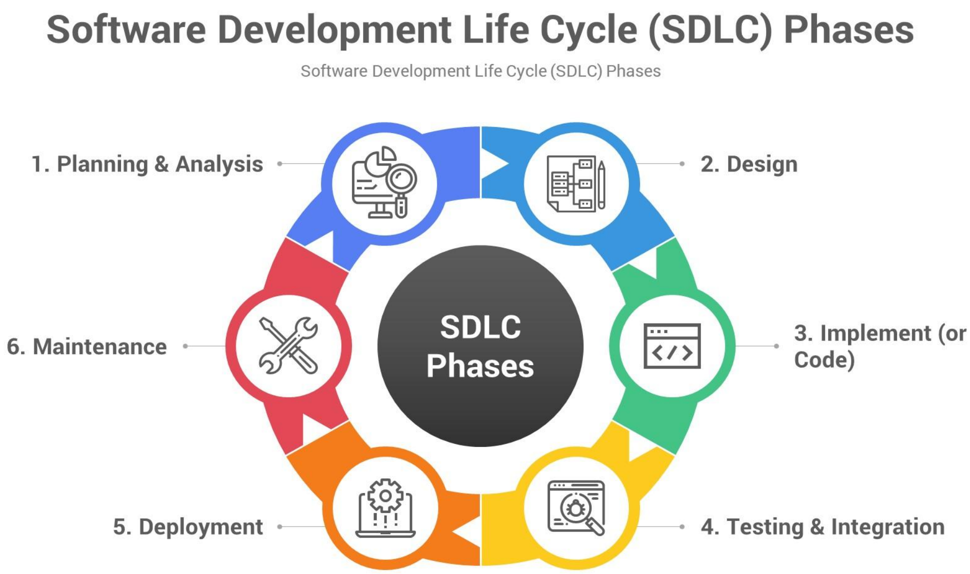

Fig 3.13 SDLC phases

3.7 SOFTWARE DEVELOPMENT MODELS

Software development models are frameworks that guide the software development process. Some of these models include the waterfall, agile, spiral, V-Model, iterative and prototype models. These models specify the different stages of the process and the way these processes are carried out. The testing that is performed is highly affected by the choice of model, which will define the where, when and how of our anticipated testing, have an impact on regression testing and essentially dictate the test methodologies to employ. [11]

3.7.1 AGILE MODEL DEVELOPMENT

We actively used Agile concepts to promote adaptability, cooperation, and customer-centricity throughout the project. Our strategy was greatly influenced by the Agile paradigm. By using iterative development, we were able to divide the project into manageable stages and continuously adapt the system to the changing demands of local users. Our regular interactions with stakeholders, especially domestic users, who gave us priceless feedback and guided our development, showed how much emphasis Agile places on collaboration. We could concentrate on providing the most valuable features first thanks to user stories and backlog prioritization. Validation and testing on a regular basis ensured consistency with user expectations and quality. Retrospectives and sprint reviews gave people a chance to think and get better. A more user-centric final result was made possible by agile approaches, which allowed us to react quickly to adjustments hence ultimately enhanced its effectiveness and user satisfaction.

3.7.2 USER FUNCTIONALITIES

- The user can check the pH value of the water
- The user can check the total dissolved solids value of the water

3.7.3 ALGORITHM FOR USER FUNCTIONALITIES

- The user opens the web app
- Sign in with google.
- The app displays the purity level.

3.7.4 PLATFORM DEPENDENCIES AND LANGUAGES

1. **React**

React is a popular JavaScript library for building user interfaces. It provides a component-based architecture, which makes it easier to manage and reuse UI elements. React also offers a virtual DOM for efficient rendering and updates, resulting in improved performance. It has a large and active community, providing extensive resources and third-party libraries for development.

2. **Next.js**

Next.js is a framework for building React applications, focusing on server-side rendering, static site generation, and routing. It provides automatic code splitting, optimized server rendering, and a file-based routing system. Next.js simplifies SEO optimization, improves performance, and offers a great developer experience.
The app was leaned towards the Next.js framework because of support for API routes in building serverless functions.

3. **Node.js**

Node.js is a JavaScript runtime that allows you to run JavaScript code on the server-side. It's known for its non-blocking, event-driven architecture, making it well-suited for building scalable and real-time applications. Node.js has a vast ecosystem of packages available through npm, which allows us to easily integrate various libraries and tools into the app.

4. **npm (Node-Package Manager)**

npm is the default package manager for Node.js. It allowed us to easily install, manage, and update third-party libraries and packages in our web app. npm offers a vast collection of open-source packages, which can significantly speed up development by providing pre-built solutions for common tasks. The command-line interface makes it easy to manage dependencies and scripts.

5. **Next-auth**

next-auth is a widely used authentication library for Next.js applications. NextAuth.js was used to implement GoogleAuth as one of its authentication providers. Meaning, NextAuth.js was configured to allow users to sign in using their Google accounts. The library abstracts the complexities of OAuth flow and provides an easy-to-use interface for integrating Google Auth and other authentication methods. We also chose it because it is a great fit for our cloud platform where the web application was hosted.

6. **Vercel**

Vercel is the cloud platform we decided to deploy and host our web application on. It specializes in providing fast and optimized deployment processes, making it easy to deploy static sites, serverless functions, and full-stack applications. Vercel offers a user-friendly interface, automated deployment, and provides built-in optimizations for performance and security. It supports automatic scaling, custom domains, and collaboration features, making it a convenient choice for hosting our application.

7. **C Programming for Arduino**

The Arduino board was programmed using the C programming language and some of the advantages of C in programming this board were:

Low-Level Control: C allows direct control over the hardware of microcontrollers, making it suitable for tasks where precise control is required, such as reading sensors or controlling actuators.

Access to Libraries: The Arduino platform provided a rich set of libraries that abstract many low-level operations, which allowed us to focus on your project's logic.

Wide Community: A large community of developers, resources, and tutorials was available to help us when we encountered issues or needed guidance.

Compatibility: Arduino boards come with their own IDE (Integrated Development Environment) that supports C programming. This simplifies the process of writing, compiling, and uploading code to the microcontroller.

Real-Time Control: C's low-level nature allowed for real-time control and responsiveness, which was crucial for our project.

Overall, working with C for Arduino programming was a great learning experience, as it gave insights into how microcontrollers operate at a fundamental level.

3.8 SOFTWARE ARCHITECTURE

The web application follows the client-server architecture. The Next.js frontend is client-side and interacts with the Node.js backend server through API endpoints. To read and publish purity readings, the server communicates with the PostgreSQL database. The server stores the purity readings in the cloud database using TRPC processes (HTTP POST API endpoints). Via GET HTTP queries, the front end asks the backend for purity readings. The front-end chart is updated, and data is managed by React Query.

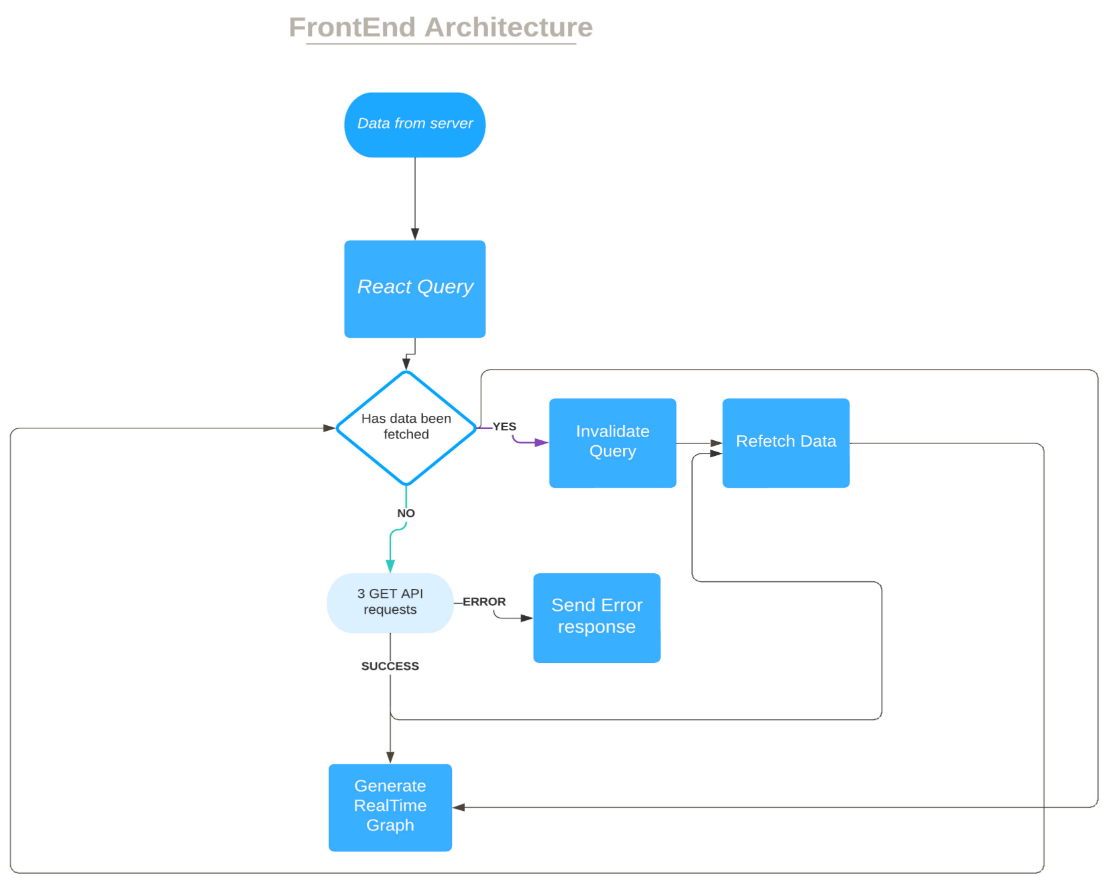

Fig 3.14 Frontend Architecture flowchart

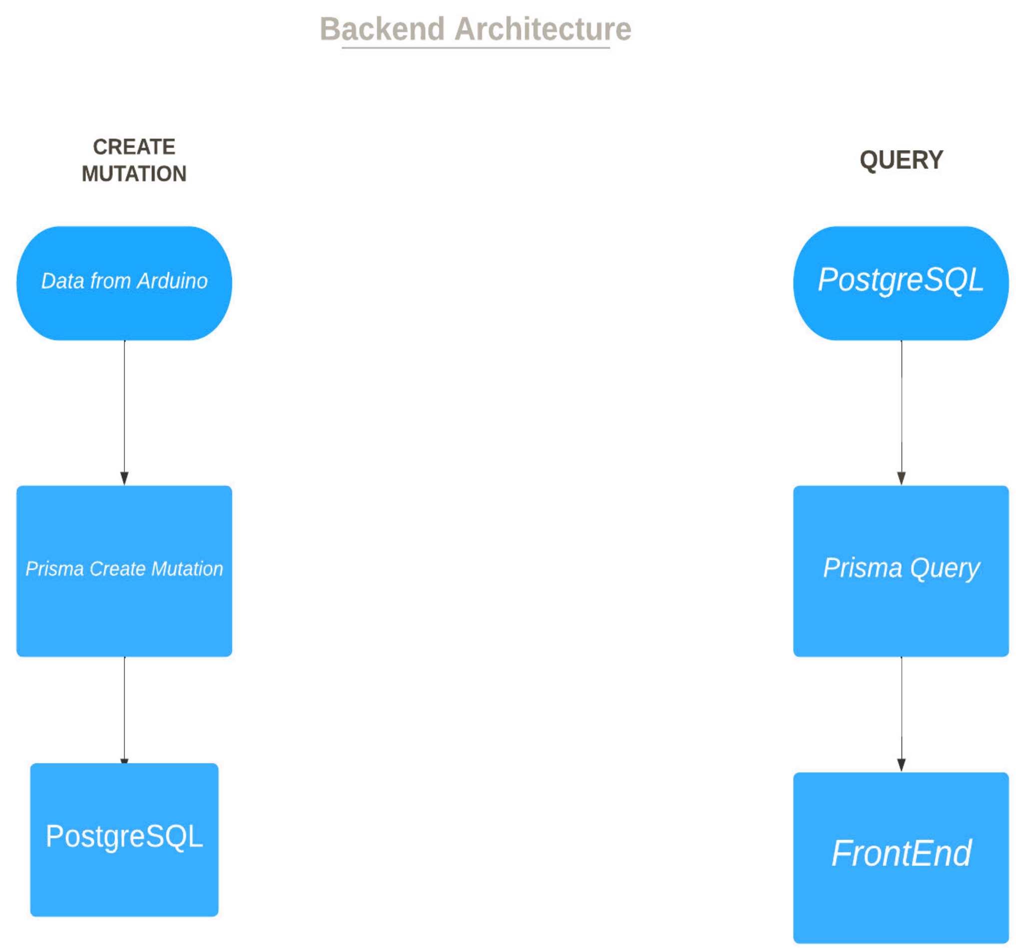

Fig 3.15 Backend Architecture flowchart

CHAPTER FOUR: TESTING AND EVALUATION

4.1 INTRODUCTION

Rigid validation becomes a cornerstone in the process of developing innovative technical solutions to ensure their dependability, correctness and overall usefulness. The testing and evaluation processes are crucial in deciding if our microcontroller-based water level controller with auto cut off and purity checker is suitable for use in practical applications. The approaches and procedures we used to thoroughly test and assess the system's functional capabilities, operational robustness, user experience and overall performance are detailed in this section.

The foundation of the development lifecycle is testing and evaluation, which act as a link between theoretical design and practical implementation. These phases offer a thorough analysis of the system's features, taking into account not only its planned uses but also its adaptability to numerous scenarios and probable difficulties. To ensure that the final product effortlessly matches user expectations and industry benchmarks, incremental adjustments are guided by the insights gained from the rigorous testing and review phases.

We thoroughly examined the system's functionality throughout our functional testing to ensure that it served its intended role, validating key components such as water level control, auto cutoff, and water purity testing. By exposing the system to the reality of the field and evaluating its stability and resilience across long timeframes, operational testing broadened this perspective. This group effort helps the system remain dependable in difficult real-world circumstances.

In the following sections, we'll go into great detail about the exact testing and evaluation techniques we used to create the microcontroller-based water level controller with auto cutoff and purity checker. Our thorough analysis of every system component's performance confirms the guarantee that the finished item not only meets but also exceeds the expectations in terms of effective water resource management and water quality evaluation.

4.1.1 TESTING AND EVALUATION

Extensive testing and evaluation were conducted during the development of the microcontroller-based water level controller with auto cutoff and purity checker to confirm its functionality, accuracy, and dependability.

4.1.2 FUNCTIONAL TESTING

We thoroughly evaluated the essential components of the system, including the water level control, auto cutoff, and water purity testing. Simulating different water level scenarios inside the tank and analyzing the system's responses allowed us to evaluate water level control. The water pump was regularly turned on when the water level dropped below the predetermined threshold and turned off when it rose above the high-water line. These evaluations confirmed the auto cutoff mechanism's precise operation.

We added different pollutants and contaminants to water samples in order to check the cleanliness of the water. The system's sensor array successfully classified water samples based on their purity by properly detecting changes in pH and TDS levels.
To validate the system's ability to recognise changes in water quality, real-world water samples were also examined against recognised standards.

4.1.3 OPERATIONAL TESTING

To assess the system's durability and long-term stability, we subjected it to extensive operational testing under real-world circumstances. This stage intended to find any potential hardware problems, sensor drift, or software bugs that might appear after prolonged use.This thorough testing helped uncover any performance degradation or unexpected behavior that could arise in practical scenarios.

4.1.4 ACCURACY AND PRECISION

We performed comparison experiments with laboratory-grade water quality measuring tools to evaluate the system's accuracy and precision. The reference instruments and the sensor array of the system were used to evaluate water samples with established purity levels. In order to make sure the system's purity checking capacity produced accurate and dependable findings, we were able to determine the degree of agreement between the system's readings and specified standards.

4.1.5 USER EXPERIENCE TESTING

We solicited opinions on the system's usability, interface layout, and general functionality from prospective end users. This qualitative analysis helped us improve the system for a more user-friendly experience by illuminating important user-centric challenges.

4.1.6 EVALUATION OF WEB INTEGRATION

We carefully examined the responsiveness, accessibility, and user interface design of the responsive web application before integrating it. We looked closely at the web app's capacity to show real-time water purity statistics. This study proved that using the web app to engage with the system from a distance was easy and seamless.

As a result of our thorough testing and assessment procedures, we can state with confidence that the microcontroller-based water level controller is an efficient tool for controlling water levels, reducing waste, and determining water quality. The system's dependability, applicability, and user-friendliness were confirmed through the functional, operational, and accuracy tests, as well as through user input and an evaluation of the web app integration. This technology has the potential to greatly contribute to effective water resource management and improved water quality monitoring across a variety of applications, as demonstrated by the testing and evaluation's positive results.

4.2 PHYSICAL DESIGN

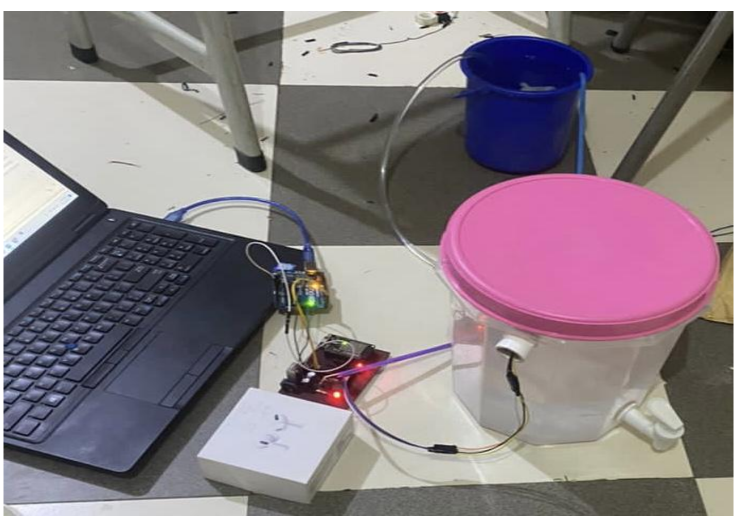

Fig 4.1 Working System

4.3 USER INTERFACE

4.3.1 login

User is authenticated at this section. A user requires a valid google mail and a password in order to login.

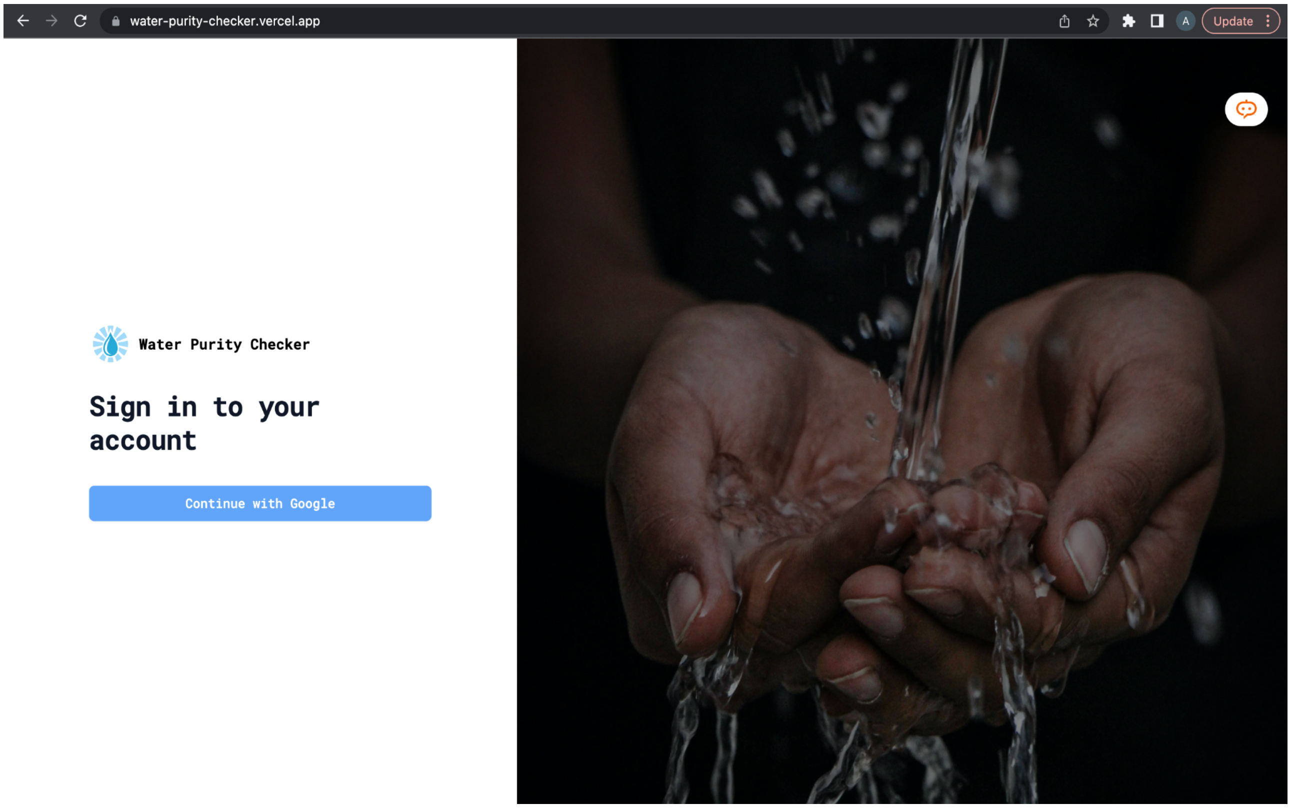

Fig. 4.2 login page

4.3.2 Dashboard

This screen provides a summary of all activities. Ongoing, are two graphs where one shows the pH value that the pH sensor picked up and beneath is a graph for the total dissolved solids in the water.

4.3.3 pH value chart

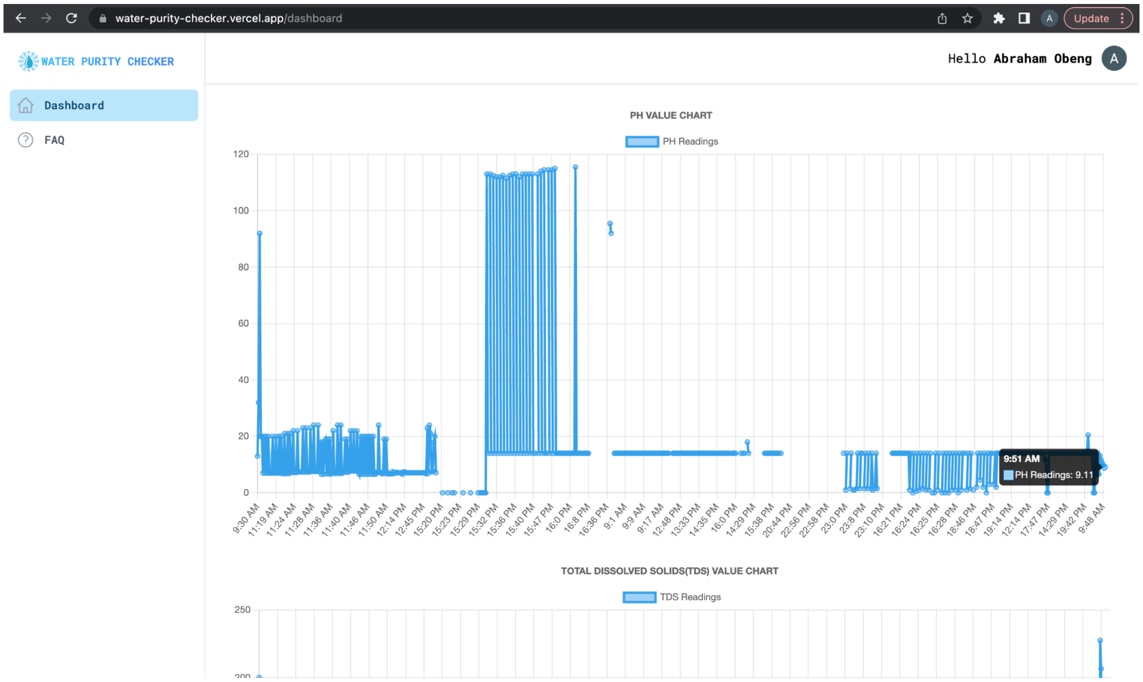

Fig. 4.3 pH value chart

4.3.4 TDS value chart

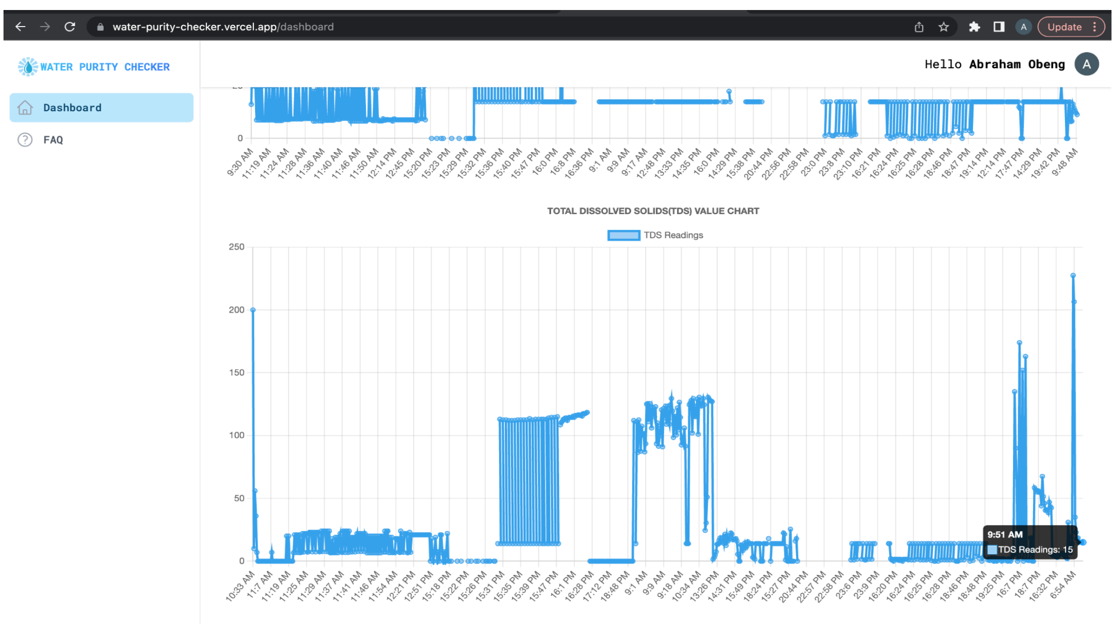

Fig. 4.4 Total dissolved solids chart

4.3.5 FAQ page

Contains a summary of some answers to questions that might be helpful to you.

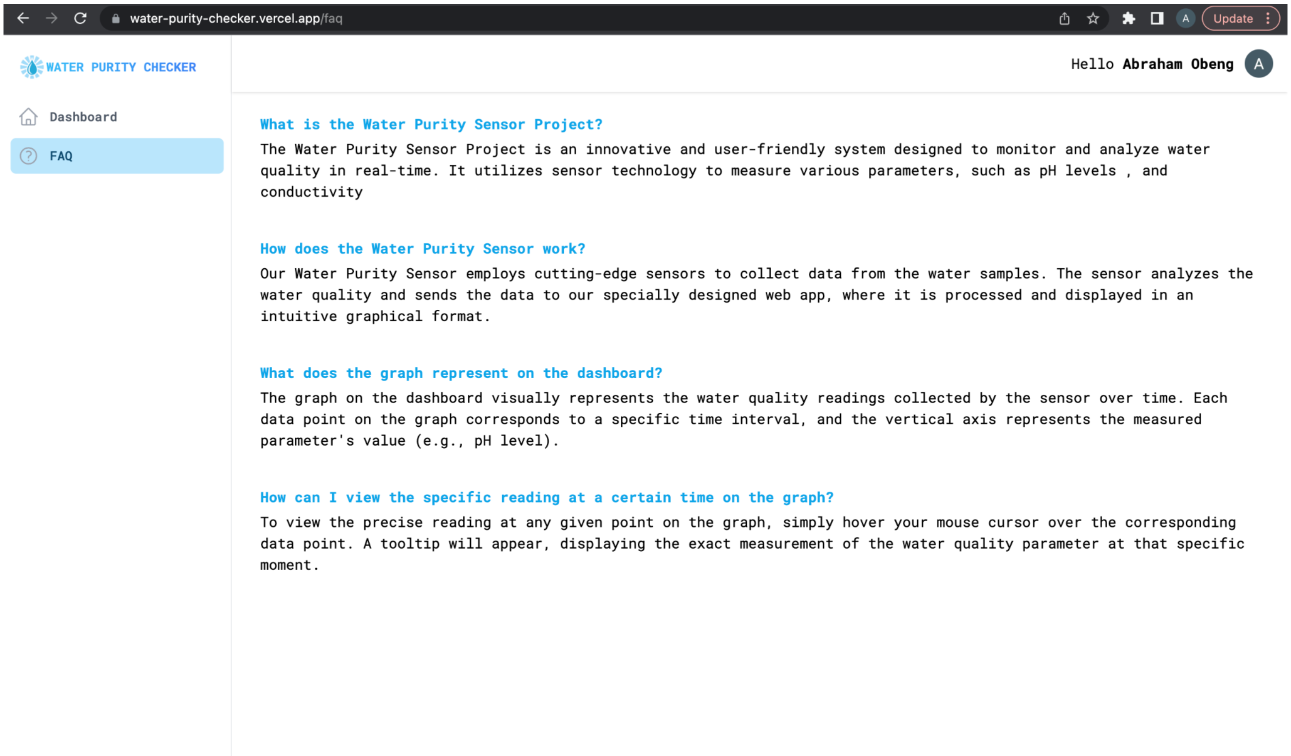

Fig. 4.5 Faq page

CHAPTER FIVE: CONCLUSION AND RECOMMENDATIONS

5.1 CONCLUSION

The Microcontroller water level controller with purity checker project aimed to address the crucial issue of minimizing water wastage and monitoring water quality and purity through an integrated digital solution. Leveraging modern technologies including React, Next.js, Node.js, and Google Authentication, we successfully developed a web application that allows users to assess water parameters remotely. The project integrated data from Arduino-based water quality sensors, empowering users to make informed decisions about water usage.

The utilization of NextAuth.js played a pivotal role in ensuring secure and streamlined user authentication. This feature-rich library simplified the implementation of authentication strategies, including Google Authentication. The project also embraced Vercel for hosting, capitalizing on serverless deployment for scalability and reliability.

5.2 CHALLENGES

While the project achieved its objectives, it was not without challenges. Some of the challenges we faced included:

- Integration Complexity: Integrating arduino with the esp 32 and ensuring their seamless interaction posed a challenge. This required meticulous planning and continuous testing.
- Authentication Configuration: Setting up Google Authentication and ensuring a smooth login experience for users required understanding OAuth 2.0 flows and configuration intricacies.
- Deployment Configuration: Configuring Vercel for optimal deployment, managing environment variables, and addressing potential deployment-related issues demanded attention.

5.3 RECOMMENDATION

The proposed solution is effective, and helps in minimizing water wastage and therefore should be adopted for use in households or hostels.To enhance the microcontroller water level controller with purity checker project's effectiveness and address challenges encountered during its development, several key recommendations are proposed. First and foremost, creating comprehensive and user-friendly documentation that outlines the integration of different technologies and the configuration process will serve as a valuable resource for future maintenance and new developers. Rigorous testing, both for the web application and Arduino-based sensors, is crucial to ensure the accuracy of data and the overall reliability of the system and by embracing these recommendations, the project can not only overcome challenges but also evolve into a robust solution that contributes positively to sustainable water management practices and environmental conservation.

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