HydraSmart

Ahmad Alkawasmeh, 101108706 (Software Engineering)
Abdal Alkawasmeh, 101198752 (Software Engineering)
Supervisor: Prof. Safaa Bedawi

Abstract
Have you ever thought of how clean the water you drink? Do you have to constantly drink bottled water? Are you tired of second guessing if you should drink tap water? water quality has been an immersing issue over the years and water quality systems have been more in demand.

In this project development, we will be able to implement an automated water quality system which will be allow users to remotely test the quality of a water sample. Using a few metrics, the system will provide the user with water quality readings and determine if the water is safe to drink by displaying a message to the user. By using this product, the user will also be able to carry and sample any water from anywhere.

This product will ensure the user consumes safe and drinking water and is quite useful to anyone. However, it may be more beneficial for those travelling or don't have access to filtered water. For example,teachers may wish to check the water quality on a field trip before children start to consume it. Therefore, by conducting a simple water test, it ensures the safety of the water.

Contents

1 Introduction

1.1 Overview and Background

We go about our everyday life without giving much thought to the quality of water we consume on a daily basis. Especially that we need to intake about 3.7 Litres of water per day [1] to maintain healthy body functions, therefore we must pay close attention to the quality of the water we consume. Currently, the most widely used technique of determining the quality of the water is by using Test Strips. Which are rectangular pieces of paper that are saturated with a chemical agent, once these paper strips are submerged in a water sample, the chemical agent will react with the water and change colour. Then this colour will indicate the test result, which then the user will need to match the colour produced by the paper strip to a result chart with all the possible colours that can be produced by the test strip and what they indicate. This method of testing the water quality is not accurate and cannot provide exact quantitated results.

1.2 Motivations and Significance

We would like to implement a better solution to replace the most common used method for water testing, paper strips. By using a portable water testing system, the user would be able to determine the quality of the water available in a pinch. This is essential as there is no other way of finding out whether the water is acidic or if it contains small particles of contaminants, and as such you wouldn't be able to judge if it is safe or healthy for consumption.

There is a wide range of applications for such a system, and it can be useful to everyone daily. However, it can be more beneficial to users such as mothers with newborn babies, teachers, and parents in general. This system would confirm the quality of the water prior to consumption.

For the parents, it would put their mind at ease after being aware of the water quality their children will consume, especially when travelling or visiting a new city for the first time where they aren't sure of how that specific municipality treats their water.

For the teachers, for example if they are accompanying children on a field trip, it would be immensely helpful to be able to check the water quality before everyone consumes it. Moreover, if the water happens to be acidic or contains contaminants, it will not provide the necessary hydration at the least, and worst-case scenario it would cause everyone to get sick. Thus, a simple test prior to consumption would allow us to mitigate any risks of drinking water of unknown quality or content.

1.3 Design Objectives

To solve the limitations on traditional water quality monitoring systems, we would like to propose the development of a water quality monitoring system, HydraSmart. This system will consist of multiple sensors that will detect real time data using parameters such as pH, conductivity, turbidity, and TTS. For convenience, the system will consist of a portable water bottle that will allow for use in travel, workplace, gym, etc. Moreover, an easy and reliable user interface will be available to the user to access real time data and control the water system remotely. This system will provide efficiency, and accuracy to allow for clean drinking water.

1.4 Design Specifications

Our proposed system will have multiple functionalities that it will perform, where each requirement will be testable to demonstrate feasibility. The functional requirements are as follows:

- The system shall be able to measure the pH level of the water
- The system shall be able to measure the amount of Total Dissolved Solids (TDS) in the water
- The system shall be able to measure the amount of Total Suspended Solids (TSS or Turbidity) in the water
- The system shall be able to measure the Electrical Conductivity (EC) of the water
- The system shall be able to measure the Temperature of the water

- The system shall be able to run remotely using a rechargeable battery
- The system shall have a graphical user interface

2 Professional Considerations

2.1 Health and Safety

The system is designed to ensure the health and safety of the user in order to ensure a safe and positive user experience. The design incorporates three hazardous components, electrical equipment, a rechargeable battery, and glassware. These components are capable of causing bodily harm to the end user if the product is mishandled or misused. However, health risks can be mitigated with appropriate precautions and safety-centred design.

Due to the utilization of electronics and electrical components in this project, there is a risk of electrical shock to the end user if the device is misused. Section 6.4 of the Health and Safety Guide outlines the concept of Guarding to prevent access to electrical components. Subsequently, the electrical connections and components will be placed in a waterproof compartment that is inaccessible to the user. Moreover, the user will not be able to make contact with the wiring and electrical components of the system, thus mitigating the risk of an electrical shock.

One of the system components will be a rechargeable battery pack, which will be used to supply power to the system and allow it to be mobile. The battery pack type is Lithium-Ion, which remains in a stable state so long the battery casing is intact. If the casing becomes punctured or compromised at any time, the battery may catch on fire [2]. This would be catastrophic as it can cause severe burns to the user. As per section 6.6 of the Health and Safety Guide, the use of Shielding is recommended for materials or chemicals that may cause explosions and fires. As such, the strategy to mitigate this risk is to encase the battery pack in metallic plates. This will reinforce the original plastic casing and would make it significantly harder to penetrate.

Two sensor probes are made of glass and could pose a health risk if they break. As per section 6.7 of the Health and Safety Guide, broken glassware should be handled and disposed of safely. Moreover, protective gloves and eye-wear should be used when handling broken glass to minimize the risk of cuts. If a sensor probe breaks, the recommended disposal method is to carefully place the broken glass in a cardboard box, taping the box shut, labelling the box with "Broken Glass", and placing it next to the garbage bin. This will minimize the risks and ensure it is handled safely by anyone that comes into contact with it. Additionally, it is recommended to apply a thick layer of tape to the exterior of glassware to prevent it from dispersing when broken. This will applied in the final product to minimize the health risks to the end user.

2.2 Engineering Professionalism

The most notable component of professional practice that pertains to the goals of this project is sustainable development. Sustainable development is concerned with preserving the environment and natural resources, in order to avoid impacting future generations' ability to make use of such resources. The resulting product from the development of this project will help reduce the amount of plastic waste resulting from disposable water bottles, thus helping to preserve the environment from pollution and non-organic waste.

Another major aspect of professional practice is health and safety, and safeguarding the public. The concept of public safeguarding pertains to making decisions that prioritize public safety. Throughout this project development, public safety was considered the fundamental concept and main motivation. The system will help upkeep the public safety and health by ensuring the water is fit for consumption, thus reducing the chance of facing health issues caused by drinking water that was not fit for consumption.

2.3 Project Management

Although the project is currently in an early stage, we still need to make sure that we have a proper management plan to stay on track. We greatly benefited from creating a Gantt Chart in order to schedule and organize the execution of the project tasks in the upcoming months. We will continue to use and update the Gantt Chart as the project progresses in order to carry out the project objectives effectively and efficiently.

Additionally, we will be using YouTrack in order to track our progress and identify any issues that must be resolved in order to continue making progress. This will also enable effective and informed collaboration between us.

The use of GitHub issue tracking will be considered as well. Although using both YouTrack and GitHub issue tracking will be redundant and unnecessary. Thus, a choice shall be made between YouTrack and GitHub issue tracking

2.4 Justification of Suitability for Degree Program

The team members consist of Software Engineering students with a parallel experience in software development, however, each mamber has a unique interest and background experience.

Ahmad has taken special interest in Linux Operating System (SYSC 4001) and integrating the Raspberry Pi with hardware components (SYSC 3010). He has always been keen to take on personal projects that utilize the Raspberry Pi microprocessor, such as a smart mirror and automatic door lock and opener. Additionally, the Introduction to Engineering (ECOR 1010) course allowed him to acquire the necessary expertise in prototyping and 3D design, which will be greatly utilized throughout this project.

Abdal's interest is purely vested in software development. More precisely in user interface design and development. Additionally, he has taken on multiple personal projects in the past involving website design and development, and he has an extensive experience in working with distributed database systems. Some examples of related work includes a sandwich ordering system web user interface which was implemented in SYSC 3010.

Therefore, it is evident the expertise and experience required to undertake this project has been greatly reinforced by the Software Engineering program. Thus, making this project a perfect fit for Software Engineering students.

2.5 Individual Contributions

Please note that due to the limited number of team members in this project, each member contributed to all the tasks outlined below and they are only categorized by each person based on the member that contributed to completing more than 50% of the mentioned task.

2.5.1 Project Contributions

Ahmad:

- Interfacing the pH Sensor and EC Sensor with the Raspberry Pi
- Conducting hardware component testing
- Conducting preliminary testing of the system in a real world application
- Interfacing the portable battery power supply with the Raspberry Pi

Abdal:

- Designing Graphical User Interface wire frame
- Implementing Graphical User Interface
- Interfacing the pH Sensor with the Raspberry Pi

2.5.2 Report Contributions

Ahmad:

- Chapter 2
- Sections 3.2 and 3.3 of Chapter 3
- Chapter 4
- Chapter 5

Abdal:

- Abstract
- Chapter 1
- Section 2.1
- Section 3.1 and 3.4

3 Theory and Techniques

3.1 Alternative Designs and Assessments

In order to design this system, there are several components involved to choose from in the decision making process where each has it's advantages and disadvantages.

In terms of hardware modules to control and connect the digital sensors, there are two main options to choose from. A Raspberry Pi contains a microprocessor and runs on Raspbian OS using python. Not to mention, it contains 40 digital GPIO pins allowing for many hardware connections [5]. An Arduino contains a micro controller, runs using C++, and is simpler to use as it does not require any OS installation. It also has an advantage over Raspberry Pi since it takes analog input, making it compatible with most sensors. However, an Arduino is not suitable for complex projects, while a Raspberry Pi allows for more software use [5]. Due to our expertise in Python, experience with the Raspberry Pi, and the complexity of the project, it was found that using a Raspberry Pi is more suitable.

Second, after thorough research, there were a few sensors that were found important to this project such as pH, temperature, turbidity, TDS and ORP sensors.

A pH sensor measures the acidity of a solution, which will help determine any pollutants, or chemicals present in the water. Also, this sensor can be used for a wide variety of water types and provides generally accurate results. However, pH sensors are expensive and require a lot of calibration [8].

An electrical conductivity sensor measures the ability of water to conduct electricity, more precisely the ion concentration of a liquid. This sensor allows to determine contaminates or chemicals such as salts. This sensor is also very prone to corrosion and is very easy to setup. However, if there are many temperature fluctuations, more calibration would be required. Another disadvantage of this sensor is it cannot differentiate between different types of ions [6].

A Temperature sensor measures the temperature of water. This helps determine the water quality due to the measure of present oxygen levels and also by watching the temperature patterns/fluctuations over time [n].

A Turbidity sensor measures the transparency/clearness of water. A high level of turbidity can indicate sediments or pollutants in water which will help determine the overall quality of water. Also, there are many metric types to choose from, depending on the application. However, this sensor comes with limitations. they can be expensive,and require calibration. Also, the sensor can be very sensitive, therefore if any contaminates are present on the probe, it may result in inaccurate readings [3]

A TDS sensor measures the total dissolved solids in water. This can help determine the amount of minerals in water. A few advantages to mention are this sensor provides fast measures and is quite cheap to purchase. If there are changes to the temperature of the water, TDS readings can be inaccurate. It is also important to mention that high TDS readings does not directly mean the water is hazardous as a water sample could simply contain many types of good minerals such as potassium, calcium etc and vice versa [8]. This can result to doubt in the quality of water.

An ORP (oxidation reduction potential) sensor measures potential for oxidation or reduction chemical reactions to take place. This sensor is quite helpful in many system such as a swimming pool, to help control the level of chlorine. However, since the pH and temperature parameters affect has an affect on ORP, it should not be used in this system to determine the oxidation/reduction [2].

3.2 Design Functionality Verification

In order to verify the accurate and correct operation of the hardware components currently implemented, an experiment is needed to verify that the components behave in the expected manner. Moreover, the experiment needed must allow control of all the variables being tested, in order to ensure the accuracy and integrity of the results. Additionally, in order to conclude that a hardware component has passed the test, its operation must align with the specifications outlined by the manufacturer. For example, if a sensor's accuracy is $\pm$ 0.5, and the expected output is 7.5, then the actual output must fall within a range of 7-8 to conclude that sensor has passed the test, otherwise, it has failed. The following list depicts the specifications outlined by the manufacturer of each hardware components utilized:

- pH Sensor: ± 0.1
- EC Sensor: ± 1 mS/cm
- Temperature Sensor: ± 0.5 °C
- Turbidity Sensor: ± 0.1 NTU
- TDS Sensor: ± 10 PPM
- ADC: ± 0.03V
- Power Supply (Battery): 4-6 hours runtime

3.3 Experiment Design and Setup

Currently, the pH Sensor, EC Sensor, ADC, and the battery power supply have been implemented. Each component was tested by conducting an experiment to verify correct operation.

To test the pH sensor, an experiment was conducted by using the sensor to measure the pH value of solutions with a known and predetermined pH value. Two solutions with pH values of 4.00 and 7.00 (respectively) were used to test the actual readings produced by the sensor against the expected values. Additionally, the sensor probe was washed with distilled water before measuring each solution to avoid cross contamination between the two different solutions. Thus ensuring the accuracy of the results.

Similarly for the EC sensor, two solutions with predetermined electrical conductance of 12.88 mS/cm and 1413 uS/cm were used to verify the actual reading produced by the sensor align with the electrical conductance values of the solutions. Additionally, the EC value of distilled water was measured for further verification of correct operation. The EC value of distilled water is expected to be nearly zero as it contains no dissolved solids.

For the ADC, a number of analog DC voltages were supplied to an input channel of the converter, then compared to the digital converted values by the converter. The supplied DC voltage values were of 3.3V, 2.5V, and 1V.

As for the portable battery power supply, the manufacturer claims it will allow the Raspberry Pi to idle for 4-6 hours. In order to test this, the battery was charged to the full capacity, then it was connected to the Raspberry Pi in order to allow it to fully discharge. A timer was started upon connecting the battery and it was stopped upon automatic shut down by the Raspberry Pi, indicating the power supply has fully discharged.

3.4 Hardware and Software Tools

3.4.1 Selection of appropriate tools and justification

To implement a feasible system, several software and tools are required throughout the project.

Developing the graphical user interface requires several source code editors/IDEs, and a plotting library to visualize data. There are several editors to choose from such as Visual studio code, Intellij, Eclipse, etc. Intellij and Eclipse are more useful for Java or object oriented programming. Intellij also has an auto-completion feature which helps the user to develop programming quickly. However, Visual Studio code was chosen as it is best to use for website development due to it's simplicity. For example, the use of the live server extension which allows the user to view the website in real-time as changes are being done[1].

In order to retrieve data from the Raspberry Pi, there are several templates to choose from: Django and Jinja2. They are both very similar, however Jinja2 achieves better performance and efficiency[9]. In order to plot data, several plot libraries are available in python such as matplotlib and Plotly. Plotly was chosen due to the many types of graphs to choose from, and it's compatibility with HTML[7].

4 Results and Discussions

4.1 Presentation of Results

4.1.1 Hardware Components Test Results

The following figures depict the hardware testing results, including the expected and actual reading value(s) from each component.

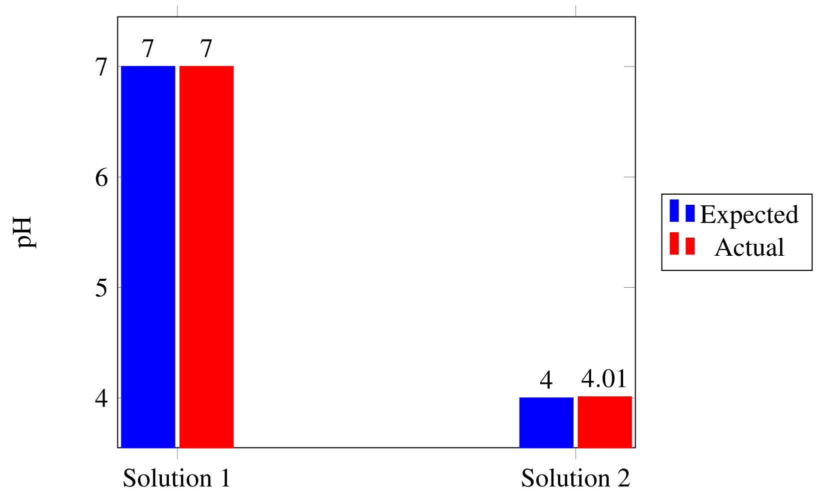

Figure 1: pH Sensor Test Results

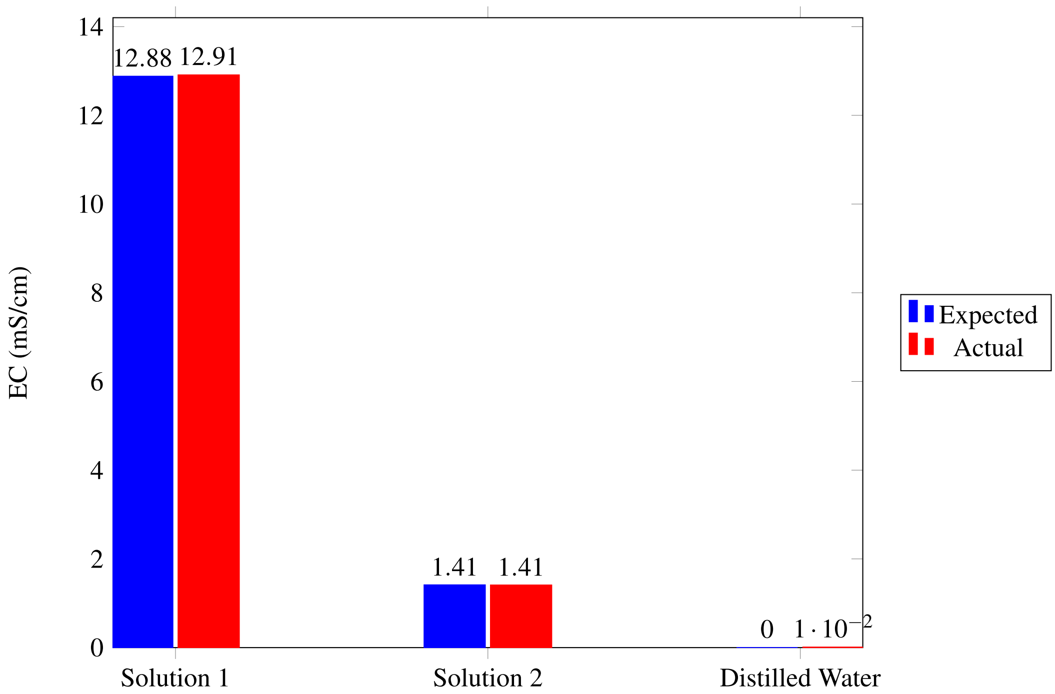

Figure 2: EC Sensor Test Results

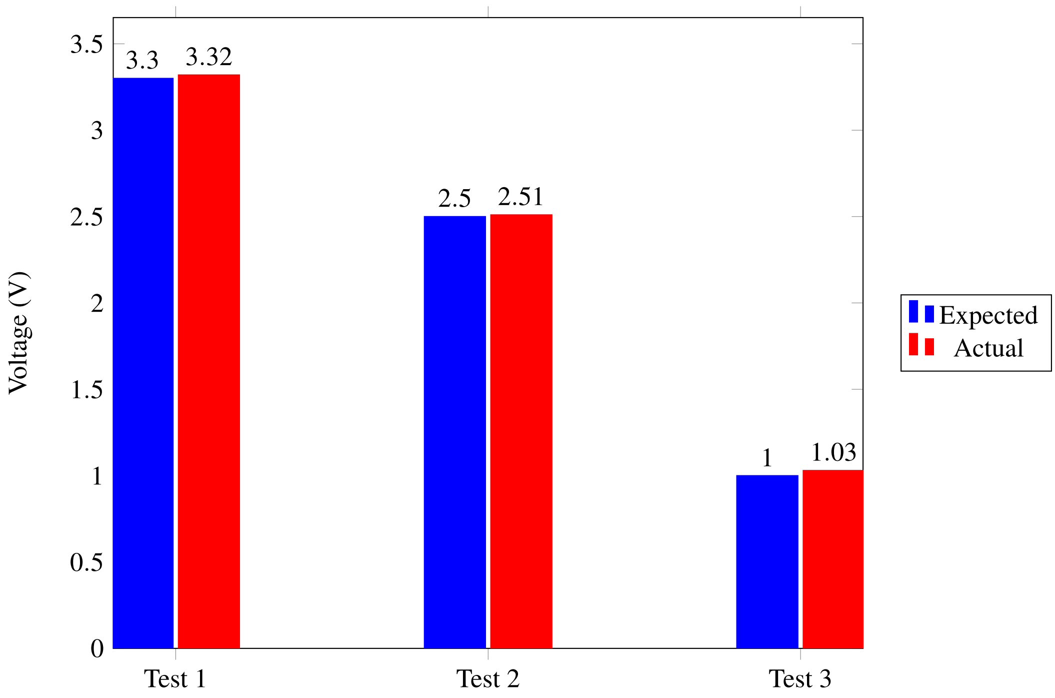

Figure 3: ADC Test Results

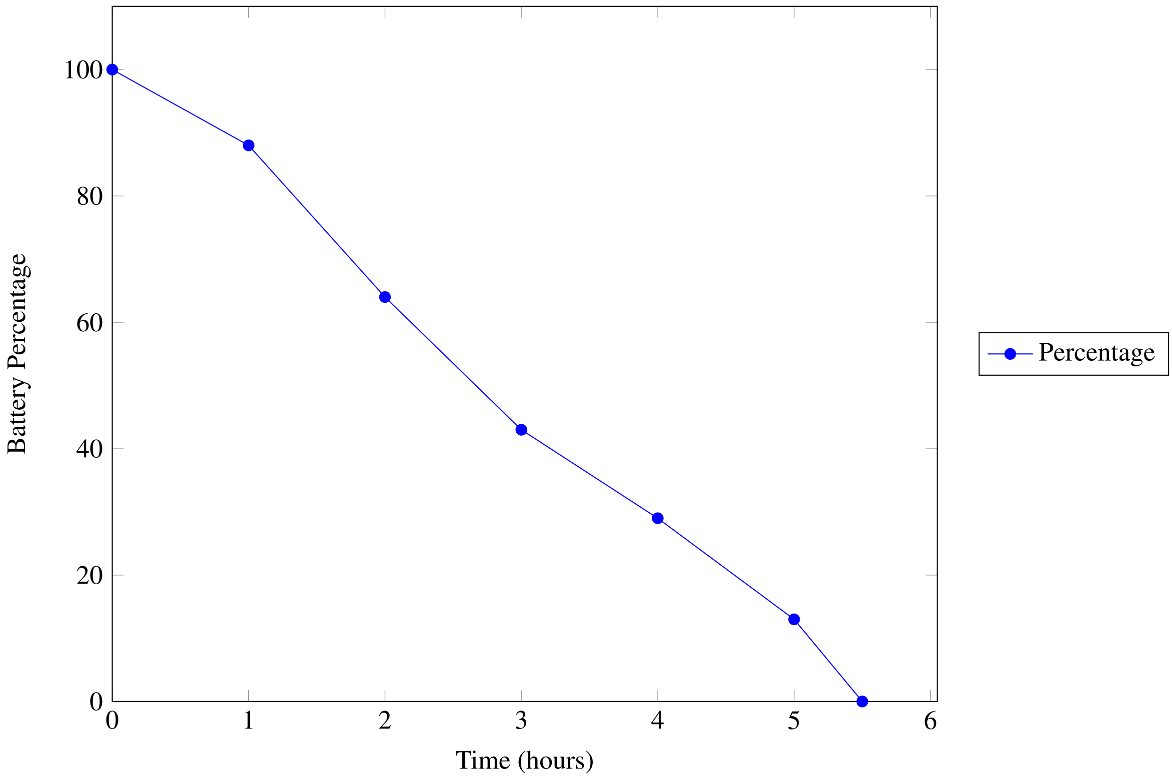

Figure 4: Battery Percentage Discharge

4.1.2 Additional Experiment Results

A second experiment was conducted in order to test the system in a real world application. The experiment consisted of collecting two types of water samples, filtered and unfiltered water samples, from various building across the campus. The filtered samples were collected from water fountains that include a built-in filter, and the unfiltered water samples were collected from a washroom sink faucet within the same building. Additionally, this experiment includes a snow sample, and an unfiltered water sample from the kitchen sink at home. Then each sample's pH and EC value was evaluated using the two sensors. The following figure depicts the resulting readings from those samples.

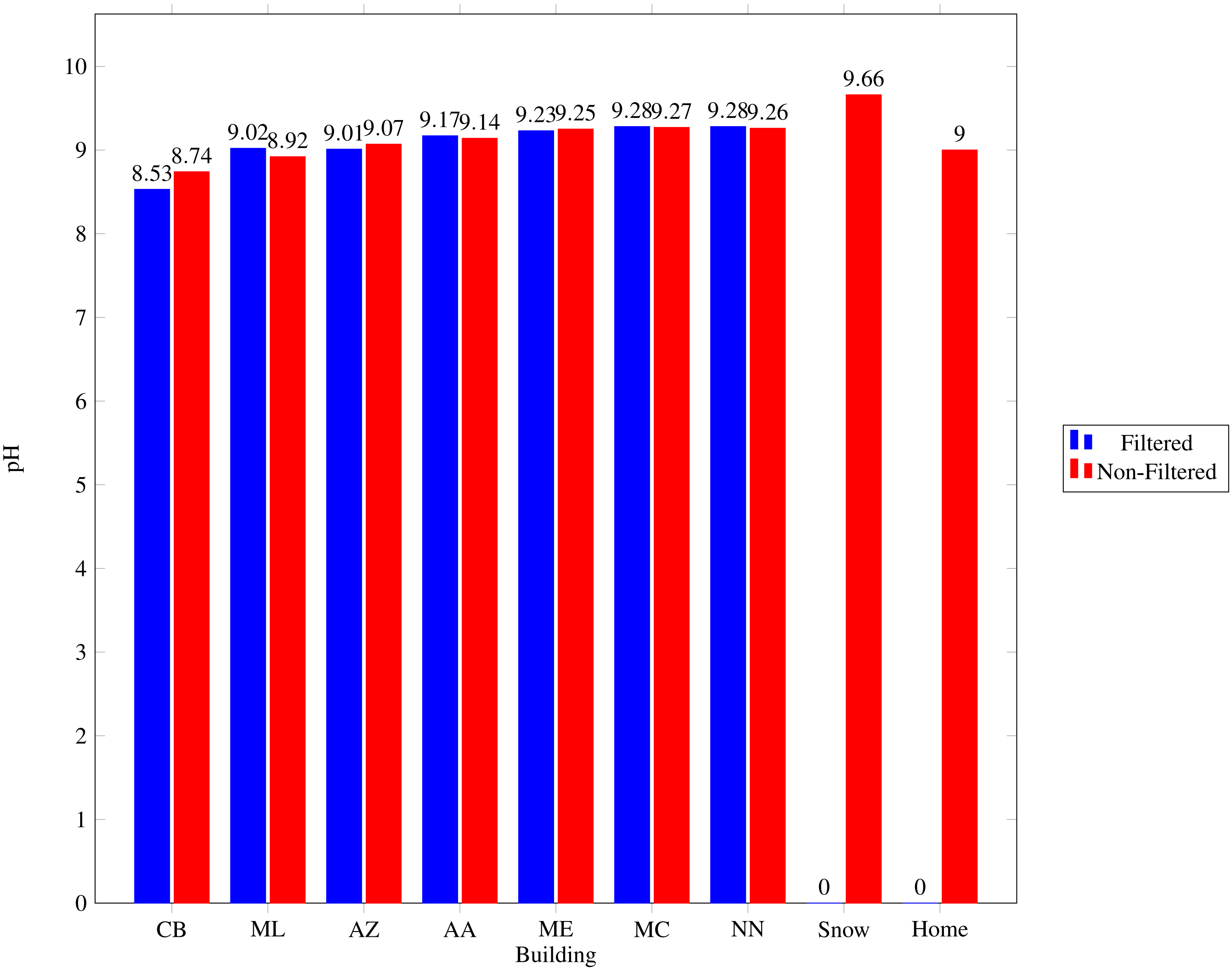

Figure 5: Filtered and Non-Filtered Water Samples pH

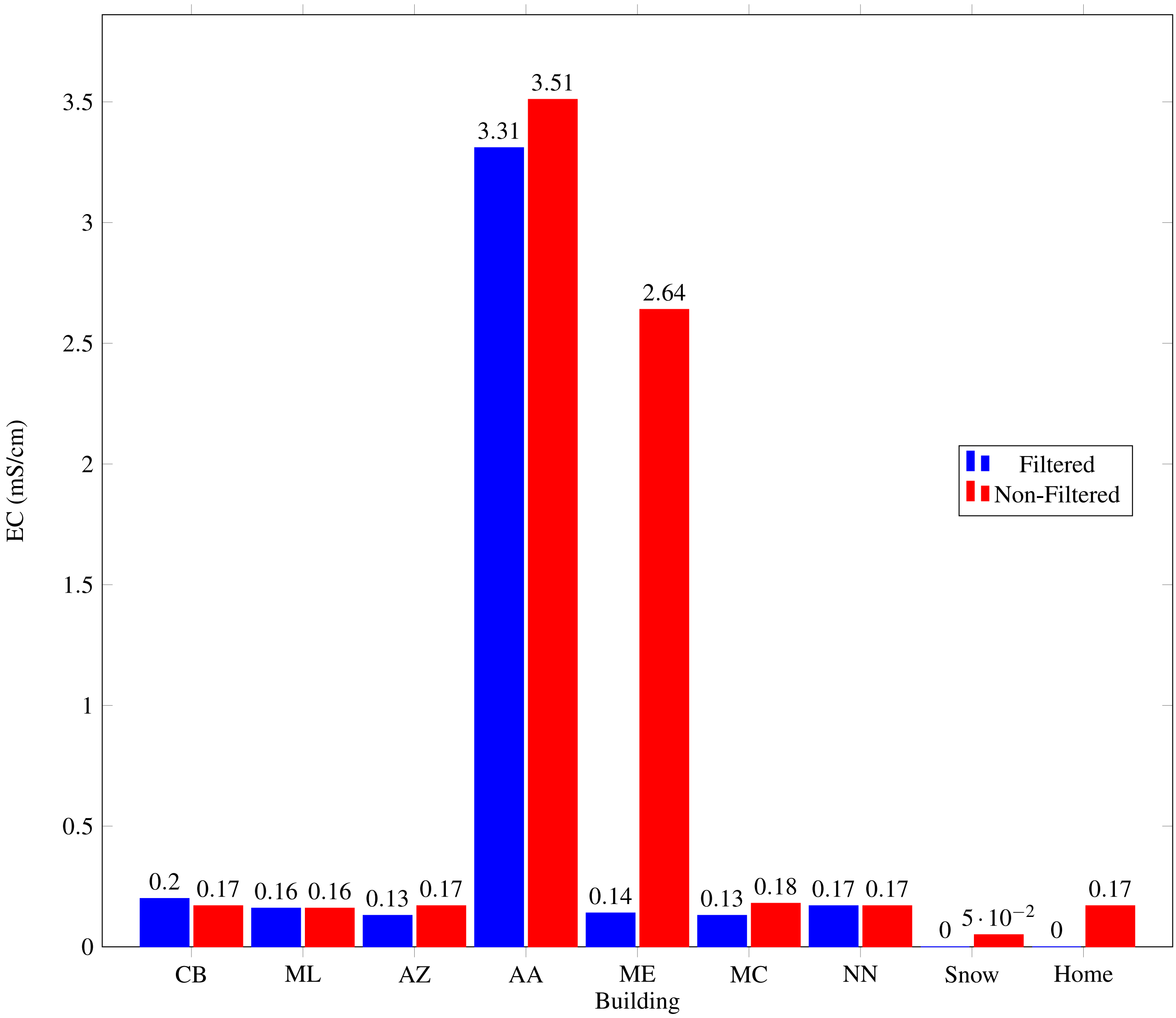

Figure 6: Filtered and Non-Filtered Water Sample EC

4.2 Evaluation and Discussion

By analyzing the sensor test results depicted in Figures 1 and 2, it is evident that the expected readings directly align with the actual readings produced by the sensors. Therefore, it can be concluded that the sensors are functioning correctly and produce accurate readings.

Similarly, the Analog to Digital Converter test results in Figure 3 indicate the actual values produced by the converter are aligned with the expected values. As such, a conclusion that the ADC is functioning correctly can be drawn from the test results.

For the battery runtime test results depicted by Figure 4, they show the total idle runtime of the Raspberry Pi on the portable power supply was 5.5 hours. This directly aligns with the manufacturer's specification of 4-6 hours, indicating that the battery power supply is functioning correctly with no issues.

Figures 5 and 6 show a comparison between the filtered and non-filtered collected water samples from various buildings across the campus of Carleton University. Specifically, Figure 5 depicts the difference in pH between the filtered and non-filtered water samples, whereas Figure 6 depicts the difference in electrical conductivity.

The difference in pH in the majority of samples was insignificant as it was within the accuracy range of $\pm$ 0.1 that is specified by the manufacturer. However, the sample taken from Canal building had a significant difference of 0.21, which indicates the filtered sample is slightly more acidic when compared to the non-filtered water sample. On the contrary, both filtered and non-filtered water samples from Canal building are the optimal pH for drinking water as outlined by Health Canada[4]. The remainder of the samples are still within the acceptable pH range of 7-10.5[4], however Canal building's filtered and non-filtered has a pH of 8.53 and 8.74 (respectively), which aligns with the optimal pH value of 8.75 as outlined by Health Canada[4]. Additionally, Figure 5 shows the pH of a snow sample, which is 9.66. This sample had the highest alkalinity of all the water samples collected, yet, it is still within the acceptable range for drinking water[4]. Therefore, the water samples collected from Campus buildings and the snow sample have shown they are within the acceptable range for drinking water as outlined by Health Canada[4].

Electrical Conductivity of water is a representation of the dissolved solids a certain water sample contains. In Figure 6, a general trend can be observed where the EC value of a filtered water sample is lower when compared to the non-filtered sample in Azreili, Architecture, Mackenzie, and Minto buildings. This indicates the filter contained in such water fountains is working and it reduces the amount of dissolved solids contained in the water. Most noteworthy, the non-filtered water sample from Mackenzie building had an EC value of 2.64 mS/cm, and the filtered water sample had an EC value of 0.14 mS/cm, which is an impressive 94.7% reduction in dissolved solids. On the contrary, the filtered water sample collected from Architecture building had the highest EC value of 3.31 when compared to the remainder of samples. Moreover, the reduction in dissolved solids by the filter contained in the water fountain is only 5.7%. This indicates the fountain's filter needs to be replaced as it most likely has accumulated pollutants within it and can no longer filter the water effectively. Similarly for Canal building, where the filtered water contained even more dissolved solids when compared to the non-filtered sample. Therefore, most of the buildings' water fountains appear to not have any issues filtering dissolved solids except for Architecture building where it seems that the water supply to the building is heavily polluted with dissolved solids when compared to other buildings. Mackenzie building also had a heavily polluted water supply, but the water fountain is evidently filtering out a high percentage of the dissolved solids.

5 Conclusion

5.1 Summary

The hardware components that have been implemented into the system thus far include the pH sensor, Electrical Conductivity sensor, Analog to Digital Converter, and the portable battery power supply. The hardware component tests produced results that align with what is expected, indicating correct operation. This was a highly regarded stage of the system development, as ambiguous or unexpected test results would indicate the components are not functioning correctly, thus more investigation would be needed to determine the source of the fault and could stall the progress. This preliminary testing stage also aids in the future implementation of the remainder of hardware components as there is now a concrete and well outlined testing plan.

5.2 Concluding Remarks and Future Work

The project development progress is heading in a positive direction with approxaimately 50% of the project have been completed thus far. Additionally, this allows for some extra time for backup in case the progress is delayed due to technical challenges or unforeseen circumstances.

The work planned for the future includes interfacing the remainder of the sensors. Which include the Turbidity, Temperature, and TDS sensors. A mobile application is also included in the future work plans as that would provide an intuitive and satisfying user experience.

Special thanks to Professor. Bedaiw and Professor. Marshall for their continued support and dedication. It has been a pleasant and an amazing experience working with you. We are looking forward to continue making progress and are excited for the remainder of the project.

Sincerly,
Ahmad and Abdal Alkawasmeh

References

[1] Liveserver.

[2] aquaread. What is orp and why measure it?

[3] atlas scientific. What is a turbidity sensor?, May 2013.

[4] Health Canada. Guidelines for canadian drinking water quality, Mar 2016.

[5] Lance Cassidy. Arduino vs raspberry pi: Which is the best board for you.

[6] electricity magnetism. Conductivity sensors.

[7] Matt Popovic. In-depth analysis: Plotly vs matplotlib in python, July 2023.

[8] rfwireless world. Advantages of ph sensor | disadvantages of ph sensor.

[9] StackShare. Django vs jinja2: What are the differences?, May 2020.

Appendix A: Project Proposal Document

ECOR4907

Capstone Project

Portable Water Quality Testing System

Project Proposal

Prepared for

Safaa Bedawi, Ph.D., P.Eng

By

Ahmad Alkawasmeh, 101108706

Abdal Alkawasmeh, 101198752

January 26, 2024

Table of Contents

1 Introduction

We are Ahmad and Abdal, 4^{th} year undergraduate Software Engineering students. The purpose of this document is to propose the project we wish to develop and work on throughout the Capstone Project. As well as capture all the fine-grained details of how this project will be carried out. The project we are proposing is an intelligent and portable water testing system.

1.1 Background

We go about our everyday life without giving much thought to the quality of water we consume on a daily basis. Especially that we need to intake about 3.7 Litres of water per day [1] to maintain healthy body functions, therefore we must pay close attention to the quality of the water we consume.

Currently, the most widely used technique of determining the quality of the water is by using Test Strips. Which are rectangular pieces of paper that are saturated with a chemical agent, once these paper strips are submerged in a water sample, the chemical agent will react with the water and change colour. Then this colour will indicate the test result, which then the user will need to match the colour produced by the paper strip to a result chart with all the possible colours that can be produced by the test strip and what they indicate. This method of testing the water quality is not accurate and cannot provide exact quantitated results.

1.2 Motivation

Therefore, a better solution is needed to replace the paper strips test most commonly used today. With a portable water testing system, you would be able to determine the quality of the water available to you in a pinch. This is essential as there is no other way of finding out whether the water is acidic or if it contains small particles of contaminants, and as such you wouldn’t be able to judge if it is safe or healthy for consumption.

There is a wide range of applications for such a system and it can be useful to everyone on a daily basis. However, it can be more beneficial to users such as mothers with newborn babies, teachers, and parents in general. This system would confirm the quality of the water prior to consumption.

For the parents, it would put their mind at ease after being aware of the water quality their children will consume, especially when travelling or visiting a new city for the first time where they aren’t sure of how that specific municipality treats their water.

For the teachers, for example if they are accompanying children on a field trip, it would be immensely helpful to be able to check the water quality before everyone consumes it. Moreover, if the water happens to be acidic or contains contaminants, it will not provide the necessary hydration at the least, and worst-case scenario it would cause everyone to get sick. Thus, a simple test prior to consumption would allow us to mitigate any risks of drinking water of unknown quality or content.

1.3 Project Objective

The objective of this project is to develop a portable and intelligent water quality testing system that will enable users to check the quality of the water on the go.

1.4 Specific Goals

More precisely, the system shall provide the user with insight about the water including its pH level, amount of Total Suspended Solids, Total Dissolved Solids, it’s Electrical Conductivity or Mineral Content and Temperature. The following is a list of functional and non-functional requirement we are aiming to achieve by the end of this project:

Functional Requirements:

- The system shall be able to measure the pH level of the water.
- The system shall be able to measure the amount of Total Dissolved Solids (TDS) in the water.
- The system shall be able to measure the amount of Total Suspended Solids (TSS or Turbidity) in the water.
- The system shall be able to measure the Electrical Conductivity (EC) of the water.
- The system shall be able to measure the Temperature of the water.
- The system shall be able to run remotely using a rechargeable battery.
- The system shall have a graphical user interface.

Non-Functional Requirements:

- The system shall be able to infer a useful observation(s) about the water quality using the sensor measurements.
- The system’s user interface shall have a simple and an advanced mode of operation.
- The simple operation mode shall be tailored to a user with no prior expertise in water quality nor the measurements produced by the sensors.

- The advanced mode of operation shall be tailored to a user with previous expertise in water quality and/or the specific measurements collected.
- The user interface shall be easy to use and intuitive.

2 Engineering Design

2.1 Project Management

Although the project is currently in an early stage, we greatly benefited from creating a Gantt Chart in order to schedule and organize the execution of the project tasks in the upcoming months. We will continue to use and update the Gantt Chart as the project progresses in order to carry out the project objectives effectively and efficiently.

Additionally, we will be using YouTrack in order to track our progress and identify any issues that must be resolved in order to continue making progress. This will also enable effective and informed collaboration between us.

The use of GitHub issue tracking will be considered as well. Although using both YouTrack and GitHub issue tracking will be redundant and unnecessary. Thus, a choice shall be made between YouTrack and GitHub issue tracking.

2.2 Justification of Suitability for Degree Program

We are both Software Engineering students with a parallel experience in software development, however, each person has a unique interest and background experience.

Ahmad has taken special interest in Linux Operating System and hardware components. He has always been keen to take on personal projects that utilize the Raspberry Pi microprocessor, such as a smart mirror and automatic door lock and opener.

Abdal’s interest is purely vested in software development. More precisely in user interface design and development. Additionally, he has taken on multiple personal projects in the past involving website design and development, and he has an extensive experience in working with distributed database systems.

Collectively, we believe that we have developed the suitable skills and experience throughout our degree program, and by taking on personal projects in the past.

2.3 Individual Contributions

2.3.1 Report Contributions

Ahmad Alkawasmeh	Abdal Alkawasmeh
Chapter 1, Chapter 3, Chapter 4, Appendences	Chapter 2, Chapter 5, Chapter 6

Table 1: Breakdown of Report Contributions of Each Member

3 Work Plan

3.1 The Project Team

We are both Software Engineering students with a main knowledge base consisting of Object-Oriented Programming. However, we've also had some exposure to working with hardware in the past, more specifically the Raspberry Pi, where we have worked on personal projects including a smart mirror and garage door opener. This makes us a strong fit for this project as we possess the necessary experience and knowledge to complete this project.

3.1.1 Roles and Tasks

The table below reflects the specific tasks that are assigned to each member, which is based on interest and prior experience of a member with that specific task.

Ahmad	Abdal
Developing the main software functionalities	Developing the main software functionalities
Unit Testing	Integration Testing
Interfacing the EC and pH sensors with the Raspberry Pi	Interfacing the TDS and TSS sensors with the Raspberry Pi
Designing the housing for the system using 3D design software	Developing the GUI
Interfacing the screen and buttons with the Raspberry Pi and GUI	Test fitting all the components into the designed housing

Table 2: Assigned Tasks to Each Member

3.1.2 Teamwork Strategy

The way we will ensure the work is done effectively and efficiently as a team I going to be mostly through GitHub version control and weekly team meetings. The team communication will be ongoing and constant throughout the project. Moreover, since we are siblings and we live together, we are in contact every day and will keep each other informed of what we are currently working on. This is to ensure we are working towards our goals effectively and efficiently.

We will also be using Jet Brains Labs YouTrack to keep track of all ongoing activities and tasks being worked on.

3.1.3 What we will need to learn

Although we are familiar with GitHub version control, we need to learn more about GitHub Issue Tracking. This tool is going to be immensely useful to ensure that issues or incompatibilities, with each of our code parts, are kept track of and solved efficiently.

We will also have to revisit 3D design software as our experience with working with the software PTC Creo was in our first year of university and we need a refresher on how to use it.

3.2 Project Milestones

The table below reflects the major milestone deadlines and the dates on which they are to be handed in.

Milestone	Date
Project Proposal	January 26, 2024
Progress Report	February 16, 2024
SW/HW Request Form	February 14, 2024
Oral Presentation	March 22, 2024
Video and Poster	June 14, 2024
Final Report	July 31 to August 10, 2024

Table 3: Major Milestones and Associated Due Dates

3.3 Schedule of Activities

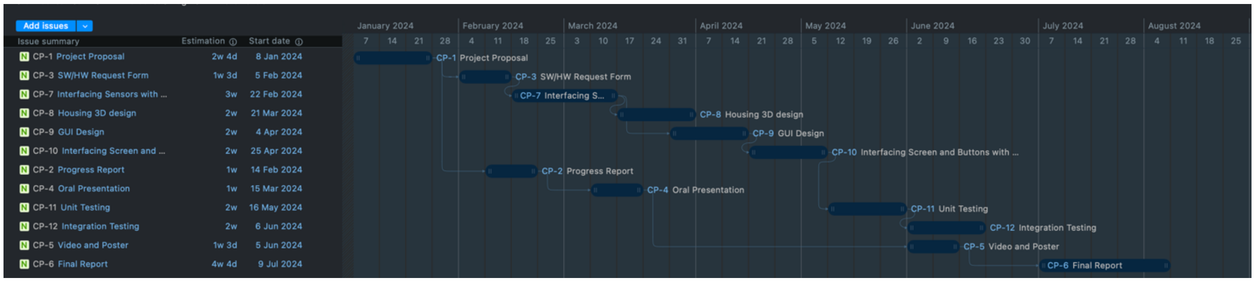

Figure 1: Gantt Chart Outlining Schedule of Project Tasks Execution

4 Project Risks and Mitigation Strategies

The risks associated with this project, although are minimal, they still exist and must be addressed appropriately with a mitigation strategy to avoid any bodily harm to the user.

4.1 Electrical Shock

Due to the utilization of electronics and electrical components in this project, there is a risk of electrical shock to the end user if the device is misused. In order to mitigate this risk. The electrical connections and electronic components will be placed in a compartment that is inaccessible to the user. Moreover, the user will not be able to make contact with the wiring and electrical components of the system, thus mitigating the risk of an electrical shock.

4.2 Fire and Burns

One of the system components will be a rechargeable battery pack, which will be used to supply power to the system and allow it to be mobile. The battery pack type is Lithium-Ion, which remains in a stable state so long the battery casing is intact. If the casing becomes punctured or compromised at any time, the battery may catch on fire [2]. This would be catastrophic as it can cause burns to the user. The strategy to mitigate this risk is to apply metallic plates to the battery pack. This will reinforce the battery casing and would make it much harder to penetrate the original thin plastic casing of the battery.

5 Hardware Required

5.1 List of Required Hardware

The following table captures the details of the hardware needs for our project.

Part	Description	Link	Quantity	Price in CAD (tax inclusive)
Microprocessor	Raspberry Pi 4 8GB	Link	1	(Available at Carleton)
Microcontroller	Texas Instruments EK-TM4C123GXL ARM Development Board	Link	1	$37
Power Supply	PiJuice Hat	Link	1	$118
ADC Converter	Analog to Digital Converter IC MCP 3008	Link	3	$16 ($5.30 per 1 count)
pH Sensor	Gravity Analog pH Sensor Kit	Link	1	$61
Turbidity Sensor	Gravity Analog Turbidity Sensor	Link	1	$15
TDS Sensors	Gravity Analog TDS Sensor	Link	1	$18
EC Sensor	Gravity Analog EC Sensor	Link	1	$107
Temperature Sensor	Gravity Digital Temperature Sensor	Link	1	$12
Potentiometer	Gravity Analog Potentiometer	Link	1	$5
Breadboard	DfRobot Solderless Breadboard	Link	1	$5
Jumper Wires	Male to Male Jumper Wires	Link	1 pack (includes 20 pieces)	$4
Jumper Wires	Female to Male Jumper Wires	Link	1 pack	$4

			(includes 20 pieces)	
Display	5” Touch Display	Link	1	$65

Table 4: Required Components, Website Links, and Price List

5.2 Trade-off Analysis

5.2.1 Microprocessor

There was a choice that needed to be made between the Raspberry Pi microprocessor and Arduino Due microcontroller [3]. Given our extensive experience with the Raspberry Pi, we decided to go with it instead of the Arduino Due.

The main differences between them is their ability to process digital and analog signals. Where the Arduino Due has the ability to process both digital and analog signals, the Raspberry Pi is only able to process digital signals.

Given the majority of the sensors we are aiming to utilize produce analog signal output, we needed to address the downfall of the Raspberry Pi. This will be achieved using the MCP 3008 Analog to Digital Converter.

5.2.2 Microcontroller

The use of a custom, dedicated microcontroller for our system will always be superior to using an off the shelf microprocessor like the Raspberry Pi. We are planning on developing a preliminary prototype with the Raspberry Pi as a proof of concept. Then if time permits, we will develop a dedicated microcontroller firmware for our system using the Texas Instruments EK-TM4C123GXL ARM Development Board. This board is more power efficient, costs a quarter of a Raspberry Pi, and will have a much smaller footprint in comparison to the Raspberry Pi. We have consulted with a graduated colleague, with a vast experience in electronics and embedded systems, about the board choice. He recommended this specific development board due to its form factor and sufficient power capability for our system.

5.2.3 Power Supply

In case of the power supply, the choice was between a power bank that is intended for use with mobile devices or a PiJuice Hat that is specifically intended for use with the Raspberry Pi. The PiJuice Hat has a much smaller footprint and integrates smoothly with the Raspberry Pi, when compared to a power bank that has a larger footprint and has to be plugged in manually every time you need to power the Raspberry Pi. Due to the downfalls of a power bank, the choice was made in favour of the PiJuice Hat.

5.2.4 Analog to Digital Converter

The choice for an Analog to Digital Converter was between the MCP3008 and ADS1x15 [4]. The MCP3008 is capable of 8 channels of input simultaneously where the ADS1x15 is only capable of 4. Also, the MCP3008 cost is one third of the ADS1x15. The better capabilities of the MCP3008 combined with its superior value, has led us to make a choice in favour of the MCP3008.

5.2.5 Sensors

The two makers of sensors we considered are Grove [5] and DfRobot [6]. Both manufacturers' sensors are capable of the same measurements' accuracies. However, Grove priced their sensors much higher than DfRobot and they had less support available for their sensors.

The fact that DfRobot's sensors were of better value combined with the availability of sufficient support and documentation, has led us to make a choice in favour of DfRobot's sensors.

5.2.6 Potentiometer, Bread Board, and Jumper Wires

The purpose of these components will only be for rapid prototyping and testing the system. After which, they will become obsolete as we plan to move on from messy wiring and circuitry to a sleeker solution consisting of a printed circuit board. Thus, the only factor that played a role in choosing these components is price. There is no reason for choosing a higher priced jumper wire, for example, if they both capable of making the required connection.

5.2.7 Display

In case of the display choice, it was the most challenging as it required planning for a much more advanced stage of our project. There was three main factors to consider, connectivity, display size, and price.

In case of the connectivity, the choice was between a display that connected through the GPIO, HDMI connector, or the Display Serial Interface. We are unable to use the GPIO option as we will need to use the GPIO for our sensors connectivity. The HDMI connector is a good option but it will still require the use of GPIO pins for touch input. This leaves us with the DSI which is capable of handling the video stream output to the display and touch input simultaneously.

Once the connectivity method was decided upon, now a suitable size needed to be picked. We wanted to pick a size that is large enough for the user to comfortable interact with the user interface, and simultaneously keeping the device form factor as small as possible. There was two size options we arrived at, 5 and 7 inches displays. The 7 inch display would be too large and nearly the size of an iPad display, thus a more suitable size would be the 5 inch display.

With the connectivity and size options decided, there is one more variable left that plays a role in choosing a display. That is the price. At this point, there is no reason for choosing a more expensive display if it achieves the same functionality as the less expensive option and reflects our needs. The choice was made in favour of the Waveform 5 inch DSI Touch Display. Since it satisfied our needs and it had great reviews, it was the best valued option for our application.

6 References

Your background and motivation sections will be more convincing if you refer to the literature (stats, articles, etc.) I suggest you use a citation manager, such as Mendeley. Otherwise, you will have to format your citations by hand. You can use any citation style (e.g., IEEE, Vancouver, Chicago); just be consistent. You can also copy pre-formatted citations directly from Google Scholar results.

[1] "Water: How much should you drink every day?," Mayo Clinic, Oct. 12, 2022. https://www.mayoclinic.org/healthy-lifestyle/nutrition-and-healthy-eating/in-depth/water/art-20044256#:~:text=So%20how%20much%20fluid%20does,fluids%20a%20day%20for%20women

[2] "Lithium-ion-batteries | DFES." https://www.dfes.wa.gov.au/hazard-information/fire-in-the-home/lithium-ion batteries#:~:text=There%20are%20several%20situations%20that,piercing%2C%20and%2For%20vibrations)

[3] "Arduino due," Arduino Official Store. https://store.arduino.cc/products/arduino-due

[4] A. Industries, "ADS1115 16-Bit ADC - 4 Channel with Programmable Gain Amplifier." https://www.adafruit.com/product/1085

[5] "Grove - Seeed Studio." https://www.seeedstudio.com/category/Grove-c-1003.html

[6] dfrobot.com, "Buy Sensors Gravity - DFRobot," dfrobot.com. https://www.dfrobot.com/topic-282-36.html

Appendix A: Microprocessor Datasheet

Raspberry Pi 4 Model B Datasheet

Appendix B: Microcontroller Datasheet

TM4C123G LaunchPad Evaluation Board Datasheet

Appendix C: Battery Pack Datasheet

PiJuice Hat Datasheet

Appendix D: ADC Datasheet

MCP3008 Analog to Digital Signal Converter Datasheet

Appendix E: pH Sensor Datasheet

Gravity Analog pH Sensor Kit Datasheet

Appendix F: Turbidity Sensor Datasheet

Gravity Analog Turbidity Sensor Datasheet

Appendix G: TDS Sensor Datasheet

Gravity Analog TDS Sensor Datasheet

Appendix H: EC Sensor Datasheet

Gravity Analog EC Sensor Datasheet

Appendix I: Display Datasheet

Waveshare 5” DSI Touch Display Datasheet