KidniFy – A mobile based patient care application for Kidney Patients

2023-032

Project Proposal Report

Perera J.P.M.L.

B.Sc. (Hons) Degree in Information Technology specializing in

Data Science

Department of Information Technology

Sri Lanka Institute of Information Technology

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DECLARATION

We declare that this is our own work, and this proposal does not incorporate without acknowledgement any material previously submitted for a degree or diploma in any other university or Institute of higher learning and to the best of our knowledge and belief it does not contain any material previously published or written by another person except where the acknowledgement is made in the text.

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The supervisor/s should certify the proposal report with the following declaration.

The above candidates are carrying out research for the undergraduate Dissertation under my supervision.

Signature of the Supervisor:	2023.04.06	
Signature of the Co-Supervisor:	2023.04.06	

ABSTRACT

In Sri Lanka, chronic kidney disease (CKD) poses a significant health concern, affecting an estimated 20% of the population. One of the factors contributing to CKD is exposure to contaminated water, which is particularly common in rural areas where access to clean water is limited. Real-time monitoring of water quality is essential for detecting contamination early and preventing CKD-related complications. This research proposes an IoT-based water quality monitoring system for CKD patients in Sri Lanka, which uses machine learning (ML) to predict water quality and displays the results in a mobile application dashboard. The system being proposed comprises two main components: hardware and software. The hardware component encompasses IoT devices used for measuring various sa In particular temperature, pH, and saturated oxygen. These devices are connected to a cloud-based platform, which collects and stores the data in real time. The software component includes an ML algorithm for predicting water quality based on the data collected by IoT devices. The ML model is trained on pre-tested water sample data and uses various algorithms to identify changes in water quality and predict future trends. The analysis results are displayed on a mobile application dashboard, providing users with real-time water quality information. The proposed system has several benefits: It enables real-time water quality monitoring, crucial for detecting contamination early and preventing CKD-related complications. IoT devices and cloud-based platforms allow remote water quality monitoring, particularly in rural areas with limited access to clean water. The ML algorithm provides accurate water quality predictions, which can help identify potential issues before they become serious problems. The mobile application dashboard provides an easy-to-use interface for users to access the water quality data and receive alerts for any issues. The proposed system will be evaluated through field trials and user feedback. The performance and effectiveness of the IoT and ML-based water quality monitoring system will be measured against traditional manual monitoring methods. The user feedback will improve the design and make it more user-friendly.

Keywords: Internet of things, Machine Learning (ML), Water Quality Monitoring, Chronic Kidney Disease (CKD), Mobile Application.

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LIST OF ABBREVIATION

API: Application Programming Interface

AWS: Amazon Web Services

CKD: Chronic Kidney Disease

DO: Dissolved Oxygen

EPA: Environmental Protection Agency

EC: Electrical Conductivity

GUI: Graphical User Interface

IoT: Internet of Things

IoTaaS: IoT as a Service

JSON: JavaScript Object Notation

LCD: Liquid Crystal Display

LED: Light Emitting Diode

MCU: Micro Controller Unit

ML: Machine Learning

MLR: Multiple Linear Regression

MQTT: Message Queuing Telemetry Transport

pH: Potential of Hydrogen

RF: Random Forest

R&D: Research and Development

SVM: Support Vector Machine

TDS: Total Dissolved Solids

WHO: World Health Organization

1. INTRODUCTION

1.1 Background and Literature Survey

There are many factors that cause CKD. One of the major risk factors for CKD is exposure to contaminated water, which is a significant problem in many parts of the country. Researchers Identified the Poor Water Quality is a possible Contributor to this CKD problem.

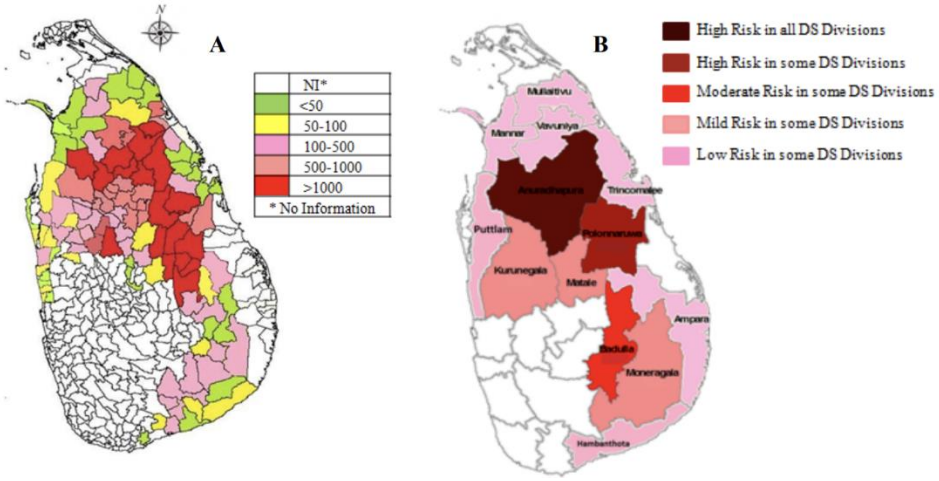


Figure 1: The reported CKD distribution in Sri Lanka

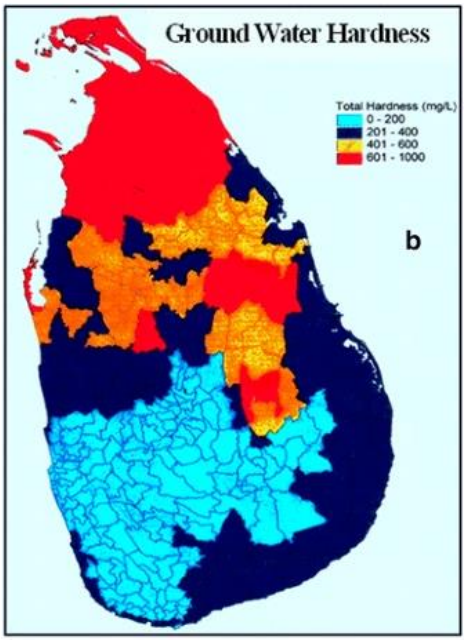


Figure 2: Ground water hardness in Sri Lanka

Despite efforts to improve water quality monitoring in Sri Lanka, there is still a lack of real-time, accurate, and reliable systems for monitoring water quality.

Recent advances on the Internet of Things (IoT) and machine learning (ML) technologies have created new opportunities for improving water quality monitoring. IoT devices can collect real-time data on water quality parameters such as temperature, pH, and dissolved oxygen, while ML algorithms can analyze this data to identify changes in water quality and predict future trends. This technology has already been used successfully in other countries to monitor water quality, but it has not yet been implemented in Sri Lanka.

The proposed IoT and ML based water quality monitoring system aims to address this gap by providing a real-time and accurate monitoring system for kidney patients in Sri Lanka. The system will consist of a network of IoT devices that will continuously monitor water quality parameters, and ML algorithms that will analyze the data to identify changes in water quality and predict future trends. The system will also provide alerts and notifications to kidney patients in case of any water quality issues, enabling them to take necessary precautions to manage their condition.

In their 2022 research publication, Yogendra Kumar and Siba K Udgata detailed their work on utilizing machine learning techniques at the edge device for identifying alarming events in water quality. Their research aimed to create an edge device that could sense water quality parameters, identify changes in water quality relative to baseline parameters, generate alert signals triggered by changes in water quality parameters surpass their threshold values, and classify various types of contamination. Three water quality indicative methods, namely the Weighted Arithmetic Index, NSF Water Quality Index, and user feedback, were employed to calculate water quality. Employing the Support Vector Machine (SVM), a lightweight machine learning model was developed based on these water quality indexes. The alarming events were clustered to identify different types of disturbing events. The research yielded promising results, showcasing the potential of machine

learning at the edge device for intelligent detection of alarming events in water quality [1] .

In 2022, Amara Parangama and his team studied in Sri Lanka to investigate potential causative factors for chronic kidney disease (CKD) in the North Central Province (NCP). The NCP region has reported the greatest incidence of chronic kidney disease (CKD) patients and fatality rate. in the country, with suspicions that specific water quality measures in drinking water may contribute to the issue. The study involved analyzing water samples collected from shallow wells that provide drinking water to both chronic kidney disease (CKD) patients and non-patients in the area of NCP region, testing for various parameters like chemical species including Cadmium, Sodium, Calcium, Fluorine, and Chlorine. Initial analysis revealed that most of the water quality parameters tested did not exceed the drinking water quality standards set by the World Health Organization (WHO). Factor analysis techniques were then used to investigate critical water quality parameters that could cause CKD. The results indicated that water samples from CKD patients showed higher Na, Cl, Mg, F, and Ca levels, grouped into one factor and identified as hydro-geologically originated. Another factor consisting of N and P, which could be attributed to nutrients from fertilizers, was also identified, in contrast, cadmium (Cd) was classified as a distinct element. On the other hand, water quality measures in samples obtained from non-CKD patients was unable to categorized into any specific group [2].

In 2021, Dinithi Weerasingha and her team presented a research paper CKD in Sri Lanka. Over the past two decades, CKD has emerged as a significant global health concern. Sri Lanka has been impacted by the rapid rise of CKD of unknown aetiology (CKDu) in agricultural regions. The paper presents a model of an ANN. that utilizes he physical and chemical characteristics of soil in agricultural zones. to determine the form of CKD. The study compares the performance of the Multilayer Perceptron (M.L.P.) ANN model with Decision Tree and Support Vector Machine (SVM) models in terms of accuracy, precision, recall, Root Mean Squared Error (R.M.S.E.), and Mean Absolute Error (M.A.E.). The findings reveal that the ANN model demonstrates superior performance of classification and prediction in

identifying the type of disease, which is crucial for the early detection and management of CKD and its etiologies in Sri Lanka [3].

In 2023, Andrew OMAMBIA and his team proposed a system for monitoring water quality and pilferage using IoT and machine learning technologies. Safe water access is considered a fundamental human right and contamination, leakages, and pilferage often occur in water supply systems. The proposed system aims to address these challenges by monitoring water quality and detecting pilferage and wastage through the use of machine learning algorithms. Water is primarily sourced from pipes and springs located around towns and consumed by consumers. The system will enable decision making through the use of machine learning algorithms [4].

In 2019, Sathira Hettiarachchi, Divan Proboshena, Hashan Rajapaksha, and Lakshan Stembo put forth a solution to address the pressing need for comprehensive research on sustainable water-quality management systems. As population growth and environmental pollution continue to escalate, the demand for such systems has become increasingly apparent. The proposed solution is a cutting-edge innovative water quality management system incorporating predictive capabilities. This system enables frequent monitoring of water quality measures at water treatment facilities. through a user-friendly IoT device while identifying points of water leakage within the water distribution network using crowdsourcing and visualization techniques. Notably, the proposed system boasts a remarkable 99% accuracy in predicting upcoming changes in water quality, along with calculating the corresponding purification costs. The design features a digital dashboard that provides concise information on leaks, customer feedback, patterns of water quality, and costs related to purification in a summarized manner [5]**.**

The literature survey reveals that there are already many IoT and ML based water quality monitoring systems being used around the world, including in neighboring countries such as India. These systems have been shown to be effective in improving water quality monitoring and reducing the risk of waterborne diseases. However, there is a lack of research on the implementation of such systems in Sri Lanka, particularly for the specific needs of kidney patients. Therefore, the proposed

research will contribute to the existing literature by exploring the feasibility and effectiveness of a water quality evaluating/monitoring system for kidney patients in Sri Lanka.

1.2 Research Gap

Current water quality monitoring systems in Sri Lanka lack the real-time monitoring and data management capabilities required to meet the needs of CKD patients.

Previous research has primarily focused on water quality monitoring for drinking water at the industrial level, with limited attention given to water quality monitoring for specific patient populations. Moreover, existing water quality monitoring systems are not designed to incorporate IoT and machine learning technologies for accurate and real-time monitoring. This highlights the need for a water quality monitoring system that is specifically tailored for CKD patients in Sri Lanka, utilizing the latest technologies available to ensure the accuracy and timeliness of water quality data.

To fill this research gap, this study proposes a water quality monitoring system that utilizing ML and IOT, for CKD patients in Sri Lanka. The system will consist of a hardware component for water quality testing and a software component for data management and analysis. The hardware component will be based on IoT technology and will be responsible for collecting water quality data in real-time. The software component will include a machine learning model trained on pre-tested water sample data to predict the water quality accurately.

The system's hardware component will consist of a microcontroller unit (MCU), various sensors such as pH and conductivity sensors, and a Wi-Fi module to transmit data to the software component. The MCU will be responsible for collecting data from the sensors and transmitting it wirelessly to the software component. The software component will include a data management system to store the collected data and a machine learning model to predict water quality based on the pre-tested water sample data.

The machine learning model will be developed using various ML techniques such as regression and classification, to accurately predict the water quality based on the collected data. The pre-tested water sample data will be obtained from accredited laboratories in Sri Lanka and will be used to train the ML model. The data management system will store the collected data and the predicted water quality data, which will be used to display the results on the mobile application dashboard.

The proposed system aims to provide a cost-effective and efficient solution for water quality monitoring, which is specifically tailored to meet the needs of CKD patients in Sri Lanka. The system's real-time monitoring capabilities and accurate predictions using machine learning will enable early detection of water quality issues and ensure timely interventions. The mobile application dashboard will provide patients and healthcare professionals with easy access to water quality data, enabling them to make informed decisions regarding their water consumption.

In conclusion, the proposed system for monitoring water quality using IOT and ML for CKD patients in Sri Lanka will bridge the existing research gap by providing a novel solution that utilizes the latest technologies available to ensure the accuracy and timeliness of water quality data. The system has the potential to significantly improve the quality of life for CKD patients by providing real-time water quality data that is tailored to their specific needs.

2. RESEARCH PROBLEM

Currently in Sri Lanka, there is no reliable and efficient system for real-time monitoring of water quality. This means that kidney patients who require regular monitoring of their water intake are not receiving timely information about the quality of the water they are consuming. This can have adverse effects on their health and well-being.

Manual monitoring methods are currently being used to monitor water quality in Sri Lanka, but these methods are limited in their ability to identify sudden changes in water quality. This means that kidney patients who rely on manual monitoring may not be alerted to sudden changes in water quality, which could have serious consequences for their health.

The current manual monitoring methods used to monitor water quality in Sri Lanka lack proper data management systems, which can result in delayed responses to water quality issues. This means that important information about water quality may not be properly recorded, analyzed, or acted upon in a timely manner.

Access to information about water quality is a major challenge for kidney patients in Sri Lanka. Currently, there is no reliable and efficient system for real-time monitoring of water quality, and even when data is available, it is often difficult to access and understand. This lack of access to information can have serious consequences for kidney patients, as they may not have the necessary information to make informed decisions about their water intake.

In addition, there are often language barriers that prevent kidney patients from accessing information about water quality. Many of the existing resources are only available in English, which can make it difficult for patients who do not speak English to access this information.

3. OBJECTIVES

3.1 Main Objectives

The main objective of this research is to develop an IoT and ML-based water quality monitoring system to provide real-time and accurate information on water quality for kidney patients in Sri Lanka, with the aim of reducing the risk of complications from exposure to contaminated water.

3.2 Specific Objectives

- Design and develop an IoT-based hardware system for collecting real-time data on water quality parameters.
- Develop and implement a machine learning algorithm for predicting changes in water quality based on the data collected by the pre-tested water sample data.
- Integrate the hardware and software components into a cloud-based platform for processing and analysis of the water quality data.
- Develop a mobile application dashboard for displaying water quality data and alerts to kidney patients in real-time.
- Evaluate the performance and effectiveness of the IoT and ML-based water quality monitoring system through field trials and user feedback.

4. METHODOLOGY

4.1 System Architecture

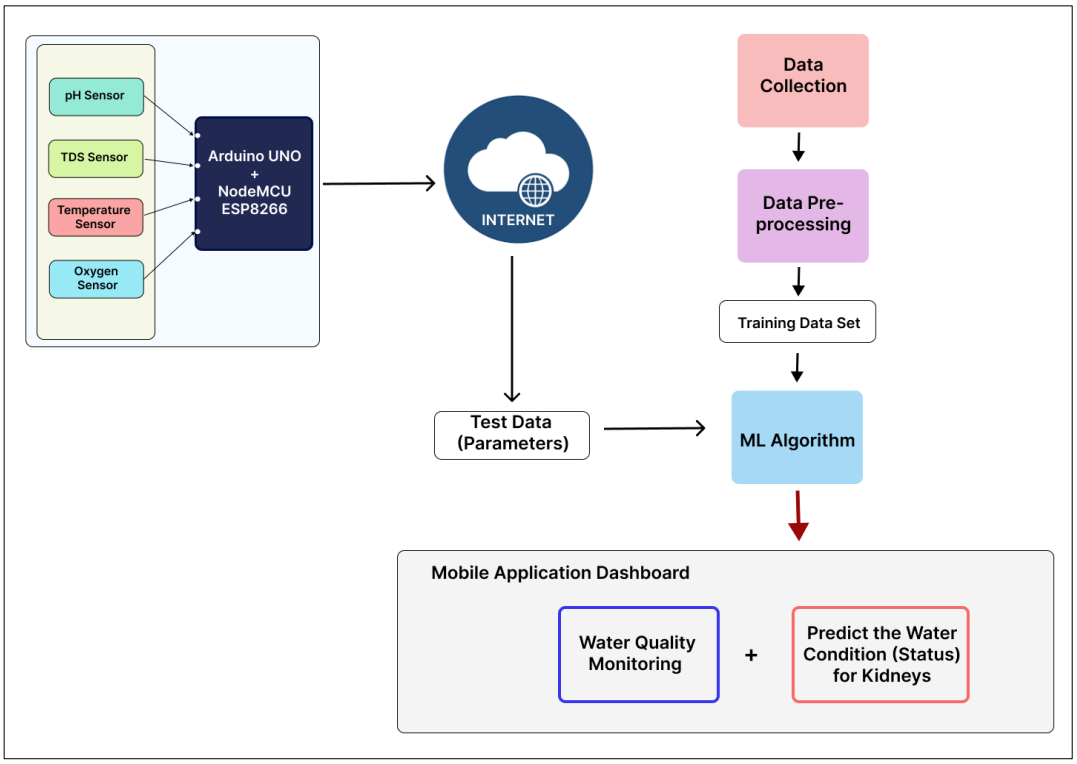


Figure 3: Component Architecture Diagram

The proposed system consists of two main components: hardware and software. The hardware component includes IoT devices for measuring different parameters that determine water quality, such as temperature, pH, and dissolved oxygen. The data collected by these devices is sent to a cloud-based platform for processing and analysis.

The software component includes a machine learning model for predicting water quality based on the data collected by the IoT devices. The ML model will be trained on historical data and will use various algorithms to identify changes in water quality and predict future trends. The results of the analysis will be displayed on a mobile application dashboard, which will provide real-time information on water quality to users.

Overall, the proposed system will enable real-time monitoring of water quality and provide early warning of any potential issues, which is particularly important for kidney patients in Sri Lanka who are at risk of complications from exposure to contaminated water.

4.2 Commercialization of the Product

1. Develop a comprehensive marketing strategy: The first step would be to develop a marketing strategy that targets kidney patients and those at risk of kidney disease. This could involve promoting the app on social media, targeted advertising, and outreach to health organizations and medical professionals.
2. Launch the mobile app: Once the marketing strategy is in place, launch the mobile app on both the App Store and Google Play Store. Ensure that the app is user-friendly and that features such as the risk prediction tool, image analysis, and water quality measurement device are easy to use.
3. Offer a free trial: To encourage users to try out the app and see its value, offer a 30-day free trial with access to all features. During the trial period, users can evaluate the app and decide whether to continue using it by purchasing a subscription. Consider offering incentives to users who subscribe after the free trial, such as a discounted subscription price or additional features not included in the trial version.
4. Partner with healthcare providers: Partner with healthcare providers such as hospitals and clinics to offer our app as a resource for their patients. We could also consider partnering with healthcare insurance providers to offer the app as part of their member benefits.
5. Collect and analyze data: Collect data from app users to identify patterns and trends in kidney disease prevalence and risk factors. Use this data to improve the app's features and functionality and to develop targeted marketing campaigns.

5. SOFTWARE / HARDWARE METHODOLOGY

Hardware Methodology

1. Selection of water quality parameters: Identify the water quality parameters that need to be monitored, such as pH, turbidity, temperature, and dissolved oxygen (DO).
2. Selection of IoT sensors: Choose IoT sensors that are compatible with the identified water quality parameters.
3. Design and development of the IoT hardware: Develop the IoT hardware that can measure the water quality parameters using the chosen sensors.
4. Calibration of the IoT sensors: Calibrate the IoT sensors to ensure that they are accurately measuring the water quality parameters.
5. Integration of the IoT hardware: Integrate the IoT hardware with the cloud-based platform for data collection and storage.

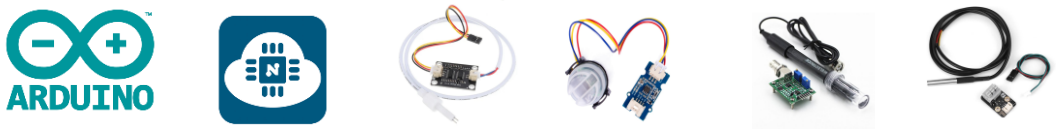


Figure 4: Hardware tools Planned to use.

Software Methodology

1. Selection of the machine learning algorithm: Identify the machine learning algorithm that will be used for water quality prediction.
2. Data preparation: Prepare the pre-tested water sample data for use in training the machine learning model.
3. Machine learning model training: Train the machine learning model using the pre-tested water sample data.
4. Integration of the machine learning model: Integrate the machine learning model with the cloud-based platform for data collection and storage.
5. Development of the mobile application dashboard: Develop a mobile application dashboard that can display the water quality data in real-time.

Figure 5: Icons of the Software tools that are planned to use

6. DESCRIPTIONS OF PERSONAL AND FACILITIES

Member	Component	Tasks
Perera J.P.M.L.	IoT & ML based Water Quality Monitoring System for Kidney Patients	Design and develop IoT hardware for water quality monitoring: This task involves designing and developing IoT hardware devices for measuring different parameters that determine water quality, such as temperature, pH, and dissolved oxygen. The devices should be reliable and accurate, and able to transmit data to the cloud-based platform in real-time. Develop a cloud-based platform for data collection and storage: This task involves developing a cloud-based platform that can collect and store the data transmitted by the IoT hardware devices in real-time. The platform should be secure, scalable, and able to handle large volumes of data. Develop and train a machine learning model for water quality prediction: This task involves developing and training a machine learning model using pre-tested water sample data. The model should be able to identify changes in water quality and predict future trends accurately. Develop a mobile application dashboard for data visualization: This task involves developing a mobile application dashboard that can display the water quality data in real-time. The dashboard should be user-friendly and provide an easy-to-use interface for users to access the water quality data and receive alerts if there are any issues.

		Conduct field trials and user feedback evaluation: This task involves conducting field trials to evaluate the performance and effectiveness of the IoT and ML-based water quality monitoring system against traditional manual monitoring methods. User feedback will be collected to improve the system and make it more user-friendly.

Table 1: Description of Personal Tasks

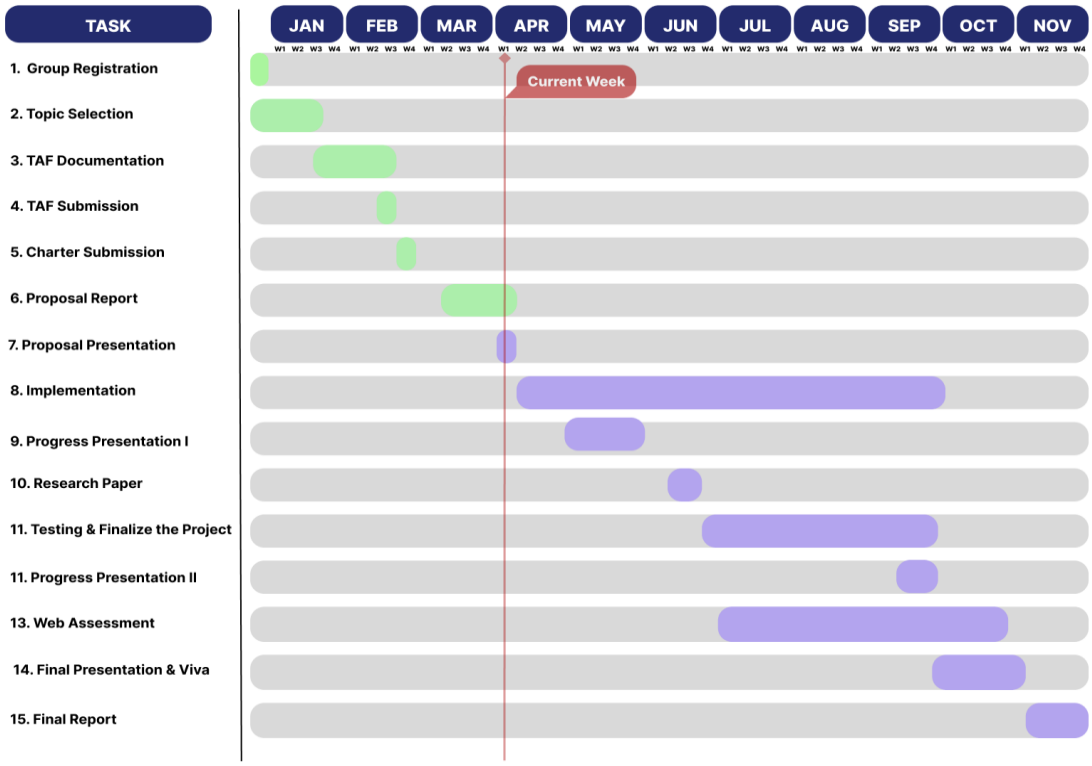
7. BUDGET AND BUDGET JUSTIFICATION

Resources	Estimated Price (LKR)
Cloud server host	25,000.00
Travelling	10,000.00
Internet	5,000.00
Stationery	2,000.00
Hardware parts/Sensors	15,000.00
Total	**57,000.00**

Table 2: Proposed Expenditures

The proposed budget total cost amount is LKR 57000. To cover this expenditure, our group plans to collect funds from group members. The budget table should detail all the project expenses, including any necessary equipment, materials, or services required to complete the project. These costs might change in the future due to unforeseen circumstances or unexpected expenses, but with a clear budget plan and contributions from group members, the project can be completed successfully.

8. GANTT CHART



The Gantt chart above represents our proposed plan for the research project, with a focus on my component. We have made progress from January until this week, which is indicated by the green color. The remaining tasks are in purple, which we plan to complete in the coming months.

This Gantt chart is an essential tool for our research plan, as it helps us manage our time and resources effectively. It shows the timelines for each task, the dependencies between them, and the overall project schedule.

Figure 6: Proposed Gantt Chart

9. WORK BREAKDOWN STRUCTURE

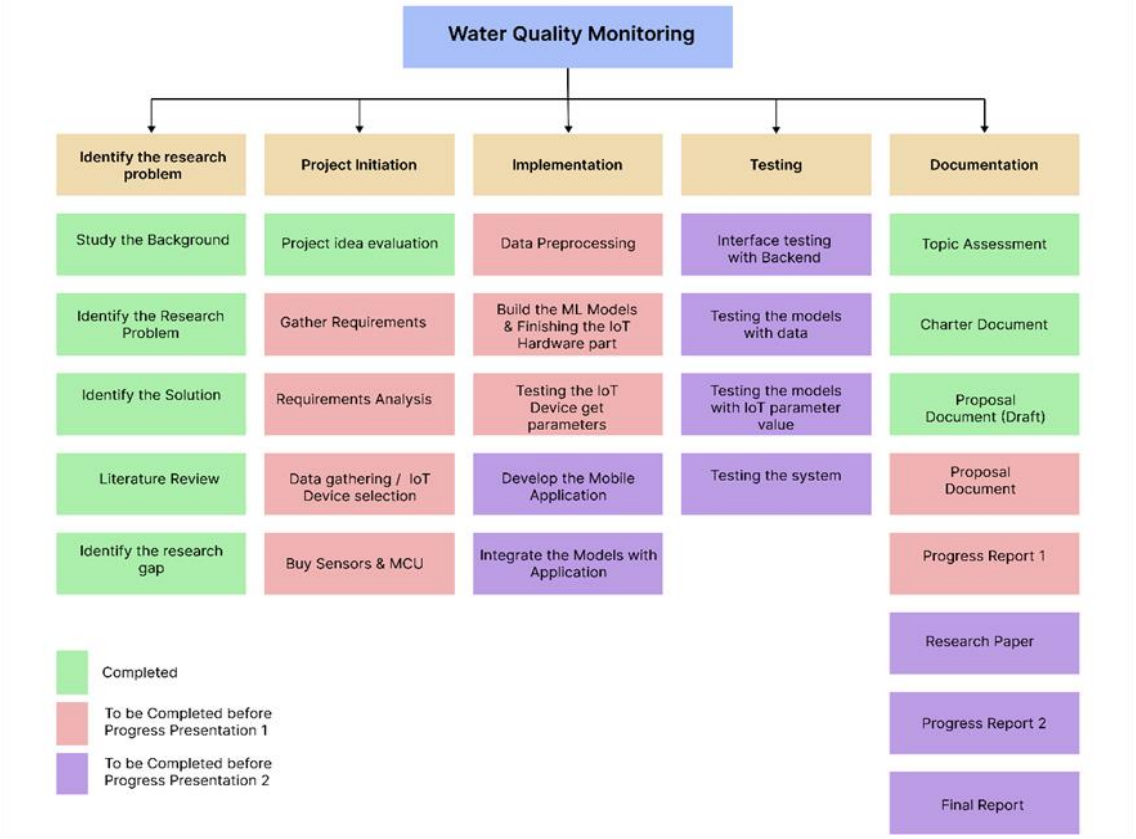


Figure 7: Work-breakdown Structure

The work-breakdown structure for this project comprises five stages: the identification of the research problem, the initial stage, implementation, testing, and documentation. In the first stage, the research problem will be identified and analyzed thoroughly to develop a comprehensive understanding of the project's objectives and requirements. The initial stage will focus on designing the hardware and software components of the IoT-based water quality monitoring system. The implementation stage will involve developing the IoT infrastructure and integrating it with the ML algorithms for water quality prediction. The testing stage will be used to evaluate the performance of the system using pre-tested water samples and optimizing the algorithms for better results. Then, Integrate with the mobile application dashboard. Finally, the documentation stage will involve preparing comprehensive documentation of the project, including technical specifications, user manuals, and the project report.

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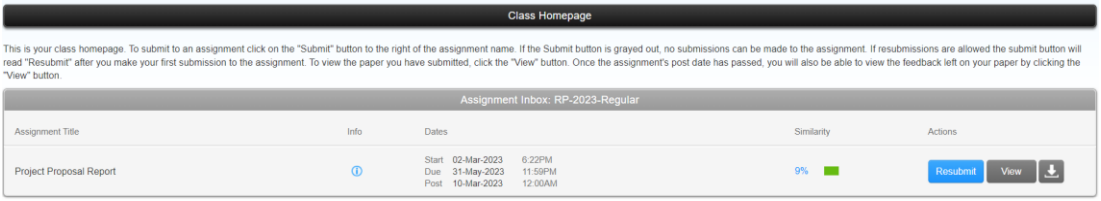
APPENDIX


Class Homepage
This is your class homepage. To submit to an assignment click on the "Submit" button to the right of the assignment name. If the Submit button is grayed out, no submissions can be made to the assignment. If resubmissions are allowed the submit button will read "Resubmit" after you make your first submission to the assignment. To view the paper you have submitted, click the "View" button. Once the assignment's post date has passed, you will also be able to view the feedback left on your paper by clicking the "View" button.
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Assignment Title
Info
Dates
Similarity
Actions
Project Proposal Report
Start 02-Mar-2023 6:22PM
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