List of Figures

Chapter 1

Wireless Water Quality Monitoring System: Transmitter

1.1 Introduction

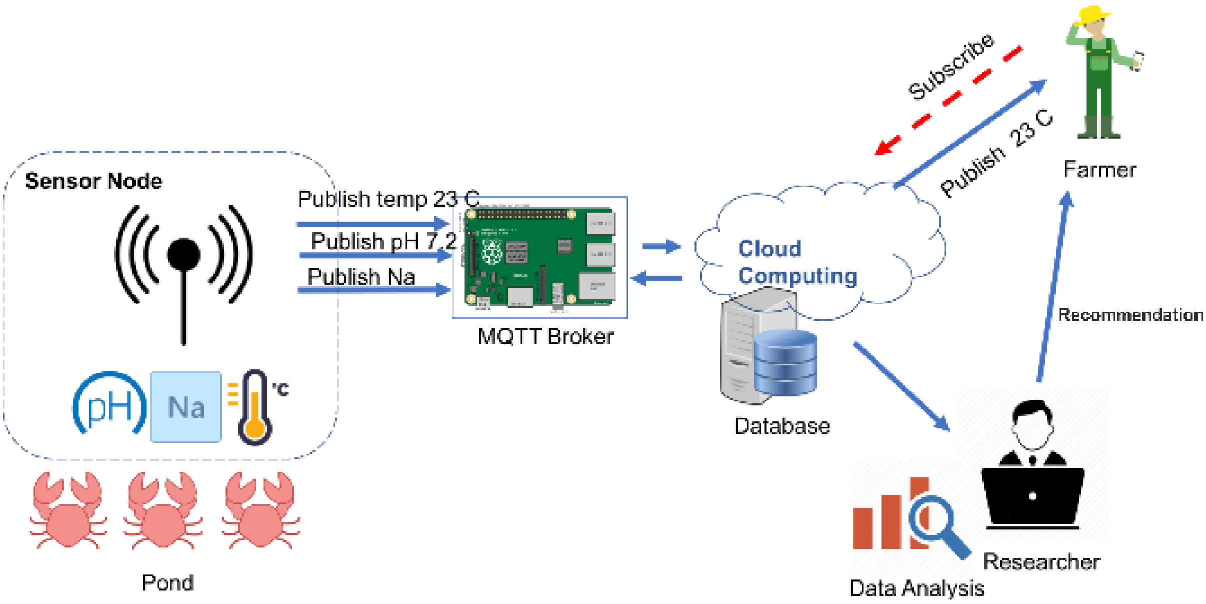


Fig 1.1 IoT-based Monitoring System

The proposed project as demonstrated graphically in **fig1.1** aims to contribute to this field by designing and implementing an efficient IoT-based smart water quality monitoring system. By harnessing the power of IoT and WSN, the project seeks to overcome the limitations of traditional monitoring approaches and provide real-time, continuous monitoring of key water quality parameters. This introductory overview sets the stage for discussing the significance of water quality monitoring, the current state of the field, and the objectives of the project.

Water quality monitoring is essential for safeguarding public health, ensuring the sustainability of ecosystems, and supporting various industries reliant on clean water sources. However, conventional monitoring methods have several drawbacks, including limited spatial and temporal coverage, high costs, and delays in data acquisition and analysis. These limitations underscore the need for innovative approaches that can deliver timely, actionable insights into water quality conditions.

Recent advancements in sensor technology, wireless communication, and data analytics have paved the way for the development of smart water quality monitoring systems. These systems integrate sensors capable of measuring various water quality parameters, such as pH, dissolved oxygen, turbidity, and conductivity, in real-time. By deploying these sensors in strategic locations and leveraging IoT connectivity, it becomes possible to create a comprehensive network for continuous monitoring of water bodies.

The objectives of the project are multifaceted. Firstly, the project aims to design a cost-effective and scalable monitoring solution that can be deployed in diverse environmental settings. Secondly, it seeks to integrate cutting-edge sensors and wireless communication protocols to enable seamless data collection and transmission. Thirdly, the project aims to develop advanced data analytics algorithms capable of detecting anomalies, predicting trends, and generating actionable insights from the collected data. Finally, the project will evaluate the performance of the developed system through rigorous field testing and validation.

In conclusion, the proposed project represents a significant step towards addressing the challenges of water pollution through innovative technological solutions. By harnessing the potential of IoT and WSN, the project aims to revolutionize water quality monitoring and contribute to the preservation of water resources for future generations.

1.2 Motivation

1. Real-time Monitoring for Immediate Action: Our IoT-based system enables continuous monitoring, providing real-time data on water quality parameters. This allows for swift responses to pollution events, mitigating risks to ecosystems and human health promptly.

2. Data-driven decision-making: By delivering actionable insights in real-time, our system empowers stakeholders to make informed decisions. From policymakers to local communities, timely access to accurate data fosters proactive interventions, driving sustainable water management practices.

1.3 Problem Statement

Assessing the RF performance of a wireless Drinking Water Quality Monitoring System (DWQMS) in urban propagation environments using the nRF24L01+ RF module poses challenges such as signal degradation and interference. Additionally, integrating collected data into IoT platforms is crucial for enhancing accessibility and facilitating effective water quality management.

1.4 Objectives

1. **RF Performance Evaluation:** Evaluate the radio frequency (RF) performance of a wireless Drinking Water Quality Monitoring System (DWQMS) utilizing the nRF24L01+ RF module in urban propagation environments, addressing challenges of signal degradation and interference.
2. **Integration with IoT Platforms:** Seamlessly integrate the collected data from the DWQMS into IoT platforms for enhanced accessibility and analysis, facilitating effective water quality management and decision-making processes.

1.5 Project Outcome and Mode of Demonstration

The evaluation of RF performance will be visually presented on an LCD screen connected to an Arduino UNO at the DWQMS base station. This immediate display will showcase real-time feedback on signal strength, interference levels, and data transmission reliability, facilitating rapid assessment of system functionality. Concurrently, data collected by the DWQMS, including readings from pH, turbidity, and conductivity sensors, will be seamlessly uploaded to and analyzed on the Adafruit IoT platform. Integration with Adafruit will ensure smooth data transfer, storage, and analysis, leveraging the platform's capabilities for real-time monitoring and visualization of water quality parameters. The pH sensor will provide insights into water acidity or alkalinity, while the turbidity sensor will assess water clarity by detecting suspended particles. Similarly, the conductivity sensor will gauge water's electrical conductivity, indicating the presence of dissolved ions. This cohesive setup will offer stakeholders immediate RF performance feedback through the LCD screen and detailed water quality data analysis via the Adafruit IoT platform, ensuring transparency and reliability in evaluating the DWQMS efficacy in urban propagation environments.

1.6Applications

1. IoT-based Smart Monitoring: Smart Water Quality Monitoring systems can be employed in urban or rural settings, providing continuous monitoring and analysis of water quality parameters. It can be integrated into existing water supply systems to ensure the delivery of safe drinking water.

2. Monitoring Rivers and Water Bodies: The system is ideal for continuous monitoring of water quality in rivers and other water bodies. It can be deployed in remote areas where regular monitoring might be challenging.

3. Aquaculture Management: These systems can be employed in aquaculture operations such as fish farms and shrimp ponds to monitor water quality parameters essential for the health and growth of aquatic organisms. Continuous monitoring can help prevent water quality-related issues and optimize production.

Chapter 2

Literature Survey

Pasika and Gandla **[1]** proposed a monitoring system that consists of a number of sensors used to measure several quality parameters like turbidity, pH value, water level in the tank, dampness of the adjoining environment, and temperature of the water. The sensors are interfaced with the Microcontroller Unit (MCU) and additional processing is executed by the Personal Computer (PC). The acquired data will be directed to the cloud using the Internet of Things (IoT) based ThinkSpeak application for monitoring the quality of the water under test. As a future directive, work should be extended to analyzing some other parameters such as nitrates, electrical conductivity, dissolved oxygen in the water, and free residual chlorine.

Mukta et al. **[2]** developed an IoT-based Smart Water Quality Monitoring (SWQM) system that helps in the incessant measurement of the quality of water based on four different parameters of water quality i.e., pH, temperature, turbidity, and electric conductivity. Four different sensors are coupled to Arduino Uno to sense the quality parameters. The data collected from all four sensors are communicated to a desktop application which is developed in the .NET platform and the extracted data are matched with the standard values. Based on the collected data from sensors, the developed SWQM model will efficaciously examine the water quality parameters by employing a fast forest binary classifier for the classification of the sample of water under test whether potable or not.

Konde and Deosarkar **[3]** proposed a method for developing a Smart Water Quality Monitoring (SWQM) system with a reconfigurable sensor interface device using an IoT environment. Sensors, Field Programmable Gate Array (FPGA) board, Zigbee-based wireless communication module were used in the proposed model. Six different water quality parameters like turbidity, pH, humidity, water level, water temperature, and carbon dioxide (CO2) on the surface of the water were considered in real-time. The proposed method will assist in guarding the safer and balanced environment of water bodies. The SWQM system reduces the cost and time in determining the quality of water in water resources as part of managing environmental and ecological balance. In the suggested future work, a WSN network will be developed involving of an additional number of nodes to encompass the coverage area.

Amruta et al. **[4]** introduced a Solar Powered Water Quality Monitoring system employing a wireless Sensor Network (WSN), with a focus on Underwater Wireless Sensor Network (UWSN) powered by solar panels. Their proposed architecture includes distributed sensor nodes connected to a base station via Zigbee WSN technology, facilitating real-time monitoring across various locations. The collected data, encompassing parameters like turbidity, oxygen level, and pH, is transmitted to the base station for analysis. This novel system offers advantages such as reduced power consumption, zero carbon emissions, and enhanced flexibility, promising effective water quality monitoring with minimal environmental impact.

Sughapriya et al. **[5]** developed a method for determining the quality of water using IoT and different sensor modules. This system uses different sensors for monitoring the water quality by determining pH, turbidity, conductivity, and temperature. The Arduino controller used will access the sensor data. With the use of IoT, the collected data is analyzed and the pollution of water can be investigated by a stringent mechanism. Additionally, the developed system sends alerts and notifications to the people and apprehensive authorities about the quality of water. The task of water quality monitoring could be achieved by with people having less training also. Installation of the water quality monitoring system could be achieved effortlessly adjacent to the water resources (target area). The proposed model comprises different sensors that compute quality parameters of water in real-time for an immediate plan of action. Also, the developed model is accurate, economical, and requires less manpower.

Unnikrishna Menon et al. **[8]** presented a method for monitoring water quality in rivers through wireless sensor networks, enabling continuous and remote monitoring of key parameters. Their system specifically targets pH, crucial for assessing water quality. The wireless sensor node is equipped with modules for processing, signal conditioning, power management, and Zigbee communication, ensuring seamless transmission of pH data to the base station. Through circuit design, simulation, and hardware prototyping, they optimized power usage and created an affordable platform for river water quality monitoring. This approach promises efficient and cost-effective management of water resources.

Prasad et al. **[7]** developed a smart water quality monitoring system in Fiji using remote sensing and IoT technology. The system focuses on analyzing Oxidation and Reduction Potential (ORP) and Potential Hydrogen (pH) to detect water pollution early. It involves multiple monitoring stations to collect recurrent data for water quality assessment. The study compares various parameters such as Turbidity, pH, temperature, and Conductivity. The system provides precise and reliable real-time monitoring results. Validation was conducted by examining four water sources at hourly intervals over 12 hours. The relationship between temperature, conductivity, and pH was observed for all samples. GSM technology was used to send alarms to users based on reference parameters for immediate action to ensure water quality. Additionally, classifiers were built using data from the four water sources for automated analysis through Neural Network Analysis.

Jerom B. et al. **[8]** introduced a Smart Water Quality Monitoring System leveraging IoT, Cloud, and Deep Learning. They highlighted the inefficiency of traditional manual sampling and lab testing methods, emphasizing the need for real-time monitoring to ensure a safe water supply. The system utilizes IoT devices and Node-MCU for continuous monitoring, with data transmitted to the Cloud via Wi-Fi. Various sensors measure different parameters to assess water quality. Data is stored in the Cloud and analyzed using deep learning techniques to predict water potability. This approach aims to address environmental issues and enhance living standards by improving water quality monitoring.

Geetha and Gouthami **[9]** developed a low-powered and naive solution for monitoring the quality of in-pipe water based on IoT. The developed model is used to test samples of water and the data collected from the sensors is uploaded over the internet is analyzed. This model is a less complex and low-cost smart water quality monitoring system with a core controller having a built-in Wi-Fi module for monitoring quality parameters like turbidity, conductivity and pH. The developed system comprises an alerting facility for informing the users on the deviance of water quality parameters. The implementation facilitates sensors to provide data over the internet to the end customers. The setup used for the experiment can be enhanced by integrating algorithms for incongruity detection in the quality of water.

Sengupta et al. **[10]** proposed a cost-effective technique for monitoring water quality and controlling it in real-time using IoT. The proposed system comprises different sensors like temperature sensor, turbidity sensor and pH sensor that are interfaced with Raspberry Pi via an Analog-to-Digital Converter (ADC). Based on the data obtained from various sensors and processing of data by the Raspberry Pi, the solenoid valve will be directed to either continue or stop the flow of water from the overhead tank to houses using a relay mechanism. This entire process takes place automatically without human intervention thus saving the time to handle the situation manually. Finally, it checks for whether water quality parameters are desired range or not. These all devices are low cost flexible and high efficiency.

Chapter 3

Requirements

The central node, also known as the base station, is the maestro of the wireless water quality monitoring system. Imagine it as a command centre, coordinating the flow of information and keeping a watchful eye on water quality. At its core lies an Arduino microcontroller, the system's brain. It receives data packets transmitted wirelessly from far-flung sensor nodes via nRF24L01+ modules. These packets are filled with raw sensor readings – the essential ingredients for understanding water quality. The central node doesn't just accept this data passively; it meticulously processes it. Think of it as a chef transforming raw ingredients. The data might be reformatted for consistency, analysed to identify trends, or even filtered to remove any errors or noise. Once processed, this valuable information finds a permanent home in a local database, typically built using SQLite. This database acts as a digital archive, meticulously storing historical data for future reference. But the central node doesn't just hoard information; it shares it too. A user-friendly graphical user interface (GUI), built with Python, presents the processed data in a clear and concise format. Think of it as a real-time dashboard displaying water quality parameters like pH, temperature, and conductivity. This allows for on-site monitoring, keeping users informed about the current state of the water. The system can even connect to the cloud using a Wi-Fi module, like an ESP8266. This opens doors for remote access – users can check water quality from anywhere with an internet connection. Imagine being on vacation and being able to ensure your home water system is functioning perfectly! The cloud also offers valuable redundancy, acting as a backup for the local database. Finally, the central node empowers users through control buttons. These buttons might allow users to fine-tune the system, enabling or disabling features like cloud uploads or customizing data displays on the GUI. In essence, the central node is a multifaceted marvel – processing data, storing it securely, making it visually accessible locally, and offering options for remote access and user control. It's the central nervous system of the water quality monitoring system, keeping a vigilant eye on the health of our water.

3.1 Proposed Block Diagram

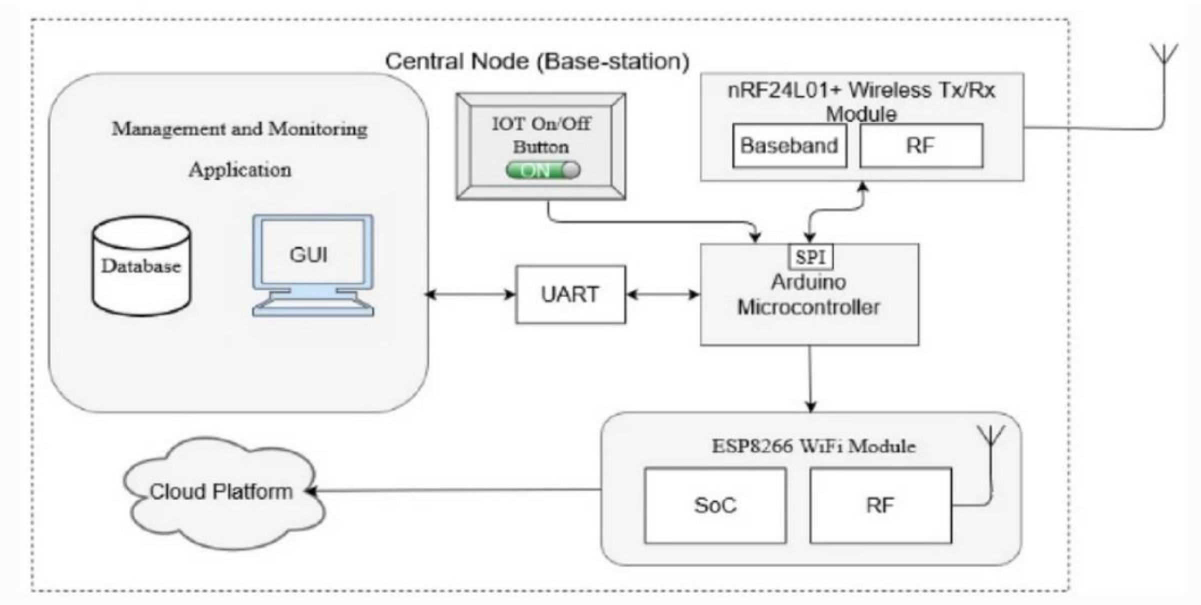


Figure 3.1: Proposed Block Diagram

The central node, the mastermind behind the water quality monitoring system, acts as a data hub, processor, and visualizer. At its core lies an Arduino microcontroller, the system's brain. It receives data packets from remote sensor nodes via nRF24L01+ wireless modules. These packets are filled with raw sensor readings like pH and temperature. But the central node does not just accept this data passively; a dedicated software application meticulously processes it, potentially reformatting it for consistency, analysing trends, or removing errors. Once processed, this valuable information finds a permanent home in a local database, ensuring historical data is readily available. Furthermore, a user-friendly graphical interface (GUI) presents the processed data in a clear and concise format, offering real-time water quality information like pH, temperature, and conductivity. The system can even connect to the cloud for remote access, allowing users to check water quality from anywhere with an internet connection. Finally, the central node empowers users with control buttons, potentially enabling them to turn the entire system on or off. In essence, the central node is a multifaceted marvel – a data processing hub, a secure data vault, and a real-time data visualization tool, all wrapped into one. It acts as the central nervous system of the water quality monitoring system, keeping a vigilant eye on the health of our water.

3.2 Software Requirements

Arduino IDE

The Arduino Integrated Development Environment contains a text editor for writing code, a message area, a text console, a toolbar with buttons for common functions and a series of menus. It connects to the Arduino hardware to upload programs and communicate with them. Programs written using Arduino Software (IDE) are called sketches.

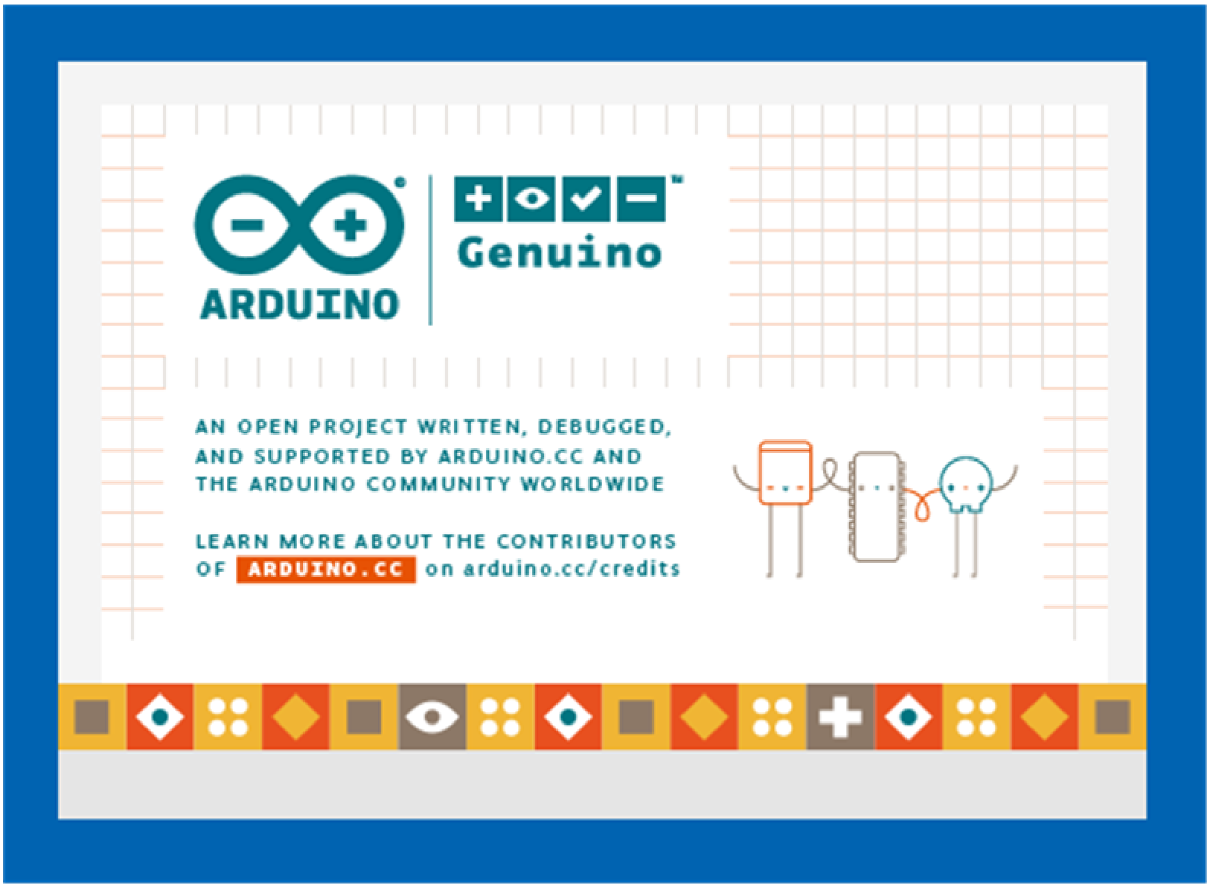


Figure 3.2: Arduino IDE

These sketches are written in the text editor and are saved with the file extension. ino. The editor has features for cutting/pasting and for searching/replacing text. The message area gives feedback while saving and exporting and displays errors. The console displays text output by the Arduino Software (IDE), including complete error messages and other information. The bottom righthand corner of the window displays the configured board and serial port. The toolbar buttons allow you to verify and upload programs, create, open, and save sketches, and open the serial monitor. Some of the key features include code editor, sketches and libraries.

Eclipse Mosquitto

Eclipse Mosquitto is an open source (EPL/EDL licensed) message broker that implements the MQTT protocol versions 5.0, 3.1.1 and 3.1. Mosquitto is lightweight and is suitable for use on all devices from low power single board computers to full servers.

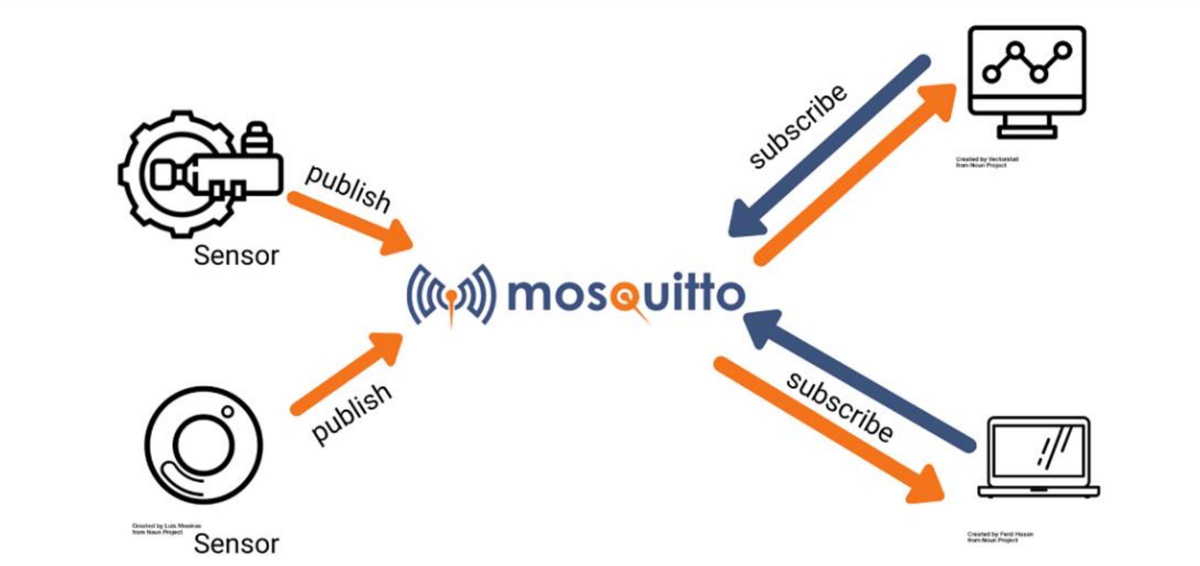


Figure 3.3: Eclipse Mosquito

The MQTT protocol provides a lightweight method of carrying out messaging using a publish/subscribe model. This makes it suitable for Internet of Things messaging such as with low power sensors or mobile devices such as phones, embedded computers, or microcontrollers. The Mosquitto project also provides a C library for implementing MQTT clients, and the very popular mosquitto_pub and mosquitto_sub command line MQTT clients.

Web Interface

Our web interface acts as a virtual window, offering real-time and historical water quality data collected by your wireless monitoring system. We are implementing this website using Asure Iot platform. Our interface utilizes interactive charts and graphs to showcase sensor readings for pH, temperature, conductivity, and more. Track fluctuations over time, identify trends, and gain valuable insights into your water quality. The web interface automatically updates with the latest sensor readings, keeping you informed about the current state of your water system.

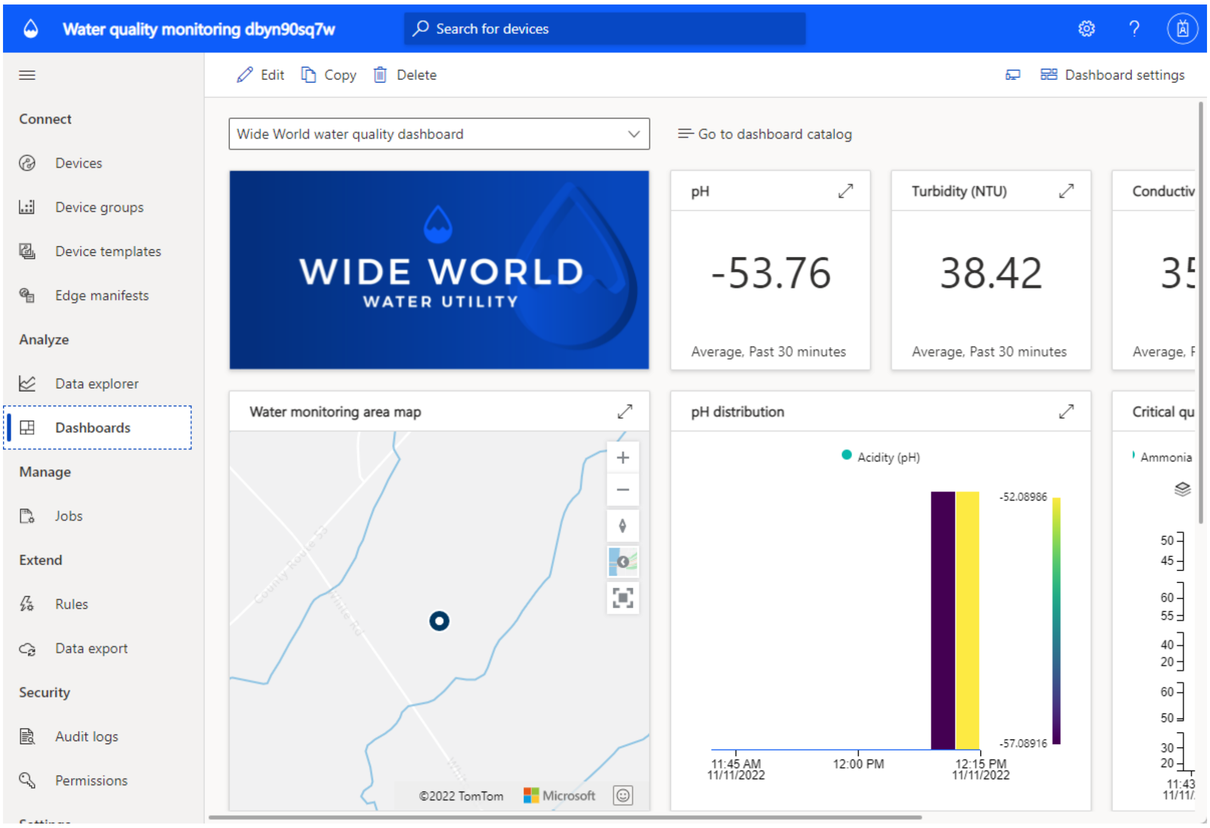


Figure 3.4: Proposed web Interface

The web interface is more than just a data dashboard. It empowers you to make informed decisions about your water system. With a clear understanding of your water quality, you can take proactive measures to maintain a healthy and safe water supply.

3.3 Hardware Requirements

NodeMCU ESP8266

The NodeMCU ESP8266 is a development board featuring the ESP8266 Wi-Fi module, designed for creating Internet of Things (IoT) projects. With its integrated Wi-Fi capabilities, GPIO pins, and microcontroller, it enables seamless connectivity and interaction with a wide range of sensors and actuators.

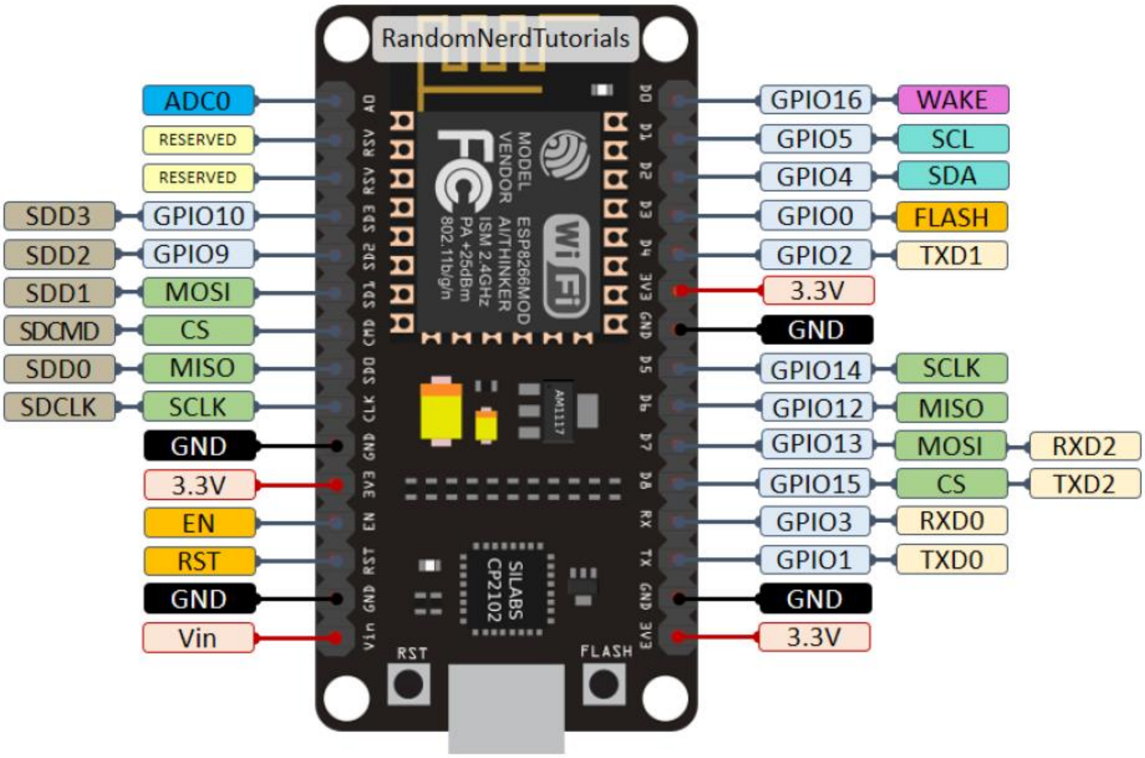


Figure 3.5: NodeMCU ESP8266

The board includes a USB to UART bridge for easy programming and communication with a computer, and it can be powered via USB or an external source. Supporting programming languages like Arduino IDE, Lua, and MicroPython, the NodeMCU offers flexibility and ease of development. Its active community provides extensive support, making it an accessible and powerful platform for prototyping and building IoT applications.

nRF24L01 Module

The nRF24L01 is a wireless transceiver module that operates in the worldwide ISM frequency band commonly used for wireless communication. It uses GFSK modulation for data transmission and is designed for ultra-low power wireless applications. The module can send and receive data using an operating radio frequency. The NRF24L01 wireless module enables underwater transmission by establishing communication between sensors and a receiving system for water quality monitoring. The sender module, connected to the sensor microcontroller, wirelessly transmits data to another module acting as a receiver. This receiver, linked to a microcontroller system, interprets and processes the received data. Utilizing NRF24L01 modules allows real-time transmission of sensor data underwater, crucial for monitoring parameters such as pH, conductivity, turbidity, and temperature. This technology finds extensive applications in environmental monitoring, aquaculture management, and scientific research in aquatic environments.

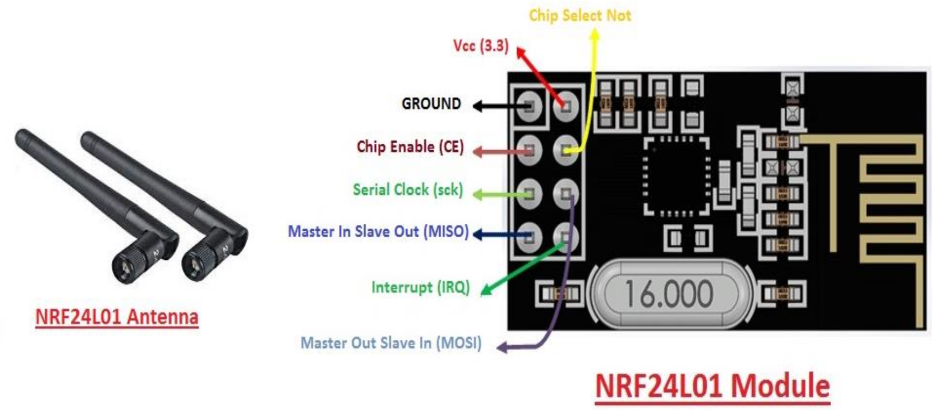


Figure 3.6: nRF24L01 Module

3.4 Methodology

1. **Requirement Analysis:**
    - Identify the key water quality parameters to be monitored (e.g., pH, dissolved oxygen, turbidity, conductivity).
    - Determine the environmental settings where the monitoring system will be deployed.
    - Define the target performance metrics for the monitoring system.
2. **Sensor Selection and Integration:**
    - Research and select appropriate sensors for measuring the identified parameters.
    - Ensure compatibility of sensors with the chosen IoT platform and communication protocols.
    - Integrate the sensors into the monitoring system, ensuring accurate and reliable data acquisition.
3. **Hardware Setup:**
    - Configure the hardware components required for the monitoring system, including microcontrollers (e.g., NodeMCU ESP8266, Arduino), wireless communication modules (e.g., nRF24L01), power supply, and sensor interfaces.
    - Establish connections between the components based on the system architecture.
4. **Software Development:**
    - Develop firmware for microcontrollers to control sensor readings, data transmission, and communication with the IoT platform.
    - Implement algorithms for data processing, anomaly detection, and trend analysis.
    - Design a user interface for system configuration, monitoring, and data visualization.
5. **IoT Platform Integration:**
    - Choose an IoT platform for data management, storage, and visualization (e.g., AWS IoT, Azure IoT, Google Cloud IoT).
    - Integrate the monitoring system with the selected IoT platform using appropriate protocols (e.g., MQTT, HTTP).

6. **Network Configuration:**
    - Configure network settings for wireless communication between monitoring nodes and the central IoT platform.
    - Optimize network parameters for reliability, range, and power efficiency.
7. **Testing and Validation:**
    - Conduct comprehensive testing of the monitoring system in simulated and real-world environments.
    - Validate the accuracy, reliability, and performance of sensor readings and data transmission.
    - Identify and address any hardware or software issues through iterative testing and debugging.
8. **Deployment and Field Testing:**
    - Deploy the monitoring system in target environmental settings, considering factors such as accessibility, power supply, and environmental conditions.
    - Monitor system performance during field testing, collecting data to assess real-world effectiveness and reliability.
9. **Data Analysis and Interpretation:**
    - Analyse the collected data to identify trends, patterns, and anomalies in water quality parameters.
    - Interpret the results to derive actionable insights for decision-making and intervention.
10. **Iterative Improvement:**
    - Continuously monitor and evaluate the system performance over time.
    - Incorporate feedback from stakeholders and end-users to make iterative improvements to the system design, functionality, and usability.

3.5 Novelty of Proposed Work

The receiver part of the project introduces a novel perspective by scrutinizing the radio frequency (RF) performance of the modern wireless Drinking Water Quality Monitoring System (DWQMS) within urban environments. It specifically focuses on assessing how effectively the receiver, equipped with the nRF24L01+ RF module, can capture and interpret data transmitted from various sensor nodes deployed in urban settings. Through meticulous field experiments conducted under diverse scenarios and conditions, the study aims to unravel the intricacies of RF propagation in urban landscapes, providing invaluable insights into optimizing the receiver's functionality for robust data reception. Moreover, the incorporation of the nRF24L01+ transceiver module within the receiver exemplifies an innovative amalgamation of wireless sensor networks (WSN) and Internet of Things (IoT) technologies, underscoring a forward-thinking approach to modern water quality monitoring systems. By shedding light on the receiver's RF performance and its implications in urban contexts, this research contributes significantly to the advancement of DWQMS, paving the way for enhanced monitoring efficiency and cost reduction in water quality management practices.

Chapter 4

Planning and Feasibility of Work

Planning:

1. Research Design: Research design refers to the overall strategy or plan that outlines how a research study will be conducted. It encompasses the methods, procedures, and techniques that researchers employ to collect and analyse data, as well as the rationale behind these choices. A well-designed research study is crucial for ensuring the validity, reliability, and generalizability of the findings. It typically includes elements such as the research questions or hypotheses, the sampling strategy, data collection methods, data analysis techniques, and ethical considerations. The research design acts as a roadmap guiding researchers throughout the research process, from conceptualization to dissemination of results.

2. System Architecture: The IoT-based water quality monitoring system utilizes sensor nodes to measure parameters like pH and dissolved oxygen, transmitting data wirelessly to a central collection point. This data is then analysed on an IoT platform, enabling stakeholders to monitor water quality in real-time and take proactive measures to safeguard ecosystems and public health.

3. Methodology: The methodology entails defining system requirements, selecting and integrating sensors, setting up hardware and software, integrating with an IoT platform, configuring wireless networks, testing, deploying, analysing data, and iteratively improving the system for accurate and real-time water quality monitoring.

4.1 Feasibility Analysis

The feasibility of implementing the receiver part of the proposed wireless water quality monitoring system is strongly supported by the utilization of modern communication technologies such as the nRF24L01+ RF module, wireless sensor networks (WSN), and Internet of Things (IoT) infrastructure. These technologies provide efficient data collection and transmission capabilities, essential for real-time monitoring of water quality parameters. Leveraging commercially available RF modules like the nRF24L01+ further enhances the feasibility by offering reliable communication with low power consumption.

1. Technological Feasibility: The selection of the nRF24L01+ RF module and integration with NodeMCU ESP8266 demonstrate the technological feasibility of the receiver component. These components facilitate seamless wireless communication between the transmitter and receiver nodes, enabling efficient data transmission in the water quality monitoring system. The use of Arduino and ESP8266 platforms simplifies development and ensures compatibility with a wide range of sensors and communication protocols.
2. Resource Feasibility: Adequate resources such as sensors, RF modules, and development platforms are readily available, contributing to the feasibility of implementing the receiver part. The availability of open-source libraries and documentation further streamlines development efforts, reducing resource requirements and time-to-market for the project. Additionally, the scalability of the system allows for easy integration of additional sensors or nodes as needed.
3. Financial Feasibility: The financial feasibility of the receiver component is supported by the relatively low cost of components such as the NodeMCU ESP8266, Arduino board, and nRF24L01+ RF module. The use of off-the-shelf components minimizes development costs, while the potential benefits of improved water quality monitoring efficiency justify the investment. Additionally, the scalability and modularity of the system enable cost-effective expansion and upgrades in the future.
4. Operational Feasibility: Operationally, the receiver component is designed to be user-friendly and easily deployable in various environmental settings. The compatibility of NodeMCU ESP8266 with Arduino IDE simplifies firmware development and debugging processes, enhancing ease of implementation. Robust communication protocols and error handling mechanisms ensure reliable data transmission, even in challenging urban propagation environments. Continuous monitoring and remote management capabilities further enhance operational feasibility by facilitating real-time data access and system maintenance.

4.2 Anticipated Bottleneck

There are several potential anticipated bottlenecks that may arise during the implementation. These bottlenecks could impact the progress and success of the study. Here are some anticipated bottlenecks:

1. Limited Range and Coverage: The receiver's reliance on wireless communication technologies like the nRF24L01+ module may encounter limitations in achieving sufficient range and coverage, especially in densely populated urban areas. Ensuring adequate

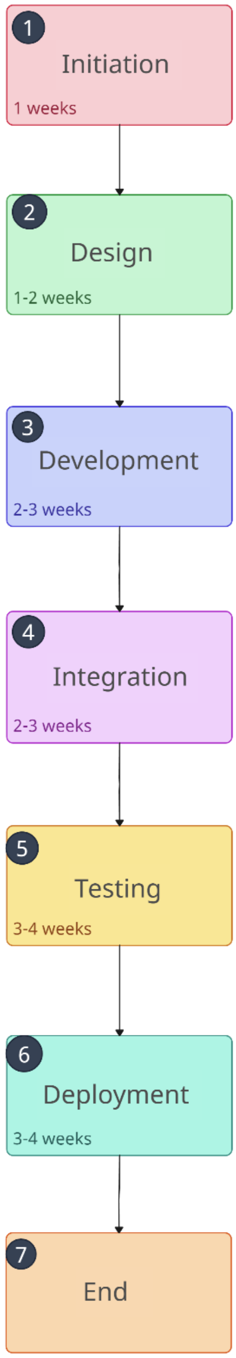
connectivity between transmitter and receiver nodes across the monitoring area may be challenging, potentially affecting data reception and system effectiveness.

2. Power Consumption: Energy efficiency is crucial for the receiver's operation, considering constraints on power sources and the need for prolonged system uptime. The power consumption of the receiver's components, including the NodeMCU ESP8266 and nRF24L01+ module, must be carefully managed to mitigate limitations on data transmission capabilities and system performance, particularly in scenarios requiring frequent data retrieval.
3. Environmental Factors: Environmental conditions such as weather variations, physical obstructions, and potential interference can influence the reliability and stability of the receiver's operation. Addressing the impact of environmental factors on wireless communication and data reception is essential for maintaining consistent system functionality and ensuring reliable water quality monitoring results.

4.3 Budget Estimation

COMPONENTS	**PRICE**
nrf24L01	168/-
NodeMcu Esp2866	285/-
Miscellaneous	150/-
Total cost	**603/-**

4.4 Pert Chart



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