

## Sungai Muar Monitoring System for Seawater Intrusion

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### Abstract

This project aims to create an automated water quality monitoring system with a conductivity sensor and GSM module to combat seawater intrusion in Sungai Muar. By monitoring the river's salinity levels continuously, the system offers real-time data to identify high salinity, indicating possible contamination. The project emphasises incorporating modern technology like I2C communication, Modbus RTU protocol, and SoftwareSerial for efficient data processing and communication. Successful tests affirm the sensor's precision and the GSM module's ability to send timely SMS alerts to relevant authorities. The collected data can be utilised to compare ideal conductivity ranges for various plants and animals, aiding in effective water management to support growth, health, and productivity while reducing the adverse effects of seawater intrusion. The performance analysis of the water monitoring system in detecting Sungai Muar's conductivity level was successful, as the prototype consistently delivered precise and reliable data with an accuracy rate of 98% during testing. The system showed high accuracy in detecting conductivity fluctuations, meeting initial objectives, and delivering expected results. The system's architecture and circuit layout were meticulously planned, and the prototype effectively measured Sungai Muar's conductivity and salinity levels, showcasing its capacity to offer accurate and reliable data, confirming its practical usability, and achieving all primary goals.

## 1. Introduction

This project is a system that uses a sensor to detect and measure the level of salinity in a river, allowing for the monitoring of seawater intrusion. It is because Sungai Muar is located closer to the university, making it simpler to conduct the studies. Therefore, a water quality sensor will monitor and measure the salinity level with the help of this system that has been developed. The water's salinity level will be used to compute the contamination level. The salinity level of a river water is only about 0.5 ppt, while that of seawater is 34 to 36 ppt [1]. The salinity level of the contaminated water level will be about more than two parts per thousand, indicating that the river water is more likely to be contained by high salt and tainted with pollutants and hence dangerous to use or drink on a regular basis. A fluctuating salinity level will serve as a cautionary sign for pollutants that this system is looking for. The system will automatically send a triggering message to the relevant representative or person in charge whenever it notices any changes in the salinity level of Sungai Muar. The relevant ministry can take further suitable actions and safety precautions if the salinity level is higher than usual based on the data that is collected.

### 1.1 Background Study

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Seawater intrusion is one of the biological and environmental issues that coastal areas confront because of human activity and the combined effects of climate change. Climate change or human action are the main causes of seawater intrusion. A worldwide problem, seawater intrusion is made worse by the growing need for freshwater in coastal areas as well as by its susceptibility to the effects of climate change and rising sea levels [2]. Surface and underground water bodies are constantly interacting in their natural conditions. Immediate economic losses or issues, such as decreased agriculture yields and industrial water shortages, can result from seawater intrusion. The ecological environment may also suffer because of it.

The project aims to develop an automated water quality monitoring system for Sungai Muar, ensuring data on the river's salinity levels impacted by seawater intrusion is provided every two hours. This will determine if the water is suitable for all living organisms, with sensors continually monitoring and storing salinity data.

In addition, the capability to send a triggering message to the relevant representative or person in charge will be incorporated into this system as it is built. River water should have a salinity level of approximately 0.5 parts per thousand (PPT). Rise in it indicates that the river water is high salinity, which places many organisms' cells under osmotic stress, a condition in which an organism's ability to absorb and expel water is influenced by the concentration of solutes in the surrounding water body. In this case, the relevant party will receive a message in this situation, and they can take appropriate action on it.

## 1.2 Problem Statement

This project is primarily intended for usage by approved users, particularly employees of corporations or the government. In this problem statement, my primary focus will be on how the government may reduce the impact of seawater intrusion on the general public by implementing an appropriate maintenance system that tracks pollutant levels. First of all, because Sungai Muar is closer to me and my area and easier for me to research, I personally selected it as my study site. The distance from Jambatan Muar to Panchor is approximately 30 km. The primary issue is that diffuse pollution brought on by seawater intrusion has severely worsened the water quality in Sungai Muar. In addition, Sungai Muar experiences increased damage, which harms marine life. Besides that, there is a detrimental effect on agriculture and animals for the residents of the Muar area [3][4]. The majority of people who live close to Sungai Muar are farmers, poultry growers, and dependent on fishing, and as a result of the river water violations, their daily income is minimal, which could cause the economy to go down. The designed system will be of more assistance for all of these issues and challenges that stated above; it will use a sensor to monitor the water salinity level in Sungai Muar.

## 1.3 Project Objectives

The purpose of this project is as listed below:

- 1) To study the level of the conductivity and salinity level in Sungai Muar in various time period.
- 2) To develop a system that monitors the level of seawater intrusion of Sungai River by detecting the conductivity level.
- 3) To analyse the performance of the water monitoring system in accurately detecting the conductivity level of Sungai Muar

## 1.4 Scope of Project

To fulfil the stated objective, the scope of this project is as following:

- 1) The study will involve establishing a specific time frame, recording conductivity and salinity levels along the river, and conducting manual sampling for laboratory analysis to validate and calibrate sensor data.
- 2) An Arduino microcontroller will be used as a system controller and will be equipped with various types of electronic equipment such as conductivity sensor to measure the total dissolved salt content in Sungai Muar, GSM module to send alert to user, and some output indicators for monitoring the progress of the process.
- 3) To evaluate the accuracy and reliability of the water monitoring system in measuring and reporting the conductivity levels of Sungai Muar over a specified period.

## 2. Literature Review

Research on automated water quality monitor systems has been conducted to monitor river water quality and reduce pollution caused by seawater intrusions. These studies provide detailed information on the device's structure, operating system, software, and framework. This chapter will provide an overview of the Sungai Muar monitoring system, including its seawater intrusion, hardware components, circuit and flow diagrams, and maintenance procedures. Despite numerous studies and research projects on automated water quality monitor systems, this chapter aims to present project information for comparison with suitable industry products.

Reviewing previous projects can help identify problems related to the development process and provide insights on improving the project's effectiveness. By reviewing these projects, we can compare and improve the effectiveness of these systems in the industry.

**Table 1** Comparison of previous projects

No	Title of project	Pros & Cons	Hardware used	Software used
1	Water Quality Monitoring with Notifications System [5]	<p>Pros</p> <ul style="list-style-type: none"> <li>• Easy to install and maintain.</li> <li>• Easier to operate.</li> </ul> <p>Cons</p> <ul style="list-style-type: none"> <li>• The design is lightly complicated</li> </ul>	<ul style="list-style-type: none"> <li>• Raspberry Pi</li> <li>• PH sensor</li> <li>• Turbidity sensor</li> <li>• Temperature sensor</li> <li>• Ultrasonic sensor</li> <li>• USB cable</li> </ul>	<ul style="list-style-type: none"> <li>• Raspberry Pi OS</li> <li>• PyCharm</li> <li>• Notepad++</li> <li>• Visual Studio</li> </ul>
2	Automation System for Monitoring the Quality of Water Sources to Maintain Their Sustainability using Microcontroller [6]	<p>Pros</p> <ul style="list-style-type: none"> <li>• Friendly user interphase and clear result shown in the LCD.</li> <li>• Many features</li> <li>• Easier to operate.</li> </ul> <p>Cons</p> <ul style="list-style-type: none"> <li>• Costly</li> </ul>	<ul style="list-style-type: none"> <li>• Arduino Mega</li> <li>• PH sensor</li> <li>• Turbidity sensor</li> <li>• Temperature sensor</li> <li>• Ultrasonic sensor</li> <li>• GSM module</li> <li>• USB Cable</li> <li>• LCD screen</li> <li>• Buzzer</li> <li>• LED</li> </ul>	<ul style="list-style-type: none"> <li>• Arduino IDE</li> <li>• Fritzing</li> </ul>
3	Development of IoT for Automated Water Quality Monitoring System [7]	<p>Pros</p> <ul style="list-style-type: none"> <li>• Can collect and store much data.</li> </ul> <p>Cons</p> <ul style="list-style-type: none"> <li>• Expensive</li> <li>• Complicated</li> <li>• Unreliable</li> </ul>	<ul style="list-style-type: none"> <li>• YSI 600R sensor</li> <li>• Raspberry Pi type B</li> <li>• Modem Wi-Fi 4G</li> <li>• Adapter</li> </ul>	<ul style="list-style-type: none"> <li>• Raspberry Pi OS</li> <li>• PyCharm</li> </ul>
4	Smart Sensor Node of WSNs for River Water Pollution Monitoring System [8]	<p>Pros</p> <ul style="list-style-type: none"> <li>• The monitoring parameters are flexible.</li> <li>• The capacity of network is big.</li> <li>• Advanced technology.</li> </ul> <p>Cons</p> <ul style="list-style-type: none"> <li>• Complicated interface</li> <li>• Complicated design</li> <li>• Expensive</li> <li>• Ineffective</li> </ul>	<ul style="list-style-type: none"> <li>• DO sensor</li> <li>• PH sensor</li> <li>• Turbidity sensor</li> <li>• Temperature sensor</li> <li>• Conductivity sensor</li> <li>• Water level sensor</li> <li>• Flow rate sensor</li> <li>• Solar panel system</li> </ul>	<ul style="list-style-type: none"> <li>• WSN system</li> </ul>
5	Development of Water Quality System to	<p>Pros</p>	<ul style="list-style-type: none"> <li>• Arduino MEGA</li> <li>• Turbidity</li> </ul>	<ul style="list-style-type: none"> <li>• Arduino IDE</li> </ul>

Monitor Turbidity and Temperature of Water Using GSM Module [9]	<ul style="list-style-type: none"> <li>• Advanced tech and useful.</li> <li>• Can be operate by all adults.</li> </ul> <p>Cons</p> <ul style="list-style-type: none"> <li>• Need regular check-up.</li> </ul>	<ul style="list-style-type: none"> <li>• sensor</li> <li>• Temperature sensor DS18B20</li> <li>• GSM SIM900 module</li> <li>• LCD screen</li> <li>• Buzzer</li> <li>• RGB lights</li> </ul>	
6 The Water Quality Online Monitoring System Based on Wireless Sensor Network [10]	<p>Pros</p> <ul style="list-style-type: none"> <li>• More advanced.</li> </ul> <p>Cons</p> <ul style="list-style-type: none"> <li>• More complexity.</li> <li>• Expensive.</li> </ul>	<ul style="list-style-type: none"> <li>• Acquisition module (STM8 MCU module and CC2530 module)</li> <li>• Coordinator module</li> <li>• Host computer module</li> <li>• GSM module</li> <li>• Mobile terminal module</li> <li>• PH sensor</li> <li>• DO sensor</li> <li>• Temperature sensor</li> </ul>	<ul style="list-style-type: none"> <li>• LabVIEW programming software</li> <li>• ZigBee Sensor Network</li> </ul>

### 3. Material and Method

The functionality of this project was determined by a review of the literature, which in turn informed its design. In actuality, the conductivity level of the Sungai Muar, which could be impacted by seawater intrusion and have adverse effects on the locals of Muar, is just kept under observation by this system. Another feature included is the use of the GSM module to send the user an SMS alert if the conductivity level changes, indicating whether the conductivity level is in a normal or high state. ThingSpeak is used to capture and store real-time data for this project. Thus, the primary hardware for this project consists of an Arduino UNO, a conductivity sensor, and a GSM module. The system is designed to be easy to use and features a user-friendly interface that can be grasped by everyone, including the average person.

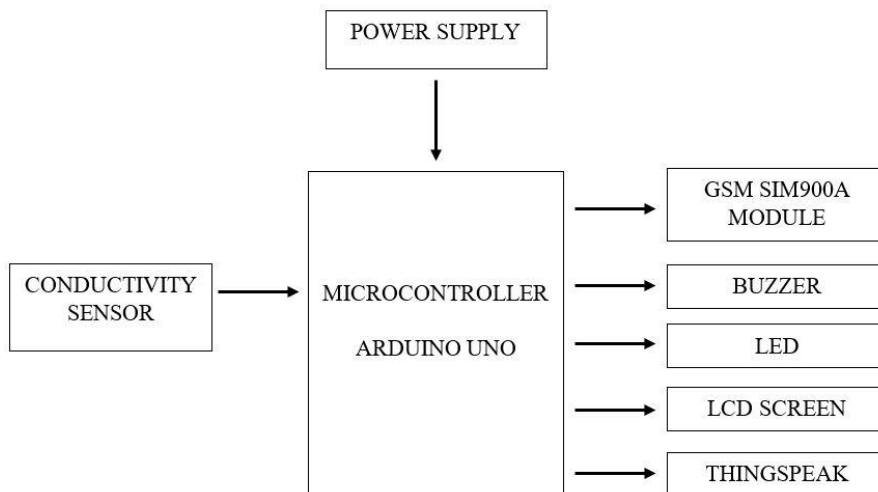
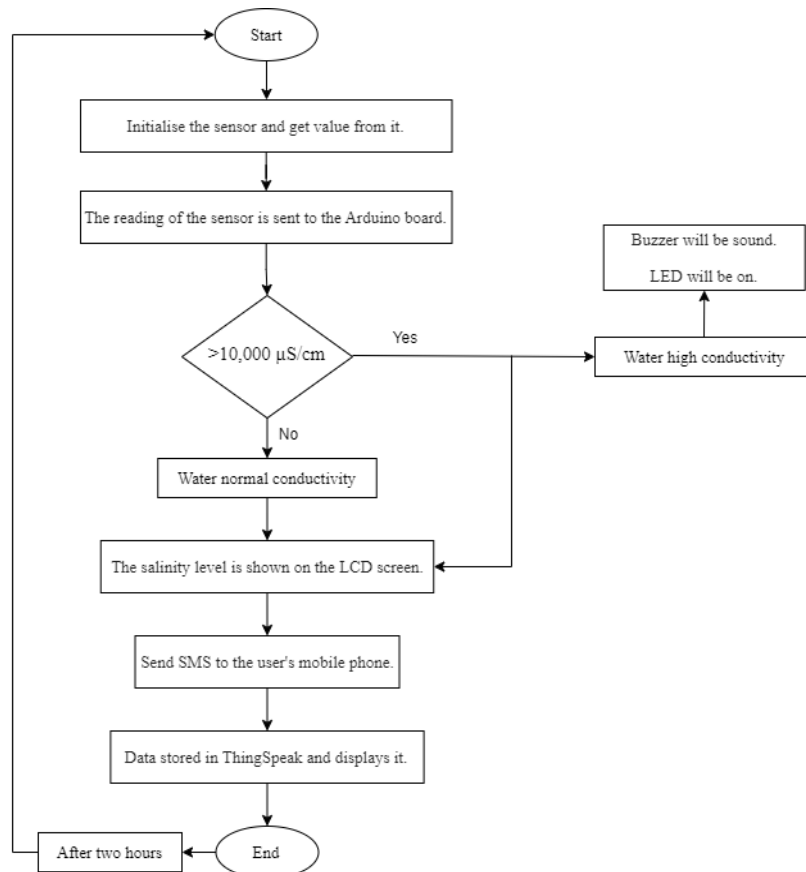


Fig. 1 Block diagram of the project

Fig 1 shows the block diagram of this project. The main parts of the automation system for monitoring water resource quality are the Arduino Uno connected with a sensor (conductivity sensor) to monitor the water quality and display the monitored value on the LCD screen [11][12][13]. Additionally, the GSM links to the

observers' mobile devices to transmit text messages that display the water condition monitoring properties [14]. Meanwhile, all the real-time data will be stored in ThingSpeak [15][16]. When the salinity level is high, the LED will light up and the buzzer will be sound.



**Fig. 2** Detailed flowchart of the project

Fig 2 displays the detailed flowchart of this project. The project involves various functions and initialises components for usage. The salinity sensor takes time to obtain readings after encountering water. An Arduino Uno serves as the system controller for receiving data. There are two possible results: water is in a normal state when the conductivity level is below 10,000  $\mu\text{S}/\text{cm}$ , or it is in a high conductivity state when it is greater than 10,000  $\mu\text{S}/\text{cm}$ . The conductivity level is displayed on an LCD screen. An SMS alert is sent to the registered user's mobile phone when the water's condition is normal or has high conductivity. A buzzer and LED light up if conductivity levels exceed 10,000  $\mu\text{S}/\text{cm}$ , indicating low water quality. Meanwhile, all the real-time data will be stored in ThingSpeak [16][17]. The programming concludes after completing the necessary functions.

#### 4. Result and Discussion

The Sungai Muar Monitoring System for Seawater Intrusion is a groundbreaking environmental monitoring technology project that offers real-time river conductivity monitoring to farmers, ranchers, and poultry growers. The system uses GSM technology to provide real-time updates on conductivity levels. This innovative integration of hardware and software enhances the system's architecture, operational effectiveness, and user accessibility. The system offers a sophisticated and reliable way to monitor water quality and notify users of saltwater intrusions. Features such as a conductivity sensor, GSM notifications, and ThingSpeak's real-time data make it a standout in the industry.

The completed, fully functional prototype of the Sungai Muar Monitoring System for Seawater Intrusion is depicted in Fig 3. A connection is used to link the sensor and the model. As long as the display is showing the default display, the system is prepared to measure the reading. Since the sensor and the water are not in contact, the sensor initially reads 0  $\mu\text{S}/\text{cm}$ . The components utilised in all perspectives are labelled in Fig. 4.



Fig. 3 Complete prototype of the project

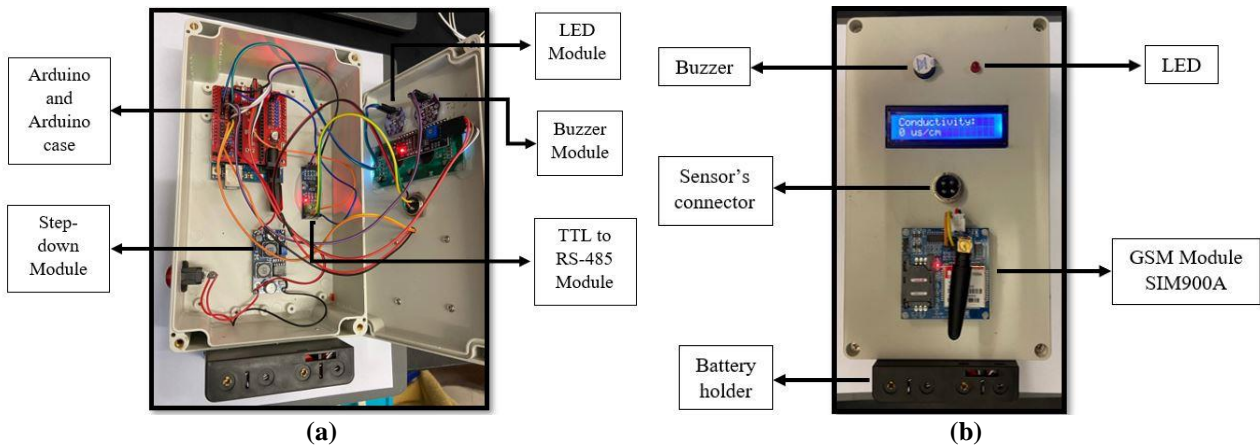
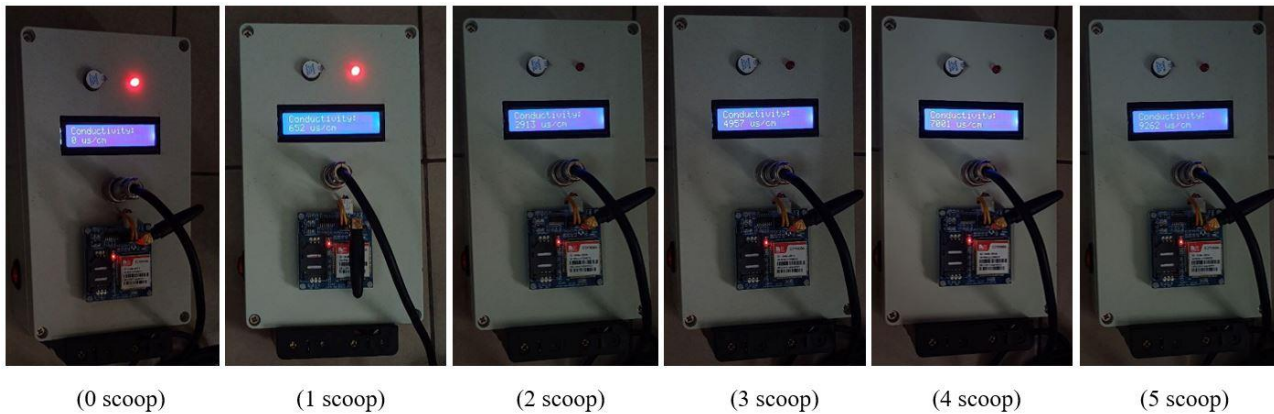


Fig. 4 Other views of the prototype with label (a) Internal view; (b) Top view

To assess the functionality of the Digital Conductivity Sensor, trials were conducted in saltwater. Each scoop weighed approximately 50 g. The test findings are presented in Table 2. A clear correlation between conductivity levels and the concentration of salt in the water was indicated by the results. To examine the sensor's performance over a larger range of salinity levels, more research will be conducted.

Table 2 Conductivity level in different saturation of saltwater

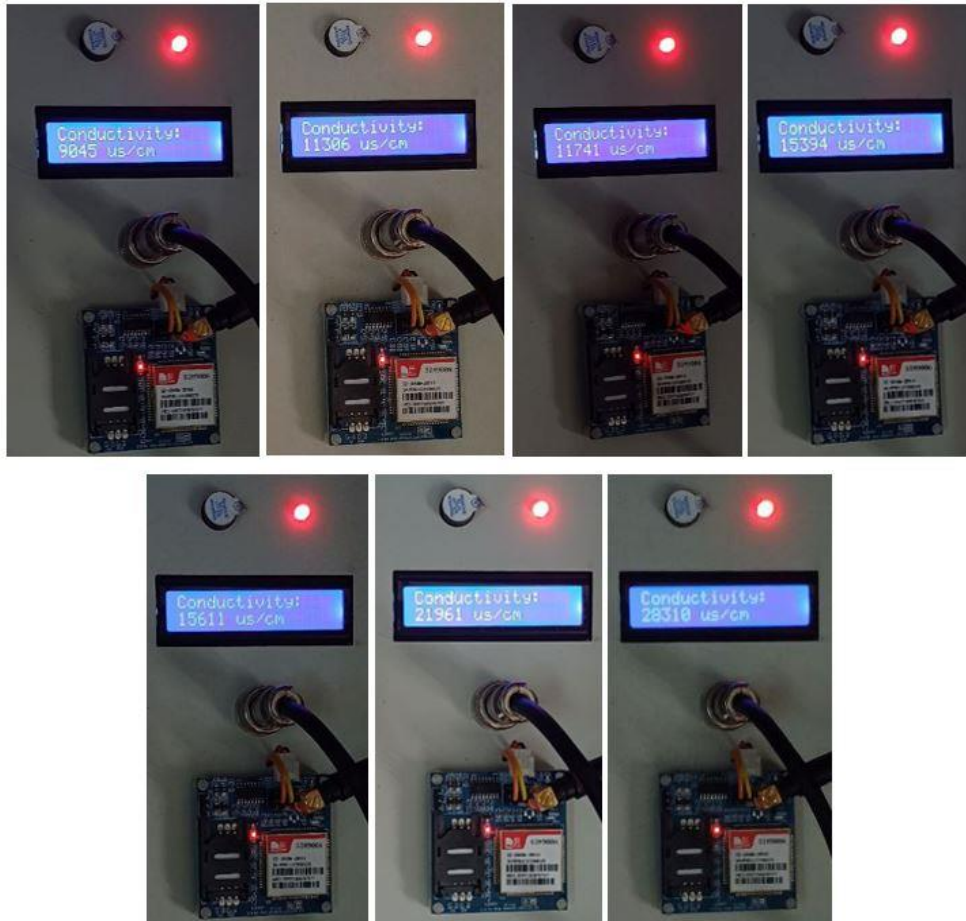
Number of scoop (salt)	Conductivity level ( $\mu\text{S}/\text{cm}$ )
0	0
1	652
2	2913
3	4957
4	7001
5	9262



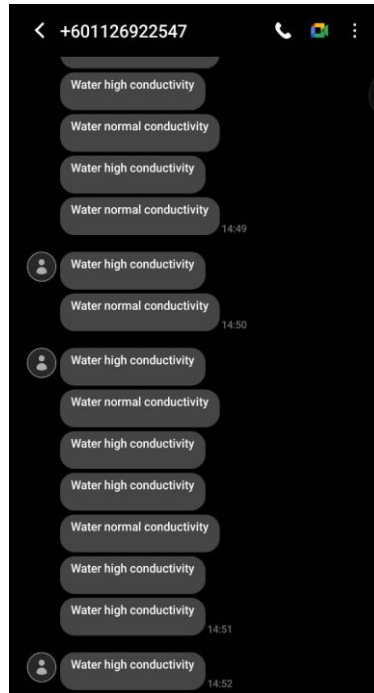
**Fig. 5** Results showing values of conductivity level on different saturation of salt water

Fig 5 shows the values of conductivity level on different saturation of salt water that displays on the LCD screen. The initial conductivity level of base water is 0  $\mu\text{S}/\text{cm}$  when no salt is added. As salt is applied gradually, the conductivity increases to 652  $\mu\text{S}/\text{cm}$  when the first scoop is added. The conductivity increases more significantly with the second scoop, reaching 2913  $\mu\text{S}/\text{cm}$ . The conductivity increases with subsequent scoops, reaching 4957  $\mu\text{S}/\text{cm}$ , 7001  $\mu\text{S}/\text{cm}$ , and 9262  $\mu\text{S}/\text{cm}$ . This indicates that adding salt increases conductivity as the water contains more ions, improving its ability to carry electricity. The test findings confirm the Digital Conductivity Sensor's functionality, demonstrating its sensitivity to variations in ion concentrations in water and its accuracy in detecting and measuring variations in water conductivity. This suggests that a rise in conductivity will result in a rise in salinity.

The final test took place at the Panchor River testing area, where the Digital Conductivity Sensor and GSM module performed effectively. Water samples were collected over three days and analysed in the laboratory. Fig 6 shows a few values of water samples from the Panchor River, while Fig 7 displays messages from the GSM module that indicate the water state. The findings will be displayed in the subsequent table, Table 3.



**Fig. 6** Results showing few values of water samples from Panchor River



**Fig. 7** Messages from GSM module that indicating the water state

**Table 3** Result table of conductivity level and water state of river water in three days

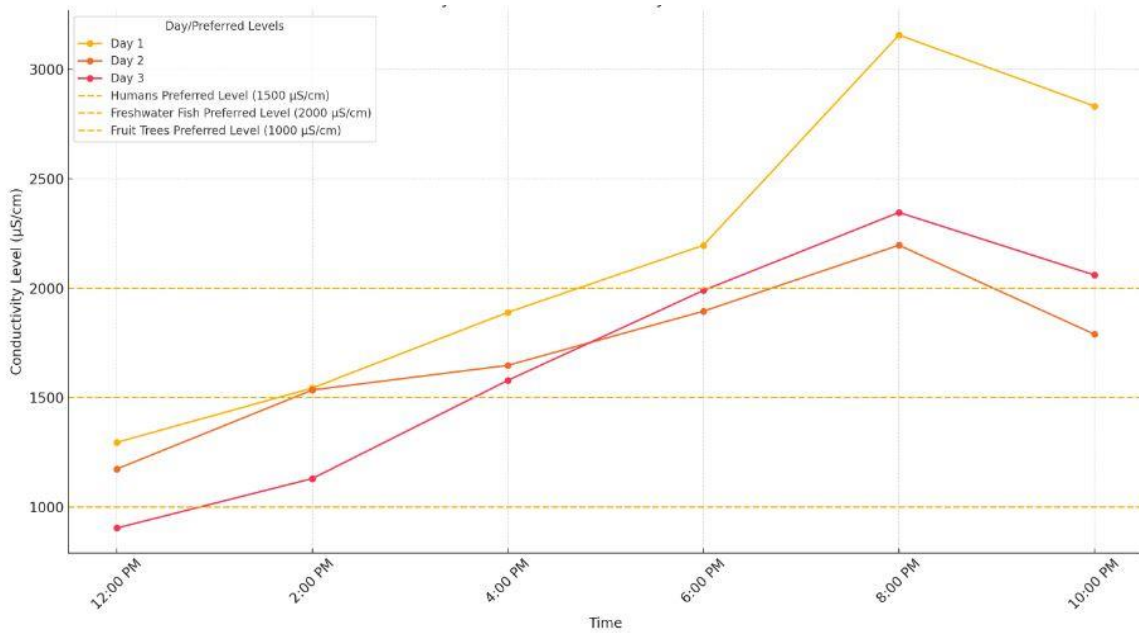
	Day & Time	Conductivity Level ( $\mu\text{S}/\text{cm}$ )	Water State
<b>1</b>	12.00PM	12956	Low Conductivity
	2.00PM	15438	Low Conductivity
	4.00PM	18894	Low Conductivity
	6.00PM	21956	High Conductivity
	8.00PM	31560	High Conductivity
	10.00PM	28310	High Conductivity
<b>2</b>	12.00PM	11741	Low Conductivity
	2.00PM	15349	Low Conductivity
	4.00PM	16475	Low Conductivity
	6.00PM	18946	Low Conductivity
	8.00PM	21961	High Conductivity
	10.00PM	17894	Low Conductivity
<b>3</b>	12.00PM	9045	Low Conductivity
	2.00PM	11306	Low Conductivity
	4.00PM	15789	Low Conductivity
	6.00PM	19894	Low Conductivity
	8.00PM	23456	High Conductivity
	10.00PM	20598	High Conductivity

Due to the lack of an appropriate datasheet, the conductivity values were changed by multiplying them by 10 in the coding. Consequently, the data was multiplied by 10 in order to read it from the sensor.

**Table 4** Result table of adjusted conductivity level and water state of river water in three days

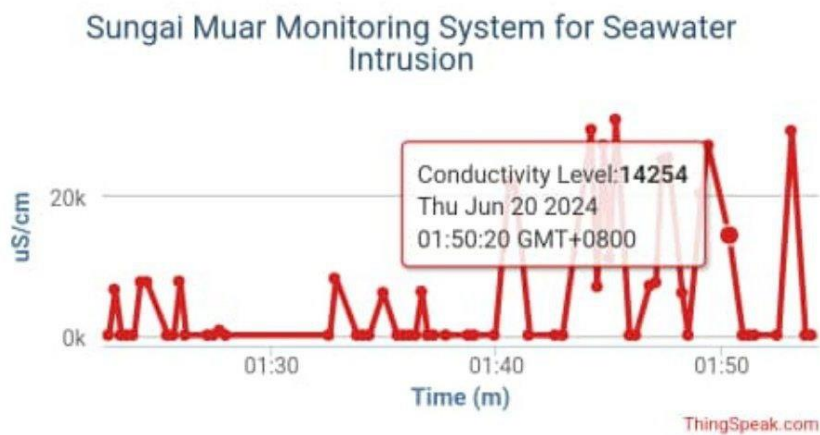
Day & Time		Conductivity Level ( $\mu\text{S}/\text{cm}$ )
1	12.00PM	1295.6
	2.00PM	1543.8
	4.00PM	1889.4
	6.00PM	2195.6
	8.00PM	3156
	10.00PM	2831
2	12.00PM	1174.1
	2.00PM	1534.9
	4.00PM	1647.5
	6.00PM	1894.6
	8.00PM	2196.1
	10.00PM	1789.4
3	12.00PM	904.5
	2.00PM	1130.6
	4.00PM	1578.9
	6.00PM	1989.4
	8.00PM	2345.6
	10.00PM	2059.8

From the results, Fig 8, a line chart, illustrates the data clearly. Different lines indicate water conductivity levels suitable for humans, freshwater fish, and fruit trees. This data will benefit farmers, ranchers, and poultry breeders near the Panchor River and Muar River.



**Fig. 8** Line graph of adjusted conductivity level of river water in three days

The Panchor River conductivity values can be used to compare the ideal ranges of plants and animals that rely on or are connected to it. These findings can inform farmers, ranchers, and poultry growers about the best times to use river water for their daily tasks and livelihoods. At 12:00 PM, the river water is suitable for humans and pets whose optimal level is below 1500  $\mu\text{S}/\text{cm}$ . Farmers should use river water for drinking and other purposes during these periods to protect their health and safety. Freshwater fish have an optimal range of 100 to 2000  $\mu\text{S}/\text{cm}$ , but farmers should refrain from using river water during busy periods. Animals, such as livestock and wild animals, should use the water for most of the day, with the exception of the largest peaks between 6:00 and 10:00 PM. It is crucial for ranchers and wildlife managers to ensure animals receive water during non-peak conductivity periods. Watering fruit trees with low ideal ranges should only be done in the morning or early afternoon before 12:00 PM to prevent saline levels from stunting growth and output. The graph (Fig 8) illustrates these conductivity values, making it a helpful tool for scheduling everyday tasks around the most efficient water use periods. Adherence to these rules and ongoing monitoring can help lessen the negative impacts of seawater intrusion on the Panchor River and Muar River ecosystems.



**Fig. 9** Display of ThingSpeak showing graph with collected data

As mentioned above, ThingSpeak software was used in this monitoring system, which makes the system an automated system. Fig 9 shows the display of ThingSpeak showing graph with collected data. For future recommendation, the prototype can be changed in a suitable and proper manner so that it can be placed in a static position where it can take readings 24/7. If that happens, the power supply also needs to be changed to direct current. A more comprehensive picture of the state of the river might be obtained by adding more sensors to track temperature, pH, DO, and other aspects of water quality. Further improving the GSM module would further boost the efficacy of the system by guaranteeing improved network coverage and dependability, especially in rural locations. Furthermore, creating a mobile application for notifications and real-time data access could greatly increase user convenience and engagement. This app was made with the intention of automatically storing the results of the monitored parameters inside the app. The user can therefore check whenever they want.

## 5. Conclusion

The Sungai Muar Monitoring System for Seawater Intrusion project aimed to design, develop, and implement an advanced environmental monitoring system to protect the Sungai Muar's water quality from saltwater intrusion. The system integrates modern technology and software, providing real-time river conductivity monitoring while ensuring smooth operation and a user-friendly interface. The system's ability to alert users to changes in conductivity through GSM technology has proven beneficial to local farmers, ranchers, and poultry growers. The project demonstrates how state-of-the-art technology can be successfully integrated into environmental monitoring, improving the system's architecture and operational effectiveness.

The system's architecture and circuit layout were carefully constructed, considering signal processing, power needs, sensor placement, and component integration. The prototype successfully measured Sungai Muar's conductivity and salinity levels, proving its accuracy in identifying fluctuations in conductivity. The performance study validated the system's practicality in practical applications. The project's thorough and deliberate approach led to the achievement of all three main objectives, indicating that the project met its main objectives and fulfilled expected results.

## Acknowledgement

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