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Study on Seawater Intrusion Detection and Investigation in the Muar River Basin

Shangkari Sivaraju[1], Mohd Shamian Zainal[1*]

[1] *Department of Electrical Engineering Technology, Department of Electrical Engineering Technology, Universiti Tun Hussein Onn Malaysia, 84600 Pagoh Johor, MALAYSIA*

*Corresponding Author: shamian@uthm.edu.my
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Abstract

Seawater intrusion is detrimental for agricultural activities, water supply, and the health of river ecosystems, such as that affecting Malaysia's Muar River. This paper looks at an affordable, IoT system made to spot seawater intrusion as it happens.The system has a salinity sensor, an ESP32 Wi-Fi chip, and GPS for finding locations. It watches salinity and location, sending info to a web platform. The Blynk app shows the info and sends out alerts.Observations from the river mouth show salinity is reduced upstream, supporting the idea that seawater intrusion happens when the river's discharge decreases. This system allows fast data collection and cheap early warnings, which helps with tracking the environment and handling water resources. Later studies might watch water quality and study long-term trends in the data.

1. Introduction

Saltwater entering freshwater is a big environmental problem for coastal rivers everywhere. When salty water mixes into freshwater areas, it ruins the water quality and creates dangers for drinking water, farms, and the wildlife that lives in the water, notably when the river isn't flowing very strongly. In Malaysia, the Muar River area in Johor is at risk for saltwater intrusion because of tides, less freshwater coming down the river, and changing weather. These things make it more likely that the salt levels will go up and down, so we need to keep a close watch to catch it early and handle our water resources well.

Past research shows that saltwater getting into coastal rivers is really affected by the tides, how much freshwater is coming from upstream, and what people do. Usually, to check the water in places like the Muar River area, people take samples by hand and test them in a lab. These ways can give you good numbers, but they take a while, don't give you information very often, and can't warn you right away. Because of this, the salt levels can rise quickly without anyone noticing, which can hurt water treatment plants, farms, and the river's ecosystem. Recent advancements in Internet of Things (IoT) technology provide breakthroughs in the possibility of continuous and real-time environment monitoring. These technologies include the acquisition of data using sensors, wireless data transmission using microcontrollers, and the visualization of data in real-time using cloud technology or mobile applications. These cited developments provide cost-effective measures in the monitoring of seawater intrusion, especially in river basins that require frequent monitoring intervals. As such, there is a significant need to develop a system that is cost-effective, used in real-time, and suitable for the Muar River Basin.

This project seeks to explore the principles of monitoring seawater intrusion using IoT technology and to design and develop a real-time monitoring system that is able to measure river salinity levels and transmit the data wirelessly to a cloud platform using an ESP32 chip and the Blynk IoT platform. The project scope will be to design and develop a real-time system that is able to transmit the data wirelessly and display it real-time using the cloud

Progress in Engineering Application and Technology Vol. 7 No. 1 (2026) p. 282-289

platform and the application, and to perform tests using a salinity (TDS) sensor to measure salinity levels and to compare the data with existing salinity benchmarks in selected points of the river basin Muar.

2. Literature Review

Past water quality studies often looked at the Internet of Things, wireless sensor networks, and GSM tech [1]. They usually checked things like pH, how cloudy the water was, temperature, how much oxygen was in the water, and how well electricity conducted [2]. These systems usually send real-time updates to warn people about water quality, but they don't focus on when seawater mixes into freshwater [3]. Some studies have created real-time systems to watch how seawater gets into land, using Raspberry Pi or Arduino [4]. These mostly measure how resistant the water is to find out how much seawater is mixing in. Plus, the systems often don't put data on the cloud, and they can't grow as big as the Sungai Muar setup [5]. When you think about it, not many use a cheap, real-time system to watch salinity using IoT, the cloud, and location tagging to spot seawater getting into rivers. This study looks to fix that by making a specific IoT system for the Muar River Basin[6]. Table 1 shows the comparison of previous projects including parameters, key contributions and research gaps.

Table 1 *Comparison of previous projects*

No.	Author(s) & Year	System / Study Focus	Technology Used	Parameters Measured	Key Contribution	Limitations / Research Gap
1	Rizqi Putri Nourma Budiarti et al. (2019)[7]	IoT-based automated water quality monitoring	Raspberry Pi, IoT sensors	General water quality parameters	Real-time online surface water monitoring	No focus on seawater intrusion or salinity intrusion detection
2	Evizal Abdul Kadir et al. (2019)[8], [9]	River water pollution monitoring	WSN,Arduino Mega	EC, pH, DO, temperature, flow rate	Multi-parameter river monitoring using WSN	High system complexity; no real-time intrusion alert
3	Delight Sekhwela et al. (2020)[10]	Water quality monitoring with notifications	Raspberry Pi, IoT, cloud system	pH, turbidity, temperature, water level	Mobile and web-based notification system	Salinity and seawater intrusion not addressed
4	Ahmed Aziz Atiast et al. (2022)[11]	Automated water quality monitoring	Arduino Mega, GSM	pH, turbidity, temperature, water level	Automated alerts to authorities	No salinity or seawater intrusion focus
5	TheevaarasanGhandi (2024) [12]	Sungai Muar Monitoring System (Year not specified)	Arduino Uno, conductivity sensor, GSM	Salinity (conductivity)	Real-time intrusion alert with 98% accuracy	No cloud platform; limited scalability

3. Methodology

This study utilized an IoT monitoring system to find seawater getting into the Muar River Basin. The system has an ESP32 microcontroller (with Wi-Fi), a salinity sensor (to determine electrical conductivity and total dissolved solids), and a GPS for tracking locations. In this project has been programming it using the Arduino IDE and using the Blynk IoT platform to see the data in the cloud and send alerts. The salinity sensor and GPS were set up with the ESP32 to gather data regularly. Then, it sends the data to the cloud wirelessly.[13]

For the research field readings has been taken at different spots along the river, from the mouth to places inland like Bukit Kepong, to see how salinity changes. Checked how well the system works by looking at sensor response,

data transmission, GPS accuracy, and alerts. In the project graphs was used to see how the system performed and to confirm that seawater was entering the river.

Figure 1 shows how the IoT system keeps tabs on seawater entering the fresh water. A salinity sensor checks the water's salt level, then a GPS unit pinpoints the location. Both are connected to an ESP32 board. This board is the brains of the operation, handling the data from the sensors. Then, the ESP32 sends the salt level and location data to the Blynk platform, so we can watch things in real time and get alerts. A power supply keeps the whole thing running without stopping.

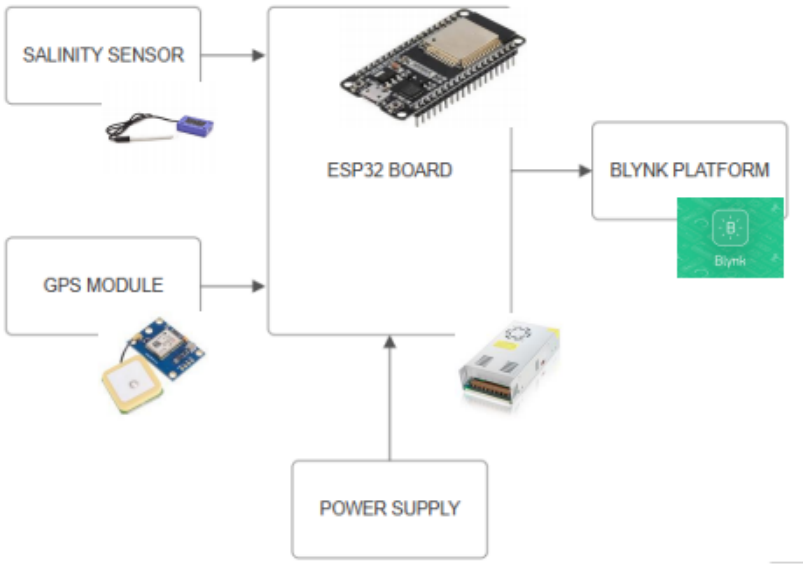

Fig. 1 *Block Diagram.*

Figure 2 shows the flowchart of the seawater intrusion. The seawater intrusion monitoring system operates systematically. It begins with the ESP32 starting up the salinity sensor and the GPS. Systematically, the monitoring system records salinity levels as well as the river location. In the case of normal salinity, the values are directed to the Blynk IoT platform for observation. In situations of high salinity, an alert notification is sent through a mobile application and an e-mail to quickly notify in case of seawater intrusion.

Progress in Engineering Application and Technology Vol. 7 No. 1 (2026) p. 282-289

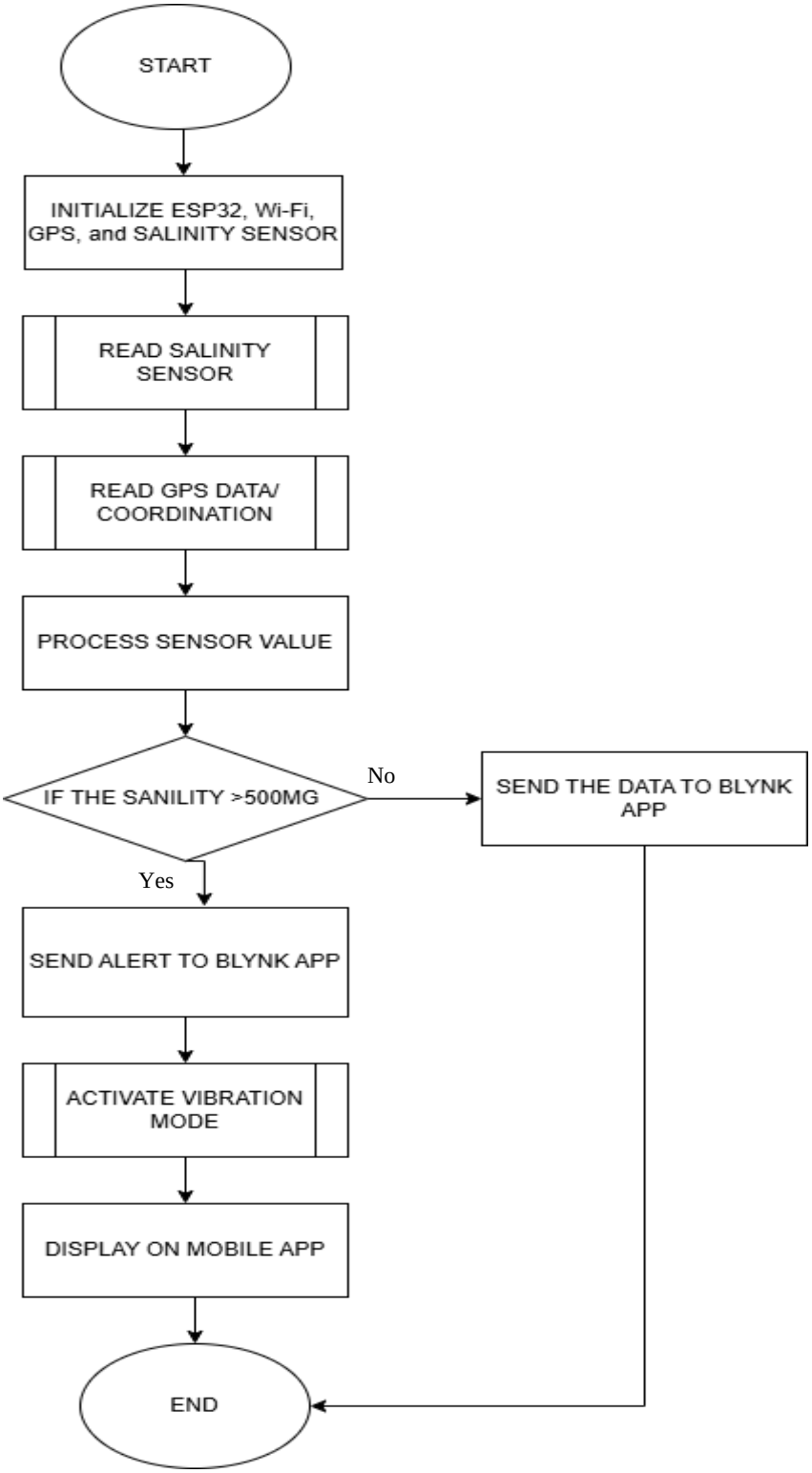

Fig. 2 *Flowchart of the project.*

4. Results and Discussion

The proposed IoT-based seawater intrusion monitoring system for the Muar River Basin is an environmental monitoring solution designed to provide real-time salinity information to relevant stakeholders. The system employs an ESP32 microcontroller integrated with a salinity sensor and a GPS module to continuously monitor river conductivity and spatial location. Real-time data are transmitted wirelessly to a cloud-based platform for visualization and alert notifications when salinity levels exceed predefined thresholds[13]. This integration of hardware and software improves system efficiency, monitoring accuracy, and user accessibility. The developed system offers a reliable and practical approach for detecting seawater intrusion and supports water quality management.

The completed prototype of the proposed system is shown in Fig. 3, while the overall system components and connections are illustrated in Fig. 4. When the sensor is not in contact with water, the conductivity reading remains at zero, and the system is ready to acquire measurements upon deployment.

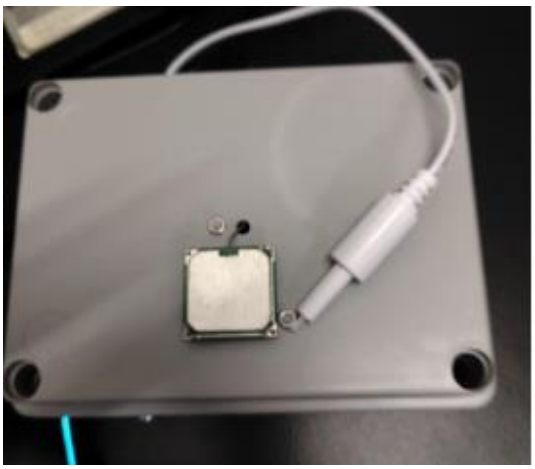

Fig. 3 *Complete prototype of the project*

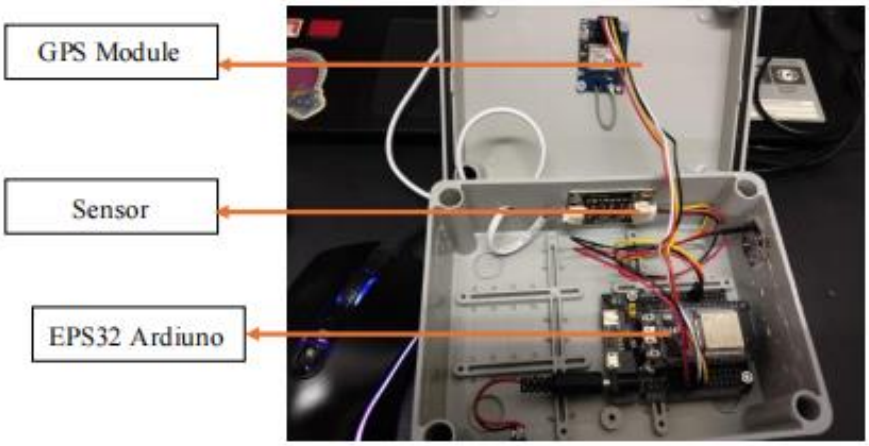

Fig. 4 *Internal View*

To evaluate the performance of the digital salinity sensor, experimental tests were conducted using saltwater samples with increasing salt concentrations. The relationship between the number of salt additions and the measured salinity in parts per million (PPM) is presented in Table 2. The results show a consistent increase in PPM values from 14 to 69.3 as the amount of salt increased, indicating a clear positive correlation between salt concentration and measured salinity. This confirms that the sensor can detect changes in salinity levels, demonstrating its suitability for seawater intrusion monitoring applications.

Progress in Engineering Application and Technology Vol. 7 No. 1 (2026) p. 282-289

The test findings are presented in Table 2. Dots of salt are measured with pichakaree and the PPM is shown below.

Table 2 *Level of salt*

Dot of salt	PPM
0	14
1	30.5
2	39.8
.3	45.2
4	58.4
5	69.3

Figure 5 shows that prototype has been tested by running it for an hour to see how well it monitors and alerts in real time. During the test, the salinity readings were sent to the monitoring platform and showed up as a live graph, like in the picture. The graph shows the salinity changing a bit over time, which means the data is being sent without stopping. When the salinity went over the limit we set, the system automatically sent an alert and an email to the user's Gmail. This shows that the system can keep an eye on salinity in real time and send alerts when needed, which is helpful for spotting seawater issues early on.

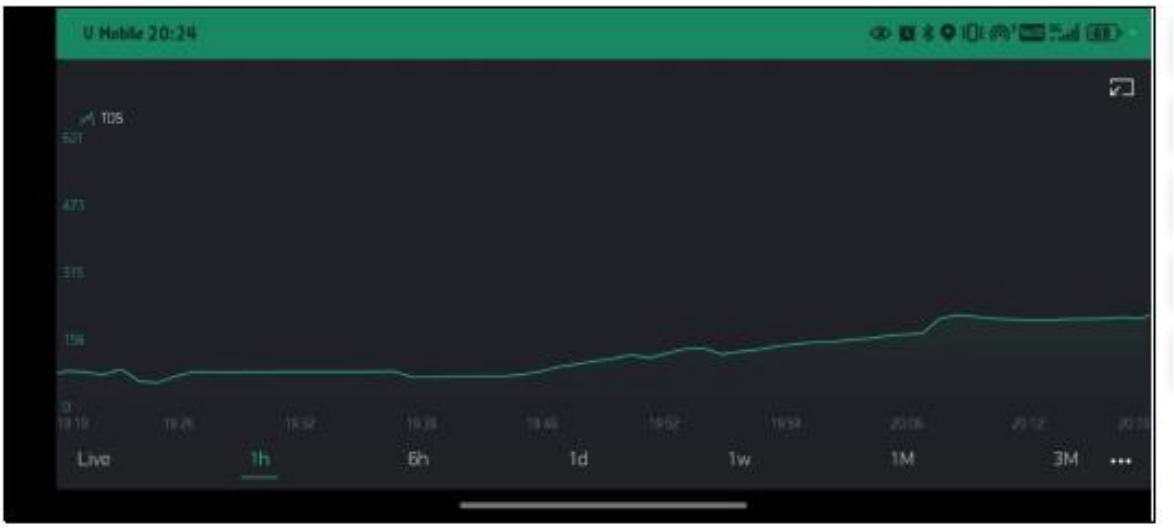

Fig. 5 *Real-time monitoring*

Figure 6 shows the Bylnk where we can see the location with longitude and latitude with the continue data analysis at top. We can also adjust the ppm as the amount we need.

Fig. 6 *View of Blynk*

The final test was conducted at the Panchor River, where the prototype was performed effectively. Water samples were collected over 21 days, as shown as graph in Figure 7.

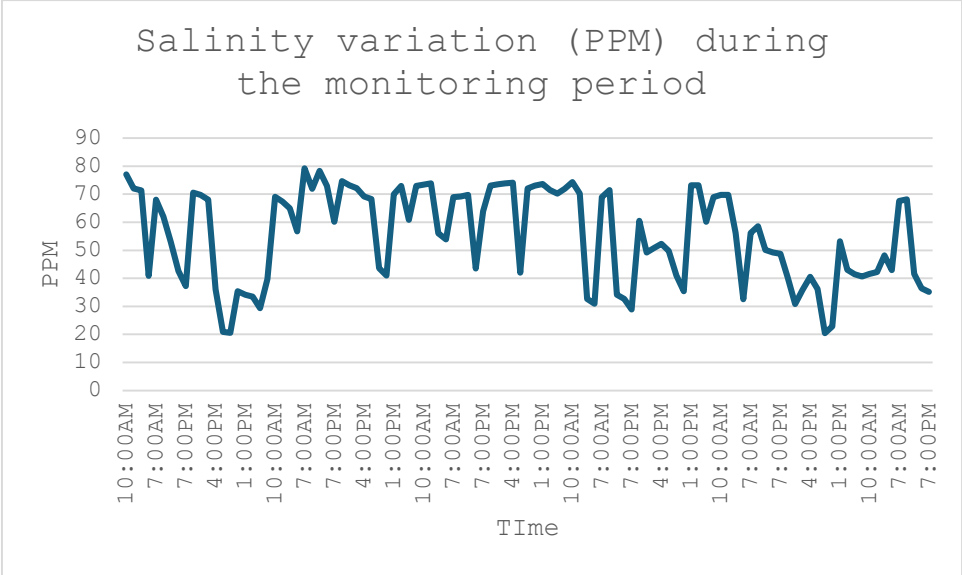

Fig. 7 *Data Graph*

5. Conclusion

The study successfully developed and tested a digital conductivity sensor prototype to monitor salinity levels in the Muar River Basin. Field tests conducted at the Panchor River over a period of 21 days showed that the prototype performed effectively in detecting variations in water salinity. The water samples collected and analyzed confirmed that the system provides reliable and consistent results. This prototype offers a practical solution for real-time monitoring of seawater intrusion, which is crucial for maintaining water quality, supporting local aquaculture and farming activities, and managing environmental impacts in the river basin. With further improvements, the system could be applied across other areas of the river to provide comprehensive monitoring and early warning of increasing salinity levels.

Acknowledgement

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