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Internet of Things Oxygen Reduction Potential Sensor for Oil Pollution Detection

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Abstract: Oil pollution is one of the disasters that occur by the human being in Malaysia and globally. It destroys the river systems and terrestrial habitat daily especially the location of the facility, the terminal, and the transportation. The main objective of this work is to develop and design an Internet of Things (IoT) oxygen reduction potential sensor that can monitor oil spills and alert the authorized person when spills happen. The system consists of an oxidation-reduction potential sensor (ORP) to measure the sanitizer's effectiveness in water. An Arduino UNO acts as a microcontroller in this system while the Wi-Fi module (ESP8266-01) is to send data from the microcontroller to the Blynk application. The Internet of Things (IoT) is a network of both electrical and internet-connected computers. This system can be linked over the Internet, allowing users to view the data from it and display real-time data of the oil spill to the user's smartphone through the cloud dashboard Blynk application. This is necessary to provide rapid monitoring of oil spill occurrences. The proposed system is developed to rapidly monitor the abnormal changes in water quality.

Keywords: Oil Pollution, Arduino UNO, Blynk, IoT

1. Introduction

Indeed, water is necessary for human survival. It protects people and the climate and makes up more than 70% of the surface of the earth and anywhere in the world, oil pollution impacts drinking water sources, streams, lakes, and oceans. In turn, this has detrimental impacts on both human health and the environment. There have been several reports of water contamination in Malaysia, particularly in rivers [1]. The criminal disposal caused the release of toxic fumes that affected 6,000 people and hospitalized 2,775 others. Nowadays, human activities that because disasters are the main problem, such as unsupervised development and construction along the rivers. One of the greatest natural disasters that can harm both human life and natural environments is an oil spill. With the river being used to deliver billions of metric gallons of oil each year. Even modern methods, like the deployment of booms and skimmers, require a lot of manpower to be carried out well, which leads to mistakes and delays but instead exposes those engaged to health concerns. As a result, the factory still faces difficulties and dangers related to the oil industry, necessitating the investigation and creation of novel

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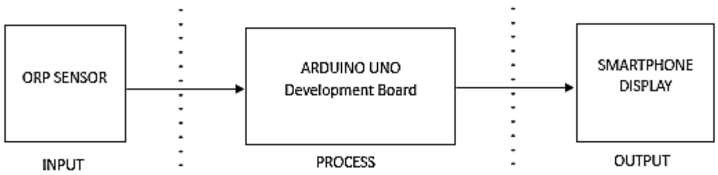
techniques and procedures designed with risk and dependability management in perspective. Unexpected rivers with oil leaks are a serious hazard [2]. Oil spills can spread every minute and are unpredictable, which are very unexpected. It is necessary to have early detection of oil.

This work focuses on the quality of oil spill monitoring systems and has been the subject of numerous investigations by earlier researchers. It is also noticeable that cleaning up an oil spill is a multi-step operation that necessitates ongoing observation of the accident site. Among some of the most mentioned incidents is the Kim Kim River in Johor, where careless parties dumped chemicals into the river, affecting the health of more than 2,000 humans and resulting in the temporary shutdown of 111 schools [3]. Implementing the necessary long-term action plans necessitates processing a more detailed stream of data from the spill site.

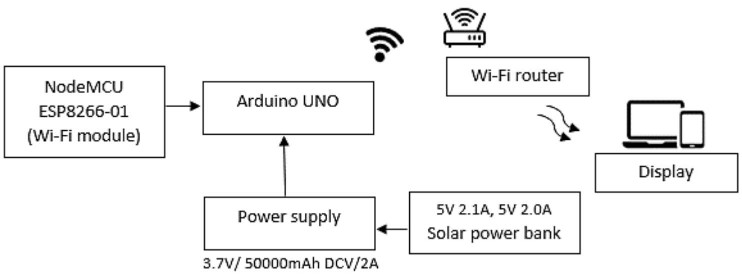
The oxidation and reduction potential (ORP) of the water in a river or lake showed its ability to eliminate contaminants such as oil spillage. When the ORP value is high, there is a lot of oxygen in the water [4]. This points out that microorganisms that degrade waste and pollutants can operate more efficiently. In particular, the higher the ORP value, the healthier the lake or river [5].

All this research utilizes Internet of Things (IoT)-based continuous analysis using oxidation-reduction potential (ORP) electrodes, which are analytical sensors (ORP). Oil accidents are terrible natural events that frequently have long-lasting effects on the local environment, ecology, and socioeconomic activities. The selection process is a complicated procedure that is driven by numerous human and non-human factors. This work focuses on examining the oil spill in the water. By visiting rivers, it has been predicted that there will be a rapid increase in oil spills because of industry. This work can also provide information based on the oil spill more quickly through the cloud dashboard Blynk application.

2. Materials and Methods



(a)



(b)

Figure 1: Block diagram of (a) sensor and (b) gateway analog reduction potential sensor water pollution

Figure 1 (a) shows the schematic block diagram of the system operation. This operation started with the oxygen reduction potential sensor which is the main component in this system in detecting the value of the oil spill. Then it moves to the Arduino UNO which is the microcontroller for this system. When oil pollution happens, the data output value will be displayed through the cloud dashboard to the smartphone of the user. Figure 1 (b) shows the getaway analog reduction potential sensor water pollution.

2.1 Calibration of ORP sensor

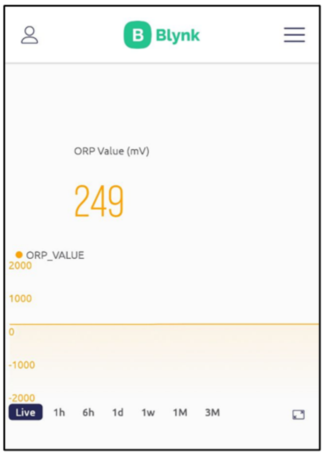
To calculate the ORP value for standard solutions with 256 mV, the programmed code for SEN0464 calibration was created using the Arduino IDE. In order to make a sensor or instrument function as accurately or error-free as feasible, a sensor or collection of sensors must be calibrated. Accurate sensor data collection is necessary for the oxygen reduction potential system in order to retain the ORP sensor's true parameter during oil spills. After uploading the code and setting up the output display in the serial monitor the results show the value of the analog ORP sensor.

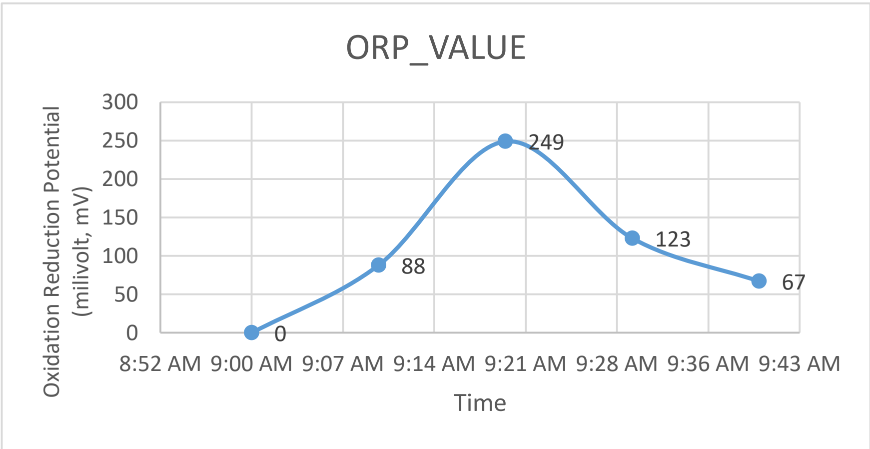
A calibration has been conducted to demonstrate the working principle of the SEN0464 Analog Reduction Potential sensor. Figure 2 shows the 256 mV (± 15 mV) standard solutions of the ORP sensor have been used. The output data will display accuracy on the Blynk application. The examination is conducted to verify the sensor's efficacy. A straightforward calibration was performed to demonstrate the operating principle of the SEN0464 Analog Oxygen Reduction Potential sensor.

(a) (b)

Figure 2: ORP sensor with 256mV standard solution (a) and (b) the sensor while doing the calibration

Figure 3 (a) shows the value output through the Blynk application of the calibration with the standard solutions of the ORP sensor. The data output can be viewed on the user's smartphone. Figure 3 (b) shows the plot of the graph starting with 0 mV at 09:00 AM and increasing to 249 mV at 09:21 AM within 21 minutes of the calibration.





(a) (b)

Figure 3: (a) The graph output value for calibration from the Blynk application and (b) Plot of the calibration for ORP value

2.2 Flow Diagram for the IoT Oxygen Reduction Potential Sensor

The implementation of this work is based on the objectives and scopes. To fulfill the objective and with the improvements to this work able to assist the user that can be overcome by monitoring and controlling the oil spill activities. Figure 4 (a), to develop the hardware, the existing application, which is the Blynk application used to connect to the Node MCU Esp8266-01 Wi-Fi module.

The overall process to be executed to complete the work successfully. The main task that needed to be done was to identify the problem statement and formulate the objectives. It is important to obtain a clear objective and scope as a guideline to perform the work. Figure 4 (b) shows the process of the sensor which is an oxygen reduction potential sensor to detect the oxygen in the water. This sensor is controlled by Node MCU Esp8266-01 Wi-Fi module to transmit data to a smartphone.

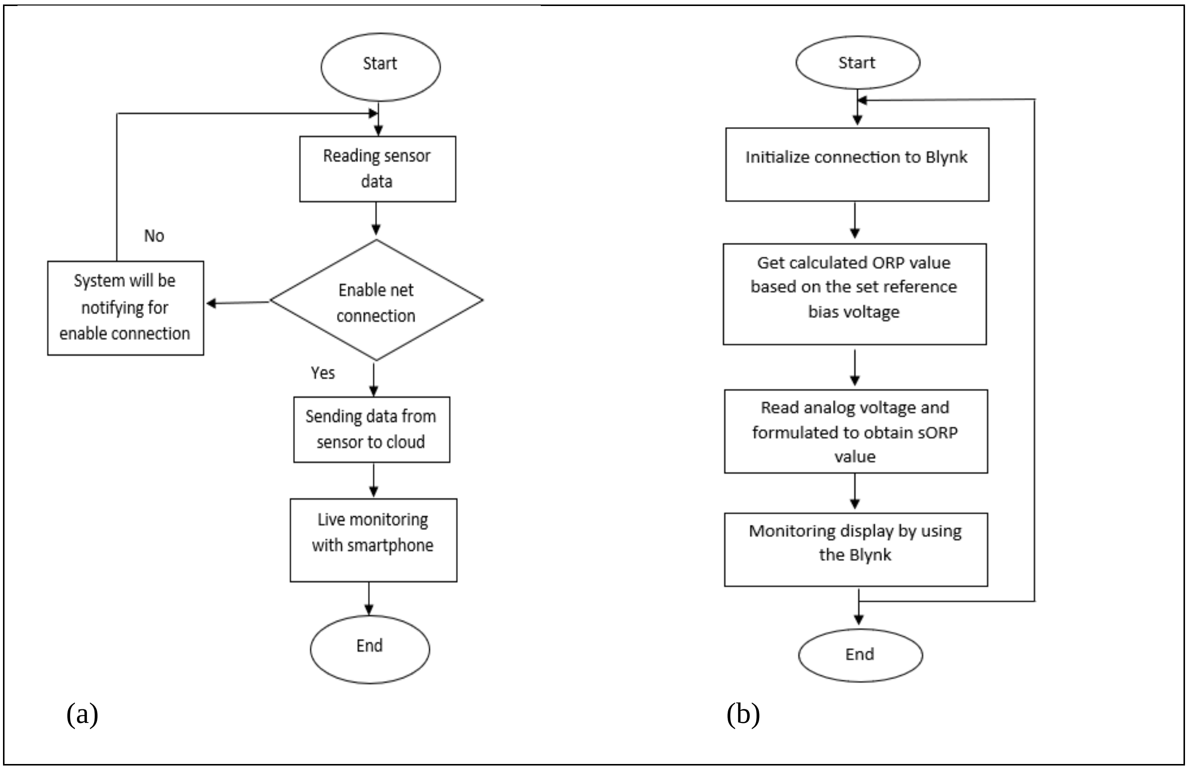


Figure 4: Flowchart of the IoT Oxygen Reduction Potential sensor (a) & (b) its process

2.3 Development of Final Functional Prototype

The final functional prototype of the IoT ORP sensor water quality hub was set up as shown in Figure 5 (a) and Figure 5 (b) for internal view, top view, rear view and bottom view respectively. An Arduino UNO is a microcontroller, ESP8266-01 is a Wi-Fi module, and a Wi-Fi router D6 4G LTE are attached to the waterproof's box upper half. For the analog oxygen reduction potential sensor, all the wires are through along the bottom of the box to attach to the Arduino UNO microcontroller.

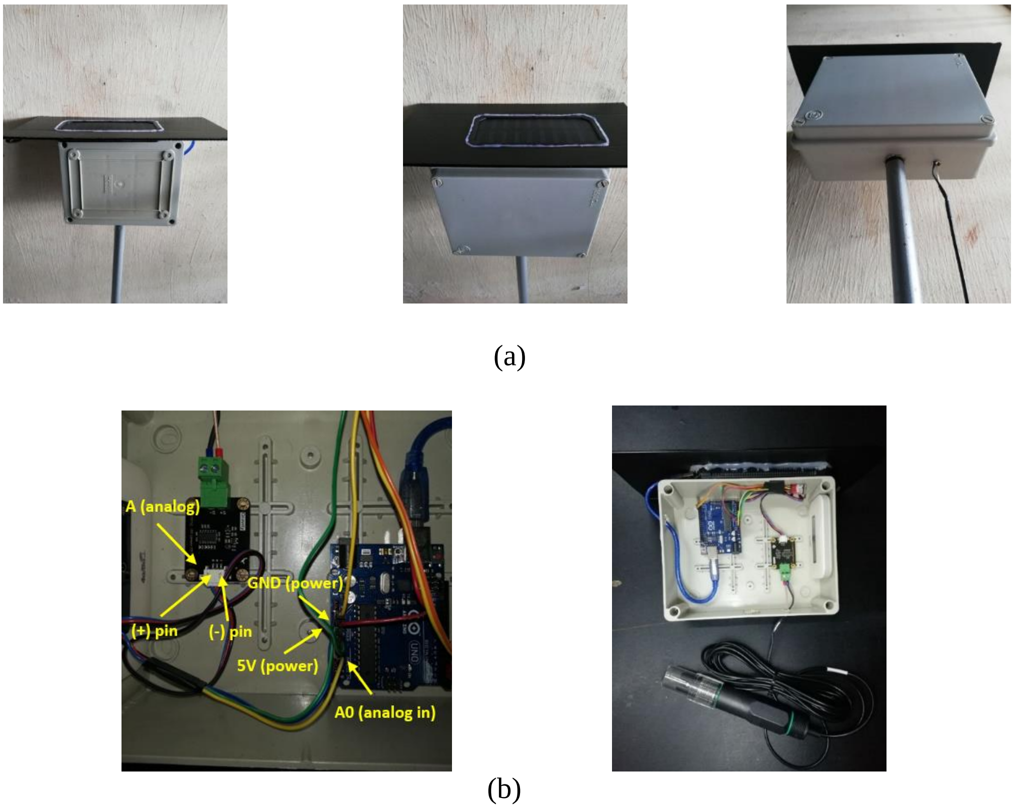


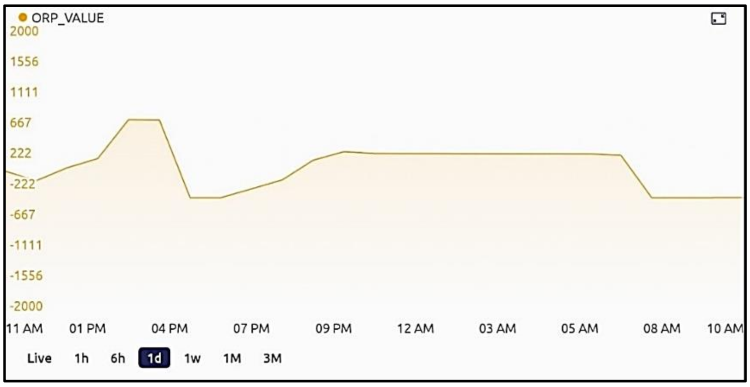
Figure 5: Rear, top and bottom view of the prototype for (a) and (b) for the internal connection

3. Results and Discussion

Figure 6 shows the getaway node was positioned more than 20 meters away from the sensor node uphill, where the water quality remained stable, while the sensor node was installed on the lakeside. The real-time monitoring of the lake was started when the prototype device installation was finished. The real-time sensor data were monitored through the Blynk application platform using a smartphone and will be displayed to the Blynk application. The prototype device was set up on June 1^{st} and June 5^{th} 2023 to monitor the river's water quality in real-time for full 24 hours, from 10 AM to 10 AM. To validate the efficacy of the developed system, the prototype has been conducted at various locations around *Sungai Batu Pahat*. A completed record of the sensor and the components data has been documented to monitor the water quality of the river.

Figure 6: Installation of sensor node at Sungai Batu Pahat

In Figure 7 (a), the ORP level range of *Sungai Batu Pahat* was between 667 mV (highest) to -411 mV (lowest) on June 1st 2023. The ORP of the river water demonstrated a decreasing trend until 6 PM and then increased until 10 PM. These changes may be due to the oil spills that are caused by diesel and natural gas engines [6]. In Figure 7 (b), the output data plot of the ORP against time taken from *Sungai Batu Pahat* have been plotted based on the real-time monitoring system for the water quality.



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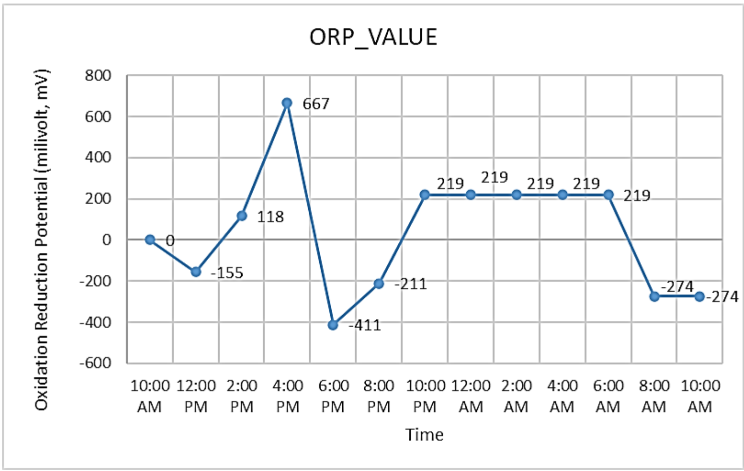
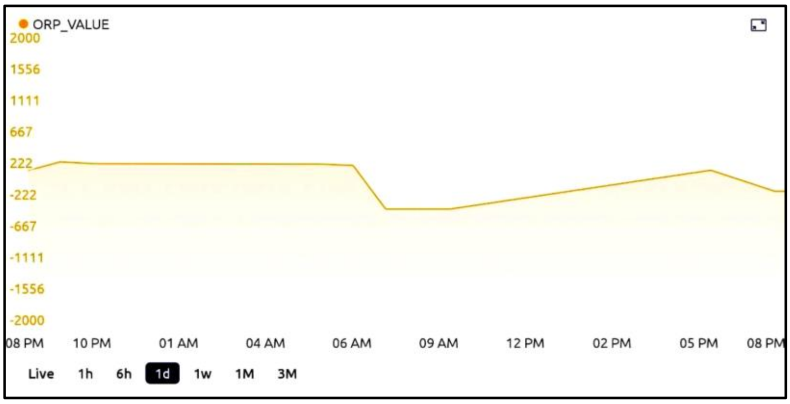


(b)

Figure 7: (a) Monitoring of real-time data through Blynk using smartphone and (b) Plot graph of ORP against time taken from *Sungai Batu Pahat* on June 1st 2023

In Figure 8 (a), the ORP level range of *Sungai Batu Pahat* was between 223 mV (highest) to -321 mV (lowest) on June 5th 2023. The ORP of the river water demonstrated a decreasing trend until 8 AM and then increase until 6 PM. The highest value 223 mV due to the carbon oxidation (carbonaceous biochemical oxygen demand stabilization). Then the value become to the lowest which is -321 mV due to the methane formation. Figure 8 (b), the output data plot of the ORP against time taken from *Sungai Batu Pahat* have been plotted based on the real time monitoring system for the water quality.



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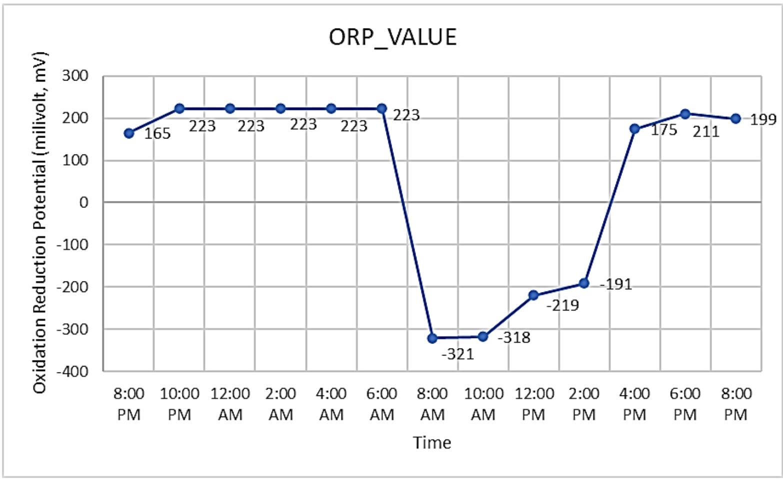
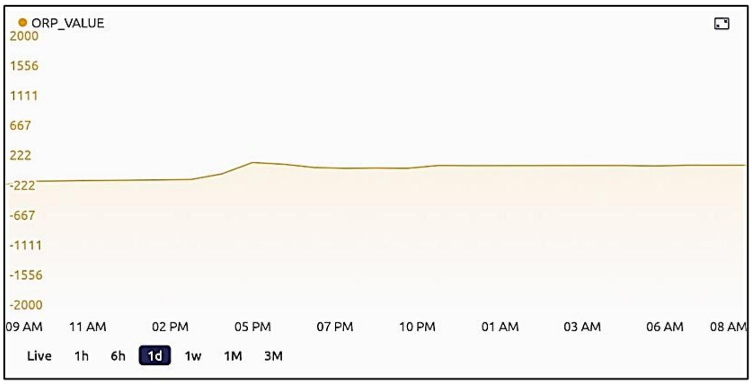


(b)

Figure 8: (a) Monitoring of real-time data through Blynk using smartphone and (b) Plot graph of ORP against time taken from *Sungai Batu Pahat* on June 5th 2023

In Figure 9 (a), the ORP level range of *Sungai Batu Pahat* was between 201 mV (highest) to -198 mV (lowest) on June 7th 2023. The ORP of the river water demonstrated a decreasing trend from 9 AM and then increased until 5 PM. The highest value is 201 mV due to the carbon oxidation (carbonaceous biochemical oxygen demand stabilization). Then the value becomes to the lowest which is -198 mV due to the acid formation. Figure 9 (b), the output data plot of the ORP against time taken from *Sungai Batu Pahat* has been plotted based on the real-time monitoring system for the water quality.



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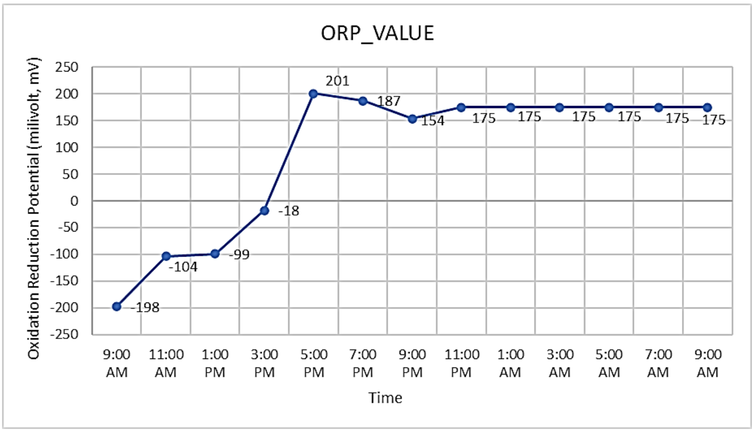

(b)

Figure 9: (a) Monitoring of real-time data through Blynk using smartphone and (b) Plot graph of ORP against time taken from *Sungai Batu Pahat* on June 7th 2023

Table 1: Biochemical activities

Biochemical activity	Approximate ORP range
Carbon oxidation (carbonaceous biochemical oxygen demand stabilization)	+50 to +200
Polyphosphate accumulation	+50 to +250
Nitrification	+150 to +350
Denitrification	–50 to +50
Polyphosphate release	–40 to –175
Acid formation	–40 to –200
Sulfide formation	–50 to –250
Methane formation	–200 to –400

From Table 1, the reading of every form of biological reaction exhibits a unique ORP range. Additionally, industrial pollutant releases may influence ORP value. At any junction in a process, an ORP instrument and mV measurement can be utilized to identify the kind of biological process taking place. The ORP measures the potential for a solution to oxidize or reduce. Increased ORP levels indicate oxidized conditions, while lower values indicate decreased ones.

4. Conclusion

The experiment has been carried out on the sensor used for this prototype to verify the characteristics and accuracy of the sensor for monitoring tasks. The analog oxygen reduction potential sensor has been carried out to measure the actual value of oxygen and quality water in the river. A simple experiment has been carried out to test the sensor's functionality by performing the calibration with the standard solution (256mV). Source codes have been developed to calculate the water quality value through the analog oxygen reduction potential sensor. An Arduino UNO microcontroller is also used in the work as the main component that receives and develops the output data. The source code to program the Arduino UNO has been developed successfully without any problems.

After completing the unit experiment for the sensor, a field test which is the final experiment has been carried out to verify the functionality of the integrated system Internet of Things Oxygen Reduction Potential Sensor for Oil Pollution Detection. From the experiments, the system functioned very well according to the design. The Internet of Things Oxygen Reduction Potential Sensor for Oil Pollution Detection can detect whether the quality of the water value either increases or decreases if the oil spills happen.

In conclusion, this effort hopefully can assist the authority and community in early oil spill detection. Knowing the spills, the authority can prepare to ambush the irresponsible party that dispose of the chemical in the river. Due to the prototype’s cheap operation cost and ease of adjusting the landmark of the sensor, it should be exposed and deployed in locations near the factory or any industry.

Acknowledgement

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