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Soil Monitoring for Agriculture Activity using Low Power Wide Area Network

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ABSTRACT

The new Covid-19 pandemic is affecting many economic sectors, such as the agricultural industry. The farmers faced many challenging constraints during the pandemic due to the enforcement of the Movement Control Order (MCO), resulting the unproductive crops. This paper proposed smart agriculture adopted with the Internet of Things (IoT) and Low Power Wide Area Networks (LPWAN) technology to be one of the possible solutions for the problems. Early precautions will minimize unproductive crops by monitoring the soil for healthy crops by monitoring the moisture and the pH level of the soil in real time. In this paper, a soil monitoring system using (Long-range) LoRa technology as one of the solutions for LPWAN to monitor the soil for agriculture has been set up. The soil moisture and pH sensors used to monitor the condition of the soil. The monitoring system uses LoRa as the communication network for the two sensors integrated into the Arduino Uno microcontroller as the transmitter and a receiver to monitor the status of the soil. This project enables the user to monitor the soil conditions and control the watering of the crops. The result concludes that this system shows 100% accuracy of the packet data received by the receiver, where the location of transmitter to the receiver was 1.4 meters apart.

1. Introduction

In 2017, Malaysia Agriculture Facts & Stats reported that 24% of the country's land was devoted to the agriculture sector. Agriculture is one of the industries that use a large amount of water compared to daily consumption, manufacturing, business and more. To keep good productivity, it is required to maintain the quality of soil such as the moisture and pH level must be in perfect condition for healthy crop production [1]. However, the traditional way of watering the crop may cause a waste of water resources, time, and energy consumption and is even costly as everything is manual. The waste of water resources usually happens to the normalize practice by most farmers to over-irrigate the crop field because of low cost of water on high value crops [2].

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Hence, to overcome this problem, one needs to monitor the usage of water. This can be done by implementing automation for the irrigation of fields by using the Internet of Things (IoT). IoT can help users such as farmers to understand the new perspective of the internet which is helpful in agriculture because it is a new emergence of communication technology [3]. Real-time soil moisture and pH level monitoring can be provided and improve the efficiency of poor irrigation as written by Ali *et al.,* [4].

IoT can provide an interface that users can use to control and monitor various aspects of the IoT system. These can allow farmers to view the systems and process the monitoring data without the need to be physically on the farm. New technology called low-power wide area network (LPWAN) with low-power, low-cost, wide-area and low data transfer wireless communication is one of the communication systems that can be applied together with the IoT application [5]. A long-range communication of LPWAN, such as a 10km rural areas, 20km and 30km distance with a low bit rate data transfer and low power consumption are shown in previous studies [6-8]. These advantages can be helpful for the farmers to monitor the moisture and pH level of soil from afar. An example of the technology that uses LPWAN is LoRa, which was started by LoRa Alliance [9]. LoRa is a long-range wireless communication technology that provides ultra-long-range connectivity and high resistance to interference while reducing current consumption [10,11]. Furthermore, LoRa also provides significant advantages in blocking and selectivity over two conventional modulation techniques, solving the traditional design compromise between range, interference immunity and energy consumption.

This paper has been divided into several parts as follows. Section II presents the related works. Then, section III states the methodology. Section IV analysed and explained the results. Lastly, section V concludes the research paper.

2. Related Works

2.1 Review of Related Work

In research of the detection of air temperature, humidity, and soil pH in showed the monitoring of air temperature, humidity, and soil pH for their smart farming of strawberry plants [12]. It did not apply real-time monitoring over the distance because the data was displayed and measured directly in the strawberry garden.

The research by Rosminah *et al.,* [13] showed the proposed smart farming system which is capable to reduce water usage by using IoT technology. The system included three layers communication system; physical layer, communication layer, and application layer. The communication layer involves the LoRa gateway. Then, the data was sent to cloud storage through Wi-Fi. Figure 1 show an example of the proposed system.

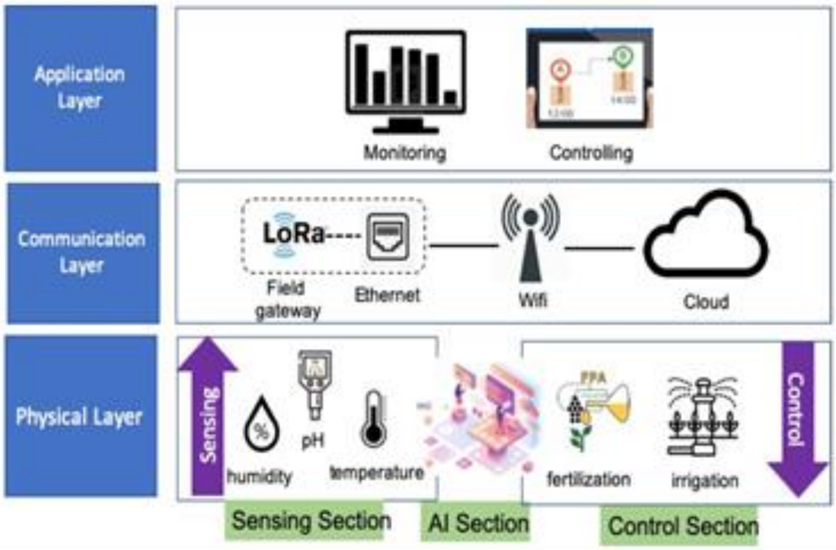

Fig. 1. An example for view of equipment for this system purpose [13]

According to Dagar *et al.,* [14], the authors proposed an agriculture monitoring system using water volume, soil pH, soil moisture sensor. The objective of the monitoring system was to improve the crop management for better resource management, cost production efficient also the quality and quantity of the crop production. The system was connected using Wi-Fi, where the data from the sensors uploaded to the cloud server.

According to Bandara *et al.,* [15], the authors proposed a cost-effective smart farm using soil moisture, temperature, water level sensors. The sensors are connected with XBee module to transfer the collected data sensor to the server. The sensors with this communication module was called as wireless sensor network. The user of the system can monitor the sensor productivity in real-time.

According to Jiang *et al.,* [16], the authors proposed a smart farming with a hybrid wireless sensor network with wireless communication using LoRa technology. The system monitors the condition of the crop using soil moisture, temperature and humidity sensors. Meanwhile, Ahmad *et al.,* [17] proposed a system to monitor and control the watering system for agriculture crop. The system used NodeMCU board to control the water pumping for the watering system and monitor the temperature, humidity and soil moisture using sensors via ThingSpeak cloud.

2.2 Soil Monitoring for Agriculture Activity Using LPWAN

The objective of this research is to help the farmers in monitoring moisture and pH levels of soil from anywhere that is away from their farm. Through this project, they can reduce the cost of water usage and increase the quality of crop production. During the pandemic, farmers faced difficulties as they were unable to monitor their crops due to the MCO, leading to a decrease in production. This low-power, low-cost, and wide-area coverage solution can be a beneficial for them in overcoming these challenges. This development of a soil monitoring system is based on LoRa as a transceiver and uses two types of sensors which are analogue soil moisture sensors for soil moisture and pH sensor for the pH level of the soil. Arduino microcontroller is used for processing data sensors and the data is then uploaded to the cloud, as it will be available to the farmers.

Analog soil moisture sensors serve as a measure of soil moisture by determining the volumetric water content. The sensor consists of two probes that regulate the current flow and record the soil moisture level. Additionally, the pH sensor detects the acidity or alkalinity of the soil, which influences the presence of minerals in the soil [18]. The data received from the sensors can be transferred to the LoRaWAN gateway as the IoT cloud.

LoRa is the communication module that is connected to Arduino Uno via Serial Peripheral Interface bus (SPI) and supported by ultra-long range spread spectrum technology [18].

3. Methodology

3.1 Flowchart

The soil monitoring system was developed with the incorporation of the LoRa system as the communication module. After being interfaced with Arduino, the system's remote communication capability was tested. Once established, a pH sensor and soil moisture sensor were connected to the Arduino microcontroller and calibrated. The entire system was then tested as a complete package and, upon successful completion of the testing, deployed in a selected field. An explanation of the results, discussion, and comprehensive documentation were performed based on the collected data, marking the conclusion of the project.

The steps to accomplish the research are stated in this section. Figure 2 shows the flowchart of the monitoring system.

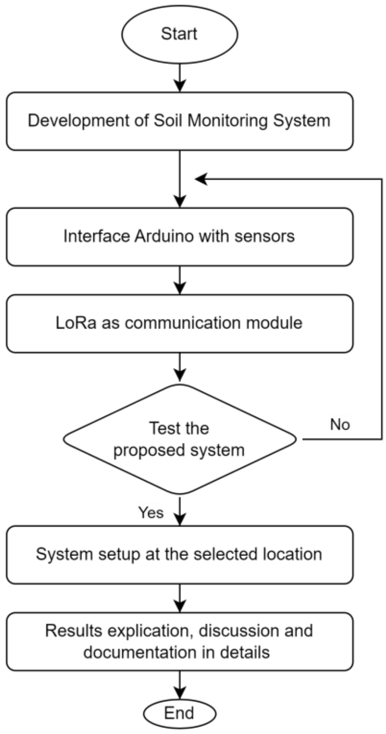

Fig. 2. The flow chart of monitoring system

3.2 Experimental Setup

Three fields were selected for the testing of the soil moisture and pH sensors, which were located at a rubber plantation, plant pot, and orchard as shown in Figure 3, Figure 4 and Figure 5 below. The sites were replicated three times in order to assess the consistency between each assembled package, as well as the variations within and between treatments during the field deployment. The distance between the transmitter with the sensors and receiver to receive and monitor the data for the sensor was set to be 1.4 meters apart.

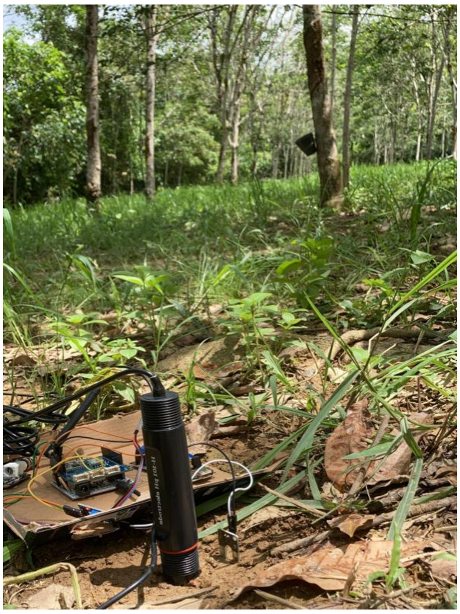

Fig. 3. The setup of connection in rubber plantation

Fig. 4. The setup of connection in plants

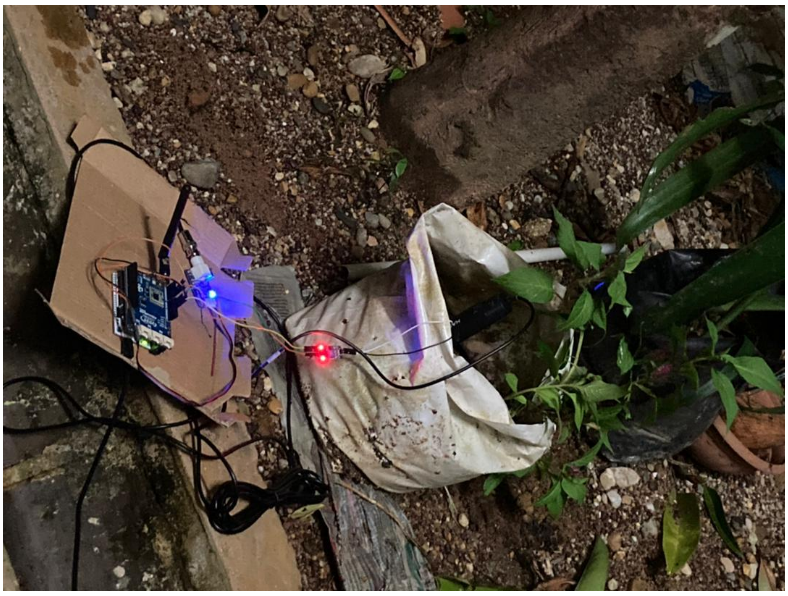

Fig. 5. The setup of connection in orchard

3.3 The equipment and locations

The equipment and locations of this project are stated in Table 1.

Table 1
The equipment and locations to be placed

Role	Equipment composition	Location
Communication Module	Lora transmitter Lora receiver	Rubber plantation, soil in plants, and orchard
Controller	Arduino Uno	Rubber plantation, soil in plants, orchard and analysing station (house)
Sensor	Soil moisture sensor pH level sensor	Rubber plantation, soil in plants, and orchard
Display	LCD Display	Analysing station (house)

4. Results and Discussions

Before the deployment of the LoRa setup at selected places, both LoRa was connected to the computer and tested to calculate the accuracy of the data from the LoRa transmitter to the receiver. Figures shown below were the data of both sensors which were soil moisture and pH level sensor transmitted from the transmitter to the receiver. Figure 6, 7, and 8 present the data collected from the soil moisture and pH level sensors, which was transmitted from the transmitter to the receiver. It was observed that the data transmitted was 100% accurate when compared to the data received. The data transmitted was displayed on COM5, while the data received was displayed on COM4. As a result, it can be concluded that the testing was accurate, and the deployment can be implemented by farmers. The data was analysed through a serial monitor of the Arduino Integrated Development Environment (IDE).

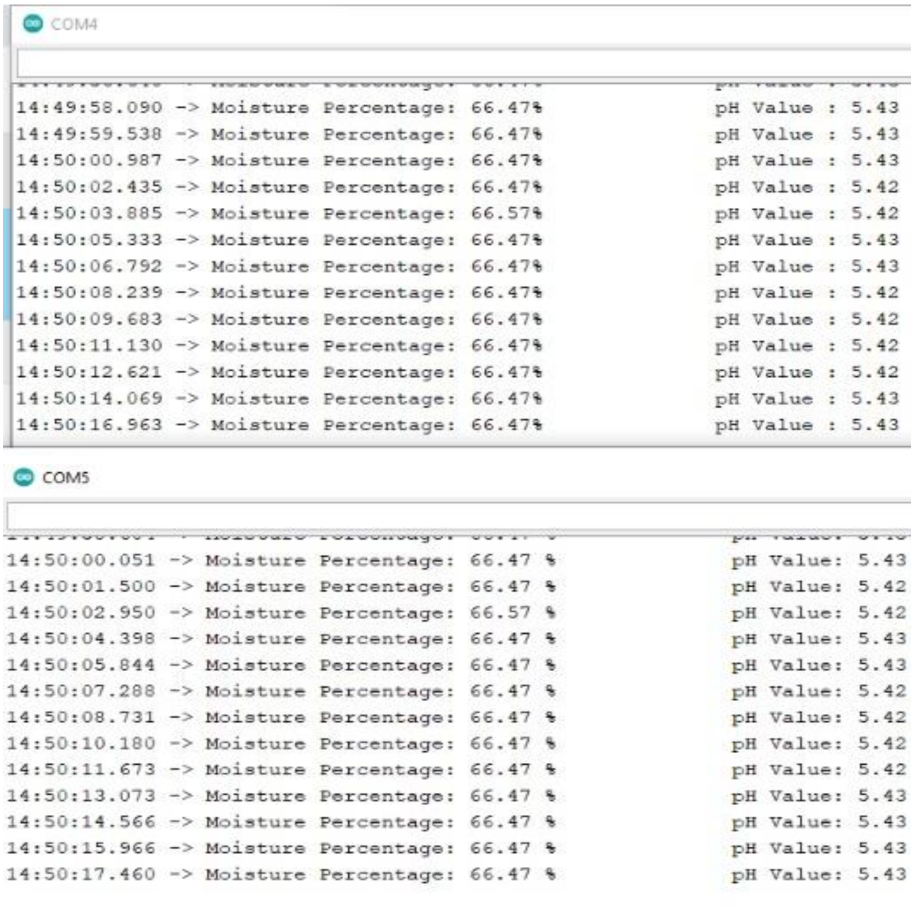

Fig. 6. The data displayed of transmitted and received at plants

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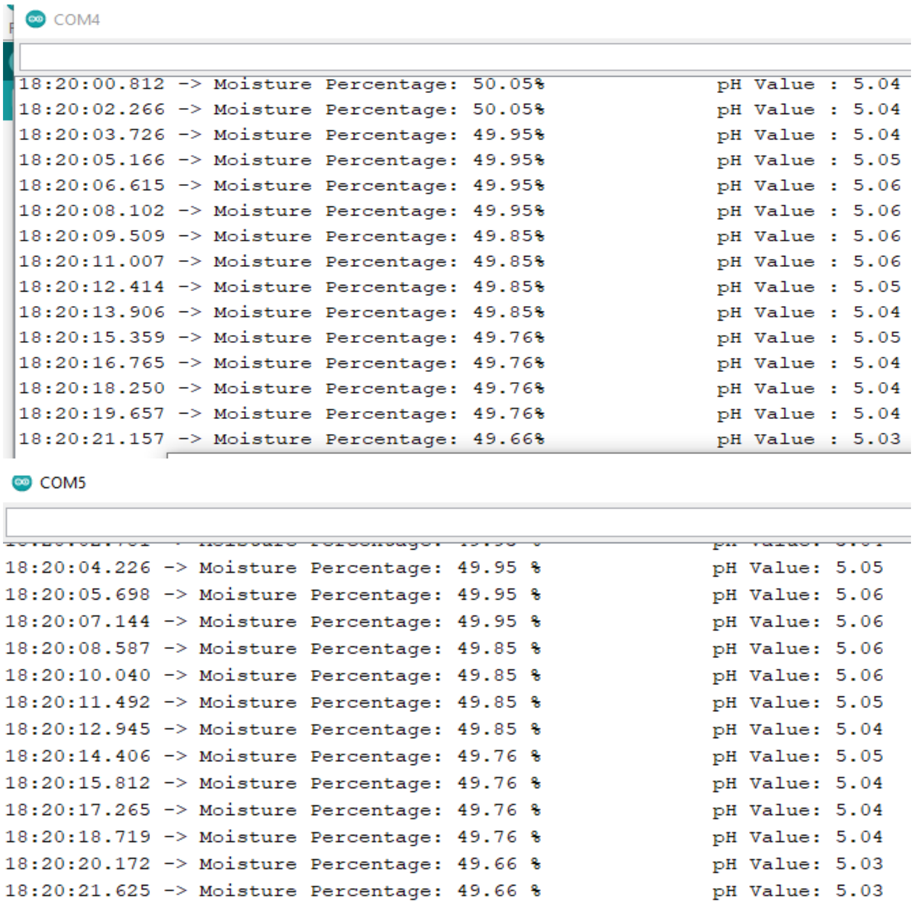
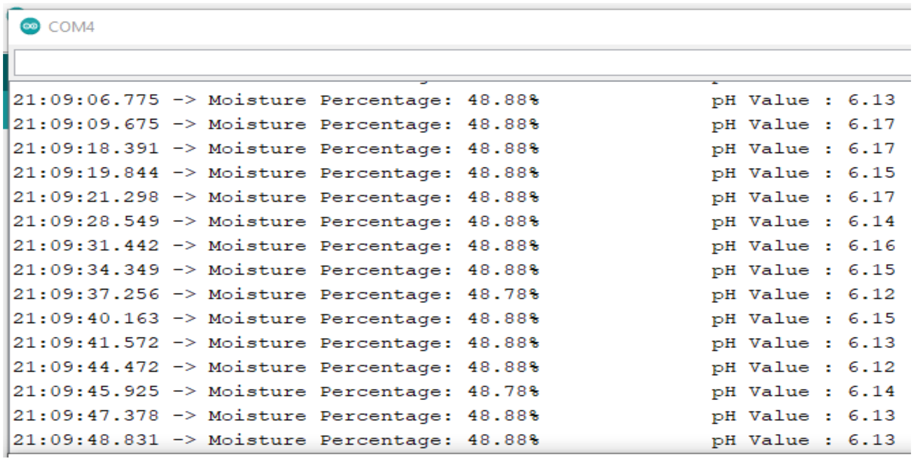


```
COM4
18:20:00.812 -> Moisture Percentage: 50.05%          pH Value : 5.04
18:20:02.266 -> Moisture Percentage: 50.05%          pH Value : 5.04
18:20:03.726 -> Moisture Percentage: 49.95%          pH Value : 5.04
18:20:05.166 -> Moisture Percentage: 49.95%          pH Value : 5.05
18:20:06.615 -> Moisture Percentage: 49.95%          pH Value : 5.06
18:20:08.102 -> Moisture Percentage: 49.95%          pH Value : 5.06
18:20:09.509 -> Moisture Percentage: 49.85%          pH Value : 5.06
18:20:11.007 -> Moisture Percentage: 49.85%          pH Value : 5.06
18:20:12.414 -> Moisture Percentage: 49.85%          pH Value : 5.05
18:20:13.906 -> Moisture Percentage: 49.85%          pH Value : 5.04
18:20:15.359 -> Moisture Percentage: 49.76%          pH Value : 5.05
18:20:16.765 -> Moisture Percentage: 49.76%          pH Value : 5.04
18:20:18.250 -> Moisture Percentage: 49.76%          pH Value : 5.04
18:20:19.657 -> Moisture Percentage: 49.76%          pH Value : 5.04
18:20:21.157 -> Moisture Percentage: 49.66%          pH Value : 5.03

COM5
18:20:04.226 -> Moisture Percentage: 49.95 %         pH Value: 5.05
18:20:05.698 -> Moisture Percentage: 49.95 %         pH Value: 5.06
18:20:07.144 -> Moisture Percentage: 49.95 %         pH Value: 5.06
18:20:08.587 -> Moisture Percentage: 49.85 %         pH Value: 5.06
18:20:10.040 -> Moisture Percentage: 49.85 %         pH Value: 5.06
18:20:11.492 -> Moisture Percentage: 49.85 %         pH Value: 5.05
18:20:12.945 -> Moisture Percentage: 49.85 %         pH Value: 5.04
18:20:14.406 -> Moisture Percentage: 49.76 %         pH Value: 5.05
18:20:15.812 -> Moisture Percentage: 49.76 %         pH Value: 5.04
18:20:17.265 -> Moisture Percentage: 49.76 %         pH Value: 5.04
18:20:18.719 -> Moisture Percentage: 49.76 %         pH Value: 5.04
18:20:20.172 -> Moisture Percentage: 49.66 %         pH Value: 5.03
18:20:21.625 -> Moisture Percentage: 49.66 %         pH Value: 5.03
```

Fig. 7. The data displayed of transmitted and received at plants

After the deployment of the LoRa set up at three different places which are the rubber plantation, soil in plants, and an orchard, there were various data collected such as moisture percentage and pH level of the soil from those three different places. The data varied with different compositions of soil. The collected data are shown in the figures below.



```
COM4
21:09:06.775 -> Moisture Percentage: 48.88%          pH Value : 6.13
21:09:09.675 -> Moisture Percentage: 48.88%          pH Value : 6.17
21:09:18.391 -> Moisture Percentage: 48.88%          pH Value : 6.17
21:09:19.844 -> Moisture Percentage: 48.88%          pH Value : 6.15
21:09:21.298 -> Moisture Percentage: 48.88%          pH Value : 6.17
21:09:28.549 -> Moisture Percentage: 48.88%          pH Value : 6.14
21:09:31.442 -> Moisture Percentage: 48.88%          pH Value : 6.16
21:09:34.349 -> Moisture Percentage: 48.88%          pH Value : 6.15
21:09:37.256 -> Moisture Percentage: 48.78%          pH Value : 6.12
21:09:40.163 -> Moisture Percentage: 48.88%          pH Value : 6.15
21:09:41.572 -> Moisture Percentage: 48.88%          pH Value : 6.13
21:09:44.472 -> Moisture Percentage: 48.88%          pH Value : 6.12
21:09:45.925 -> Moisture Percentage: 48.78%          pH Value : 6.14
21:09:47.378 -> Moisture Percentage: 48.88%          pH Value : 6.13
21:09:48.831 -> Moisture Percentage: 48.88%          pH Value : 6.13
```

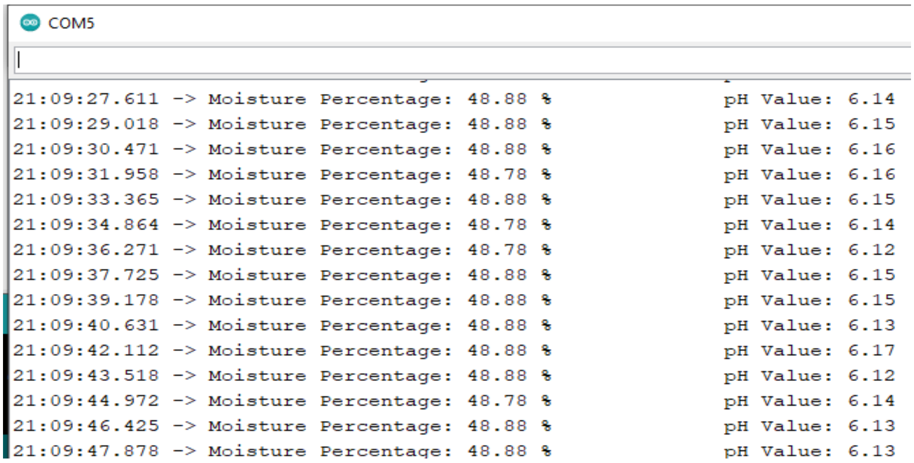


Fig. 8. The data displayed of transmitted and received at orchard

4.1 Moisture Percentage and PH Level of Soil in the Rubber Plantation

Data presented in Table 2 was collected at the rubber plantation over a period of one hour, with a time interval of 10 minutes between each measurement.

Table 2
Moisture percentage and pH level in the rubber plantation

Time	Moisture percentage (%)	pH level
15:00	66.67	5.45
15:10	65.88	5.42
15:20	65.90	5.37
15:30	64.81	5.35
15:40	63.44	5.31
15:50	62.37	5.28
16:00	61.49	5.26

Figure 9 and 10 show the representations of these data, respectively. The data showed that the moisture percentage decreased from 66.67% to 61.49% during the hour of data collection. This trend was also observed in the recorded data for pH levels.

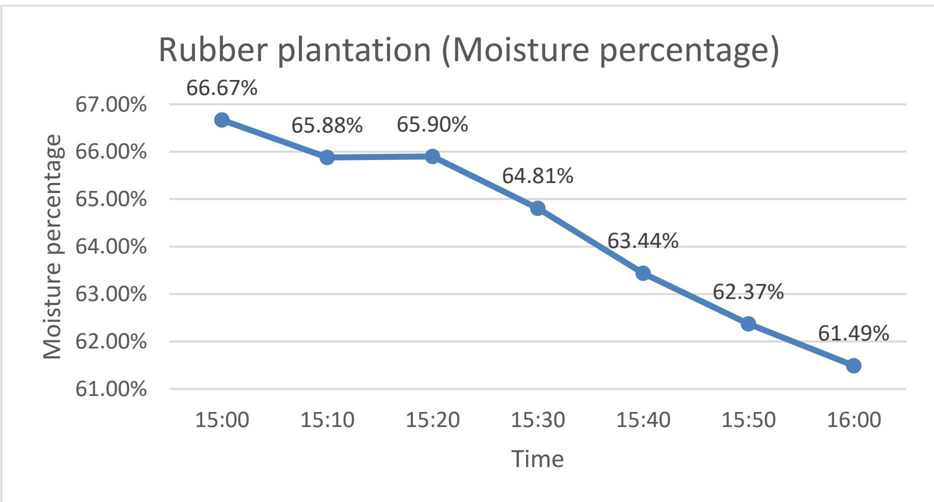


Fig. 9. The line chart of moisture percentage versus time in rubber plantation

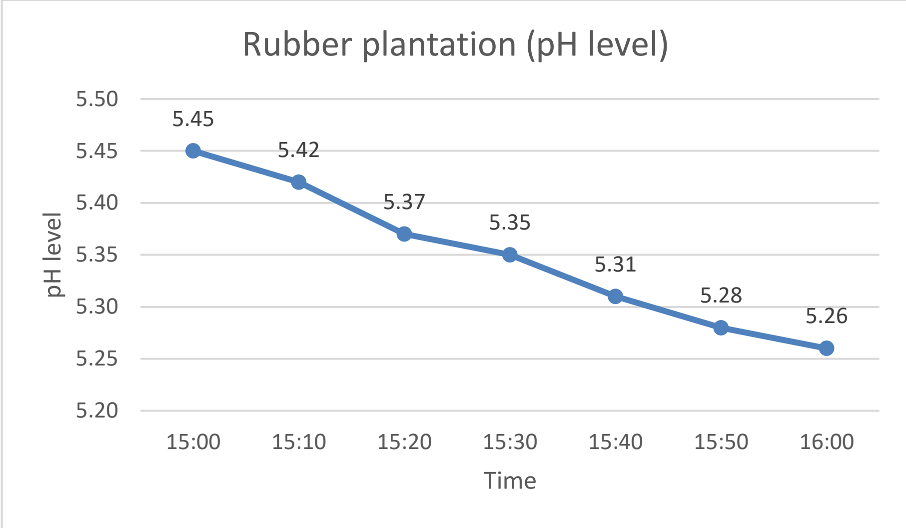


Fig. 10. The line chart of pH level versus time in rubber plantation

4.2 Moisture Percentage and PH Level of Soil in Plants

Table 3 shows the collected data of moisture percentage and pH level of soil from 18:35 until 19:35 taken from soil in plants with a time interval of 10 minutes each.

Table 3
Moisture percentage and pH level in soil in plants

Time	Moisture percentage (%)	pH level
18:35	50.34	2.75
18:45	52.59	1.76
18: 55	51.52	1.90
19:05	50.44	3.35
19:15	49.46	3.47
19:25	48.68	3.57
19:35	47.80	3.76

Figure 11 and 12 show the representations of these data, respectively. The moisture percentage value from 18:35 until 18:45 shows an increased value from 50.35% to 52.59%. From 18:55, the value decreased to 51.51% and continue decreasing in 10 minutes intervals until 19:35 with a value of 47.8%. However, in pH levels, the value at 18:35 decreased from 2.75 to 1.9 at 18:55 and then increased to 3.35 at 19:05 until, 19:35, the value was 3.76.

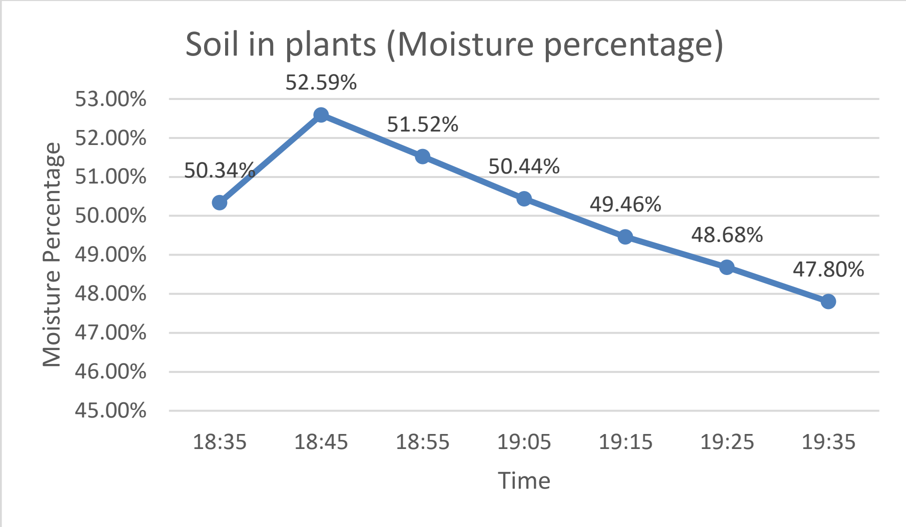


Fig. 11. The line chart of moisture percentage versus time in soil in plants

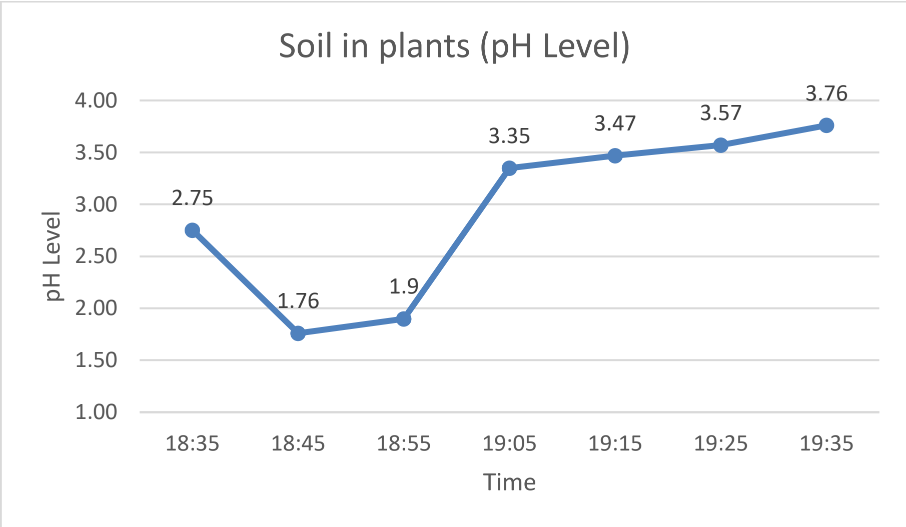


Fig. 12. The line chart of pH level versus time in soil in plants

4.3 Moisture Percentage and PH Level of Soil in an Orchard

Table 4 shows the collected data of moisture percentage and pH level of soil collected from received to the transmitter from 21:15 to 22:15 with an interval of 10 minutes each.

Table 4
Moisture percentage and pH level in an orchard

Time	Moisture percentage (%)	pH level
21: 15	48.48	5.88
21: 25	48.58	4.61
21: 35	48.88	3.86
21: 45	49.07	3.09
21: 55	49.46	2.00
22:05	49.95	1.25
22:15	50.24	0.67

Figure 13 and 14, show the moisture percentage and pH level taken in an orchard versus time respectively. The moisture percentage increased from 48.48% to 50.25% whereas, for pH levels, the reading showed a decrement from 5.88 to 0.67.

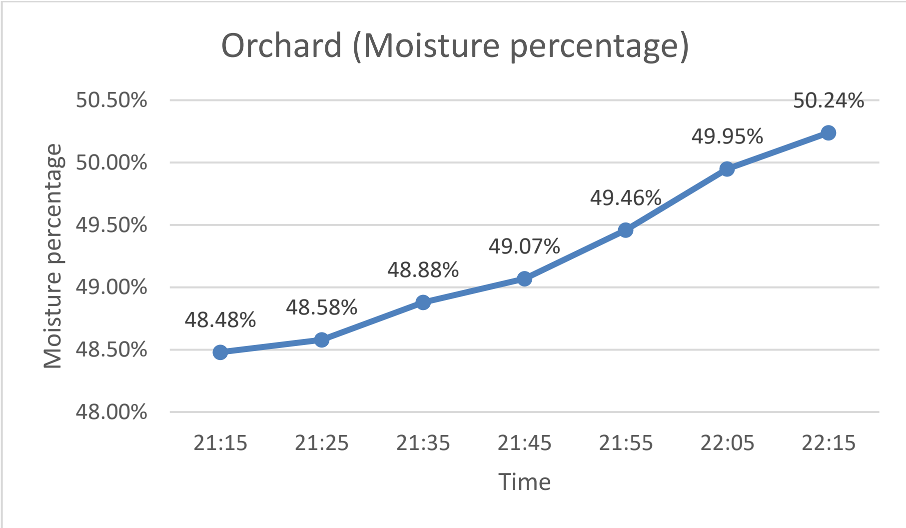


Fig. 13. The line chart of moisture percentage versus time in orchard

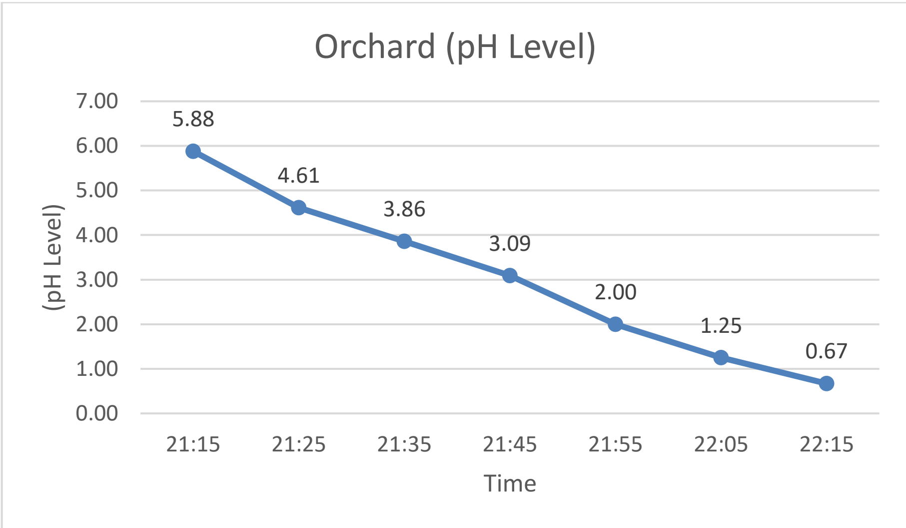


Fig. 14. The line chart of pH level versus time in orchard

5. Conclusion

This paper discussed the works and results of moisture and pH levels of the soil monitoring system at the rubber plantation, soil in plants, and an orchard by using LPWAN, LoRa specifically, as the communication network. The real-time monitoring data received from sensor nodes can be analysed through the serial monitor of Arduino IDE. In the future, this research can be improved by adding the cloud for the data storage. From that, the data can be monitored from anywhere by the users. Furthermore, to enhance the automated system, more sensor nodes can be added, and this is in line with the current Industry Revolution 4.0 needs.

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