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The Online Monitoring System of Toxic Gas Levels in the Ijen Mountain Area

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Abstract. Mount Ijen Crater is one of the popular tourist destinations in East Java, Indonesia. Mount Ijen Crater presents a beautiful blue fire view. However, behind its beauty, the Mount Ijen area has the potential danger of toxic gases. In old time there have been casualties due to the disasters of toxic gases that appear in the Ijen Mountain area. This study developed a toxic gas monitoring system which can be accessed online through the website. An array sensor is integrated into the raspberry-mini pc, and the data is stored in the online database. The levels of carbon monoxide and hydrogen sulfide gas can be real-time monitored from anywhere via the internet network. This study can be used for an early warning system for toxic gas disasters in the Mount Ijen area.

INTRODUCTION

In the industry 4.0 era like today, tourism management must consider the use of internet of things technology, primarily to ensure the safety of visitors to tourist areas related to weather conditions and the environment around them [1][2]. The manager of tourist attractions must pay attention to the condition of the surrounding environment to ensure the safety of visitors. Some examples of tourist areas that require environmental monitoring are volcano mountains and waterfalls. In the case of the volcano area, it is necessary to establish a toxic gas level monitoring system that ensures the safety of visitors.

The Mount Ijen region which is located in East Java is a famous tourist spot in Indonesia. It has a crater and blue fire, which is an attraction for tourists. However, the crater area is a dangerous area for visitors because the concentration of toxic gas levels can change at any time [3] [4], [5], [6], [7]. Ijen Crater was reported to have spewed poison gas that poisoned 30 people who lived in four villages around the slopes of Mount Ijen. Vomiting of poisonous gas from the Ijen crater is unpredictable [4]. Such conditions lead to a lot of research in this field.

Types of toxic gases that are dangerous in the Ijen crater are CO and H_2S. Hydrogen sulfide (H_2S) leakage can cause an explosion and produce catastrophic consequences such as huge economic losses, personal poisoning and environmental pollution [8], [9], [10]. Several cases of major disasters have occurred, such as a large explosion accident in Kaixin-China on December 12, 2003 which caused the death of 243 people and 65,000 people were evacuated due to H_2S poisoning. This disaster caused an economic loss of 64.3 million RMB [11], [12]. Predicting the possibility of releasing H_2S (RH) is needed to avoid catastrophe and reduce serious consequences [13].

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Much research has been done on the control and monitoring of toxic gas systems, including the development of ammonia prototype control and monitoring systems of leakage using a machine learning method [14]. Junyeop Lee made a low-cost sensor to detect H_2S. His study aims to use a cost-effective, easy to fabricate chemical textile sensor for the detection of H2S [15]. Zeng Jian from NASA is building a satellite-based system to monitor Volcanic Eruptions using OMI / OMPS, ASTER, and MERRA-2 2019 [16]. Other research is the development of a geochemical nose application incorporating electrochemical sensors for gas measurements in volcanic plumes 2012 [17]. D. Kim developed a portable analyzer that is used for the simultaneous detection of CO_2 and HF gases emitted by volcanoes [18]. In the Ijen Mountain area, Setyohadi has developed a tool using an early warning system for the detection of toxic gases using an array of sensors that can adjust to environmental conditions [19].

However, the above research cannot be monitored online and in real-time. Referring to the previous research, the author will improve monitoring system by adding a real-time monitoring tool for CO and H_2S gas concentration using Web. It can be used as a reference for surrounding communities that want to visit Mount Ijen by checking the state of CO and H_2S gas concentrations in Mount Ijen via the website.

RESEARCH METHOD

Hydrogen Sulfide (H2S) is a poisonous and flammable gas. This gas can also arise from volcanic activity. Hydrogen sulfide is formed from the process of breaking down organic matter by bacteria. H_2S is found in oil and gas, stagnant water like swamps and is also formed in industrial processes and other biological processes. Carbon monoxide is formed when there is a lack of oxygen in the combustion process. Carbon monoxide is very toxic so it is the most common cause of poisoning [11]. Domestic carbon monoxide poisoning can be prevented by using a carbon monoxide detector.

In this study, we built a monitoring system using the Node-RED programming tool. Node-RED provides a browser-based editor for designing GUIs (Graphical User Interfaces) by connecting nodes in the dashboard palette. We use the MQTT protocol for data transmission. According to Atmoko, Message Queuing Telemetry Transport (MQTT) is one of the IoT protocols that has advantages that can be used for network optimization with low bandwidth and energy requirements for minimum computing [20]. These advantages are ideal for use in applications placed in rural areas such as Ijen crater. MQTT protocol has been widely used in the internet of things applications such as monitoring and controlling industrial arm robot [21] and monitoring unmanned surface vehicle [22].

We started by making display designs and prototypes. After the framework and display design are complete, the next step is making a prototype. It starts from making a circuits of Arduino Mega shields, a seven-segment circuits and the circuits of LED bars. After all the circuits has been completed, the next step is doing installation all the components in the box panel. Finally, Sensor performance test was carried out. The toxic gases found in the Mount Ijen region are carbon monoxide and hydrogen sulfide gas. Therefore, monitoring of this system uses sensors MQ-136 and MQ-7. The MQ-136 sensor is used to measure hydrogen sulfide levels in the water. The MQ-7 sensor is used to measure the levels of carbon monoxide gas in the water. The DHT-11 sensor is also added to measure the temperature and humidity values in the Ijen region. All sensors are connected to the ATMEGA-2560 microcontroller. The output of the system is LED screens, status LEDs, LCD graphics, seven segments, and buzzers. Figure 1 is a block diagram of the system.

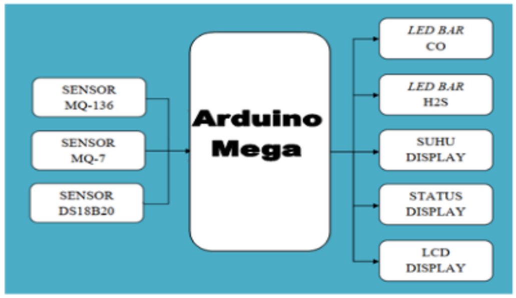

FIGURE 1. Block diagram of the system

LED bars are available for pollution display levels: good, medium, unhealthy, very unhealthy, and dangerous. The status LED serves to display the status of Mount Ijen under normal conditions. This condition uses standard from BMKG Indonesia disaster status. The seven segment display is used to display the degree of temperature in the Mount Ijen area. Figure 2 is a display of devices used for monitoring systems.

FIGURE 2. Display of monitoring system

Cloud Computing Design

Figure 3 Describes the IoT system used in this study. Arduino Mega will sending sensor data to nodeMCU via serial communication. Arduino sending data to nodeMCU using JSON data. Data received by nodeMCU will be automatically sent to the broker after there is a connection. If MQTT has not been connected, the failed indicator will be seen on the nodeMCU serial monitor. The data received will be displayed using node-RED and stored in the database.

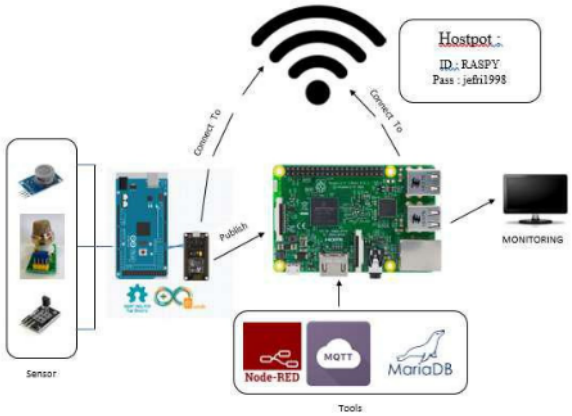

FIGURE 3. IoT system diagram

TESTING RESULT

Sensor reading test MQ-136 is done by looking for deviation values. The deviation value is the difference between the value of the Drager X-am 7000 gauge with the value of the sensor reading. Distance values are obtained by subtracting the reading value of the Drager X-am 7000 gauge with the value of the MQ-136 sensor reading. Accuracy test results of MQ-136 sensor readings are shown in table 1.

TABLE 1. Accuracy Test Result

NO	MQ-136 (H2S)			
	Time	**calibrated measuring devices (Drager X-am 7000)**	**Sensor MQ-136**	**deviation**
1.	22:11 - 22:15	0.05 ppm	0.73 ppm	0.68 ppm
2.	23:14 - 23:18	0.48 ppm	1.24 ppm	0.76 ppm
3.	03:38 - 03:42	0.02 ppm	0.51 ppm	0.49 ppm
4.	03:46 - 03:52	0.03 ppm	0.65 ppm	0.62 ppm
5.	03:53 - 04:02	0.05 ppm	0.61 ppm	0.56 ppm
6.	11:36 - 11:40	0.02 ppm	0.77 ppm	0.75 ppm
7.	13:19 - 13:23	0.55 ppm	2.13 ppm	1.58 ppm
8.	13:31 - 13:35	0.17 ppm	1.15 ppm	0.98 ppm
9.	13:41 - 13:45	0.008 ppm	0.013 ppm	0.005 ppm
10.	14:11 - 14:15	0.02 ppm	0.23 ppm	0.21 ppm
	Average Error	0.14 ppm	0.80 ppm	0.66 ppm

Data is displayed in each column based on the average reading of the MQ-136 sensor value every 5 minutes, and in each minute, 5 data samples are taken. Every 5 minutes there are 25 sample data is processed and taken averaged from the data logger that has been made. On the other hand, to find the average value on the Drager X-am 7000 gauge, the author records manually and matches to the data logger. The unit of value used in the sensor reading MQ-136 is PPM (Part Per Million). The process of testing the accuracy of the MQ-7 sensor reading same as the MQ-136 sensor reading accuracy-test process described above. Data from the reading of the MQ-7 sensor is shown in table 2.

TABLE 2. MQ-7 Sensor Data

	STATUS			
NO	**Time**	**Sensor MQ-7**	**Sensor MQ-136**	**Status**
1.	22:11 - 22:15	2.02	0.73	Normal
2.	23:14 - 23:18	10.77	1.24	Danger
3.	03:38 - 03:42	2.08	0.51	Normal
4.	03:46 - 03:52	1.96	0.65	Normal
5.	03:53 - 04:02	1.97	0.61	Normal
6.	11:36 - 11:40	2.21	0.77	Normal
7.	13:19 - 13:23	2.59	2.13	Normal
8.	13:31 - 13:35	3.76	1.15	Normal
9.	13:41 - 13:45	7.88	0.013	Danger
10.	14:11 - 14:15	5.07	0.23	Normal

Building a website with node-red begins with connecting nodes in a structured manner. Website developers with node-red must set each node used. Nodes are configured with settings and some scripts. This node-red script uses the javascript programming language. In the planning stage, the website is designed with a single-page website. The code on node-red is created according to the flowchart in figure 4.

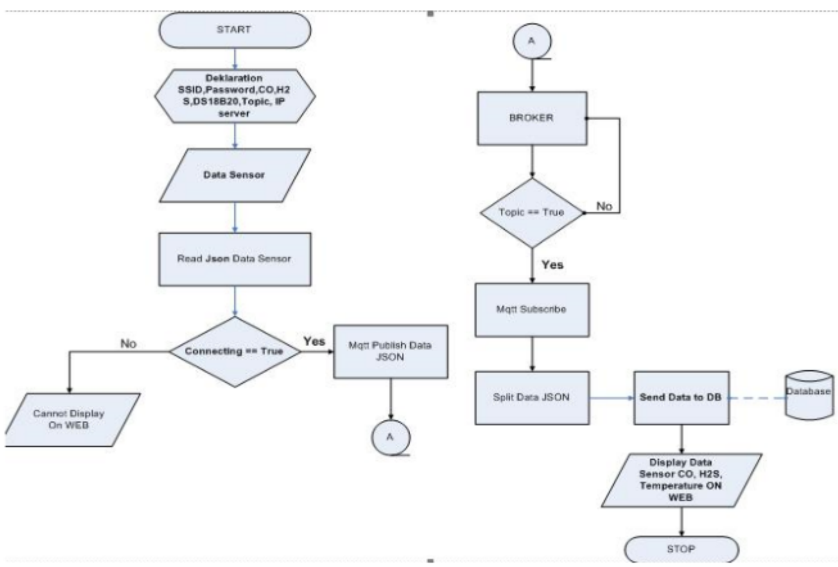

FIGURE 4. Flowchart system

A circuits of nodes that are configured in such a way produce a website design that can be accessed by typing "IP_Address: port / UI" (192.168.43.152:1880/ui) on the browser URL tab so that it appears as in Figure 5. The current sensor value is displayed in the form of a gauge. The value of sensors stored in the database can also be accessed in graphical form.

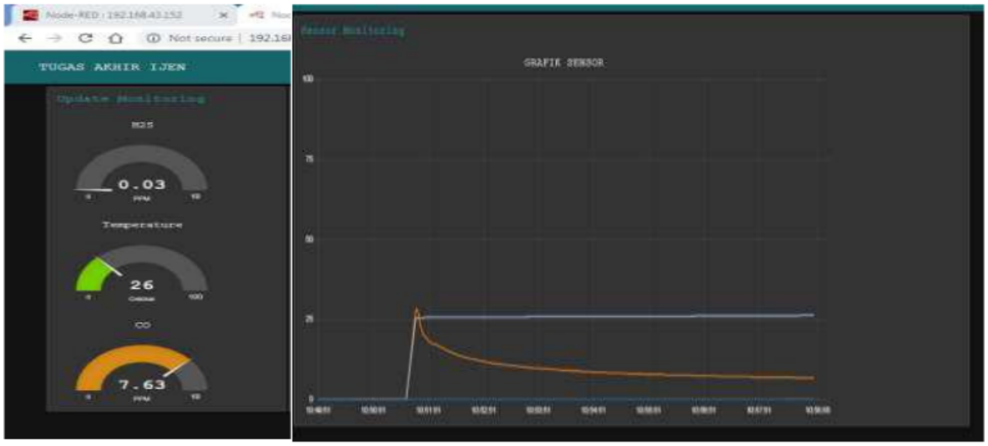

FIGURE 5. Web-based Interface

CONCLUSION

This paper makes a toxic gas level monitoring system that is useful to increase the security of a tourist area in the Ijen mountain area. The system is built using Hydrogen Sulfide and Carbon Monoxide sensors that can be monitored remotely via the website. Testing is done by comparing the performance of calibrated measuring instruments with sensors that show good results. Sensor performance can be monitored through the website with an interactive and real-time display.

REFERENCES

1. M.S.K. Awan, A. Nadeem, S. Amer, "DMSim: A Virtual Environment for Managing Natural Disasters", 14th Int. Conf. Smart Cities Improv. Qual. Life Using ICT IoT, (2017), pp. 26–30
2. R.A. Atmoko, A.S. Aisjah, G. Nugroho, "Analysis of Spatial Characteristic of Maritime Weather in Java Sea", IPTEK Journal of Proceedings Series, (2016), 2(1)
3. M. Mukherejee, L. Shu, L. Hu, G. P. Hancke, C. Zhu, "Sleep Scheduling in Industrial Wireless Sensor Networks for Toxic Gas Monitoring", IEEE Wireless Communications, (2016)
4. R. Aman, "Ijen Crater Tourist Site Closed Due to Toxic Gases," The Jakarta Post, (2018), [Online]. Available: http://www.thejakartapost.com/travel/2018/03/22/ijen-crater-tourist-site-closed-due-to-toxic-gases.html. [Accessed: 25-Apr-2018].
5. E. Science, "Dynamic Simulation Method of Toxic Gas Diffusion in Complex Geographic Environment."
6. Z. Sun, H. Wang, Y. Chen, L. Shu, M. Mukherjee, "Understanding the Impact of Planarized Proximity Graphs on Toxic Gas Boundary Area Detection", International Conference on Recent Advances in Signal Processing, Telecommunications and Computing, SigTelCom, (2017), pp. 109–114
7. L.I.N. Qiang, "Study on Wellsite Toxic Gas Leakage and Dispersion of High Temperature High Pressure Gas Wells with High Sulfur Content", (2010), no. 1
8. S. Ghosh, S. Chatterjee, A. Kundu, S. Maity, H. Saha, "Thermal Analysis of Cantilever MEMS Based Low Power Microheater Array for The Selective Detection of Explosive and Toxic Gases", Proc. - ISPTS-1, 1st Int. Symp. Phys. Technol. Sensors, (2012), vol. 1, pp. 290–293
9. S. Ghosh, A. Roy, S. Singh, H. Saha, V.K. Ojha, P. Dutta, "Sensor Array for Manhole Gas Analysis", Proc. - ISPTS-1, 1st Int. Symp. Phys. Technol. Sensors, (2012), pp. 9–12
10. L.C.L. Chen, S.Y.S. Yang, Y.X.Y. Xi, "Based on ZigBee Wireless Sensor Network The Monitoring System Design for Chemical Production Process Toxic and Harmful Gas", Comput. Mechatronics, Control Electron. Eng. (CMCE) Int. Conf., (2010), vol. 4, pp. 425–428
11. B. Geng, Y. Bao, "Monitoring System about Temperature, Humidity and Toxic Gas" no. Iccasm, (2010), pp. 632–634

12. B. Prihandoko, M. I. Ramadhan, “An Analysis of Natural Disaster Data by Using K-Means and K-Medoids Algorithm of Data Mining Techniques”, 15th Int. Conf. Qual. Res. Int. Symp. Electr. Comput. Eng., (2017), pp. 221–225
13. J. Sweeney, “Integration of Toxic Gas Monitoring Systems Into Building Fire Alarm Systems at Harvard University”, Bienn. Univ. Microelectron. Symp. - Proc., (2010)
14. P.O. Hanggara, “Prototype control and monitoring system safety device from leakage ammonia at marine loading arm with comparison of Neural Network (NN) and Extreme Learning Machine (ELM) method”, International Symposium on Electronics and Smart Devices (ISESD), (2017), pp. 85-89
15. L. Junyeop, “Low-Cost Colorimetric Textile Gas Sensor for Detection of Hydrogen Sulfide”, The Electrochemical Society, (2017)
16. https://ntrs.nasa.gov/search.jsp?R=20190000655)
17. T.J Roberts, “Electrochemical sensing of volcanic gases”, Chemical Geology, (2012), 332-333, 74–91
18. D. Kim, S. Kim, J. An, S. Kim, “A Portable Colorimetric Array Reader for Toxic Gas Detection”, ISOEN 2017 - ISOCS/IEEE International Symposium on Olfaction and Electronic Nose, (2017), pp. 0–2
19. D.P.S. Setyohadi, H.Y. Riskiawan, S. Kautsar, P. Destarianto, “Development of Low Cost Toxic Gas Explosive Modeling System using Wireless Array Sensor Netwok”, IOP Conference Series: Earth and Environmental Science, (2018), vol. 207
20. R.A. Atmoko, R. Riantini, M.K. Hasin, “IoT Real-time Data Acquisition Using MQTT Protocol”, J. Phys.: Conf. Ser., (2017), vol. 853, pp. 012003
21. R.A. Atmoko, D. Yang, “Online Monitoring & Controlling Industrial Arm Robot Using MQTT Protocol”, IEEE International Conference on Robotics, Biomimetics, and Intelligent Computational Systems (Robionetics), (2018), pp. 12-16
22. R.A. Atmoko, D. Yang, M.Y. Alfiani, L. Subiyanto,”Controlling Unmanned Surface Vehicle Using MQTT Protocol”, Journal Of Computer Networks, Architecture and High Performance Computing, (2019), 1(2, Juli), 21-28

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