Real-time Air Quality Index monitoring experiments using SDS011 sensors and raspberry pi

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Abstract. This study aims to propose a real-time Air Quality Index (AQI) monitoring using SDS011 sensors and raspberry pi as a server to detect Particulate Matter (PM)2.5 and PM10. To calculate the AQI standard values, we refer to BMKG as the board responsible for regulating it. We collected data on the campus area close to the textile industry area in Purwakarta, West Java, Indonesia for 1440 minutes. From the experiments, the results of the AQI value for PM2.5 are between 66-110 or equivalent to 19.1 to 39.7 ug / m3, while for PM10 between 26-70 or equivalent to 23.1 to 43.9 µg / m3. This value shows the performance of the SDS011 sensor can work well. Furthermore, to be publicly accessible, the AQI and PM values are sent to the web every minute without having to refresh the web page. For further development, it is possible to make a low-cost portable monitoring device using SDS011 sensors and raspberry pi that can be placed in areas considered pollution-prone as a warning system when pollution has passed the permitted threshold.

1. Introduction

Air quality is now a serious concern in various countries in the world. Awareness of the daily levels of air pollution as a one factor in air quality is important not only for citizens [1] but also for animals, plants, oceans, aquatic life worldwide [2]. Based on WHO data, air pollution has the biggest environmental impact on health today. It is estimated that it has caused 4.9 million deaths and 147 million loss of healthy life every year [3].

Various studies related to air quality monitoring have been carried out by previous researchers [4-7], including more specific measurements to detect particles below 2.5µm in various countries [8–11]. Related to that, studies for real-time data monitoring based on IoT and web have been developed, including monitoring sites belonging to IQ Air for global scale, and BMKG for local scale [12-15]. However, IQ Air only displays Particulate Matter $(PM)_{2.5}$ data and BMKG displays $PM_{2.5}$ and also PM_{10} [16,17]. The data is only updated every hour and only in big city areas.

This study aims to fill the gap in monitoring the air quality index that combines $PM_{2.5}$ and PM_{10} particles that are sent every minute to the web, especially in small cities in Indonesia. Then, we propose to measure the real-time air quality index using SDS011 sensors [18] and raspberry pi as a low-cost server [19] to detect $PM_{2.5}$ particles and also PM_{10}. At the time, data is sent to the web every minute without refreshing the web page. We conducted data collection for this paper in the campus area which is close to the textile industry in Purwakarta as one of the small cities in West Java, Indonesia.

2. Method

This research uses an experimental method with duration to collect data around 1440 minutes [20,21]. In the first step, we determine the particulate matter to be measured i.e. $PM_{2.5}$and PM_{10}. Next, we determine the sensor specifications that can detect these particles. Then, we chose high precision sensor SDS011, because this sensor can capture particle concentrations between 0.3 to 10µm in the air [22]. Data from the sensor is sent serially through the ttyUSB0 raspberry pi port with a baud rate value 9600. Furthermore, the incoming data is processed using the python instruction and stored using the *.PY extension [23]. Furthermore, the data is sent and stored in *.JSON and *.JS format and displayed via HTML file, so it can be accessed through a web browser and automatically refreshes every minute. To make the display more attractive, we added the CSS file. All files are stored in the /var/www/html/ folder as localhost in Raspberry pi using Lighttpd server [24]. To access data from the localhost then we use IP address based on the network given to raspberry pi. Figure 1 explains the block diagram of this experiment.

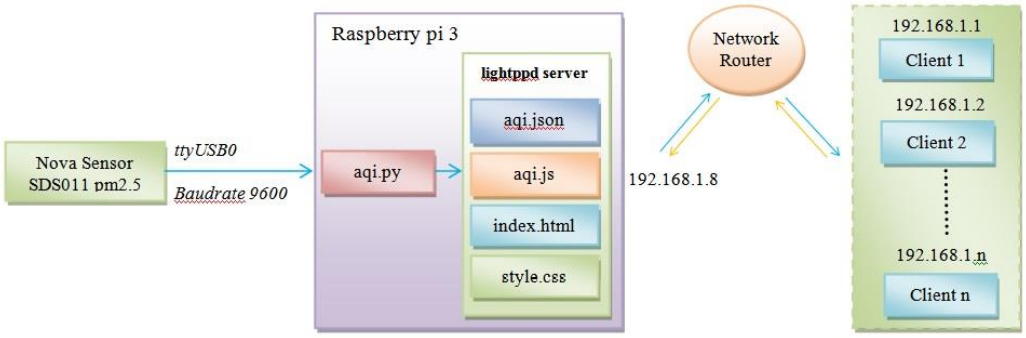

Figure 1. Block diagram of real-time air quality monitoring using SDS011 sensor and raspberry pi.

To differentiate AQI levels, we classify the AQI display colors based on BMKG regulations such as table 1. Referring to BMKG, the threshold value for PM_{10} is 150 µgram/m3, while $PM_{2.5}$ is 65 µgram/m3. For countries outside Indonesia, the classification of AQI values may be different i.e. Following the EPA as described in table 2. Because BMKG only provides a scale of PM_{10} conversion to AQI values, in this study, the scale of $PM_{2.5}$ conversion to AQI values were adopted to the EPA scale [25].

Table 1. Classification of Air Quality Index (AQI) refers to BMKG.

(AQI) Values	$PM_{2.5}$ (µgram/m3)	PM_{10} (µgram/m3)	Level of Health Concern	Color
0-50	0-12	0-50	Good	Green
51-100	12.1-35.4	51-150	Moderate	Blue
101-200	35.5-150.4	151-350	Unhealthy	Yellow
201-300	150.5-250.4	351-420	Very Unhealthy	Red
301-500	250.5-250.5	>420	Hazardous	Maroon

Table 2. Classification of Air Quality Index (AQI) refers to EPA.

(AQI) Values	$PM_{2.5}$ (µgram/m3)	Level of Health Concern	Color
0 -50	0-12	Good	Green
51-100	12.1-35.4	Moderate	Yellow
101-150	35.5-55.4	Unhealthy for Sensitive Groups	Orange
151-200	55.5-150.4	Unhealthy	Red
201-300	150.5-250.4	Very Unhealthy	Purple
301-400	250.5-350.4	Hazardous	Maroon
400-500	350.5-500	Hazardous	Maroon

3. Result and discussion

To access data from the server, we tried using a different browser on a mobile, tablet or PC and the data display is quite good. In this experiment, we used the IP address 192.168.1.8 on browser or localhost on raspberry pi. Figure 2 shows the data view using the chrome browser and figure 3 show the display of data from sensor on raspberry pi.

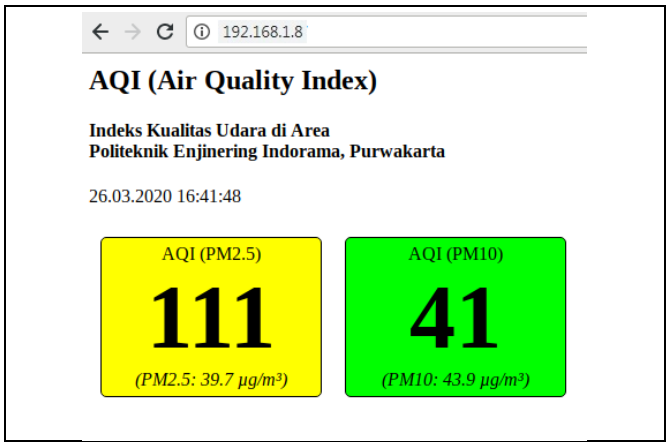

Figure 2. Real-time AQI display of $PM_{2.5}$ and PM_{10} using the chrome browser.

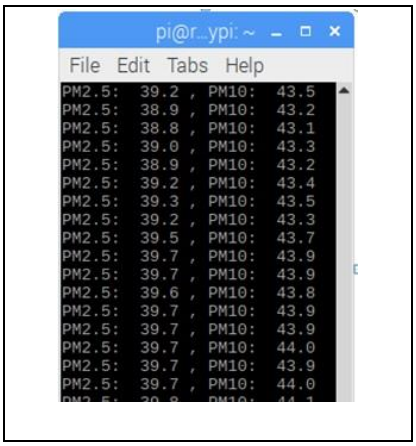

Figure 3. $PM_{2.5}$ and PM_{10} data display in raspberry pi

A comparison chart of AQI for $PM_{2.5}$ versus AQI for PM_{10} can be seen in figures 4 and 5. The results of the AQI value for $PM_{2.5}$ are between 66-110 or equivalent to 19.1 to 39.7 ug / m^3, while for PM_{10} between 26-70 or equivalent to 23.1 to 43.9 µg / m^3. From the graph it can be analyzed that the increase in particulate matter (PM) $_{2.5}$ is always directly proportional to the increase in particulate matter $(PM)_{10}$.

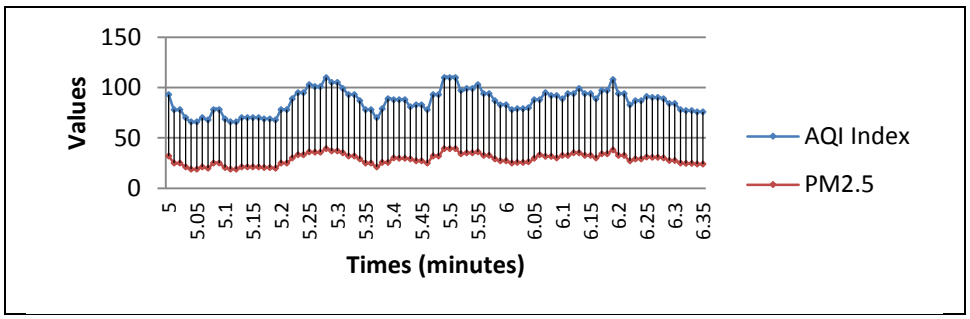

Figure 4. Data performance of AQI vs PM2.5

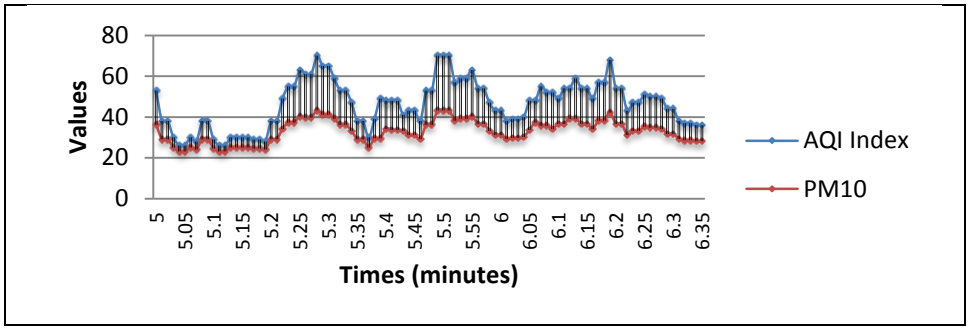

Figure 5. Data performance of AQI vs PM10.

In this experimental study, the testing phase of the SDS11 sensor and raspberry as server performance has been well achieved. However, the appearance in the web browser is still limited to AQI and particulate matter (PM) values, not yet displayed in real-time charts. We also do not calibrate the sensor, but only follow the sensor specifications specified by the manufacturer.

4. Conclusion

SDS011 sensor has a good level of precision in detecting particulate matter 2.5 and 10 in the air. From this research, we can add real time charts on the web for further development. So, it is possible to make a low-cost portable monitoring device based on the SDS011 sensor and raspberry pi which can be placed in places that are considered pollution-prone. Then, it becomes a warning system when pollution has passed the permitted threshold.

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References

[1] Paper C, View S and Muthuswamy S 2018 *Analysis of Air Quality Index*
[2] Landge P D and Harne R R 2018 *Air Quality Monitoring System for City: A Review* 5–6
[3] Institute H E 2019 State of Global Air (MA Health Effect Institute)
[4] Wardoyo A Y P, Dharmawan H A, Nurhuda M and Adi E T P 2019 Developing A Low Cost Particulate Matter Measurement System *IOP Conf. Ser. Earth Environ. Sci.* **391** 1 012078
[5] Sung Y, Lee S, Kim Y and Park H2019 Development of a smart air quality monitoring system and its operation *Asian J. Atmos. Environ.* **13** 1 30–38
[6] Huang M and Wu X 2019 A Review of Air Quality Monitoring System Based on Crowdsensing *International Symposium for Intelligent Transportation and Smart City* 286-296 (Singapore: Springer)
[7] Kuula J, Mäkelä T, Aurela M, Teinilä K, Varjonen S, González Ó and Timonen H 2019 Laboratory evaluation of particle size-selectivity of optical low-cost particulate matter sensors *Atmos. Meas. Tech. Discuss.* 1–21
[8] Liu H Y, Schneider P, Haugen R and Vogt M 2019 Performance assessment of a low-cost PM 2.5 sensor for a near four-month period in Oslo, Norway *Atmosphere (Basel)* **10** 2
[9] Asadollahfardi G, Zangooei H and Aria S H 2016 Predicting PM2.5 Concentrations Using Artificial Neural Networks and Markov Chain, a Case Study Karaj City *Asian J. Atmos. Environ.* **10** 2 67–79
[10] David L M, Ravishankara A R, Kodros J K, Pierce J R, Venkataraman C and Sadavarte P 2019 Premature Mortality Due to PM2.5 Over India: Effect of Atmospheric Transport and Anthropogenic Emissions *GeoHealth* **3** 1 2–10

[11] Wardoyo A Y P, Dharmawan H A, Nurhuda M and Adi E T P 2020 Optimization of PM2. 5 Measurement System Using NOVA SDS011 Sensor *Journal of Physics: Conference Series* **1428** 1 012053
[12] Neogi S, Galphat Y, Punjabi H and Jethani M 2020 IoT Based Air Quality Monitoring System - A Survey *Springer Nat. Switz. AG 2020* **31** 120–126
[13] Veeramanikandasamy T, G. R. S, A. Balamurugan, A. P. Ramesh, and Y. A. S. Khadar, "IoT based Real-time Air Quality Monitoring and Control System to Improve the Health and Safety of Industrial Workers *J. Eng. Des. Technol.* **9**
[14] Nasution T H, Muchtar M A and Simon A 2019 Designing an IoT-based air quality monitoring system *IOP Conf. Ser. Mater. Sci. Eng.* **648** 1
[15] Kurnia D and Widiasih V 2019 Impementasi NodeMCU dalam Pemberian Pakan Ayam Otomatis dan Presisi Berbasis Web *J. Teknol.* **11** 2
[16] Air I A V 2018 *WORLD AIR QUALITY REPORT : Region & City PM2.5 Ranking*
[17] BMKG 2020 *http://bmkg.go.id," Badan Meteorologi, Klimatologi dan Geofisika*
[18] Budde M 2018 Suitability of the Low-Cost SDS011 Particle Sensor for Urban PM-Monitoring *Suitability of the Low-Cost SDS011 Particle Sensor for Urban PM-Monitoring* 5–6
[19] Newmarch J 2017 Linux Sound Programming 537–545
[20] Harland D J 2015 An Introduction to Experimental Research An Introduction to Exploratory Research *Nursing (Lond)* **4** 3 6
[21] Tanner K 2018 Experimental research *Research Methods: Information, Systems, and Contexts: Second Edition* 337–356 (Elsevier Ltd)
[22] Co N F 2014 *Laser PM2 . 5 Sensor*
[23] Molloy D 2016 Programming on the Raspberry Pi *Exploring Raspberry Pi* 159–216
[24] Server L W, Technology C M, Waite A and Microsystems S 2008 *An Open Source Web Solution - Lighttpd Web Server and Chip Multithreading Technology* **820**
[25] Agency U S E P and Division I 2014 Air Quality Index (AQI) *Encycl. Qual. Life Well-Being Res.* 120–120