

Perancangan Sistem Monitoring Polutan Particulate Matter Berbasis Komunikasi LoRa 920 MHz dan Internet-of-Things (IoT) di Lingkungan Universitas Indonesia = Design of a Monitoring System for Particulate Matter Pollutant Using 920 MHz LoRa Communication and Internet-of-Things (IoT) in the Universitas Indonesia Area

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Abstrak

Pencemaran udara sebagai dampak dari pertumbuhan industri dan aktivitas manusia telah menjadi perhatian global. Salah satu kategori polutan udara yang berbahaya bagi kesehatan manusia adalah *particulate matter* (PM) 2.5. Laporan IQAir mencatat rata-rata konsentrasi PM2.5 di Indonesia per tahun 2022 sekitar 30,4 mikrogram per meter kubik, atau enam kali lipat lebih besar dari standar aman WHO. Dalam menanggapi kompleksitas masalah ini, penelitian ini merancang sistem deteksi dini dan *monitoring* polutan PM2.5 berbasis komunikasi LoRa 920 MHz dan Internet-of-Things (IoT) dengan sensor *low-cost* DSM501A. Penggunaan komunikasi LoRa, dengan menggunakan modul LoRa RFM95 pada frekuensi 920 MHz, menawarkan jangkauan transmisi atau *coverage* yang luas. Hasil deteksi partikel *particulate matter* divisualisasikan dalam bentuk laman web berbasis React Vite, Tailwind CSS, dan Node.js. Pengujian QoS komunikasi LoRa dilakukan dengan memprediksi *path loss* dan RSSI dengan pendekatan Okumura-Hata, serta mengukur nilai aktual SNR, RSSI, dan PDR, pada 10 titik pengujian di kawasan Universitas Indonesia. Hasil pengujian menunjukkan transmisi sinyal LoRa berhasil terkirim pada 8 dari 10 titik pengujian, dengan rentang jarak dari 8 m hingga 362.43 m, dengan nilai RSSI yang variatif pada rentang -85.87 dBm hingga -111.27 dBm, nilai SNR pada rentang 8.30 dB hingga -8.83 dB, serta PDR% pada rentang 100 % hingga 12.5 %, yang menunjukkan bahwa variabel LoRa seperti *spreading factor*, *bandwidth*, dan frekuensi, maupun variabel lingkungan, seperti jarak, area lintasan propagasi, dan vegetasi sangat mempengaruhi QoS transmisi sinyal LoRa di kawasan urban. Sementara itu, pada periode 14 hari pengumpulan data, total rata-rata polutan PM2.5 berdasarkan kategori waktu adalah pada tanggal 4 Juni 2024, yakni 149.42 mikrogram per meter kubik. Berdasarkan total rata-rata PM2.5 harian, indeks tertinggi terdapat pada hari Rabu, 5 Juni 2024, yakni 113.35 mikrogram per meter kubik. Rata-rata tertinggi indeks PM2.5 berdasarkan kategori waktu selama 14 hari pengumpulan data adalah pada siang hari.

.....Air pollution, as a consequence of industrial growth and human activities, has become a global concern. One of the categories of air pollutants that poses a significant threat to human health is particulate matter (PM) 2.5. The IQAir report recorded an average PM2.5 concentration in Indonesia in 2022 of approximately 30.4 micrograms per cubic meter, which is six times higher than the WHO's safe standard. In response to this complex issue, this study designs an early detection and monitoring system for PM2.5 pollutants based on 920 MHz LoRa communication and the Internet of Things (IoT) using the low-cost DSM501A sensor. The use of LoRa communication, utilizing the LoRa RFM95 module at a 920 MHz frequency, offers a wide transmission range or coverage. The detected particulate matter data is visualized in the form of a web page based on React Vite, Tailwind CSS, and Node.js. The QoS testing of LoRa communication is conducted by predicting path loss and RSSI using the Okumura-Hata model and measuring actual values of SNR, RSSI,

and PDR at 10 test points within the University of Indonesia area. The test results indicate that LoRa signal transmission successfully reached 8 out of 10 test points, with distances ranging from 8 m to 362.43 m, with varying RSSI values between -85.87 dBm and -111.27 dBm, SNR values between 8.30 dB and -8.83 dB, and PDR% ranging from 100% to 12.5%, showing that LoRa variables such as spreading factor, bandwidth, and frequency, as well as environmental variables like distance, propagation path area, and vegetation, significantly affect the QoS of LoRa signal transmission in urban areas. Meanwhile, during the 14-day data collection period, the total average PM2.5 pollutants by time category was on June 4, 2024, at 149.42 micrograms per cubic meter. Based on the total daily average PM2.5, the highest index was on Wednesday, June 5, 2024, at 113.35 micrograms per cubic meter. The highest average PM2.5 index by time category during the 14-day data collection period was during the daytime.