ABSTRACT

Air pollution is a serious environmental issue in Indonesia, particularly in urban areas with high levels of urbanization and transportation activities. The presence of pollutants such as ozone (O_3), nitrogen dioxide (NO_2), carbon monoxide (CO), ammonia (NH_3), and fine particulate matter (PM2.5 and PM10) has significant impacts on public health and environmental quality. The limited number of monitoring stations and restricted access to information highlight the need for a more efficient and affordable monitoring system. This study developed an Internet of Things (IoT)-based air quality monitoring system utilizing MiCS-6814, MQ-131, and DSM501A sensors, integrated with an ESP32 microcontroller, Firebase cloud storage, and a web-based application for data visualization. The system incorporates machine learning-based calibration to enhance measurement accuracy and was evaluated through black box testing and the Scale Usability Scale (SUS). Experimental results show that the sensors achieved accuracies of 90.9% for NO_2, 91.05% for PM2.5, 86.89% for PM10, and 60.37% for O_3. The dashboard attained 100% functionality in black box testing and scored 91.75% in SUS evaluation, indicating excellent usability. Furthermore, a Long Short-Term Memory (LSTM) model was employed to predict the Air Quality Index (AQI) for the next 24 hours, yielding an MAE of 8.10, RMSE of 13.10, and MAPE of 13.10%, corresponding to a prediction accuracy of 86.90%. These results demonstrate that the proposed system can provide reliable air quality monitoring and has the potential to support air pollution mitigation strategies at the community and urban area level.

Keywords: air quality monitoring, IoT, ESP32, machine learning, PM2.5, interactive dashboard.