

ABSTRACT

Waste management has become one of the environmental problems that continues to increase along with population growth and human activities. One of the waste treatment methods widely used is a low-smoke waste incinerator; however, the combustion process still produces hazardous gas emissions such as carbon monoxide (CO), nitrogen oxides (NO_x), and sulfur dioxide (SO₂). This study aims to design and develop a microcontroller-based combustion measurement device capable of monitoring gas emission levels in real-time in a household-scale low-smoke waste incinerator. The research method used was an engineering experiment with a system design and development approach. The system consisted of MQ-7, MQ-135, and MQ-136 sensors as gas detectors, an Arduino Uno as the data processor, a LoRa SX1278 module as a wireless communication medium, an ESP8266 as the data receiver, and Google Sheets as an online data visualization platform. The test results showed that the system was able to detect changes in gas concentration from the combustion process in real-time and transmit data stably through LoRa communication. Overall system testing successfully recorded 388 measurement data points during 27 minutes 5 seconds of combustion. The highest CO gas concentration recorded was 13.747 ppm at 3 minutes 49 seconds, the NO_x concentration reached 5.190 ppm at 2 minutes 38 seconds, while the highest SO₂ gas concentration reached 6.566 ppm at 2 minutes 1 seconds during the combustion process. This study focuses on the trends in exhaust gas emissions during the combustion process. Based on the research results, the designed monitoring system was able to function effectively as a practical, economical, and applicable emission monitoring solution for small-scale low-smoke waste incinerators.

Keywords: waste incinerator, emission, microcontroller

INTISARI

Pengelolaan sampah menjadi salah satu permasalahan lingkungan yang terus meningkat seiring bertambahnya jumlah penduduk dan aktivitas masyarakat. Salah satu metode pengolahan sampah yang banyak digunakan adalah tungku pembakar sampah minim asap, namun proses pembakaran tetap menghasilkan emisi gas berbahaya seperti karbon monoksida (CO), nitrogen oksida (NO_x), dan sulfur dioksida (SO₂). Penelitian ini bertujuan merancang dan membuat alat ukur hasil pembakaran berbasis mikrokontroler yang mampu memantau kadar emisi gas secara *real-time* pada tungku pembakar sampah skala rumah tangga. Metode penelitian yang digunakan adalah eksperimen rekayasa (*engineering experiment*) dengan pendekatan rancang bangun sistem monitoring. Sistem terdiri atas sensor MQ-7, MQ-135, dan MQ-136 sebagai pendeteksi gas, Arduino Uno sebagai pengolah data, modul LoRa SX1278 sebagai media komunikasi nirkabel, ESP8266 sebagai penerima data, serta Google Sheets sebagai media visualisasi data secara daring. Hasil pengujian menunjukkan bahwa sistem mampu mendeteksi perubahan konsentrasi gas hasil pembakaran secara *real-time* dan mengirimkan data secara stabil melalui komunikasi LoRa. Pengujian keseluruhan sistem berhasil merekam 388 data pengukuran selama 27 menit 5 detik pembakaran. Konsentrasi tertinggi gas CO tercatat sebesar 13.747 ppm pada menit ke-3 detik ke-49, konsentrasi NO_x mencapai 5.190 ppm pada menit ke-2 detik ke-38, sedangkan konsentrasi tertinggi gas SO₂ mencapai 6.566 ppm pada menit ke-2 detik ke-1 selama proses pembakaran berlangsung. Penelitian ini berfokus pada pola tren emisi gas buang saat proses pembakaran. Berdasarkan hasil penelitian, sistem *monitoring* yang dirancang mampu bekerja dengan baik sebagai solusi pemantauan emisi yang praktis, ekonomis, dan aplikatif untuk tungku pembakar sampah minim asap skala kecil.

Kata Kunci: tungku pembakar sampah, emisi, mikrokontroler