ISSN 2362–0412

ABS-015

Development of an Air Quality Monitoring and Treatment System for Biomass Heat Generators

S.C.A. Sooriyaarachchi[1], J.A.P.H. Jayaweera[1], K.M.B. Sandika[1], D.M.I.D. Gunathunga[1], B.H.C.S. Thilakarathna[1], K.K.D.C.S. Weerarathne[1], Y.M.A.L.W. Yapa[2]*

[1] Department of Engineering Technology, Faculty of Technology, University of Ruhuna, Sri Lanka

[2] Department of Chemistry, Faculty of Science, University of Ruhuna, Sri Lanka

**Corresponding author:* sanjeewani@fot.ruh.ac.lk

Biomass is widely regarded as a renewable alternative to fossil fuels; however, its combustion can generate harmful emissions such as carbon monoxide (CO), nitrogen oxides (NO_x), and particulate matter (PM), which contribute to global warming, acid rain, and adverse health effects. The Intergovernmental Panel on Climate Change (IPCC) has reported that continued reliance on fossil fuel-based energy systems could increase global average temperatures by 1.4°C to 5.8°C by 2100. This research developed an integrated IoT-based air quality monitoring and treatment system for biomass heat generators, capable of real-time measurement and analysis of combustion characteristics, including CO, NO_2, and particulate matter ($PM_{1.0}$, $PM_{2.5}$, PM_{10}). The multistage treatment system consists of a reagent spray reactor (180°C–400°C) using AdBlue for ammonia generation, a selective catalytic reduction reactor (300°C–700°C) for NO_x reduction, and a TiO_2-coated photocatalytic reactor (150°C–250°C) illuminated by UV-A light. The exhaust gas monitoring system was implemented using an ESP32 microcontroller integrated with MiCS-4514, PMS7003, and DHT11 sensors, with data transmitted to cloud-based platforms for remote monitoring and an automated email alert system. The experiment was conducted using rubber, cinnamon, and Gliricidia wood at five mass increments (0.25 kg–1.25 kg), each across 20–40 minute combustion cycles. The results demonstrated significant emission reductions across all biomass types. Rubber wood achieved reductions of 48.75% in NO_2, 32.06% in CO, 40.83% in $PM_{1.0}$, 76.53% in $PM_{2.5}$, and 76.21% in PM_{10}. Cinnamon wood showed reductions of 32.38% in NO_2, 28.84% in CO, 44.10% in $PM_{1.0}$, 72.40% in $PM_{2.5}$, and 72.17% in PM_{10}. Gliricidia wood exhibited reductions of 41.71% in NO_2, 30.81% in CO, 42.31% in $PM_{1.0}$, 73.97% in $PM_{2.5}$, and 74.74% in PM_{10}. The proposed integrated system offers a cost-effective and scalable solution for small to medium-scale industries, enabling compliance with emission regulations while supporting sustainable biomass-based energy utilization.

Keywords: Biomass combustion, Emission reduction, Gas monitoring system, Gas treatment system, Selective catalytic reduction