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Confirmation letter

This is to confirm that the manuscript entitled "Comparing Greenhouse Gas Emissions from Municipal Solid Waste Across Municipality Types in Thailand: A Province-Scale Study" by Virin Kittithammavong, Ampira Charoensaeng and Sutha Khaodhiar has been accepted for publication in the scientific journal *Environmental Research, Engineering and Management* and will be published in Vol. 82, No. 3 (2026).

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Comparing Greenhouse Gas Emissions from Municipal Solid Waste Across Municipality Types in Thailand: A Province-Scale Study

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Thailand is among the countries most vulnerable to climate change, ranked 8th by the Global Climate Risk Index (CRI) for the period 1999-2018. In response, the National Strategy 2018-2037 outlines pathways for both adaptation and mitigation. The waste management sector is a notable contributor to greenhouse gas (GHG) emissions, accounting for more than 16,000 Gg CO_2-eq, approximately 4-5% of Thailand's total emissions. Municipal solid waste (MSW) management is particularly relevant in developing countries, where emissions vary considerably across municipality types. This study aims to determine GHG emissions from MSW management in Phitsanulok Province, Thailand, using questionnaire-based data collected from municipalities. Emissions were calculated for both end-of-life treatment and transportation stages. The results reveal significant differences across municipality types. City municipality generated the highest average emissions (26,531 tonnes CO_2-eq/year), followed by town municipality (4206 tonnes CO_2-eq/year), subdistrict municipality (1837 tonnes CO_2-eq/year), and subdistrict administrative organization (1168 tonnes CO_2-eq/year). While total emissions were greatest in the city municipality, per capita emissions did not scale proportionally, reflecting differences in population density, waste generation, and management practices. This province-scale analysis provides new insights into the role of municipality type in shaping waste-related emissions. The findings underscore the importance of differentiated climate mitigation strategies in the waste sector to develop more sustainable, low-carbon MSW management systems in Thailand and other developing countries.

Keywords: carbon emissions, landfill, solid waste, waste composition.

Introduction

Climate change is a major global threat, intensifying environmental risks and disrupting societies worldwide. Human-induced increases in greenhouse gas (GHG) concentrations have been linked to a rise in the frequency and severity of extreme weather events, including tropical cyclones, floods, droughts, wildfires, and heatwaves. According to the Emergency Events Database (EM-DAT) of the Centre for Research on the Epidemiology of Disasters (CRED), the number of recorded natural disasters has risen sharply since the 1980s, reaching 410 events in 2023 (Ritchie and Rosado, 2024). These disasters have profound consequences, resulting in loss of human and animal lives, damage to ecosystems, and significant social and economic costs. For example, the Arctic experienced its second-highest air temperatures and second-lowest sea ice extent on record in 2020 (UN, 2021), while an unprecedented cold wave in Texas the same year disrupted energy systems and caused widespread damage. More recently, Typhoon Ragasa, the most powerful tropical cyclone of 2025, killed at least 17 people in Taiwan and brought destructive winds and heavy rainfall to Hong Kong and China (Miller, 2025).

Climate change is driven by rising global temperatures, primarily caused by anthropogenic GHG emissions. Total human-induced GHG emissions have continued to increase, reaching 59 gigatonnes carbon dioxide equivalent (CO_2-eq) in 2019, about 54% (21 gigatonnes CO_2-eq) higher than 1990 levels (IPCC, 2022). The major sources of these emissions are the power industry, industrial combustion and processes, buildings, transportation, fuel exploitation, agriculture, and waste (EU, 2024). The waste sector is the seventh-largest contributor to global GHG emissions, accounting for approximately 5% of the total (EU, 2024; Oo et al., 2024). Notably, GHG emissions from the waste sector in 2023 were 56% higher than in 1990, highlighting the increasing importance of sustainable waste management in climate mitigation (EU, 2024).

In the waste sector, GHG emissions in developed countries have generally declined, according to global inventories (EU, 2024). For example, between 1990 and 2023, the United States reduced waste-related GHG emissions by 38%, the United Kingdom by 82%, and Germany by 73%. In contrast, emissions in developing countries have risen sharply over the same period. China recorded a 212% increase, while Cambodia, the