The potential of biochar to reduce carbon emissions from organic fertilizers

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The agricultural sector faces increasing awareness regarding its environmental footprint, particularly concerning the contribution of animal waste storage and management to global greenhouse gas (GHG) emissions. These emissions, primarily carbon dioxide (CO_2) and methane (CH_4), directly challenge the sustainability of livestock production systems. Traditional storage practices for animal wastes create ideal conditions for microbial activity that releases GHGs into the atmosphere. Developing innovative and scalable mitigation strategies is paramount for transitioning toward low-carbon agriculture. This study investigated the effectiveness of biochar addition as a practical and effective strategy to minimize CO_2 and CH_4 emissions arising from different common animal waste substrates. Three distinct types of animal waste were selected for evaluation: liquid digestate (post-anaerobic digestion), conventional slurry, and solid manure. The experiment was designed to compare the GHG fluxes from each substrate in its original, untreated form versus its form amended with biochar. Emissions were rigorously monitored over a 21-day incubation period utilizing the static chamber methodology coupled with a high-precision portable gas analyzer. The biochar was incorporated into the substrates at a specific ratio of 2:1 (substrate to biochar, on a mass basis), aiming to maximize the surface area contact and adsorption potential of the amendment. The results demonstrated a clear effect of biochar that substantially reduced the emissions of both CO_2 and CH_4 across all three substrates compared to their untreated counterparts. The highest overall emissions were observed in the slurry treatment, confirming its high potential for gas release. In slurry, biochar addition achieved notable reductions since CO_2 and CH_4 emissions decreased by 26% and 21%, respectively. However, the most pronounced effect of the biochar was seen in the digestate treatment. Here, the addition of biochar led to a remarkable decrease in gaseous fluxes, resulting in a 45% reduction for CO_2 and a 78% reduction in CH_4. This higher performance suggests a strong synergistic interaction between biochar and the complex composition of the digestate. Even for solid manure, which inherently exhibited a lower tendency to emit carbon-based gases, biochar proved highly effective. The amendment caused relevant decreases in CO_2 emissions (40%) and an impressive reduction in CH_4 emissions (81%). This highlights biochar's versatility as an effective amendment across different waste consistencies. To quantify the overall environmental benefit, the emission reductions were translated into a decrease in Global Warming Potential (GWP), a standardized measure integrating the radiative forcing of CO_2 and CH_4. Biochar successfully reduced the environmental impacts of the treatments, achieving a GWP reduction of 55% for digestate, 22% for slurry, and 44% for manure. The findings demonstrate that incorporating biochar into animal waste management practices is a powerful and viable strategy for mitigating agricultural GHG emissions. Given the significant reductions in CH_4, the use of biochar represents a critical step toward creating climate-smart organic fertilizers. Future research should focus on optimizing the biochar inclusion rate and exploring the long-term effects on nutrient retention and soil health when these amended wastes are applied to agricultural land.

Keywords

Digestate; Slurry; Manure; Methane; Global Warming Potential

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