Innovative Approaches to Accelerated Organic Solid Waste Decomposition: Evaluating the Co-substrate Potential of Sludge, Manure, and Leachate

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Abstract

Pakistan's landfill sites often fail to meet environmental standards, lacking biogas facilities and proper leachate management systems. This study investigates the impact of different treatments—leachate, sludge, and manure—on enhancing organic waste decomposition and biogas production. Using anaerobic reactors, we found that leachate treatment resulted in the highest biogas yield and waste decomposition rates. Comparatively, aerobic decomposition proved more efficient than anaerobic processes. Implementing these treatments could significantly improve waste management practices, reducing greenhouse gas emissions and mitigating public health risks.

Introduction

- Pakistan's dumping sites fail to comply with environmental norms.
- Absence of biogas facilities and proper leachate collection systems.
- Landfill Gas (LFG) Composition:

LFG typically consists of: 45–50% Carbon Dioxide (CO_2), 50–55% Methane (CH_4), <1% Non-methanic organic compounds (Ozkya et al., 2004).

- Environmental and Health Impacts:

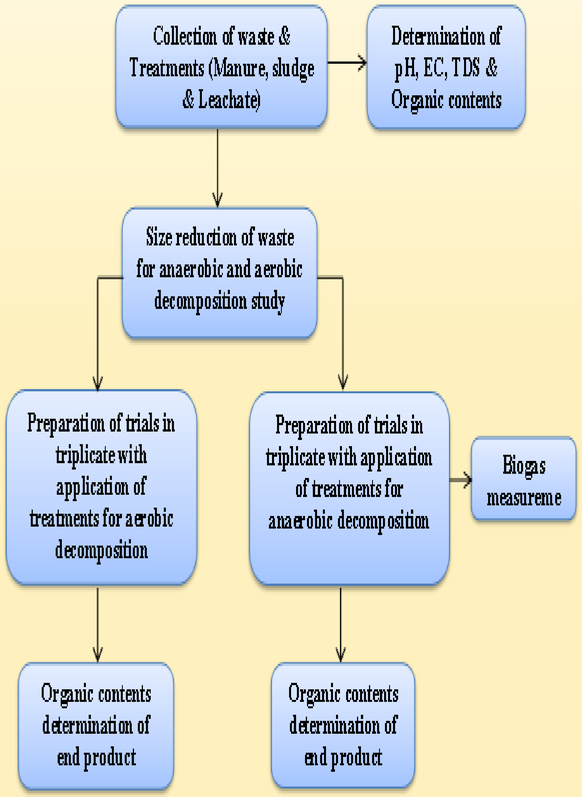
Given that a significant portion of municipal solid waste (MSW) comprises organic content (Hartmann & Ahring, 2006), the anaerobic and aerobic decomposition of MSW leads to the emission of greenhouse gases (GHGs) such as CO_2, CH_4, and NO_2 (Bonger et al., 2011) which contribute to environmental degradation and public health risks.

Objectives

Core objectives of the study were,

- Assess the effectiveness of treatments (leachate, sludge, manure) in promoting waste decomposition
- Investigate the combined impact on biogas production and waste decomposition

Methodology



Results

Key Findings:

Highest Gas Production:

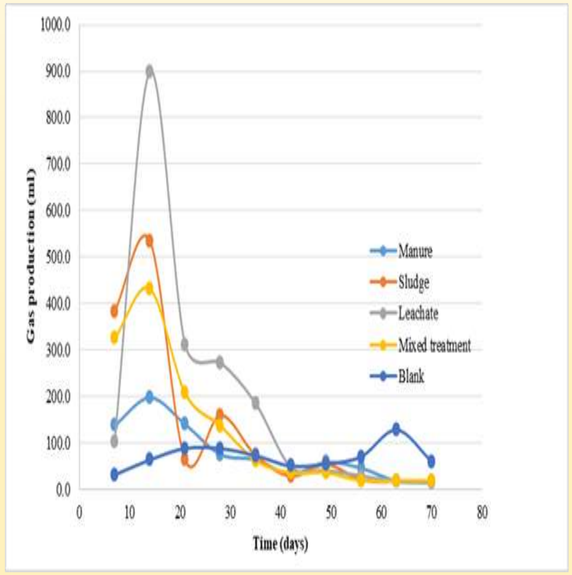
- Leachate-treated reactor (TL): 899 ml.

Other treatments: TS (535 ml), TMX (432 ml), TM (197 ml).
Control (TB): 128 ml.

Peak Production Period:

- Maximum gas production during the 2nd week.
- Gradual decrease in gas production observed until the 70th day.

Results



Comparison of Decomposition Rates:

Leachate (TL):
Aerobic: 65.53% Anaerobic: 47.76%

Sludge (TS):
Aerobic: 53.63% Anaerobic: 28.66%

Mixed (TMX):
Aerobic: 45.09% Anaerobic: 24.67%

Manure (TM):
Aerobic: 30.50% Anaerobic: 14.44%

Control (TB):
Aerobic: 22.11% Anaerobic: 7.77%

Key Observations:

- Leachate treatment led to the highest decomposition rates.
- Aerobic decomposition was more effective than anaerobic decomposition.

Conclusions & Implications

- Treated reactors produced more biogas and had faster waste decomposition
- Aerobic decomposition was more effective than anaerobic decomposition

Implications for Waste Management:

- Effective treatments (leachate, sludge, manure) can enhance biogas production and accelerate waste decomposition
- Adoption of these methods can mitigate environmental and public health risks

Future Research:

- Optimization of treatment combinations for maximum efficiency
- Scaling up research to real-world landfill settings

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