Preface

Floral waste (FW) and agricultural residues like rice straw (RS) represent a significant portion of organic waste that contributes to environmental degradation, particularly through landfill emissions and greenhouse gas production. The conventional methods of disposing of these wastes, such as burning or dumping, exacerbate pollution levels and fail to capitalize on their potential as valuable organic matter for soil enrichment. Composting offers a scientifically supported and sustainable alternative to these methods, providing a way to recycle organic waste into nutrient-rich compost that can be reintroduced into agricultural systems, reducing the need for chemical fertilizers and improving soil health. This study investigates the composting of FW and RS, focusing on the microbial processes that drive the breakdown of organic matter and the role of different inoculants in enhancing the composting efficiency. Specifically, the research explores the use of anaerobic digester slurry (ADS) and raw cow dung (CD) as inoculum for the composting of FW. By comparing these two inoculants, the study aims to uncover their influence on microbial diversity, compost maturation, and nutrient availability. The results revealed that the microbial diversity and community dynamics varied significantly between the two inoculants. Notably, a marked increase in nitrate and phosphate concentrations was observed after day 40 of composting, attributed to the microbiome's role in driving the compost maturation process. In particular, *Bacillus* showed a notable increase in CD compost (63.35%), whereas *Streptomyces* exhibited significant growth in CD (129.5%) compost. Furthermore, FW composting facilitated the proliferation of archaea such as *Haloarcula* and *Haloferax*, which are effective at breaking down organic matter in high-salt environments, while reducing methane-producing archaea, indicative of favorable aerobic composting conditions. The composting of FW using CD showed an enhanced richness of microbial species, while ADS composting demonstrated greater diversity within the microbial community. This suggests that ADS, with its rich microbial flora, holds considerable promise for optimizing the composting of FW, leading to more efficient organic matter breakdown and potentially improving soil quality when applied to agricultural fields. The study also explores composting as a method for managing RS, a common agricultural residue that is typically burned, contributing significantly to air pollution and greenhouse gas emissions. Composting RS not only provides an alternative waste management solution but also results in valuable compost that can be used to enhance soil fertility. The research compares the performance of ADS and CD as inoculants in the composting of RS and highlights the critical role of microbial communities in optimizing the composting process. Key microbial taxa, like *Acinetobacter*, *Serratia*, *Bacillus*, *Flavobacteria*, *Pseudomonas*, and *Prevotella*, were found to increase significantly in mature ADS compost compared to CD. Additionally, archaea such as *Haloarcula* and *Haloferax* showed higher abundance in ADS compost, reflecting the positive influence of the digestion process on composting efficiency. The study found that ADS with RS compost exhibited higher microbial richness and diversity, as evidenced by higher Chao 1 and Shannon index values, suggesting that ADS promotes a more robust microbial environment conducive to faster composting and higher-quality compost. While the benefits of composting FW and RS are clear, the study also addresses the emerging issue of microplastic (MP) contamination in organic waste. MP, particularly polyethylene terephthalate (PET) and polystyrene (PS), were found to significantly disrupt microbial processes essential for RS degradation. PET and PS were selected based on their frequent presence in floral waste, might introduced through plastic packaging, synthetic ribbons, and decorative thermocol. These materials often enter composting systems unintentionally and degrade into persistent MPs, affecting microbial activity, delaying compost maturity, and reducing compost quality. Their inclusion in the study reflects real-world contamination scenarios relevant to decentralized composting systems. The presence of MP led to decreased microbial diversity and altered community structures, which affected the compost's physicochemical properties and delayed its maturation. While it is recognized that all microorganisms possess the ability to respond to environmental stress, certain genera—such as *Bacillus*, *Pseudomonas*, and halophilic bacteria like *Halomonas*—are found to adapt under adverse conditions. Their increased presence in the MP-treated composts suggests a community shift favoring stress-resilient taxa in response to microplastic-induced contamination. This shift in microbial communities was reflected in lower nitrate levels, reduced humic acid content, and compromised germination indices in PET and PS treatments compared to control composts. Furthermore, MP contamination led to a significant reduction in unique operational taxonomic units (OTUs), which negatively impacted nitrogen cycling, increased salinity, and reduced compost stability. The findings highlight the need for effective strategies to mitigate the impact of MP on composting processes to ensure the sustainability of agricultural practices that rely on compost. By integrating advanced composting system designs with a focus on microbial dynamics and the challenges posed by MP contamination, this thesis offers a holistic approach to organic waste management. This research comprehensively assesses the role of different microbial inocula and emerging contaminants in the composting of agricultural and floral residues. Initially, core microbiome diversity in digested versus raw manure was explored to understand their compositional differences and influence on microbial dynamics during rice straw composting. Building on this, the same inocula were evaluated in the co-composting of floral waste, focusing on changes in physicochemical parameters and microbial succession. The study also investigated the impact of microplastic contaminants—specifically polyethylene terephthalate (PET) and polystyrene (PS)—on microbial structure and compost quality, reflecting real-world contamination scenarios. Finally, a techno-economic analysis was conducted to evaluate the technical feasibility and economic viability of rice straw composting under various treatment conditions. These integrated approaches offer valuable insights for optimizing composting systems and advancing sustainable organic waste management.