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In-situ Composting Strategies for Sustainable Food Waste Digestate Management

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IBA 生物資源與農業研究所
INSTITUTE OF BIORESOURCE AND AGRICULTURE

- Top 88 of Top 2% scientist in Biotechnology-Stanford University Report, 2020
- Top 47 Scientists in China in Environ. Sci. area, World Academic Impact Ranking
- Bronze Bauhinia Star by the Government of Hong Kong in 2022
- Medal of Honor by the Government of Hong Kong in 2011
- Appointed as Justice of Peace in 2013

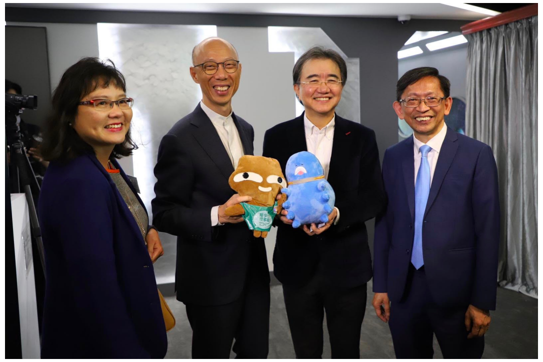
- Director, Institute of Bioresource and Agriculture
- Director, Sino-Forest Applied Research Centre for Pearl River Delta Environment
- Director, Hong Kong Organic Resource Centre
- Executive Director of Earth Tech Consultancy Co. Ltd.
- Over HK$200 millions of research funding
- Organized 8 international conferences in the last ten years

Prof. Jonathan W. C. Wong, BBS MH JP
Dept of Biology, Hong Kong Baptist University
Honorary Professor, University of Queensland
Academician of the European Academy of Sciences of Arts

MAJOR RESEARCH AREAS

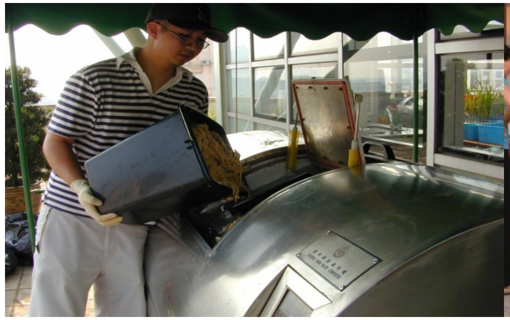
Bioconversion of Biowaste for Fertilizer and Biogas, organic farming, waste separation, soil remediation

Anaerobic digestion for biogas production



Promote organic and sustainable development

Design and Built the Pilot Composting Plant at the Kowloon Bay Waste Recycling Centre



Community waste separation and composting

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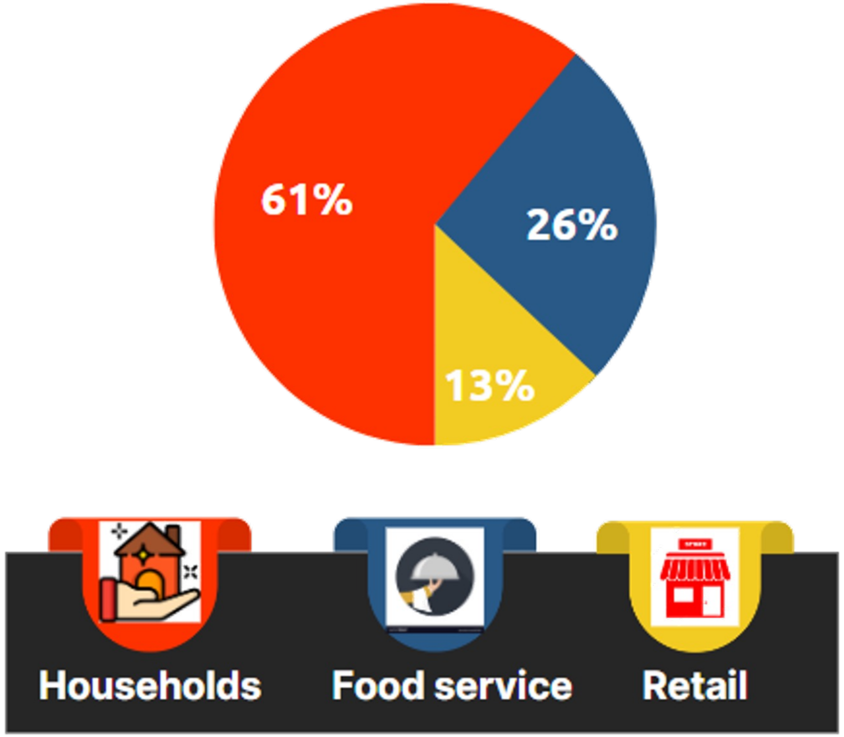
Outline of Presentation

- Food waste and anaerobic digestion
- Digestate management
- Composting of digestate in Hong Kong
- In-situ composting strategies
    - C/N ratio adjustment
    - Physical additive
    - Microbial additive
- Conclusions

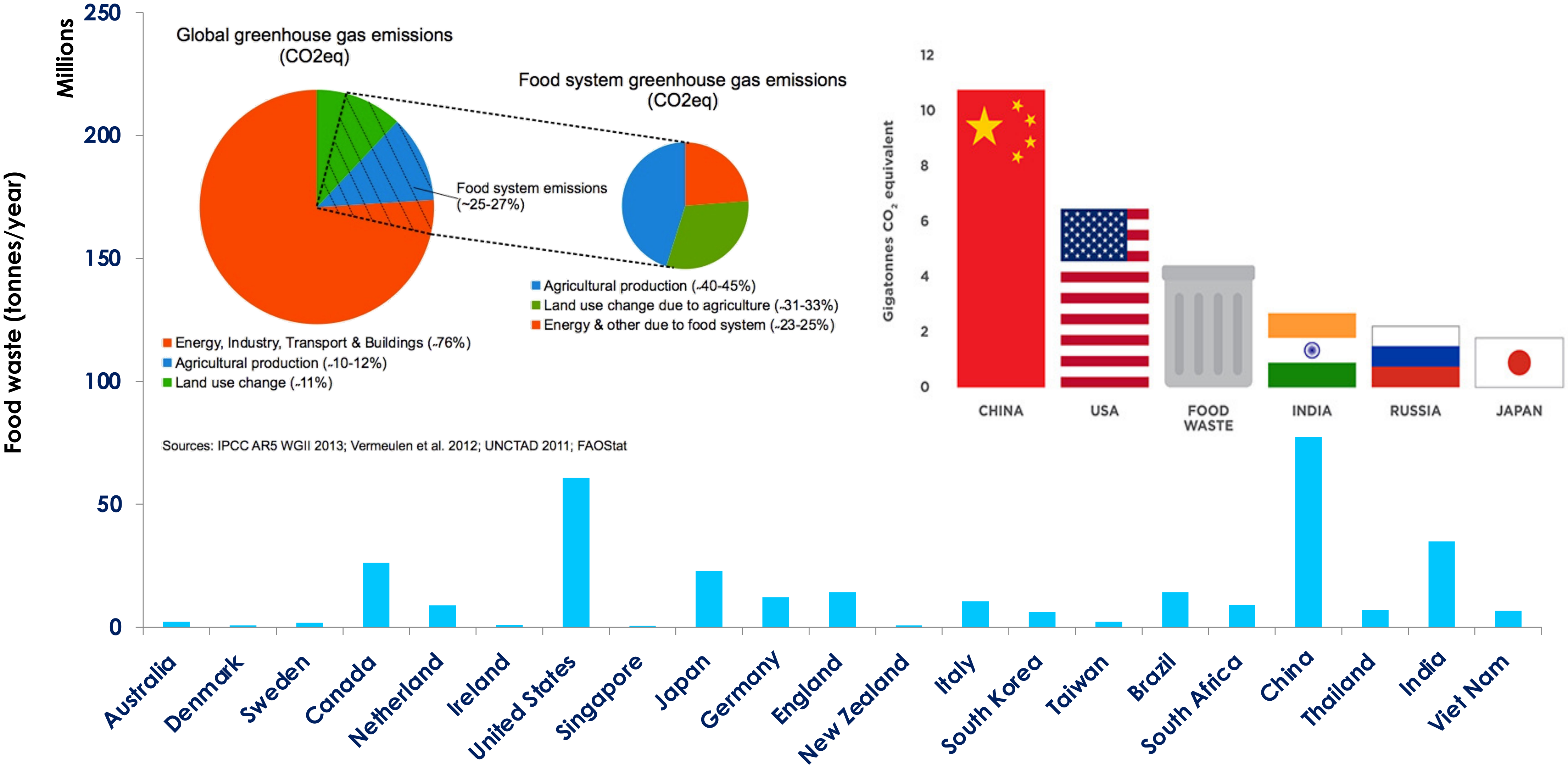
Global Food Waste Production

931 million tons/year

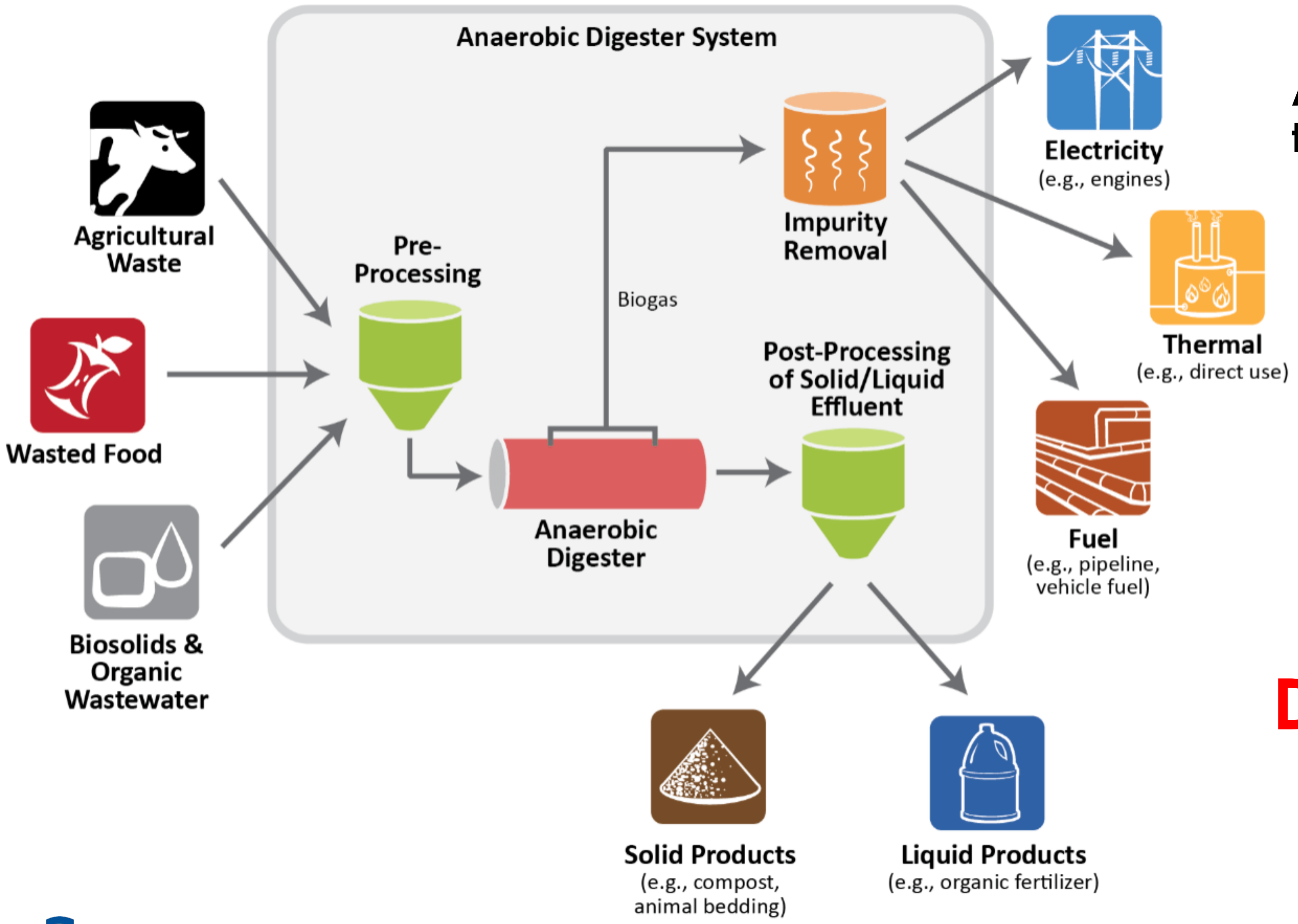


Source: UNEP, 2020

Food Waste & its Implications on Resources



Role of Anaerobic Digestion in Food Waste Management



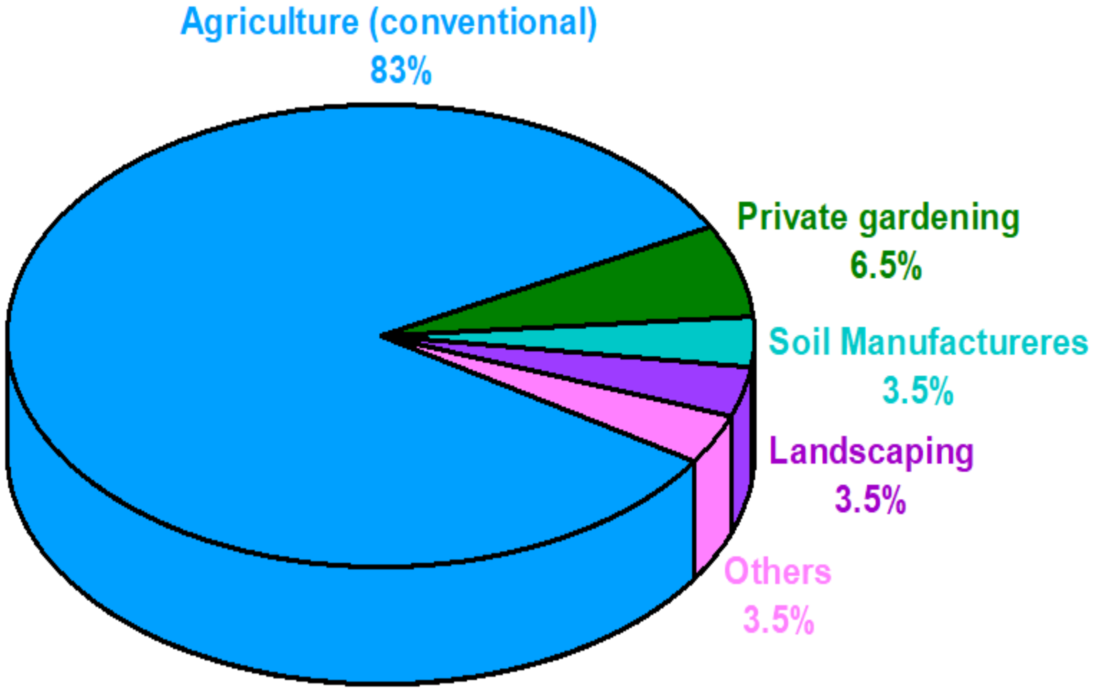
Anaerobic digestion as carbon neutral technique:

- AD collects methane and provides a source of renewable energy that is carbon neutral (provides energy with no net increase in atmospheric CO2
- Reduction of GHG emission
- Digestate produced has high nutrients in the form nitrogen which can be used as fertilizer

Digestate management is still challenging

Source: European Biogas Association, 2020

Challenges Associated with Digestate Management

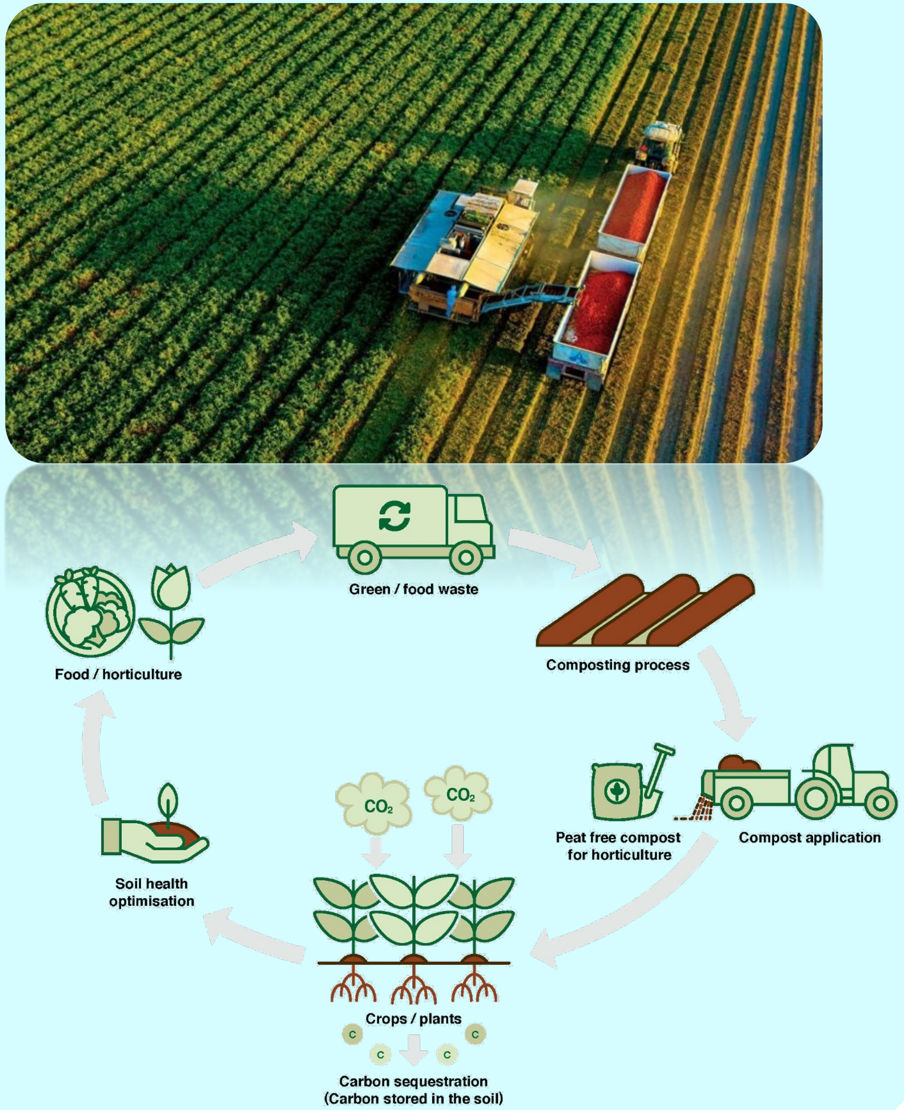


Global Digestate Distribution

- Anaerobic digestate is associated with environmental impacts
  - Water pollution through leaching (nutrients runoff - eutrophication, NO_3^- discharge to surface water and groundwater),
  - Soil contamination (toxic elements concentration e.g. heavy metals),
  - Threat to human health by food contamination (e.g. presence of pathogens) and
  - Volatile emissions to air estimated equal to 139 g CO_2-eq/ kg digestate.

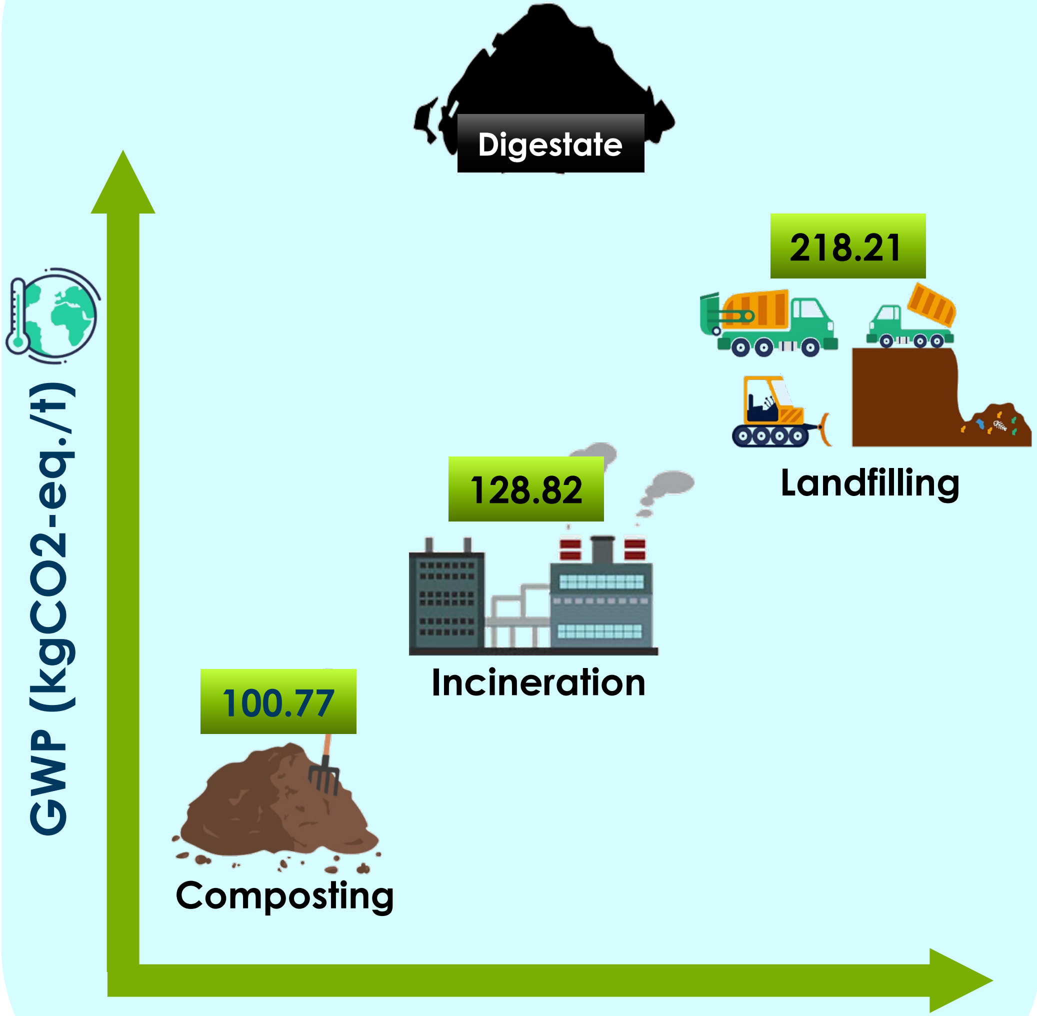
Benefits of Composting

Carbon Sequestration



Source: Envar, 2020

Climate Change



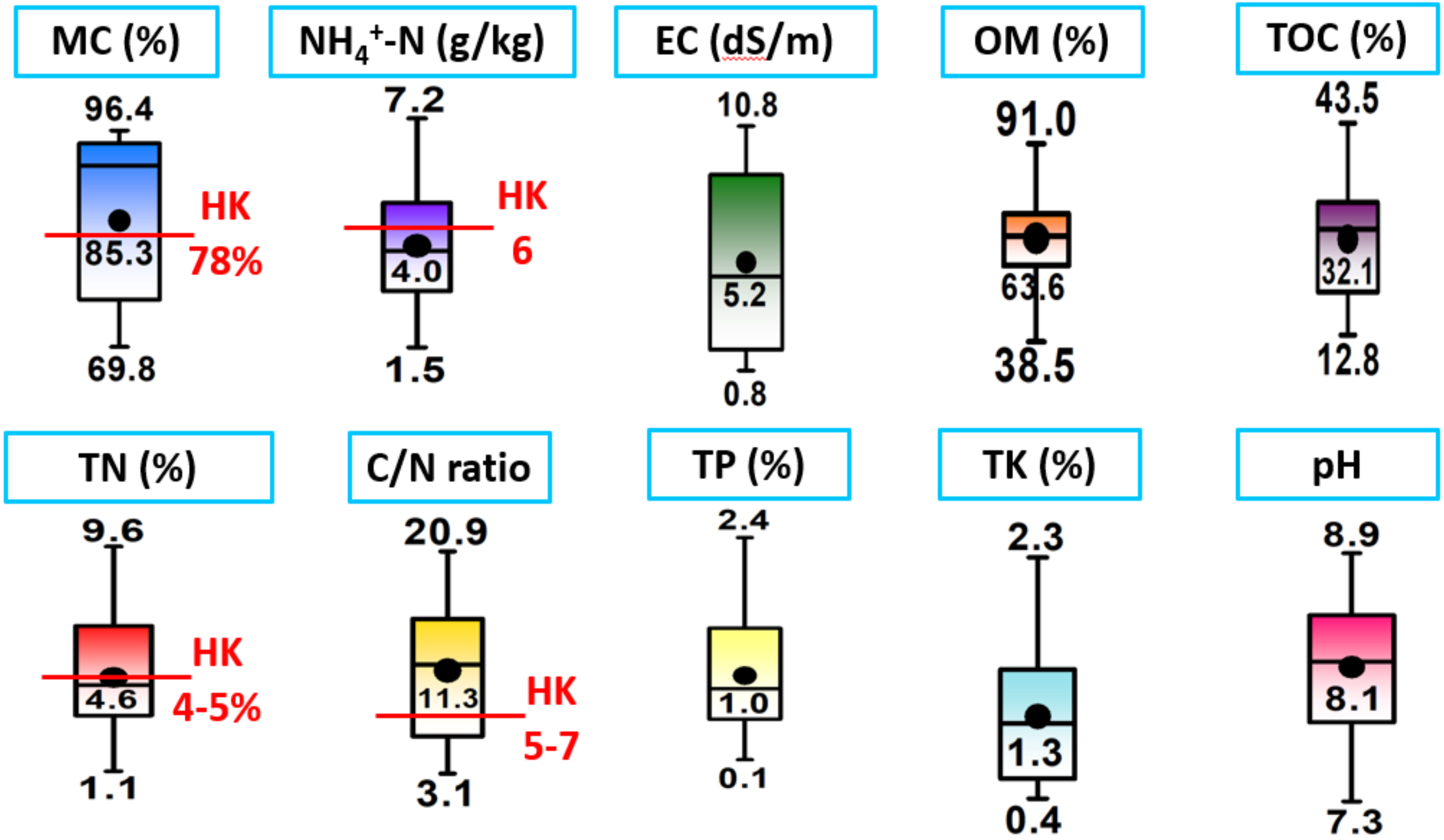
Source: Chen et al., 2021 (Bioresource Technology)

Aerial View of ORRC1 in Hong Kong

Digestate Discharge

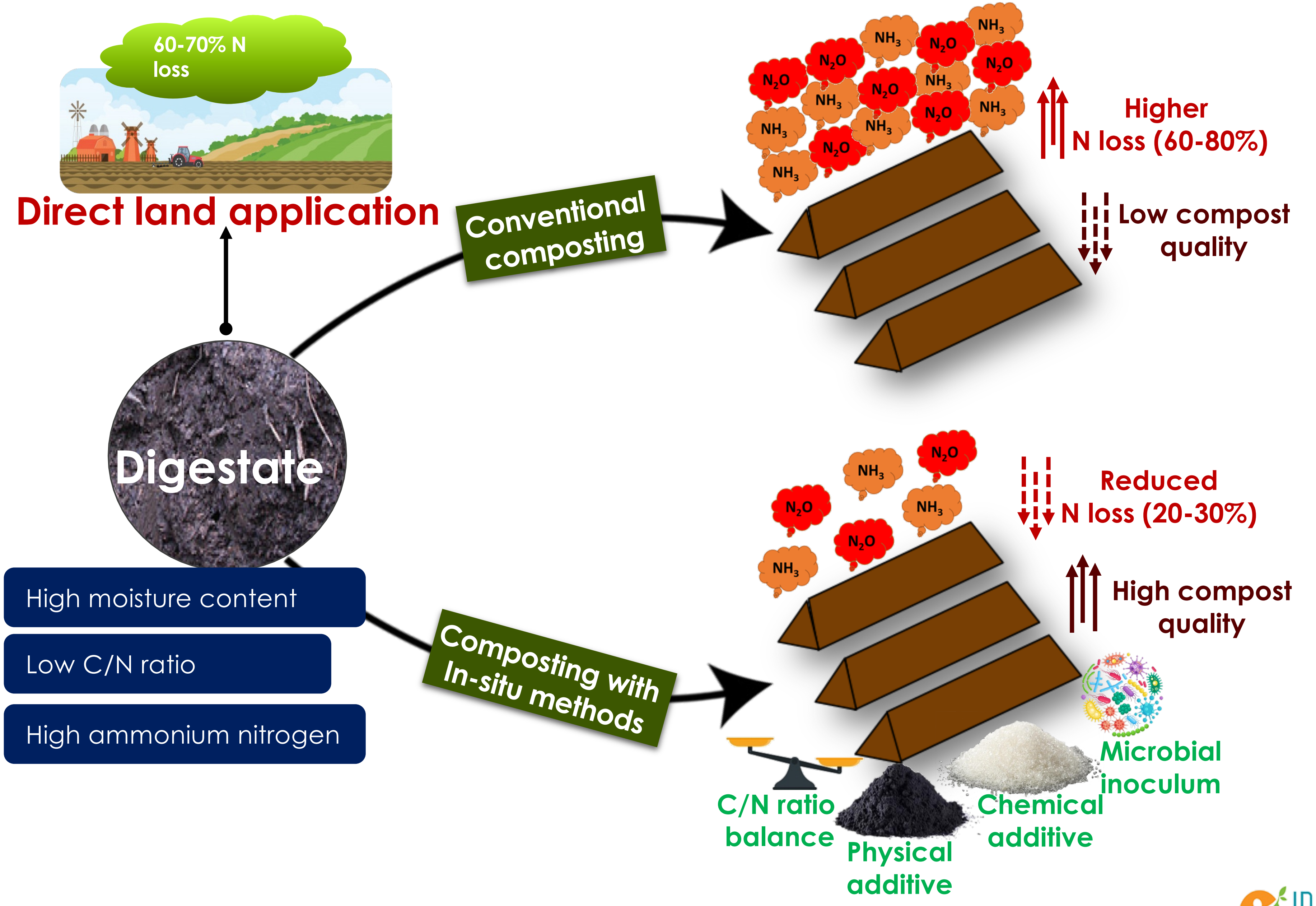
Tunnel Composting

Food Waste Anaerobic Digestate Characteristics



Source: Manu et al., 2021 (Bioresource Technology)

Digestate Composting: Conventional vs In-situ Strategies

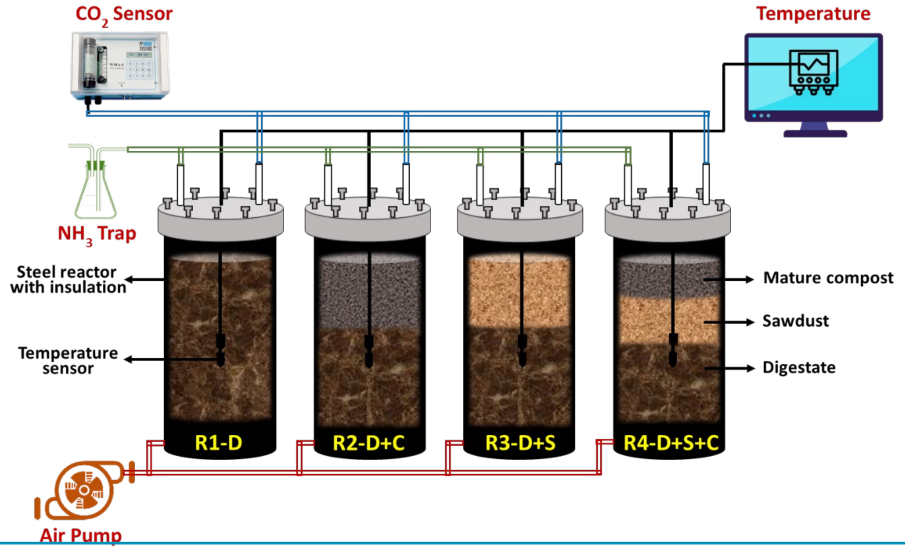


Source: Manu et al., 2021 (Bioresource Technology)

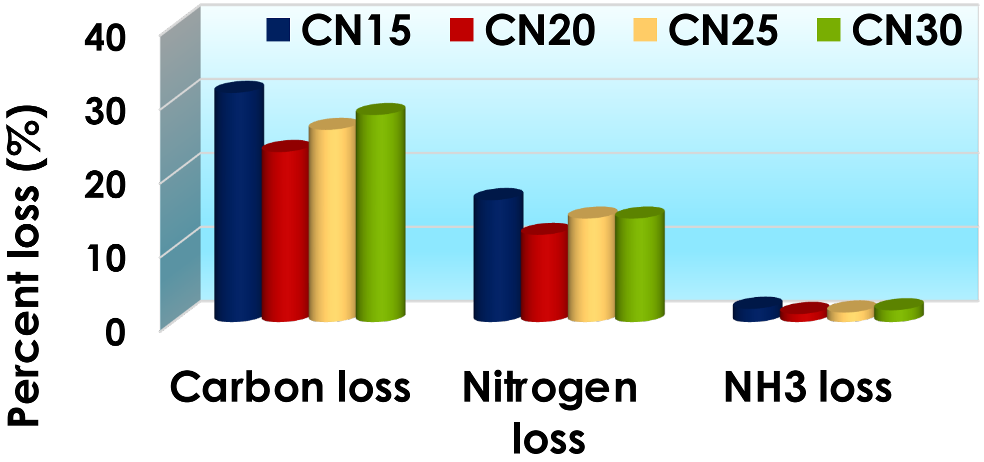
In-situ strategy: C/N ratio adjustment

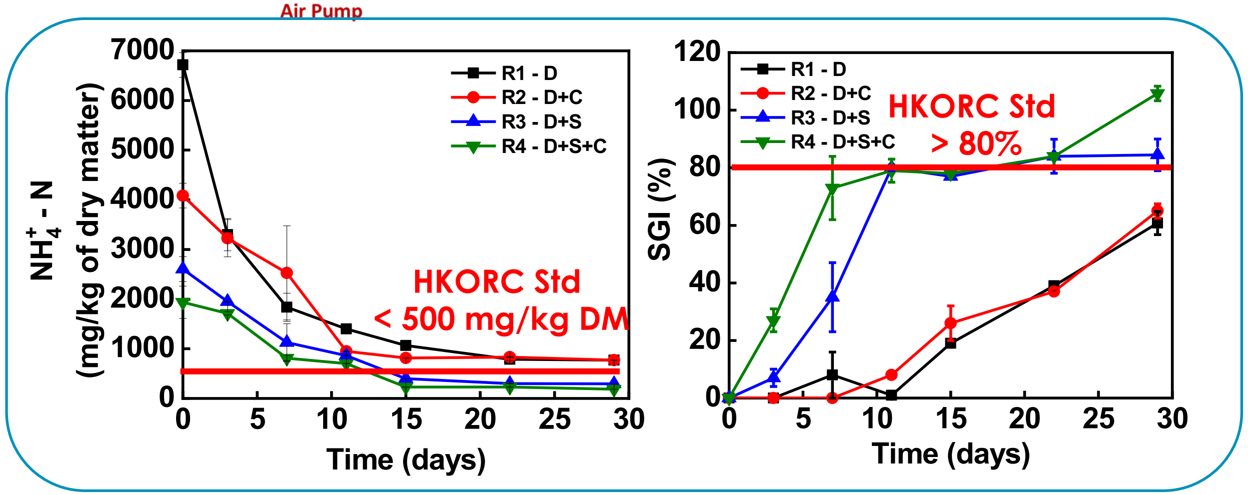
Feedstock Optimization

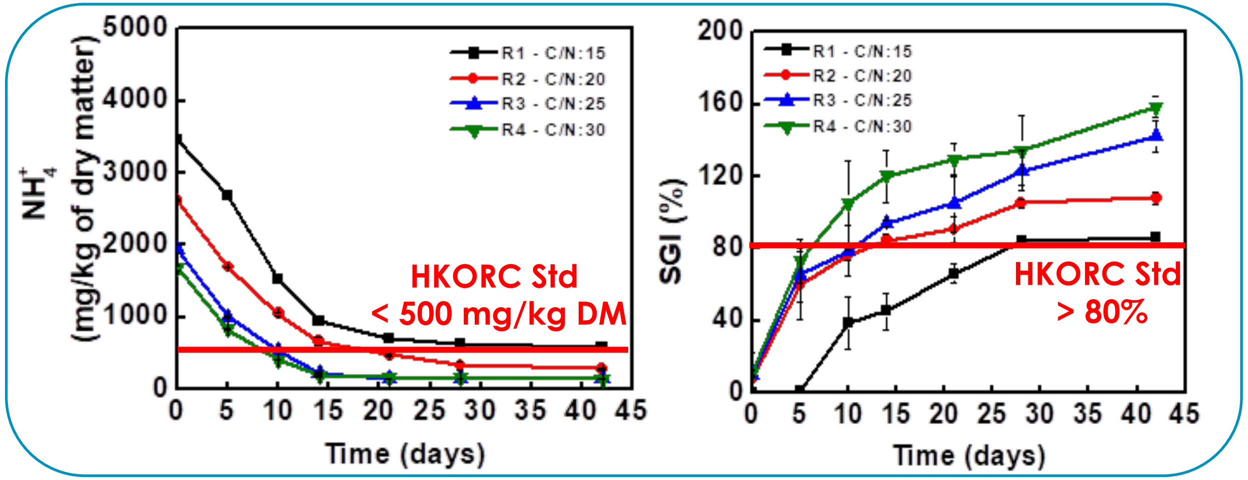
Feedstock Optimization



C/N ratio Optimization



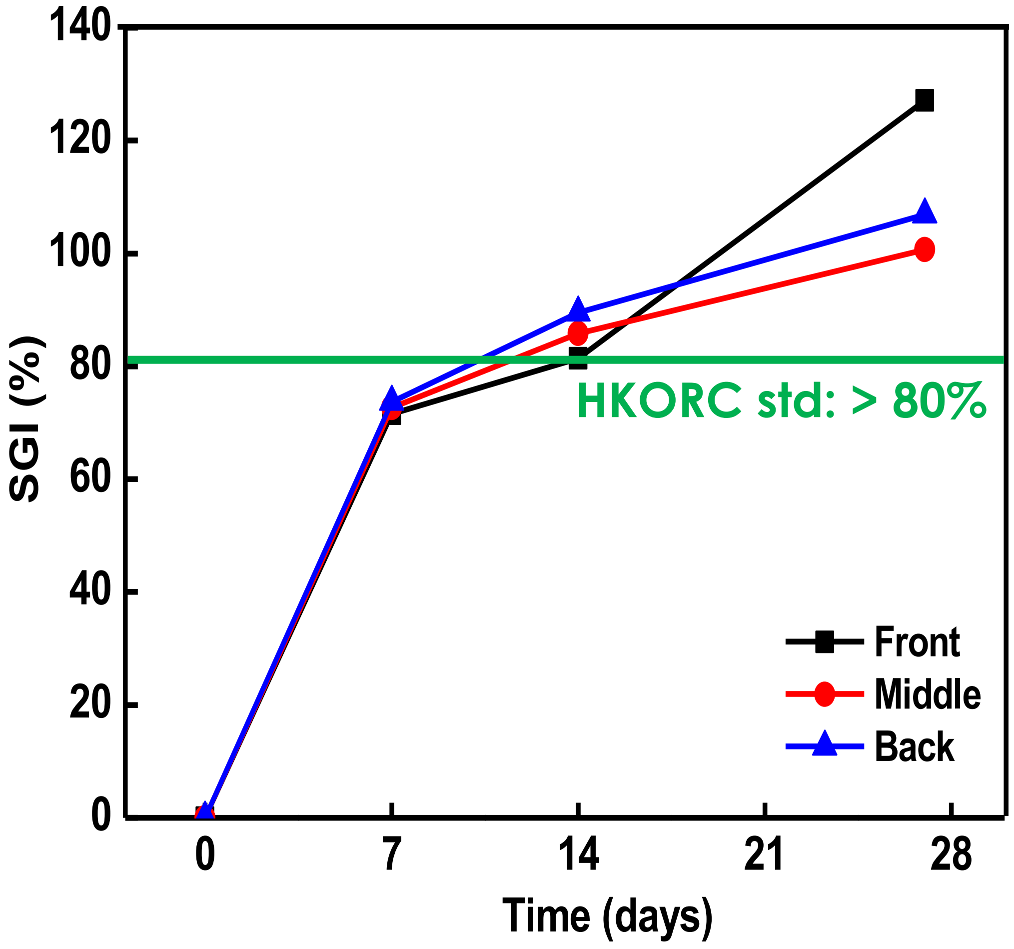


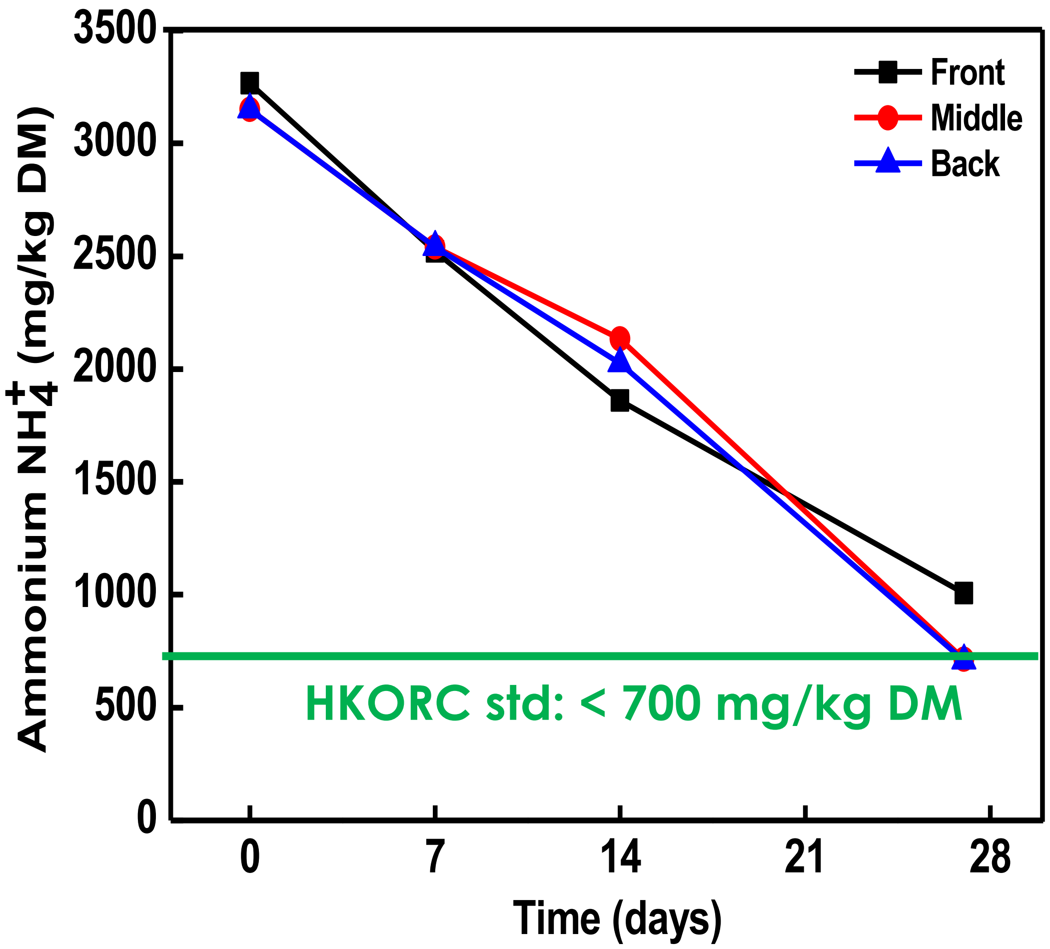


Source: Song et al., 2021 (Bioresource Technology)

Field Experiment 3: Co-composting with Sawdust

Feedstock (fresh wt): Digestate (50%) + structurant (25%) + sawdust (16.7%) + mature compost (8.3%)



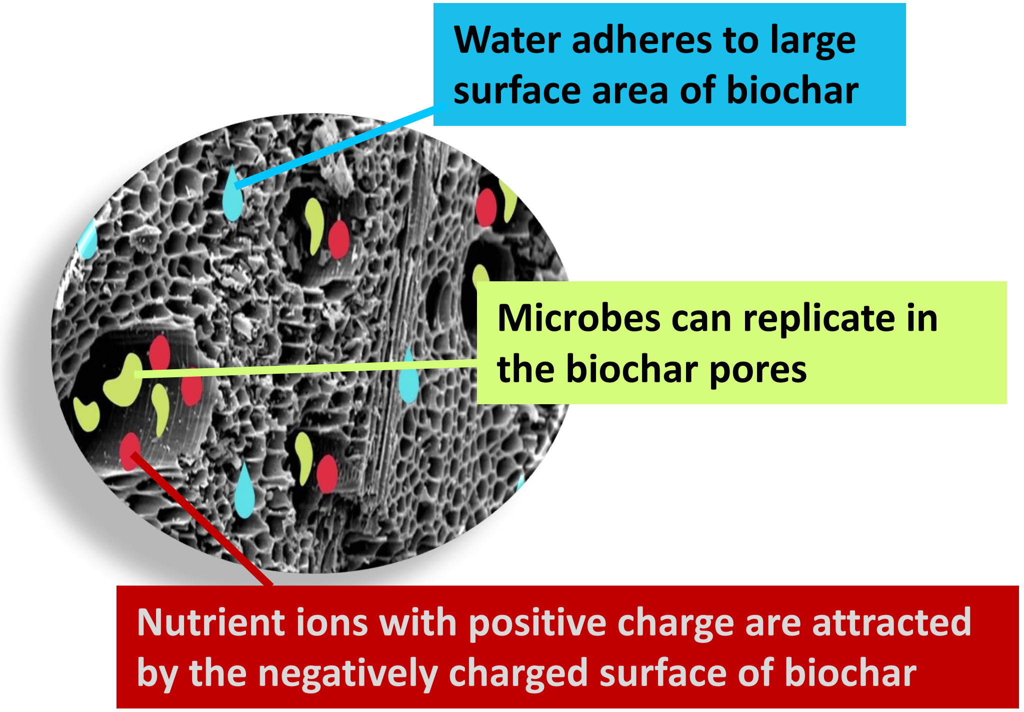


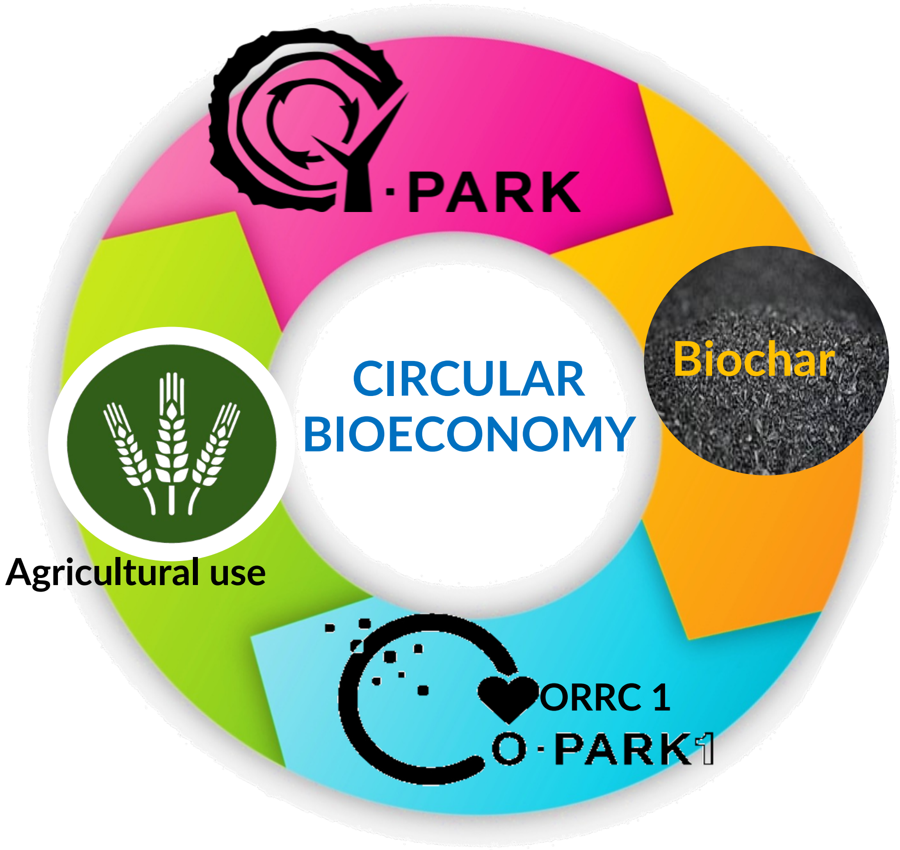
In-situ strategy: Physical Additive

Why Biochar in Digestate Composting?

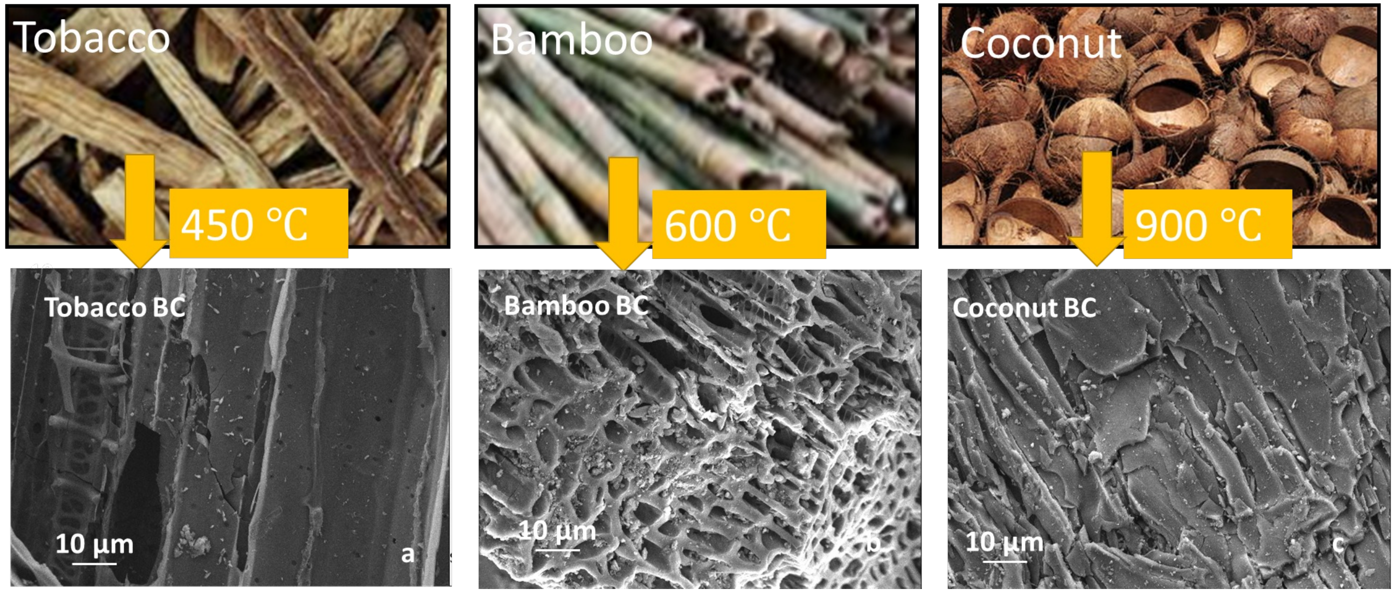
- Biochar is a widely used amendment in composting
- Biochar characteristics such as high surface area and cation exchange capacity will help in reducing N loss

- To promote circular bio-economy in Hong Kong
- Market creation for biochar produced at Y-Park by HK government

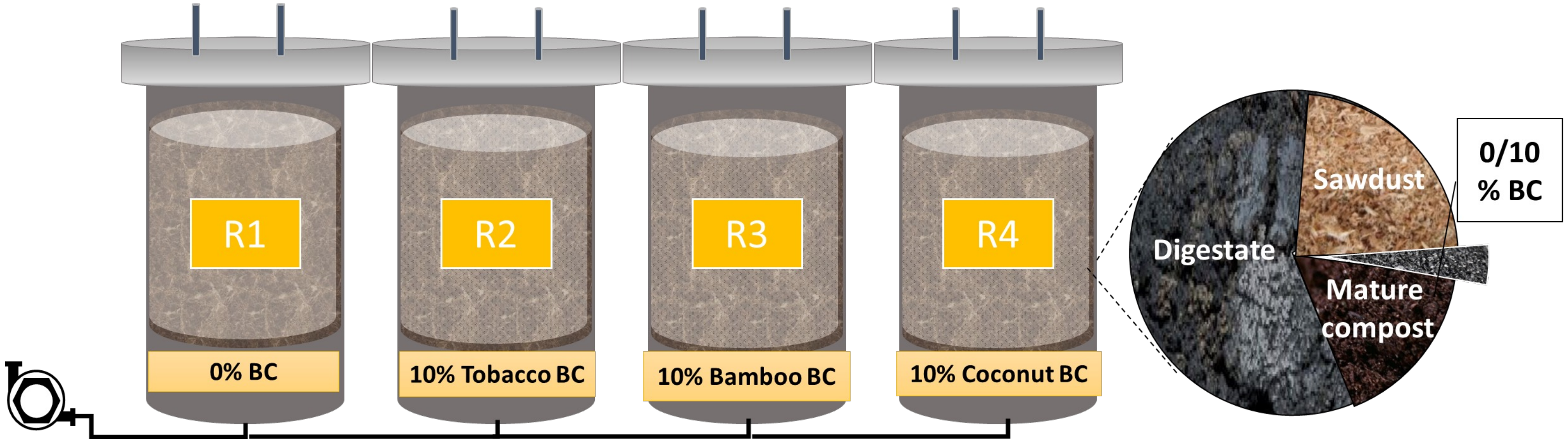




Digestate Composting with 3 Types of Biochar

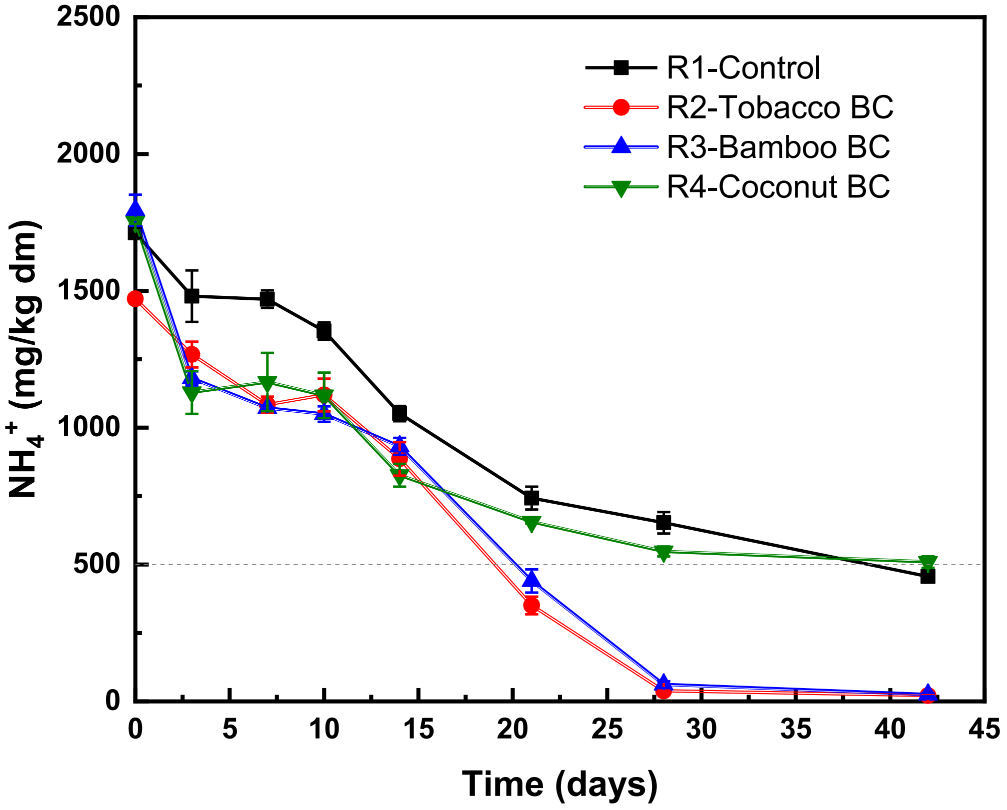


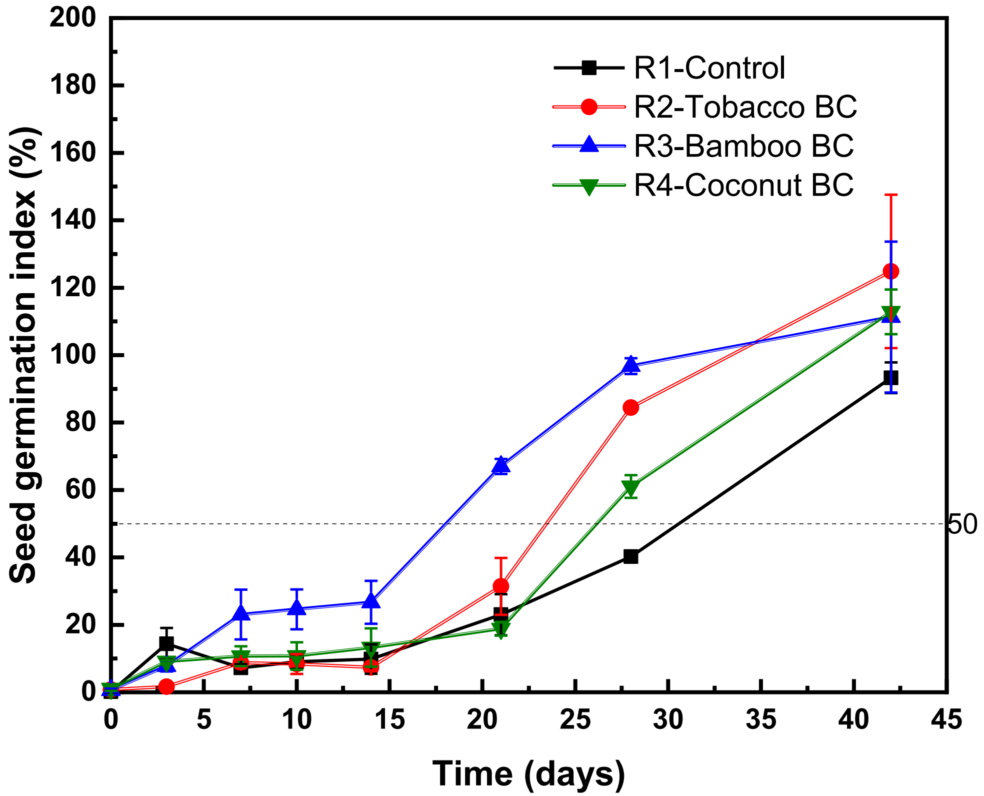
BET surface area: 8.2 m²/g | BET surface area: 7.5 m²/g | BET surface area: 19.1 m²/g



Source: Li et al., 2023 (Waste Management)

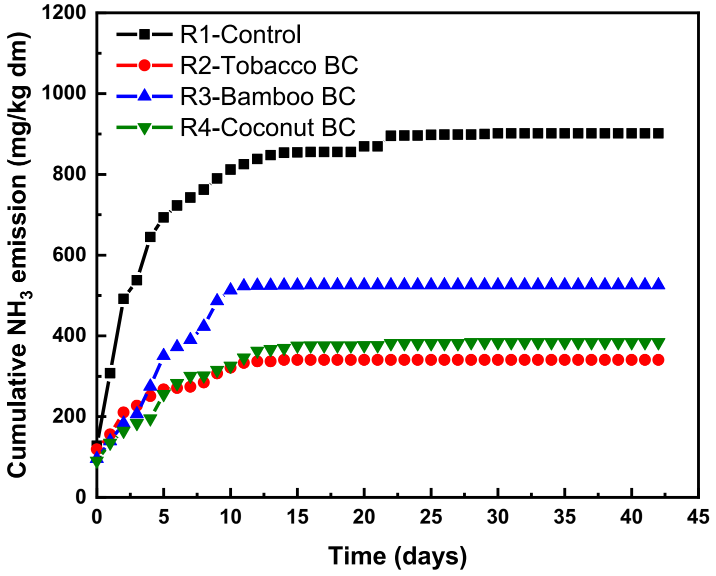
Digestate Composting with Biochar

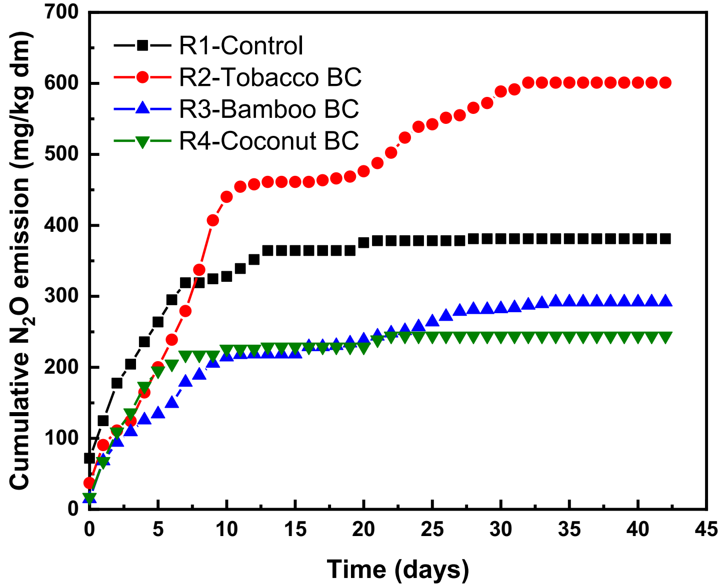


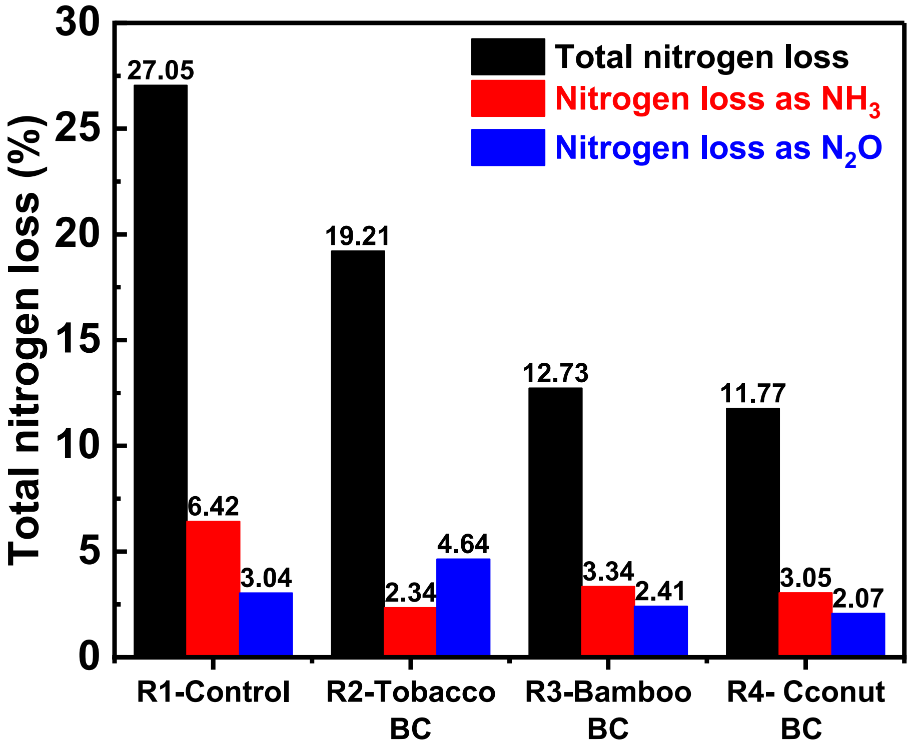


Source: Li et al., 2023 (Waste Management)

Digestate Composting with Biochar

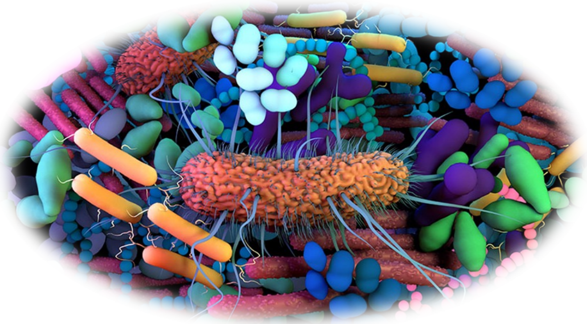




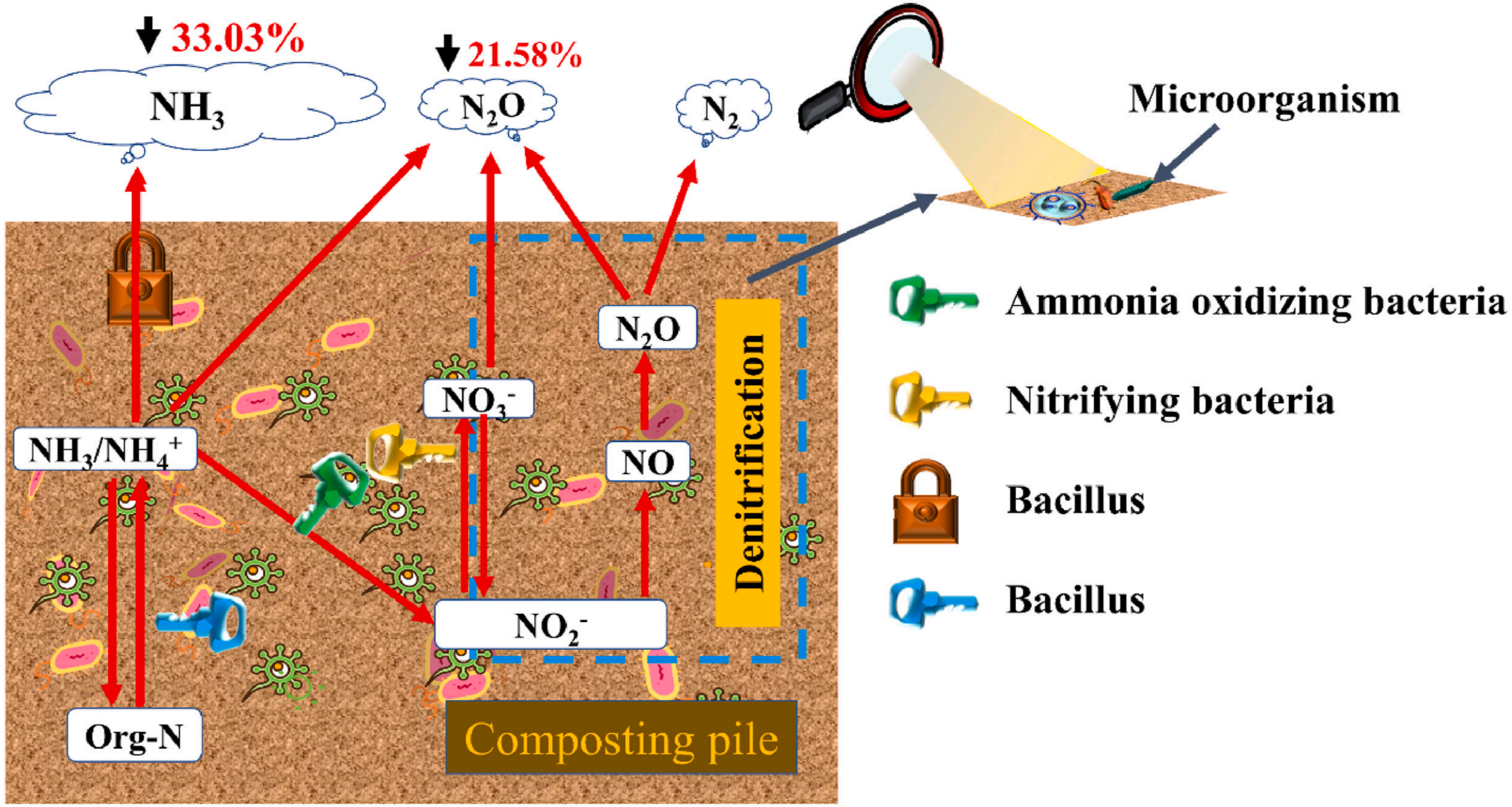


Source: Li et al., 2023 (Waste Management)

In-situ strategy: Microbial Additive



In-situ strategy: Microbial Additive



Commonly used microbial additives in composting:

- Ammonia oxidizing bacteria (AOB)
- Nitrite oxidizing bacteria (NOB)
- Commercial nitrifiers
- Mixed cultures

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Source: Shan et al., 2021 (Journal of Cleaner Production)

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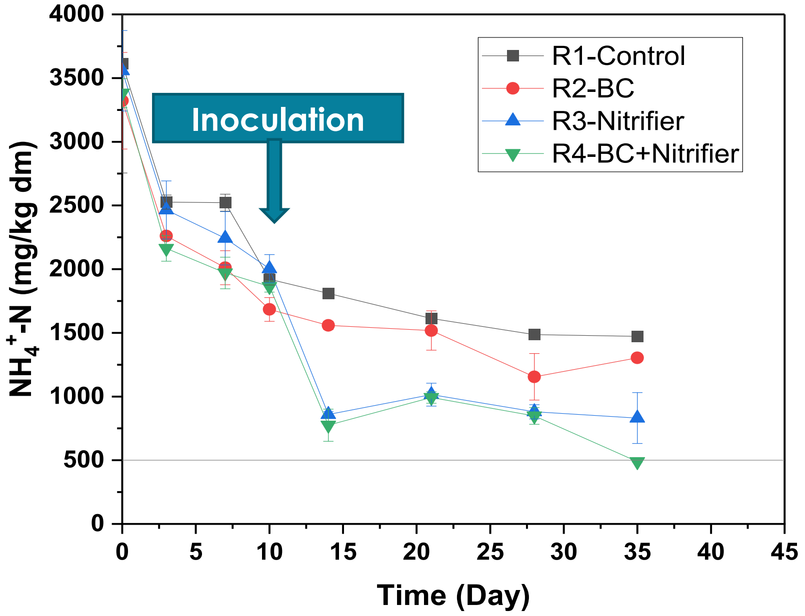
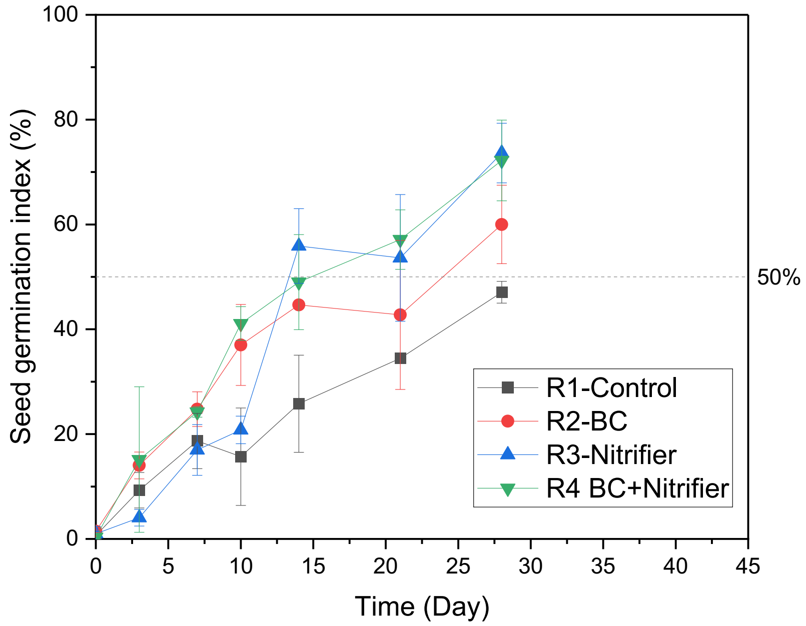
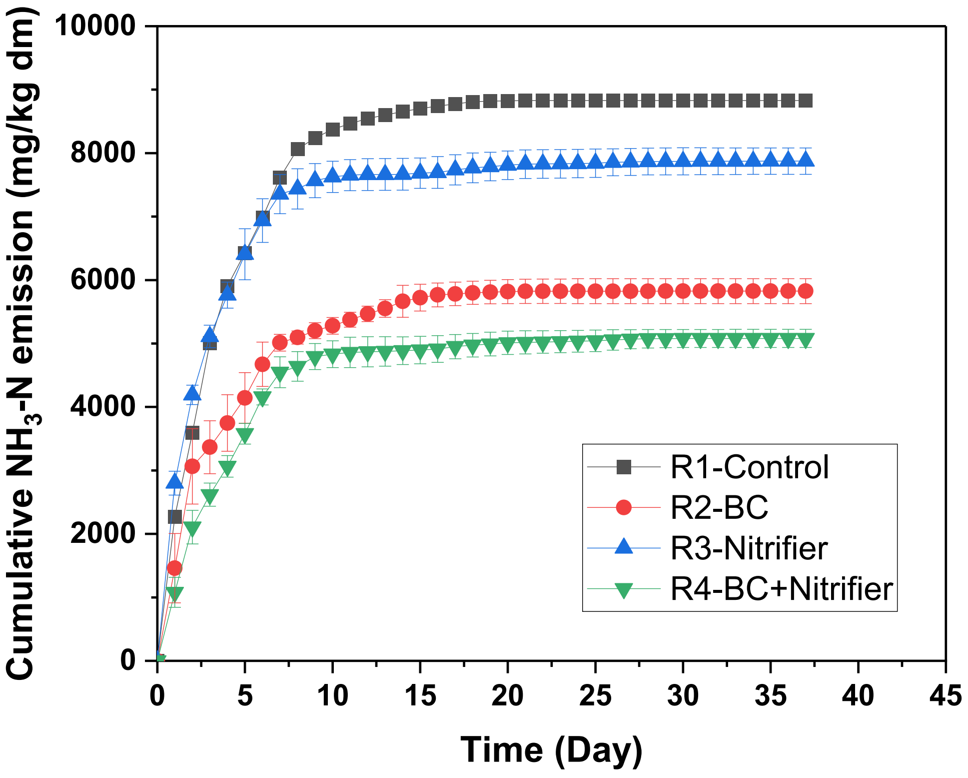
FWD Composting with Biochar and Microbial Additives

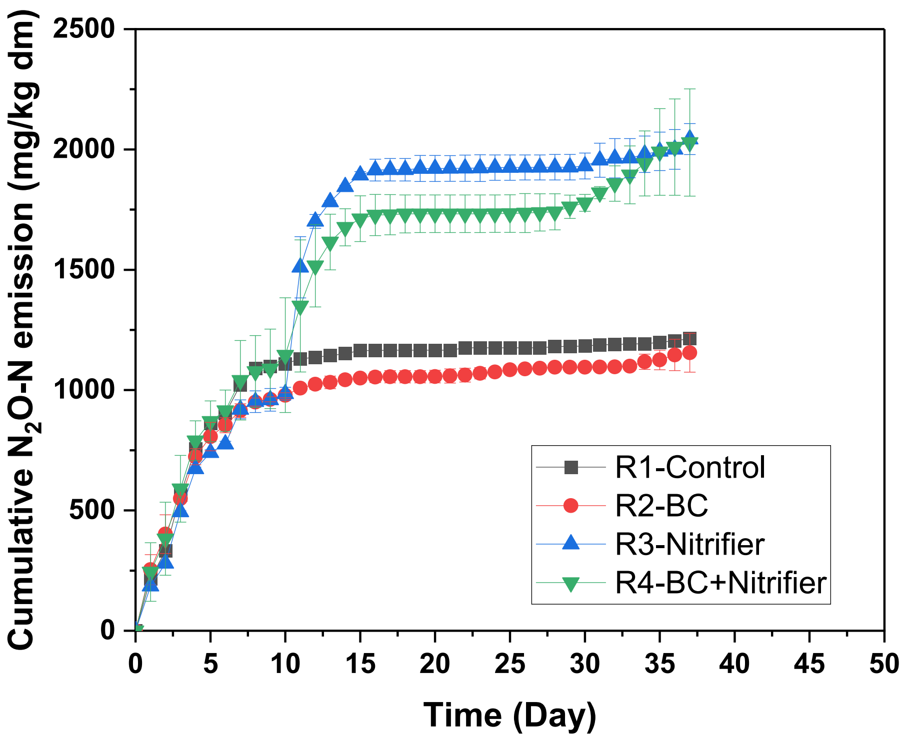
Treatments	Coconut Biochar	Commercially available nitrifiers
R1-Control	-	-
R2-BC	10% on day 0 (dry wt.)	
R3-Nitrifier	-	5% on day 10 (after thermophilic phase)
R4-BC + Nitrifier	10% on day 0 (dry wt.)	5% on day 10 (after thermophilic phase)





FWD Composting with Biochar and Microbial Additives





Conclusions

- In-situ composting strategies are beneficial in digestate composting to conserve the nitrogen, to alleviate ammonium inhibition, to reduce the composting duration and to improve the compost quality
- Among different strategies, 10% coconut biochar was found to be effective in reducing nitrogen loss by mitigating NH3 and N_2O emissions
- Addition of microbial consortium along with biochar demonstrated better performance by enhancing the nitrification process
- In-situ composting strategies such as C/N ratio adjustment and additive strategies could significantly reduce the composting duration at Hong Kong's first biological food waste treatment facility 'ORRC1'

Acknowledgements

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Thank You!

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