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Smart Membrane-Covered Composting: Technology and Field Applications in China

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Part 1. Brief Introduction

The **Nanjing Institute of Agricultural Mechanization (NIAM)**, affiliated with the Chinese Academy of Agricultural Sciences (CAAS), is dedicated to agricultural mechanization, intelligent equipment, and sustainable agricultural development.

Established in 2013, the **Agricultural Waste Utilization Equipment Research Team** comprises 11 members. The team focuses on developing innovative technologies and intelligent equipment for agricultural waste treatment and resource recovery. Its mission is to promote green and low-carbon agriculture, improve rural environmental management, and support rural revitalization through technological innovation. By integrating scientific research with practical applications, the team contributes to more efficient, sustainable, and environmentally friendly agricultural production systems.











Part 2. Technology Overview

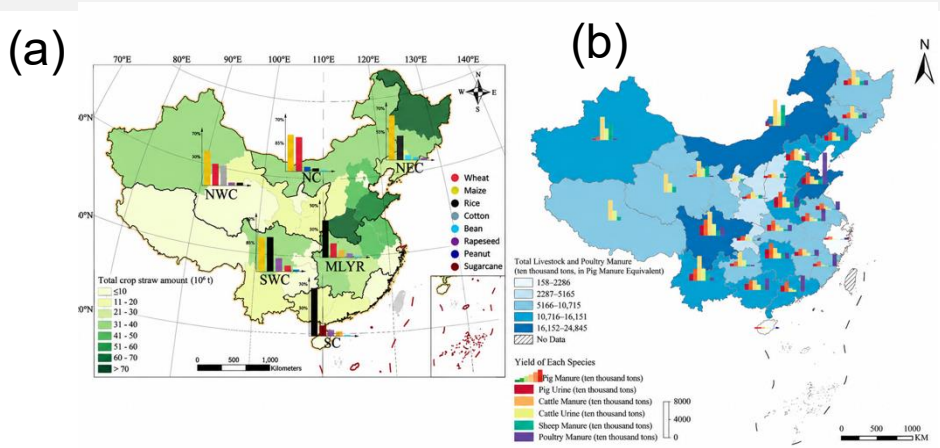
Why Do We Need Smarter Composting?

Challenges in Agricultural Organic Waste Management

- Large quantities of livestock manure and crop residues require efficient treatment and recycling.
- Conventional composting can involve greenhouse gas emissions, nutrient losses, high energy consumption, and substantial labor requirements.
- Sustainable solutions are needed to improve waste treatment efficiency while recovering valuable organic resources.

The shortcomings of traditional composting technologies

- High GHG and odor emissions
- Significant Carbon and Nitrogen losses
- High energy and labor requirements
- Limited composting efficiency



(a)Total crop residue production in six agricultural regions of China (Zhao et al., 2024) and (b) Livestock manure production in China's 31 Provinces (Ye et al., 2026)



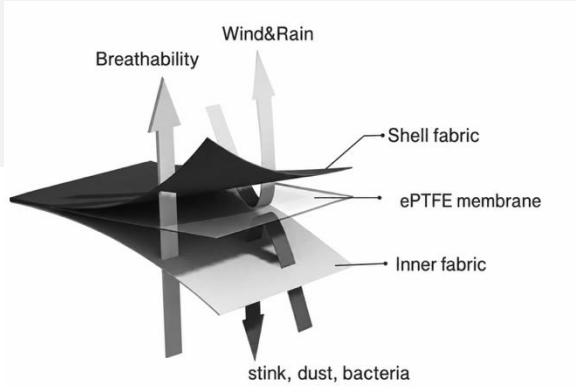


Part 2. Technology Overview

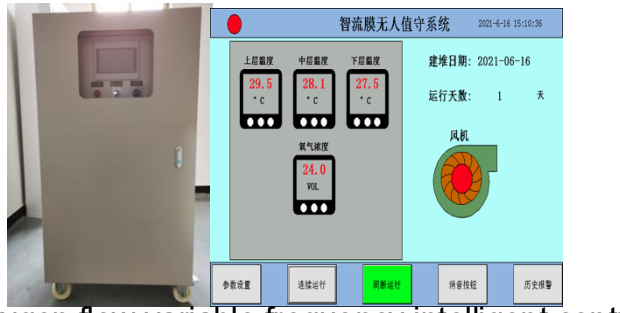
How Does Smart Membrane-Covered Composting Work?

An Integrated Aerobic Composting System

- **Selective Membrane:** A three-layer, semipermeable membrane helps control the composting environment and reduce pollutant emissions.
- **Forced Aeration:** A multi-channel aeration system regulates oxygen supply and improves fermentation conditions.
- **Intelligent Control:** Real-time monitoring of temperature, oxygen, and airflow enables adaptive process regulation



Schematic diagram of a three-layer semi-permeable membrane structure



Multi-channel oxygen flow variable frequency intelligent control syste



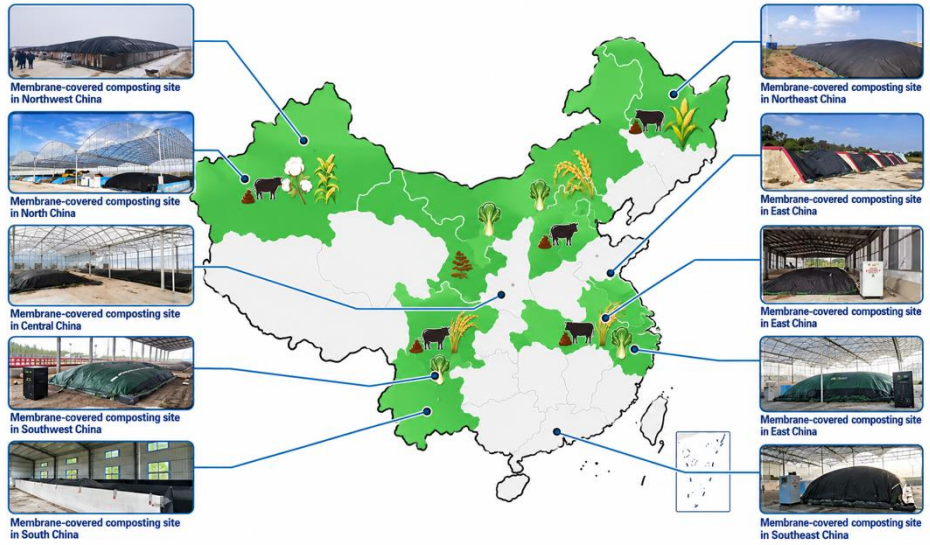
IoT-based Intelligent Control system

Part 3. Field Applications and Case Studies

Field Applications Across China

From Technology Development to Practical Implementation

- **16 provinces** covered by technology deployment
- **35 cities and counties** involved in reported applications
- **100+ equipment units** deployed
- **40+ composting projects** establish



Two Practical Deployment Models

Model 1. Decentralized Village-Based Composting

- 61 demonstration sites established
- Typical annual treatment: approximately 6,000 tonnes per site
- Organic fertilizer production: 2,500–3,000 tonnes/year
- Labor requirement: approximately 1 worker
- Operating cost: RMB 25–30/tonne

Model 2. Centralized Large-Scale Composting

- 12 demonstration sites established
- Annual treatment: over 30,000 t per site
- Organic fertilizer production: approximately 15,000 t/year
- Labor requirement: 3–5 workers
- Operating cost: RMB 20–25/tonne

Part 3. Field Applications and Case Studies

Adaptability Across Livestock Farming and Crop Production

Sheep Manure
Shiyan, Hubei Province



Cattle Manure
Qionglai, Sichuan Province



Pig Manure
Jiaxing, Zhejiang Province



Chicken Manure
Nanjing, Jiangsu Province



Crop residues
Wuxi, Jiangsu Province



Fruit and vegetable waste
Suqian, Jiangsu Province



Garden waste
Lishui, Jiangsu Province



Part 4. Benefits and Perspectives

Improved Emission Control and Energy Efficiency



41.3%
reduction in NH_3 emissions



30.7%
reduction in N_2O emissions



72.5%
reduction in CH_4 emissions



23.6%
reduction in electricity consumption

Key Features

- Intelligent aeration and process monitoring
- Reduced reliance on mechanical turning
- Modular equipment for different treatment scales

Environmental Benefits

- Reduced NH_3, CH_4, and N_2O emissions under evaluated experimental conditions
- Improved aeration efficiency and lower electricity demand
- Recovery of organic matter and nutrients from agricultural waste

Economic Benefits

- Village-based model: approximately RMB 25–30/tonne
- Centralized model: approximately RMB 20–25/tonne
- Relatively low labor requirements in the reported demonstration models

Agricultural Benefits

- Organic fertilizer production from locally available wastes
- Improved integration of crop production and livestock farming
- Support for local nutrient recycling and circular agriculture

THANK YOU

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