



GreenGas Composting for Sustainable Agriculture and Renewable Energy

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The rapid increase in organic waste generation from agriculture, households, and agro-industries has created serious environmental and energy-related challenges worldwide. GreenGas composting is an integrated waste management technology that combines anaerobic digestion and composting to convert biodegradable wastes into renewable energy and nutrient-rich organic manure. Agricultural residues, livestock manure, food waste, and agro-industrial by-products are utilized for biogas production and compost recovery. The produced biogas contains approximately 55–70% methane, which can be used for cooking, electricity generation, and heating applications. The digestate obtained after biogas production is further composted to produce high-quality organic fertilizer rich in essential nutrients and beneficial microorganisms. Studies have shown that integrated biogas-compost systems can reduce greenhouse gas emissions by nearly 40–60% while improving soil fertility and crop productivity. GreenGas composting supports sustainable agriculture through efficient nutrient recycling, reduced dependence on chemical fertilizers, and environmentally safe waste management. Therefore, GreenGas composting is considered a promising climate-smart technology for renewable energy generation and sustainable farming systems.

Keywords : GreenGas composting, Biogas, Renewable energy, Organic waste, Sustainable agriculture, Biomethane, Biofertilizer, Anaerobic digestion, Composting, Circular bioeconomy

Introduction

Organic waste accumulation has become a major global environmental concern due to increasing population growth, industrialization, and agricultural intensification. Large quantities of crop residues, animal manure, food waste, and agro-industrial wastes are generated every year, leading to pollution problems when improperly managed. Traditional disposal methods such as burning and landfilling contribute significantly to greenhouse gas emissions and environmental degradation. Sustainable waste management technologies are essential for addressing these challenges while improving agricultural productivity and energy security. GreenGas composting has emerged as an innovative approach that integrates biogas production and composting for efficient organic waste utilization. This technology converts biodegradable materials into renewable energy and nutrient-rich organic manure through biological processes. In GreenGas composting systems, organic wastes undergo anaerobic digestion in airtight conditions where microorganisms break down organic matter to produce methane-rich biogas. The remaining slurry or digestate is then composted aerobically to produce stabilized organic fertilizer. This dual-purpose system provides both renewable energy and high-quality compost, making it highly beneficial for sustainable agriculture. The use of GreenGas composting technology helps reduce dependence on chemical fertilizers and fossil fuels. It also improves soil health, nutrient recycling, and microbial activity while reducing environmental pollution. The technology supports climate-

smart agriculture by minimizing methane emissions from unmanaged wastes and promoting carbon sequestration in soils. Modern innovations such as microbial inoculants, IoT-based monitoring systems, temperature sensors, and AI-assisted process optimization are further improving the efficiency and commercial applicability of GreenGas composting systems. Due to its environmental, agricultural, and economic advantages, GreenGas composting is gaining increasing importance in sustainable farming and renewable energy sectors.

Principles of GreenGas Composting

GreenGas composting is based on the integration of anaerobic digestion and aerobic composting processes. In the first stage, biodegradable organic materials are decomposed by anaerobic microorganisms in the absence of oxygen. This process produces biogas containing methane and carbon dioxide. Methane acts as a renewable energy source suitable for cooking, heating, and electricity generation. The digestate obtained after biogas production still contains valuable nutrients and partially decomposed organic matter. In the second stage, this digestate undergoes aerobic composting in the presence of oxygen. Beneficial microorganisms stabilize the material and convert it into mature compost rich in humus and plant nutrients. The efficiency of GreenGas composting depends on factors such as temperature, moisture content, carbon-to-nitrogen ratio, pH, aeration, and microbial activity. Proper management of these factors enhances biogas yield and compost quality.

Feedstock Materials Used

Various organic wastes can be utilized in GreenGas composting systems. Common feedstock materials include:

Crop residues, Sugarcane trash, Rice straw, Food waste, Vegetable and fruit residues, Livestock manure, Poultry litter, Dairy waste, Agro-industrial by-products, Coir pith and press mud. These materials are rich in biodegradable organic matter suitable for microbial decomposition and nutrient recycling.

Process of GreenGas Composting

Collection and Segregation

Organic wastes are collected and separated from non-biodegradable materials such as plastics and metals to ensure efficient processing.

Size Reduction

Large waste materials are shredded into smaller particles to increase the surface area for microbial activity.

Anaerobic Digestion

The prepared waste is introduced into anaerobic digesters where microorganisms convert organic matter into methane-rich biogas under oxygen-free conditions.

Biogas Recovery

The generated biogas is collected and stored for energy applications such as cooking, electricity generation, and heating.

Composting of Digestate

The residual digestate is transferred to composting units where aerobic microorganisms stabilize the material into mature compost.

Compost Maturation

The compost is cured for several weeks until it becomes dark, odorless, and nutrient-rich organic manure.

Role in Sustainable Agriculture

GreenGas composting contributes significantly to sustainable agriculture by improving soil fertility and reducing environmental pollution. The compost produced enhances soil organic matter, water-holding capacity, nutrient availability, and microbial activity. It also reduces soil erosion and improves crop productivity. The use of organic compost minimizes dependence on synthetic fertilizers, thereby lowering production costs and reducing chemical contamination in soils and water bodies. Farmers can utilize renewable biogas energy for

farm operations, reducing fossil fuel consumption and energy expenses. GreenGas composting also promotes circular agriculture by recycling agricultural wastes into valuable resources. This integrated approach supports long-term soil health and sustainable crop production.

Renewable Energy Generation

Biogas produced through GreenGas composting serves as an important renewable energy source. The methane present in biogas can be used for:

Cooking fuel, Electricity generation, Water heating, Farm machinery operations, Industrial thermal applications. Biogas energy reduces dependence on conventional fossil fuels and contributes to energy security in rural areas. Biomethane generated from upgraded biogas can also be used as vehicle fuel.

Environmental Benefits

GreenGas composting offers numerous environmental advantages:

GreenGas composting provides significant environmental benefits by converting biodegradable wastes into useful products such as renewable energy and organic manure. The technology helps reduce greenhouse gas emissions by preventing the uncontrolled decomposition of organic waste in open dumping sites and landfills, where large amounts of methane are normally released into the atmosphere. By utilizing agricultural residues, food waste, livestock manure, and agro-industrial wastes efficiently, GreenGas composting minimizes environmental pollution and promotes sustainable waste management practices. The production of biogas reduces dependence on fossil fuels such as coal, LPG, and diesel, thereby lowering carbon emissions and contributing to climate change mitigation. In addition, the compost produced from digestate improves soil organic matter, enhances microbial activity, and increases soil carbon sequestration, which further supports environmental sustainability. GreenGas composting also prevents open burning of crop residues, reducing air pollution and protecting ecosystem health. Moreover, the recycling of nutrients through compost application decreases the excessive use of chemical fertilizers, minimizing soil and water contamination. Thus, GreenGas composting serves as an eco-friendly technology that supports cleaner energy production, efficient waste recycling, improved soil health, and long-term environmental conservation.

Future Prospects

Future developments in GreenGas composting focus on improving efficiency, automation, and commercialization. Advanced microbial inoculants, smart sensors, AI-based monitoring systems, and automated digesters are enhancing process performance. The integration of GreenGas technology with precision agriculture, smart farming, and climate-resilient agricultural practices is expected to expand its adoption globally. Increasing awareness about renewable energy and organic farming will further promote GreenGas composting as a sustainable solution for future agriculture.

Conclusion

GreenGas composting is an eco-friendly and sustainable technology that converts organic waste into renewable energy and nutrient-rich compost. The integration of anaerobic digestion and composting supports efficient waste management, renewable energy generation, and soil fertility improvement. This technology reduces environmental pollution, greenhouse gas emissions, and dependence on chemical fertilizers and fossil fuels. GreenGas composting also promotes circular bioeconomy practices by transforming agricultural and organic wastes into valuable resources. With growing emphasis on climate-smart agriculture and renewable energy, GreenGas composting has immense potential to contribute towards sustainable agricultural development and environmental conservation.

References

1. Food and Agriculture Organization (2019). Sustainable Biogas and Compost Production for Climate-Smart Agriculture. FAO Publications, Rome.
2. International Renewable Energy Agency (2020). Renewable Energy from Organic Waste: Biogas and Composting Technologies. IRENA Report.
3. United Nations Environment Programme (2021). Organic Waste Management and Circular Bioeconomy Approaches. UNEP Publications.
4. Karthikeyan, O. P., & Visvanathan, C. (2018). "Bioenergy Recovery and Compost Production from Organic Waste through Anaerobic Digestion." *Renewable Energy*, 122, 49–56.
5. Singh, J., & Kalamdhad, A. S. (2014). "Effects of Microbial Inoculants on Composting of Organic Fraction of Municipal Solid Waste." *Waste Management*, 34(11), 2039–2045.