Autonomous Device for Converting Food Waste into Fertilizer

M. Kannan[1]; S. Akash[2]; N. Mohan[3]; S. V. Sakthivel[4]

[1,2,3,4] Department of Mechanical Engineering,
KIT-Kalaignarkarunanidhi Institute of Technology, Coimbatore, Tamil Nadu, India-641402

Publication Date: 2025/11/08

Abstract: The study relies on the development of a device that helps in decomposition of wet waste such as food and more wastes like it. The prototype focuses on developing a device that converts food waste into fertilizer without any of the human intervention. Old traditional method depends on digging a larger pit in which all the wet waste is dumped and turned into a compost. Compost is a term that defines the process of converting the food waste which helps in turning the normal soil into a nutrient rich soil that enhances the vitamins and nutrients of an individual plant or tree grown on the soil. Fertilizer is a more relative term to compost but here the type of producing it and the utilization totally differs. A fertilizer helps in increasing the growth rate of a plant rapidly by acting as an additional source of nutrient. Also, the traditional method takes more than 30 to 90 days for completely converting the food waste into a useful compost. So, this device helps in converting the food waste into fertilizer faster than the traditional process and making it a more profitable product for each and every individual who use this device.

Keywords: *Decomposition, Wet Waste, Fertilizer, Human Intervention, Compost, Autonomous Device, Profitable Product.*

How to Cite: M. Kannan; S. Akash; N. Mohan; S. V. Sakthivel (2025) Autonomous Device for Converting Food Waste into Fertilizer. *International Journal of Innovative Science and Research Technology*, 10(11), 54-58. https://doi.org/10.38124/ijisrt/25nov087

I. INTRODUCTION

Food waste is one of the most dangerous environmental challenges of our time. Every day, households, restaurants, and food industries deliver huge amounts of edible and inedible food, most of which ends up in landfills. Here, we waste valuable resources and contribute to greenhouse gas emissions, especially methane. At the same time, the agricultural sector continues to rely heavily on chemical fertilizers, which can degrade soil health and harm ecosystems over time.

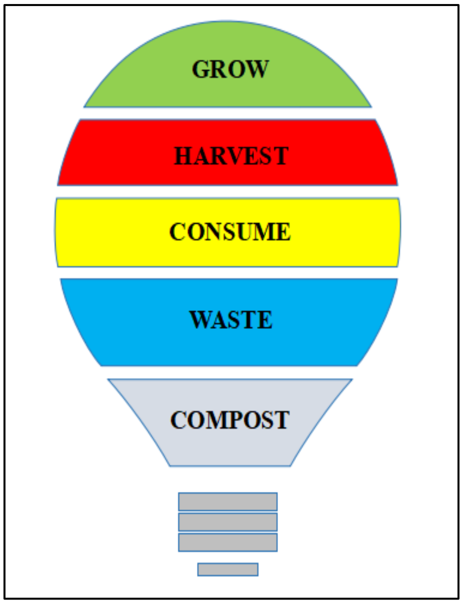

Fig 1: Traditional Method

ISSN No:-2456-2165 https://doi.org/10.38124/ijisrt/25nov087

The project "Autonomous Device For Converting Food Waste Into Fertilizer" explores a practical and carries out a eco-friendly solution that connects these two issues. The idea is simple transform waste into value added products, right from your place. By using automation and smart design, this device aims to make composting accessible, efficient, and nearly effortless for everyday users, whether in homes, small farms, or businesses.

This project focuses on how automation, sensor technology, and biological processes can be combined into a compact system that not only reduces the burden of food waste but also promotes sustainable agriculture. It also focuses on to reduce the human intervention for the decomposition of food waste. In this paper, we will be able to gather some knowledge about the demands and needs of the world for this kind of devices.

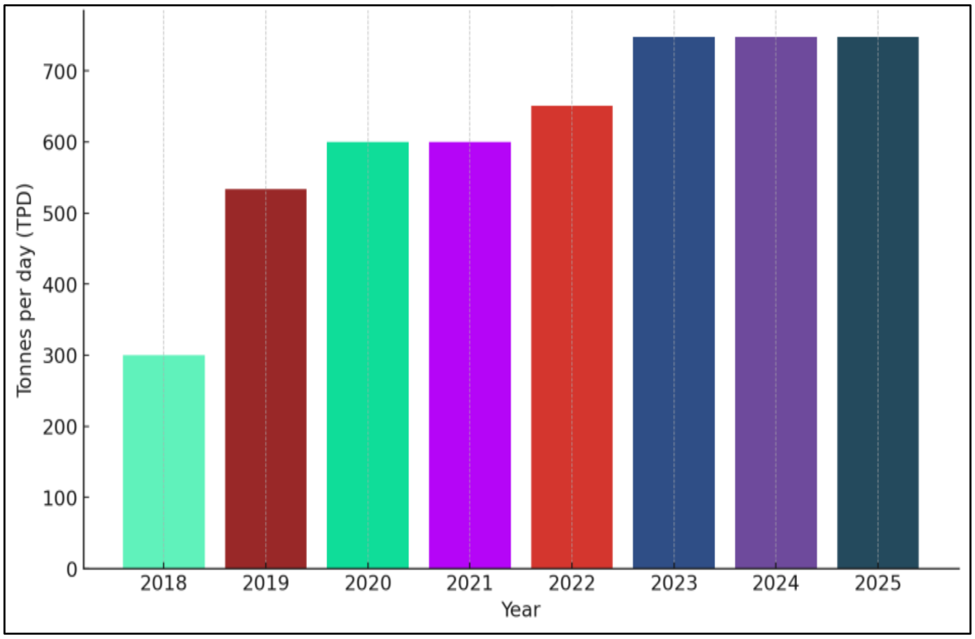

Fig 2: Wet Waste Produced (Per City)

II. MATERIALS

The several Materials used for fabricating this project are listed below:

- Stainless steel box or chamber
- Motor
- Blades
- Heating coils
- Microprocessors
- Micro-controllers
- Solenoid Valve
- Sensors

Additional Compost used to convert food waste into fertlizer are:

- Shredded paper
- Lactic Acid
- Sodium Bicarbonate ($NaHCO_3$)
- Coir pith (Coconut Husk Fiber)

III. WORKING

The autonomous device for converting food waste into fertilizer operates on the principle of controlled aerobic composting, wherein organic waste is decomposed by microorganisms under regulated environmental conditions. The stainless steel chamber serves as the main composting unit, providing a corrosion-resistant and insulated environment to retain heat and minimize odor leakage. Food waste deposited in the chamber is heated using heating coils to maintain thermophilic temperatures (50–65 °C), thereby accelerating microbial activity and eliminating harmful pathogens and helping in removing the moisture and making it as dry waste. These dry wastes are then shredded and mixed by blades driven by a motor, which increases the surface area of the material and ensures uniform oxygen distribution. Sensors embedded within the chamber continuously monitor temperature, moisture, and gas concentrations. Based on these inputs, a micro-controller governs the operation of the motor, heating elements, and a solenoid valve that regulates airflow and exhausts gases to maintain optimal composting conditions. The microprocessor, working in coordination with the micro-controller, is responsible for higher-level control, data logging, and user interface functions, enabling semi-smart operation. By automating mixing, aeration, heating, and

ISSN No:-2456-2165 https://doi.org/10.38124/ijisrt/25nov087

moisture regulation, the device reduces human intervention and prevents the development of anaerobic conditions that cause foul odors. As to speed up the process additional materials are used to control the odor produced, to increase it's freshness. As a result, the overall time taken is reduced to one to two hours, the system stabilizes the organic matter and produces nutrient-rich compost that can be directly used as fertilizer. The working of this device integrates biological decomposition with mechanical and electronic control to ensure an efficient, eco-friendly, and an autonomous way to convert waste into fertilizer within a short-span.

IV. METHODOLOGY

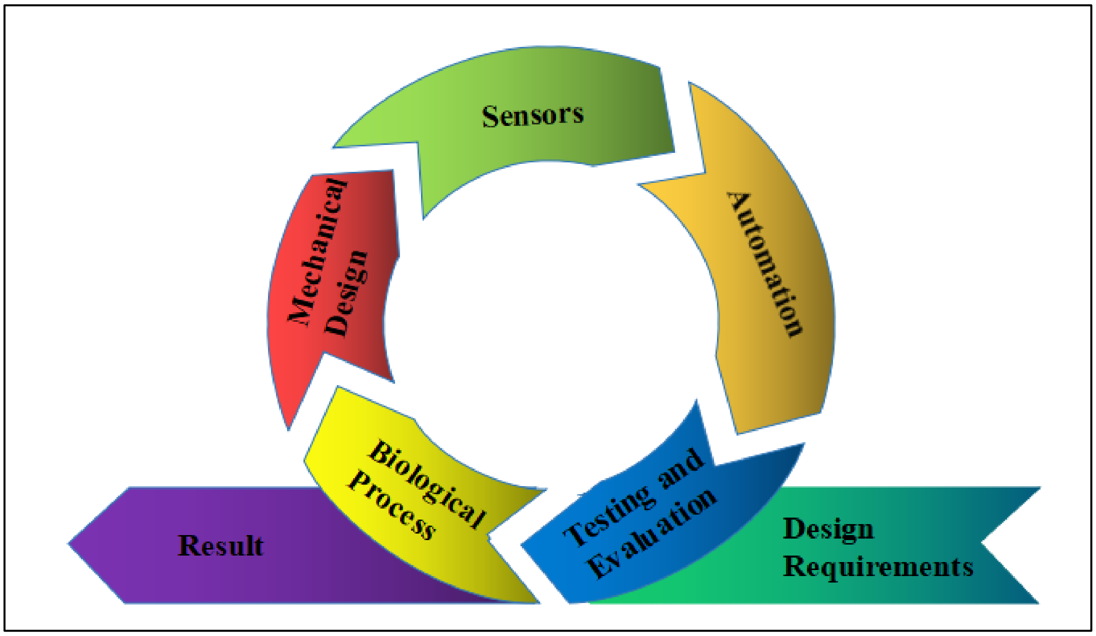

Fig 3: Methodology

- *Identification of Design Requirements*

The first step involves defining the system specifications such as the amount of food waste to be processed, the desired processing time for ferilizer production, the choice of power supply, and essential safety features. These requirements form the foundation for selecting materials, components, and overall system design.

- *Selection of Biological Process*

Aerobic composting is chosen as the core biological process because it relies on oxygen-dependent microorganisms that efficiently decompose organic matter into nutrient-rich compost while minimizing foul odors and harmful by-products with addition to shredded paper, lactic acid and sodium bi-carbonate to maximize the speed of the conversion process.

- *Mechanical Design*

The waste chamber is designed using stainless steel for durability and hygiene, while mixing blades and an aeration system are incorporated to ensure proper shredding, oxygen flow, and uniform decomposition. This design enhances efficiency and prevents the formation of anaerobic conditions.

- *Integration of Sensors*

Temperature, humidity, and moisture sensors are installed to monitor composting conditions in real time. These sensors provide critical feedback to maintain the required environment for microbial activity and compost quality.

- *Automation with Micro-controllers*

A micro-controller such as Arduino or Raspberry Pi is programmed to control the motor, blades, heating coils, and solenoid valve based on sensor inputs. This automation ensures minimal human intervention and consistent process regulation.

- *Testing and Evaluation*

The final step involves testing the device with actual food waste to measure composting efficiency, quality of the final fertilizer, and overall system performance. Adjustments are made based on the results to improve reliability and scalability.

V. RESULT AND EXPECTED OUTCOMES

The autonomous device for converting food waste into fertilizer is developed to demonstrate efficient and sustainable waste management through controlled aerobic composting. The system ensures that food waste is shredded, mixed, aerated, and maintained at optimum conditions of temperature and moisture, resulting in faster decomposition compared to traditional composting methods. Initial trials are anticipated to show that the device can reduce the volume of food waste by up to 60–70% within one to two hours, producing stable, nutrient-rich compost suitable for agricultural or gardening applications.

The integration of sensors and micro-controller based automation is to provide consistent monitoring and control of critical parameters, ensuring high-quality fertilizer with minimal human intervention. Also, the stainless steel chamber design and odor control mechanisms are utilized to make the system hygienic, safe, and user-friendly. The expected outcome is not only an effective reduction in food waste but also the generation of value-added product such as fertilizer, promoting environmental sustainability and supporting economy practices of an individual user. This project aims to offer a scalable and practical solution for households, institutions, and communities to manage food waste autonomously.

VI. DISCUSSION

The developed device effectively addresses major challenges in food waste management, including odor control, space limitations, and high labor requirements. By operating autonomously, it reduces dependency on manual effort and specialized knowledge of composting techniques, thereby making it suitable not only for households but also for community level applications such as residential complexes, hostels, and institutions. The system contributes to sustainability goals by supporting circular economy practices, where organic waste is transformed into nutrient-rich fertilizer rather than being sent to landfills. Its community scale design ensures higher waste handling capacity while maintaining efficiency and hygiene standards. In addition, the modular nature of the device allows adaptability to different scales of use and waste generation patterns. Future enhancements could focus on integrating renewable energy sources to further minimize environmental impact and incorporating IoT-based monitoring systems to enable remote supervision and data-driven optimization of composting performance.

VII. CONCLUSION

The autonomous device for converting food waste into fertilizer demonstrates an effective, sustainable, and user-friendly solution for organic waste management. By integrating mechanical, thermal, and electronic systems with sensor-based automation, the device accelerates aerobic composting while maintaining optimal temperature, moisture, and aeration conditions. The resulting nutrient-rich compost provides a valuable resource for agriculture and gardening, contributing to environmental sustainability and circular economy practices. Designed for community-level use, the system reduces labor requirements, mitigates odor issues, and efficiently handles larger volumes of food waste. Overall, this project highlights the feasibility and practicality of autonomous waste-to-fertilizer conversion, offering a scalable approach to reducing landfill contributions and promoting eco-friendly resource recovery.

REFERENCES

[1]. Waste-Derived Fertilizers: Conversion Technologies, Circular Bioeconomy Perspectives and Agronomic Value by Dolores Hidalgo, Jesús M. Martín-Marroquín, Francisco Corona and Francisco Verdugo https://doi.org/10.3390/agronomy15092167
[2]. Bioeconomy-Based Approaches for the Microbial Valorization of Citrus Processing Waste by Ioannis Stavrakakis, Paraschos Melidis, Nektarios Kavroulakis, Michael Goliomytis, Panagiotis Simitzis and Spyridon Ntougias https://doi.org/10.3390/microorganisms13081891
[3]. Green Catalysis: The Role of Medicinal Plants as Food Waste Decomposition Enhancers/Accelerators by Liziwe L. Mugivhisa and Madira C. Manganyi https://doi.org/10.3390/life15040552
[4]. Biodigesters for Sustainable Food Waste Management by Jay N. Meegoda, Charmi Chande and Ishani Bakshi https://doi.org/10.3390/ijerph22030382
[5]. Comparative Analysis of Horticultural and Animal Waste Compost: Physicochemical Properties and Impact on Plant Growth by Miguel Ángel Domene, Felipe Gómez, Rocío Soria, Ana B. Villafuerte, Isabel Miralles and Raúl Ortega https://doi.org/10.3390/agronomy15030516
[6]. Bioconversion of Poultry Litter into Insect Meal and Organic Frasstilizer Using Black Soldier Fly Larvae as a Circular Economy Model for the Poultry Industry: A Review by Anand Raj Kumar Kullan, Arumuganainar Suresh, Hong Lim Choi, Elke Gabriel Neumann and Fatima Hassan https://doi.org/10.3390/insects16010012
[7]. Study of the Process of Calcium Sulfide-Based Luminophore Formation from Phosphogypsum by Marina A. Egorova, Daniil I. Monastyrskiy, Oleg A. Medennikov, Nina P. Shabelskaya, Zlatislava D. Khliyan, Vera A. Ulyanova, Sergey I. Sulima and Elena V. Sulima https://doi.org/10.3390/molecules29225486
[8]. Classical Batch Distillation of Anaerobic Digestate to Isolate Ammonium Bicarbonate: Membrane Not Necessary! by Alejandro Moure Abelenda and Jonas Baltrusaitis https://doi.org/10.3390/bioengineering11111152

[9]. Combination between Composting and Vermicomposting of OFMSW: A Sicilian Case Study by Enrico Licitra, Maria Gabriella Giustra, Gaetano Di Bella and Antonio Messineo https://doi.org/10.3390/environments11080183
[10]. Solar-Dried Biofertilizers from Marine Waste: Enhancing the Circular Economy by Beatriz Castillo-Téllez, Margarita Castillo Téllez, Martha Fabiola Martín del Campo, Edgar Oswaldo Zamora González, Alfredo Domínguez Niño and Gerardo Alberto Mejía-Pérez https://doi.org/10.3390/su16156593
[11]. Investigating the Impacts of Wastewaters on Lettuce (*Lactuca sativa*) Seed Germination and Growth by Liam P. Reynolds, Vitória F. C. Leme and Paul C. Davidson https://doi.org/10.3390/agriculture14040608
[12]. Biomass Waste Conversion Technologies and Its Application for Sustainable Environmental Development—A Review by Ghenwa Kataya, David Cornu, Mikhael Bechelany, Akram Hijazi and May Issa https://doi.org/10.3390/agronomy13112833
[13]. Edible Insects: A New Sustainable Nutritional Resource Worth Promoting by Mengjiao Li,Chengjuan Mao,Xin Li,Lei Jiang, Wen Zhang, Mengying Li, Huixue Liu, Yaowei Fang, Shu Liu, Guang Yang and Xiaoyue Hou https://doi.org/10.3390/foods12224073
[14]. Bioponics—An Organic Closed-Loop Soilless Cultivation System: Yields and Characteristics Compared to Hydroponics and Soil Cultivation by Florentina Gartmann, Julian Hügly, Nikita Krähenbühl, Nadine Brinkmann, Zala Schmautz, Theo H. M. Smits and Ranka Junge https://doi.org/10.3390/agronomy13061436
[15]. Agent-Based Simulation and Micro Supply Chain of the Food–Energy–Water Nexus for Collaborating Urban Farms and the Incorporation of a Community Microgrid Based on Renewable Energy by Marwen Elkamel, Luis Rabelo and Alfonso T. Sarmiento https://doi.org/10.3390/en16062614
[16]. A Review of Organic Waste Treatment Using Black Soldier Fly (*Hermetia illucens*) by Nur Fardilla Amrul, Irfana Kabir Ahmad, Noor Ezlin Ahmad Basri, Fatihah Suja, Nurul Ain Abdul Jalil and Nur Asyiqin Azman https://doi.org/10.3390/su14084565
[17]. Biotransformation of Citrus Waste-II: Bio-Sorbent Materials for Removal of Dyes, Heavy Metals and Toxic Chemicals from Polluted Water by Neelima Mahato, Pooja Agarwal, Debananda Mohapatra, Mukty Sinha, Archana Dhyani, Brajesh Pathak, Manwendra K. Tripathi and Subramania Angaiah https://doi.org/10.3390/pr9091544
[18]. Effect of Mineral and Organic Fertilization on *desi* and *kabuli* Chickpea (*Cicer arietinum* L.): Plant Growth and Production, Hydration Properties, Bioactive Compounds, and Antioxidant Activity by Antonella Pasqualone, Carmine Summo, Davide De Angelis, Giovanna Cucci, Davide Caranfa and Giovanni Lacolla https://doi.org/10.3390/plants10071441
[19]. A New Method to Recycle Dairy Waste for the Nutrition of Wheat Plants by Saif Alharbi, Ali Majrashi, Adel M. Ghoneim, Esmat F. Ali, Abdullah S. Modahish, Fahmy A. S. Hassan and Mamdouh A. Eissa https://doi.org/10.3390/agronomy11050840
[20]. Conversion of Spent Coffee and Donuts by Black Soldier Fly (*Hermetia illucens*) Larvae into Potential Resources for Animal and Plant Farming by Hayden Fischer, Nicholas Romano and Amit Kumar Sinha https://doi.org/10.3390/insects12040332
[21]. Utilizing Anaerobic Digestates as Nutrient Solutions in Hydroponic Production Systems by Karl-Johan Bergstrand, Håkan Asp and Malin Hultberg https://doi.org/10.3390/su122310076