

RESEARCH ARTICLE

ASSESSMENT OF HOUSEHOLD KITCHEN WASTE COMPOSTING AND QUALITY ANALYSIS FOR SUSTAINABLE FOOD SYSTEMS IN AKKARAIPATTU MUNICIPALITY, SRI LANKA

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ABSTRACT

Food is a fundamental human necessity, yet food waste remains a significant challenge in developing countries, impacting all stages of waste management from collection to disposal. Factors contributing to food waste include food production processes, local lifestyles, and industrialization. Composting is recognized as an effective method to valorize food waste. In Akkaraipattu Municipality, Sri Lanka, kitchen waste composting is implemented by the Municipal Council through the Alim Nagar composting plant. This study aimed to enhance household kitchen waste management to support resilient food systems aligned with sustainable development goals. A questionnaire survey was conducted alongside a comprehensive analysis of compost quality produced across four production cycles annually. Physical properties assessed included moisture content, bulk density, compost color, and sand content. Chemical analyses involved pH, electrical conductivity, and nutrient profiling of nitrogen (N), phosphorus (P), potassium (K), calcium (Ca), magnesium (Mg), sodium (Na), and organic carbon content. Biological properties evaluated comprised bacterial, fungal, and nematode populations. Results demonstrated consistent quality attributes in the compost produced, providing insights and recommendations for optimizing kitchen waste management and strengthening local sustainable food systems.

KEYWORDS

Food waste, Composting, Kitchen waste management, Sustainable development, Compost quality

1. INTRODUCTION

Food waste has been acknowledged as an important aspect of human activities that cause environmental problems, especially in developing countries, where it creates a negative effect every stage of waste management, collection, disposal, and so on (Morone et al., 2019). It is necessary to take all the stakeholders' participation in the long-term solutions development to the problem (Thi et al., 2015). In developed countries, food waste is mainly produced by households; for instance, in the UK, around 8 million tonnes of food, which is approximately 12% of all food and drink consumed, and 30% of the total household waste are thrown away every year (Bond et al., 2013). The measures taken to reduce food waste via awareness campaigns targeted at consumers show their promise but have to cope with the challenge that people form habits of throwing food away day in and day out, which are hard to break (Kim et al., 2020). Additionally, a considerable number of consumers do not recognize how much food waste they produce, and this does not only lower their willingness to get exposed to the waste reduction education but also brings to light the necessity of conducting the interventions at life stages that are conducive to behavior changes, such as during the times of university attendance or retirement (Verma et al., 2020).

The United Nations Sustainable Development Goals (SDGs), which advocate for the changing of the agricultural and food systems to end hunger, achieve food security, and improve nutrition by 2030, consider sustainable food systems to be the backbone of their actions (Varzakas and

Smaoui, 2024). The production of these goals obliges the world food systems to be more productive, inclusive, environmentally friendly, and resilient. Among others, the SDGs of ending hunger (SDG 2), promoting sustainable agriculture (SDG 2), fostering economic growth (SDG 8), and climate change mitigation (SDG 13) are directly to the food waste and losses reduction. This, in turn, highlights the global imperative to improve food waste management to support sustainable development (Mustafa et al., 2021).

Even though various researches have recommended making residents more cognizant of the recycling methods that really work, there is still no shortage of practical solutions that will ease and sustain such behaviors right at the doorstep. Most of the families do not have access to easy-to-use devices or systems that can carry out the processing of food waste in an effective manner. For this reason, it is very important to match the recycling systems of the household resources with the environmental awareness of the inhabitants so as to not just spread knowledge but also take action together in a very efficient manner. Composting is one of the oldest and the best green waste management techniques that offer huge savings in controlling the environmental impacts of waste disposal.

The data from 2025 shows that global food waste is still a major problem, especially in the regions of South Asia, where the problem is large due to inefficient supply chains, lack of cold storage, and the way consumers behave (Parfitt et al., 2010). For instance, in 2024, India's food wastage was about 78 million tons, and the main reasons for this were the systemic

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inefficiencies. The above data highlight the urgent need for composting and regular household food waste management practices becoming part of the broader sustainability frameworks (Sarangi et al., 2024).

Kitchen waste disposal in the Akkaraipattu Municipality, Sri Lanka, has been affected by population growth, urbanization, increased economic activity, and lack of awareness regarding kitchen waste disposal. The recycling program that the Akkaraipattu Municipal Council has done with the Alim Nagar composting plant is the most practical and effective way of dealing with food waste at the local level. This is because they collect kitchen waste from the households, compost it, and then sell it as nutrient-rich compost. This study establishes the socio-environmental importance of food waste management, links it to sustainable development objectives, frames the local context of Akkaraipattu Municipality, and highlights the global scale of the problem with recent data, thereby setting a comprehensive foundation for the study.

2. METHODS AND METHODOLOGY

2.1 Study Area

The research was carried out in the Akkaraipattu Municipality area and at the Alim Nagar Composting facility in Sri Lanka. Akkaraipattu is situated at around Latitude 7.3240° North and Longitude 81.9167° East, with a height of approximately 5 meters above the Mean Sea Level. The eastern area of the country is where it is located and it has a tropical climate with clearly defined dry and wet seasons. The region has an annual rainfall of around 1,200 mm, while the temperature and humidity range from 27 to 32°C and 70% to 85%, respectively. Sample collections were from all the areas and it has been indicated in figure 1.

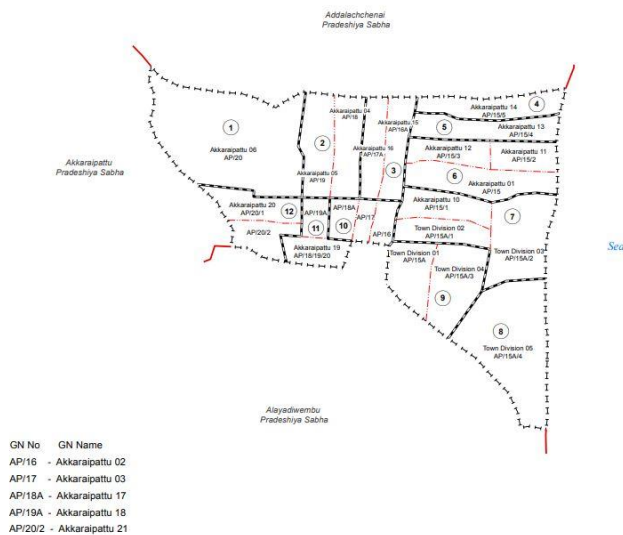


Figure 1: Sample collection sites at Akkaraipattu Municipality region and Alim Nagar

2.2 Sample and Data collection

The study utilized a mixed-methods approach, employing both qualitative and quantitative techniques, to cover all angles of the municipal solid waste management in the Municipality of Akkaraipattu that also included the Alim Nagar Composting Plant. Key informants such as the Municipal Council Commissioner, Engineer, and Technical In-charge of Solid Waste Management were interviewed semi-structuredly, collection supervisors, and management assistants at waste sites were also included in the observations that were done directly in the field to see the processes and infrastructure of the waste management facilities. Polling surveys quantified the households waste generation, disposal habits, and demographics (e.g., annual population growth rate, density in persons/km², total municipal extent, household numbers, GN divisions, daily waste volumes, composition, and collection percentages), while secondary data from official Solid Waste Management Unit reports provided the necessary context for comprehensive insights and validation through triangulation.

2.3 Data Analysis

Alim Nagar Composting Plant's compost was subjected to a quality assessment which included evaluating its physical, chemical and biological properties; meanwhile, the analysis was performed four times a year to be in line with the plant's quarterly compost production cycle. The physical

properties that were studied include moisture content, amount of sand, color of compost and bulk density which are important signs of compost's maturity and usability. Among the chemical traits, pH and conductivity were the main factors used to measure how stable the compost was and how available the nutrients were. Nutritional analysis was carried out to find out the percentage of the major macronutrients nitrogen (N), phosphorus (P) and potassium (K), as well as calcium (Ca), magnesium (Mg) and the organic carbon content which was an indicator of the fertilizing potential of the compost. The focus of the analysis of biological properties was the detection of beneficial microorganisms like bacteria and fungi along with the nematodes which support the compost's biological activity and the health of the soil. This thorough examination secured that the compost was up to the quality standards for agricultural application.

3. RESULTS

The Akkaraipattu Municipality area covers a variety of agricultural activities and waste management practices, with the Alim Nagar Composting plant being the main actor in the district's organic waste management and the source of organic fertilizers for local farms. The location and climate of Akkaraipattu town favor the composting process due to the mildness and steady nature of its humidity and temperature.

Table 1: Physical compost property of moisture percentage, color, bulk density and sand content

Sample	Moisture %	Color	Bulk Density	Sand content
K1	21.56%	Black	788.75kgm ⁻³	0.72
K2	24.38%	Black	788.75kgm ⁻³	0.69
K3	25.66%	Black	784.24Kgm ⁻³	0.68
K4	23.04%	Very Dark	794.98kgm ⁻³	0.74
K5	23.52%	Greyish Brown	797.26kgm ⁻³	0.81
K6	24.1%	Very Dark	794.98kgm ⁻³	0.79
K7	20.1%	Greyish Brown	792.7kgm ⁻³	1.16
K8	18.9%	Very Dark	794.988kgm ⁻³	0.89
K9	19.2%	Greyish Brown	780.00kgm ⁻³	1.19
K10	21.96%	Black	792.71kgm ⁻³	1.26
K11	17.57%	Black	794.988kgm ⁻³	1.27
K12	23.62%	Black	778.928kgm ⁻³	1.28
K13	19.9%	Black	792.71kgm ⁻³	1.17
K14	22.77%	Black	792.71kgm ⁻³	1.21
K15	19.66%	Black	792.71kgm ⁻³	1.08

Table 1 shows the physical characteristics of the compost samples such as moisture content, color, bulk density, and sand fractions. The moisture

content ranges between 17.57% and 25.66%, while the color of the compost varies from black through greyish brown and very dark, which are signs of the different stages of decay. Bulk density numbers are recorded around 778.9 to 797.3 kg/m³, which is a reflection of the density of compost. Sand content is between 0.68 and 1.28, which is the proportion of inorganic material in the sample.

Table 2: Chemical compost property of pH and Electric conductivity

Sample	pH	Electric conductivity
K1	4.457	7.465
K2	4.457	6.435
K3	5.540	6.498
K4	6.726	6.470
K5	6.925	6.498
K6	6.966	6.258
K7	7.074	6.591
K8	7.284	6.600
K9	7.326	6.500
K10	7.332	7.429
K11	7.372	7.637
K12	7.376	7.352
K13	7.429	7.540
K14	7.382	7.150
K15	7.423	6.168

Table 2 presents the chemical properties with pH values that range from very acidic (around 4.457) in some samples through neutral (close to 7.0) to slightly alkaline (up to 7.4) in others, confirming a matured compost. Electrical conductivity (EC) readings vary from about 6.168 to 7.637 dS/m, thereby signaling different concentrations of salts and nutrients associated with the respective composts in terms of their stability and fertility.

Table 3: Analysis of compost - Nutrient Properties

Parameters	Analysis 1
Total Nitrogen(N)(%)	1.1
Phosphorus (P)(%)	1.1
Potassium(K)(%)	2.3
Magnesium (Mg) (%)	0.9
Calcium (Ca)(%)	3.8
Sodium (Na)(%)	0.4
Organic Carbon (%)	17.9

Table 3 contains the nutrient analysis of a representative compost sample. Major macronutrients found include nitrogen (1.1%), phosphorus (1.1%), potassium (2.3%), calcium (3.8%), magnesium (0.9%), and sodium (0.4%). The compost also has a very high organic carbon content of 17.9%,

which demonstrates its fertility as well as its contribution to the soil organic matter.

Table 4: Analysis of compost -Biological properties

Biological Properties	Count
Total Plate Count of Bacteria (CFU/ml)	22.7x 10 ⁹
Fungal Content (CFU/ml)	7.1x10 ⁷
Nematode Count (Live Nematodes)	Present

Table 4 summarizes the biological properties, showing a high total bacterial plate count of 22.7 × 10⁹ CFU/ml and fungal content at 7.1 × 10⁷ CFU/ml, indicating rich microbial activity essential for organic matter decomposition. The presence of live nematodes further denotes active biological processes and soil health benefits imparted by the compost.

4. DISCUSSION

The physical traits of the compost from Alim Nagar (Table 1) not only matched but were also in line with the international standards like CCME Category A guidelines (moisture 20-50%) and ECN-QAS (optimal 20-40%). The moisture content measured 17.57-25.66% which was within the range of mature, stable moisture content hence, being perfect for unrestricted agricultural use. The bulk density (778.9-797.3 kg/m³) also perfectly matched the global benchmarks (500-900 kg/m³) given by Woods End Research and the US Composting Council which also indicated the very good handling and soil integration (Brinton, 2000). The low sand content of 0.68-1.28% was compliant with the German and CCME limits (<5% >5mm fraction; ≤1 piece >25mm per 500ml). The color change from black to greyish brown confirmed the composting per the TMECC sensory indicators (Nolan et al., 2022).

The acidity of the compost was reduced from 4.457 (early acidic samples) to 7.3-7.4 (neutral) which corresponds to the ECN-QAS (6.5-8.5), CCME (5.5-8.5), and PAS 100 standards. This was due to the organic acids being stabilized in high-quality compost (Tognetti et al., 2007). The electrical conductivity (6.168-7.637 dS/m) is above the low salinity ideals (<4 dS/m ECN growing media) but is still below the phytotoxic thresholds (>10 dS/m CCME/US EPA Class A). The conductivity levels were similar to MSW composts in developing scenarios and safe per Ag Index guidelines when associated with low Na.

The nutrient profiles (Table 3) surpassed the standards set by CCME, PAS 100, and EU: N (1.1%) and P (1.1%) were more than the usual range of 0.5-1.5%; K (2.3%) was providing a great supply; Ca (3.8%), and Mg (0.9%) contributed to the structure/chlorophyll as per global norms; organic C (17.9%) >12-15% was guaranteeing humus benefits; Na (0.4%) <1% was the safe limit (CCME, 2005). Thus, this compost of Alim Nagar would be considered superior to the average MSW products throughout the world.

Microbial activity (Table 4) excels: bacteria (22.7 × 10⁹ CFU/ml) and fungi (7.1 × 10⁷ CFU/ml) far exceed ECN bioactive thresholds (>10⁶ CFU/g) and CCME stability (respiration <400 mg O₂/kg VS/h equivalent), indicating pathogen suppression and decomposition efficacy (ECN, 2019). Live nematodes reflect balanced ecology per TMECC, affirming soil health potential.

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