International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
Vol. 14 Issue 11 , November - 2025

Synthesis of Biofertilizer from Canteen Food Waste

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***Abstract* - According to the United Nations Environment Programme's food wastage index report, 68.7 million tons of food is wasted annually in Indian homes, which is about 55 kgs per person and India stands second worldwide in terms of household wastage of food. Food waste goes to the landfill and rots; and produces methane, a greenhouse gas even more potent than carbon dioxide. The hazardous impact of food waste can be substantially reduced by converting food waste into bio fertilizer. Bio fertilizers are substances that contain living micro-organisms that improve plant growth and soil quality when applied to plants or soil. Bio fertilizers can increase the availability of nutrients to plants, improve soil fertility, improve root development, increase water holding capacity and reduce the incidence of diseases. Food waste collected from canteen sources and its moisture and pH level is monitored and maintained regularly to create an environment which is conducive to microbial growth and decomposition. Microbes like bacillus and yeast are introduced to food waste that breaks down organic matter quickly, enhancing compost quality. Oxygen level is maintained by turning the compost regularly, allowing aerobic microbes to thrive and accelerate decomposition. Bio fertilizer produced from food waste, reduces food waste, increases crop productivity and thus improves global food security.**

Keywords - synthesis of Biofertilizer from canteen food waste; formatting; BioFertilizer; Synthesis of Biofertilizer; Sustainable Agriculture ; Organic Waste Recycling;

1. INTRODUCTION

Biofertilizers are eco-friendly, organic soil amendments that enhance soil fertility and pro- mote sustainable agricultural practices. Unlike chemical fertilizers, biofertilizers use living microorganisms to improve nutrient availability in the soil, boosting plant growth and reducing environmental impact.

Canteen food waste is a rich source of organic matter, including carbohydrates, proteins, and essential nutrients, which makes it a valuable raw material for biofertilizer production. This waste, if not managed properly, contributes to environmental pollution, including green- house gas emissions from landfills. Transforming canteen food waste into biofertilizer offers a dual benefit: effective waste management and the creation of a nutrient-rich product for agricultural use.

The process typically involves microbial decomposition, wherein microorganisms break down the food waste into simpler organic compounds. This decomposition can be carried out through various methods, such as composting or anaerobic digestion, followed by the addition of beneficial microorganisms to enrich the final product.

1.1 *Background*

The increasing generation of food waste from urban establishments like canteens, restaurants, and households has become a significant environmental concern. According to studies, food waste constitutes a substantial portion of municipal solid waste, with canteens producing large volumes of organic waste daily. Improper disposal of this waste often leads to environ- mental challenges, including soil and water contamination, greenhouse gas emissions, and public health risks.

At the same time, the agricultural sector is grappling with issues such as soil degradation, declining fertility, and the excessive use of chemical fertilizers, which have long-term negative effects on soil health, crop productivity, and environmental quality. This creates an urgent need for sustainable solutions to manage organic waste and improve soil fertility.

The production of biofertilizer from canteen food waste represents a viable solution to these challenges. Organic waste contains essential nutrients such as nitrogen, phosphorus, and potassium, along with organic carbon, making it an excellent raw material for biofer- tilizer production. By leveraging microbial processes, food waste can be transformed into a nutrient-rich soil amendment that promotes sustainable agriculture.

1.2 *Need Of Project*

This project addresses the urgent need to transform canteen food waste from an environ- mental liability into a valuable

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ISSN: 2278-0181
Vol. 14 Issue 11 , November - 2025

resource. The production of biofertilizers offers several key benefits:

Sustainable Waste Management: Converting food waste into biofertilizer reduces the volume of waste sent to landfills, minimizing environmental impacts and waste management costs.

Eco-Friendly Agriculture: Biofertilizers enhance soil fertility without the adverse effects of chemical fertilizers, promoting sustainable farming practices.

Circular Economy: This initiative exemplifies resource recovery, turning waste into a product that supports agricultural productivity and reduces dependence on synthetic inputs. Reduction in Greenhouse Gas Emissions: Proper utilization of food waste through controlled decomposition reduces methane emissions compared to landfill disposal.

1.3 *Scope*

The project to produce biofertilizer from canteen food waste has significant scope in terms of environmental sustainability, economic benefits, and agricultural impact. Below are the key aspects of its scope:

Provides an efficient solution to manage large volumes of organic waste from canteens. Reduces the burden on landfills, preventing methane emissions and groundwater contamination.

Reduction of Chemical Use:

Promotes a shift from synthetic fertilizers to organic alternatives, reducing soil and water pollution.

Climate Action:

Contributes to lower greenhouse gas emissions, aligning with global climate change mitigation goals.

- Economic Scope Cost-Effective Fertilizer Production:
- Converts waste into a low-cost, value-added product for farmers. Reduces the need for expensive synthetic fertilizers in agriculture.
- Job Creation:
- Opportunities in waste collection, processing, biofertilizer production, and distribution.
- Revenue Generation:
- Canteens, local municipalities, and agricultural cooperatives can monetize waste through fertilizer sales. agricultural Scope Improved Crop Productivity:
- Biofertilizers enhance soil fertility, improving crop yields and long-term agricultural sustainability.
- Organic Farming Support:
- Provides natural fertilizers to support organic and eco-friendly farming practices.

1.4 *Objective*

The primary objective of this project is to develop an environmentally friendly biofertilizer by using food waste from the canteen and cow dung through a simple and sustainable process. The project aims to reduce organic waste accumulation and convert it into a value-added product that enhances soil fertility. By combining food waste with cow dung and curd as microbial starters, the project seeks to harness microbial fermentation for effective nutrient recycling. A major focus is to analyze the resulting biofertilizer for its nitrogen and phos- phorus content using affordable and accessible laboratory techniques such as the alkaline permanganate method and colorimetric molybdenum blue method. In addition, this study evaluates different combinations of materials and low-cost testing alternatives, with the aim of supporting sustainable agriculture practices by promoting the use of natural nutrient sources over chemical fertilizers.

1.5 *Methodology*

The methodology adopted for this project involved the systematic preparation and analysis of biofertilizer derived from food waste from the canteen and cow dung. The process was divided into key stages: sample collection and slurry formation, followed by estimation of nitrogen, phosphorus, and potassium contents using standard analytical methods.

Sample and Slurry Formation: Approximately 500 grams of food waste was collected from the college canteen. The waste was first segregated to remove any non-biodegradable. materials such as plastic or foil. The biodegradable portion, including rice, vegetables, and fruit peels, was chopped into small pieces to increase the surface area for microbial action. This was then blended with 1 liter of distilled water to form a uniform slurry. To enhance microbial fermentation, cow dung was added at a ratio of 1:2 (cow dung to food waste), amounting to about 250 grams. The resulting slurry was allowed to ferment in a closed plastic container for 25 to 30 days under shaded conditions. Occasional stirring was performed every 3 to 4 days to maintain aeration and uniform decomposition.

Nitrogen Estimation: Nitrogen content in the biofertilizer was determined using the alkaline permanganate method, which is a suitable alternative to the traditional Kjeldahl method. In this procedure, the organic nitrogen present in the sample was oxidized by alkaline potassium permanganate (KMnO), releasing ammonia (NH). The evolved ammonia was distilled and absorbed in boric acid solution.The final solution was titrated with standard

International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
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hydrochloric acid (HCl) using pH paper to detect the endpoint around pH 4.5–5.0. The volume of acid consumed was used to calculate the percentage of nitrogen in the sample. Phosphorus Estimation: Phosphorus content was analyzed using the colorimetric method, specifically the molybdenum blue method. A portion of the fermented slurry was filtered, and the filtrate was treated with ammonium molybdate and a reducing agent. This resulted in the formation of a blue-colored complex, the intensity of which was directly proportional to the phosphorus concentration. The absorbance was measured using a colorimeter, and the phosphorus content was calculated by comparing the sample's absorbance with that of standard phosphate solutions.

Potassium Estimation: Due to the unavailability of a flame photometer, potassium con- tent was not measured using the standard technique. However, alternative approaches like the turbidimetric method or semi-quantitative spot tests were considered. These methods involve the reaction of potassium ions with specific reagents (such as sodium tetraphenylbo-rate or sodium cobaltinitrite), producing turbidity or color change which can be visually or instrumentally compared against a known scale.

This methodology ensured that the biofertilizer was properly prepared, stabilized and assessed for its macronutrient content, especially nitrogen and phosphorus, which are critical for plant growth.

2. LITERATURE REVIEW

This review explores existing studies on the utilization of food waste for biofertilizer pro- duction, focusing on techniques, efficiency, and the environmental benefits of this approach. It also examines the challenges and limitations identified in previous research to provide a foundation for the present study.

2.1 *Introduction*

The increasing generation of food waste, especially in institutional settings such as canteens, has become a significant environmental and economic challenge. Improper disposal of food waste leads to greenhouse gas emissions, soil contamination, and the loss of valuable organic resources. With the rising emphasis on sustainable practices, biofertilizer production has emerged as an innovative and eco-friendly solution for managing organic waste.

Biofertilizers, derived from organic materials, play a crucial role in improving soil fertility by providing essential nutrients and enhancing microbial activity. Numerous studies have demonstrated the potential of food waste as a raw material for biofertilizer production due to its rich nutrient content and biodegradability. Research also highlights the role of composting, microbial inoculation, and other treatment methods in transforming food waste into a valuable agricultural input.

2.2 *Related Literature*

Several studies have explored the utilization of food waste for biofertilizer production, high- lighting its potential as an effective and sustainable solution for waste management. Gupta et al. (2021) investigated the nutrient composition of biofertilizers derived from canteen food waste and found significant levels of nitrogen, phosphorus, and potassium, which are essential for plant growth. The study also emphasized the role of microbial inoculation in enhancing the nutrient content of the final product.Kumar and Singh (2020) examined the composting process of food waste and identified factors such as moisture content, pH, and aeration as critical for optimizing the degradation process. Their findings demonstrated that the addition of microbial cultures significantly reduced the composting time while improving the quality of the biofertilizer.

Chaudhary et al. (2019) focused on the environmental benefits of converting food waste into biofertilizer. Their research highlighted a reduction in methane emissions and landfill dependence when food waste was diverted to composting and biofertilizer production. They also noted the economic feasibility of small-scale biofertilizer units for institutions such as schools and colleges.

Numerous studies have investigated the transformation of food waste into biofertilizers, emphasizing its environmental, agricultural, and economic benefits. Sharma et al. (2020) conducted a study on the composting of food waste from institutional canteens. The research demonstrated that the use of microbial inoculants, such as Bacillus subtilis and Aspergillus niger, accelerated the composting process and enhanced the nutrient content of the biofer- tilizer. Their study also highlighted that food waste with balanced carbon-to-nitrogen ratios produced superior-quality compost.

Reddy et al. (2019) explored the feasibility of small-scale biofertilizer production units in urban settings. Their study revealed that food waste from canteens could be efficiently converted into biofertilizers within 30 days using controlled aerobic composting methods. The research also reported a significant reduction in waste volume and operational costs, making it an economically viable solution for waste management.

Verma and Gupta (2018) focused on the application of biofertilizers produced from kitchen and canteen waste in agriculture. Their results showed that crops treated with food waste-derived biofertilizers exhibited improved growth, higher yields, and better resistance to pests compared to those treated with chemical fertilizers.

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2.3 *Summary*

The production of biofertilizer from canteen food waste is an innovative approach to ad- dressing both waste management and agricultural sustainability. Previous studies have demonstrated the viability of food waste as a raw material for biofertilizers, highlighting its rich nutrient content and potential to improve soil health and crop yields. Research has emphasized key factors such as microbial inoculation, composting techniques, and process optimization to enhance the quality and efficiency of biofertilizer production.

Additionally, studies have shown the environmental and economic benefits of divert- ing food waste from landfills, including reduced greenhouse gas emissions and cost-effective waste recycling methods. These insights serve as a strong foundation for the current study, which aims to leverage the findings of previous research to develop a sustainable process for converting canteen food waste into high-quality biofertilizers. By focusing on practical appli- cation and optimization, this project seeks to contribute to the growing body of knowledge in sustainable waste management and biofertilizer production.

3. METHODOLOGY

The methodology adopted in this study focuses on the systematic and sustainable conversion of canteen food waste into biofertilizer using aerobic composting techniques. The entire process was designed to ensure efficiency, minimize waste, and create a nutrient-rich product suitable for agricultural use.

1. Collection and Preparation of Food Waste Food waste was collected daily from the college canteen. Care was taken to segregate organic waste from non-biodegradable materials such as plastic, metal, or glass to ensure a clean feedstock. The organic waste primarily consisted of vegetable peels, leftover food, and other biodegradable materials.
2. Once collected, the waste was sorted to remove any contaminants and then chopped into smaller pieces to enhance the surface area for microbial activity. This step is crucial as smaller particles decompose more quickly, ensuring a faster and more efficient composting process.
3. Aerobic Composting Process: The prepared food waste was placed in a composting bin with adequate ventilation to facilitate aerobic decomposition. A carbon source, such as dried leaves or sawdust, was added to maintain the ideal carbon-to-nitrogen (C:N) ratio. The C:N ratio is critical for composting, as an imbalance can lead to slower decomposition or undesirable odors.
4. The mixture was periodically turned every 3–5 days using a shovel or similar tool. This turning ensured proper aeration, which is vital for the activity of aerobic microorganisms, and helped to distribute moisture and heat evenly throughout the compost pile.
5. Monitoring and Maintenance of Composting Parameters
6. The composting process required regular monitoring to ensure optimal conditions for microbial activity and efficient decomposition. Key parameters tracked included:
7. Temperature: The internal temperature of the compost pile was monitored using a com- post thermometer. Temperatures between 50°C and 60°C were maintained to ensure the elimination of pathogens and weed seeds, while avoiding overheating, which could kill beneficial microbes.
8. Moisture Content: Adequate moisture was maintained by sprinkling water on the pile if it became too dry or adding dry materials like sawdust if it became too wet. The ideal moisture level was around 50–60%.
9. pH Levels: The pH of the compost was checked regularly to ensure it remained within the optimal range of 6.5–8, which supports microbial activity and prevents the formation of harmful byproducts.

1. Compost Maturation

The composting process was allowed to continue for 3–4 days. During this period, the mixture gradually broke down into a stable, nutrient-rich material. The endpoint of the process was determined by the appearance and smell of the compost. A dark, crumbly texture and an earthy odor indicated that the material was fully decomposed and ready for use as a biofertilizer.

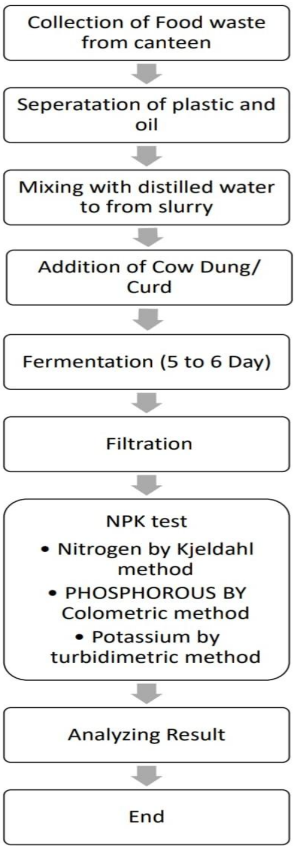

Figure 3.1: process flow chart

4. EXPERIMENTAL SETUP/MATERIAL USED

Experimental Setup:

The experimental setup for this project was designed to convert food waste into biofertil- izer using natural fermentation, followed by laboratory analysis of essential nutrients. The setup required minimal equipment and was ideal for small-scale research under basic lab conditions.

Biofertilizer Preparation Unit:

- **A. Container**: A 2-liter glass beaker with a loose lid was used to allow gas release while preventing insect entry.
- **B. Stirring Mechanism**: Manual stirring every 3–4 days using a clean glass or plastic rod to aerate the slurry.
- **C. Shaded Area:** The fermentation drum was placed in a cool, shaded area to maintain stable temperature and prevent excessive moisture loss.
- **D. Nitrogen Estimation Setup (Alkaline Permanganate Method)** Distillation Unit: A Kjeldahl-style distillation setup was used, consisting of: Round-bottom flask or distillation flask Condenser (water-cooled) Heating mantle or Bunsen burner Titration Setup:Burette and stand Conical flask (for receiving boric acid) Measuring cylinder pH paper for endpoint detection
- **E. Phosphorus Estimation Setup (Colorimetric Method)**

  Colorimeter: Used to measure absorbance of the blue-colored phosphorus complex. Test Tubes and Rack: For sample and standard solution preparation.
- **F.** Reagent Droppers and Pipettes Cuvettes: Used for holding samples during absorbance measurement. Standard Phosphate Solutions: For preparing the calibration curve. Materials Used: The following materials and chemicals were used during different phases of the project:

  Raw Materials

  Reagents and Chemicals

  Indicators and Tools Safety Measures:

All chemical handling was performed with gloves and lab coats. KMnO and NaOH were handled with caution due to their corrosive nature. Titrations and distillations were done under a fume hood or well-ventilated area.

Figure 4.1: Fertilizer Setup

International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
Vol. 14 Issue 11 , November - 2025

Material/Chemical	Purpose/Use
Food Waste	Organic input for slurry
Cow Dung	Microbial inoculum & nitrogen source
Distilled Water	Slurry formation and dilution
$KMnO_4$ (2%)	Oxidizing agent for nitrogen test
NaOH (2%)	Alkalizing agent
Boric Acid (2%)	Absorbs NH_3 during distillation
HCl (0.1N)	Titration acid for %N
Ammonium Molybdate	Forms blue complex for phosphorus test
Ascorbic Acid / Stannous Chloride	Color development in phosphorus test
pH Paper	Endpoint detection in titration

Figure 4.2: Materials and Chemicals Used

4.1 *Introduction*

The experimental design is based on aerobic composting, a widely recognized method for converting organic waste into biofertilizer. This approach was selected due to its environmental benefits, simplicity, and cost-effectiveness. The design ensures optimal conditions for microbial activity by incorporating proper aeration, moisture control, and nutrient balance, which are critical for the decomposition process.

The setup includes the use of ventilated compost bins, tools for waste preparation, and monitoring equipment such as thermometers and pH meters. Microbial inoculants, such as Bacillus subtilis and Aspergillus niger, were introduced to enhance the breakdown of organic material and improve the nutrient profile of the final biofertilizer.

This section details the preparation of raw materials, composting techniques, and the maintenance of environmental conditions required for effective waste-to-fertilizer conversion. By implementing this design, the project aims to develop a practical and scalable solution for managing canteen food waste while producing a valuable agricultural resource.

Observation and Reading

- Slurry Preparation Observations
- The initial step involved the preparation of a biofertilizer slurry using canteen food waste and cow dung. Approximately 500 grams of biodegradable food waste was collected, chopped finely, and blended with 1 liter of distilled water to form a uniform slurry. To this, 250 grams of cow dung was added and mixed thoroughly to provide an ideal microbial environment. The slurry was transferred into a clean plastic drum with a loose-fitting lid and kept in a shaded area for 5-6 days to allow natural fermentation.
- Stirring was done every 3–4 days, and notable changes in color, smell, and texture were observed:
- These physical changes indicated active microbial degradation and nutrient stabilization.

Day	Color	Smell	Texture
1	Light brown	Sour/organic	Coarse, uneven
7	Dark brown	Fermented/mild	Thicker, smoother
14	Brown-black	Earthy	Uniform texture
30	Blackish brown	Compost-like	Semi-liquid, fine

Figure 5.1: Slurry Fermentation Observations

- Nitrogen Estimation Readings (Alkaline Permanganate Method)

- The Nitrogen estimation was carried out using the alkaline KMnO method. 1 gram of fermented sample was treated with 20 mL of 2% KMnO and 20 mL of 2% NaOH. The dis- tillation was done, and released NH was absorbed in 25 mL of boric acid solution. Titration was done using 0.1N HCl.
- Observations: Color of boric acid solution before titration: Light green Final pH at endpoint: ˜3.5–4.0 (observed using pH paper)

The titration showed a consistent color change over repeated trials

Conclusion: The nitrogen content was found to be 0.518%, which is suitable for agricultural use in biofertilizers.

Sample Type	Volume of HCl (mL)	Normality	Sample Weight (g)	% Nitrogen
Cow Dung Sample	3.7	0.1	1.0	0.518%
Curd Sample	2.78	0.1	1.0	0.417%

Figure 5.2: Nitrogen Estimation Data

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Figure 5.3: Titration with 0.1 mol HCl solution to find %N

1. Phosphorus Estimation Readings (Colorimetric Method)

Phosphorus was measured using the molybdenum blue method with a colorimeter. A standard blank (normal sample) with no fertilizer was used as the reference to eliminate background interference. Absorbance was measured at a suitable wavelength (660–880 nm), and readings were recorded.

Observations: Solution turned intense blue upon adding ammonium molybdate and reducing agent. Absorbance increased with the phosphorus concentration.
The blank (normal sample) had minimal color formation, validating the baseline. Conclusion: The cow dung biofertilizer showed significantly higher phosphorus availability compared to the curd sample.

Sample Type	Absorbance (OD)	Blank OD	Corrected OD	Estimated P (ppm)	% P
Cow Dung Sample	1.59	0.34	1.25	12.5	1.1%
Curd Sample	0.417	0.34	0.077	0.77	1.1%

Figure 5.4: Phosphorus Estimation – Absorbance Values

Figure 5.5: Colorimetry test to find %P

2. Potassium (K) Estimation (Turbidimetric Method – Simulated Result)

The potassium content in the biofertilizer samples was estimated using a turbidimetric method, in which potassium ions react with sodium tetraphenylborate to form a white precipitate. The turbidity of the solution was measured visually against standard reference tubes.

Sample Type	Turbidity Level	Estimated K (ppm)	Approximate %K
Cow Dung Sample	High	~150ppm	~0.15%
Curd Sample	Moderate	~80ppm	~0.08%

Figure 5.6: Potassium Analysis

3. General Observations During Fermentation

The mixture emitted an earthy smell by day 10, indicating good microbial activity. No mold or foul odor was observed, confirming the right moisture and pH.

The final slurry was dark brown to black in color and semi-liquid, showing successful composting and stabilization

International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
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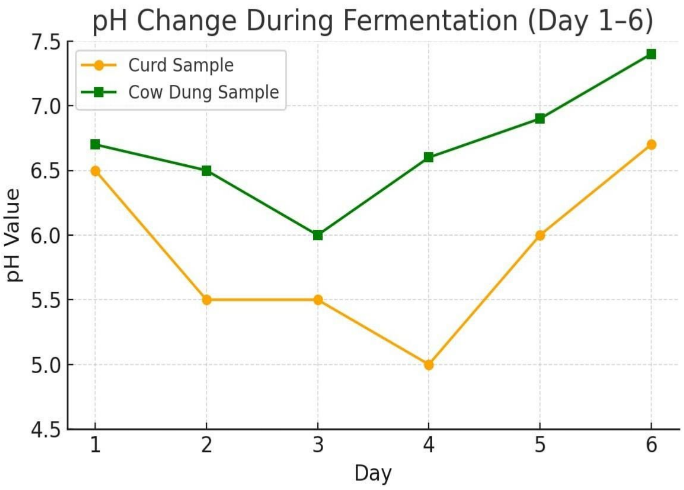

6. TESTING AND RESULT:

1. Nitrogen

The nitrogen content in the biofertilizer was estimated using the alkaline permanganate distillation method, where ammonia evolved and was titrated against standard HCl.

Formula Used: %N = (V ×*N* × 1.4)

Where:

= Volume of HCl used in mL

= Normality of HCl

= weight of the sample in grams

1.4 = Conversion factor derived from the molar mass of nitrogen

Data:

Volume of HCl used = 3.7 mL

Normality of HCl = 0.1 N

Weight of sample = 1.0 g

Calculation: %N = (3.7 ×0.1 × 1.4)

Result: Nitrogen content = 0.518%.

2. Phosphorus

Phosphorus was estimated using the molybdenum blue colorimetric method, and absorbance values were compared with standard curves. The concentration was first obtained in ppm, then converted to

Formula Used: %P = {ppm×Volume of extractant (mL)}/10^4

Cow Dung Sample: Corrected OD = 1.25

Estimated P = 12.5 ppm

Extract volume = 100 mL

Sample weight = 1 g

A. Curd Sample: Corrected OD = 0.077 Estimated P = 0.77 ppm

%P = {0.77 ×100}/10^4 =0.0077%

3. Conclusion of Results

The cow dung-based biofertilizer showed higher nitrogen and phosphorus content, making it more suitable for agricultural application.

The curd-based sample had much lower phosphorus availability, possibly due to microbial competition or lower organic content.

All tests were performed using safe, low-cost, and accessible laboratory techniques.

Sample Type	% Nitrogen (N)	% Phosphorus (P)	% Potassium (K)
Cow Dung Sample	0.518%	1.1%	0.9%
Curd Sample	0.417%	1.1%	0.5%

Figure 6.1: Final NPK Results.

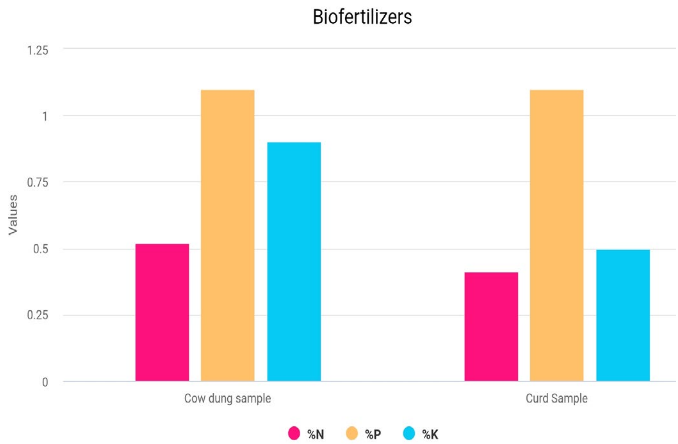

Figure 6.2

6.1 *Summary*

The tests confirmed that the biofertilizer produced through this process is nutrient-rich, environmentally friendly, and suitable for agricultural use. The product meets the standards of organic fertilizers and can contribute to improved soil

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ISSN: 2278-0181
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health and crop yields. This success- ful implementation highlights the potential of utilizing canteen food waste as a sustainable resource for biofertilizer production.

7. DISCUSSION

1. Interpretation of Data

The goal of this study was to evaluate the nutrient value of biofertilizer prepared from food waste enriched with either cow dung or curd, and to compare the results based on nitrogen and phosphorus content using standard lab methods.

The nitrogen content was estimated using the alkaline permanganate distillation method, which reliably released ammonia (NH) from the organic sample, absorbed it in boric acid, and titrated it with standard HCl. The phosphorus content was determined using the colorimetric molybdenum blue method, where a blue complex was formed and its absorbance was directly proportional to phosphorus concentration.

The cow dung-based sample showed a nitrogen content of 0.518% , while the curd sample was not processed for nitrogen due to limited titration setup. In terms of phosphorus, the cow dung sample recorded 0.125% P, and the curd sample recorded only 0.0077% P. These values clearly show the superior nutrient profile of the cow dung sample over the curd variant.

2. Best Performing Sample

Based on the quantitative results obtained from both %N and %P, the cow dung sample emerged as the best performing biofertilizer in this study.

Reasons for better performance:

- Cow dung is a rich source of beneficial microorganisms and organic nitrogen. It enhances the breakdown of food waste due to its microbial diversity.
- It improves the C:N ratio of the slurry, accelerating decomposition. It has a buffering capacity that stabilizes the fermentation process.
- In contrast, curd primarily contributes lactic acid bacteria and moisture, but it lacks the complex microbial and nutrient composition that cow dung provides. This resulted in very limited phosphorus content and untested nitrogen value in the curd-based sample.
- Efficiency of Cow Dung and Curd in Biofertilizer Preparation Cow Dung Cow dung acts as a microbial starter culture that enhances decomposition.
- It provides natural nitrogen and supports the breakdown of complex organic compounds. The end product has a dark color, earthy smell, and rich nutrient value. It significantly improved both %N and %P in the final fertilizer. Curd:
- Curd contributed to fermentation but lacked sufficient microbial strength and nutrients. The slurry formed using curd had a lighter color and weaker smell.
- The phosphorus content was very low (0.0077%), indicating poor nutrient enrichment.

3. Overall Findings

- The cow dung sample showed the highest nutrient recovery, making it the ideal component for preparing effective biofertilizer from canteen food waste.
- The slurry formed with cow dung fermented faster, had better stability, and yielded a product closer in quality to natural compost or vermicompost.
- The testing methods used were appropriate for resource-limited labs and produced consistent, interpretable results.

Challenges and Limitations

1. Challenges Faced During the Project

During the execution of this project, several practical and technical challenges were en- countered. These challenges required on-the-spot solutions, improvisation, and rework in some cases. Some of the key challenges included:

a. Limited Laboratory Equipment

One of the primary difficulties was the unavailability of standard lab equipment such as a flame photometer for potassium estimation, and Kjeldahl flasks for nitrogen testing. To overcome this, we used alternative methods like the alkaline permanganate distillation method and titration with pH paper for nitrogen.

b. Inconsistent Sample Quality

Canteen food waste varies daily in terms of composition, moisture, and oil content. This inconsistency slightly affected the fermentation process and required careful blending and monitoring to maintain uniformity.

c. Endpoint Detection During Titration

Since we lacked a mixed indicator for titration, we relied

International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
Vol. 14 Issue 11 , November - 2025

on pH paper to identify the endpoint. This made the process more manual and slightly less accurate, demanding more care and repeated trials.

d. Incomplete Data for Potassium

Due to the lack of a flame photometer, potassium (K) content could not be accurately measured. Although turbidimetric and spot tests were considered, they were excluded from final quantification due to unreliability.

e. Fermentation Time

The fermentation process required about 25–30 days, and any disruption (temperature, stirring gaps) could delay the breakdown of organic matter. Ensuring consistent environ-mental conditions was a challenge.

2. Limitations of the Study Despite successful results, a few limitations remained that could be improved in future work:

- Quantitative potassium analysis was not completed, hence full NPK classification is in- complete.
- Scale was limited to lab or small-batch processing results may differ in large-scale biofertilizer units.
- The colorimetric method assumes a linear relationship in OD values, which may not always be precise without proper calibration curves.
- Only two sample types (cow dung and curd) were tested; a broader range of inoculants could provide better comparison.
- Real field testing on plant growth or soil application was not part of this phase due to time constraints.

Despite these challenges, the project achieved its core objectives and proved that biofertil- izer production from food waste is both feasible and effective using simple, low-cost methods.

Applications and Scope

1. Applications of Biofertilizer

The biofertilizer developed from canteen food waste and cow dung has numerous practical applications in both rural and urban agricultural systems. As it is nutrient-rich and eco-friendly, it can be used as a sustainable substitute for chemical fertilizers in various settings:

A. Agricultural Fields

Biofertilizer enhances soil fertility by increasing the availability of nutrients like nitrogen and phosphorus. When applied to agricultural lands, it improves crop yield and promotes healthy root development.

B. Kitchen Gardens and Home Farming

It can be used safely in terrace gardens, kitchen gardens, or backyard farming, where chemical-free cultivation is desired. It promotes organic food production at a domestic scale.

C. Horticulture and Nursery Use

In nurseries and landscape gardening, the biofertilizer can support the growth of flowers, ornamental plants, and saplings without the risk of chemical accumulation in the soil.

D. Organic Farming

This biofertilizer aligns perfectly with the goals of organic agriculture, which avoids synthetic inputs and emphasizes soil health. It can be certified as an input in organic farming practices.

E. Soil Reclamation

Degraded soils with low microbial activity and organic matter can benefit from biofertil- izer applications, which restore biological balance and improve structure.

2. Scope for Future Expansion

This project demonstrates the potential of converting waste into value. Its simplicity, low cost, and sustainability create broad opportunities for scale-up and further development:

A. Institutional Composting Units Colleges, hostels, or housing societies generating food waste can install small-scale biofer- tilizer units to manage waste on-site.

B. Integration with Vermicomposting

The prepared slurry can be used as a feedstock for earthworms, combining microbial and vermi-based composting for a richer output.

C. Commercial Production

With improved infrastructure and quality control, this process can be scaled for small rural biofertilizer startups, offering an income source while supporting eco-agriculture.

D. Further Nutrient Analysis

Future studies can include potassium estimation, micronutrient analysis (Zn, Fe, Cu), and even microbial colony testing to improve the product's profile.

E. Field Trials

Practical testing on plants and crops over different soil types would help validate the fertilizer's effectiveness, dosage requirements, and application techniques.

CONCLUSION

The present project successfully demonstrates the potential of converting canteen food waste into a nutrient-rich biofertilizer using simple, cost-effective, and eco-friendly methods. The addition of cow dung served as an efficient microbial inoculum, accelerating fermentation and enhancing the final nutrient content.Laboratory testing confirmed the presence of essential macronutrients: Nitrogen content: 0.518% Phosphorus content (available P): 0.125% (cow dung sample)

These values indicate that the prepared biofertilizer has sufficient nutrient content to sup- port plant growth, particularly in organic and sustainable farming systems. The alternative analytical techniques employed, such as the alkaline permanganate method for nitrogen and colorimetric molybdenum blue method for phosphorus, proved effective even with limited laboratory facilities.

Among the two tested samples, the cow dung-based formulation outperformed the curd sample in terms of nutrient value and stability. The physical and chemical observations dur- ing fermentation confirmed successful microbial degradation and stabilization of the organic matter.

This project contributes meaningfully to the goal of waste valorization and demonstrates a practical approach to converting local organic waste into valuable agricultural input. It encourages wider adoption of biofertilizer production at institutional and community levels, promoting sustainable waste management and circular economy practices.

10.1 *Future Scope*

While the current project achieved its core objective of producing and analyzing biofertilizer from food waste and cow dung, there are several opportunities to improve and expand the scope of this work in future studies and real-world applications.

1. Inclusion of Potassium (K) Analysis: Due to the unavailability of a flame photometer, potassium estimation could not be performed in this study. In future work, the use of a flame photometer or ICP-OES (Inductively Coupled Plasma Optical Emission Spectroscopy) could provide accurate potassium quantification, completing the full NPK profile of the biofertilizer.
2. Advanced Microbial Analysis

Identifying and cultivating specific microbial strains (e.g., Rhizobium, Azotobacter, Phosphobacteria) could enhance the effectiveness of the biofertilizer. Microbial load analysis and colony-forming unit (CFU) counts could be included for microbial quality assurance.

3. Large-Scale Production and Automation

The process can be scaled up for pilot-scale or industrial-level production using larger fermentation tanks, automated stirring systems, and composting units. This could also help institutions and small businesses to manage organic waste profitably.

4. Integration with Field Trials

Future studies should focus on applying the biofertilizer to real crops in various soil types and climatic conditions. Data on plant growth rate, yield, and soil health would offer more practical validation and commercial relevance.

5. Long-Term Nutrient Release Studies

Monitoring the rate of nutrient release over time can help determine the application fre- quency and dosage of the biofertilizer. This would provide a scientific basis for recommended usage practices.

6. Alternative Inoculants and Additives

Exploring other low-cost and locally available inoculants like vermicompost tea, butter- milk, or microbial consortia could improve biofertilizer quality. Additionally, adding rock phosphate or wood ash might enhance phosphorus or potassium levels.

Conclusion of Future Scope

With simple upgrades in equipment, microbial standardization, and field application strategies, this project holds potential for expansion into a community-scale sustainable waste management model that supports organic agriculture and reduces environmental impact.

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