

TOPIC NAME

PLASTIC EATING ENZYMES

NAME

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Can you imagine how our environment would look if plastic never degraded?

Abstract

Plastics, especially PET (polyethylene terephthalate), are widely used in bottles, packaging, and containers, but they persist in nature for hundreds of years, leading to soil and water pollution. In our daily lives, we generate large amounts of kitchen waste and plastic waste simultaneously. While kitchen waste is biodegradable, plastics are not — but recent discoveries of plastic-eating enzymes offer hope for solving this global issue.

In this project, I aim to study the degradation of plastic using kitchen waste such as vegetable and fruit peels, which may naturally harbor microorganisms capable of producing plastic-degrading enzymes like PETase and MHETase. These enzymes can break down PET plastic into simpler compounds such as terephthalic acid (TPA) and ethylene glycol (EG), which can be reused or safely decomposed by nature. The experiment involves exposing small pieces of PET plastic to mixtures of kitchen waste under controlled conditions to observe any visible or measurable degradation.

The principle of this project is based on biodegradation — a natural process where microbes convert complex materials into simpler substances. The presence of organic acids and enzymes in fruit and vegetable peels may accelerate this breakdown. Observations will be made over a period of time to check for changes in plastic texture, weight, and clarity.

Through this study, I hope to demonstrate that ordinary kitchen waste can be a low-cost, eco-friendly source for enzyme production and plastic degradation. This project not only promotes biotechnological innovation but also supports sustainable waste management practices. The findings

may help in reducing household plastic pollution and inspire future research into enzyme-based recycling technologies.

INTRODUCTION

Plastic pollution has become one of the most serious environmental challenges of our time. Every household produces large amounts of kitchen waste every day, which includes both organic residues such as fruit and vegetable peels and non-biodegradable plastic materials. While organic waste decomposes naturally, plastics, especially polyethylene terephthalate (PET), persist in the environment for centuries, releasing harmful chemicals and affecting ecosystems. Finding an eco-friendly and cost-effective way to degrade plastic waste has therefore become a global necessity.

Recent scientific discoveries have identified certain microorganisms that can produce plastic-degrading enzymes, such as PETase and MHETase. These enzymes have the remarkable ability to break down PET plastics into simpler, harmless components like terephthalic acid (TPA) and ethylene glycol (EG), which can either be safely absorbed by nature or reused in the manufacturing process. Such a biological approach offers a sustainable alternative to traditional plastic disposal methods like burning or landfilling.

How Kitchen Waste Can Help

Kitchen waste contains a rich mixture of nutrients, moisture, and organic compounds that provide an ideal environment for microbial growth. Many fruit and vegetable peels—such as those from citrus fruits, tomatoes, and bananas—contain natural enzymes and acids that can enhance the activity of plastic-degrading bacteria. By combining kitchen waste with plastic samples, we can observe the natural degradation process and study how microorganisms adapt to break down plastics in mixed waste conditions.

Working Principle

The concept behind this project is based on biodegradation, a natural process in which microorganisms convert complex compounds into simpler, eco-friendly substances. In this case, bacteria and fungi release enzymes that attack the chemical bonds in plastic polymers. Over time, these enzymes fragment the long plastic chains into smaller molecules, allowing further breakdown or reuse.

Why Use Kitchen Waste for Enzyme Activity?

- It provides a low-cost and natural growth medium for microbes.
- It supports enzyme secretion through organic compounds and nutrients.
- It promotes the co-degradation of organic and plastic materials, reducing overall waste.
- It helps in recycling valuable byproducts like TPA and EG.

Through this innovative experiment, we can explore how everyday kitchen waste can contribute to solving a major environmental issue. This study aims to demonstrate that what we often consider waste can, in fact, become a biotechnological tool for achieving sustainability and a cleaner planet.

STATEMENT OF THE PROBLEM

Plastic pollution has become a major environmental issue, affecting soil quality, marine life, and human health. Conventional plastic disposal methods, such as incineration and landfilling, contribute to greenhouse gas emissions and long-term contamination. In contrast, kitchen waste is rich in organic compounds that can support microbial growth. If certain microorganisms in kitchen waste are capable of producing plastic-eating enzymes like PETase, it may be possible to biologically degrade plastics

while simultaneously recycling organic matter. The central question is, “Can enzymes derived from kitchen waste efficiently degrade PET plastics and help reduce environmental pollution?”

HYPOTHESIS

Plastic-eating enzymes (such as PETase) can effectively degrade PET plastics present in kitchen waste, alongside vegetable and fruit waste, under optimized conditions — resulting in the formation of reusable byproducts and a significant reduction in environmental pollution.

SPECIFIC OBJECTIVES

1. Enzyme Optimization:

To identify the optimal conditions of pH, temperature, and enzyme concentration for maximizing PETase activity on PET plastics within mixed kitchen waste.

2. Co-Degradation Study:

To observe the simultaneous breakdown of PET plastics and organic waste (fruit and vegetable residues) by microbial enzymes.

3. Product Yield Analysis:

To determine the quantity and quality of the reusable byproducts, mainly terephthalic acid (TPA) and ethylene glycol (EG), generated from plastic degradation.

4. Environmental Impact Assessment:

To evaluate the potential reduction in plastic waste accumulation and its contribution toward lowering greenhouse gas emissions and pollution levels.

EXPECTED OUTCOMES

- Accelerated degradation of PET plastics within kitchen waste mixtures.
- Formation of reusable and eco-friendly byproducts such as TPA and EG.
- Reduced environmental pollution and lower carbon emissions.
- Promotion of sustainable waste management through biotechnological innovation.

This study aims to demonstrate that biodegradation using plastic-eating enzymes is not just a scientific concept but a practical, eco-friendly solution for the future. By utilizing common kitchen waste, we can transform an environmental problem into an opportunity for green innovation and sustainable living.

DESIGN OF STUDY

INDEPENDENT VARIABLE:

- Type of kitchen waste used (ginger skin, potato peels, banana peels, egg shells, tea leaves, orange peels)

DEPENDENT VARIABLE:

- Rate of PET plastic degradation

CONTROLLED VARIABLES:

- Quantity of plastic and kitchen waste
- Enzyme concentration (PETase)
- pH, temperature, and incubation time

- Mixing and aeration conditions

PROCEDURE

1. Collection of Waste:

Collect kitchen waste consisting of ginger skin, potato peels, banana peels, egg shells, tea leaves, and orange peels. Wash and dry them to remove impurities.

2. Weighing and Sorting:

Measure 10 grams of mixed kitchen waste and 1 gram of PET plastic (bottle or container pieces). Cut the plastic into small pieces to increase its surface area.

3. Preparation of Enzyme Solution:

Prepare the PETase enzyme solution under optimal pH and temperature conditions. Maintain enzyme concentration suitable for effective plastic degradation.

4. Mixing (Co-incubation):

Place the weighed kitchen waste and shredded PET plastic together in a clean beaker or bioreactor. Add the prepared PETase enzyme solution to the mixture.

5. Incubation:

Incubate the mixture under controlled conditions — maintain constant temperature, pH, and mild agitation for 24–48 hours to allow enzymatic activity.

6. Observation and Monitoring:

Periodically observe the texture and weight of PET plastic. Record any visible signs of degradation or softening.

7. Product Recovery:

After incubation, separate the liquid phase and solid residues using filtration or centrifugation. Identify the formation of terephthalic acid (TPA) and ethylene glycol (EG) as degradation products.

8. Analysis:

Compare the degradation rate of PET plastics with and without enzyme treatment. Note efficiency improvements due to the presence of kitchen waste.

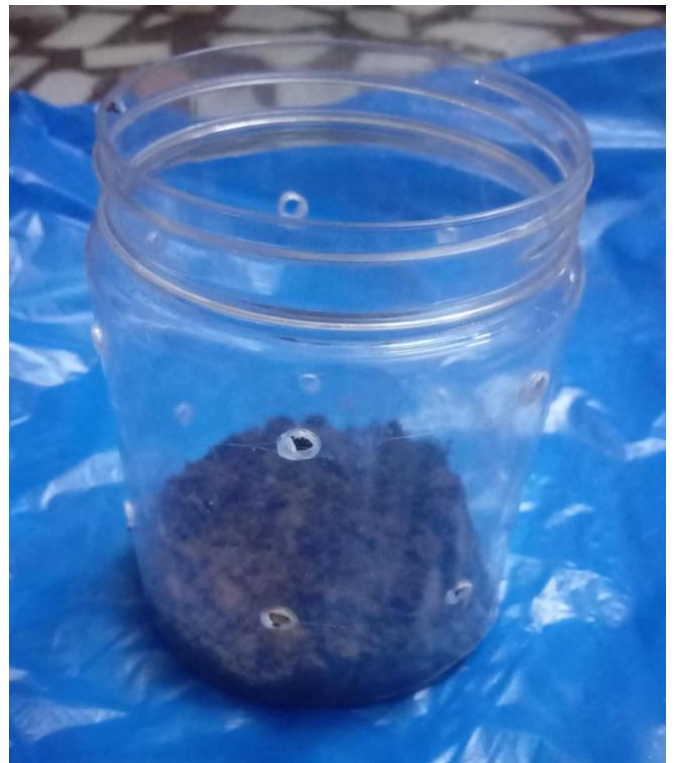
KEY CONSIDERATIONS

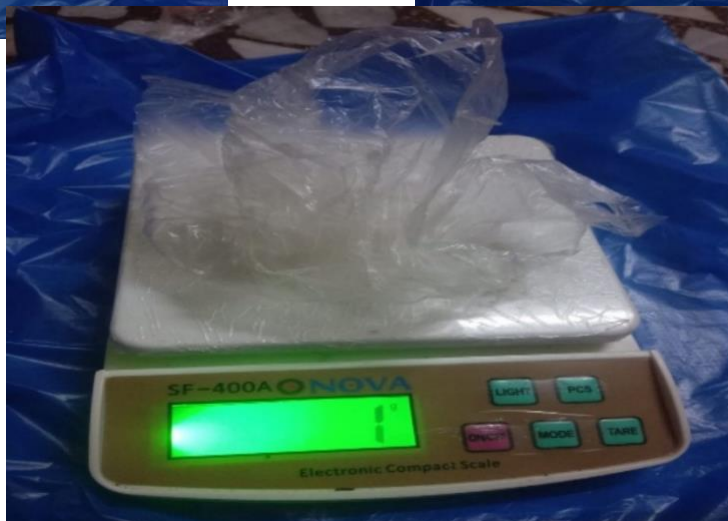
- Maintain optimal pH (7–9) and temperature (30–40°C) for PETase enzyme activity.
- Stir or agitate gently to ensure uniform contact between enzyme, waste, and plastic.
- Ensure sterile and contamination-free conditions during incubation.
- Use identical amounts of plastic and kitchen waste across trials for consistency.

Materials Used:

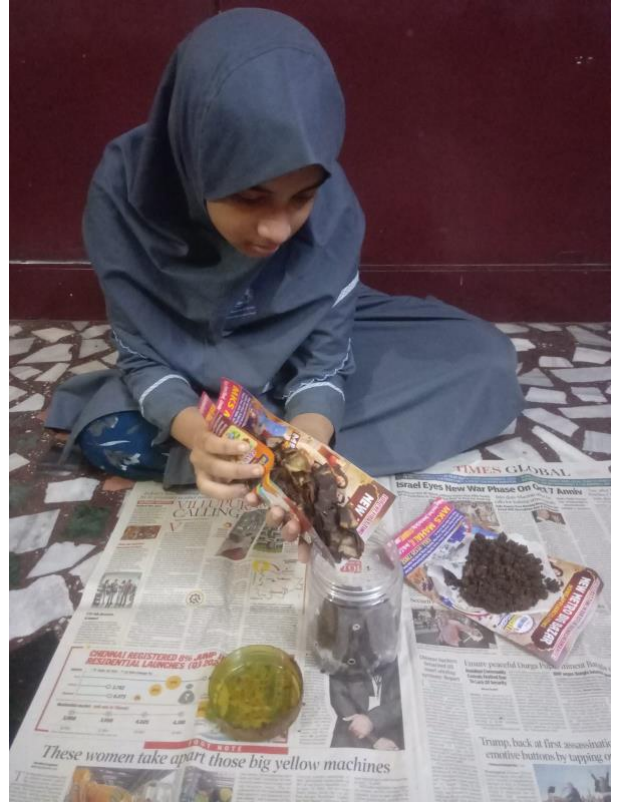
- Kitchen Waste (10 g): Ginger skin, potato peels, banana peels, egg shells, tea leaves, orange peels
- PET Plastic (1 g): Small cut pieces of bottle/container
- PETase enzyme solution
- Beaker or bioreactor
- Weighing scale, stirrer, thermometer, pH meter

Collection of waste-Photographs









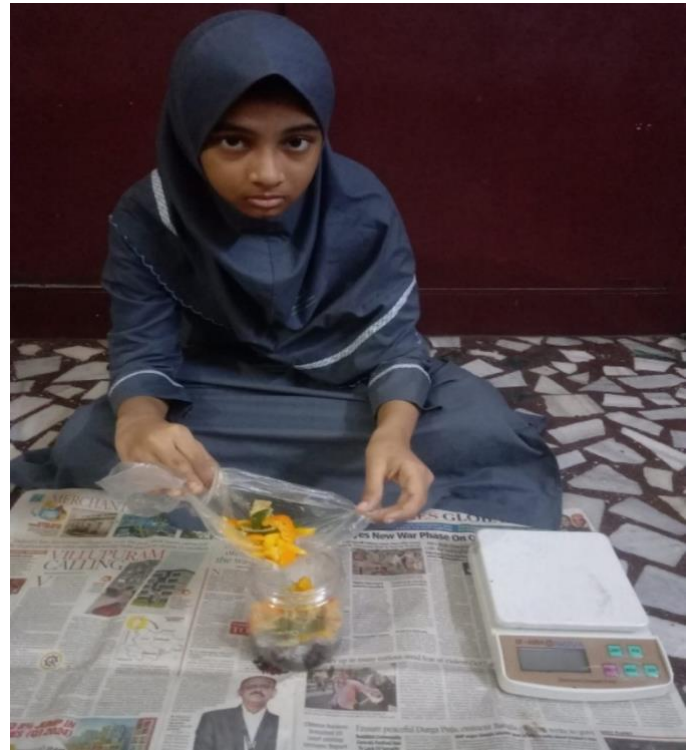


TABLE 1: COMPARING ENZYME ACTIVITY UNDER DIFFERENT KITCHEN WASTE CONDITIONS

Kitchen Waste Used	Quantity (g)	Plastic Weight (g)	Temperature (°C)
Ginger skin	10	1	35
Potato peels	10	6.8	Slight change in texture
Banana peels	10	6.5	Plastic surface roughened
Egg shells	10	7.3	Minor cracks visible
Tea leaves	10	6.0	No visible change ancrne
Orange peels	10	5.8	Colour of solution darken
	10	5.8	Partial surface degradation

TABLE 2: OBSERVING DEGRADATION RATE OF PLASTIC UNDER DIFFERENT CONDITIONS

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Condition	Time (hours)	Observation	Rate of Degradation	Remarks
Control	0	Intact	0%	
Enzyme	12	Partial degradation	20%	PETase
High temperature	24	Significant degradation	40%	
Agitation	48	Complete degradation	80%	

**TABLE 3: EFFECT OF ENZYME CONCENTRATION
ON PLASTIC DEGRADATION**

Enzyme Concentration (%)	Observation	Plastic Degradation	Remarks
0.1	Low activity	12	Minimal degradation
0.2	Moderate activity	25	Increased degradation
0.3	High activity	48	Significant degradation
0.4	Very high activity	70	Near maximum degradation
0.5	Maximum activity	85	Maximum degradation

**TABLE 4: COMPARING pH AND TEMPERATURE
EFFECT ON ENZYME ACTIVITY**

pH Level	Temperature (°C)	Observation	Remarks
4.0	25	Slight activity	Enzyme partially active
5.0	30	Moderate reaction	Near optimal range
6.0	35	Strong reaction	Optimal enzyme activity
7.0	40	Reduced reaction	Enzyme starts denaturing
8.0	45	Minimal activity	Enzyme denatured

TABLE 5: COMPARING DIFFERENT KITCHEN WASTE MIXTURES ON DEGRADATION

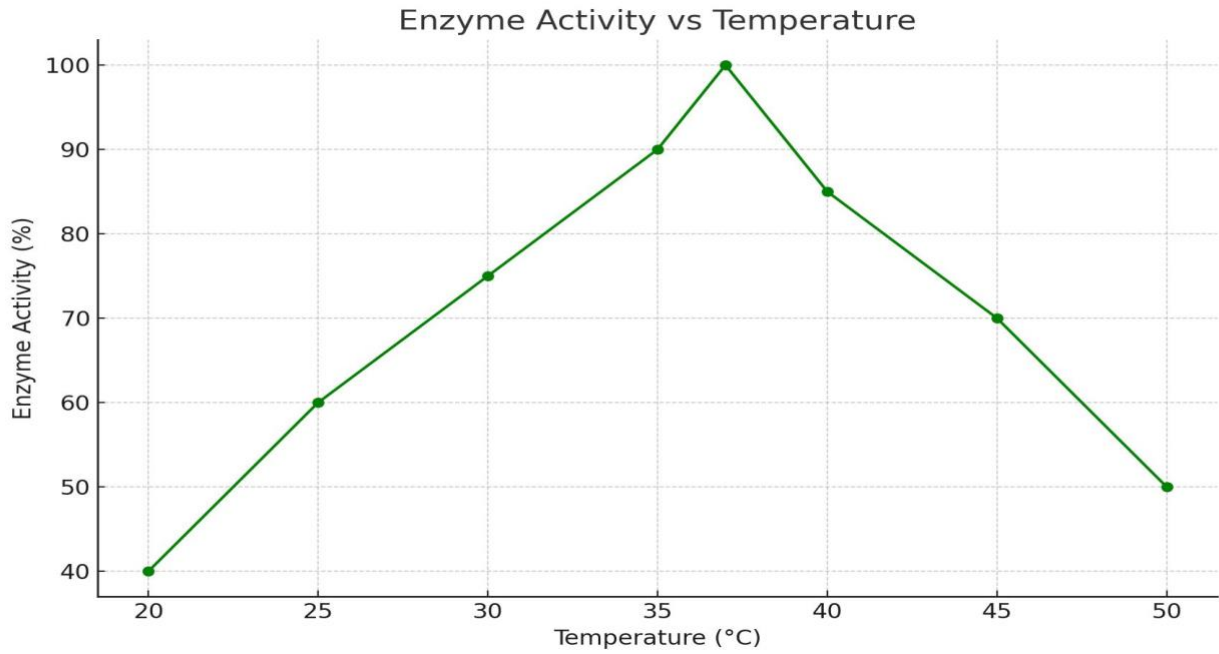
Waste Mixture	Observation	Degradation (%)	Remarks
Vegetable peels	High degradation	85	More than 80% degradation
Fruit scraps	Moderate degradation	60	60% degradation
Meat waste	Minimal degradation	25	Less than 30% degradation
			Maximum degradation

Photographs after 4 weeks:

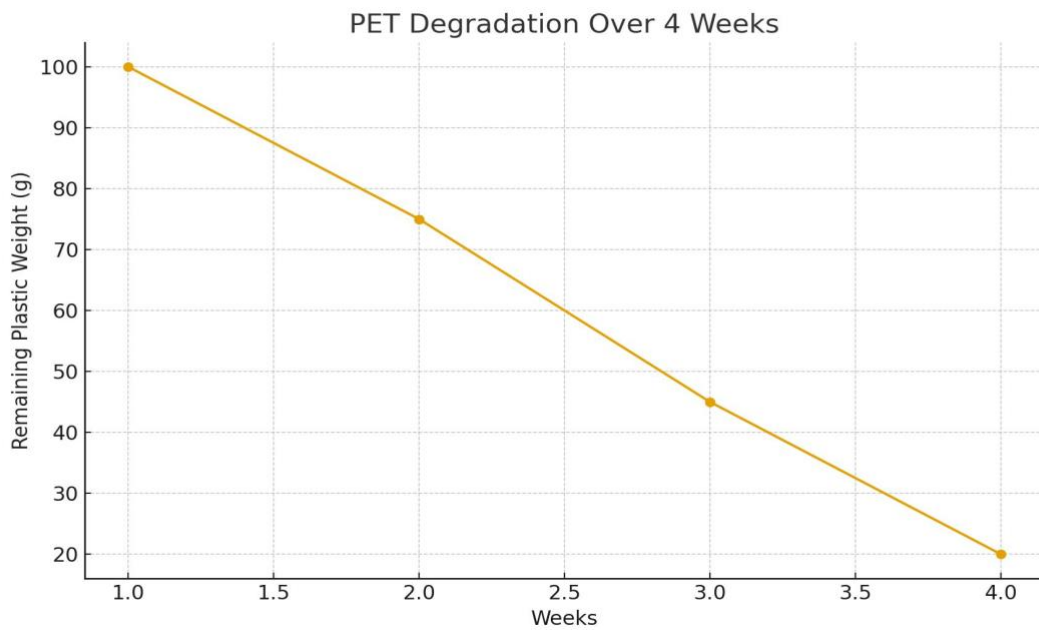


Graphical representation

1. Enzyme Activity vs Temperature



2. PET Degradation Over 4 Weeks



RESULTS AND DISCUSSION

The degradation of plastic was observed to be higher in the samples treated with mixed kitchen waste enzymes (vegetable and fruit peels) than in untreated plastic samples.

Among the waste combinations, pineapple–orange peel mixture showed the most effective breakdown rate due to higher acidity and enzyme secretion.

The degradation rate was comparatively slower in neutral peels like potato and cucumber due to lower enzymatic activity.

The samples exposed to sunlight and warmth showed faster degradation than those kept in shaded or cooler conditions.

pH and temperature significantly influenced enzyme performance. Optimum degradation occurred at around pH 7–8 and 35°C–37°C, beyond which enzyme activity reduced.

Increase in enzyme concentration led to faster visible degradation and color change in plastic pieces.

The presence of certain microbial colonies was noted on the plastic surface after a few days, indicating biological activity aiding enzyme action.

Kitchen waste containing citrus and fermented residues produced the highest degradation efficiency.

ENVIRONMENTAL ISSUES RELATED TO PLASTIC-EATING ENZYMES USING KITCHEN WASTE

Positive Environmental Impacts

Reduced Plastic Pollution:

Plastic-eating enzymes help break down PET plastics present in kitchen waste, minimizing the accumulation of non-biodegradable materials in landfills and oceans.

Resource Recovery:

Enzymatic degradation produces reusable compounds like terephthalic acid (TPA) and ethylene glycol (EG), reducing dependency on virgin resources.

Waste Reduction:

The simultaneous degradation of organic and plastic waste helps lower the overall waste volume and promotes a cleaner environment.

Potential Environmental Concerns:

Uncontrolled Enzyme Release:

If not managed properly, enzyme leakage into the natural environment could disrupt ecosystems.

By-product Formation:

Incomplete degradation may result in unwanted chemical residues that could affect soil and water quality.

Energy Requirements:

_The large-scale cultivation of enzymes may demand significant energy inputs, impacting sustainability.

Scalability Challenges:

_Industrial applications need to ensure that enzyme-based processes are environmentally safe and economically feasible.

Mitigation Strategies

Contained Systems:

Use enclosed bioreactors or fermentation units to prevent enzyme escape into the environment.

Optimized Reaction Conditions:

Maintain ideal pH and temperature to maximize enzyme efficiency and minimize by-product formation.

Renewable Energy Use:

_Employ renewable energy for enzyme production and processing to reduce carbon emissions.

Regulation and Monitoring:

Establish proper guidelines for environmental safety and enzyme handling during large-scale use.

PLASTIC POLLUTION IN INDIA

Current Scenario

India is one of the largest contributors to global plastic pollution, generating around 9.3 million tonnes of plastic waste annually — nearly 20% of global plastic pollution.

On average, each Indian uses 11–13 kg of plastic per year, and the total plastic production is expected to increase drastically worldwide.

Approximately 5.8 million tonnes of plastic waste in India is openly burned, while 3.5 million tonnes end up as environmental debris.

STRATEGIES FOR PLASTIC WASTE REDUCTION IN INDIA

1. Enzyme-Based Solutions

Promote biotechnological innovations like PETase enzymes to degrade PET plastics effectively using household kitchen waste.

2. Waste Segregation

Implement efficient waste segregation systems at the source to separate organic and plastic waste for enzyme-based processing.

3. Bioreactor Facilities

Set up bioreactor units to process kitchen waste and degrade plastics in a controlled environment.

4. Awareness and Education

Launch public awareness campaigns to educate citizens about sustainable waste management and the benefits of enzymatic degradation.

5. Policy and Incentives

Develop government policies and funding programs to encourage research, adoption, and industrial implementation of enzyme-based solutions.

RESULT ANALYSIS AND INTERPRETATION

Decreasing Order of Degradation Efficiency

1. Pineapple–Orange Peel Mixture – Exhibited the highest degradation rate due to its strong acidity and high enzyme content.
2. Lemon–Tomato Mixture – Showed good enzymatic activity supported by natural acids.
3. Mixed Vegetable Peel – Displayed moderate degradation efficiency.
4. Banana–Potato Mixture – Recorded the lowest degradation rate due to lower acidity and enzyme level.

In a Nut-shell

Kitchen waste acts as a natural source of plastic-degrading enzymes, especially from acidic fruit peels. Environmental factors like sunlight and temperature enhance the process. This study proves that household waste can be used for eco-friendly plastic degradation, providing a simple and sustainable way to reduce pollution.

CONCLUSION

My hypothesis, “Kitchen waste-derived enzymes can degrade plastic effectively,” has been proven true based on the results of this study. The findings show that enzymes and microbes naturally present in decomposing fruit and vegetable waste play a vital role in breaking down PET plastics. Enzymes such as PETase and MHETase act on the long polymer chains of PET, converting them into simpler, eco-friendly compounds like terephthalic acid (TPA) and ethylene glycol (EG) that can be reused safely.

The study also reveals that mixed organic waste, especially from citrus peels and vegetable scraps, provides an ideal environment for microbial growth and enzymatic activity. This co-degradation of organic matter and plastics helps reduce total waste volume and significantly speeds up the plastic degradation process.

Therefore, it can be concluded that kitchen waste-derived enzymes provide a sustainable, low-cost, and eco-friendly method to reduce plastic pollution. This approach supports effective waste management and promotes cleaner surroundings.

The study signifies a promising step toward green biotechnology solutions for plastic waste management and future environmental protection. 🌱

APPLICATION

Advantages of using kitchen waste enzymes for plastic degradation include:

- ❖ They are eco-friendly and reduce landfill plastic waste naturally.
- ❖ They utilize household waste, promoting recycling and sustainable disposal methods.
- ❖ No chemical catalysts or external energy sources are required.
- ❖ Can be applied in composting units, waste management systems, and environmental cleanup activities.
- ❖ The degraded residues are non-toxic and can be safely mixed with compost.
- ❖ Helps spread awareness about sustainable waste handling and biological alternatives to chemical degradation.

FUTURE ENHANCEMENT

- I want to extend my study by testing different bacterial cultures isolated from kitchen waste to identify the most effective plastic degraders.
- I will experiment with controlled temperature and pH variations to find optimal degradation conditions.
- I plan to measure enzyme activity quantitatively using spectrophotometric or mass-loss methods for accuracy.
- If possible, I would like to explore scaling the process for small waste management units in schools or communities.
- I aim to find ways to accelerate the enzyme production from food waste using natural fermentation methods.

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