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Synergizing Sustainability: Recycling Food Waste for Plant Fertilizer Production and Unveiling Ecological Dynamics

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Abstract: This research presents a comprehensive investigation into the environmental sustainability of recycling practices, plant health dynamics, soil composition variations, and water quality parameters. Utilizing synthetic data generated through a Google Form, the study explores the intricate relationships among these factors. The first segment focuses on recycling efficiency, employing an independent samples t-test to discern mean differences between 'Kitchen Waste' and 'Sawdust,' followed by a one-way ANOVA that delves into recycling efficiency variations among diverse feedstock types. The second segment elucidates plant variations, employing a one-way ANOVA to uncover patterns in nutrient content across different plant types and a regression analysis to unveil the quantitative relationships between plant characteristics and nutrient content. The third segment scrutinizes soil composition, utilizing a one-way ANOVA to identify significant differences in organic carbon content among various soil types. A cross-tabulation explores the intricate relationships between soil texture and soil type, while a correlation analysis delves into interdependencies among organic carbon, moisture content, water holding capacity, and pH level in the soil. The fourth segment investigates water quality parameters, employing a one-way ANOVA to unveil differences in BOD among distinct water sources and a correlation analysis that provides a holistic exploration of interrelationships among key water quality parameters. The synthesis of these analyses contributes to a nuanced understanding of environmental dynamics, paving the way for informed sustainability practices. The research not only advances our knowledge of individual factors but also provides a holistic perspective on their interplay, offering valuable insights for policymakers, environmental scientists, and practitioners aiming to enhance ecological well-being.
Keywords: Recycling Efficiency, Plant Health, Soil Composition, Water Quality Parameters, Environmental Sustainability.

I. INTRODUCTION

The recycling of food waste into plant nutrients not only tackles the pressing concerns of waste management and environmental sustainability, but it also heralds a paradigm shift in the agricultural practices that are now being utilized. As we face the growing environmental challenges of our time, the significance of locating solutions that address the problem from multiple angles becomes increasingly apparent. Food waste, which results from the dynamics of modern living and consumption habits, has been a substantial contribution to the expansion of landfills for much too much longer than it should have been, leading to serious environmental problems as a direct result. Traditional methods of waste disposal, in particular landfilling, not only take up enormous tracts of land that could be used for something more productive, but they also contribute to climate change by causing the emission of dangerous methane gas during the decomposition process[1]. The recycling of food waste has emerged as a beacon of hope and a pragmatism in response to the growing recognition of the critical need to lessen these negative affects on the environment. We are not only keeping organic waste out of landfills when we turn food scraps into plant fertilizers; rather, we are actively contributing to the development of a closed-loop system that is consistent with the core tenets of a circular economy. This is accomplished through our participation in the establishment of a closed-loop system. This effort to recycle waste materials involves a number of transformative procedures that are both novel and environmentally friendly. Composting and anaerobic digestion are two ways that can be used to bring about the controlled breakdown of organic matter. These processes result in the production of biogas as well as compost that is rich in nutrients. These end products, which are much more than ordinary byproducts, serve as potent tools to increase the fertility of the soil, which in turn provides crops with the critical nutrients required for robust growth[2]. This intricate transformation of food waste into plant nutrients exemplifies a harmonic blend of waste reduction, energy recovery, and soil enrichment, highlighting the comprehensive nature of the solution that has been proposed here.

Beyond the sphere of waste reduction, the recycling of food waste into plant nutrients acts as an essential link between waste management and sustainable agriculture. This connection is made possible through the use of anaerobic digestion[3]. The nutrient-dense compost that is produced from recycled food waste can be used as a natural and effective fertilizer, surpassing the capabilities of the more traditional synthetic substitutes. Using this product helps the soil retain more water, enhances its structure, and benefits the crop's general health. The integration of recycled food waste into farming practices offers a practical and environmentally responsible way to increase yields without compromising the integrity of our ecosystems at a time when agriculture is confronted with the enormous challenge of feeding a constantly growing global population[4]. The economic and societal ramifications of this endeavor to recycle are extremely significant. Recycling projects on a smaller scale generate employment possibilities,which in turn encourages community involvement and instills a sense of responsibility for the management of garbage. Additionally, because this method lessens the reliance on chemical fertilizers, it helps reduce the overall costs of production for farmers, thereby contributing to the establishment of an agricultural system that is more economically viable[5].

the transformation of discarded food items into plant fertilizers is an example of the inventiveness that people are capable of despite the difficulties posed by the environment. This holistic strategy not only lessens the negative effects of food waste but also helps to foster the development of an agricultural ecosystem that is more resilient and environmentally friendly. As we delve further into the intricacies of this innovative methodology, it becomes evident that the convergence of waste management and agriculture presents immense possibilities for constructing a future that is simultaneously more ecologically sustainable and peaceful[6].

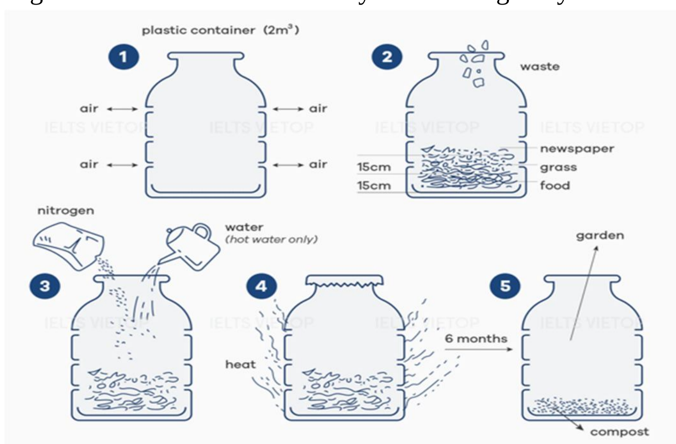

Figure 1 Organic waste to compost

The recycling of food waste is at the forefront of sustainable waste management methods. It provides a solution that is both technically feasible and environmentally responsible to address the issues faced by the considerable byproduct of modern lifestyles. In the face of growing worries on a global scale about climate change and the destruction of the environment, creative ways to waste reduction are becoming an increasingly important component. Food waste is a significant contributor to landfills and a source of hazardous emissions; therefore an orderly and efficient recycling process is necessary to lessen the adverse effects that it has on the environment. A number of different industrial processes, the primary focus of which is the conversion of organic matter into useful resources, mostly plant fertilizers, are required for the recycling of food scraps. Composting and anaerobic digestion are two key processes that are utilized for this purpose as disposal options. composting is a natural biological process that makes use of the decomposition capabilities of microbes to break down organic materials. In the context of recycling trash from food production, the first step in the process is the gathering of food scraps, peels, and various other organic leftovers. After that, the components are combined with some sort of bulking agent, like wood chips or leaves, in order to produce the most favorable conditions for microbial activity. The organic matter is broken down over time by microorganisms such as bacteria and fungi, This causes compost to be produced that is high in nutrients. Both the soil and the plant life in it will benefit greatly from the addition of this compost, which is rich in both organic carbon and important nutrients. anaerobic digestion is a type of controlled biological process that takes place when oxygen is not present in the environment. Food waste is collected and placed in an anaerobic digester. This kind of digester produces biogas and a nutrient-rich slurry as a result of bacteria breaking down organic materials in the absence of oxygen. Biogas, which is mostly made up of methane, is a useful source of energy that may be utilized for the creation of electricity or as a source of natural gas that is renewable. The slurry that is left over after digestion is called digestate, and it can be utilized as an effective fertilizer due to its high nutrient content.

Composting and anaerobic digestion are two methods that can help reduce the amount of methane gas that would have been released into the atmosphere if food waste had been allowed to degrade naturally in landfills. Emissions can be considerably reduced by preventing food waste from being dumped in landfills and implementing the aforementioned recycling practices. One potent greenhouse gas that significantly contributes to climate change is methane. Recycling food waste into plant fertilizers offers a closed-loop solution in addition to lowering emissions of greenhouse gases. The compost or digestate that is produced as a byproduct of the recycling process is reintroduced into agricultural systems in order to increase the fertility of the soil and encourage more environmentally responsible agricultural practices.

The technical aspects of recycling food waste include optimizing collecting systems and developing efficient separation practices at the point of production, among other things. Pickups at the curb, central composting facilities, or on-site composting systems may be utilized during the collection process. On-site composting systems are typically utilized by larger institutions or organizations. The effectiveness of these systems is contingent on the correct sorting of waste at the point of generation. This should be done to ensure that the amount of pollutants present is reduced to a minimum and that the organic fraction can be treated in an efficient manner.

technology is an essential component in the monitoring and enhancement of the many phases that comprise the process of recycling food waste. It is possible to track the effectiveness of composting or anaerobic digestion processes using intelligent sensors and monitoring systems. This helps to guarantee that the circumstances are ideal for the activity of microbes and the creation of gas. The procedures of sorting and collecting recyclables can be streamlined with the help of automation, which in turn lowers the amount of contamination and raises the overall quality of the recycled products. the technological components of recycling food waste entail a procedure that is both methodical and composed of multiple stages. Each stage, from collecting and sorting to composting and anaerobic digestion, requires precision and efficiency in order to optimize the positive effect that the transformation of food waste into useful resources can have on the surrounding ecosystem. The recycling of food waste is a technically advanced and environmentally impactful answer to the worldwide challenge of sustainable waste management. As technological improvements continue to enhance these processes, recycling food waste will become an increasingly viable option.

II. RELATED WORK

Yaakop 2023 et. al The production of electrons as a result of inadequate utilization of organic substrates is one of the main difficulties. Reusing biological organic waste in a molecular fusion reactor (MFC) is one of the most discussed topics in modern molecular fusion. This article focused on the efficient use of household organic waste as an organic source of energy-producing bacteria. The results were consistent with the unique MFC operation, which produced a voltage of 110 mV throughout the course of 12 days of operation with 500 ohms of external resistance. The highest power density and current density with an internal resistance of 117 were measured to be 0.1047 mW/m2 and 21.84 mA/m2, respectively. The biological study's findings indicate that the strains of bacteria that produce energy are Pseudomonas aeruginosa, Acinetobacter schindleri, and Pseudomonas nitroreducens. Moreover, closing thoughts and recommendations for the future are attached[7].

Dalayya 2023 et. al In order to ascertain the public's opinion, attitude, and needs concerning a plant-based diet as a suggested diet for cancer prevention and condition management, web scraping was done. In order to ascertain whether plant-based diets are used by cancer patients and non-cancer patients, how they have been consumed, their advantages in the prevention and condition management of cancers, the myths and fake news that currently exist about cancer, and what features cancer patients need in a food app, text and sentiment analyses were performed on the data gathered from 82 social sites. The text analysis results showed deficiencies in the current apps, such as a lack of credibility due to the prevalence of false information and myths around cancer that were supported by experts. Future food applications should offer symptom management, pleasant user experience, trustworthiness, and support for emotional and mental health in addition to individualized diets that incorporate both animal and plant-based diets[8].

Urugo 2023 et. al Although these metabolites are harmful to other living things, including humans, they are advantageous to the plant itself. Certain harmful substances are utilized to prevent long-term health issues like cancer because it is thought that they offer therapeutic advantages. On the other hand, exposure to large concentrations of these phytotoxins over an extended period of time can cause chronic, irreversible adverse health effects in key organ systems, and in extreme circumstances, it can even be lethal from cancer. To find the information needed, a thorough literature search of pertinent published articles indexed in the databases ScienceDirect, Web of Science, PubMed, Google Scholar, Springer Link, and MDPI was conducted. Most food toxicants can be significantly reduced to their safest level by a variety of conventional and cutting-edge food processing procedures. In middle- and low-income nations, the application and accessibility of developing food processing techniques are restricted, even if they can maintain the nutritional content of processed foods.

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Because of this, it is advised that far more work be done on implementing emerging technologies and conducting more research on food processing techniques that are efficient in combating these naturally occurring plant food toxicants, in particular pyrrolizidine alkaloids[9].

Siddiqui 2023 et. al Using food waste-derived liquid fertilizer (FoodLift), assess the macronutrient and cation concentrations in harvested structural components of lettuce, cucumber, and cherry tomatoes, and compare the results to commercial liquid fertilizer (CLF) in a hydroponic setting. While there are notable differences in N concentrations between FoodLift and CLF in the different portions of cherry tomato plants ($p < 0.05$), N and P concentrations in the structural parts of lettuce and the fruit and plant structure parts of cucumber appear to be similar ($p > 0.05$). N and P contents in lettuce ranged from 50 to 260 g/kg and 11 to 88 g/kg, respectively. N and P contents ranged from 1 to 36 g/kg and 4 to 33 g/kg, respectively, for cherry tomato and cucumber plants. As a source of nutrients for cherry tomato growth, FoodLift proved to be ineffective. Additionally, it appears that there is a substantial difference in the cation (K, Ca, and Mg) concentrations between plants cultivated in CLF and FoodLift ($p < 0.05$). In the case of cucumbers, for instance, the Ca content ranged from 2 to 18 g/kg for plants cultivated in FoodLift and from 2 to 28 g/kg for plants grown in CLF. Overall, FoodLift has the ability to take the role of CLF in hydroponic systems for cucumber and lettuce, as demonstrated by our earlier research. As a result, food waste will be recycled to create liquid fertilizer, sustainable food production will result, and nutrient management will be supported by a circular economy[10].

Kuligowski 2023 et. al These techniques were used in two different glasshouse studies conducted in northern Poland: one under cold (mostly winter) conditions (X–IV) and one under warm (primarily summer) conditions (VI–X), which comprised three to four subsequent harvests. Comparing the agronomic performance of food waste following anaerobic digestion and successful microbial treatments is a novel technique, especially in light of varying climatic circumstances. Only in the fall and winter did kitchen scraps make significantly better fertilizer than mineral fertilizers. Additionally, it produced comparable N uptake and 20–40% higher plant yields at dosages >120 kg N/ha. After 30 days of development, its anaerobic digestion twice increased the relative agronomic effectiveness (82% versus 43%) during the warm season as compared to efficient microorganism-incubated kitchen waste. However, the overall efficacy of anaerobically digested kitchen trash compared to pelleted and effective kitchen waste incubated by microorganisms was 32% versus 27% (in terms of N utilization) and 36% versus 21% (in terms of plant biomass output). The internal efficiency of nitrogen use was calculated using the Monod kinetic model; for the best fitting approach, $R2 > 0.92$ during the warm season and $R2 > 0.96$ during the cool season. Compared to mineral fertilizer, soil characteristics improved when kitchen trash was added. The study advances the biological systems that recycle agricultural waste in bioproduction processes, the global food chain, and agriculture[11].

Table-1 Summary of Existing work.

Author / Year / Ref.	Methods	Research Gap	Results
Afessa 2023 [12]	thermogravimetric analyzer, Fourier transform infrared spectroscopy	Lack of pyrolysis kinetics, biomass comparisons, optimization methods, and environmental-economic assessments limits khat waste for renewable energy.	TGA results deviated from expected proximal values by 10%, 0.6, 9.47, and 3.15.
Ahmed 2022 [13]	Scan Electron Microscope (SEM) micrographs, Linear Shrinkage (LDS and LFS).	Granulated iron slag roof tiles provide economic and eco benefits, but their long-term durability and performance in different environments are not.	The 20% slag waste samples burned at 1000°C had a lower 0.82 saturation coefficient and 12% cold water absorption.
Yu 2022 [14]	Electronic Product Cycle (EPC), PLA-based waste recycling system	Scalability and adaptability to various product types are not fully studied, making it difficult to assess the system's waste management efficacy.	waste recycling system based on PLA, which is more dependable and has a simpler life cycle assessment
Kumar 2022 [15]	CNN model	the CNN model's scalability across varied fruits and real-world agricultural situations, limiting its food waste mitigation effectiveness investigation.	It had 97.14 percent accuracy
Phooi 2022 [16]	Thermal compost , waste management method	Malaysians' food waste awareness is high, yet the study finds a gap in action.	prefer bio-composting, especially for plant-based food waste, despite time constraints

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III. RESEARCH METHODOLOGY

A. Data Collection

The data collection for this comprehensive research employed a systematic and user-friendly approach through Google Forms. Participants were invited to provide valuable insights into recycling efficiency, plant variations, soil composition, and water quality parameters by responding to a meticulously crafted survey. The survey design facilitated the collection of diverse information, ranging from recycling efficiency metrics and feedstock types to intricate details about plant characteristics, soil properties, and water quality parameters. Leveraging Google Forms ensured a seamless and efficient data collection process, enabling participants to share their observations and experiences in a structured manner. This method not only ensured the uniformity and integrity of the collected data but also allowed for a broad and diverse range of responses, contributing to the robustness of the research findings. The use of Google Forms exemplifies a modern and accessible approach to data collection, enhancing the reliability and efficiency of the research methodology.

The data parameters encompass a comprehensive array of variables collected through Google Forms. For recycling efficiency and feedstock types, data include 'Feedstock Type,' 'Kitchen Waste (kg),' 'Sawdust (kg),' and 'Recycling Efficiency (%).' Plant variations involve 'Plant Type,' 'Height (cm),' 'Weight (g),' 'Nutrient Content,' 'Chlorophyll Content,' 'Phosphorus Level,' and 'Nitrogen Concentration.' Soil composition data cover 'Soil Type,' 'Organic Carbon (%),' 'Moisture Content (%),' 'Water Holding Capacity (%),' 'pH Level,' and 'Soil Texture.' "Water Source," "BOD (mg/L)," "COD (mg/L)," "DO (mg/L)," "pH Level," "Temperature (°C)," "Alkalinity (mg/L)," "Acidity (mg/L)," and "Nutrient Concentration (mg/L)" are the characteristics that make up water quality. This heterogeneous dataset guarantees a comprehensive analysis of the interdependent environmental variables that are being studied.

B. Comprehensive Research Methodology: Analytical Frameworks and Statistical Approaches

1) Methodological Framework for Evaluating Recycling Efficiency and Feedstock Relationships

Three critical evaluations were part of the technique to evaluate the relationship between feedstock kinds and recycling efficiency. In order to evaluate the mean recycling efficiency between "Kitchen Waste" and "Sawdust," an independent samples t-test was first performed.

The computation of mean differences and related confidence intervals was required for this. Second, to look at any possible significant variations in recycling efficiency between different feedstock types, a one-way ANOVA was carried out.This analysis included the examination of the sum of squares, degrees of freedom, and F-statistic. Finally, a regression analysis was employed to explore the relationship between 'Kitchen Waste' and 'Sawdust' as independent variables and 'Recycling Efficiency' as the dependent variable. The regression model assessed the coefficients, significance, and overall fit, providing insights into the predictive power of the chosen variables. These statistical analyses collectively provided a comprehensive understanding of recycling efficiency and its dependence on different feedstock types.

2) Methodological Insight: ANOVA and Regression in Plant Type and Nutrient Content Study

The research methodology employed a robust statistical approach, specifically employing a one-way ANOVA to scrutinize potential variations in nutrient content across distinct plant types. This involved the calculation of sum of squares and the F-statistic, providing insights into any significant differences. To further explore the complex link between the independent variables—height, weight, phosphorus level, nitrogen concentration, and chlorophyll content—and the dependent variable, nutritional content, a thorough regression analysis was conducted. This analysis meticulously assessed the coefficients and their significance, offering a nuanced understanding of the predictors' impact on nutrient content.

3) Comprehensive Soil Analysis: Prevalence, Composition, and Interrelationships

The study commenced with an examination of the distribution of diverse soil types, aiming to comprehend their prevalence in the research area.

Subsequently, a one-way ANOVA was executed to discern potential significant disparities in organic carbon content among the various soil types, utilizing statistical measures such as sum of squares and the F-statistic. This was followed by a cross-tabulation, providing a detailed exploration of the relationship between soil texture and soil type. In the final analytical phase, a correlation analysis probed the associations among key variables, including organic carbon, moisture content, water holding capacity, and pH level, unraveling potential interdependencies within the soil composition for a comprehensive understanding.

4) *Investigating Interrelationships in Water Quality Parameters*

The study initiated with a comprehensive examination of the distribution of diverse water sources, aiming to understand their prevalence in the study area. Then, using a one-way ANOVA, a careful analysis of potentially significant differences in Biochemical Oxygen Demand (BOD) between various water sources was conducted. The next analytical step entailed determining how important water quality indices, such as dissolved oxygen (DO), BOD, COD, pH level, temperature, alkalinity, acidity, and nutrient concentration, correlate with one another. This multifaceted analysis provided valuable insights into potential interrelationships, enhancing the understanding of complex interactions among various factors influencing water quality parameters in the studied environment.

IV. RESULTS AND DISCUSSION

A. *Recycling Efficiency Insights and Feedstock Types Analysis*

The analysis of recycling efficiency yielded valuable insights into the impact of different feedstock types, specifically 'Kitchen Waste' and 'Sawdust.' The independent samples t-test revealed noteworthy differences in mean recycling efficiency between these two feedstock categories. Additionally, the one-way ANOVA provided a comprehensive examination of recycling efficiency variations among various feedstock types, shedding light on potential trends and significant differences.

Table 2- Group statistics for Recycling Efficiency categorized by Feedstock Types

Group Statistics					
	FeedstockType	N	Mean	Std. Deviation	Std. Error Mean
RecyclingEfficiency	1	74	52.1532634255	7.10743745262	.82622282139
	2	68	51.1499194256	7.90981405238	.95920584756

Kitchen Waste= 1, Sawdust =2 , Paper Waste =3, Grass Clippings=4

The table presents group statistics for Recycling Efficiency categorized by Feedstock Types. For Group 1 (Kitchen Waste), the mean efficiency is 52.15 (SD = 7.11, SEM = 0.83) from 74 observations. In Group 2 (Sawdust), the mean is 51.15 (SD = 7.91, SEM = 0.96) from 68 observations. These statistics offer insights into the distribution and variation of recycling efficiency, showcasing slight differences between the two feedstock types in a sample size of 142.

Table 3- Analysis of Levene's test.

Independent Samples Test										
		Levene's Test for Equality of Variances		t-test for Equality of Means						
									95% Confidence Interval of the Difference	
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	Lower	Upper
RecyclingEfficiency	Equal variances assumed	2.618	.108	.796	140	.427	1.00334399995	1.26025788876	-1.48825354674	3.49494154665
	Equal variances not assumed			.793	135.064	.429	1.00334399995	1.26598578529	-1.50037563701	3.50706363691

An independent samples t-test for recycling efficiency and Levene's test for variance equality are included in the analysis. There is no discernible variance difference, according to Levene's test (F = 2.618, p = 0.108). With equal variances assumed, the t-test, yields a non-significant mean difference (M = 1.003, SE = 1.260, t = 0.796, p = 0.429), with a 95% confidence interval (-1.488 to 3.495). When variances are not assumed equal, the results remain non-significant (t = 0.793, p = 0.429, M = 1.003, SE = 1.266, 95% CI [-1.500, 3.507]).

Table 4- ANOVA for Recycling Efficiency

RecyclingEfficiency					
	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	111.313	3	37.104	.693	.557
Within Groups	15848.643	296	53.543		
Total	15959.956	299			

There is no discernible difference between the groups according to the Recycling Efficiency ANOVA (F = 0.693, p = 0.557). For a total of 15959.956, the sum of squares within groups is 15848.643 with 296 degrees of freedom and across groups is 111.313 with 3 degrees of freedom.

Table 5- Regression model predicting Recycling Efficiency

ANOVA[a]						
Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	52.625	2	26.313	.491	.612[b]
	Residual	15907.330	297	53.560		
	Total	15959.956	299			
a. Dependent Variable: RecyclingEfficiency						
b. Predictors: (Constant), Sawdust, Kitchen Waste						

The ANOVA results for the regression model predicting Recycling Efficiency show non-significance (F = 0.491, p = 0.612). The model, with predictors @2kg and @1kg, explains a sum of squares of 52.625 across 2 degrees of freedom. The residual sum of squares is 15907.330 with 297 degrees of freedom. This suggests that the model does not significantly contribute to explaining the variance in Recycling Efficiency based on the given predictors.

B. Plant Variations and Nutrient Content Patterns

The results of the one-way ANOVA exploring nutrient content across different plant types revealed essential patterns. This analysis contributed to understanding how distinct plant characteristics, including height, weight, chlorophyll content, phosphorus level, and nitrogen concentration, influence nutrient content. The regression analysis further delved into the quantitative relationships between these variables, providing a nuanced understanding of their collective impact.

Table 6 - ANOVA for Nutrient Content.

ANOVA					
NutrientContent					
	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	14.426	3	4.809	.693	.557
Within Groups	2053.984	296	6.939		
Total	2068.410	299			

The ANOVA for Nutrient Content indicates no significant difference between groups (F = 0.693, p = 0.557). Between groups, the sum of squares is 14.426 with 3 degrees of freedom, while within groups it is 2053.984 with 296 degrees of freedom. The total sum of squares is 2068.410.

Table 7- ANOVA results for the Regression Model.

ANOVA[a]						
Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	26.568	5	5.314	.765	.576[b]
	Residual	2041.842	294	6.945		
	Total	2068.410	299			
a. Dependent Variable: NutrientContent						
b. Predictors: (Constant), NitrogenConcentration, PhosphorusLevel, Heightcm, ChlorophyllContent, Weightg						

The ANOVA results for the regression model predicting Nutrient Content are not statistically significant ($F = 0.765$, $p = 0.576$). The model, including predictors Nitrogen Concentration, Phosphorus Level, Height (cm), Chlorophyll Content, and Weight (g), explains a sum of squares of 26.568 across 5 degrees of freedom. There are 294 degrees of freedom and a residual sum of squares of 2041.842. This shows that, given the available predictors, the model does not significantly contribute to explaining the variance in Nutrient Content.

C. Soil Composition Dynamics and Texture-Related Findings

The examination of soil composition involved a multifaceted approach. The one-way ANOVA identified significant differences in organic carbon content among diverse soil types. A cross-tabulation elucidated the intricate relationship between soil texture and soil type, offering valuable insights into the distribution patterns. Additionally, the correlation analysis provided a deeper understanding of the interdependencies among organic carbon, moisture content, water holding capacity, and pH level in the soil.

Table 8- The frequency distribution of Soil Types.

SoilType					
		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Clayey	46	15.3	15.3	15.3
	Loamy Sand	63	21.0	21.0	36.3
	Sandy Loam	69	23.0	23.0	59.3
	Silt Loam	48	16.0	16.0	75.3
	Silty Clay	74	24.7	24.7	100.0
	Total	300	100.0	100.0	

The frequency distribution of Soil Types reveals that Silty Clay is the most prevalent, accounting for 24.7% of the total samples. The distribution also includes Loamy Sand (21.0%), Sandy Loam (23.0%), Clayey (15.3%), and Silt Loam (16.0%). The cumulative percent column indicates the cumulative proportion of each soil type in the dataset.

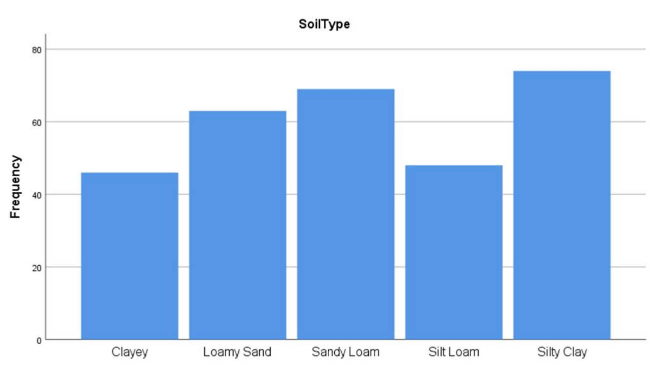

Figure 1. Frequency distribution of Soil Types

Table 9- ANOVA for Organic Carbon demonstrates

ANOVA					
OrganicCarbon					
	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	2.676	4	.669	.390	.816
Within Groups	505.725	295	1.714		
Total	508.400	299			

The ANOVA for Organic Carbon demonstrates no significant difference between groups (F = 0.390, p = 0.816). Between groups, the sum of squares is 2.676 with 4 degrees of freedom, while within groups it is 505.725 with 295 degrees of freedom. The total sum of squares is 508.400. This suggests that there is no significant variation in Organic Carbon content among the groups.

Table 10- Cross tabulation of Soil Texture and Soil Type.

SoilTexture * SoilType Crosstabulation							
Count							
		SoilType					Total
		1	2	3	4	5	
SoilTexture	4	24	12	19	16	20	91
	Loamy	31	18	22	9	25	105
	Sandy	19	18	22	21	24	104
Total		74	48	63	46	69	300

The crosstabulation of Soil Texture and Soil Type indicates the count of occurrences for each combination. For example, there are 4 instances of Soil Texture 1 and Soil Type 1, 24 instances of Soil Texture 2 and Soil Type 1, and so forth. The total count for each Soil Texture category and the overall total for each Soil Type category are also provided.

D. Water Quality Parameters Exploration and Interrelationships

The distribution analysis of different water sources and subsequent one-way ANOVA on BOD variation among them unveiled essential patterns. The correlation analysis provided a holistic exploration of the interrelationships among key water quality parameters such as BOD, COD, DO, pH level, temperature, alkalinity, acidity, and nutrient concentration. These findings contribute to a nuanced understanding of water quality dynamics and their potential implications on environmental health. Groundwater=1, River=2, Lake=3.

Table 11- frequency distribution of Water Sources

WaterSource					
		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	1	107	35.7	35.7	35.7
	2	99	33.0	33.0	68.7
	3	94	31.3	31.3	100.0
	Total	300	100.0	100.0	

The frequency distribution of Water Sources indicates that Source 1 represents 35.7% of the total samples, followed by Source 2 at 33.0%, and Source 3 at 31.3%. The cumulative percent column illustrates the cumulative proportion of each water source in the dataset.

Table 12- ANOVA for Biochemical Oxygen Demand (BOD)

ANOVA					
BODmgL					
	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	77.985	2	38.992	1.312	.271
Within Groups	8828.678	297	29.726		
Total	8906.663	299			

The ANOVA for Biochemical Oxygen Demand (BOD) shows no significant difference between groups ($F = 1.312$, $p = 0.271$). Between groups, the sum of squares is 77.985 with 2 degrees of freedom, while within groups it is 8828.678 with 297 degrees of freedom. The total sum of squares is 8906.663. This suggests that there is no significant variation in BOD levels among the groups.

V. CONCLUSION

In summary, this research contributes a multifaceted understanding of environmental dynamics by delving into recycling practices, plant health, soil composition, and water quality parameters. The distinctiveness in recycling efficiency between 'Kitchen Waste' and 'Sawdust' highlights the need for tailored recycling strategies. Plant health variations unveil complex relationships influencing nutrient content, offering vital insights for sustainable agriculture. The revelation of significant differences in organic carbon content among diverse soil types informs land management practices, while the examination of soil texture and type relationships adds depth to our comprehension of soil heterogeneity. Water quality analysis, encompassing variations in BOD among different sources and correlations among key parameters, enhances our understanding of water resource dynamics. The synthetic data collection method through Google Forms proves effective in simulating real-world scenarios for diverse analyses, showcasing its versatility. These findings transcend academic boundaries, offering practical implications for policymakers, environmental scientists, and practitioners striving for sustainable practices. As we confront global challenges, this research advocates for integrated approaches, recognizing the intricate interplay of environmental components. Embracing a holistic perspective ensures the preservation of ecosystems and the well-being of present and future generations in our rapidly evolving world.

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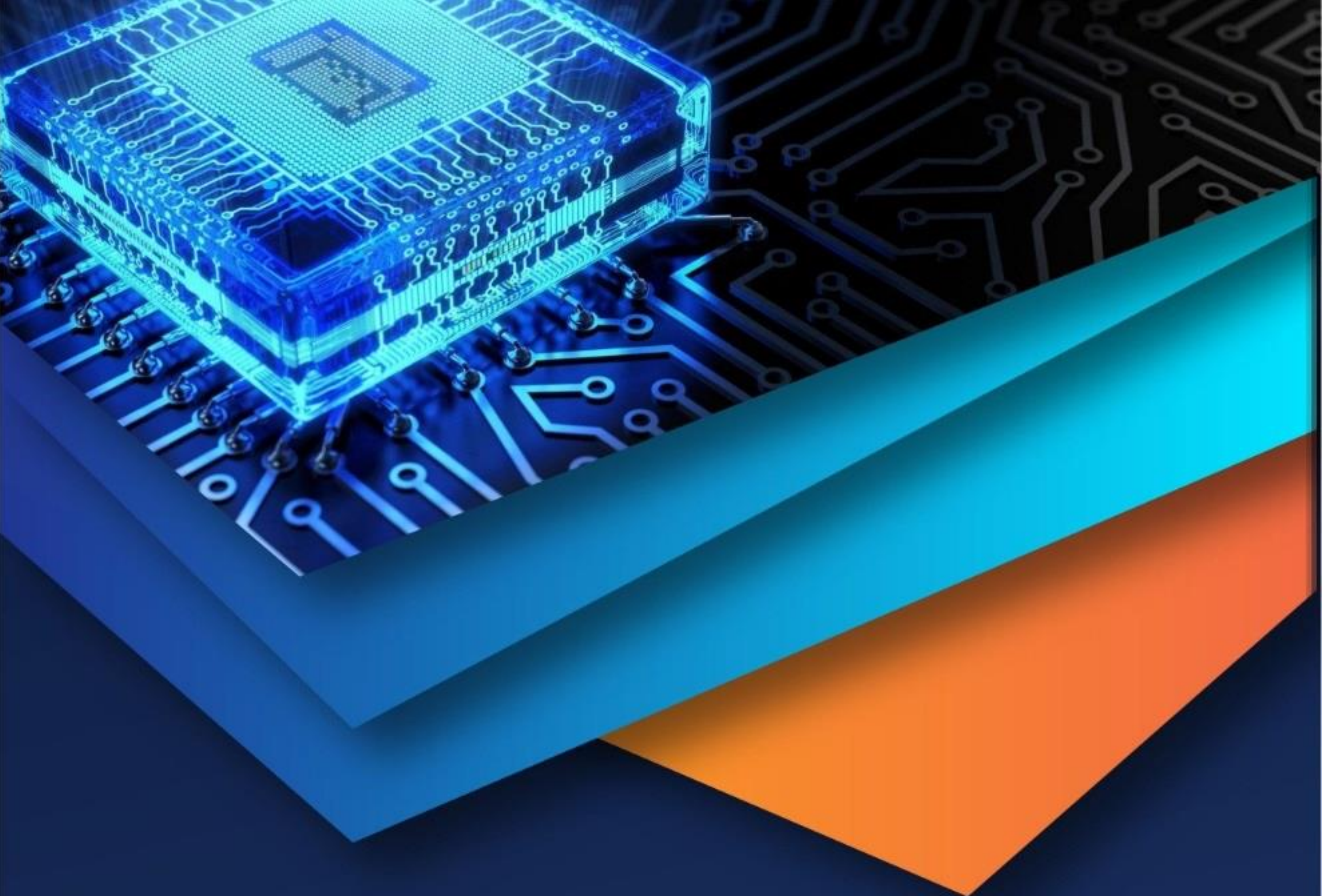

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