Assessing the potentiality of Eco-Enzyme as a household cleaning agent.

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Abstract: *Eco-Enzyme, a fermented solution derived from kitchen waste, sugar, and water with a proportion, presents a sustainable solution of chemical-based household cleaning agents. This study evaluates the potentiality of Eco-Enzyme as a multipurpose cleaner to reduce kitchen waste, and associated health and environmental benefits. The study was conducted in Mirzapur, Bangladesh, covering a survey of fifty households using a semi-structured questionnaire. Qualitative data was collected through Key Informant's Interviews, and Focus Group Discussions. Results write down that 72% of households produce over 5 kg of daily kitchen waste, with 70% using 3.5 kg of waste to produce eco-enzymes, and contribute to reducing kitchen waste disposal daily. Eco-enzyme can be used widely for kitchen (100%), floor (98%), and laundry (98%) cleaning. Compared with the chemical cleaning agents, eco-enzyme users experienced fewer health issues, such as skin allergies (16% vs. 92%) and nausea (0% vs. 22%). The study explores eco-enzymes' efficacy, cost-effectiveness, and environmental benefits, advocating its adoption to mitigate chemical-related pollution.*

Keywords: Eco-Enzyme; Household cleaning; Kitchen waste; Sustainability; Health impacts.

1. INTRODUCTION

Kitchen waste forms 50–60% of solid waste in Bangladesh, contributing to environmental pollution through landfill accumulation, and greenhouse gas emissions [1] Kitchen trash or rubbish is often seen negatively, as filthy, stinky, and a source of disease. Garbage is close by; it surrounds us. Organic waste is a usual form of waste found in the home. Every day, stuff is created and discarded without any reason. Indeed, if people realize, what is sometimes referred to as rubbish and is often discarded offers a plethora of advantages. If correctly managed, people may hesitate to discard it. The rationale is that trash may be converted into compost or eco-enzymes. Now, the question of what is Eco-enzyme? Eco-enzyme is a deep- brown, sweet-sour fermented liquid made from fruit and vegetable peels, sugar, and water in a 1:3:10 ratio, offers a promising solution. This formulation is developed by Dr. Rosukon companion. Eco-enzymes serve as a multipurpose cleaner, organic fertilizer, and environmental purifier [4]. This study assesses its potential use as a household cleaning agent, focusing on waste reduction, multipurpose applications, health benefits, and challenges.

Fig.1: Road side waste dumping at Dhaka city Bangladesh [2].

Fig.2: Landfill at Chittagong, Bangladesh [3].

The increasing use of chemical cleaning agents in Bangladesh, driven by population growth and economic development, poses health and environmental risks [5]. These agents contribute to air, water, and soil pollution, worsening landfill overcapacity [1]. Eco-enzyme, being organic and cost-effective, could address these issues by repurposing kitchen waste and reducing reliance on harmful chemicals. Prior studies have explored organic waste for sustainable solutions, including cleaning agents [6]. The goals of this study are to evaluate eco-enzyme's efficacy as a cleaner, its role in waste reduction, and its health and environmental impacts compared to chemical alternatives. Bangladesh, with an estimated population of approximately 164.69 million people (Bangladesh Bureau of Statistics (Bangladesh Bureau of Statistics., 2020), is seeing rapid socio-economic development. As financial conditions improve and urban lifestyles evolve, there has been a significant rise in the consumption of cleaning agents and household products. However, any of these cleaning agents are synthetic and chemical-based

rather than organic or eco-friendly (Haqu et al., 2021). These chemical substances pose risks not only to human health but also to the environment and the broader ecosystem. Alarmingly, public awareness about the adverse effects of chemical cleaners stays limited, leading to widespread and often excessive usage (Rahman &Hossain., 2019).Increased consumption of chemical cleaning agents also contributes to environmental pollution, particularly when disposed of improperly. Bangladesh already struggles with waste management issues, as only about 7.5% of the total waste—both organic and inorganic—is adequately treated (KLHK (Ministry of Environment and Forestry of Indonesia), 2017). The remainder is typically dumped in open landfills, incinerated, or left untreated, with up to 69% being transported to landfills (KLHK (Ministry of Environment and Forestry of Indonesia), 2017). This reliance on landfills is unsustainable, as these facilities are quickly reaching ability. For instance, it was anticipated that the Bantar Gebang landfill—one of Southeast Asia's largest—would reach full capacity by 2021 (Dinas Lingkungan Hidup DKI Jakarta, 2020). A significant concern associated with landfilling is the accumulation of organic waste, which undergoes anaerobic decomposition. This process emits methane (CH_4), a potent greenhouse gas that is approximately 30 times more effective at trapping heat in the atmosphere than carbon dioxide (CO_2) (Intergovernmental Panel on Climate change.,, 2014).Such emissions contribute to climate change and pose severe health risks to communities living near landfill sites (Islam et al., 2022). Therefore, there is an urgent need to explore natural, biodegradable alternatives such as eco-enzymes to reduce dependency on chemical cleaners and alleviate the growing pressure on landfills.

2. MATERIALS AND METHODS

2.1 Study Area

The study was conducted in Mirzapur Pourosava, Tangail, Bangladesh (24°01'–24°13' N, 89°58'–90°15' E), a town with 6,129 households and a population of 28,602 [5].Mirzapur generates significant organic waste, making it suitable for evaluating eco-enzyme production.

2.2 Study Design

A mixed-method approach was employed, combining quantitative and qualitative techniques. A survey of 50 households was conducted using simple random sampling techniques, targeting individuals primarily responsible for cleaning. Three focus group discussions (FGDs) involved 50 female participants (21 employees, 27 housewives, 2 businesswomen), and three key informant interviews (KIIs) with a housewife, an employee and a businessman.

2.3 Data Collection

Primary data was gathered through a semi-structured questionnaire assessing waste production, eco-enzyme usage, and health impacts. FGDs and KIIs offer qualitative insights into user experiences and challenges. Secondary data was sourced from journals, reports, and environmental studies. Eco-enzyme was prepared following the standard protocol: 1 part sugar, 3 parts fruit/vegetable peels, and 10 parts waters, fermented for three months in airtight plastic containers.

2.4 Data Analysis

Quantitative data were analyzed using SPSS for descriptive statistics and regression modeling to assess the relationship between eco-enzyme production, waste dumping, and waste reduction. Qualitative data from FGDs and KIIs were thematically analyzed to show use patterns and issues. Comparisons with chemical cleaning agents were drawn from an unpublished source

2.5 Eco-enzyme Preparation, Application and Impact

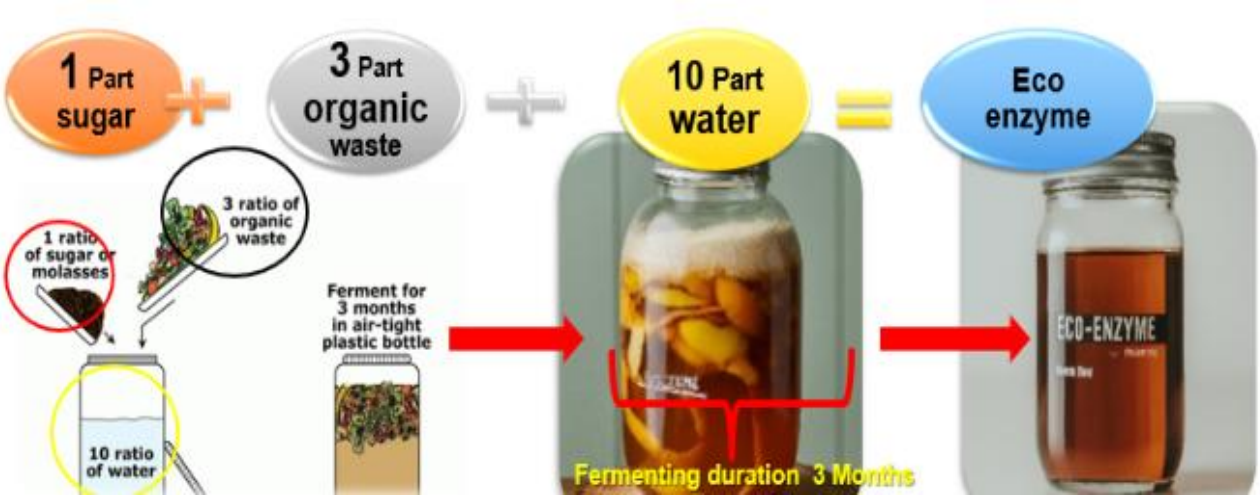

Fig.3. Eco-enzyme preparation process.

Sugar, Scraps & Water: Combine chopped scraps (3 parts), brown sugar (1 part), and water (10 parts). Fermented for 3 months: Seal tight, store cool & dark. Burp daily (for 1 month) for pressure release. Strain & enjoy. After 3 months, the Eco-enzyme should be deep brown and have a pleasant vinegar scent. the eco-enzyme production process can be summarized as: Organic Waste + Microbes + Sugar + Water = Eco-Enzyme. Enzymes in Eco-Enzyme exhibit various roles: they decompose organic matter, transform chemical structures, compose new biological compounds, and act as biocatalysts to accelerate biochemical reactions [8] These functions contribute to ecological balance and sustainability by aiding in natural cycles and enhancing nutrient availability in ecosystems. Eco-enzymes play a vital role in mitigating environmental challenges such as greenhouse gas accumulation. It aids in the conversion of ammonia (NH_3) into nitrate (NO_3^-), which serves as a vital plant nutrient [9]. Additionally, EE helps the fixation of carbon dioxide (CO_2) into carbonate (CO_3^{2-}), beneficial to aquatic ecosystems [8].Some studies suggest that microbial activities during fermentation may contribute to ozone (O_3) formation, which helps detoxify

heavy metals from the atmosphere [9]. The resulting ecological loop enhances soil fertility, promotes plant-animal nutrient exchange, and supports[12].In sustainable farming, Eco-Enzyme serves as a bio-fertilizer, natural herbicide, fungicide, and pesticide, replacing hazardous Agrochemicals [13]. It enhances soil structure , boosts microbial health and supports plant resistance against pests and diseases. When concentrated, Eco-Enzyme functions as an organic weed remover, while at high dilution levels (1:1000),), it acts as a soil and plant enhancer [14] As a non-toxic multipurpose solution, Eco-enzyme is widely applied in domestic cleaning and hygiene. It cuts odors, mold, grime, and bacteria from kitchens, bathrooms and other surfaces. Eco-Enzyme also acts as a natural deodorizer, insect repellent, and laundry aid [15]. Its chemical-free profile makes it a safe choice for families, especially those with children or sensitive skin. Multiple DIY applications further extend Eco-Enzyme's utility. A scouring paste made with fermented peels and baking soda helps clean greasy kitchenware. Natural fabric softeners can be formulated with EE, baking soda, water, and vinegar [16]. A bleach alternative uses food-grade hydrogen peroxide, baking soda, and lemon juice. A pesticide-removal soak (2 teaspoons of EE per liter of water for 45 minutes) can clean fruits and vegetables effectively [15]. Eco enzyme continues its work after household use: It can purify underground water by breaking down toxins as it flows through soil layers [16].It neutralizes air pollutants, including volatile chemicals, cigarette smoke, and car exhaust. It clears blocked pipes and drains naturally through enzymatic breakdown of residues. It repels household pests without harming the environment or indoor air quality [17]**.** Bangladesh, with an estimated population of approximately 164.69 million people [18], is seeing rapid socio-economic development. As financial conditions improve and urban lifestyles evolve, there has been a significant rise in the consumption of cleaning agents and household products. However, most of these cleaning agents are synthetic and chemical-based rather than organic or eco-friendly [19]. These chemical substances pose risks not only to human health but also to the environment and the broader ecosystem. Alarmingly, public awareness about the adverse effects of chemical cleaners stays limited, leading to widespread and often excessive usage [20]. Increased consumption of chemical cleaning agents also contributes to environmental pollution, particularly when disposed of improperly. Bangladesh already struggles with waste management issues, as only about 7.5% of the total waste—both organic and inorganic—is adequately treated [21]. The rest is typically dumped in open landfills, incinerated, or left untreated, with up to 69% being transported to landfills [21]. This reliance on landfills is unsustainable, as these facilities are quickly reaching ability. For instance, it was predicted that the Bantar Gebang landfill—one of Southeast Asia's largest—would reach full capacity by 2021 [22].A significant concern associated with landfilling is the accumulation of organic waste, which undergoes anaerobic decomposition. This process emits methane (CH_4), a potent greenhouse gas that is approximately 30 times more effective at trapping heat in the atmosphere than carbon dioxide [23].Such emissions contribute to climate change and pose severe health risks to communities living near landfill sites [24].Therefore, there is an urgent need to explore natural, biodegradable alternatives such as eco-enzymes to reduce dependency on chemical cleaners and alleviate the growing pressure on landfills.

2.RESULT

Table 1. Waste production , Utilizing and Dumping

Quantity	Waste produce from kitchen		Waste for making eco enzyme		Daily waste dumping	
	Frequency	(%)	Frequency	(%)	Frequency	(%)
Less than 1 Kg	0	-	4	8%	15	30%
1-2 kg	13	26%	10	20%	35	70%
3-4 kg	1	2%	36	72%	0	-
More than 5 kg	36	72%	0	-	0	-

Table 2. Reduce kitchen waste

Reduce Kitchen Waste	B	Sig.	95.0% Confidence Interval for B	
			Lower Bound	Upper Bound
Eco-enzyme production	1.295	0	1.139	1.452
Waste Dumping	1.8	0	1.612	1.988

In table 1 & 2, Despite the fact that 72 percent of individuals produce more than 5 kg of kitchen waste daily, and that no one can make eco-enzyme from all of the kitchen waste, it is shown in this table and graph that 72 percent of respondents make 3-4 kg of eco-enzyme from kitchen waste and that 70 percent of people dump 1-2 kg of waste daily. Based on the independent variable, a regression model was constructed to predict the reduce kitchen waste as the dependent variables. B=1.295 and 1.8, p =0 and 0, respectively, for the total reduce kitchen waste. The study found that 72% of households generate over 5 kg of kitchen waste daily (Table 1 and 2). Of these, 72% used 3–4 kg to produce eco-enzyme, reducing daily waste disposal to 1–2 kg for 70% of respondents (Table 1). A simple linear regression model confirmed a significant relationship between eco-enzymes production (B=1.295, p=0) and waste dumping (B=1.8, p=0) with reduced kitchen waste (Table 2 and 3).

Table 3. Regression Model for Waste Reduction

Reduce Kitchen Waste	Coefficient (B)	p-value	95 % Confidence Interval for B	
			Lower Bound	Upper Bound
Eco-enzyme production	1.295	0	1.139	1.452
Waste Dumping	1.8	0	1.612	1.988

A multiple linear regression analysis was conducted to examine the effects of eco-enzymes production and waste dumping on the reduction of kitchen waste. Results, as presented in Table 9, write down that both independent variables significantly contribute to kitchen waste reduction. Specifically, the coefficient (B) for eco-enzyme production was 1.295 ($p < 0.001$), with a 95% confidence interval ranging from 1.139 to 1.452. This suggests that an increase in eco-enzyme production is associated with a corresponding increase in reduced kitchen waste. Similarly, waste dumping showed a strong positive effect, with a coefficient of 1.800 ($p < 0.001$) and a 95% confidence interval of 1.612 to 1.988. These findings imply that both eco-enzyme initiatives and effective waste dumping practices are statistically significant predictors of kitchen waste reduction. The significance of the p-values ($p = 0.000$) confirms the robustness of the model, underscoring the potential of integrated eco-friendly practices in mitigating household waste generation. Eco-enzyme showed broad acceptance as a household cleaning agent, with near-universal application across key domestic areas.

Fig. 4: Eco-enzyme is widely used as a natural cleaning agent.

Table 4: Eco-enzyme is widely used as a natural cleaning agent.

Application	Never (%)	Rarely (%)	Occasionally (%)	Usually (%)	Excessively (%)
Kitchen	0	0	0	98	2
Floor	0	0	0	100	0
Laundry	0	0	0	2	98
Glass	0	0	86	12	2

According to the data (Table 4), 100% of respondents used eco-enzyme for kitchen cleaning, reflecting its strong suitability for removing grease and keeping hygiene in food preparation zones. Similarly, 98% reported using it on floors, showing an elevated level of trust in its ability to clean large surface areas effectively while being safe and environmentally friendly. In the case of laundry, 98% of users also applied eco-enzyme, with most saying excessive use driven by the feeling that natural cleaners need higher quantities for effective stain and odor removal. In contrast, glass cleaning was significantly less frequent, with only 14% of users reporting usual or excessive use. This limited application is due to the specific demands of glass surfaces, such as the need for streak-free clarity, which eco-enzyme may not consistently provide without specialized formulation. These findings highlight eco-enzyme's strong potential as a multipurpose cleaner, especially in high-use areas, while also pointing to opportunities for improvement in its formulation or guidance for use on delicate surfaces like glass.(Table 4) Multipurpose Uses of Eco-Enzyme (Table 5), Eco-enzyme is widely used as a natural cleaning agent, especially for kitchens, floors, and laundry, where most users report regular or excessive use. Eco-enzyme can be used at the lowest possible cost; none of the participants said that it was nevertheless not expensive, 14 percent said that it was time-consuming and had a foul odor; otherwise, 64 percent said that they had no concerns. Overall, eco-enzyme is considered an effective and affordable alternative to chemical cleaners. Cleaning chemical agents affects the environment, 72 % of respondents agree that the chemical cleaning agent causes environmental degradation, and just 16% report with neither agreeing nor disagreeing. (Table 6) Eco-enzyme cleaning agent used with issues. Cleaning chemical agents affects the environment, 72 % of respondents agree that the chemical cleaning agent causes environmental degradation, and just 16% report with neither agreeing nor disagreeing (Table 7) Comparison between physical difficulties of eco-enzyme agent user and chemical agent user. When comprehensively compared and closely analyzed, individuals who regularly and consistently used eco-enzyme cleaning agents reported significantly fewer and remarkably reduced health-related issues and environmentally triggered physical discomforts than those who habitually relied on chemical-based cleaning products (Table).

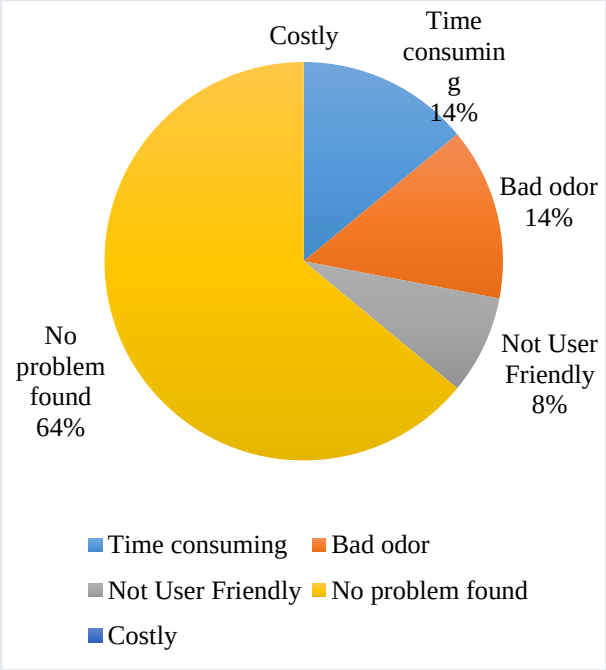

Fig.5. Eco-enzyme cleaning agent uses with issues.

Table 5. Eco-enzyme cleaning agent uses with issues.

Time consuming	Bad odor	Not User Friendly	No problem found	Costly
14%	14%	8%	64%	0%

Table 6: Eco-enzyme cleaning agent uses with issues.

Comments	Frequency	Percent
Strongly agree	0	0
Agree	36	72
Neither agree nor disagree	8	16
Disagree	6	12
Strongly disagree	0	0

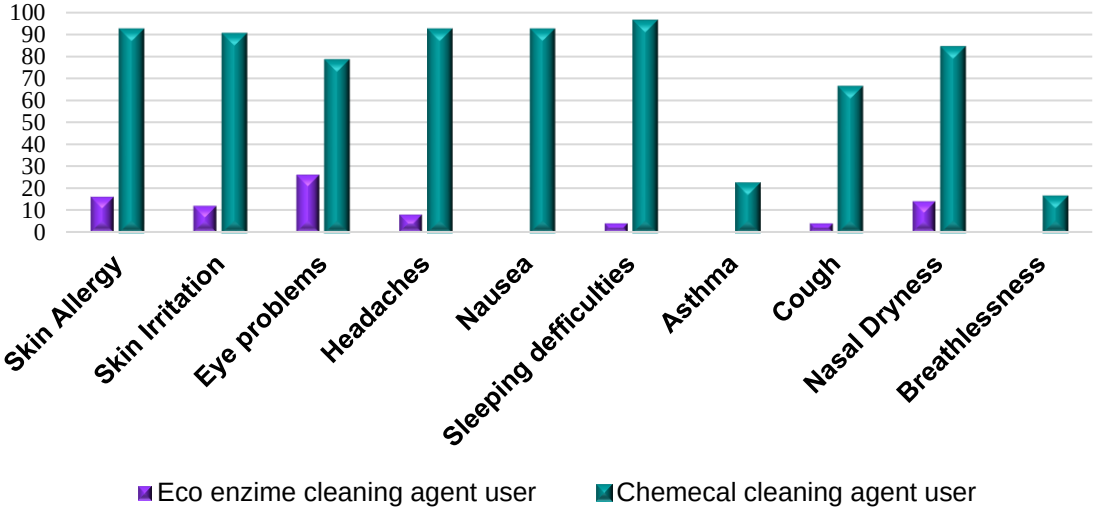

Fig. 6 :Comparison between physical difficulties of eco-enzyme agent user and chemical agent user.

Table 7:Comparison between physical difficulties of eco-enzyme agent user and chemical agent user.

Difficulties	Eco enzyme agent user (%)	Chemical agent user (%)
Skin Allergy	16	92
Skin Irritation	12	90
Eye problems	26	78
Headaches	8	92
Nausea	0	92
Sleeping difficulties	4	96
Asthma	0	22
Cough	4	66
Nasal Dryness	14	84
Breathlessness	0	16

This conclusion is drawn from two sources: (1) original and primary field data collection directly from eco-enzymes users, and (2) health impact statistics derived from a master's thesis by Susmita (2021), which though unpublished provided detailed comparative findings on chemical cleaner exposure. The contrast in health outcomes was both large and statistically meaningful. Field data revealed that none of the eco-enzyme users reported symptoms of nausea or asthma. In sharp contrast, Susmita (2021) recorded that 22 percent of chemical cleaner users experienced nausea, and 66 percent reported asthma-related symptoms. These findings are further supported by a peer-reviewed study by Pisutpaisal & Hunnangkul in 2017 [25], which confirmed that eco-enzyme applications significantly reduce harmful health and environmental effects compared to conventional chemical cleaning agents. This combined evidence strongly suggests that eco-enzymes offer a safer and more environmentally friendly alternative to synthetic chemical cleaners.

4.DISCUSSION

The study proves eco-enzyme's efficacy as a household cleaning agent, aligning with prior research on organic waste use [6]. By converting 3–4 kg of daily kitchen waste into eco-enzyme, households reduce waste

disposal by up to 70%, mitigating landfill pressure and methane emissions [1].The regression analysis highlights a strong correlation between eco-enzymes production and waste reduction, supporting its role in sustainable waste management. Eco-enzyme's widespread use for kitchen, floor, and laundry cleaning reflects its practicality and effectiveness. Its antibacterial and antifungal properties, attributed to acetic acid and probiotics formed during fermentation [26], make it a natural antiseptic, reducing reliance on chemical cleaners. Health benefits are clear, with eco-enzyme users experiencing significantly fewer issues than chemical users, consistent with findings on biodegradable cleaners [27]**.** Environmental benefits include reduced chemical pollution in water and soil, as an eco-enzyme is biodegradable and purifies water bodies when residue flows underground [28]. Challenges like odor and fermentation time are manageable with simple modifications, enhancing user acceptance. Community-level adoption could transform eco-enzyme production into a small-scale industry, using kitchen waste for economic and environmental gains. Solutions for problems caused by eco-enzymes, recommendation by respondents are (a) As per respondents' suggestion, making an eco-enzyme takes a significant amount of time. For which a variety of approaches can be used. To speed up the creation of eco-enzymes, for example, yeast might be added to the mixture; It will only take 20 days for those enzymes to be available. Also, make use of any leftover pulp from a prior batch as well. As a result of this procedure, the eco-enzyme will be ready in 30 days.(b). Few participants in the study expressed displeasure with the harsh odor of the eco-enzyme solution, prompting them to suggest multiple ideas to mitigate the odor, which is detailed here. To create a refreshing scent, add orange/lemon peel, pandan leaves, or other fragrant ingredients to enzymes. Eco-Enzyme can also be scented by dissolving 10 percent of fragrant substances in the Eco-enzyme solution and allowing it to ferment for another one month after that. Aromatic elements include, for example, kaffir lime leaves, mint, lemongrass, rosemary, basil, curry leaves, pandan leaves as well as flowers and other plants.

5.CONCLUSION

Eco-enzymes are a practical, sustainable alternative to chemical cleaning products. Its use in the home environment has been shown to provide effective cleaning, significant waste reduction and health and environmental benefits. Its use in households has the potential to reduce landfill waste, reduce chemical pollution and improve public health. The following recommendations are proposed: community-driven initiatives for eco-enzyme production, government regulations on the use of chemical cleaners and promotion of organic alternatives. Future research should explore industrial-scale production and long-term environmental impacts. This study showed how eco-enzymes can be a safe and natural way to clean while helping to reduce the use of harmful chemicals. Based on this idea, the author is now doing PhD research to use echo-enzymes in a broader and more scientific way. The PhD topic is "Optimizing hydrogen-efficient biogas production by anaerobic co-digestion of waste sludge with eco-enzymes and nano zero-valent iron (nZVI)." This research will try to produce clean energy such as hydrogen and methane using waste materials. Eco-enzyme residues and a special ingredient called nZVI will be added to help the process work better. The goal is to convert waste into energy, reduce pollution and protect the environment. This future work is well related to the current research and shows how eco-enzymes can help in both household and large-scale environmental solutions. Following the sentiment of the results of the various parameter studies, we can come to the following conclusions about the parameters. According to the results of this study, the use of cleaning chemicals has negative health effects, which is becoming an increasingly important concern. We need to address this issue now to solve the emerging problems. The results of this study lead to the formulation of the following suggestions to reduce the harmful effects of cleaning chemicals and change the frequency of their use. : Public representatives should work to raise awareness, also provide training and encourage its use in the neighborhood. Considering the benefits of its use, the use of chemical agents, as well as its use, should be increased. We all have a responsibility to take care of the Earth, which desperately needs our help. We should make concerted efforts to protect nature and restore ecosystems to ensure that future generations can live in a healthy and sustainable environment. And eco-enzyme production is a simple but effective strategy to protect the environment. Eco-enzyme production is a kind of recycling process because the required material for it is food waste other than meat. Regular eco-enzyme production by all of us will be beneficial for our community and ultimately for the environment.

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