Review Article

Review on Versatile Application of Bio-Enzymes for Sustainable Environment

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Abstract: Enzymes are biological catalysts, sometimes referred to as biocatalysts, that accelerate reactions in living things. They can be extracted from cells and utilized to catalyze a variety of commercially significant activities. Fresh fruit and vegetable waste ferments in the presence of water and jaggery to form organic chemicals known as bio-enzymes. It is shown that the greatest option for household and agricultural applications is the biodezyme. It is a naturally occurring, non-toxic, non-flammable, and noncorrosive liquid enzyme formulation fermented from vegetable extracts that enhances soil's engineering properties, enables greater soil compaction densities, and boosts stability. Soil stabilization and improvement are frequently employed as a substitute for inadequate materials on the site. Stabilizing soils can improve their durability and strength or stop erosion and dust production. Every day, more and more non-traditional chemical stabilizers are being used to improve soil. To enhance the mechanical performance and suitability of clayey soils, a bioenzyme was created. Enzymes speed up reactions so they can happen within a time frame that is useful to biology. Fruit and vegetable waste is organic and contributes significantly to soil, water, and air pollution. Enzyme Bio-cleaners are organic compounds that include enzymes that are made by using specific microorganisms like yeast and bacteria to ferment fresh fruit and vegetable wastes with brown sugar and water. This anaerobic fermentation produces natural chains with the ability to break down, change, construct, and catalyze processes, making it an incredible domestic cleaning aid in addition to other uses. The research and important work on Bio-enzymes are reviewed in this study. It aids in the reduction of trash and transforms it into a material that is affordable, readily available, and perhaps fully beneficial to society.

Keywords: Bio-enzymes, biocatalysts, fermentation, eco friendly chemical stabilizers , organic waste management

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1. Introduction

One type of organic substance is an eco-enzyme. Fruit and vegetable peels and other fresh kitchen trash are fermented to create this complicated solution. This kind of homemade vinegar is manufactured by fermenting kitchen trash with sugar as a substrate to reduce the alcohol. Fruit peels and other organic waste can typically be used to make bio-enzymes. Because of their unique qualities, such as their high acidity value, strong flavor and scent, high vitamin C content, and possible health advantages, tangy fruit peels are used. Eco-enzyme has antibacterial, antifungal, and insecticidal qualities. It can be used as a cleaning agent as well. The first person to create bio-enzyme was Poompanvong. Other names for bio-enzymes include ecoenzymes, rubbish enzymes, terrazymes, fruit enzymes, flower enzymes .

Eco-enzymes are a group of enzymes that quickly catalyze a variety of activities. Chemically speaking, eco-enzymes are a mixture of polypeptides, polysaccharides, bioactive substances, and other substances that are created on their own by some bacteria. The fermentation of bio-enzymes involves the addition of water, fermented fruit and vegetable waste, brown sugar, or carbohydrates.(1)

Biological macromolecules, mostly proteins, that function as extremely effective catalysts in living systems are known as Bio-enzymes, or simply enzymes. By reducing activation energies, they speed up chemical reactions and allow metabolic pathways to continue under mild conditions (neutral pH, physiological temperature) that would otherwise be kinetically prohibitive. Enzymes have historically been used in biochemistry and cell biology, but in recent decades, business and researchers have increasingly used them for environmental applications. This transformation has been prompted by urgent sustainability issues such resource depletion, pollution, and climate change.

A lack of rainfall, nutrient-depleted soil, and climate change have all contributed to production problems in many regions in recent years. In an effort to increase productivity, farmers regularly apply chemical pesticides, herbicides, and fertilizers. Even though these compounds have positive effects as first, they eventually deplete soil nutrients by damaging beneficial bacteria and leaving the soil even more barren. Additionally, during irrigation, dangerous pesticides and herbicides seep into groundwater. A major concern is producing long-lasting, appealing products that are both economical and ecologically friendly. Enhancing soil quality with natural fertilizers like bio-enzymes and bio-composites.[2]

Bio-enzymes , their primary constituents are fruit and vegetable peels, which are regarded as waste and thrown away, Bio-enzymes are completely organic and help reduce waste. They are completely organic, non-toxic, non-corrosive, and non-hazardous liquids.[3]

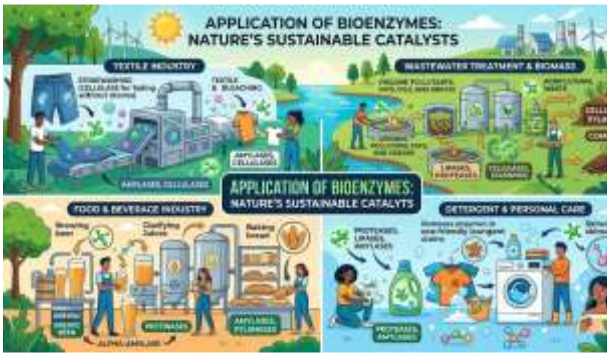

Fig.1 Application of Bio-enzymes

2. Preparation Of Bio-Enzymes

Bioenzyme preparation involved gathering fruit peels (Pineapple, Orange, and Lemon separately) from nearby juice vendors and combining them with water and jaggery in a 3:1:10 ratio in individual airtight plastic containers. To speed up the fermentation process, a small amount of yeast was added. To release the gases produced by fermentation, the containers were opened every other day. All three liquids were filtered after 45 days.[4]

Preliminary Screening and Quantitative Analysis of the Extracts

Protein Estimation: The Lowry-Bronsted method was used to estimate the amount of protein in the sample. The standard was bovine serum albumin. To create the standard graph, a series of protein solutions with progressively higher concentrations (0, 2, 4, 6, 8, and 10 mg/ml) were made, and their absorbance was measured at 660 nm. The standard graph was used to determine the protein content of the samples [5]

Sugar Estimation: Sugars present in the sample were evaluated using DNSA reagent. Dextrose was employed as the standard. A series of sugar solutions in increasing order (0, 0.125, 0.25, 0.375, 0.5, 0.625, 0.75 mg/ml) of their concentrations were prepared, their absorbance was measured at 520nm, for generating the standard graph. 1ml of each sample were diluted with 9 ml of distilled water and 0.1ml of this extract was evaluated. The values of the sugar content present in the samples were estimated using the standard graph and then were multiplied by the dilution factor.

Acetic Acid Estimation: Acid-base titration was used to measure the amount of acetic acid in the samples. Phenolphthalein was used to titrate the samples against sodiumhyroxide (NaOH). It was observed how much NaOH was needed to neutralize the acetic acid in the sample. The sample's acetic acid content was determined using the normality equation (N1V1=N2V2). [5]

3. Bio-Enzymes Applications

Bio-enzymes have been shown to have a wide range of applications, from agriculture to the home. A variety of bio-enzyme used because Bio-enzymes are entirely natural and aid in waste reduction, their applications are numerous. It is the greatest substitute for the harsh, aggressive, and non-biodegradable cleaning products on the market that are based on chemicals. The best aspect is that anyone can make them in their homes and kitchen gardens without the need for a fermenter or other special equipment.[1]

3.1Bio-enzyme for soil improvement

Biological methods integrate engineering practices with ecological principles, they have become a promising alternative to traditional ways in soil improvement initiatives. With this method, systems are designed and built with living plant materials as essential structural elements.[7] It provides advantages from an ecological and environmental perspective in addition to an engineering one.[8]

The two main biological approaches are bio-enzyme and microbial/enzymatically induced carbonate precipitation s(MICP/EICP). In MICP/EICP, urease breaks down urea into carbonate ions, which then react with surrounding metal ions to generate precipitated carbonate minerals. By filling, covering, and cementing the microstructure, these minerals may enhance the characteristics of the soil.[9]

3.1.1 *Engineering properties of bio-enzyme stabilized soils*

Physical Properties

It has been shown that bio-enzymes can improve the physical characteristics of soils. For instance, they can raise the maximum dry density (MDD) while decreasing the liquid-plastic limit, plasticity index (PI), and optimal moisture content (OMC). It is clear from summarizing the findings of typical studies on bio-enzyme stabilized soils that soil parameters and enzyme dose have an impact on the improvement effect in the physical qualities of stabilized soil. This improvement can be modest to substantial, and in certain situations, it might even result in unfavorable outcomes like a decline in MDD.

The amount of bio-enzyme used has a significant impact on the physical characteristics of stabilized soils. Research has indicated that at low enzyme dosages, the compaction properties (MDD and OMC) may only slightly improve.[10] [11] [12] [13] [14] [15] [16] [17] It has been suggested that the inconsistent and uneven soil found in laboratories may also be the cause of this. Increasing the amount of enzymes can effectively decrease the electric double layer's thickness, increasing soil improvement's efficacy.[18]

In general, when the dosage of enzymes increases, the improving effect of soils tends to first grow and subsequently decrease.[19] High plasticity soils, however, might require higher enzyme dosages to meet the threshold needed for successful soil improvement; otherwise, the MDD would continue to rise and the OMC will continue to fall until the ideal enzyme dosage is reached.[20]

In conclusion, research on enzyme-treated soil has produced a wide range of results, from negligible to substantial improvement and even the opposite.

These differences are explained by things like soil characteristics, enzyme specificity, and enzyme dose. Because independent laboratory testing is required to confirm their efficacy, it is imperative to approach claims or findings from enzyme producers with caution.[21]

Chemical Properties

The bio-enzyme treatment has shown potential to enhance the mechanical properties of soil [22][23] such as increasing the unconfined compressive strength (UCS) and California bearing ratio (CBR), etc. Summarizing the details of representative studies on the initial soil properties/sample preparation methods and mechanical properties of bio-enzyme stabilized soils. A. Water content, specimen preparation techniques, soil characteristics, enzyme specificity and dosage, and other factors all affect how much the mechanical properties of stabilized soil increase. In summary, Bio-enzymes have the potential to improve the mechanical strength of soil, but their effectiveness depends on a number of variables, such as water content, sample preparation method, soil characteristics, enzyme specificity and dosage, etc. Nonetheless, there is still disagreement over how soil characteristics affect the mechanical strength of enzyme-stabilized soils, which calls for more investigation into the actions of the enzymes and the structure of the products they produce.

Although the use of bio-enzymes in environmental geo-technics has shown a lot of promise, there is still a clear deficiency in the methodical arrangement of the information that is now available. The main ideas of this book, which aims to assess the advancement of bio-enzyme technology, are summed up as follows:

Plant fermentation and animal extraction are the sources of bio-enzymes, a new class of natural, organic, and biodegradable soil enhancement products. They usually contain proteins, surfactants, and other unique ingredients and have no detrimental effects on the environment. Bio-enzymes may improve soil by lowering the net negative charge on soil particle surfaces through processes like cation exchange, specific binding, and surfactants. This would decrease the thickness of the electric double layer and the water affinity.

Bio-enzymes could modify the engineering properties of soil, generally yielding favorable effects. They could reduce the liquidplastic limit and the OMC, while enhance the MDD, UCS, and CBR. However, the improvement performance depends on the soil properties, enzyme dosage, specificity, and sample preparation, among other factors.

Bio-enzymes could be synergized with other stabilizers for soil improvement, and these bio-enzymatic composites might more considerably improve the physical and mechanical properties as well as other geotechnical characteristics of soils, and enhance the modification efficiency.

The engineering applications of bio-enzyme have demonstrated its capacity to mitigate common pavement diseases, decrease maintenance expenses, and enhance construction efficiency.

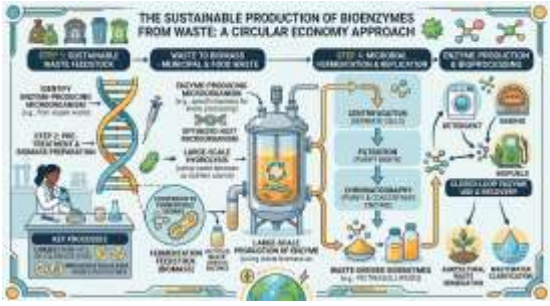

Fig.2. Bio-enzyme formation process

3.2 Bio-Enzymes: Enhancing Water Quality and Sanitation

Lakes are essential parts of Earth's ecosystems. Lakes provide a variety of benefits, including groundwater recharge, habitat for wildlife, climate regulation, and water supplies. A significant barrier to accomplishing SDG 6 is lake pollution, which compromises water quality, harming ecosystems, and putting human health at risk. Increased nutrient input from these sources, fueled by increased human activity in the lake's surrounding areas, is probably what is causing the surge in eutrophication [24]. Eutrophication, which causes algal blooms, lowers oxygen levels, and disturbs aquatic life, is a result of excess nutrients from agricultural runoff. Furthermore, hazardous substances like pesticides and heavy metals are introduced into lakes by domestic and industrial waste, rendering the water unfit for human consumption. Since many lakes are important sources of drinking water, pollution greatly raises treatment costs and, in extreme situations, makes these water sources unusable. Communities that depend on contaminated lakes face significant health risks due to exposure to hazardous materials and waterborne illnesses. By endangering aquatic species that are vital to ecosystems and livelihoods, pollution also reduces biodiversity. The deterioration of water quality has a negative economic impact on sectors like tourism, fishing, and agriculture. The health of ecosystems and human well-being are seriously threatened by the loss in water quality, which has negative effects on drinking water standards, biodiversity, and the growth of dangerous algal blooms. [25]

Treating wastewater, promoting sustainable farming methods to reduce runoff, and raising community knowledge of water conservation are some ways to address these issues and advance SDG 6. To guarantee sustainable freshwater management, it is essential to enforce pollution restrictions, restore degraded lakes, and safeguard key water zones. Chemical treatment of water results in the production of non-biodegradable byproducts, residual chemicals, high operating costs, and a rise in the waterbody's toxicity. Enzymes are specialized biological molecules, frequently proteins, that operate as natural catalysts to speed up metabolic reactions in living things [26].Organic matter is broken down by bio-enzymes, which also raise DO and decrease BOD and COD. The use of Bio-enzymes provides a more accessible and sustainable solution to water treatment.

Enzymes, which are mostly made of proteins and peptides, can be readily extracted from contaminated streams without posing disposal problems because they are biodegradable by microbes. [27] Wastewater can be used for a variety of purposes, such as floor cleaning, car washing, and gardening, after being pre-treated using garbage enzymes. [28]

A bio-enzyme solution for purifying water bodies can be made by combining one liter of bio-enzyme with ten thousand liters of fresh water and letting it ferment in a sealed container for twenty-four hours. This technique makes it possible to scale bio-enzyme quantities effectively in a day with little effort. Tankers with sprayers are then used to apply the prepared solution throughout the pond. After the first application, this therapy should be repeated every 30 days. An initial survey was carried out to gather water samples and analyze important parameters like DO (Dissolved Oxygen), BOD (Biochemical Oxygen Demand), and COD (Chemical Oxygen Demand) in order to evaluate the efficacy of the treatment. These criteria were reassessed after three months of monthly treatments, and the results showed notable improvements. [29]

Wastewater can be used for a variety of purposes, such as floor cleaning, gardening, and car washing, after being pre-treated using garbage enzymes.[30] Bio-enzymes are used on a very small scale and are still largely unknown in India. [31]

Treatment with Bio-enzymes must be viewed as a significant process. This paper describes the manufacture of Bio-enzymes from kitchen waste, such as fruit and vegetable peels, and the use of Bio-enzymes to purify the water in Saroornagar Lake. The procedure demonstrated the bio-enzyme's efficacy in treating wastewater. [32]

In summary, The application of bio-enzyme led to a considerable rise in dissolved oxygen levels, which improved with time and at greater enzyme concentrations. In the current investigation, treatment with a 5% bio-enzyme solution has shown greater efficacy. BOD significantly dropped, demonstrating the organic pollutants' efficient breakdown. Both organic and chemical pollutants decreased, as seen by the notable drop in COD. When access to sophisticated water treatment facilities is restricted, the demonstrated effectiveness of bio-enzymes in enhancing water quality underscores their promise as an affordable and sustainable water treatment alternative. The study offers a creative, environmentally responsible method for rehabilitating freshwater habitats, highlighting the revolutionary significance of biotechnology in sustainable water management.

3.3 Impact Of Bioenzyme On Plant Growth And Maturation In Vegetable Crop

Agriculture is the primary industry in India. India's GDP and employment are mostly derived from agriculture, making it essential to the nation's economic growth. Therefore, ensuring that agriculture continues to be profitable is essential for a nation like India.[1]Despite an 11.0% growth in vegetable area, just 2.8% of India's total agricultural land is used for vegetable crops. Over the past ten years, the nation's vegetable output has grown significantly, with increases in land area, yield, and efficiency of up to 60% and 44.7%, respectively. Global vegetable production from 40 million hectares is 606 million tons, according to FAO statistics from 1998.

Olericulture is the process of growing, preserving, preparing, and selling vegetables. Vegetables are low in calories and high in vitamins and minerals like B-carotene, vitamin B, folic acid, vitamin C, vitamin E, dietary fiber, carbs, protein, and energy.[2]

A bio-composite is made up of inorganic and non-polymeric components that increase mechanical strength and protect against environmental deterioration, as well as a natural fiber matrix (resin) for reinforcement. Bio-composites are inexpensive materials with the ability to enhance soil nutrient quality, reduce pathogen growth, improve soil texture, and boost plant productivity. Bio-composites shield the environment from pollutants because they are natural fertilizers. Agro-waste-derived enzymes are used as bio-catalysts to enhance crop growth, cell metabolism, cell division, compost breakdown, and micronutrient release. Therefore, the consumption of bio-enzymes facilitates the proper distribution of nutrients found in fiber or biomass, leading to quick development.[33]

In summary, The data collected indicate that the use of bio-enzymes improves plant development and growth. Among the three treatments, the bio-enzyme treatment had far more germination and plant growth than the control. The presence of soluble sugars, carbohydrates, proteins, organic acids, vitamins, etc. may be the cause of this increase in bio-enzyme development. In order to bolster the findings, the study[34] looked at how Bio-enzymes affect photosynthetic activity and chlorophyll content, which can be impacted by a drop in soil nitrogen levels, which in turn affects plant development. According to the study's findings, using Bio-enzymes significantly increases the amount of chlorophyll. The purpose of the study was to look at how different parameters are affected by Bio-enzymes. By increasing the number of beneficial bacteria in the soil, the application of Bio-enzymes enhances soil fertility and quality. These biological enzymes were even used as insecticides, fungicides, and weed killers, and the study found that they also functioned as plant development regulators.[1]

3.4 Enzyme Bio-Cleaners From Production Of Fruit Waste

The usage of synthetic cleaning agents, which have the potential to discharge hazardous compounds into the environment and drastically alter pH, has caused significant environmental concerns in recent years.

The most recent cleaning technologies, however, include enzyme-containing cleaning solutions that are highly efficient, safe, and selective in their activity. They are also less expensive to prepare.[35,36] Enzyme bio cleansers are an organic solution made by using specific microorganisms like yeast and bacteria to ferment fresh fruit and vegetable wastes with brown sugar and water. Natural protein chains, mineral salts, organic acids, alcohol, and enzymes are produced by this fermentation process. The resulting Bio-enzymes are an excellent cleaning tool for usage in industrial, medical, and home settings because of their ability to break down, alter, generate, and catalyze activities. Since enzyme bio-cleaners are becoming the ideal choice for consumers in the future for a variety of applications and a sustainable environment, they are referred to as natural green chemicals.

The purpose of the enzyme bio-cleaning solution is to quickly, affordably, and safely get rid of filth. It breaks down organic and chemical waste fast and effectively without producing any harmful gases or odors. Therefore, it will be necessary to produce a suitable substitute for the synthetic cleaning solution in the future with regard to biodegradability, low toxicity, non-corrosiveness, environmental friendliness, improved cleaning qualities, and higher efficiency and stability in various environmental circumstances. Bio-Bacterial innovation is the foundation of these cutting-edge environmentally friendly cleaning products. This invention, which contains billions of beneficial bacteria, eliminates the source of cleaning problems rather than hiding them. Cleaning is made easier and more environmentally friendly with bio cleaner, which promises a natural solution to common cleaning problems without the need for harsh chemical cleaners.

Both bacteria and enzymes cooperate to clean in bio-enzymatic cleansers, depending on one another to complete the task. When sprayed to surfaces, the enzymes break down stains, dirt, and odors, which the bacteria then eat. These microscopic "cleaners" proliferate and continue to eliminate traces of dirt and odor from surfaces hours or even days after the original application, provided that the soil is present and the surfaces are sufficiently moist.

Although they are originally extracted from bacteria, enzymes can also be utilized in some cleaning products without the presence of bacteria. For instance, the chemical reactions of other chemicals in laundry detergents are catalyzed by enzymes. They aid in the breakdown of soils in wash water, making it easier for water to remove them. For various cleaning tasks, including carpet cleaning, laundry detergents, degreasing, drain maintenance, general surface cleaning, restroom cleaning, and odor removal, bio-enzymatic formulations are very effective.[37]

In summary, The goal of the current project was to produce and analyze the fermentation parameters of an enzyme bio-cleaning solution using agricultural waste and residues, such as fruit waste, with the aid of bacteria (*Bacillus sp.*) and yeast (*Sacharomyces sp.*), along with less expensive sources of carbohydrates like brown sugar and water medium. In conclusion, cleaning is crucial for the dehairing process in tanning industries, maintaining cleanliness, preventing rust formation, cleaning floors, removing stains, etc. We think the enzyme cleansers would eventually take over the majority of the Indian market because of their high efficiency and safety.

4. Conclusion

One highly useful organic waste product that aids the nation in lowering the amount of organic dump garbage is bio enzyme. Based on the results, it can be concluded that using Bio-enzymes will help the nation meet the 2030 SDGs. Since many other factors are interconnected, we can also state that bio-enzymes are a promising vital factor for the country's advancement and the expansion of the worldwide market. However, bio-enzymes will also play a role in achieving the SDG objective 2030.

Liquids containing Bio-enzymes lessen environmental toxicity, which will help reach SDG 2030. A nation's SDG objectives cannot be met by a single element; instead, a number of factors are taken into consideration, one of which is bio-enzyme. Although it would have a shorter shelf life and possibly less cleaning efficacy over time, a Bio-Enzyme with a pH of 4.7 would function. Because it contains classes of digestive enzymes, this bio-enzyme can be used for household cleaning and can remove the majority of stains. The study had certain limitations, including the use of only two kinds of kitchen waste, the Bio-Enzyme production not being carried out under ideal conditions (the jar was opened daily, which should have been stopped after the start of anaerobic respiration), and the failure to test various ratios of bananas to lemons.

This project helps society transition to a chemical-free, sustainable environment. Additionally, Project Nesara works with non-governmental organizations (NGOs) and gives the poor access to jobs.

Ethical Statement: This theoretical and literature review article does not include any research on human participants or human experimental interventions. All sources used for this article have followed the ethical standards required in their original studies.

Conflict Of Interest Statement: Authors have also declared that there are no conflicts of interest regarding this article.

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