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Wealth from Waste: A Review of Garbage Enzyme

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Abstract - *The world will generate 2.59 billion tonnes of waste every year by 2030. Within this waste, organic waste is emerging as a significant contributor to climate change as the world's demand for food rises. Landfills are a common management technique but cause groundwater pollution, disturb ecosystems and cause health problems in surrounding residential colonies. Apart from other common and safe ways to manage raw organic waste including composting, biofuels etc., Garage Enzyme or Eco Enzyme is a viable option. It is made from the fermentation of raw organic waste with water and organic sugar. It has applications ranging from wastewater treatment to soil treatment and disinfection. This theoretical study surveys the materials, methods and properties of eco enzyme solution. It then goes on to review various applications of eco enzyme solution. Further, the limitations are discussed along with the future scope of this solution in solving ecological problems of the world.*

Key Words: Garbage Enzyme, Eco Enzyme, Solid Waste Management, Wastewater Treatment, Environmental Engineering

1. INTRODUCTION

Organic waste management is becoming one of the major challenges in the postindustrial era. Global food waste and loss is responsible for 8% of GHG emissions annually [1]. About 60% of all food wasted around the world is made of fresh fruit and vegetable waste which is generated through production, processing, eating, cooking, peeling and cutting activities by FMCG companies, restaurants and households. About 80% of this waste can be reused since it has fiber content, moisture and other nutrients .[2]

It ends up in landfills which are hazardous for residencies and also produce toxic leachate which can degrade groundwater. The organic waste in these sites is acted upon by bacteria which produces a gas 25 times more potent than carbon dioxide: methane. Therefore, alternate methods are being researched.

Garbage enzyme is an organic solution produced by the fermentation of fresh kitchen waste, organic sugar (brown sugar, jaggery, molasses etc.) and water. It has the potential to solve the environmental challenges of the 21st century in a cost-effective manner.

1.1 Enzymes

Protein molecules in the bodies of living beings that catalyze chemical reaction are known as Enzymes. They act as biological catalysts and catalyze only specific molecules (substrates). They provide the right orientation and surface area for the reactants, thus reducing activation energy. They themselves remain unreacted during the reaction. Enzymes are used in many industries including foods, beverages, detergents, textiles, leather, chemicals, biomedical etc. The amylases are a group of enzymes that hydrolyze starch molecules to generate smaller polymers composed of glucose units. They are already well known to enhance the treatment of starch containing food wastewaters. Proteases are known to solubilize proteins in waste streams resulting in residue solids used for animal fodder (for cattle and fishes). Lipase has been used for prevention of fat blockage or filming in waste systems before discharging wastewater into the sewage system. Slaughterhouse wastewater, which is rich in fats, has also been treated with lipase group of enzymes.

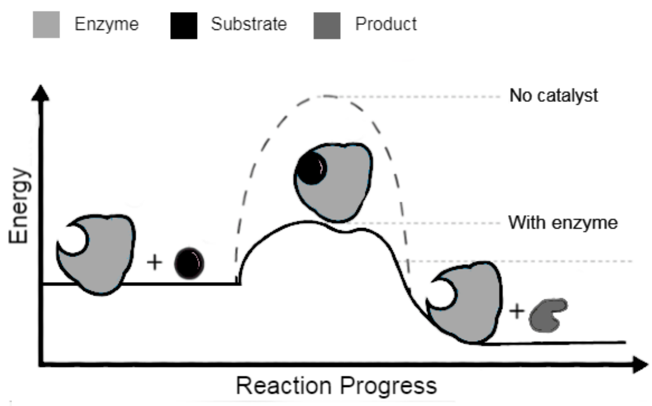

Fig -1: Common mechanism of action of Enzymes

1.2 Enzymes Production

Microbial Fermentation process is common in biochemical engineering to produce enzymes on a larger scale.

Scale-up is required which is achieved by fermenters of different volumes.

Fermentation is the metabolic process of breakdown of complex sugar into simpler ones.

Along with photosynthesis and aerobic respiration, fermentation is a way of extracting energy from molecules. During fermentation, due to a lack of complex digestive systems, microbes pre-digest the potential food source such as organic and inorganic materials outside their cell boundaries first. To achieve this pre-digestion, microbes excrete enzymes through their outer membrane with its supportive cell wall into the environment. [3] Microbes can be made to produce large quantities of enzymes under suitable growth conditions. They can be cultivated by using inexpensive media and production can take place in a short period of time.

1.2 A Solution for Waste Crisis

Raw organic waste is a well-known non edible source of lipids, amino acids, carbohydrates, and phosphates. Biomass contains 30–50% of cellulose, 20–40% of hemicellulose and 10–15% lignin. Cellulose is the main assembly of lignocellulosic biomass which is a glucose polymer. During fermentation of waste, after glucose and other simpler sugars are produced, the process continues till ethanol is produced by the action of yeast called Saccharomyces Cerevisiae. Further, ethanol is oxidized into acetic acid by the Acetobacter Aceti group of bacteria [4]. The end result is a multipurpose solution which can work as a cleaner, insecticide, pesticide and organic fertilizer. It can be used for pre-treating wastewater and preventing drain blockages as well.

2. PREPARATION OF G.E

Organic Sugar (brown sugar, jaggery, molasses etc.), raw organic materials (Fruit and vegetable peels, petals, fresh leaves etc.) and water are mixed together in the ratio of 1:3:10 to prepare Garbage Enzyme.

Extra sugars are provided externally because as the microbial colonies grow, they need more energy to digest complex food sources. Organic sugars are preferred over refined sugars because of high mineral content which serves as food for microbial fermentation. Use of molasses may be better compared to other sugar sources. This is because molasses sugar is the unwanted substance from sugar production that contains microorganisms. Due to the presence of these microorganisms, the organic matter in fruit wastes is further and faster decayed.[5]

The mixing process is done in an air-tight plastic container which is able to expand. During the first month, gasses are released during the fermentation process. Pressure built up in the container is released daily or in two days to avoid rupturing for the first month.

The container is left undisturbed in a cool, dry and well-ventilated place. It is left to ferment for 3 months to produce GE solution. The fermentation yields a brownish liquid, which is separated from the solids. The solution is filtered after 3 months to obtain the required solution.[3]

Fig -2: GE prepared from fermenting sugar, waste and water in the ratio of 1:3:10 by weight

3. PROPERTIES OF G.E

The color of GE is dark brown but the type of raw material used could be responsible for change in color and odor. Use of more vegetable peels makes it smell pungent compared to fruit peels, which leave a fragrant smell.

Chemical analysis indicates 0.15 ml/ml of alcohol content and 4.8 g/ml acetic acid on an average along with the presence of majorly Amylases, Lipases and Proteases groups of enzymes. Depending on the type of peels used, other enzymes in small quantities may be found (Papain enzyme from papaya peel etc.).[6]

Biological analysis of GE indicated probable presence of bacteria and yeasts like Pseudomonas, Yersinia, A. niger, Trichoderma viride, Saccharomyces cerevisiae and Rhizopus stolonifera. It is possible that a few other species could have died in an extremely acidic environment. [6]

The quantitative aspect of parameters changes with time, type of organic waste and type of natural sugar used for fermentation.

DESCRIPTION	PARAMETER	0 DAYS OF FILTRATION	30 DAYS OF FILTRATION	60 DAYS OF FILTRATION
Measure of acidity and basicity.	pH	3.09	3.41	4.01
Measure of dissolved combined content of all organic and inorganic substances.	TDS (mg/L)	2012	1415	1012
Represents the amount of oxygen consumed by bacteria and other microbes under aerobic conditions at specified temperature.	BOD (mg/L)	1252	535	83
Represents the amount of oxygen needed to oxidize organic matter	COD (mg/L)	44620	2523	153

Table -1: Typical physico-chemical parameters of GE changing over time [7]

4. APPLICATIONS OF G.E

4.1 Wastewater Treatment

80% or more wastewater returns to the environment without adequate treatment. Wastewater treatment methods mainly include physicochemical and biological methods. Physicochemical methods like chemical oxidation, distillation, membrane-based separation techniques, and adsorption work, but they are expensive and cause further pollution and damage. Biological methods are eco-friendly and remove most pollutants in wastewater. These methods use plants, microbes and enzymes for treating wastewater. [8]

The different physicochemical treatments like flocculation, chemical precipitation, coagulation, floatation, and membrane separation offer benefits like flexibility to change temperature, the simplicity of control and activity, and speed. They also have disadvantages, such as their operational expenses due to high energy utilization, the utilized chemical compounds, and costs for sludge removal. Therefore, Enzymatic processes can be a viable option for pretreatment of wastewater.

Enzymes act by dissociating the molecules to simpler forms and microbes utilize these intermediates in their metabolism, which results in complete degradation of substances. Microbes grow faster due to increase in availability of intermediates and therefore produce more enzymes which in turn degrade the substrate. This becomes a cyclic process.

Extracellular polymeric substances bind microorganisms together and help in adhesion of biofilms to surfaces. Hydrolytic enzymes present in GE destroy the physical integrity of extracellular polymeric substances or EPS that leads to weakening of the waste flock and solid settling in wastewaters treated with GE.

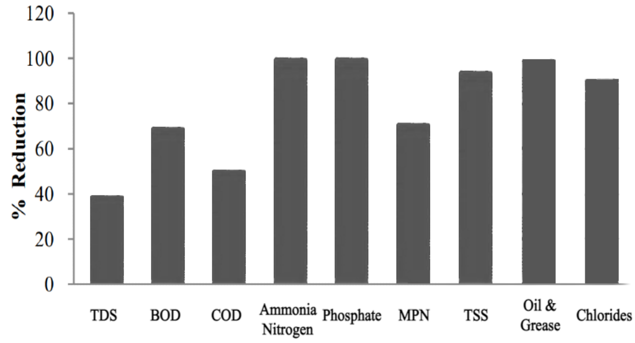

Chart -1: Common pollutants and their removal from wastewater using 10% GE (Data plotted using [3][9])

Garbage Enzyme has been successfully used to treat Greywater, Sewage Wastewater, Dairy Wastewater and Landfill Leachate. Treatment time for wastewater treated with GE varies from study to study and depends on how effective the GE solution is. Wastewater treatment time can be decreased if finely crushed organic waste is used for the preparation of enzyme solution, leading to better fermentation. Treatment time was found to be 5 days when enzyme is used 60 days after filtration as it takes time for the parameters in GE to stabilize.[3][7] For other studies, the minimum treatment time was observed to be 25-27 days from available literature.

4.2 Agriculture

Eco-enzyme can be used as a natural fertilizer and biopesticide because the ingredient to make it is kitchen waste which is an organic material. The insecticide property is likely due to the pungent smell of acetic acid. The composition of GE also makes it suitable for agriculture. Brown sugar or molasses is a carbohydrate source which breaks into carbon, oxygen, and hydrogen when it decomposes. These serve as nutrients for the soil. Protein from vegetables decomposes to give nitrogen which also fertilizes the soil.[10].

The results of a study show that the tendency of the best concentration to influence the growth of lettuce crop is 10 cc / L. Giving eco garbage enzyme solution gives a real increase in stem circumference, root growth, and dry weight of plants.[13]

Similar Results have been observed for aloe vera and chili plants.[11]

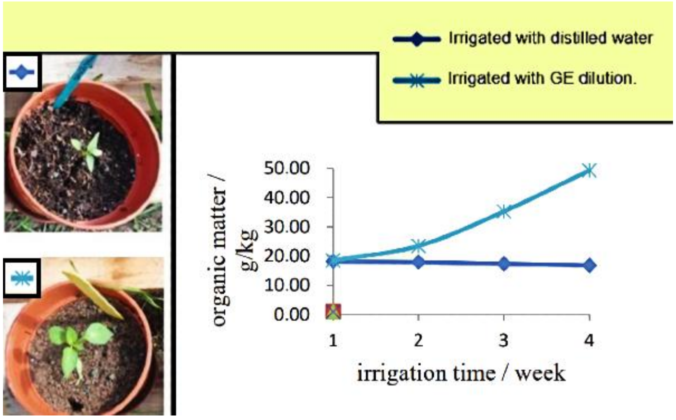

Chart -2: Results of 10% Garbage Enzyme irrigation on a chili plant compared with a plant irrigated with distilled water after 10 weeks.[11] . The graph on right from a different study showing improvement of soil quality with Garbage Enzyme [12]

4.3 Cleaning and Disinfection

Eco enzyme also displays cleaning properties. Acetic acid present in it is a good descaling agent that removes limescale. Removal of stains and oil blots can be attributed to the activity of lipase enzyme.

The antimicrobial potential of garbage enzyme for four microorganisms was measured by the zone of inhibition around the disc placed on the inoculated agar plate. When compared with control standards, the bacterial and fungal zone of inhibition for 15% garbage enzyme solution was higher than references.

Disinfectant potential of garbage enzyme was compared with phenol. The result indicated that the garbage enzyme can be diluted four times as much as phenol, till attaining equivalent killing power for the test organism as that of phenol.[5]

Another real-life study showed that the concentration of eco enzyme at 50% and above exhibited significant antibacterial activity against Enterococcus faecalis.

Enterococcus faecalis is one of the most common bacterial species. These bacteria also live in the mouth and reproductive tract of humans. They are resistant to hot, salty, or acidic environments.[14]

These studies show that Eco Enzyme is a powerful disinfectant. Along with the role of enzymes in breaking microbial flocks as mentioned above, acetic acid also contributes to the antimicrobial properties of Garbage Enzyme. Acetic acid crosses bacterial cell membranes because of the pH gradient, leading to the disruption of cellular metabolic activities of bacteria.

4. LIMITATIONS AND SCOPE

Eco enzyme is a multipurpose liquid which costs about 3-4 times less when compared to commercial cleaning agents and can be made at a fraction of the cost of industrial fertilizers and insecticides. It has the potential to solve the problems of solid waste management and therefore climate change. It is, in itself, completely biofriendly.

On the other hand, studies show that metal ions such as Ca^{2+}, Na^{+} and K^{+} was overall not affected in terms of reduction of the ions themselves. This could potentially be due to the natural properties of enzymes that do not react with the metal to form a secondary product. This restricts the usage of eco enzymes.[15]

There are plenty of studies on batch scale production and utilization of garbage enzymes but a stable and continuous method of production on an industrial scale is still to be seen. There is a need to determine the exact molecular mechanism of GE so that similar and more effective solutions can be developed using solid waste. Also, additives need to be discovered which reduce the fermentation period. These factors when combined hinder entrepreneurial activities.

The real success of eco enzyme lies in its ability to empower the cottage industries. Other than technical challenges, eco enzyme still faces major challenges. There is still a lack of awareness and therefore very little demand and production. Waste segregation into organic and non-organic waste is only seen in the metropolitan households of developing countries. Fruit juice vendors and small eatery operators see no incentive in selling organic waste to commercial facilities. Utilization of waste to resources for commercial activity is still not exempt from taxes in many countries.

The municipal corporations in developing countries can actively participate in the collection and segregation of organic waste as well as in the production and selling of GE to farmers and households at an economical price.

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