



# Microbial Enzymes: A Summary Focusing on Biotechnology Prospective for Combating Industrial Pollutants

Debosmita Sikdar<sup>1</sup>(✉), Ivy Kanungo<sup>1</sup>, and Dipanwita Das<sup>2</sup>

<sup>1</sup> Government College of Engineering and Leather Technology, LB Block, Sec III,  
Salt Lake, Kolkata 700106, India

debosmita.sikdar@gmail.com

<sup>2</sup> Amity University, New Town, Kolkata 700135, India

**Abstract.** Environmental issues are growing at an alarming rate and addressing the same is the need of the hour. Hazardous industrial pollutants and discharges are adding to the misery. Therefore, new ideas and technologies are being created and adopted to deal with ever increasing conservational troubles. Due to the burning issue of environmental pollution rising daily, a paradigm shift towards more sustainable and greener has to be pondered on. Microbial enzymes are such versatile, useful and beneficial weapons those can be exploited to combat the above-mentioned issues. In this aspect various works have been done and different sources of isolation of microbes and their fermentation process for procuring enzymes from them have been investigated in detail in those work. Pualsa Jagdish *et al.*'s work (2013) from Viva College, Virar, and Maharashtra entails that Lipase enzyme was procured from curd and waste oil was used as substrate. Lipase was produced by *Lactobacillus* sp. Whose lipolytic activity was calculated to be 0.082 U/mg. This enzyme if isolated under favorable conditions can be used to be applied for various industrial purposes in order to suppress the pollution rate and reduced the dependency on market-based chemicals and reagents those are highly dangerous and harmful. Work of Ashutosh Nema *et al.* (2019) [1], talks about the use of lipase enzyme as well as proteases are used as catalysts in biodiesel production as an effective and economical approach. According to Wu *et al.*, large scale productions of protease have been achieved from *Aspergillus* species for their application in food and beverage industries. Alkaline proteases were reported to be produced under solid state fermentation processes by *A. flavus* and *A. oryzae*. Ikram-Ul-Haq and Mukhtar (2015) [2] stated that *Penicillium* sp. Alkaline proteases were generated under both solid state and submerged fermentation. The *Mucor* sp. of fungi can produce protease for milk clotting and can substitute rennin in the cheese making industry. Fungal enzymes are commonly used in industries over bacterial enzymes due to various technical reasons such as the feasibility of gaining enzymes at a high concentration in the fermentation medium and easier downstream processing. This way it can be encapsulated that microbial enzymes are savior in the field of pollution remediation and replacer of harsh and hazardous chemicals for carrying out various industrial applications.

**Keywords:** microbes · enzymes · industrial pollutants · fermentation · lipase · protease

## 1 Introduction

Biodegradation stands for breaking down materials into environmentally acceptable products and biomass by the action microorganisms and their enzymes. This entails environmental as well as economic benefits. Microbial bioremediation is an attractive option over conventional techniques, such as incineration or chemical treatment, for disposing of pollutants. Recent evolution in microbiological and genetics techniques have handed over us the driving force to engineer microbes and their enzymes required for developing biodegradative pathways. Work of Pablo M. Ahmed *et al.* (2018) shows degradation and detoxification of industrial pollutants by microorganisms and demonstrating that microbial consortia development is a strategy that improves and optimizes bioremediation processes [3]. Zhaojie Cui *et al.* (2017) represented in their work the effective microbial remediation of *Mucor sp.*, *Actinomucor* and *Mortierella sp* and reduction in heavy metal activity [4]. Quite lately, genetic engineering has opened up new avenues for redesigning and remodelling microbial enzymes to be used in multiple industries. In addition, some of the emerging issues in the fields of agriculture, environment and human health can be resolved with the support of green technologies derived from microbial enzymes.

## 2 Microbial Sources

Microbial sources selected for procuring enzymes from them mainly comprise bacteria, fungi and yeasts. Main industrial include protease,  $\alpha$ -amylase, lipase, glucose isomerase [1]. The special uniqueness of enzymes which draw our interest to exploit them for commercial and industrial applications is: heat-tolerance, thermophilic nature, tolerance to wide range of pH, stability of enzyme activity over other harsh reaction conditions [5]. For example the enzymes procured from the microbes such as *Basidiomycetes*, *B. subtilis* are used for treating the wastewater got from paper and pulp industries. Likewise the enzymes from *Penicillium* and *Pseudomonas sp.* Are used for textile industry waste and oil and grease degradation. Along with that it is also worth mentioning that the microbial consortia and the enzymes extracted from them have the capacity for performing bio-transformation, biosorption, bioaccumulation, biodegradation of complex compounds, bio fertiliser and bio pesticide production, micronutrients solubilisation and biological nitrogen fixation etc. Hence through these ways microbes and their enzymes get involved in sustainable environmental management.

## 3 Microbial Enzymes

Primarily, enzymes were extracted from different organs of animals, but presently are produced from microbial because i) large scale production of enzymes, ii) The process of extraction and purification is easier in comparison to plant and animal sources, iii) production rate is higher, iv) genetic manipulation can carried out to get higher yield of enzymes [2]. Enzymes hydrolyze complex molecules into simpler units to involve in biochemical processes.

## 4 Industrial Enzyme Production

Growing eminence on biotechnological undertakings has started to outgrow the commercial demands for chemically derived catalysts. The progress in genetic manipulations has enabled large-scale production of enzymes (mainly crude in nature) [6]. Cultivation of microorganism by using low cost media as well as growth of microorganisms within a shorter span of time are the key features. In addition to it, using genetic engineering techniques on them to derive desired product is another attraction. Isolation, purification and recovery processes are easy with microbial enzymes as compared to plant and animal sources [7]. Therefore, most of industrial enzymes are shaped from microbial origin. The submerged conditions are mostly preferred over solid-substrate fermentation because yields are more and rates of contamination are lesser [8]. The growth conditions for fermentation like substrate, O<sub>2</sub> supply, pH and temperature, rpm are maintained at most favorable levels after inoculating the medium with culture of choice. The preferred enzyme produced may be extracellular in nature in case of fungal cells that are secreted into the culture medium where as might be intracellular that bound within the cells in case bacteria. The commercial enzymes might be crude or purified depending on the necessities [9]. The recoveries of extracellular fungal enzymes are very easy as it lies in the broth as compared to an intracellular bacterial enzyme.

## 5 Industrial Applications of Microbial Enzymes

Microbial enzymes like proteases, lipases, lactase, esterases and catalase are used as dairy enzymes for improving the characteristics, yield, shelf-life and safety of milk products. To enhance the quality of bread, increasing its moisture content and softness and texture, lipases, xylanases and amylases are involved in bakeries [10]. Enzymes such as catalase, amylase and pectinases are used for fruit juice processing and clarification, increasing the yield, easing the operations and cost-effectiveness in beverage industries. Xylanases, cellulases and ligninases find application in paper pulp industries for improving deinking processes, softness, drainage improvement and waste quantity reduction. In leather sectors, for the purposes of curing, soaking, liming, dehairing, bating, picking, degreasing and tanning, microbial lipases and proteases are employed. Alkaline proteases along with lipases are used in dehairing, degreasing and making leather soft, supple and pliable. Reduction in value of BOD and COD and odor in effluents are major advantages of using enzyme assisted technologies. Cellulases, pectinases, lipases, esterases and lipases are highly beneficial to be used in biopolishing and bioscouring of fabric, cotton softening, denim finishing, desizing, wool finishing, and modification of synthetic fibers for textile industries. Detergent industries comprise use of Amylases and lipases for removal of starch and fat containing residues and stains. Cutinases and proteases are used in laundry and dishwashing detergents.

## 6 Waste Water Treatment

The utilization of enzyme for waste management and waste water treatment for degradation of toxic pollutants. The industrial effluents as well as household garbages have

many chemical entities being hazardous and poisonous to the living system as well to the environment. Microbial enzymes can treat industrial effluents by bioconversion of toxic compounds to safer products [10]. A number of enzymes employed for this purpose are amidases, amylases, amyloglucosidases, cellulases, glucoamylases, lipases, nitrile hydrolases, pectinases and proteases. In the same way enzymes, like laccase, manganese peroxidase, lignin peroxidase and tyrosinase biocatalyze the elimination of chlorinated phenols from industrial effluents [11, 12].

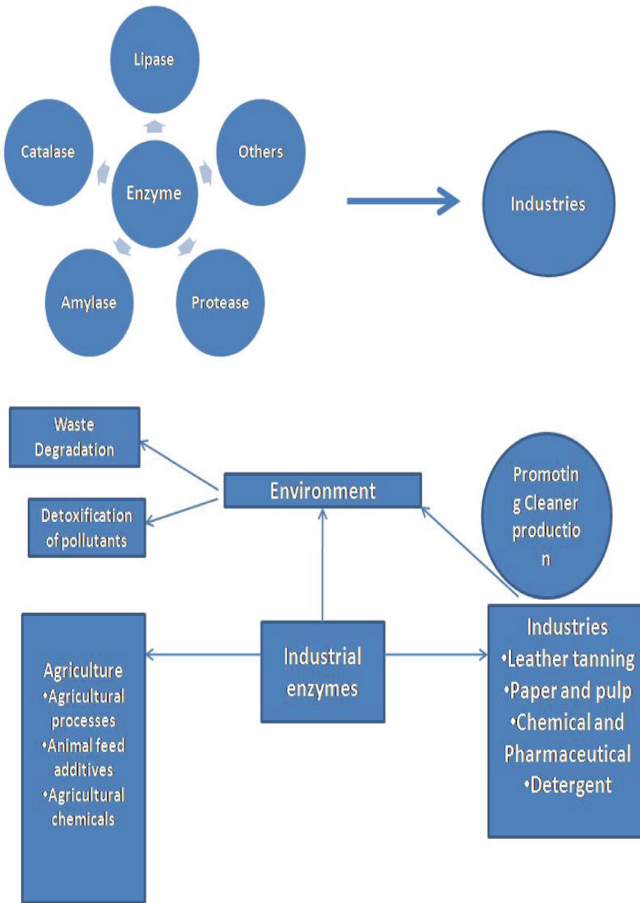
## 7 Conclusion

Irrational human activities have immensely amplified the production and release of pollutants in the environment. Microbial enzymes can be a valuable mechanism for eliminating them. Microbial enzymes in this aspect can act as a vital weapon to biodegrade a large variety of contaminants, including heavy metals, toxins, dyes, polycyclic aromatic hydrocarbons, and plastics, in place of conventionally used harsh chemicals. They powerfully break down pollutants by utilizing them as substrates to produce nontoxic end-products from them [13, 14]. Though, for effective degradation, various important factors to be taken care of are pH, temperature, microorganisms, and incubation time and contaminants availability. Enzymes with better physiological conditions can be produced as a result of engineering processes and alteration techniques. Genetic engineering and microbiological advancements immensely help in tailoring the yield of the enzyme with higher efficiency according to our choice [15, 16]. The efficiency of enzyme can be enhanced by the process of enzyme immobilization for pollutant degradation [17, 18]. This study will be an aid in proper understanding of utilizing microbial enzymes for holistic, social and commercial use as well as pave way for futuristic approaches to use microbial enzymes as driver of industrial sustainability.

## 8 Figures and Tables

**Table 1.** List of advantages of enzymatic degradation.

- Flexibility in operational conditions
- Easier to control
- Rapid process
- Cost-effective process
- Highly specific process (Fig. 1)



**Fig. 1.** Applications of industrial enzymes

**Authors' Contributions.** All the authors contributed equally in this work.

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