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Mini Review

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Microbial diversity of aquatic ecosystem and its industrial potential

Abstract

Studies suggested that microbes account for most of the diversity of life on our planet, due to their presence in almost all ecosystems. The microbial world encompasses most of the phylogenetic diversity and from varied climatic extremities. Recently, several researches are now focused on isolate and study of novel microbes and extracting the valuable chemicals and products out of it. Although, it was estimate that less than one percent of all microbial species have been identified so far, and most of the researchers believe that more deeper study of microbes will reveal novel biochemical's and byproducts useful for humans, such as enzymes, proteins, drugs, biofuels, etc. Thus, now there is an urgent need to have more critical study of all the possible microbial adaptation present and to study their life cycle in varied environmental niches, which will gave us some clear picture to understand global microbial diversity and their evolution. Thus, in our present review we have tried to provide quick pragmatic evidence of aquatic microbial diversity and focus on some of their industrial important enzymes.

Keywords: microbial diversity, aquatic ecosystem, enzymes, phylogenetic diversity, biological diversity, biofuels, lentic ecosystem

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Introduction

Microbial diversity is an important constituent of an overall global biological diversity present in this planet. Microbial diversity that we observe today is the consequence of nearly 4billion years of evolutionary change. Apart from several niches present in earth, the freshwater lakes are important habitats for diverse microbial communities. Freshwater and marine environments differ in many ways including salinity, average temperature, depth, and nutrient content, but both provide many excellent habitats for microorganisms. Reports suggested that freshwater environments provide diverse ecological habitats and important environmental resources. Prokaryotes are among the most important contributors to the transformation of complex organic compounds and minerals in freshwater sediments.[1,2] As approximately there is 250000 cubic kilometers of freshwater on earth, in the forms of lakes, inland seas and rivers, all of which potentially harbor as diverse microorganisms as assemblage as been discovered in open oceans.[3–7] We all are aware of the fact that the microorganisms are essential for life on earth to function, maintain and continue. Since formation of this planet, they have played very critical role, including being the first to colonize and also provide with transform effects of naturally occurring or man-made disruption to the environment. Bacteria were the only free living cellular organisms existing since 3.5billion year ago. Their survival, propagation and ability to inhabit a wide variety of environments demonstrate their evolutionary success. Biodiversity is the varieties of life on earth at all its levels, from genes to ecosystems and the ecological and evolutionary processes that sustain it.[8] Biodiversity is not limited to describe the various species living in a certain habitat but it also identifies the genetic variation and the functionality of these species within their ecosystems. Therefore, nowadays biodiversity tools are in limelight, which are useful in the identification of the many unknown and undescribed microbial species living on earth. Thus, the term microbial biodiversity is gaining more importance not only to understand their evolution but also to further determine their ecological impact on certain niches and changing climate. A recent report suggests that there may be up to 1million species of prokaryotes yet only 3,100 are known and have been fully described in Bergey's Manual.[9] Thus, several nations show their commitment to protecting their environment, and have included ecological diversity conservation to its countries protection policies.[10]

Aquatic ecosystem

In aquatic ecosystem the lakes play an important habitat for most microorganisms. The ecosystem in lake is term as Lentic ecosystem.[11] A typical lake or pond serves as an example to represent the various zones and the kinds of microbiota found in a body of fresh water. The littoral zone along the shore has considerable rooted vegetation, and light penetrates throughout it. The limnetic zone consists of the surface of the open water area away from the shore. The profundal zone is the deeper water under the limnetic zone. The benthic zone contains the sediment at the bottom.[12] Microorganisms especially bacteria are present in all regions of lake/pond ecosystem. Lake microorganisms participate in various biogeochemical cycles, such as decomposing organic material into nutrients as food for other organisms and control the water quality in lakes.[13,14] These microorganisms also play a critical job in remineralizing and restoring the nutrients which influence the materials circulation in aquatic ecosystems.[15] Likewise, research done by McNally et al.,[16] stated that sediment soil microorganisms in lake able to carry out biodegradation of contaminant compound, such as polycyclic aromatic hydrocarbons (PAHs). Beside this, the microorganisms also play an important food and nutrient sources for other organisms, present in the aquatic ecosystem such as protozoa. The past studies suggested that in absence of aquatic microorganisms, the food chain system may be disturbed greatly and ecosystem imbalance may occur, eventually affect the existence of biotic and abiotic system associated with it. According to Madsen[17] the lake is a site of tremendous microbial activity and the microorganisms, which play an important role on nutritional chains as well as maintaining the biological balance.

In Indian scenario, the country is profuse in surface water resources especially fresh water sources. If we talk about the drinking water, about 80% of rural residents rely on untreated ground water for potable water supplies. Rivers and lakes are the major sources of fresh water supply, but almost 70% of India's surface water resources and ground water reserves have been contaminated.[18] In country the major source of fresh water after rivers are the lakes, these lakes water is used for different purposes, such as drinking water for residents nearby, irrigation, recreation value, fisheries cultivation and habitat for wild life. Some of these lakes are considered to be sacred. However, recently some studies shows that human activities have affected the water quality of the lakes, which includes the religious activities, tourism, bathing, washing, open defecation, surface drainage, irrigation runoff, discharges of industrial wastes and domestic wastewaters. Therefore, lakes are sensitive ecosystems and quickly respond to any natural or human-induced changes in the watershed. They are potential sinks for various organic pollutants,[19] which they receive from different sources (e.g. sewage, industrial effluents, vehicle exhaust, etc.). Thus, here comes the role of our tiny natural scavengers, in the form of microorganisms, which are widely distributed in nature for their treatment ability and maintain the ecological balance. These microorganisms are well adapted and diversified in almost all lakes. Researchers have also used these as an indicator for the suitability of water quality.[20]

Industrial importance

The microbes besides working as scavengers in these aquatic ecosystems are nowadays also gaining attention for their byproducts and are being extracted for production of useful chemicals. If we look at the industrial importance of these microbes we found that most of aquatic bacteria are a rich source of hydrolytic enzymes such as amylases, lipases, proteases, phospholipase, catalases and other important industrial enzymes (Figure 1). Mudryk & Podgorskar[21] had drawn the attention to the ability of bacteria from lake to synthesis various extracellular enzymes. Similarly, the enzyme know as proteases produced by microorganism has industrial potential due to its wide biochemical applications in food industries, medicinal formulations, detergents and waste treatment.[22] At present, the largest part of the enzyme market is occupied by the alkaline proteases due to its varied applications and the major proportions of these are derived from *Bacillus species*. Lake lipolytic bacteria were also found producing the enzyme known as phospholipase. This enzyme plays a key role in bakery and used in bread making, egg yolk industry and refinement of vegetable oils. The article by Dastager et al.,[23] reported that a enzyme named α-amylase is important in many industrial processes and constitute 25% of the enzyme market of the world. Amylases enzyme used in hydrolysing of the starch molecules into its simple form i.e., glucose units.[24] All these industrial enzymes are selected on the ability of the microbes potential and their expression of the genes in microbial hosts or cloned version, with commercially attractive amounts.[25]

Aquatic microorganisms, genetic and biochemical diversity is still in its nascent phase, and considerable potential of enzymes with ample application potentials are still unrevealed. There are several kits available in the market for the extraction of these commercially important enzymes for example API ZYM kit has been used by many researchers to elucidate the extracellular enzymatic activity of bacterial strains. The researches were interested in the enzymatic extraction of microbial origin by several exiting research such as presented by Mudryk & Podgorskar[26] which shown that neustonic and planktonic bacteria carried out the enzymatic activity and degradation of organic macromolecules in an Estuarine Lake. There are similar studies presented by several research groups around the world. Therefore, nowadays there are several technological advances in exploring microbial diversity in aquatic ecosystem. Which have revealed that a large proportion of microorganisms are still undiscovered and their ecological roles are largely unknown. Vigilant selection of microbes and intelligent design of test assays are the key steps in developing new technologies for effective utilization of microorganism origin enzymes in food industries, detergent industries, for sustainable agriculture practices, environmental protection and human and animal health. Several microbial applications are widely known in unravel major agricultural problems (i.e., poor crop productivity, plant health protection and soil health maintenance) and environmental issues like bioremediation of soil and water from organic/ inorganic pollutants. Moreover, enzymes have received worldwide attention due to their potential applications in the biodegradation of agronomic wastes, and are being increasingly used in textile, paper-pulp, pharmaceuticals and food industries. Several sophisticated biochemical and molecular approaches introduced to microbial ecophysiology[27–29] resulted in completely new ideas on the role and significance of microbial processes in the functioning of aquatic ecosystems. Recently we are heading towards the aquatic prokaryotic metagenomic sequencing which will providing a marvelous information/database for discovering new metabolic capabilities of the microorganisms and will open out new ways to conceptualize and study microbial biodiversity.[30] With more information and updates we are also getting clear evidences of multiple interactions of these microorganisms such as complex interactions of bacteria with other aquatic biota and ecosystem function. The results of several studies when compiled clearly show that these microorganisms are a major biological force in nutrient cycles and ecosystem structure. Thus these tine organisms can be studied well and can be of varied use especially for the extracellular enzymes production as a byproduct. Thus we get a clear picture of the industrial enzyme market by the increasing demand of the enzymes and their costing. Thus, now it's a high time to explore the prospects of microbes by optimized there growth conditions and production.

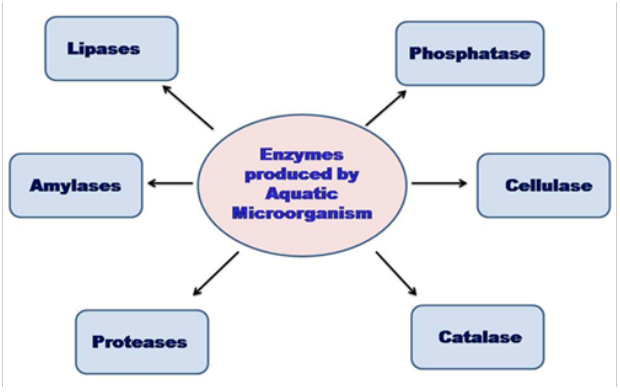

Figure 1 Schematic diagram showing the potential of aquatic microorganism in terms of industrial important enzymes production.

Conclusion

In the current review we have tried to compile few recent researches on the aquatic biodiversity, especially microorganism and the valuable products i.e enzymes that's contribution in the industrial sector and world market. The scope of the byproducts of the microbial products like enzymes is currently in demand at global scale and there

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are ample possibilities for exploration of microbial wealth in the near future with the latest techniques in several other upcoming fields, it's still just commencement, but it has huge potential for expansion and applications with industrial benefits.

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Conflict of interest

The author declares no conflict of interest.

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