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Bioremediation: A tool for sustainable development of aquaculture

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Abstract
The growth of the aquaculture industry is gaining momentum day by day. The ever-increasing population, required food and nutritional security from the limited available resources *viz.* land and water magnifying the problems of diminishing productivity. The indiscriminate use feed, chemicals (aqua inputs) results in increasing pollutants led to producing significant amounts of wastes, including metabolic by-products which are responsible for making the situation more worsen. In today's scenario, the focused must be on the productivity of the resources instead of production. To increase the productivity of the affected land and water one must found the sustainable way of treatment, in this context bioremediation is an innovative approach which is safe and less costly compare to the existing ones. In this technique, the use of live microbes is employed in the degrading the complex pollutants or harmful waste into simple and harmless products. The use of these microbes (bacteria's) not only improve the water quality but also promoting the health aspects of the culture organisms and thus maintaining the sustainability of aquaculture ecosystems. Bioremediation plays a significant role in aquaculture and actively participated in the process of mineralization of complex organic load into simpler forms which can be assimilated by the planktons and improve the primary productivity of the system. Further, the bioremediations agents (heterotrophic nitrifying and denitrifying microbes) plays a significant role in nitrification and denitrification process to remove unwanted nitrogen compounds and contribute to improving the overall health of the pond ecosystem.

Keywords: Bioremediation, sustainable, aquaculture

Introduction
The growth of the aquaculture industry is secured high ranking among the other food-producing sectors in the world. Aquaculture. The fish and its by-products assure the nutritional security to more than millions of people and offer better food security, revenue and livelihood scope. In 2016, global aquaculture production is reported to be approximately 171 million tonnes [6]. World per capita fish supply was reported 20.3 kg in 2016. Presently India, after China, is the world's second-largest aquaculture country. Global aquaculture production is estimated to touch around 171 million tons in 2016 [6]. Whereas, world per capita fish consumption reached to 20.3 kg in 2016. India is the securing second rank in aquaculture after China. The production of fish during 2017-18 was reported 12.61 million metric tons MMT. The total contribution from fisheries to the National Gross Value Added (GVA) is recorded 0.96% and 5.37% to the agricultural GVA [1].
Intensification of aquaculture has increased production of aquaculture but it also invited the problem of the undisposed waste generation system, this waste is rich in organic load, chemicals, pathogens and other harmful non-degradable stuff. These wastes can cause water quality deterioration upon release to the external environment and outbreak of disease. The common method for dealing with this problem is a continuous exchange of pond water with external freshwater, and the second method to decrease major pollutants in the water is by adopting Recirculatory aquaculture system (RAS) with different types of the water treatment process.
But it's incredibly costly. As a result, aquaculture has become a significant source of pollutants for the aquatic ecosystem and a cause of wetland degradation [11]. The recently implemented approach of using microbes for enhancement to degrade this harmful complex waste by using either in-situ or ex-situ approach is widely practised which offers within system treatments and provide the optimum water quality, fewer pathogens and removal of

heavy metals hence improving the status of aquatic health also significantly contributing in the sustainability of aquaculture [2]. In these techniques, the selected microbes are used either in single or in combination to perform the role of bioremediation and reducing the pollutant which is discharge from aquaculture [5].

Definition and its use in aquaculture: Bioremediation is a method of eliminating contamination from complex waste by using micro-organisms, without using harmful chemicals. It is an innovative technology that implements the use of beneficial micro-organisms called bio remediating agents [10] for the optimization of water quality and soil by modifying the harmful microbial load in ponds to boost the mineralization process of organic loads and remove unwanted harmful substances.

Principals and types of bioremediation

Bioremediation is the process where organic material is biologically degraded under controlled conditions below the levels of concentration limits set by government authorities. Bioremediation can be much more efficient when microbial growth and activity are supported under natural environmental conditions. Its implementation also involves modifying environmental conditions so that bacterial growth and degradation can proceed more rapidly and turn them into harmless substances [12]. During this technique, the role of redox clean-up reactions plays a major role, where anaerobic or aerobic metabolism involves oxidation and reduction reactions or redox reactions are utilized for detoxification further, oxygen reduced to water and oxidize the organic compounds and anaerobic reaction can use nitrate. In return, biomass is gained for bacterial or fungal growth. Particularly in these techniques, combined efforts are needed, indigenous microbes found naturally in polluted sites are of useful. Mainly bioremediation can be broadly classified into three categories *viz.* biostimulation, bioaugmentation, intrinsic bioremediation.

Waste generation in aquaculture

Aquaculture productivity mainly relies primarily on physical, chemical and biological factors of the culture environment. Inadequate management practices in culture system led to the frequent occurrence of harmful substance and toxic gasses like hydrogen sulphide, ammonia, and carbon dioxide cause stress in shrimp and consequently disease occurrence [13]. However, the quality and quantity of product vary depending on the adoption of practices during the culture period and species. A potential source of waste generation in a culture system mainly comes from due to point and non-point water connectivity further, unutilized feed and faecal material, metabolise by-products, bio-biostatic and fertilizer, moulting and dead algal waste [15].

Organic load and bioremediation

Carbon is one of the most important elements for all living beings on earth. The element contributes a significant role to live, grow, and reproduce at different stages of life. Similarly, carbon provides energy for body function especially for heterotrophic microbes and algae, which in turn used in the breakdown of the complex structure into simpler ones, therefore in aquaculture such microbe and the associate enzymatic activities, can be utilized to break down the complex agglomeration harmful substances due to inappropriate management in the culture system. Further, bioremediation includes beneficial microbes which can remove carbonaceous waste from water and help to increase the bacterial population quickly. The common bacteria's which employed are *Bacillus* spp. like *Bacillus subtilis*, *Bacillus licheniformis*, *Bacillus cereus*, and *Bacillus coagulans*. The quantity of those bioremediation agents in a water body decide the degradation rate and must be supplied from outside to speed up the degradation process. When there is adequate quantities of Bacillus strains are applied to the pond water, they can perform better. They compete with the native harmful flora and fauna in different i.e. food and space etc. [16] and increase their number after multiplication. The application of bacillus spp. may be used for bio-augmentation, by mixing with sand and spread to the bottom of the pond [17]. Mostly a combination of bacteria's shows more promising results compares to single *spp.* like the application of *Lactobacillus* and *Bacillus spp* provide the promising results in organic matter degradation.

Bioremediation of nitrogenous compounds

The application of nitrogen in the form of feed and further as excreta increases its accumulation as nitrogenous substances in culture pond, which in turn, increase the level of ammonia and other toxic substances and speed up the process of water quality degradation, even though cyano-bacteria nitrogen fixation and atmospheric deposition are often important [3]. The anaerobic microbes which can facilitate the process of nitrification process and reduce the nitrogenous substances into harmless nitrogen gas [14]. There were more than 14 identified genera of microbes which help in reducing the nitrogenous complex into the simpler form and mediating nitrification process, the dominant among this list are *Pseudomonas* and *bacillus* [7].

Bioremediation of hydrogen sulphide

Hydrogen sulphide generally encountered in newly constructed ponds. Sulphate is highly soluble and mainly trap in the bottom sediments. During aerobic conditions, this sulphur is existing in the form of sulphate and do not expose to the water residing above bottom but during the anaerobic conditions developed this harmless sulphate reduced to sulphide, which is toxic and hence harm to the culture organisms. To control this conversion form sulphate to sulphide mainly depends on the pond bottom chemistry and chemical processes by microorganisms in the sediment [4]. The hydrogen sulphide gas created by microbial metabolism of sulphate under anaerobic condition in this process oxygen also involved [9]. The use of sulphide oxidising bacteria can be very useful to convert the harmful sulphide to oxidised sulphate, therefore photosynthetic sulphur microbes *viz.* chromatiaceae and chlorobiaceae are mainly used in bioremediations process particularly in the form of water and soil probiotics, the mode of application in the pond bottom after mixing with the sand for effectively reduced hydrogen sulphide gas [12].

Advantages

It's safe, natural and sustainable and aesthetically pleasing means of reducing the disposed waste from the system without the use of chemicals. It's allowing the detoxification of complex substances up to an acceptable range. The method of treatments enables us to approach either in-situ or ex-situ treatments. This is significantly less expensive compare to other alternative treatments. It helps to reduce the deposition of sludge and hence play a significant role in increasing primary productivity and production.

Disadvantages

While this technique is having certain disadvantage as well like its time-consuming process, therefore, the remediation process can take a longer period. It mainly deals to reduce the harmful concentration of substance but not assured the complete omission. Mainly this technique is restricted mostly for biologically recyclable substances whereas, the other chemicals or toxics substances are not resistant to fast and complete degradation. The degraded products sometimes can be much more harmful than parent compounds.

Conclusion

A variety of commercial items claims to clean the pond bottom, improve better water quality and enhance overall health conditions, especially in intensive aquaculture. The use of bioremediation is considered to be easy and implemented on-site or off-site and reduces the amount of waste to be recycled. The application of bacteria bioremediation agents into the pond bottom which can enhance the productivity to maintain environmental sustainability of aquafarming. Applying beneficial and biodegrading microbes to water and soil into the pond is a sustainable solution for aquaculture to minimize environmental effects. The normal activity of bacteria and their interactions into aquatic ecosystem support for the development of bioremediation technologies for the treatment of waste from aquaculture pond. Successful bioremediation involves enhancing primary productivity that stimulates aquaculture production.

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