VARIOUS BIOREMEDIATION TECHNIQES IN AQUACULTURE

Abstract

Aquaculture is the fastest-growing food production industry and a key component of national development and poverty reduction initiatives in many countries. Aquaculture output rises as capture fisheries stabilise. About 93% of aquaculture output comes from underdeveloped nations. Its polyculture and integrated farming method, which maximised farm resource usage, including waste, made it ecologically friendly. Additional fish are being farmed by increasing the amount of water, feed, fertiliser, and chemicals used in the farming process, as well as by cultivating additional land and water. This has led many to believe that aquaculture may contribute to water pollution and degrade wetland ecosystems. Biologically-involved Bioremediation Strategies, such as In-situ and Ex-situ approaches, are very helpful in remediation during the culturing process by addressing the contaminated situations.

Keywords: Aquaculture, Bioremediation, Aquatic environment, In–situ and Ex–situ.

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I. INTRODUCTION

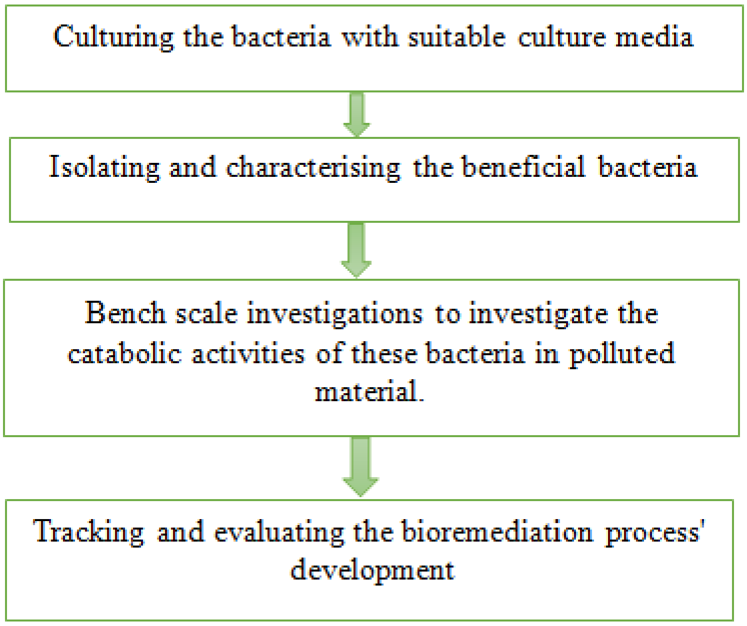
Aquaculture is one of the fastest-growing food sectors and an essential economic evolution in many countries. Over the last few decades, there has been a persistent decline in marine fisheries because of the overexploitation of marine resources and the increasing world population. The demand for food has also increased (Boopathy et al., 2009). Humans consume aquatic seafood. The aquaculture sector produces fifty per cent of them; the other half the percentage is capture fisheries (FAO, 2020), which is essential to developing novel technology to increase aquaculture production worldwide. Liberating a considerable amount of pollutants from the aquaculture industry, like uneaten feed and faeces in the water, has brought a high level of contrary environmental impact. These organic matters cause the worsening of both contained sediment and waterbodies. (Crab et al., 2007). Environmental contamination is considered a significant problem worldwide and a menace to human health and environmental functioning. The modern lifestyle, growing production of goods and the overwhelming habitats of the people in industrialized and emerging countries are leading ever changes in the environmental areas by human activities called "Anthropogenic Activities" (Biotechnological book Sonia malik) industrialized risk of environmental effect caused by intensive aquaculture practices. According to Gondwe et al. (2012) and Vezzulli et al. (2008), the higher level of biological waste and noxious components produced by aquaculture Living organisms in the water body consumes large amounts of component higher than that excretion of the component is called "Bio magnification". This affects the food chain process to cause an antagonistic effect on human health (Sonia malik et al., 2016). Aquaculture waste is the root of the new developing disease due to antibiotic resistance to humans and harmful algal bloom in water bodies, so proper sewage treatment is essential for aquaculture waste (Hegaret, 2008 & Rubert, 2008).

"Bioremediation" is the biotechnology process of treating environmental pollution with the help of microorganisms. These microorganisms destroy, transform and immobilize the environmental contaminants. With the help of microorganisms to eradicate contaminants from the environment, bring back contaminant sites and protect the further contamination is the newly developing substitute technique to environmental treatment (Amiya Panigrahi et al., 2005). Use of microorganisms (both genetically modified organisms (GMOs) and naturally occurring ones) to clean the infected areas, which is how the remediation is endlessly enhanced (David et al.1995: Tebo et al.,1995). Preventive and bioremediation techniques that are effective, affordable and environmentally friendly will be required to improve effluent water quality before discharging into receiving waters of sensitive areas as the aquaculture sector develops (Jones et al., 2001). In this chapter, we will discuss the bioremediation techniques involved in the aquaculture industry.

II. BIOREMEDIATION PROCESS

Beneficial microbes segregate enzymes to fracture the contaminant into simple, digestible compounds. The beneficial bacteria ingest the organic pollutant and digest it like food compounds with other energy sources. (Debtanu Barman et al., 2020).

Steps of Bioremediation



III. BIOREMEDIATION STRATEGIES

The Bioremediation process is classified into two types based on the aeration of the area and the degree of saturation.

1. **In–Situ Techniques:** In situ methods use living organisms or enzymes to help get rid of contaminants. Whether or not they work depends on how the site is set up and what kind of soil is there. These techniques are preferred due to lower costs and fewer disturbances, as they prevent excavation and the transport of contaminants. (Debtanu Barman et al., 2020).

   - **Bioventing:** Bioremediation is a frequently employed in situ treatment method that involves the provision of air and nutrients to contaminated soil through wells, with the aim of stimulating the growth and activity of native microorganisms. Bioventing is a remediation technique that employs controlled ventilation at low rates to provide the necessary amount of oxygen for biodegradation while simultaneously minimising the volatilization and release of contaminants. The utilisation of this method seems to be efficacious for uncomplicated hydrocarbon compounds, particularly in cases where environmental contamination is situated at significant depths below the surface (Pamela et al., 2010).

   - **Biosparging:** Biosparging forces air beneath the water table to increase groundwater oxygen concentrations and the bacteria's biological breakdown of pollutants. This improves soil-groundwater interaction by increasing mixing in the saturated zone. Small-diameter air injection ports provide more excellent system design and construction flexibility. (Antony et al., 2006).

- **Bioaugmentation:** Bioremediation commonly involves the introduction of autochthonous or allochthonous microorganisms into contaminated sites. According to the study conducted by Anjaneyulu et al. (2005), the efficacy of employing diverse microbial cultures within a land treatment unit is constrained by two criteria.: 1) non-indigenous cultures seldom compete with indigenous populations successfully enough to create and sustain beneficial population levels. 2) If the land treatment unit is adequately managed, most soils with long-term contact with biodegradable waste include indigenous bacteria that are good degraders.(Adnan Amin et al.,2013).

- **Phytoremediation:** Phytoremediation is a bioremediation process using plants to remove, transfer, stabilize, and destroy contaminants in soil and groundwater. Plants act as filters and metabolize natural substances, with some having metal-absorption capabilities and symbiotic associations with microbes. (Debtanu Barman et al., 2020).

2. **Ex- Situ Techniques:** Ex-situ methods are used on soil and groundwater removed by excavation (soil) or pumping (water). These methods require extracting or removing contaminated soil from the ground. (Paniagua-Michel. 2003).

- **Land Farming:** Land farming is a primary method in which polluted soil is dug, put over a prepared bed, and tilled regularly until contaminants are degraded. The purpose is to promote the aerobic breakdown of harmful substances by indigenous bio degradative bacteria. It promotes indigenous bacteria while requiring less monitoring and upkeep.(Debtanu Barman et al., 2020).

- **Bioreactors:** Slurry reactors use bioremediation to clean polluted soil and water from a contaminated plume via a designed containment system. These confinement tanks produce a three-phase mixing environment, which speeds up the bioremediation of soil-bound and water-soluble contaminants. The water slurry comprises contaminated soil and biomass that can degrade target pollutants. (Ruenglert panyakul et al.,2004). Generally, the pace and amount of biodegradation in a bioreactor system are more significant than in situ or solid phase systems because the enclosed environment is more manageable and hence more regulated and predictable.

- **Biopiles:** Biopiles can be described as a hybridization of land agriculture and composting techniques. Engineered cells are constructed in a manner resembling aerated compost heaps. Phytoremediation techniques represent an enhanced iteration of land farming methods, which aim to mitigate the physical losses of contaminants by minimising leaching and volatilization. Petroleum hydrocarbon surface contamination is frequently addressed through the use of these substances. Biopiles facilitate the proliferation of autochthonous aerobic and anaerobic bacterial populations (Asano, et al., 2007).

IV. BIOREMEDIATION OF AQUACULTURE CONTAMINATED WATER

In the emerging world, one of the fastest-growing food sectors is aquaculture. (Moriatry et al., 1999). It was initially considered a greener practice due to its traditional Polyculture and integrated farming methods focused on the most efficient use of farm resources, including farm waste (Adnan et al., 2013). Aquaculture employs intensive farming technology to spread land and water; nevertheless, it is increasingly regarded as a potential polluter of aquatic ecosystems because of increased input utilization (Pillay et al., 1992).

Waste Production in Aquaculture Sector: Aquaculture and hatchery-produced wastes can be categorized as

- Aquatic animal faecal matter and excessive feeds
- Aquatic organisms metabolic activity by-products
- Remaining biocides and biostat compounds
- Agricultural and aquaculture fertilizers obtain wastes.
- Waste is produced during the shellfish moulting process and algal blooms (Sharma & Schenno, 1999).

V. USES OF BIOREMEDIATION IN AQUACULTURE WASTEWATER

1. **Bioremediation of Nitrogenous Compounds:** Bacteriological denitrification is the most viable approach for eradicating harmful nitrogenous compounds from aquaculture (Adnan Amin et al., 2013). Ammonia accumulation occurs from excess feed, organic mineralization, and metabolic excretion. Ammonioxidizing bacteria are essential in converting ammonia to nitrite (M.Y.Jasminetal,2019). Common nitrifiers in aquaculture include autotrophic and heterotrophic bacteria from the genera Nitrosomonas, Nitrosovibrio, Nitrosococcus, and Nitrospira (Anthony & Philip, 2006). Nitrite is toxic and requires conversion to nitrate, a safer nitrogen form. Nitrobacter, Nitrococcus, and Nitrospira are common nitrite-oxidizing bacteria. Heterotrophic nitrifiers produce low levels of nitrite and nitrate using organic nitrogen sources. (Ming Yu Li et al., 2011). Denitrification is the final phase in the nitrogen cycle.

$$\mathbf{NO3 \rightarrow NO2 \rightarrow NO \rightarrow N2\ O \rightarrow N2}$$

2. **Bioremediation of Phosphorus:** Bacterial enzymes such as phosphatases and phytases, which release PO4 from organic molecules, create phosphorus. The solubility of inorganic phosphatases is affected by pH. Phosphorus remediation research in aquaculture is sparse (Adnan Amin et al., 2013). Lananan et al. (2014) recently reported on the possibility of symbiotic phosphorus bioremediation utilizing effective microorganisms (EM) and microalgae. Research shows 99.15% phosphorus removal per day in ponds with Bacillus sp. mix, reducing phosphorus levels by 81%. (Reddy et al., 2018)

3. **Bioremediation of Organic Detritus:** Microbes and algae may easily access organic materials, primarily carbon chains. Bioremediation should have microorganisms that can remove carbonaceous waste from water. *Bacillus* sp, *Paenibacillus* sp, and *Lactobacillus* sp are ideal for organic detritus bioremediation, with Lactobacillus being utilized with Bacillus. (Debtanu Barman et al.,2020).

4. **Probiotics in Aquaculture Bioremediation:** Introducing probiotics and enzymes to the ponds entails manipulating the microorganisms to promote the mineralization of organic matter and eliminate unwanted chemical compounds. This method is the most recent attempt to improve water quality in aquaculture. (Debtanu Barman et al.,2020).

Table 1: Probiotics and Their Role

Bacillus sp.	Mineralization and Breakage of proteins
Nitrosomonas sp.	Oxidation of ammonia
Nitrobacter sp.	Oxidation of nitrites
Aerobacter sp.	Reduction of organic matter
Cellulomonas sp.	Breakage of plant material

(Akpor O. B. et al., 2010).

VI. ADVANTAGES AND DISADVANTAGES OF BIOREMEDIATION

- Bioremediation is an environmentally friendly waste treatment for contaminated water, using harmless products like carbon dioxide, water, and cell biomass.
- Bioremediation effectively destroys various contaminants, transforming hazardous compounds into harmless products, reducing liability, and ensuring safe treatment and disposal of contaminated materials.
- It is possible to effectively eliminate target pollutants rather than transferring them from one environmental medium to another, such as from land to water or air.
- On-site bioremediation may be done without interfering with ongoing operations and with less danger to the environment and human health during waste transportation. (Adnan Amin et al., 2013)

Disadvantages of Bioremediation

- Bioremediation targets biodegradable compounds, but not all are susceptible, and potentially toxic products may arise.
- Many biological processes are pretty specialized. The availability of metabolically competent microbial populations, proper environmental growth conditions, and optimum quantities of nutrients and pollutants are crucial site requirements for success.
- Research is needed to develop bioremediation technologies suitable for complex contaminants in complex mixtures, including solids, liquids, and gases, overcoming challenges in extrapolating from bench and pilot-scale studies.
- Bioremediation is sometimes more time-consuming than other treatment alternatives, such as excavation and soil removal or burning. (Debtanu Barman,2020).

VII. CONCLUSION

Bioremediation is one of the emerging biotechnology tools used for environmental pollutant control. This technology is currently in development, so scientists are researching further about the process and improvised technology that is easy to handle.

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