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Biological Engineering- The Way to Restore Algal Bloom Affected Water Bodies

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SUMMARY

The occurrence of Harmful Algal Blooms (HABs) is a growing environmental concern worldwide. Anthropogenic nutrient enrichment and climate change are the primary causes of the global proliferation of harmful algal blooms, which pose a major challenge to the sustainability and usage of our aquatic resources. Biological engineering is one such method emerging as an eco-friendly alternative offering long-term benefits. This article discusses biological methods for eliminating HABs to lower their prevalence and toxic levels in aquatic ecosystems.

INTRODUCTION

When phytoplankton biomass in aquatic environments increases suddenly and prolifically to reach cell density of millions of cells/ml it is referred as algal bloom. It may be toxic or nontoxic algal bloom. "Harmful Algal Blooms" (HABs) refer to the spread of harmful microalgae that contaminate seafood with its toxin producing ability and result in large-scale fish mortality. It causes hypoxia and creates marine dead zones, changes in community structure that impact food webs, and deterioration of water quality. The occurrence of HABs is a growing environmental concern worldwide. Lots of management strategies were studied to combat HAB events in aquatic ecosystems. Biological engineering or biomanipulation is one such method to reduce HABs and is defined as the intentional modification of an ecosystem by adding or removing species (particularly predators). The term describes a method of biomanipulation used to lower algae biomass in lakes by manipulating food webs.

Key Applications of Biomanipulation in Aquatic Ecosystems:

Controlling Eutrophication: Biomanipulation can help combat eutrophication by restoring the balance between algae (primary producers) and zooplankton grazers. Removing planktivorous fish allows larger zooplankton like Daphnia to thrive and graze down algal blooms, improving water clarity.

Managing Harmful Algal Blooms (HABs): Introducing predators that feed on toxic algae, such as silver or grass carp, can help control the growth of HABs and reduce the risk of toxin accumulation.

Restoring Fish Communities: Biomanipulation can be used to selectively remove invasive or undesirable fish species, allowing native fish populations to recover and enhancing overall biodiversity.

Enhancing Benthic Habitats: Controlling excessive macrophyte growth or organic matter accumulation in lake bottoms can be achieved through the introduction of herbivorous or bottom-feeding fish species.

Biomanipulation methods:

1. Top Down method: Top Down applies alternating control downward on trophic levels.

Top-down factors are pressures applied by higher trophic level to control the population dynamics of the ecosystem. Top predator either suppresses the abundance of its prey or alters their behaviour to limit their rate of population growth. Top-down control results in an oscillating trophic cascade (suppression at one level increases numbers at the next level).

Example: Grazing by herbivores like zooplankton and snails can significantly reduce algal biomass and prevent lower trophic levels from monopolizing essential resources.

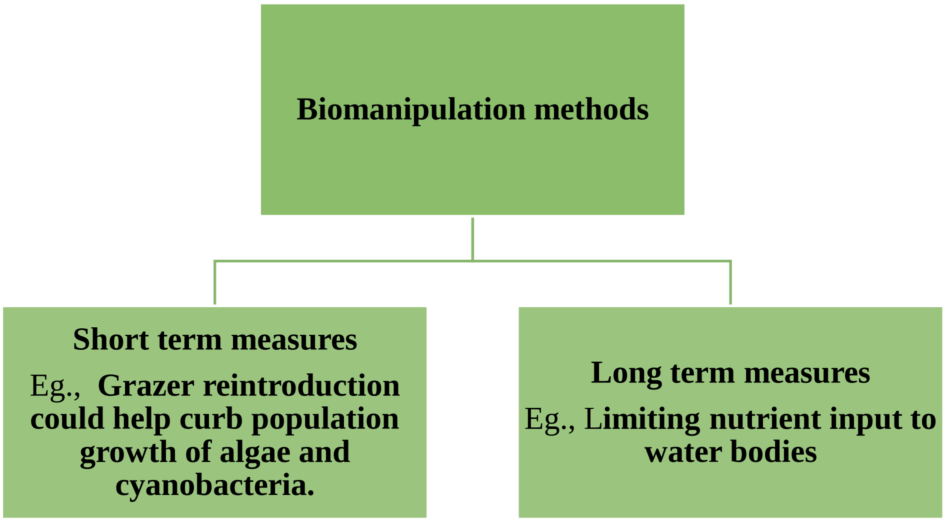
2. Bottom-up method:

Bottom-up applies direct control upward on trophic levels. Bottom-up factors are pressures that limit the availability of resources to lower trophic levels (e.g. producers). A lack of resources at lower trophic levels suppresses the abundance of organisms at higher trophic levels. Population growth will be reduced for all higher levels as suppression of the bottom restricts the energy supply to the top. Human activity can often limit resource availability and hence inadvertently exert bottom-up pressure on an ecosystem.

Example: Reducing nutrient inputs is crucial for controlling algal blooms

Other approaches:

- Fish biomanipulation (filter-feeding fish biomanipulation (non-traditional biomanipulation), piscivores biomanipulation (traditional biomanipulation), and omnivorous fish biomanipulation)
- Zooplankton biomanipulation,
- Planting of submerged macrophytes,
- Constructing ecological floating beds (EFBs), and
- The addition of effective microorganisms (EM) has been attempted to restore lake ecosystems.



Longevity of biomanipulation:

In aquatic ecosystems, interrelated elements (physical, chemical and biological) determine how long biomanipulation will endure in aquatic ecosystems, especially in terms of its ability to mitigate harmful algal blooms and improve water quality. The long-lasting and immediate effects of biomanipulation activities are influenced by the ecosystem's resilience, nutrient inflow, predator-prey dynamics, and climate. Constant monitoring of water bodies and the ability to adjust to changing circumstances are essential for the durability of these effects. For achieving the long-term benefits of biomanipulation implementing sustainability measures, such as passing legislation to reduce nutrient pollution. Essentially, biological, environmental, and administrative factors determine the long-term viability of biomanipulation, requiring an ecosystem-based approach to protect the precious ecosystem (Anabtawi et al., 2024).

CONCLUSION

Manipulating the trophic structure and species composition of aquatic ecosystems helps to restore ecological balance and improve water quality, biodiversity, and overall ecosystem health of the algal bloom-affected water bodies. Along with this thorough monitoring and selecting appropriate strategies often prove to be the most effective course of action to mitigate algal bloom in water bodies.

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