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Plankton and Benthos as Pollution Indicator

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SUMMARY

Plankton and benthos, two integral components of aquatic ecosystems, have emerged as crucial indicators of environmental pollution. This abstract provides an overview of the role these organisms play in assessing the health of aquatic environments and their sensitivity to various pollutants. Plankton, encompassing phytoplankton and zooplankton, are microscopic organisms that drift in aquatic environments and are highly responsive to changes in water quality. Benthos, including bottom-dwelling organisms like algae, mollusks, and crustaceans, inhabit the sediment layer of aquatic systems and also respond to pollutant levels. Plankton and benthos are sensitive to a wide range of pollutants, including heavy metals, nutrients, pesticides, and organic contaminants. Their responses can manifest as altered community composition, decreased diversity, and changes in abundance. Moreover, the bioaccumulation of pollutants in these organisms can lead to biomagnification through the food chain, ultimately affecting higher trophic levels, including fish and, potentially, humans. The integration of plankton and benthos in pollution monitoring programs offers several advantages. These organisms serve as early warning indicators, responding quickly to environmental stressors. Furthermore, they can provide insights into the spatial and temporal distribution of pollutants in aquatic systems. Their role in biomonitoring can aid in the assessment of the effectiveness of pollution control measures and inform regulatory actions.

INTRODUCTION

Bio-indicators are used to monitor the health of the natural ecosystem in the environment. Each organism within a biological system offers information about the health of its surroundings, such as plankton, which responds quickly to changes in the environment and serves as a significant biomarker for measuring water quality and as an indicator of water contamination. It was studied that there is a significant correlation between ecosystem abiotic and biotic components, as well as the usefulness of phytoplankton and zooplanktons as bio-indicators for detecting aquatic body health and trophic status. Some species of planktons can resist harsh abiotic circumstances and thrive in contaminated environments, suggesting a high level of tolerance, whereas sensitive species were absent, indicating a low level of tolerance. As a result, the utilization of these organisms in water quality monitoring studies can be improved by using these species. The major anthropogenic factors influencing the coastal marine waters are land reclamation, dredging, Overexploitation of resources, unmanaged tourism, and other anthropogenic causes like pollutant discharge from the point and nonpoint sources, the introduction of alien invasive species, ocean acidification, and climate change

The following are some of the advantages of using Bio indicator:

- Biological consequences can be determined.
- Assists in the monitoring of the antagonistic and synergetic effects of various contaminants on the environment.
- Toxicology can be monitored at an early stage, as well as the adverse impacts of toxins on plants and humans.
- Due to their abundance, they can be easily tallied.
- In comparison to other specialized measuring systems, it is economically viable.

Phytoplankton

Phytoplanktons are similar to other terrestrial plants as they also contain chlorophyll and require sunlight for photosynthesis. Most are photoactive in nature and swim in the upper surface of the sea, where light infiltrates the water. Photosynthesis and their development are closely related, each one being a function of usage of food supplements and light. They accounts for only 1% of the photosynthetic organism on Earth but alone contributes 50% of global net primary production. Phytoplanktons are also known as microalgae that are quite sensitive to contamination, and this may be reflected in their population levels and/or rates or photosynthesis.

Trophic status of planktons

	Oligotrophic	Eutrophic
Phytoplankton Species	*Ceratium hirudinella*	*Ankistrodesmus falcatus*
	Closterium pseudodianae	*Scenedesmus quadricauda*
	Dimorphococcus lunatus	*Closterium acerosum*
	Dinobryon sp.	*Chlorella vulgaris*
	Euastrum sp.	*Cryptomonas erosa*
	Gloeocapsa sp.	*Cyclotella sp.*
	Merismopedia elegans	*Euglena oxyuris*
Zooplankton Species	*Actinophrys sp.*	*Alona pulchella*
	Bosmina longirostris	*Aspidisca sp.*
	Coleps sp.	*Asplanchana brightwelli*
	Daphnia sp.	*Brachionus angularis*
	Voritcella nebularia	*Brachionus calyciflorus*
	Notholca sp.	*Chydorus sp.*
	Cyclops bicuspidatus	*Colpidium sp.*
	Euchlanis dialata	*Epistylis sp.*
	Keratella procurva	*Eucyclops sp.*

Zooplanktons

Zooplanktons are also microscopic animals living near to the surface of the water body. They are poor swimmers. They feed upon bacterioplanktons, phytoplankton, or detritus and constitute a vital food source for fish and the main food supplement too many other marine species. Zooplanktons do not directly depend on nutrients to survive but their growth can be affected by the quantity and quality of algae, bacteria and detritus in an aquatic body. In oligotrophic water bodies, the nano-phytoplankton is the dominant fraction and allows rapid growth zooplanktons like filter feeders such as calanoids and large cladocerans But in eutrophic environments, small filter-feeders such as rotifers and small-bodied cladocerans (bosminids) are abundant. To determine the status of a freshwater body it is necessary to measure seasonal variations and presence of zooplanktons. Different species, biomass diversity of zooplanktons can be used to determine the strength of a biological system. The potential of zooplankton as a bio-indicators species is high as that their development depends on some abiotic (e.g. saltiness, stratification temperature and pollutants) and biotic parameters (limitation of food, predation and competition etc)

Water status and habitat of various Zooplankton species

Species	Habitat	Water status	References
Moina sp. *Daphnia sp.* *Bosmina sp.*	Himalayan lake	Polluted	Jha and Barat, 2003
Brachionus angularis Brachionus quadridentatus *Keratella cochlearis*	Lake	Eutrophic	Panikkar et al., 2022
Arcella vulgaris *Difflugia sp.* *Brachionus angularis Brachionus falcatus Brachionus terminalis*	Himalayan lakes	Eutrophic	Islam et al., 2022
Microcystis aeruginosa, *Anabaena bergii*	Reservoir	Polluted	Katsiapi *et al.*, 2011
Ankistrodesmus falcatus,	River	Polysaprobic	Jindal and Sharma

Chlorella vulgaris, *Chlamydomonas* sp.,			2011
Spirogyra sp., *Tribonema sp.*, *Closterium sp.*	Reservoir	Polluted	Hulyal and Kaliwal, 2009
Euglena oxyuris	River	Eutrophic	Sampoorani et al. 2002
Ulva lactuca	Bay	Sewage pollution	Wu *et al.*,2022

Importance of benthos in coastal monitoring Programs:

The benthic zone (bottom) of coastal marine ecosystems is relevant in maintaining the productivity, energy flow and nutrient recycling process. Organisms living in these zones are referred to as "benthos" which play a key role in the ecosystem processes, They are characterized by their sessile or sedentary nature, having a relatively long life span, susceptibility to any changes in the overlying water mass and sediment conditions. Several studies have also revealed their relatively rapid response to anthropogenic as well as natural disturbances and their role in energy transfer in the aquatic food web. Macroinvertebrates are the major group of animal communities in the zoobenthos and they are highly sensitive to ecosystem disturbances.

Marine benthic biotic indices and their relevance to coastal monitoring programs

Coastal marine ecosystems are characterized by high biological productivity and varying environmental conditions. Anthropogenic pressure from eutrophication, shipping (oil spills and invasive species), industrial activities, dredging and dumping, mariculture, fishing, tourism, ocean acidification, climate change, and other developmental activities impact the benthic diversity, at the gene to ecosystem level. Even though benthic organisms are excellent indicators of ecosystem disturbances, their application remains difficult in transitional waters due to their dynamic nature and different geomorphologic features. Benthic organisms are excellent indicators of biotic integrity due to their sedentary life with a relatively long life span, high level of tolerance to different stress levels, a key role in nutrient cycling, and significance in energy transfer to higher trophic level.

Effect of temperature change on plankton diversity

Temperature directly affects their metabolism, which includes photosynthetic and respiratory activities. Blooms in polar and sub-polar seas indicate that low temperature does not prevent their exponential growth. The most significant changes in phytoplankton species composition are likely to be mediated by changes in thermal stratification patterns. The metabolic rate of heterotrophic organisms is more sensitive to temperature. Consequently, warming may increase consumption by herbivore animals more strongly than primary production. It can strengthen top-down control over primary production by increasing grazing rates and thus affect phytoplankton production. Because mixing events are frequently accompanied by variations in resource availability of light and nutrients, vertical mixing is one of the important elements that influences phytoplankton growth performance within the water column.

Effect of change in nutrients on plankton diversity

The availability of nutrients for plankton growth is also affected by water column mixing. The upward flux of nutrients is inhibited by improved water column stratification by vertical mixing, from deep-water strata. As a result, nutrient-depleted conditions are becoming increasingly prevalent in the environment. Mechanistic models suggest that less vertical mixing will change the competitive advantage between buoyant cyanobacteria and sinking phytoplankton species in more eutrophic settings. Greater hypolimnetic oxygen depletion can also result from increased stratification, which has far-reaching implications for internal nutrient loading in both lakes and seas. As a result, climate change may raise phosphorus concentrations in conjunction with prolonged anoxic conditions. Increasing runoff can change the resource ratio in certain types of systems, depending on the geochemistry of the catchment, and hence alter phytoplankton species' competitive advantage.

Effect of seasonal variation on planktons

Plankton blooms are common in seasonal aquatic habitats, where they drive a variety of ecosystems and community activities and provide a substantial source of energy for higher trophic levels. Seasonal phytoplankton succession is a community phenomenon governed by the population dynamics of diverse primary producers and consumers. Individual species' life histories and physiological reactions to changing abiotic environments drive blooms. Population feedbacks influence the timing and amplitude of blooms, which are mediated by resource dynamics and predator-prey interactions. The timing and magnitude of seasonal plankton blooms are shifting in response to climate change, according to a large number of studies, which agrees with predictions from dynamical models of pelagic producer–grazer systems.

CONCLUSION

Plankton and benthos serve as valuable indicators for assessing the health and quality of aquatic ecosystems. These two components of aquatic environments offer insights into various aspects of ecosystem dynamics and can be essential tools in environmental monitoring and assessment. Plankton, consisting of phytoplankton and zooplankton, can indicate water quality, trophic status, climate change impacts, and overall biodiversity. Benthic organisms, living on or within the sediment at the bottom of water bodies, can be used to assess sediment quality, ecosystem health, habitat quality, and ecological function. By studying plankton and benthos, scientists and environmental managers can gain a more comprehensive understanding of the state of aquatic ecosystems. This information is crucial for making informed decisions related to conservation, restoration, and the mitigation of environmental impacts. By monitoring and analyzing these biological indicators, we can work towards the sustainable management and protection of our water resource. All of this research revealed a significant correlation between ecosystem abiotic and biotic components, as well as the usefulness of phytoplankton and zooplanktons as bio-indicators for detecting aquatic body health and trophic status. Some species can resist harsh abiotic circumstances and thrive in contaminated environments, suggesting a high level of tolerance, whereas sensitive species were absent, indicating a low level of tolerance. As a result, the utilization of these organisms in water quality monitoring studies can be improved.

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