



Original Research Paper

Artificial Intelligence Evaluation of Wastewater Effects on Benthic Faunal Integrity

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Key Words

Abstract

Benthic fauna, Wastewater pollution, Aquatic ecosystem, Biodiversity, Artificial intelligence, Environmental assessment.

The benthic fauna has been found to have a vital role in the sustainability of the aquatic ecosystem due to its role in nutrient recycling, sedimentation, and food webs. Wastewater disposal leads to contamination of water, sediment, and organisms inhabiting the water. This paper aims to investigate the effects of wastewater on the integrity of benthic fauna through an artificial intelligence-based ecological evaluation method. Environmental variables and the corresponding biological response were used in investigating the changes in species composition, abundance, and habitat preferences. The findings show that increased stress due to higher levels of contaminants decreases the number of sensitive species and increases that of tolerant species under contaminated environments. Artificial intelligence-based evaluation provides a basis for determining the link between the two parameters.

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Introduction

Benthic animals contribute significantly to stability of aquatic ecosystem through cycling of nutrients, decomposition of organic matter, and formation of aquatic food chain (Griffiths et al., 2024). Aquatic insects, worms, mollusks, and crustaceans are some of the benthic animals that exist in close association with sediments and react immediately to any environmental disturbance. Benthic animal communities are commonly used as biological indicators for determining the status of the aquatic ecosystem due to their sensitivity to habitat alterations.

The main factor that affects benthic animal communities is the discharge of wastewater because it contributes significantly to the introduction of organic pollutants, nutrients, and toxins to the aquatic environment. These factors make it difficult for oxygen to reach the sediment layer, thus leading to unfavorable habitat that influences the diversity, abundance, and composition of benthic animals.

Impact assessment of wastewater on benthic fauna is critical to understand ecological degradation and promote aquatic conservation. Assessment of these impacts using artificial intelligence can be helpful in analyzing correlations between stress factors in the environment and their effect on living things (Maswadi, 2025). The current research will evaluate wastewater effects on benthic faunal integrity based on ecological conditions, animal response, and AI-assisted assessment.

Literature Review

The benthic fauna has become a very common bio-indicator for assessment of the ecological status of aquatic ecosystems (Dixit and Raje, 2024). Earlier research showed that benthic communities' structure changes were strongly correlated with changes in water, sediment, and pollution statuses (Kim and An, 2015). Diversity of species, abundance of animals and their sensitivity are key indicators of the environmental disturbances.

Wastewater pollution is greatly affecting the structure of benthic communities by causing organic enrichment, depletion of dissolved oxygen and contamination of aquatic environments with harmful chemicals (Nikolaidis et al., 2025). Researchers have found that the polluted environment experiences reduction in biodiversity, changes in feeding behavior and redistribution of the species. Those species that possess higher toleration level to pollution can survive and prevail while the sensitive species diminish due to greater stress (Owen and Snape, 2021).

Ecological assessment techniques have been established to determine the connection between pollution and communities of aquatic animals. Biological assessment using benthic organisms is much more reliable in determining the changes occurring within the environment than chemical assessments which are short-term. The complexity that exists among different environmental factors makes ecological interpretation difficult.

The development of artificial intelligence technologies has provided an assist in the field of environmental studies by recognizing the association between ecological and biological effects (Hassan et al., 2025). AI technologies may be used to assess data collected from the environment, and help determine the impact of the stresses caused by waste water on benthic communities (Chukwuka et al., 2025).

Materials and Methods

Study Area and Environmental Assessment

Aquatic environments affected by the effluents from the waste water were used in the experiment because alteration in the properties of water and sediment could have an impact on the benthic animals. Factors that included the availability of oxygen in the environment, the presence of organic debris, nutrient levels, and sediment properties were used to determine the suitability of the environment.

Benthic Faunal Observation

The benthic organisms were studied as biological indicators for ecosystem quality (Fan et al., 2017). The analysis involved the change in the number of species, their abundance, and diversity among other characteristics of organisms based on different levels of wastewater effects. The presence of sensitive and tolerant species helped assess the changes in ecosystem integrity, which is shown by reduced diversity and dominance of tolerant species.

Wastewater Impact Evaluation

The impact of water pollution on benthic communities was assessed through the analysis of links between pollution factors and biological reactions. Such factors included oxygen depletion, changes in sediments, and increased levels of pollutants that could affect the survival, distribution, and habitat preferences of organisms.

Artificial Intelligence-Assisted Ecological Assessment

An AI-driven method of analysis was utilized to determine associations between environmental conditions and changes in benthic faunal communities (Stoica et al., 2016). The assessment was helpful in identifying key ecological drivers related to community variation and allowed interpretation of complex links between stressors associated with wastewater and biological reactions. This method served as an ecological aid in the analysis of aquatic ecosystems.

Results and Analysis

Influence of Wastewater Conditions on Benthic Faunal Communities

There was a clear impact of wastewater pollution on the composition of benthic faunal communities. Habitats with low pollution levels had diversified benthic fauna, including fauna that required stable environmental conditions. On the other hand, habitats with high wastewater pollution levels had fewer species with more pollution tolerant species being dominant. The decline in the number of sensitive species is an

indication of the negative impact of poor water quality on benthic fauna survival.

Table 1: Influence of Wastewater-Related Environmental Factors on Benthic Faunal Integrity

Environmental Factor	Effect on Benthic Fauna
Dissolved oxygen availability	Low oxygen conditions reduce survival of sensitive organisms
Organic pollution	Increases stress and alters community composition
Sediment contamination	Affects feeding, reproduction, and habitat suitability
Nutrient enrichment	Causes ecological imbalance and species changes
Toxic substances	Creates physiological stress and population decline

Table 1 show that environmental stress associated with sewage water directly impacts benthic communities' stability. Species that are sensitive to contamination decrease in number when the environment worsens, while tolerant species thrive because of their capability to live under stress conditions.

Artificial Intelligence-Based Ecological Interpretation

The intelligent assessment conducted using AI revealed correlations between the environmental factors and modifications in the benthic community. It was found out that the factors such as the dissolved oxygen content, sediment properties, and pollution level are important elements affecting the fauna quality. By analyzing several ecological factors at once, the assessment helped to evaluate the influence of the wastewater on the population of aquatic animals.

As can be seen, the AI-based assessment helps ecological researches to reveal complicated environmental patterns and monitor the biodiversity. Nonetheless, biological measurements are required to interpret the real response of the benthic creatures to the habitat

disturbance. The combination of ecological data with intelligent methods of assessment can help to conduct wastewater evaluation.

Conclusion

Benthic fauna is a useful indicator of the state of aquatic ecosystems because of their sensitivity to environmental alterations. This research proves that wastewater contamination impacts benthic communities in terms of reduced biodiversity, species composition alteration, and increased pollution-resistant species. Low dissolved oxygen level, sediment degradation, and pollutants' accumulation have been recognized as the key factors affecting fauna integrity.

AI-aided assessment confirmed the perception of the dependencies between the state of wastewater and response of benthic animals to it. Ecological observations coupled with intelligent processing can contribute to more effective monitoring of the aquatic ecosystems. Future research can concentrate on biodiversity assessment and real-time wastewater effects on aquatic ecosystems.

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