

The Role of Sustainable Technology in Mitigating the Impact of Pollution on the Marine Environment

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Abstract: Marine pollution is one of the environmental problems that can disrupt the balance of ecosystems, reduce water quality, and have an impact on marine life and human activities. Increasing industrial activities, marine transportation, settlements, and coastal activities also increase the potential for waste and pollutants to enter the marine environment. Therefore, an approach is needed that not only focuses on handling pollution after it occurs, but also on efforts to prevent and reduce pollutant sources in a sustainable manner. Sustainable technology has an important role in supporting these efforts through the application of waste treatment technology, environmental quality monitoring, emission reduction, use of renewable energy, and the development of a more efficient environmental management system. This article discusses the role of sustainable technology in mitigating the impact of pollution on the marine environment, the main problems faced, and a review of the technological approaches that have been applied. The results of the discussion show that sustainable technology can be an important part of marine pollution control if supported by proper management, continuous monitoring, regulation, and the involvement of various parties. Thus, the application of technology needs to be directed not only at the ability to overcome pollution, but also at pollution prevention and the long-term sustainability of marine ecosystems.

Keywords: Sustainable Technology; Eco-Friendly Technology; Marine Pollution; Pollution Mitigation; Environmental Management

1. Introduction

The sea is one of the components of the environment that has a very important ecological, social, and economic function. Marine ecosystems are habitats for various types of organisms and support human activities such as fisheries, transportation, tourism, and economic activities of coastal communities. However, the development of human activities in land, coastal, and marine areas can increase pressure on the environment, one of which is in the form of marine pollution [1].

Marine pollution can come from various sources, such as domestic waste, industrial activities, port activities, marine transportation, oil spills, plastic waste, and runoff from land areas. Pollutants that enter the marine environment can reduce water quality and disrupt the life of organisms. If not controlled, pollution can cause damage to ecosystems and have an impact on communities that depend on marine resources [2].

Technological developments provide opportunities to help reduce these problems through the application of waste treatment technology, water quality monitoring systems, renewable energy, and more efficient environmental management methods. Sustainable technology not only focuses on the ability to overcome pollution, but also considers resource use efficiency and environmental impact in the long term. Therefore, this article discusses the role of sustainable technology in mitigating the impact of pollution on the marine environment as well as various approaches that can support sustainable management of the marine environment [3].

2. Discussion of the Main Problem

The main problem in marine pollution is the entry of various types of pollutants from human activities

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into the aquatic environment. Domestic waste can carry organic matter, nutrients, and microorganisms, while industrial activities can produce waste that contains certain chemicals and metals. In addition, shipping and port activities can also produce oil, fuel, operational waste, and waste that have the potential to pollute the marine environment [4].

This pollution can cause changes in the physical, chemical, and biological conditions of the waters. The accumulation of plastic waste, for example, can disturb marine organisms and damage habitats. Meanwhile, an increase in nutrient content in the waters can cause excessive algae growth that has the potential to reduce the quality of the waters. The impact of pollution can also be felt by humans through the disruption of fisheries, tourism, and economic activities of coastal communities [5].

Sustainable technology can be used to help overcome these problems. Wastewater treatment technology can reduce the content of pollutants before they are discharged into the environment, while sensors and digital monitoring systems can help monitor water quality conditions faster and more sustainably. In addition, the use of renewable energy and more efficient technology can help reduce emissions and resource use. Thus, sustainable technology can support the prevention, control, and monitoring of marine pollution [6].

3. Review and Criticism of Existing Approaches

Various technological approaches have been used to reduce marine pollution, one of which is waste treatment technology. Wastewater treatment can reduce the content of pollutants before the waste enters the environment. This approach can provide benefits in maintaining water quality, but its effectiveness is highly dependent on the design of the technology, the characteristics of the waste, the treatment capacity, and the operation and maintenance of the system [7].

Approaches that only focus on treating waste after it is generated have limitations. If the amount of waste continues to increase, the treatment system can experience an increase in workload and require greater resources. In addition, environmental monitoring technology can also face obstacles in the form of procurement costs, equipment maintenance, the need for experts, and limited infrastructure. Therefore, the application of technology needs to be accompanied by a reduction in pollution from the source [8].

Technologies also need to be assessed based on their entire use cycle. A technology is not enough to be assessed solely on its ability to reduce one type of pollution, but also needs to consider energy use, raw materials, maintenance costs, waste generated, and environmental impact over the life of its use. Thus, a sustainable technology approach needs to be carried out in an integrated manner through prevention, treatment, monitoring, evaluation, and continuous improvement [9].

4. The Author's Perspective or Argument

Sustainable technology has great potential in helping to reduce the impact of pollution on the marine environment. However, technology cannot be the only solution because the success of mitigation is also influenced by environmental management, regulations, supervision, and community behavior. Therefore, technology needs to be placed as part of a mutually supportive environmental management system [10].

The application of technology should place more emphasis on pollution prevention rather than just dealing with pollution after it has occurred. Reducing waste from the source, improving process efficiency, waste treatment, and using cleaner energy can be done simultaneously. The use of digital technologies such as sensors, water quality monitoring systems, data processing, and early warning systems can also help provide information about changes in marine environmental conditions more quickly [11].

The application of sustainable technology must consider the conditions and needs of each region. Differences in environmental conditions, infrastructure, costs, human resources, and pollution characteristics cause a technology to not necessarily be applied in the same way in every region. Therefore, the application of technology needs to be combined with regulations, environmental education, monitoring, and community participation so that efforts to mitigate marine pollution can take place effectively and sustainably [12].

5. Conclusion

Marine pollution is an environmental problem that can originate from various human activities, such as domestic activities, industry, shipping, ports, and activities in coastal areas. This pollution can reduce the quality of waters, disrupt the marine ecosystem, and have an impact on community activities that depend on marine resources. Therefore, mitigation efforts are needed that are able to reduce pollution while maintaining the

sustainability of the marine environment.

Sustainable technology can play a role in supporting mitigation through waste treatment technology, environmental quality monitoring, renewable energy utilization, and more efficient management systems. However, the application of technology still has various challenges, such as the need for costs, infrastructure, maintenance, and human resources. Technology also needs to be evaluated based on its impact on the environment as a whole so that its application is truly in accordance with sustainability principles.

Based on the discussion, sustainable technology needs to be implemented as part of an integrated approach that combines pollution prevention, waste treatment, environmental monitoring, regulation, and community participation. Proper implementation can help reduce the impact of pollution while increasing the effectiveness of marine environmental management. With this approach, sustainable technology can support efforts to protect marine ecosystems and use marine resources responsibly in the long term.

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