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The Impact of Human Activities on Corals

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Abstract. Coral reef ecosystems are one of the most vital and dynamic ecosystems on earth, teeming with a diverse array of marine life and playing a crucial role in maintaining the health of the oceans. By delving into the multifaceted impacts of human activities on coral reef ecosystems, this paper examines the devastating consequences of various anthropogenic factors, such as the booming tourism industry, the pervasive microplastic pollution problem, and oil spills and other forms of marine pollution. The protection and restoration of coral reef ecosystems through a wide range of measures provides a safer and healthier habitat for coral reefs, thereby ensuring that coral reefs can continue to play an important role in the marine ecosystem. Only by adopting such a comprehensive and proactive approach can humankind ensure the sustainable use of coral reefs. Furthermore, this article proposes a series of protective measures and strategic improvement plans designed to rehabilitate and restore coral reef ecosystems to their former glory, ensuring their survival for future generations to marvel at and benefit from.

Keywords: Coral reef, Coral bleaching, Recovery.

1. Introduction

In recent times, the ecosystem of coral reefs has been facing an unparalleled array of challenges, largely due to the intensification and proliferation of human activities across the globe. A multitude of studies, conducted by researchers from various countries around the world, have indicated that numerous human endeavors, such as the rapid expansion of tourism development, the rampant discharge of pollutants into the environment, and the extensive extraction of oil, have inflicted severe and often irreparable damage upon coral reef ecosystems[1-3]. These detrimental activities have resulted in a significant decline in the biodiversity of coral reefs, leading to a loss of species that once thrived in these underwater habitats. Consequently, the functional integrity of these ecosystems has been compromised, affecting their ability to support marine life and provide essential services to human communities.

In response to these pressing and alarming issues, scholars and conservationists have put forth a series of comprehensive measures aimed at the protection and effective management of coral reef ecosystems. These measures encompass the establishment of marine protected areas, where human activities are regulated or restricted to minimize impact on the natural environment. Additionally, there have been efforts to impose stringent restrictions on fishing activities to prevent overfishing, which can lead to the collapse of fish populations and disrupt the balance of marine ecosystems[3]. The reduction of pollution emissions has also been a key focus, as it helps to mitigate the adverse effects on marine life and preserve the health of coral reefs.

Furthermore, humans have taken proactive steps in the restoration of coral reefs, working diligently to rehabilitate ecosystems that have been damaged by human activities. This involves the cultivation of coral fragments in nurseries and their transplantation back into the ocean, as well as the removal of physical damage caused by anchors and other destructive practices. These restoration efforts aim to accelerate the recovery of damaged reefs and enhance their resilience against future threats.

This article delves deeply into the impact of human activities on coral reefs, providing a scientific foundation that is crucial for the formulation of effective protection and management strategies. By understanding the extent of the damage caused by human actions, policymakers and conservationists

can develop targeted interventions to safeguard these vital marine ecosystems for future generations. The comprehensive approach suggested by scholars not only addresses immediate threats but also lays the groundwork for the long-term sustainability and resilience of coral reef ecosystems in the face of ongoing human-induced challenges. It is imperative that these measures are implemented with urgency and commitment, as the survival of coral reefs is inextricably linked to the well-being of the planet and the future of marine biodiversity.

2. Factors Affecting the Destruction of Coral Reefs

A survey found that the coral reef coverage rate in the Hongtang Bay area of Sanya is 14.3%, lower than the survey results in 2016 and 2018, and the coral reef coverage rate is extremely uneven, with significant changes in its main population. The shell-shaped and clump-shaped corals with strong tolerance gradually replaced the branched corals with weak tolerance and strong sensitivity as the dominant groups in the community [4]. The same problem also exists in the Great Barrier Reef of Australia. According to long-term monitoring by the Australian Institute of Marine Science, coral coverage remained relatively stable from 1986 to 2010, fluctuating between 20% and 30%. The consecutive coral bleaching events from 2010 to 2017 caused the coral coverage rate to drop to the lowest of 13.5%, and from 2017 to 2022, the coral coverage rate significantly recovered to the highest record of 36.5%. At the same time, investigations have shown that the dominant population of corals has also changed, becoming more heat-tolerant and resistant to bleachings, such as Porites, Pocillopora and Gonopore[5].

In the past few decades, not only have humans had a negative impact on coral reefs, but the impact of climate change on coral reefs has also been increasing, resulting in a significant decrease in the coverage of live coral reefs worldwide. The dual impacts of climate change (such as ocean warming and acidification) and human activities (such as ocean pollution, increased suspended solids, coastal development, overfishing, coral diseases and pests) have led to severe degradation of coral reef ecosystems.

2.1. Impact of Climate

Human activities are closely related to global climate change, especially since industrialization. The emission of large amounts of greenhouse gases has led to a continuous rise in global temperatures, causing profound impacts on ecosystems and biodiversity. Glacier melting and rising sea levels pose a threat to the survival of coastal cities, with particularly significant impacts on marine ecosystems, particularly the destruction of coral reefs. The rise in seawater temperature has become the main cause of coral bleaching worldwide. The increase in seawater temperature not only slows down the calcification rate of corals, which is a crucial process for building their skeletons but also has a negative impact on their photosynthesis. Photosynthesis is the foundation of the interaction between corals and symbiotic algae. Once this symbiotic relationship is imbalanced, corals will lose their bright colors and experience whitening. Coral bleaching not only affects the appearance of corals, but more seriously, it causes damage to their physiological functions. When bleaching occurs, the symbiotic algae inside the coral are expelled, causing the coral to lose an important source of nutrients. The lack of this nutrient significantly increases the tissue loss rate of corals, especially those that have already whitened. Research shows that the tissue loss rate of coral bleaching is higher than that of coral maintaining normal color, indicating that the increase in seawater temperature not only directly leads to coral bleaching, but also indirectly weakens the coral's resistance to other environmental pressures. Its health condition is directly related to the stability of the entire marine ecosystem. The reduction of corals means that many marine organisms that rely on coral reefs for survival have lost their habitats and food sources, leading to the destruction of the ecological chain[6].

In addition to the significant impact of global climate change caused by human activities on the ecological environment of coral reefs, other human behaviors also directly affect the ecosystem of coral reefs, further exacerbating their destruction. This article will focus on the direct impact of these

related human activities on coral reefs and explore how to protect and restore coral reef ecosystems by changing these behaviors.

2.2. Impact of Human Activities

2.2.1. Tourism and diving activities

In recent years, the expansion and strengthening of ocean tourism activities have led to a continuous increase in the number of participants in diving and various other forms of underwater entertainment activities. As more and more people are attracted to the ocean, research has shown a clear and direct correlation between the degree of coral reef damage and the frequency of human diving explorations. The main factors causing this environmental impact are closely related to the behavior of diving enthusiasts. The equipment used by these divers often comes into accidental contact with fragile coral structures, and some tourists exhibit behaviors that exacerbate this situation, including not only touching, but also walking, kneeling, standing, and even jumping on fragile coral reefs. These behaviors may cause irreparable damage to these complex underwater ecosystems[1].

2.2.2. Nutrient content

Due to the development of nearshore tourism, a large amount of pollutants are discharged into the ocean. The increase in the concentration of nitrogen oxides, organic nitrogen, and inorganic nitrogen in the water can have a negative impact on coral physiology: the increase in nitrogen oxide, such as nitrate content, can inhibit coral skeletal growth, reduce coral coverage and species diversity [7,8]. Human activities can alter the concentration ratios of nutrients in water bodies: when there is an excess of dissolved inorganic nitrogen in the environment, diatom cells obtain relatively less phosphate from the outside, resulting in nutritional imbalance. In addition, the continuous increase in nitrogen and phosphorus content in seawater also promotes the growth of large algae[9], competing with corals for substrate.

2.2.3. The resuspension of sediment

It is easy for diving tourists to disturb the seabed sediment with their flippers, leading to an increase in suspended particulate matter in the diving area[10]. The suspended solids generated by land runoff, coastal development, port terminals, bridges and other marine engineering construction can also have an impact on coral reefs under the action of ocean currents. On the one hand, the substances and energy required by corals mainly come from the photosynthesis of their symbiotic diatoms. The increase in suspended solids will reduce the transparency of the water, affecting the photosynthesis of diatoms and thus affecting the growth of corals; On the other hand, suspended solids can also form sediment that affects coral respiration, fertilization, attachment, and survival[3].

2.2.4. The impact of marine microplastics (MPs) on coral reef ecosystems

Microplastics, commonly referred to as MPs, are pervasive throughout the world's oceans and are found in a wide array of marine life forms, extending to the intricate structures of coral reefs. The ingestion of these tiny plastic particles can inflict physical harm on living organisms, disrupting their reproductive processes and potentially resulting in their demise. In a study conducted by Hall et al., they embarked on a feeding experiment involving Dipsastrea pallida, a species of coral native to the Great Barrier Reef in Australia. The researchers introduced microplastics into the corals' environment and subsequently discovered plastic fragments embedded within the coral's gastrointestinal tissues. The results of this experiment indicated that when corals are exposed to elevated levels of microplastics, their overall health can be compromised. This exposure can lead to a range of detrimental effects, underscoring the critical need for further research into the impacts of microplastics on marine ecosystems and the organisms that inhabit them[11].

2.2.5. Potential hazards of biofilm on microplastic surfaces to corals

According to research, coral diseases are closely related to microbial communities, and MPs are good carriers of numerous pathogens. Moreover, MPs have the characteristics of lightweight, easy floating,

and long-distance drift transmission ability. Therefore, the pathogens carried on MPs are likely to be potential pathogens that cause coral diseases[2]. Lamb et al. conducted disease risk assessments on 124000 reef-building corals from 159 coral reefs in the Asia Pacific region and found that plastic waste can promote the colonization of pathogens; When coral comes into contact with plastic, the likelihood of disease increases from 4% to 89%[11].

2.2.6. Eutrophication of seawater

Land-based runoff input, domestic sewage, and aquaculture wastewater discharge may all lead to eutrophication in coral reef areas. The reproductive capacity, egg size, and fertilization rate of corals will decrease, while the number of malformed embryos will increase and the population of coral larvae will decrease[12]. Eutrophication of seawater can also disrupt the competitive balance between corals and macroalgae, leading to massive proliferation and growth of macroalgae in reef areas, resulting in suffocation and death of mature corals. Eutrophication of seawater can accelerate the infection rate of coral diseases and exacerbate the impact of diseases on corals.

2.2.7. Oil extraction

During the process of oil extraction, leakage incidents may occur, causing oil pollution to cover the surface of corals, affecting the efficiency of photosynthesis and leading to coral death. The noise and vibration generated during drilling operations may lead to the detachment of coral symbiotic algae and the occurrence of coral bleaching; Suspended particulate matter may block the respiratory pores of coral polyps, affecting their survival[13].

In the construction process of oil extraction platforms, a large amount of sea space needs to be occupied and the seabed terrain needs to be changed. This will damage the ecological environment of coral reefs and have adverse effects on their ecosystems and stability[14].

2.2.8. Ocean shipping

Ocean-going vessels may collide with coral reefs during navigation, damaging their structure and causing biological death. The dragging and fixing of anchorages can also cause physical damage to corals. Ships generate a large amount of oil pollution and domestic sewage during their journey, which can have a serious impact on coral reef ecosystems. If a ship transporting hazardous chemicals leaks, these chemicals may directly kill corals or alter the chemical properties of seawater, affecting Literature References

References are cited in the text just by square brackets [1]. (If square brackets are not available, slashes may be used instead, e.g. /2/.) Two or more references at a time may be put in one set of brackets [3, 4]. The references are to be numbered in the order in which they are cited in the text and are to be listed at the end of the contribution under the heading *References*, see our example below.

3. Suggestions for Repairing and Protecting Coral Reefs

Coral reef ecosystems are of immense ecological significance and possess substantial economic value, serving as vital habitats for a diverse array of marine life and supporting fisheries and tourism industries. Simultaneously, the process of coral reef restoration is characterized by its systemic complexity, which has garnered the attention of numerous scientists who are dedicated to continuously exploring and conducting in-depth research within the field of coral reef ecological restoration.

3.1. Improvement and Limitations of Diving Activities

Relevant organizations should provide professional training for divers, including avoiding contact with diving equipment, scratching coral reefs, prohibiting direct contact with coral reefs, and staying away from newly formed or repaired coral reefs. At the same time, it is necessary to improve diving skills and environmental awareness, maintain slow movement in the sea, reduce the impact on the

underwater environment, discover and remove nonbiological waste during diving, and improve the living environment of coral reefs.

3.2. Reductioning of Plastic Pollution

Reducing the impact of microplastics on coral can be achieved by the government introducing relevant laws to restrict the use of nonessential plastic products, stopping the release of microplastics into the ocean, and raising citizens' awareness of plastic pollution and protecting the marine environment; Regularly conduct cleaning activities on the ocean to remove plastic pollutants from the ocean.

3.3. Avoiding Eutrophication of Seawater

By promoting organic agriculture, reducing the use of fertilizers and pesticides, strengthening sewage discharge management, improving drainage quality, promoting new energy vehicles, reducing pollution caused by exhaust emissions, and establishing protected areas to ensure the protection of the ecological environment of coral reefs, the impact of seawater eutrophication on coral reefs can be effectively reduced.

3.4. Prevention of Oil Leakage

To ensure the protection of marine ecosystems, it is crucial to establish and enhance the environmental oversight mechanisms specifically tailored for the petroleum development sector. This involves intensifying the regulatory scrutiny over various critical operations such as drilling activities, the construction of offshore platforms, and the processes related to the treatment of oil pollution. By employing drilling equipment that is designed to produce minimal noise and vibration, we can significantly diminish the disruptive impact of these operations on delicate coral reef ecosystems. Additionally, it is imperative to bolster sewage treatment protocols to ensure that any waste generated is managed responsibly and does not contribute to the degradation of coral reef environments. Through these comprehensive measures, aim to prevent oil pollution from adversely affecting the health and sustainability of coral reefs, thereby preserving the biodiversity and natural beauty of these underwater habitats.

3.5. Standardize Ocean-going Vessels

The government needs to establish strict environmental regulations to regulate ocean shipping and reduce the damage it causes to coral reefs. At the same time, promote the use of environmentally friendly ships to reduce pollutant emissions during ship navigation. Actively carry out ecological restoration work on coral reefs and restore the ecological functions of damaged coral reefs.

4. Conclusion

The impact of human activities on coral reef ecosystems is rapidly increasing and has become a focus of global attention and concern. Domestic and foreign scholars have accumulated a large number of survey results in this specific field, providing strong support and guarantee for the protection work aimed at protecting coral reefs. However, with the increasingly severe environmental challenges, it is necessary to persist in strengthening research on coral reefs. This requires a thorough investigation into the complex mechanisms by which human activities affect these fragile underwater ecosystems. Therefore, it is necessary to develop and implement more effective strategies for protecting and managing coral reefs. To protect and restore coral reef ecosystems, multiple measures must be taken. These measures must include strict measures to control pollution and reduce harmful emissions, promote sustainable tourism practices, and carefully plan urban development in coastal areas. By implementing these comprehensive measures, people can provide a safer and healthier habitat for coral reefs. This in turn ensures that coral reefs can continue to play their important role in the marine ecosystem, benefiting future generations. Only by adopting such a comprehensive and positive

attitude can humanity ensure the sustainable use of coral reefs precious ecological treasures are filled with biodiversity and support countless forms of marine life.

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