Marine Pollution and its Mitigation Strategies

Shumaila Yousaf[1], Prof. Dr. Farkhanda Manzoor[2], Tehreem Iftikhar[1], Zakia Kanwal[3]

Abstract

Marine pollution is posing an unparalleled threat to the world's seas, with far-reaching effects on biodiversity, ecosystem health, and human well-being. This paper offers a thorough examination of the causes, effects, and methods for mitigating marine pollution, with an emphasis on oil spills, plastic pollution, runoff from agriculture, and industrial waste. The efficacy of current mitigation strategies, such as alterations in behavior, legislative initiatives, and technological advancements was assessed. Our analysis emphasizes the need for a multifaceted strategy that tackles consumption patterns, waste management techniques, and climate change, the three main sources of marine pollution. The researchers identified important research gaps and future directions, such as the creation of frameworks for international cooperation, climate-resilient infrastructure, and circular economy practices. With the goal of reducing marine pollution and advancing sustainable ocean management, this assessment intends to provide evidence-based policy and practices.

Keywords: Marine, Pollution, Mitigation strategies, Marine pollution sources, Marine Pollution Effects, Plastic, and Oil spills, Agriculture runoff, industrial waste.

1. Introduction

Marine pollution poses a significant threat to the health of our oceans, marine life, and human well-being. This review article provides an overview of the current state of marine pollution, its sources, effects, and mitigation strategies.

The definition of marine pollution is the introduction of materials or energy into the marine environment by humans, either directly or indirectly, that has a negative impact on the environment and causes hazards to human health, challenges to marine activities, deterioration of seawater quality for different purposes, and loss of amenities. Chemicals and litter are the main components of marine pollution; the majority of the rubbish originates on land and is carried into the ocean by waves or winds. The ecology, the health of all living things, and global economic systems are all harmed by this pollution (Verma, Pant, Sign, & Tiwari, 2020a), Because of the detrimental effects of chemicals, whose levels are rising alarmingly, pollution of the marine environment is an international issue (Sarkar, Ray, Shrivastava, & Sarker,

[1] Department of Zoology, Lahore College for Women University, Jail Road, Lahore, Pakistan,
Email: shumailayousaf572@gmail.com
[2] Department of Zoology, Minhaj University Lahore,
corresponding Author Email: dean.srd@mul.edu.pk
[3] Zoology Department, Lahore College for Women University Jail Road, Lahore, Pakistan

https://doi.org/10.58932/MULG0047

2006).

Pollutants from throughout the world that affect the marine environment include diseases, sediments, solid waste, heat, fresh water, brine, toxic inorganics, toxic organics, petroleum, nutrients, radioactive materials, oxygen-depleted materials, acids, bases, and unsightly items. Controlling these marine contaminants is a complex task. This is because there are many different ways that humans use the marine environment, and these different uses have different impacts. A moving ship might need to use a harbor channel in addition to releasing pollutants like trash from foreigners living there, oil from pumping its bilges, and heat from condenser discharge. This could lead to sedimentation problems associated with the required maintenance dredging as well as a shift in salinity (Joshi, 2014).

1. Sources of Marine Pollution

Marine pollution takes numerous forms and originates from many sources. Several pollutants are harmful to marine life when present in high enough amounts (Boesch, Burroughs, Baker, Mason, Rowe, & Siefert, 2001). The three primary sources of marine pollution are atmospheric fallout, runoff mostly via rivers, and direct discharge as solid waste and effluents from land and human activities at sea (e.g., shipping) (Wilhelmsson, Thompson, Holmström, Lindén, & Eriksson-Hägg, 2013).

1.1 Plastic

Plastics are a significant pollution in the world's seas. Over 80 percent of the garbage discovered in the seas comes from human activity, and the ever-increasing plastic dependency of the human population has flooded both the land and the oceans. Animals and marine life are at risk from plastic waste and debris in the waters, since it may choke and strangle them to death. The increasing amounts of plastic waste in the oceans are choking, consuming, and entwining both above- and below-ground life (Verma, Pant, Sign, & Tiwari, 2020b). These synthetic polymers can resist the ocean environment for years or even decades due to their chemically designed durability and slow rate of biodegradation. Ocean plastic has many negative effects on the environment. Seabirds consuming animals ranging from plankton to marine mammals, the migration of microbes and colonizing species to perhaps non-native environments, and the concentration and transfer of organic toxins to marine life at different trophic levels are a few examples of these. (Law *et al*., 2010).

1.2 Agriculture Runoff

Agricultural runoff, discharge of fertilizers and pesticides, and untreated waste water constitute around 80% of marine pollution globally (Zitko, 2000). Fisheries have been significantly impacted by the degradation of the maritime environment. Influence of the land runoff on eutrophication is significant, and nitrogen from agriculture has historically been the primary nutrient supply. Thus,

agriculture is a key contributor to contemporary fish deaths. Coastal zones around the world are dealing with one of the most important ecological problems: coastal eutrophication brought on by agricultural runoff. A range of consequences, including as dangerous algal blooms, zones of hypoxia or anoxia, and a decline in biodiversity, have been brought about by the increase in nutrients in marine ecosystems. (González *et al*., 2020). For example, agricultural runoff with fertilizers can lead to eutrophication in lakes, resulting in fish mortality due to oxygen deprivation (Yakamercan & Aygün, 2021).

1.3 Industrial Discharge

Through industrial waste and urban sewage, pollutants are immediately released into rivers and the sea as poisonous and dangerous water. Some of the minerals released during mining operations can lead to issues that could disrupt coral polyps' growth and life cycle. These minerals and heavy metals, such mercury, affect the quality of the water, unbalance the oxygen content, and eventually deposit on the continental shelves, which serve as spawning grounds for the majority of fish species (Duraisamy & Latha, 2011).

1.4 Oil Spills

Oil spills are now classified as man-made disasters that have a major negative impact on public safety, economic benefits, ecological safety for people, and the health of the marine ecosystem. The following are the primary causes of maritime oil spills: One of the primary causes of maritime oil spills is oil leakage from ships, which includes both accidental and regular vessel leaks. At addition, there are other causes of oil spills, including outdated ships, outdated technology, centralized shipping lanes, and a deficiency of sophisticated traffic control systems at the ports; additionally, collisions, groundings, impacts on rocks, and marine tragedies are commonplace events for oil tankers and other ships. Oil spills drastically damage the marine ecology and contaminate the maritime environment. Not only will it pollute the sea surface and beaches, but it will also harm marine life in many ways. It implies that oil spills from oil tankers might cause more damage to the marine ecology than other cargo catastrophes. Oil spills may inflict not only significant physical injuries and deaths, as well as financial losses, but also marine biological damage that is difficult to recoup and pay for. There are several reasons why oil spills occur, including inadequate attention from managers and operators, ignorance, malfunctions in facilities, technology, and equipment, poor decisions or incorrect operations, management supervision, and other errors (Mei & Yin, 2009) .

1.5 Sewage and Waste

Sewage is a sort of wastewater generated by a community of people. Sewage discharge delivers a variety of contaminants into the aquatic habitat, including chemicals, heavy metals, and bacteria. These contaminants have the potential to upset the ecosystem's natural equilibrium and endanger marine life. For instance, releasing

heavy metal-laden industrial waste into a river might contaminate fish and other food chain species. Eutrophication can result from the high concentrations of nutrients, such as nitrogen and phosphorus, found in sewage. Overabundance of nutrients in the water encourages algae and other aquatic plants to develop quickly. Fish and other marine animals suffer when these creatures decay and die because they reduce the amount of oxygen in the water (Bamaniya, Iqbal, & Bambhaniya, 2023).

2. Effects of Marine Pollution

Marine pollution has wide-ranging, significant effects on ecosystems, human health and economy.

2.1 Ecological Effects

Important marine ecosystems including coral reefs, mangroves, and sea grass meadows may be harmed by pollution. These ecosystems provide important services such as coastal protection, carbon sequestration, and nursery grounds for marine organisms. Pollution, especially from sedimentation and chemical runoff, can suffocate and alter these ecosystems' natural functioning (Fabricius, 2005).

2.2 Effects on Human Health

Contaminated Seafood: Eating contaminated seafood puts human health at risk due to the buildup of harmful chemicals in marine creatures. Due to their high nutritional content, fish is vital for a balanced diet. However, hazardous metals can enter the human body and cause a variety of ailments when fish tissues collect metals in different concentrations and when that exceeds the permissible threshold. Fish intake therefore has the potential to be a significant source of metal exposure and a resulting health concern for humans (Isangedighi & David, 2019). In addition to posing several risks to human health, heavy metals including cadmium, mercury, lead, and arsenic are also strong carcinogens and mutagenic agents (IARC, 2009).

Waterborne Diseases: Pathogens that cause waterborne illnesses including cholera, hepatitis, and gastroenteritis can be found in contaminated waterways. These viruses have the potential to negatively impact human health and cause disability, disease, disorders, or even death if action is delayed (Landrigan *et al*., 2020). When people use contaminated water for drinking, cooking, or cleaning, these bacteria are spread. (WHO, 2022).

2.3 Economic Effects

Fisheries and Aquaculture Fisheries and aquaculture production and sustainability are impacted by pollution. Fishing-dependent communities may suffer financial losses as a result of declining fish supplies brought on by habitat deterioration and pollution (FAO, 2020).

Tourism: Tourism may decrease as a result of marine pollution, which can harm coastal regions' visual appeal, especially when it comes to oil spills and plastic

waste. The allure of maritime places is further diminished by beach restrictions and biodiversity loss, which has an effect on local businesses (Peterson *et al*., 2003).

3. Mitigation Strategies

3.1 Habitat Restoration

Restoring damaged habitats can improve population recovery and biodiversity. Promising initiatives include marine protected areas, artificial reefs, and coastal rehabilitation. Marine Protected Areas (MPAs) are a comprehensive instrument for management that have been made necessary by the need to effectively safeguard fragile habitats, including non-target species. MPAs currently encompass 26.9 million km2, or 7.4% of the ocean area, or 5.3% if only fully implemented MPAs are taken into consideration. In 2000, only 3.2 million km2, or 0.9%, of the ocean was protected. The growth rate of MPA coverage is approximately 8% annually. MPAs currently encompass 26.9 million km2, yet just 3.2 million km2 (0.9%) of the ocean was protected at the time. Additionally, there has been a global upsurge in active efforts for habitat protection and restoration in the twenty-first century. Benefits from these efforts include better water quality after oyster reef restoration. Furthermore, by re-establishing sea grass, saltmarsh, and mangrove ecosystems, Blue Carbon strategies which are included in the nationally determined contributions (NDCs) of over 50 countries and form the basis of the Paris agreement are being used to lessen climate change and enhance coastal protection.

3.2 Fisheries Management

Rebuilding depleted populations can be aided by catch quotas, marine reserves, and sustainable fishing methods. For a long-term recovery, ecosystem-based fisheries management is crucial. At both local and regional levels, the successful restoration of diminished fish populations has been attained by means of tried-and-true management strategies such as restricted areas, catch and effort limitations, control over fishing gear and capacity, catch shares, and co-management agreements. Detrimental subsidies, homelessness and a lack of work alternatives, unreported, unregulated, and clandestine fishing, as well as the adverse ecological effects of many fisheries, are examples of enduring issues (Magera, Mills Flemming, Kaschner, Christensen, & Lotze, 2013).

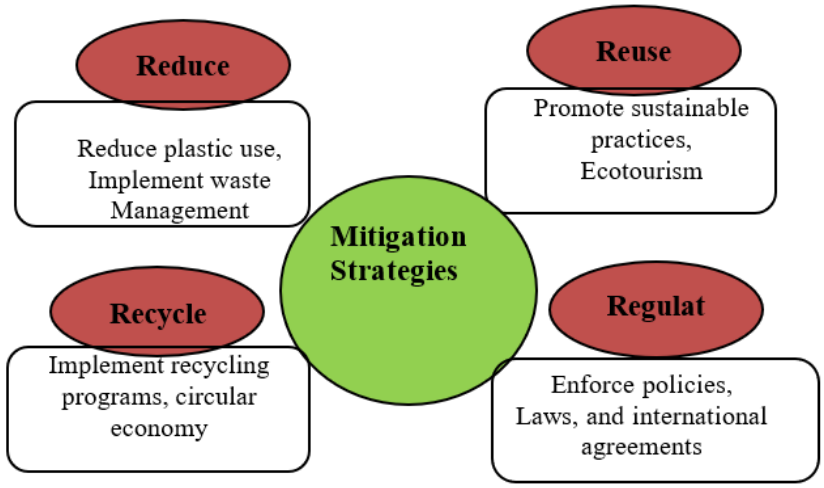

Figure 1. Strategies to mitigate marine pollution

3.3 Pollution Reduction

Marine life damage can be lessened by reducing industrial waste, agricultural runoff, and plastic pollution. It is essential to put in place efficient waste management and pollution control measures. Better safety rules have also resulted in a 14-fold decrease in the number of significant oil spills from oil tankers, which were 24.7 times annually in the 1970s but only 1.7 times annually from 2010 to 2019. It was doubtful ten years ago if nitrogen reductions would lead to better coastal water quality. Nonetheless, a number of achievements, such as the net recovery of sea grass meadows in the US, Europe, the Baltic Sea, and Japan, have since been confirmed as having advantageous ecological effects. (Duarte, Conley, Carstensen, & Sánchez-Camacho, 2019).

3.4 Climate Change Adaptation

It is essential to support assisted migration, habitat modification, and climate-smart conservation strategies used by marine species to adapt to climate change. Human activity is changing the planet Earth through the burning of fossil fuels, urbanization, deforestation, agriculture, and industrial processes. As climate change affects food and water availability and quality, increases air pollution, alters the dynamics of disease transmission and vector distribution, and reduces eco-physical buffering against extreme weather and climate events, the urgency of the health risks associated with it will only increase. Improvements are critically needed if health systems are to deal with these new issues (Tong & Ebi, 2019).

3.5 Public Awareness and Education

Increasing public awareness of the origins and effects of marine pollution is essential for promoting acceptable behavior and inspiring behavior changes. Public

education efforts can encourage people to use less plastic, dispose of their garbage properly, and consume seafood sustainably. Community participation in beach cleanups and citizen science programs may also promote a sense of responsibility for the marine environment.

Conclusion

The global economy, human health, and marine ecosystems are all seriously threatened by marine pollution. Mitigating this problem demands an integrated approach that includes the reduction of land-based and ocean-based contaminants, effective oil spill response strategies public education, and international collaboration. By implementing these methods, we can maintain marine biodiversity, grow economy, ensure the long-term viability of ocean resources and secure future generations' health.

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