

Research Article

# Maritime Pollution in Pakistan and Its Impact on Marine Life: Challenges and Way Forward

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## Abstract

Marine pollution is a major threat to marine biodiversity, ecosystems and socio-economic conditions of coastal communities in Pakistan. Driven by industrial, agricultural and plastic pollution, mounting levels of marine pollution are largely resulting in habitat destruction, biodiversity loss and difficulties in conduct of subsistence activities. Lack of waste management system and public awareness further compound the problem. The present study gives a comprehensive analysis of marine pollution, its sources, types and mechanism as well as the damage it does to marine environment. The study also examines existing domestic and international legislation on marine pollution eradication and puts forth recommendations in the form of both short and long term measures for pollution mitigation in Pakistan. The study also emphasizes the need to sensitize public attention on this pressing issue and advocates awareness campaigns regarding oil spill response preparedness, investment in resilient infrastructure and plastic pollution eradication initiatives. Long term measures stem from analysis of several case studies of island countries. These measures include protection of critical infrastructure, ecosystem conservation as well as increased research and development. Effective implementation of these measures can help Pakistan transition into a sustainable and secure future.

## Keywords

Marine Pollution, Pakistan, Karachi Harbour, Industrial Waste, Agricultural Pollutants, Plastic Pollution, Subsistence Activities, International Legislation, Long Term Measures

## 1. Introduction

Marine pollution is a grave threat to sensitive marine environment and ecosystems in Pakistani coastal areas. It jeopardizes biodiversity, threatens fisheries and affects subsistence activities of coastal communities resulting in compromised socio-economic conditions of local population. Despite several pieces of domestic legislation and many regulatory bodies being in place, implementation remains a challenge.

The damage to marine environment and ecosystems in Pakistan is due to various sources which include industrial,

agricultural and plastic pollution. Apart from this, maritime activities such as shipping and port operations are also sources of marine pollution.

The present study conducts a thorough examination of the causes, sources, intensity and impact of marine pollution in Pakistan with a special focus on pollution in Karachi Harbour which is a hub of maritime activities in Pakistan. Employing a qualitative research method, the study aims to achieve many objectives. These include analysis of sources and extent of

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pollution, impact of marine pollution on ecosystems and subsistence activities, evaluation of existing regulations and international conventions on marine pollution and finally, propose both short and long terms measures for eradication of marine pollution in Pakistan.

By achieving these objectives, the present study seeks to enhance understanding of marine pollution and its various dynamics in Pakistan and give insight to policymakers and regulatory bodies for effective management and mitigation of marine pollution. Through concerted efforts, it is possible to conserve Pakistan's marine environment for future generations.

## 1.1. Problem Statement

The damage to marine ecosystems coming from industrial, agricultural and plastic pollution along with maritime activities is a grave threat to marine biodiversity, fisheries, and subsistence activities of coastal communities. There are several pieces of domestic legislation and many regulatory bodies, but effective implementation and enforcement mechanism still remain a challenge. Moreover, poor infrastructure for waste management and limited public awareness add to the gravity of the issue.

## 1.2. Literature Review

A thematic review was conducted to organize and synthesize existing literature based on finding recurrent themes. An exhaustive literature review yielded previous research on marine pollution in Pakistan and its impact on marine life. Chhatwal [1] delves into the intricate dynamics of environmental pollution, encompassing both land and marine ecosystem. Through a comprehensive exploration, Chhatwal provides foundational insights into the origins, impacts, and management strategies pertaining to pollution. Despite being published over three decades ago, Chhatwal's work remains highly relevant, offering timeless perspectives on the historical evolution of pollution issues and early attempts to mitigate their effects. By examining the historical context of pollution control efforts, Chhatwal's work lays the groundwork for understanding contemporary environmental challenges and underscores the importance of proactive measures to address pollution in both terrestrial and marine environments.

Dr Asif Ali Abro and other have highlighted the impact of untreated municipal sewage on marine environment along Karachi coast. About 471 million gallon municipal wastewater finds its way into the sea every day. Karachi being the most populated city with a big industrial area produced about 12000 metric tons of solid waste of which about half is discharged into the sea. These colossal amounts of pollution impinge heavily on marine life and environment. With these alarming statistics it can be said that Karachi coast is experiencing a dire sanitation crisis. The authors have proposed that

projects initiated under the Greater Karachi Sewerage Plan be implemented on priority basis.

Faiza Ilyas in her report brings a stark reality to light regarding the untreated domestic and industrial waste that finds its way into the sea in Pakistan [2]. This report sheds light on a critical issue that has far-reaching implications for marine ecosystems, public health, and the overall well-being of coastal communities. The report underscores the alarming statistic that over 90 percent of untreated domestic and industrial waste is discharged directly into the sea in Pakistan. These various types of pollutants include domestic waste as well as industrial waste often containing toxic chemicals and heavy metals. This revelation highlights the magnitude of the problem of marine pollution in the region, the damage it does to marine life and the urgent need for decisive action to address it. By drawing attention to this critical issue, the report emphasizes the need for regulatory interventions and mitigation measures to curb the flow of untreated waste into the sea.

Industrial activities in coastal regions have been recognized as significant contributors to environmental pollution, with implications extending beyond terrestrial ecosystems to marine environments. In the study conducted by Idrees, Nergis, and Irfan [3], the focus was placed on monitoring industrial emissions and assessing air quality in Karachi, Pakistan, a coastal city experiencing rapid industrialization. The authors aimed to illuminate the intricate relationship between industrial activities, air pollution, and its repercussions on marine ecosystems. By scrutinizing various pollutants and contaminants present in the air, the researchers provided nuanced insights into the magnitude of industrial contributions to air pollution within the coastal city. The research findings highlighted the prevalence of harmful gases, particulate matter, and other airborne pollutants emitted by industrial facilities in Karachi. These emissions not only deteriorate air quality but also pose indirect threats to marine ecosystems and coastal environments due to their interconnected nature. The study underscored the critical need for understanding the complex linkages between land-based pollution and its consequences for marine ecosystems.

Ahmad, Aslam, and Hussain's [4] study provides a comprehensive assessment of plastic pollution in the coastal areas of Karachi, Pakistan, focusing on specific locations including West Warf, Kemari Jetty, and Manora. Through a detailed case study the authors meticulously analyzed the prevalence and impacts of plastic pollution in these coastal regions. Their research provides valuable insights into the extent of plastic pollution, shedding light on the diverse range of plastic debris present in marine environments. By elucidating the detrimental effects of plastic pollution on marine ecosystems, wildlife, and coastal communities, the study underscores the urgent need for effective mitigation measures to address this pressing environmental issue. The findings of Ahmad et al.'s study contribute significantly to the existing literature on plastic pollution in coastal areas, emphasizing the importance of concerted efforts from policymakers, environmental agen-

cies, and local communities to combat plastic pollution and safeguard marine ecosystems for future generations.

### 1.3. Research Methods

A qualitative research method was employed to conduct the present study. Data was gathered through secondary sources including books, journal articles, and web based sources, etc.

### 1.4. Research Objectives

- 1) To analyze the sources and extent of maritime pollution in Pakistan
- 2) To assess the impact of maritime pollution on marine ecosystems and coastal communities
- 3) To evaluate the effectiveness of existing regulations in addressing maritime pollution
- 4) To propose immediate and long-term measures for mitigating maritime pollution in Pakistan

## 2. Analysis of Marine Pollution in Pakistan

In Pakistan, marine pollution is predominantly constrained to those areas which receive high amounts of waste coming from industries and both sea based and land based human activities [5]. Although, the coast of Pakistan faces semi-diurnal tides, owing to which they are washed twice a day removing some of the pollutants. However, inside the harbors and creeks the pollutants oscillate for several days, until they are dispersed and most of the time settle down at the bottom. Pakistan's maritime environment is deteriorating due to a complex combination of variables, ranging from plastic waste to industrial and human waste. Even though Pakistan is part of the London Convention on the Prevention of Marine Pollution, Dumping of Wastes and Other Matter, an agreement to prevent dumping of garbage into the sea, there is still no practical implementation of pollution prevention measures. This waste includes things like plastic bags, bottles, sewage, and even waste from hospitals that could be dangerous. Because of this pollution, the beautiful blue water at the popular sea view sites in Karachi, has turned black.

### 2.1. Mechanism of Marine Pollution from Karachi

Karachi being country's most populated city harbouring a large number of industries is major source of marine pollution. About 100 km long, Karachi coast of Pakistan is situated between the Ghara Creek and river Hub on the west. Starting from Hub river outfall, open sea coast of Karachi ends at Korangi Creek [6]. While there is no clear consensus on any single population count in Karachi, it is safe to say that it has now reached an alarming figure about 30 million. There are

about 6600 industrial units in Karachi divided in four main industrial areas including the Site Association of Industry, the North Karachi Association of Trade and Industry (NKATI), the Korangi Association of Trade and Industry (KATI) and the F. B Area Association of Trade and Industry (FBATI) [7]. There being no proper system of waste disposal, recycling or treatment in any of these industrial areas, pollution from industrial areas and domestic sewage eventually end up in the coastal waters of Karachi. It is taxing marine environment beyond acceptable limits and is responsible for ecological decay and damage to environment. Existing sewage treatment plants are either non-functional or operating at greatly reduced capacity [8].

#### *Example of Karachi Port and Port Qasim*

Karachi Port and Port Qasim are two big ports in Karachi and additionally there are two fish harbours. Approximately, 35% of cargo is handled by Port Qasim while Karachi Port caters 60% of outgoing trade of the country. Dumping of waste oil, release of oily bilge water, oil spills and other sources of pollution from port operations are persistent worries. There is a need to develop sustainable technologies to make port practices environment friendly.

### 2.2. Sources and Types of Marine Pollution in Karachi Harbor

There are different types of pollution, i.e. air pollution, soil pollution, water pollution, etc.; however, in reality, there is only one form of pollution as all pollutants whether in the air or on land eventually end up in the oceans. Sources of marine pollution from land as well as maritime activities are discussed below:

#### *Land Based Sources of Marine Pollution*

##### *Industrial waste*

Every year, the International Union for Conservation of Nature (IUCN) estimates that thousands of tonnes of industrial waste are dumped into the sea. In Pakistan, coastal areas are the hub of industrial waste. In Karachi, where major industries are located, industrial waste contaminates the sea and becomes the main source of marine pollution. Industrial waste poses a great threat to marine life. In Karachi, the absence of effluent treatment plants, especially in two of the major industries [9], Sindh Industrial Trading Estate (SITE) and Korangi Industrial and Trading Estate, leads to the discharge of waste containing hazardous materials including heavy metals and oil, into the parts of rivers, creeks, and harbors.

The area surrounding Port Qasim [10] has witnessed substantial developments, particularly in industries such as chemicals, oil refineries, and tanneries. These industries convert various substances into the effluents, including hydrocarbons, heavy metals, and fertilizers. Discharges from petroleum industries contains a range of materials, including grease, oil, phenol, and heavy metals like iron, chromium, copper, and zinc. The areas around Karachi's harbour and Port Qasim are considered hotspots with a significant amount

of contaminated water present in that area, posing a threat to marine life. Sindh Environmental Protection Agency [10] (SEPA) is actively working for the protection of the marine environment. According to them, SEPA took legal action against those polluting the marine environment, but industries employed various tactics to evade accountability. This shows that industrial waste is the major source of marine pollution.

#### *Agricultural Pollutants*

Pakistan is an agricultural country and a large-scale agricultural activity takes place in coastal areas of the country. Agricultural pollutants in the form of chemical fertilizers, nutrients, pesticides and herbicides, etc. enter our seas. These pollutants contain several heavy metals including zinc, cadmium, lead and nickel, etc. which often pass through water treatment systems [11] and end up in the sea. The Sindh EPA has the authority to regularize pesticide use; however, it is not doing so. These agricultural nutrients not only harm fresh water bodies but also enter coastal waters and affect marine life. Other than herbicides and pesticides, nutrient pollution from agricultural activity also endangers marine life. Excess nutrients like phosphorus and nitrogen, when released into sea, cause algae and seaweeds to grow exponentially. This causes oxygen levels in water to deplete making it difficult for marine life to survive [12].

#### *Domestic Wastes*

Wastewater, sewage and other domestic effluents are another manmade hazard to marine life. In Pakistan's coastal areas, domestic waste having gone through various channels, eventually ends up in the sea. According to WWF 2019 report, Karachi city alone produces about 475 million gallons wastewater daily out of which around 88% enters Arabian Sea untreated [13]. This waste from various domestic sources entering our seas is also another threat marine life has to face.

#### *Plastic Wastes*

One of the major sources of pollution is plastic waste. The Indus River, a vital source of water for communities in Pakistan, is facing challenges related to plastic pollution. According to a survey conducted by the World Bank an estimated 90 percent of the plastic in the Upper Indus Basin ends up in the river, causing harm to aquatic life. Sanitary products with multilayered packaging are considered the most common type of plastics found in rivers that end up in the oceans. Plastic waste usually accumulates at barrages and canals, degrading into multiple micro plastics and toxins, not only affecting the quality of water but also marine life. Micro plastics further accumulate in marine species, simply causing a threat to marine life. In Pakistan, poorly handled plastic trash frequently finds its way into rivers, streams, and eventually the sea. This includes single-use plastics like bags, bottles, and packaging materials. Around 55 billion plastic bags are used annually in Pakistan, according to a report by the World Wide Fund for Nature [14] (WWF) Pakistan. Many of these bags are disposed of inappropriately and end up in marine habitats.

#### *Micro plastics*

Tiny plastic particles that are less than 5 millimeters in size

are known as micro plastics. Marine life is significantly threatened by micro plastics. According to the study conducted by the Marine Science and Technology Bulletin, micro plastics were found in a variety of fish in the coastal area of Karachi. After analyzing 336 fish specimens [15], micro plastics were found both in the gills and digestive systems of the fish. Plastic pollution, in this way, is one of the main sources of marine pollution in Pakistan.

#### *Riverine Transport*

Much of the plastic waste is transported through rivers in Pakistan. Indus River [16] acts as a conduit from transporting the plastic waste from urban areas towards the coast. Urban areas serve as the hub of plastic waste owing to the concentration of population, industrial activities, and different consumption patterns. The accumulated plastic wastes from the urban centers reach the coast through rivers. In this way, riverine transport plays a major role in transport of plastic to the ocean, posing a threat to marine life. Furthermore, the Indus River, which feeds into the Hub River, plays an important role in transporting plastic waste from cities to the coast. The Indus carries approximately 11,977 tonnes [16] of plastic to its mouth each year, with nearly 10,000 tonnes entering the Arabian Sea, endangering marine life and coastal environments. Low-density polyethylene (LDPE), sanitary products, and multilayered packaging are the most common types of plastic found in these waters transported through Hub river.

## **3. Pollution from Maritime Activities**

### **3.1. Shipping and Port Activities**

Historically, shipping and ports have operated with little damage to environment; however, oil spills of 1960s caused immense marine pollution and death of seabirds. It brought maritime transport into global focus and triggered the institution of MARPOL. Shipping today is responsible for 947 million tons of CO<sub>2</sub> annually constituting 3% of total global emissions. [17] Pakistan's shipping industry contributes greatly to the country's economy as about 90% of Pakistan's trade is seaborne. However, pollution from shipping including oil spills, waste discharge from ships as well as harmful emissions from maritime transport have been damaging to marine environment. Due to lack of latest green technologies onboard ships and on ports, the situation has worsened over time.

### **3.2. Dredging and Wrecking**

Marine environment is greatly suffering as a result of the widespread dredging and reclamation operations. Such operations are taking place in Karachi's Clifton Beach. These processes affect the chemical, biological, and physical environment in both short and long term. Deoxygenation of coastal and the subsurface waters has immediate repercussions, including direct physical harm to marine life. Moreover,



chemical and biological alterations brought about by dredging and reclamation diminish the diversity, biomass, and quantity of marine life. Fish and shellfish, which are essential parts of the marine food chain, are at risk due to high quantities of heavy metals from these operations.

### 3.3. Shipbreaking

Shipbreaking industry in Pakistan is also a significant contributor to marine pollution as industrial activities mostly take place near coasts. These activities produce large amounts of wastes including chemicals, heavy metals and other dangerous substances. These substances are mostly disposed of very irresponsibly. Shipbreaking activities involve dealing with hazardous substances such as lead-based paints, dangerous left-over substances in merchant vessels and the like. These can pose risks to human safety and when these substances along with many others are released into the sea, they cause irreparable damage to marine life and quality of water. Mostly shipyards in Pakistan lack facilities to prevent pollution and waste management systems, pollution including toxins i.e. lead, mercury, and other carcinogens affect workers, surrounding communities and overall environment. It takes an enormous toll on fisheries, agriculture, etc.

### 3.4. Ship Generated Waste

Ships are floating cities and moving from port to port during their normal operations, generate a lot of waste. Waste generated by ships themselves and by crew or passengers onboard includes bilge water, cargo residues, ballast water, food, sewage and garbage. In Pakistan, the problem of vessel-generated waste is a hazard for sensitive balance of marine ecosystems. Harmful discharge of waste from ships contaminates coastal waters and causes immense damage to marine life including birds and animals.

### 3.5. Oil Spills

In 2003, a Maltese oil tanker Tasman Spirit carrying Iranian crude oil ran aground near Karachi port spilling approximately 30,000 tons of oil into the sea. [18] Another example of it is that of oil tanker MT Heng Tong 77, as there was a substantial oil spill into the Arabian Sea as a result of the ship colliding with a bulk carrier. Widespread environmental harm was caused by the spill, as oil slicks traveled across the surface of the water and reached coastal regions, including coast of Karachi. Such accidental oil spills are very dangerous and can have continuous deteriorating impact long after the accidents occur. In case of an oil spill accident, oil swiftly spreads on the ocean surface and covers everything which comes into contact with it. It results in killing of marine animals, plants and also seabirds. Seabirds and marine animals, having oil on their bodies, become susceptible to hypothermia as they lose their ability to bear cold temperatures. Moreover, these birds swallow oil and die due to internal damage and

organ failure. Oil spills can also affect fish eggs resulting in birth and developmental abnormalities.

### 3.6. Tourism

Maritime tourism is a booming industry worldwide. Many coastal countries have developed strong and robust maritime tourism sectors which contribute significantly to their GDPs. As of 2021, global marine tourism market size has been estimated to be 71670 million USD. [19] Although Pakistan is yet to develop a robust maritime tourism sector, yet marine pollution from tourist visits is very much noticeable. Garbage, litter and plastics on the beaches and contamination of coastal waters from recreational activities (diving, snorkeling, boating, etc.) has damaged coastal marine environment.

## 4. Impact of Marine Pollution on Marine Life and Subsistence Activities

### 4.1. Loss of Biodiversity

Marine biodiversity is being affected owing to marine pollution. An example of lamp shells which are a type of small shellfish that were prominent for inhabiting regions like Karachi Fish Harbour, Korangi Creek, and Landhi for approximately 20 million years, are now found nowhere. Moreover, in the last 50 years, 85% decline has been reported in shark landings and many of fish species including black fin cisco, galapagos damsel, silver trout, and yellow fin trout have gone extinct [20]. The decline in marine biodiversity due to marine pollution is impacting marine activities. This loss of biodiversity not only disrupts the mechanism of the marine ecosystem but also threatens the lives of those who are dependent on these activities. Preserving the biodiversity of coastal waters has become essential now.

### 4.2. Fishing Industry

The increase in pollution is leading to depletion of sea resources directly impacting marine life. According to the experts, approximately 80 percent of the coastal population is dependent on fisheries as a source of livelihood. This sector provides employment to 1.5 million people with more than half the workforce in the coastal areas of Sindh and Balochistan. In places like Ibrahim Hyderi, people have observed a group of fishermen sitting idly over the coast as there is more garbage than fish in coastal waters, leading to unemployment. Studies on fisheries in Sindh have revealed that a number of commercially important species of fish has now reduced to dangerous levels because of mounting pollution in waters and destruction of mangrove forests. Annual catch of 'Palla' and 'Dangar' has reduced to 200 tons from 600 tons in 1986. This troubling trend is due to marine pollution, which is posing an adverse effect on the people directly involved in fisheries.

Pollution is leading to a reduction in fish stocks, leading to habitat degradation, fishing grounds, and the disruption of the food security of the community dependent on fisheries. Most of the coastal communities rely on fishing as a primary source of income and food. Pollution is also contaminating fish stocks<sup>1</sup>, making them unsafe for consumption or reducing their abundance. This directly affects the livelihoods and food security of fishermen and their families.

### 4.3. Marine Transportation and Shipping Activities

Shipping and marine transportation are at risk from marine pollution, especially from oil spills. Accidents involving oil leaks harm ships, interfere with navigation, and raise operating expenses for maritime corporations. Ship infrastructure<sup>2</sup> is corroded by contaminants in the sea, increasing maintenance expenses. Pollution also causes navigational routes to become blocked, which delays cargo operations, hinders maritime trade, and puts shipment businesses at risk, ultimately endangering the safety of maritime workers.

### 4.4. Arrested Socio-Economic Growth of Local Communities

Local communities are heavily impacted by marine pollution, which has driven away many marine species. Fishermen who depend on coastal areas for catching shrimp, fish, and other marine life have observed a continual decline in these populations. Marine experts note that untreated sewage entering the seawater severely affects local communities, as many residents are engaged in fishing for their livelihood. The fishing sector offers numerous employment opportunities, and many locals rely on it as their primary profession. The depletion of fish stocks due to marine pollution is significantly affecting these communities, often forcing people to seek alternative subsistence activities in other regions of the country, effectively causing enforced migration.

### 4.5. Aquaculture Operations

In Pakistan, marine pollution significantly impacts aquaculture operations, particularly fish and shrimp farming, which are considered vital components for food security and the country's economy. Pollution coming from industrial activities, including chemical runoff, untreated sewage, pesticides, and fertilizers used in agricultural activities, poses a serious threat to aquaculture activities. Aquatic species exposed to toxic substances [21] lead to a reduction in their mortality rates and also accumulate in the tissues of shrimp and fish, making them unfit for human consumption. The delicate ecological balance of aquaculture systems is affected

by marine pollution, which impacts water quality indicators including pH and dissolved oxygen levels, which are essential for the survival and growth of aquatic life.

## 4.6. Domestic Legislation in Pakistan for marine Pollution Mitigation

### 4.6.1. Pakistan Environmental Protection Ordinance

There are a number of regulatory bodies for managing marine pollution in Pakistan. Pakistan Environmental Protection Ordinance plays a critical role in terms of addressing the threats to marine ecosystem. It provides a legal framework for regulating the activities that contribute the most towards marine pollution including industrial discharge, waste dumping, and plastic wastes. It aims to mitigate the adverse impact of marine pollution on biodiversity and coastal communities.

#### Marine Pollution Control Board

In order to address marine pollution problems in Pakistan, specifically within Karachi Harbour, the Karachi Port Trust (KPT) formed the Marine Pollution Control Department in the year 1996. The harbor, is exposed to a variety of pollutants that come directly from land-based sources. These pollutants include untreated urban and industrial waste coming directly from the city, which amounts to over 400 million gallons per day (mgd) as well as operational waste from hundreds of fishing vessels at Karachi Fisheries. The pollutant load is also increased by ship emissions from Karachi Port and garbage from commercial and industrial buildings around the harbor's edge.

### 4.6.2. Pakistan and International Conventions on Marine Pollution

International conventions and protocols play a crucial role in addressing marine pollution and promoting cooperation among nations to protect marine environment. Some key conventions and their aims are discussed below:

### 4.6.3. United Nations Sustainable Development Goals (SDGs)

Following a historic summit of world leaders leading to adoption of 2030 agenda for Sustainable Development, on 1 January 2016 17 UN SDGs came into force. SGD 14 is about "Life Below Water" and provides for measures to be adopted for protection of marine life. Pakistan still needs to do more in terms of SGD 14 to mitigate pollution and protect marine biodiversity.

### 4.6.4. MARPOL (International Convention for the Prevention of Pollution from Ships)

It is the main convention to prevent various types of pollution from ships. MARPOL was adopted in 1973 and updated by protocols in 1978 and 1997. Annexures I to VI of MARPOL prohibit various sources of pollution from ships includ-

1 Shahbaz Rana (Ministry of Commerce and Trade Group), in discussion with the expert, February 2024

2 Interview with marine expert, Fazal Elahi Bilal, February 12, 2024

ing oil pollution, garbage and noxious substances, etc. During the last 50 years of MARPOL, the number of oil spills has reduced almost by 90%. Pakistan ratified MARPOL on November 22, 1994.

#### 4.6.5. London Convention and Protocol

It is one of the first conventions to protect marine environment from harmful human activities. The convention was enforced in 1972 and aimed at promotion of effective control of marine pollution and take measures to prevent release of wastes and other matter into the sea. The convention prohibits the dumping of certain harmful substances and lays down guidelines for the disposal of other materials to minimize damage to marine environment. Pakistan adopted the convention in April 1975.

#### 4.6.6. Basel Convention on the Control of Transboundary Movements of Hazardous Wastes and Their Disposal

Basel convention came into force on March 22, 1989 and has a universal membership. It aims to protect environment and human health from harmful impact of generation and transboundary movement of hazardous wastes. Pakistan adopted the convention on July 26, 1994.

#### 4.6.7. Pakistan as a signatory to UNCLOS

Pakistan is obligated to abide by the rules set forth in the United Nations Convention on the Law of the Sea (UNCLOS) [22] concerning the management of the world's oceans. Pakistan is subject to international commitments for environmental preservation and regulating the marine pollution being a signatory to the United Nations Convention on the Law of the Sea (UNCLOS). Pakistan is required to take action to stop as well as manage marine pollution originating from man-made activities, including sewage, industrial runoff, and waste emerging from agricultural activities. By enacting the necessary rules and regulations, Pakistan is required to safeguard and maintain the marine environment, which includes coastal regions and the exclusive economic zone (EEZ).

#### 4.7. Shortcomings in Enforcement and Regulatory Efficacy

Pakistan's significant population growth has put considerable strain on its natural resources, leading to environmental challenges including marine pollution. Following the country's accession to the United Nations Convention on the Law of the Sea (UNCLOS), the Pakistan Environmental Protection Ordinance 1983 (PEPO) [1] was also introduced to address these issues in a structured manner. However, the effectiveness of the ordinance was hindered by its enforcement capacity and its focus on penalizing entrepreneurs rather than assisting them in transitioning to more environmentally friendly processes and technologies. Likewise, Pakistan,

while committed to MARPOL 73/78 Annex V, has yet to ratify MARPOL 97 Annex VI. This decision is primarily attributed to financial limitations, as ratification would necessitate substantial investments in port reception facilities along with the proper mechanism of disposal of oil waste and untreated sewage water. Unfortunately, Pakistan faces challenges in terms of allocating the necessary funds for this endeavor, compounded by a shortage of adequately trained personnel to effectively implement these measures.

In the same way, Pakistan hosts one of the world's largest ship breaking industries, yet there's currently no established strategy for the Environmentally Sound Management (ESM) of the hazardous waste generated from this entire process, in accordance with the Basel Convention. Efforts are underway to develop an action plan to implement the Basel Convention within the ship breaking industry, alongside awareness campaigns for workers. Despite having National Environmental Quality Standards (NEQS) in place, hazardous chemicals brought onboard ships for scrapping remain unchecked. There's a noticeable reluctance to enforce policies, likely due to concerns that regulations could deter business, with ships from OECD countries potentially seeking alternative ship breaking industries without stringent cleaning requirements.

#### 4.8. Recommendations for Mitigation and Management

To address marine pollution in Pakistan, a combination of short-term and long-term measures is essential. These measures should focus on mitigating current pollution sources, preventing further contamination, and promoting sustainable practices.

##### 4.8.1. Immediate Measures

###### *Public awareness campaigns*

In Pakistan, a concerted effort to raise public awareness about the dire consequences of marine pollution and the critical need for responsible behavior and effective waste management practices among coastal communities, fishermen, shipping companies, and recreational users should be prioritized. Through extensive public awareness campaigns, initiatives including highlighting the detrimental effects of pollution on marine ecosystems, livelihoods, and public health can be resolved. By utilizing various mediums such as television, social media, and community outreach for raising public awareness can solve the issue of marine pollution. Likewise, educating fishermen about the impacts of littering, oil spills, and overfishing on fish stocks and marine biodiversity, urging them to adopt sustainable fishing practices and proper waste disposal methods can prove advantageous. By fostering a culture of promoting responsible maritime practices, Pakistan can safeguard its marine environment for future generations.

###### *Oil spill response/preparedness*

In order to protect marine environment from pollution, Pakistan should respond effectively to oil spill incidents. It

should invest in advanced equipment including containment booms, skimmers, specialized vessels, and ensure its availability and functionality through regular maintenance and upgrades. Likewise, rapid response teams equipped with specialized skills and equipment should be established and strategically positioned along the coastline to swiftly handle incidents related to oil spills.

#### *Plastic waste reduction*

Implementing immediate, short term measures for reducing plastic pollution, such as banning single-use plastics, promoting reusable alternatives, and conducting beach clean-up campaigns to remove existing plastic debris from coastal areas can protect marine environment. In Pakistan, the alarming increase in plastic pollution is posing significant threat to marine ecosystems. With an estimated 55 billion plastic bags being used annually and a projected 15% increase in their usage, the country is facing a mounting crisis. The urgent and decisive action is imperative to curb the usage of plastics and mitigate the detrimental effects on both Pakistan and the planet as a whole.

### **4.8.2. Long Term Measures**

#### *Case Studies of Island countries*

Pakistan can control marine pollution by learning from the effective conventions and laws applied by the Islands in Indian Ocean. Examples of Seychelles and Maldives who have implemented stringent measures to control marine pollution, which Pakistan can also emulate to protect its marine environment.

##### **1) Seychelles**

Seychelles has ratified various international conventions with the aim of reducing marine pollution. The London Convention (Convention on the Prevention of Marine Pollution by Dumping of Wastes and Other Matter) and the MARPOL Convention (International Convention for the Prevention of Pollution from Ships) are the two main conventions [23] ratified by Seychelles. These conventions provide frameworks for controlling maritime pollution sources, including oil spills, plastic waste and other sewage sources. In order to lessen the effects of marine pollution on its coastal waters and marine ecosystems, Seychelles has complied with these treaties and put related restrictions into place. By developing debt-for-nature swaps, embracing the blue economy idea, and growing Marine Protected Areas, Seychelles has gone above and above what was required to achieve SDG 14.5. [24]. Seychelles is an example for marine environment conservation around the world, actively working to meet SDG targets through international alliances and creative conservation techniques.

##### **2) Mauritius**

Mauritius has taken a number of steps to control marine pollution. In order to evaluate the dangerous marine microalgae levels and the quality of the coastal waters, the government has put in place long-term monitoring programs for a clean marine environment. In adherence to the standards set

by the government, various physico-chemical parameters and coliform bacteria levels in coastal water quality are routinely evaluated to protect the marine environment. The Ministry's Laboratory Division conducts water quality assessments at marine aquaculture locations as part of its monitoring program. Pakistan can also implement long-term monitoring programs for maintaining coastal water quality similar to that of Mauritius to prevent marine pollution.

##### **a) Protection of maritime commerce infrastructure**

The improvement of security protocols and infrastructure support for the Pakistan Navy and the Pakistan Marine Security Agency (PMSA) must be given top priority by the government in order to preserve the strategic significance of the country's port along with the protection of maritime commerce infrastructure. As these sites are essential for both wartime and peacetime operations; therefore, the need of the hour is to focus on infrastructure development to ensure efficient operation and maintenance, enhance security protocols using modern surveillance technology, and offer capacity-building efforts to improve staff capabilities in marine security operations. By implementing these measures, Pakistan may fortify its economic resilience and national security through safeguarding its ports and marine trade infrastructure.

##### **b) Investment in Waste Management Infrastructure**

There is a need to develop and invest in robust waste management infrastructure, including sewage treatment plants, recycling facilities, and landfill sites, to effectively manage and reduce the discharge of pollutants into the marine environment. As untreated sewage is a major source of marine pollution, sewage treatment plants, in that context, are essential. Pollutants and dangerous substances can be eliminated from sewage before it is released, guaranteeing that only clean water enters marine habitats. Likewise, investing in recycling facilities is a crucial measure in combating marine pollution.

##### **c) Ecosystem-Based Approaches**

Implementing ecosystem-based approaches can reduce marine pollution in the long run. The creation of marine protected areas (MPAs) along the coastline of Pakistan can prove to be advantageous and a crucial tactic to handle marine pollution [25]. These MPAs can provide environments for fish, coral reefs, and other marine animals to flourish by acting as sanctuaries for marine biodiversity. Pakistan can safeguard its delicate ecosystems from detrimental practices like pollution, overfishing, and damaging fishing methods by designating specific areas as MPAs and enforcing regulations on human activity within them.

##### **d) Research and Innovation**

Another long-term measure which Pakistan can take to manage marine pollution is by investing in research and innovation. Pakistan can improve its capacity to avert, monitor, and mitigate marine pollution by allocating the budget to the development of innovative technology and solutions. By promising directions for innovation including pollution detecting devices and eco-friendly packaging materials. These technologies have the potential to address the main sources of



marine pollution, including plastic trash, and can enable early detection of pollution occurrences and sustainable cleanup efforts. [26] In order to protect Pakistan's marine ecosystems for future generations and to expedite the implementation of novel solutions, collaboration between academic institutions, government agencies, and business sector partners can also prove to be pernicious.

## 5. Conclusion

Marine pollution is a pressing concern for Pakistan. As a country rich in marine resources and having a considerable number of coastal communities directly dependent on marine activities, Pakistan needs to take drastic measures to overcome the issue of marine pollution. It, however, requires concerted efforts, integrated approaches, and collaborative partnerships among government agencies, civil society organizations, private sector stakeholders, and the public. Things are still not beyond recovery. By implementing sustainable solutions, strengthening regulatory frameworks, promoting technological innovations, raising public awareness, and fostering community engagement can help Pakistan protect its marine environment and transition into a sustainable and environment friendly future.

## Abbreviations

KPT	Karachi Port Trust
MGD	Million Gallons Per Day
SDG	Sustainable Development Goals
UNCLOS	United Nations Convention on Law of the Sea
PEPO	Pakistan Environmental Protection Ordinance

## Conflicts of Interest

The authors declare no conflicts of interest.

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