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Marine Pollution at Karachi Harbour: Challenges and Way Forward for Progress Towards SDG-14

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Abstract

Marine pollution is a critical issue in Pakistan, especially at Karachi Harbor, because it is of great importance and have long lasting impact on international trade. On one hand, it is decreasing marine biodiversity while on the other it has devastating effects on coastal communities. To mitigate and reduce the severity, there are several national level initiatives such as National Marine Disaster Contingency Plan (NMDCP), National Maritime Policy, enforced by Pakistan Maritime Security Agency (PMSA). In addition to it, the BARRACUDA Exercise has also been designed to enhance a coordinated response against marine pollution especially incidents of oil spills. Greater Karachi Sewerage Plan SP-III is one of the major steps taken to address the issue of sewerage water that enters directly into sea and is harmful for the marine life. SDG-14 provides an international commitment to conserve 'life below water' and preservation of livelihood through the available marine resources along with the conservation of trade.

Keywords: *Karachi Harbour, Marine Pollution, SDG-14, Trade*

Introduction

Marine pollution or ocean pollution is a serious environmental crisis of the contemporary world, as it is indirectly impacting the activities on the surface of the earth. Almost 70% of these activities are under the influence of marine pollution. Seas are being contaminated with waste worth billions of pounds and chemicals, all entering directly daily, mostly due to land-based human activities. The key contributors to pollution are runoff from farms, road sites, construction material with pollutants, intentional release of toxic waste, plastics (eight million metric tons of plastic per year), oil spills, littering (a trillion plastic bags a year), and deep-sea ocean mining. The effects are far-reaching, creating direct impacts on marine organisms through excess nutrients and debris, which causes a shortage of oxygen in seawater

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and forms dead zones where not much life can survive. Worst of all, ocean pollution is a menace to human health as it spirals down the food chain and ruins human health (Edo et al., 2024; *Ocean Pollution: Causes, Effects, Prevention*, 2024).

Realizing the gravity of the issue, the United Nations Millennium Development Goals (MDGs) have provided a framework to counter it along with other critical issues like poverty, hunger, disease, illiteracy, and discrimination against women, which were to be achieved by 2015, and have started track the progress since 1990. Few of these goals are directly related to health (WHO, 2018). Despite the global awareness no major progress was made that lead to development of another global framework under Sustainable Development Goals (SDGs), a post-2015 agenda with 17 Goals at its core (*THE 17 GOALS Sustainable Development*, n.d.). Among them is SDG 14 that clearly mentions the sustainability of 'life below water', includes the biodiversity conservation in oceans and seas.

Karachi, the largest city in Pakistan and one of the major seaports in South Asia is facing a serious environmental crisis due to a massive contamination of harbor waters by industrial waste, sewage and oil spills. Although Karachi Port Trust had set up a Marine Pollution Control Department in 1996, there has been no significant improvement. More than 411 million gallons per day of liquid effluents enter the harbor damaging marine life, mangroves, vessels and human health. Pakistan is signatory of various legal frameworks such as the Pakistan Environmental Protection Act (1997), international regulations such as MARPOL, the London Convention and the Basel Convention but implementation is weak. The 18th Amendment established a system of federal-provincial coordination to fulfill the international commitments. The S-III sewerage plan (planned in 2007, unleashed in 2013) was introduced by the government to treat up to 460 MGD. But COVID-19, funding conflicts, and poor coordination have rendered sewage treatment targets mostly unachievable (Tahir, 2017; Tahir, 2025).

Although Karachi produces around 470 million gallons per day (MGD) of wastewater, it only treats 55 MGD of it, releasing the rest of it untreated in the Arabian Sea through drains and rivers. The physicochemical parameters reflect the high concentration of turbidity, TDS, salinity, COD, BOD, and the toxic heavy metals (Pb, Cd, Ni, Hg) in the water at different offshore distances. Furthermore, the tidal conditions demonstrate that the concentrations of the pollutants are beyond safe limits. This is dangerous to mangroves, aquatic organisms, human health and coastal infrastructure (Nergis et al., 2025).

Moreover, untreated industrial and municipal waste accelerates corrosion of ships' hulls and machinery as it contains toxic chemicals and heavy metals. Due to the presence of excessive litter and debris in sea water, it often chokes intake pipes,

causing engine overheating, malfunctions, and prolonged downtime for repairs. Such delays in berthing and un berthing of ships affect the scheduling of ports, efficiency of cargo handling, and lead to large-scale economic losses to the country. Moreover, the existence of solid waste and oil residues in harbors also heightens the maintenance of propellers, rudders, and other submerged structures. Further, the hydrodynamic resistance of corroded hulls is increased leading to low fuel efficiency and increasing the cost of voyage. Dry docks and loading equipment, as well as piers, are also degraded due to the long-term exposure to contaminated waters. All these factors reduce the credibility of maritime trade routes, augment operational risks of shipping companies, and reduce the competitiveness of a port. In the absence of proper pollution control measures, long-term sustainability of maritime trade is at stake (Shahzad, 2023).

Factors contributing to Marine Pollution at Karachi Harbor

There are number of factors that contribute to marine pollution at Karachi Harbour that not only affect the marine biodiversity but also have a ripple effect on the coastal communities and maritime trade of Pakistan. Marine life is threatened by ingestion and enlargement due to plastic waste and micro plastics that enter the ocean via rivers and coastal dumping. Runoff of agricultural activities into the sea introduces fertilizers and pesticides into the sea, which leads to eutrophication, an algal bloom that consumes oxygen. The food chain becomes contaminated by industrial waste and heavy metals which are dangerous to marine life and human health. Besides that, thousands of gallons of untreated municipal sewage finds its way to the seas daily, which renders the coastal water and disturbs the lifestyle of marine animals (Exchange, 2025).

South Asia generates 334 million metric tons of solid waste annually, with 70–80% ending up in oceans. Pakistan generates 49.6 million tons of solid waste annually, lacks managed landfill sites, and has the highest percentage of mismanaged plastic waste in South Asia. Karachi generates 12,067 tons of municipal solid waste daily, a large amount of which leaks into the marine ecosystem. The city is among the top three marine litter hotspots in Africa and South Asia. Marine debris damages vessels, entangles marine animals, and pollutes ecosystems (Ahmad et al., 2023).

Shipping and port activities, although vital to the Pakistani economy (90 percent of trade is by sea), emit oil spills, waste discharge, and harmful emissions (947 million tons of CO2) per year around the world. Dredging and reclamation at places such as Clifton Beach lead to the deoxygenating, low biodiversity and physical damage to marine organisms. Waste produced by the ships (bilge water, sewage, garbage) also pollutes the coastal waters. Large oil spill, incidents like the 2003

Tasman Spirit spill (30,000 tons), kill wildlife and sea birds and lead to developmental defects of fish eggs. Even the underdeveloped maritime tourism in Pakistan has its share in terms of littering and contamination of beaches due to destructive tourism. All these factors are responsible for irreparable harm to marine ecosystems, fisheries, and coastal communities, requiring prompt regulatory and technological action (Sheikh & Hameed, 2024). Lyari River is known to be a significant source of industrial and municipal waste into the channel, carrying organic nutrients that in turn support some vegetative growths such as mangroves yet at the same time, it hinders the overall water quality due to their ability to create sustained hypoxic conditions in some localized areas like the Manora channel where tidal flushing cannot effectively disperse the pollutants.

Impacts of Marine Pollution

Marine pollution has extensive impacts that affect marine ecosystems, economy and human health. Pollutants such as plastics, oil, chemicals, and the consumption of micro plastics disrupt the reproductive system, growth, and behavior of marine organisms, which in most cases results in population decline. This also drives biodiversity loss by destroying critical habitats like coral reefs and sea grass beds, disrupting food chains and endangering species that depend on these ecosystems. This degradation is a direct threat to human health, marine life sustainability in the long run. Human health is also under a big threat, as seafood contaminated by heavy metals or microplastics can lead to neurological damage and hormonal imbalances, and contaminated beaches and waters can transmit waterborne diseases (Exchange, 2025; PEPA, n.d.).

Pathogens entering the food chain through sewage will often be transmitted back to humans through seafood. Potentially fatal diseases such as typhoid and cholera are in fact highly prevalent in Pakistan. Another effect of marine pollution is that a lot of the waste and litter dumped in the ocean eventually washes up on beaches, and hence ruins beach aesthetic and tourism. Polluted beaches pose a higher risk of contagious diseases (Pakistan, 2016).

Impact on Marine Biodiversity

Pakistan's lifeline, the Indus River, is severely polluted by plastic waste constituting 40% of all solid waste in the river making it the second most polluted river globally in terms of plastic concentration. More than 90% of plastic waste from the Upper Indus Basin that ends up in the river with low-density polyethylene (LDPE) from single-use plastics (bottles, bags, containers) alone comprises 43% of all plastics found. Consequently, this devastates aquatic life, reduces fish species diversity, threatens and endangered Indus River Dolphin, destroys mangroves, and causes

bioaccumulation and bio magnification of micro plastics through the food chain. Rural communities dependent on the river suffer severe health impacts, while nearly 10,000 tons of plastic annually reach the Arabian Sea, harming coastal and marine ecosystems (Jabeen, 2023).

The facts are grim. Lamp shells, which have been residents of Karachi Harbour for the past 20 million year, are now extinct. During last 50 years, shark landings decreased by 85 percent and several species of fish such as black fin cisco and silver trout have gone extinct. This loss of biodiversity interferes with the functioning of marine ecosystems. The 80 percent population linked with coastal based fishing industry that employs 1.5 million individuals is disintegrating. Commercially important species like Palla and Dangar have seen 600 to 200 tons catches drop annually since 1986 (Sheikh & Hameed, 2024). Approximately 88% of Karachi's sewage is dumped untreated into the Arabian Sea through open drains. Within two decades, sponges, corals, and jellyfish have vanished. Shrimp and fish populations have severely diminished within a five-to-seven-kilometer radius. Dead fish, crabs, turtles, and seashells have now litter beaches like Clifton (ENVPK, 2024).

Impact on Trade

Marine pollution at Karachi Harbor is causing severe economic and strategic damage by accelerating corrosion of ships, submarines, and port infrastructure. It causes the reduction of the vessel's lifespan by approximately 33% and costing of $1 billion on repair by the Pakistan Navy. The harbor is designated a 'National Vulnerable Area' due to its critical importance for Pakistan Navy operations, maritime commerce, and national security. However, untreated sewage, industrial effluent, and solid waste, with approximately 20% of garbage entering the harbor, have made seawater highly corrosive. Mild steel corrodes at 9.20 g/m² per day in Karachi Harbor as compared to 5.48 g/m² in open seawater. This corrosion causes frequent machinery breakdowns, plastic debris clogs cooling instruments, and accelerates the deterioration of jetties, berths, and hydrographic equipment. Losing 33% of a naval ship's life expectancy equates to a loss of $90 million per vessel (Shahzad, 2023).

National Strategies to Mitigate Marine Pollution

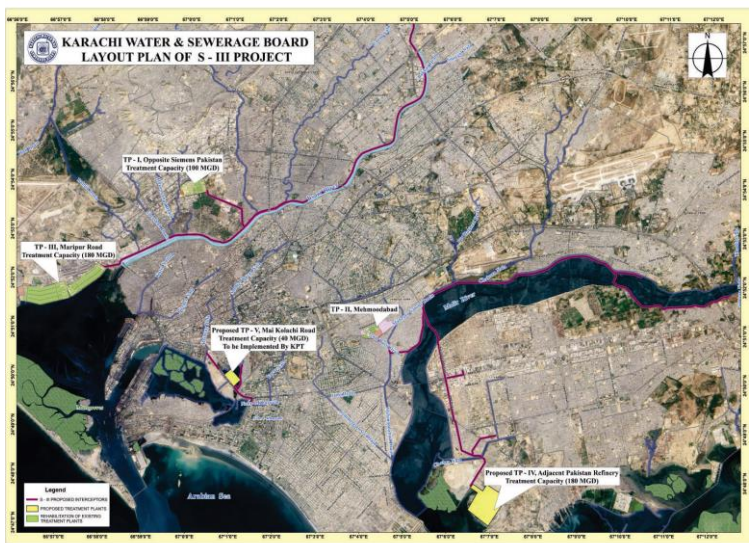
Pakistan has come up with a multi-layered approach to curb marine pollution and integrates national policies with international commitments and institutional measures. The core of this initiative is the National Maritime Policy (NMP) 2025 that fosters the development of the blue economy in a sustainable way and requires the imposition of stringent environmental pollution regulations at international level. The National Marine Disaster Contingency Plan (NMDCP) is operationally an intervention plan to respond to oil and chemical spills in coordination with Pakistan

Maritime Security Agency (PMSA) to the vessels which are outside the port limits. Further, MARPOL 73/78 (1994) governs ship source pollution, and includes oil, garbage, and noxious substances. Such institutional frameworks are the reinstated Marine Pollution Control Board (MPCB) and the PMSA to enforce it along the coastal areas and the pollution response unit of the Karachi Port Trust.

Karachi Drainage System and Treatment Capacity

Karachi with an estimated population of around 22 million, is presently facing a severe environmental crisis due to discharge of untreated sewage through natural streams / drains and rivers into the Sea. Presently, 100% of the total municipal sewerage generated is discharged untreated into the costal water of Karachi city. Despite multiple agencies having legal responsibility, over 90% of industrial wastewater including largest industrial estates (SITE and Korangi) flows untreated into the sea, devastating marine life. No combined effluent treatment plants are working properly. The Sindh Environmental Protection Agency evades accountability through legal tactics, passing responsibility to other institutions. Although SEPA has prosecuted and 170 industries have constructed treatment plants, overall enforcement is very slow (Ilyas, 2022).

Figure: *Extracted from the presentation of Greater Karachi Sewerage Plan S-III by KW&SB*



Source: Extracted from the presentation of Greater Karachi Sewerage Plan S-III by KW&SB S-III includes the development of several key sewage treatment plants (STPs) strategically located across the city.

The city produces 400-450 million gallons of sewage every day, most of which is currently released into the Lyari and Malir rivers. The process of direct dumping is severely polluting the marine environment at the coast. S-III project is one of the most important projects aimed at solving the Karachi Sewerage Crisis. The project will capture, treat and dispose this sewage in a safe manner to safeguard marine lives, human health, and coastal ecosystems. The main elements are the transmission packages in the Lyari and Malir basins, upgrading of the existing treatment plants, and the construction of new ones.

Table 1: *Current Status of Sewage Treatment in Karachi*

Total Sewage Generated	470 MGD
Present Treatment	Nil
Direct Discharge into Sea	470 MGD

Treatment Plant	**Original Capacity**	**Current Treatment**
TP-I	51 MGD	Nil
TP-II	46 MGD	Nil
TP-III	54 MGD	Nil

Source: Extracted from the presentation of Greater Karachi Sewerage Plan S-III by KW&SB

Other treatment plants are TP-I, which is located in Haroon Abad, and TP-II, which was proposed in the Korangi Industrial Area. TP-III and TP-IV have to be constructed at Mauri Pur and in Mahmood Abad, respectively. The main focus of the project was on TP-I and TP-III. TP-II and TP-IV were discarded later due to land issues and logistical problems. The proposed sites have multiple problems, such as space limitations and the inability to acquire the required land to construct the site. TP-I is capable of treating 100 MGD of sewage, and it is planned to be installed in stages, whereby it will have an initial capacity of 35MGD, then 65MGD, and finally attain its full capacity. The Chief Minister of Sindh set the targets between 30 and 35 MGD and direction has been given to complete it by June 30, 2026. TP-I is estimated to be completed by December 2026. TP-III is based in Mauri Pur and was partially operationalized in 2018 with a 54 MGD treatment capacity. Nonetheless, this has also reduced over time to 35 MGD because of improper maintenance and degradation of infrastructure. Plans are currently underway to upgrade TP-III to handle 180 MGD, with a planned date of completion of December 2026. Moreover, trunk sewer systems are in progress to direct sewage of large basins like Lyari and Malir to these treatment plants. The Lyari basin in particular has seen the completion of a 33-kilometre sewer pipeline between Surjani Town and Mauri Pur which was partially completed (N. U. A. Tahir, 2025). Coastal management, strong implementation of national and international regulations (like IMO rules of MARPOL) and better waste water

treatment are necessary in order to reduce any additional harm and, secure the sustainable growth of the area (Irfan et al., 2025).

Table 2: *Sewage Treatment Facilities*

Sewage Treatment Plant	Existing	Proposed	Unit
Treatment Plant 1, Haroonabad SITE	51	100	MGD
Treatment Plant 2, Mehmoodabad	46	Sewage pumping station	MGD
Treatment Plant 3, Mauripur	54	180	MGD
Treatment Plant 4, Korangi (NEW)	-	180	MGD
New Treatment Plant 5 at Mai Kolachi (To be implemented by KPT)	-	40	MGD
Total	151	500	MGD

Source: Extracted from the presentation of Greater Karachi Sewerage Plan S-III by KW&SB

TP-IV is an integrated wastewater treatment and recycling facility that involves the monitoring of the flow and quality of the water at different locations. According to a recent survey, it was found that more than 3,600 industries in the region need about 42 million gallons of water per day, which highlights the importance of the combined system to include efficient sewage management and proper infrastructure (*Timely Completion of City's Sewerage Projects Ordered,* 2025).

NMDCP and BARRACUDA Exercises:

The exercise is directed and led by the Pakistan Maritime Security Agency (PMSA) involving the Pakistan Navy, port authorities, oil terminal operators, civil administration, and private industry to emphasize the multi-stakeholder approach to effective response to oil spill. In 2003, oil tanker named MT Tasman Spirit grounded near Karachi Harbour that resulted in the release of about 30,000 metric tons of crude oil. The destruction of the beaches of Clifton and Manora has unveiled the major institutional gaps. This resulted in the formation of National Marine Disaster Contingency Plan (NMDCP), which became law in 2007 and was updated in 2019, and Exercise BARRACUDA became its operational expression of the plan. The main focus of the exercise is to control pollution, containment of oil spills, search and rescue (SAR), establish global cooperation, training at sea, workshops and sessions. The framework of exercise is tested practically and analyzed through tiered response. Tier-I deals with minor spills which include less than 7 tons. Tier-II response (to spills

between 7 and 700 tons) capacity, largely tested against near shore conditions. It normally deals with oil spill response vessels (OSRV) and included surveillance and monitoring. It also included help from satellites and aircrafts. In Pakistan it only included Tier-II level and tested near shore or on land. Tier-III deals with more than 700 tons of oil spills and review as catastrophic. Responses started with generation of containment and followed with the use of booms (300 m long) to control the spill and skimmers, to eliminate oil dispersant, spraying oil and taking protection measures. First the most common accidental spills, satellite imagery revealed 92 cases of intentional discharge of oily bilge water in the Exclusive Economic Zone of Pakistan in 2017-2023, which supports the necessity to improve the monitoring of this phenomenon with the help of Synthetic Aperture Radar on aircraft or satellites. Second, the increasing maritime transportation of hazardous and noxious substances (HNS) that is not oil is accompanied by the need to have specialized response capabilities, which are still scarce. With the increase in maritime traffic and energy imports, the ongoing preparation towards full Tier-II capability, greater surveillance, and HNS preparedness will be vital in ensuring the successful national response to arising marine pollution threats (Shabbir, 2025).

SDG-14 and Sustainable Marine Conservation

Ports become the key players in this scheme on the global scale because it is in direct contact with the maritime ecosystems. Localized pollution control relates to SDG 14 goals due to their integration of biodiversity, friendly working practices, water quality monitoring and reduction of effects of dredging. These practices can at the same time help to promote economic resilience and environmental integrity in most coastal economies particularly in developing regions where the economies rely on sea based industries. The scope of SDG 14 also included the realm of climate action through its direct focus on ocean acidification.

SDG-14 focuses on ‘Life below Water’ as Oceans play a dominant role in the hydrological cycle, climate regulation, and carbon dioxide absorption. However, 80% marine pollution is due to land-based activities (agricultural runoff, industrial waste, sewage, plastic dumping) and 20% from marine sources (shipping, oil spills, mining) severely threatens ocean biodiversity. Key pollutants include excess nutrients causing eutrophication and algal blooms, plastic waste (8 million tons flow to oceans annually), heavy metals, and greenhouse gas emissions leading to ocean acidification and warming. Despite contributing only 0.9% of global emissions, Pakistan ranks eighth on climate vulnerability index (Javed et al., 2024).

Although Pakistan had access to the shared systems of monitoring through the regional seas programs but still depends on the long term national level

commitments to translate the findings into actual enforcement. Although there are multiple sources of pollution but several gaps in the evolution of the legislation failed to keep pace with the demands of the technical component, and the political instability resisting to the pressure of contradicting economic interests. A case study of Karachi Harbor is an excellent example of how the historical course, including the first regulatory milestones, participation in the global conventions, disproportionality in the enforcement policies, and alterations of the industrial interests predetermine the modern opportunities to achieve the SDG 14 vision and sustainable use of maritime resources. Pakistan is working to prevent and significantly reduce marine pollution, in particular from land-based activities, including marine debris and nutrient pollution.

SDG 14 strives to reduce structural imbalances between ocean resources and the conservation of these resources. The fair sharing of costs is also a self-evident issue, and the absence of sustainable mechanisms is also a real problem. The Karachi coast marine pollution is a critical and continual environmental crisis that needs urgent, intersectoral, and multi-sectoral intervention. The existing laws and institutional structures in Pakistan are not sufficient since they do not provide a lead agency and enforcement (Khan et al., 2025).

Challenges

The Lyari River single handedly contributes approximately 50% of Karachi harbor's pollution load (Saher et al., 2019). Sindh Environmental Protection Agency (SEPA) has the authority to enforce pesticide standards, but it failed to implement. Responsibility is fragmented across the irrigation, agriculture, and EPA departments, with no coordination. Heavy metals require costly advanced treatment (ultrafiltration, ozonation) unavailable in Sindh, allowing toxins to enter household water and cause serious health issues like blue-baby syndrome in infants (Mughal, 2018).

Weak enforcement and inadequate monitoring structures undermine policy structures that are meant to reduce such impacts. Even though the quality of effluents that are released by industries in Pakistan is regulated by the legislative frameworks of the country, there is still intermittent adherence to the regulations by the industries in the country. The principle of penalties by the polluter has not been widely implemented; industry businesses are still polluting without imposing any costs on their damage to the environment and, as a result, the environment suffers over time. The local institutional players like the Karachi Port Trust are showing its inability to coordinate response between the various departments of the government; there is lack of synchronization and proper integration. Direct relevance to historical trends is that even after the policies have improved since the late 20th century, the pace of urbanization along the coastline of Karachi has exceeded the ability to regulate the

environment. The rapid urbanization has contributed solid waste to the waters of the harbor because there is no proper infrastructure and storm drain filtration systems.

Jurisprudence and Enforcement Issues

Industries get off the hook despite the Sindh Environmental Protection Agency taking legal action. Fertilizers, herbicides, pesticides and agricultural pollutants inject heavy metals and surplus nutrients (phosphorus, nitrogen) into coastal waters, leading to algal growth and oxygen depletion, which suffocates marine life. Household waste contributes about 475 million gallons of untreated sewage (88 percent into the Arabian Sea) each day. The problem of plastic pollution is serious, as 55 billion plastic bags are consumed, and micro plastics were discovered in the gills and digestive systems of fish. The Indus River conveys almost 10000 tons of plastic a year to the Arabian Sea (Sheikh & Hameed, 2024).

The issue of ocean pollution is worldwide. It is a product of several sources and transcends national borders. It is the result of irresponsible, shortsighted, and unsustainable use of the resources of the earth. It threatens the marine ecosystems. It hinders the generation of oxygen in the air. Its threats to human health are great and growing, but it is still incompletely understood. Its economic costs are yet to be summed up. It is possible to avoid ocean pollution. Similar to any kind of pollution, ocean pollution can be managed by implementing law-based, policy-based, technology-based, and enforcement-based data-driven strategies that prioritize the key sources of pollution. These tools have been utilized by many countries to manage air and water pollution and are now being used to manage ocean pollution. The achievements made this far show that it is possible to exert control to a wider extent. Harbors that have been heavily polluted have been cleaned, estuaries rejuvenated and coral reefs have been restored. Ocean pollution prevention generates numerous advantages. It enhances economies, boosts tourism, assists in the restoration of fisheries and enhances human health and well-being. It promotes the Sustainable Development Goals (SDG). These benefits will last for centuries (Landrigan et al., 2020).

The current system to deal with marine pollution in Pakistan specifically in the Karachi harbor, is a mixture of national legislation, institutional strategies, and global obligations, albeit having some differences in their pragmatism at the implementation stage. At the national level, Pakistan has established legal and regulatory frameworks to control marine pollution, focusing on industrial discharge, waste dumping, and the protection of coastal ecosystems. These structures are designed to minimize the effects of pollutants on marine biodiversity and coastal communities by regulating and monitoring the environment. Major institutions are

working in collaboration for the implementation of their regulations. The Karachi Port Trust (KPT) is the main body that is in charge of controlling pollution in the harbor. It formed the Marine Pollution Control Department (1996) to control, prevent and react to the pollution by ships, industries, and municipal sources. Other activities performed by this department are mangrove rehabilitation and the encouragement of environmentally friendly operations in ports.

There are various other stakeholders that constitute part of the governance structure besides KPT such as, the Directorate General Ports & shipping, port authorities, environmental agencies and municipal bodies. It is anticipated that these institutions will work together on pollution, waste management as well as environmental surveillance as a model of multi-agency governance. On the policy front, Pakistan is also oriented towards different international conventions on marine pollution (including the rules on oil spills and ship-based pollution) that offer the principles on how to manage the marine contamination and to ensure sustainable use of the sea.

Moreover, the operational structures encompass cleanup, and surveillance programs and preventions like regulating the release of industrial effluents, handling of port wastes, and minimizing runoff pollution particularly during the monsoon seasons when the inflows of pollution are at its peak. Nonetheless, even with this structure in place there are loopholes created by poor enforcement, weak infrastructure and coordination problems which restrain its overall performance.

Way Forward for Pakistan

The most effective approach to control the situation is the development of a comprehensive control policy including more stringent regulations, improved waste treatment, education of the population, and the cooperation of government, industry, and civil society to ensure the conservation of the marine environment and resources in the future. Pakistan has a well-developed legal system comprising of domestic ordinances and international conventions to combat marine pollution, which is largely ineffective because of poor enforcement, scarcity of funds, political will, and reluctance by the regulators. At the domestic level, there is the Pakistan Environmental Protection Ordinance that provides a legal framework on industrial discharge, waste dumping and plastic pollution. In 1996, the Karachi Port Trust created a Marine Pollution Control Department. On the international level, Pakistan is a signatory of the MARPOL (1994), the London Convention (1975), the Basel Convention (1994) and UNCLOS, and signatory to UN SDG 14 (Life Below Water). However, the implementation has identified critical shortcomings. The Pakistan Environmental Protection Ordinance is aimed at punishing industries instead of helping them to switch to cleaner technology. Treatment of sewerage eliminates

contaminants using physical, chemical and biological treatment. Nevertheless, Karachi only treats 55 million gallons per day (MGD) of the 470 MGD produced and discharges the remainder to the sea. Treatment of the waste in the industries is also low only 10 MGD treated of 78 MGD. There is poor solid waste collection at an average of 50% in the country and none of the cities has a good disposal system. Waste that is not collected blocks outlets, harbors mosquitoes that carry diseases and finds its way into rivers and fields. Pakistan Environmental Protection Act (1997) offers a framework, but the enforcement is very slow. Recycling and the consumption of waste is highlighted as one of the important methods of pollution control. At Karachi Port, the environmental management systems lock the overboard valves and offer shore reception facilities in accordance with the MARPOL standards. Lastly, government and civil society must raise public awareness through campaigns that encourage recycling, caution the citizens of the dangers of pollution and encourage them to act in a more environmentally friendly way. In the absence of these combined efforts, the pollution of the coast is uncontrollable.

Conclusion

Marine conservation initiatives at Karachi Harbour face significant challenges at the implementation level, primarily due to weak governance, continuous pollution, and socio-economic pressures. Although environmental regulations and conservation programs exist, their enforcement remains inconsistent because of limited institutional capacity and poor coordination among agencies such as port authorities, fisheries departments, and environmental bodies. The biggest challenge is that the inflow of sewage, industrial effluents, and solid waste into the harbor continues to compromise the restoration processes, such as the mangrove rehabilitation and protection of the marine habitat. Moreover, congestion and ineffectiveness of harbor facilities lead to unhygienic environments, complicating the implementation of the standards. The fact that the local fishing population is mostly economically dependent also complicates the implementation, as a matter of fact, fishermen are more interested in livelihoods than sustainability, leading to overfishing or the use of illegal equipment. Effective monitoring and policy implementation are also hindered by institutional fragmentation, untrustworthy information, and insufficient technical knowledge. Meanwhile, the continuous decline of habitats and their invasion of coastal ecosystems, as well as the effects of climate change, exacerbate these problems. These factors, in conjunction with the lack of public awareness and the culture of low compliance, give rise to the situation where conservation efforts can hardly produce any meaningful and lasting results, even though their intentions are well-intended.

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