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## Marine Pollution and its Impact on Marine Fisheries, Security of Food and Economy Study of Gulf of Kachchh

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**Abstract:** *Marine Pollution has emerged as an acute threat to the marine ecosystem. Marine Pollution is defined as 'the discharge of waste into the sea resulting in harm to living resources, hazards to human health, a hindrance to fishery & impairment of quality for use of seawater'. Marine pollution is associated with the changes in the physical, chemical & biological conditions of seawater. The industrial effluent, pesticides and chemical fertilizers from the agricultural field and plastic wastes and other marine debris have rendered marine organisms vulnerable to various health risks.*

**Key Words:** Marine Pollution, marine ecosystem, hazards to human health, hindrance to fishery.

Each year lakhs of marine mammals worldwide suffer injury or death by getting entangled in plastic or ingesting it through the food chain. Single-use plastic represents 70% of the plastic waste littering the marine environment. The sustenance of marine biodiversity is greatly determined by larval dispersal of a marine organism which itself is at risk. Marine population and their supporting ecosystem are subject to a multitude of threats, marine pollution being a major one. We have witnessed various instances wherein land-based pollution makes its way into the marine ecosystem like the alleged Iron Mining in Goa polluted the rivers of Bicholim, Mondovi and terekhol/Banda River which discharges into the Arabian Sea. This has badly affected the fisheries and food security of the people especially the coastal fishing community which by and large depends on the daily fish catch for sustenance.

The marine fisheries sector provides a livelihood to nearly 4.0 million people of India and meets the food and nutritional requirements of a significant proportion of the population. Also, it contributes to the export earnings of the country. Sustainable harvest of the marine fishery resources is necessary as overexploitation of the resources is likely to harm the diversity and cause a reduction in the availability of some of the resources. The sector contributes to an economic wealth valued at nearly Rs. 65,000 crores annually. The marine fisheries of the country consist of small-scale and artisanal fishers belonging to the mechanized, motorized and non-mechanized sectors and a range of other stakeholders, including governmental and non-governmental agencies. The marine fisheries resources are not non exhaustive and over-exploitation coupled with pollution would lead to loss of biodiversity and reduced availability of resources for our future generations. One of the major threats to this sector is Pollution which can cause mortality or in other cases slow ongoing morbidity in the fish species which subsequently enters the food chain, causing greater damage to other organisms including human health.

**Significance of the Area of Study-** Gulf of kachchh, located on the northwest coast of India lies between 20°50'-23°35' N latitude and 60°05'-70°22' E longitude. It is spread over an area of 7300 km square and is a highly productive and diversified ecosystem. The southern coastal belt of the kachchh is a biologically rich ecosystem composed of mudflats, submergible shoals, islands, sandy beaches, rocky shore, coral reefs, and mangroves. The ecosystem provides a congenial habitat for most aquatic animals including large varieties of fish. It also witnesses large scale migration of fish and shrimp juvenile at the beginning of the monsoon. Besides these islands, there are a number of wave-cuts, eroded shallow banks like the Pirothan, Deda, Donna, Sankhodhar Beyt, Paga, Adatra and Boria, which supports a wide variety of aquatic species and coral reefs which has symbiotic coexistence with the marine fish.

India is one of the top marine fish producing countries of the world and at present, the country is at 7th position in global marine capture fish production after China, Indonesia, USA, Russia, Japan, and Peru. The estimate of landings of marine fishery resources along the coast in the mainland of India for the year 2016 is 3.63 million



metric tonnes. The contribution by the marine states towards the total landing is highest in Gujarat i.e. 7.74lakh tonnes (21.3%) followed by Tamil Nadu(19.5%)and Karnataka(14.6%) The physical features of the southern part of the Gulf of Kachchh favor fishing. A cluster of mangrove-forested islands near the southern coast of the Gulf generates nutritive detritus, which nurtures prawns and fish in large numbers. The rich algal vegetation associated with the reef islands contributes to raising the level of dissolved oxygen in the waters. Its vast inter-tidal mudflats are conducive to traditional fishing with indigenous craft and gear; a relatively even seafloor supports trawling operations for demersal species. However, this advantage gets overturned due to the ever-increasing pollution and debris disposal.

The location of the Gulf of Kachchh and its geography gives it an added advantage. Though Gujarat does not have very high consumer demand for fisheries, most of the catch is exported. The nearness of the Gulf of Kachchh to one of the most emerging and potential fish markets i.e. Africa can help increase export and boost the economy. According to an estimate by the World Fish Centre, 2005, In order to maintain its current consumption level, Africa will need 27% more fish per year in 2020. Besides the freshwater fish, smoked, dried and low value processed fish represents the largest majority of fish consumed by the rural population and by low-income classes of an urban area in Africa.

**Figure 1: Map showing Gulf of Kachchh and it's the Coastal hinterland**



Source: Google Maps



source: <http://www.jamnagar.org/mnp.htm>

**Defining the problem-** In a tropical country like India, wherein the marine fisheries are supported by multispecies assemblages, severe collapses in the fishery seems unlikely. However, the marine fish production of the country has meagerly increased. This is a concern as the marine fisheries sector in India is characterized by the dominance of small scale subsistence-based fishery.

In the Gulf of Kachchh, rampant pollution and contamination of the marine ecosystem take a toll on the fish and the dependent community. The coastline between Jamnagar and Salaya off the Gulf of Kutch is a location with intense industrial development. Many mega industries have been set up like Integrated Petrochemical Refinery at Sikka (RPL) and Vadinar (ESSAR, IOC); Thermal Power Project, Cement Factory & Fertilizer Factory at Sikka, etc. The operation of these mega industries and associated factories, which are cropping up around the areas pose a severe threat to the fragile marine ecosystem of the Gulf.

About 70% of India's crude oil is imported through major ports (major ports are Kandla and Mundra ) and several smaller facilities in the Gulf of Kachchh. While large patches of mangrove forests remain along the Gulf of Kachchh, the region presents a range of pollution-related challenges stemming from Marine operation pollution. The region's ecosystem has endured a lot of damage from destructive fishing practices that use chemicals and pesticides. The region's flora and fauna are also at risk from potential oil spills from a large number of tankers that ply these waters. These factors together affect the marine resources while the harmful chemicals that enter the food chain due to the processes of bioaccumulation and in some cases, biomagnifications of the pesticides and harmful metals pose



risk to human health.

**Marine fisheries and the dependent economy-** The State of Gujarat has a coastline of 1600 Kms with an exclusive economic zone of 2.14 lakh sq.km. As per the data of commissioner of fisheries of the state of Gujarat, in the year 2018-19, the total inland fish production was 1.43 lakhs M.T while the major chunk of production came from marine fish production which was 6.99 lakhs M.T. The total value of marine fish production alone was Rs.5.06 lakhs. Out of the total production, exports account for 3.05 lakh M.T (MPEDA) in quantity and Rs. 5.20 crores in value. The data is evident to highlight the significance of marine fisheries to the economy and trade to the state of Gujarat and to the country by large.

Fishing is an important source of livelihood in Gujarat with a total fishermen (male and female) population of 5.58 lakhs and active marine fishermen population 1.40 lakh. Export is an important source of income for Gujarat Coastal towns which have some major centers for fish trade in Gujarat. Ribbonfish, croaker fish, squid, and prawns are some popular varieties exported from these markets. As per estimates, prawns alone accounts for 60% of the annual average fish production in Kachchh.

<b>Table 1: Major Species of Marine Fisheries</b>			
<b>Trade Name</b>	<b>Scientific Name</b>	<b>Trade Name</b>	<b>Scientific Name</b>
1.Sand Lobster	Thenus Orientalis	7.Bombay Duck	Harpondon Nehereus
2.Rock Lobster	Panulirus Homarus	8.Indian Salmon	Eleutheronema tetradactylum
3.Silver Pomfret	Pampus Argentius	9.Chinese pomfret	Pampus Chinensis
4.Black Pomfret	Parastromateus niger	10.Flower Prawn	Penaeus semisulcatus
5.Ribbon Fish	Leptacanthus Savala	11.Jawala	Acetes Indicus
6.Ghol	Protonibea Diacanthus	12.Squid	Loligo Duvacelii

**Source: Commissioner of fisheries, Government of Gujarat**

In 2017-18, Gujarat's marine exports were to the tune of \$ 791.39 million (MPEDA). The biggest importer of Gujarat's fish was the USA which imports nearly 50% of the total value of exports from Gujarat while exports to China, Vietnam, and Japan were 15% each. The remaining fish went to European countries.

**Marine pollution and its major sources-** There are various ways in which pollutants may enter the aquatic environment and affect fish health in the Gulf of Kachchh. It is pertinent to understand that world seas and oceans are interconnected and pollution and discharge of effluent to one place will ultimately affect the global waters though in the long term. Closer is the point of contaminant discharge, immediate is the impact on marine life. The major sources of marine pollution are:

Pollutants entering the aquatic environment as a result of natural occurrences like Algae bloom or marine bloom. Algae Bloom may result in a rapid increase in the population of algae in an aquatic system. Harmful algal bloom (HABs) occurs when colonies of microscopic algae grow out of control, and can produce toxins that can kill



aquatic fish and mammals. And may cause extreme human illness or even death in extreme cases. Algae are non-toxic but can eat up all the oxygen in the water as they decay, clog the gills of fish and invertebrates or smother corals and submerged aquatic vegetation. While yet others can just discolor water and form huge smelly piles on beaches or contaminate drinking water.

Some pollutants like pesticides enter the aquatic ecosystem from land and have been often found in the tissues of aquatic animals. Most of the pesticides have persistence in the water for only a few weeks or at the most months but a few are considerably more persistent and most of these are among the organochlorine group of insecticides.

Out of the total pesticides used in India, agriculture and horticulture fields use 67% and insecticides account for 75% of the total. Organochlorine alone accounts for 40% of the insecticides used. They include such compounds as DDT, dieldrin, lindane, endosulfan, and heptachlor.

It is generally accepted that organochlorine pesticides especially DDT and its metabolites DDE and TDE (DDD) are long term contaminants in the marine environment. Since most of the organochlorine is non-volatile, insoluble and strongly absorbed on particulate material such as soil therefore it is surprising that they are so widespread in the marine environment. The probable routes of entry of these pesticides are via the atmosphere, rivers, sewage outfalls, and sewage sludge. The intensive urbanization, industrialization, and agrochemicals and pesticides get discharged through the Gulf of Kachchh bound rivulets.

**Table 2: Some persistent pesticides and Bio Concentrates**

<b>Persistent organic pollutants</b>	<b>Some persistent Pesticides</b>
1. Low water Solubility	1.ALDRIN*
2.Persist in the environment	2.DIELDRIN*
3.Accumulation in the food chain	3.CHLORDANE*
4.Lypophilic	4.DDT
5. Travel long distances	5.ENDRIN*
	6.HEPTACHLOR*
6.Concentrate on marine animals	7.MIREX
7. It May produce toxic effects	8.TOXAPHENE*

[Note: \* denotes the pesticides banned for manufacture, import and use in India (ICAR-Indian Institute of Spices Research)]

**Source: Children's Health and Environment, World Health Organization**

There are many industries functioning near Hazira(along Gulf of Cambay), such as Oil & Natural Gas Corporation (ONGC), Indian Oil Corporation (IOC), Gas Authority of India Limited, ESSAR Limited, Heavy Engineering Plant, Reliance Petrochemical Complexes, National Thermal Power Corporation Limited, KRIBHCO Limited. Due to the proximity of these industries close to the sea, a large number of effluents get discharged in the nearby areas of Tapi estuaries and ultimately the effluent reaches the sea causing bio pollution. The same situation is also arising in the nearby region of Amla Khadi (Gulf of Cambay) due to the industrial expansion of Nandesari and surrounding areas. Since waters of the Gulf of Khambhat are connected to that of the Gulf of kachchh hence pollution



at one point turns out to be an issue for the other.

**Table 3: Levels of DDT entering the sea**

SOURCE	DDT (in nanograms)
RAIN	10-300 ng/l
RIVERS	5-100 ng/l
SEWAGE	36-130 ng/l
SLUDGE	10-500 ng/kg*
*	ng/kg wet mass

Note: Volume of water in Kachchh: 220,000 million cubic meters Source: <https://www.jstor.org/stable>

Pollution from shipping activities and accidents like those from oil spills due to faulty handling of Single-point Moorings (SBM) operation in the Gulf of Kachchh may be directly responsible for the deaths of a large number of aquatic animals. The Gulf of Kachchh due to its proximity to the Persian Gulf has attracted the establishment of facilities for transferring, piping, loading of crude oil and petroleum products, mainly the Arabian crude. Also, intentional discharges of oil or oily waste from the pumping of bilges or de-ballasting cargo tanks or from tank washing are other causes for marine operations based pollution in the Gulf of Kachchh. The marine ecosystem of the gulf is therefore at risk of accidental and operational oil spills.

**Impact on fisheries-** The impact of pollutants on marine fisheries may be immediately leading to sudden and large scale mortalities of aquatic organisms. For instance, fishes are killed due to oil spills or severe contamination by toxic pesticides. While in other cases, lower levels of discharge may result in bioaccumulation of pollutants in aquatic species and the damage may occur long after the pollutants have passed through the environment.

Some pollutants have long term manifestation which is often the result of exposure to lower quantities of pollutants over time which leads to chronic damage. The sub-lethal concentration of pesticides like DDT and lindane which are still used in India (Abhilash and Singh, 2009); heavy metals like cadmium and components of sewage affect the immune system of fish either by stimulating or suppressing the production of antibodies. Exposure to sewage sludge and cadmium released from anthropogenic sources like metal smelting and refining, metal processing, pulp, and paper production and also from cigarettes (cadmium is also naturally found), leads to liver damage in the fish. Contamination of Cadmium is also the cause of renal problems.

External damage to the gills, opercula, fins, and skin have been reported following exposure to a wide range of compounds like copper, phenol, pulp mill effluent, and ammonia. NH<sub>3</sub> is the principal form of toxic ammonia. The level of toxicity is both pH and temperature-dependent. Hence, with increasing greenhouse gases (GHGs) emissions coupled with marine pollution, NH<sub>3</sub> pollution can get toxic. Fish are less tolerant of ammonia than plants and invertebrates. Hatching and growing rate of fish gets affected. Ammonia toxicity is one of the main causes of unexplained loss of fish juveniles. At extreme ammonia levels, fish may experience convulsions, coma, and death. With higher levels of (>0.1 mg/liter NH<sub>3</sub>), even relatively short exposure can lead to skin, gills, and eye damage.

Pesticides like DDT have been associated with reduced hatching and blue sac disease (incomplete organogenesis and body development). In addition, DDT may bioaccumulate significantly in fish and other aquatic species leading to long term impact. However, fish uptake of DDT remains size-dependent with smaller fish taking up relatively more than larger fish. Pesticides have also been associated with lymphocytic, ulceration and liver disease like neoplasia.

Contaminated fish food like the macroalgae or the benthic dinoflagellates (unicellular protists) which when bloom, can produce neurotoxins that affect the muscle function in susceptible organisms. Humans may also get



affected by eating fish or shellfish containing the toxins.

Anthropogenic Pollutants, in addition to the normal reduction in feeding and activity during cold weather, causes stress and reduced levels of lipids in fish which causes winter stress syndrome (WSS). Fish can develop this in response to the chemical stressor or biological stressors such as parasites. WSS may cause an energy drain that may result in the largescale death of the fish. Though WSS is important but as yet unquantified mortality factor in many circumstances.

**Impact on human health and survival-** Since humans are closely related to the fish through the food chain, any fatal disease or infection can make their way to human beings. Additionally, the tendency of bioaccumulation of heavy metals like lead and mercury too can pose a risk to human health especially as many of these metals have been alleged as a carcinogen. However certain bacterial diseases like mycobacteriosis and nocardiosis which affect a wide range of marine fish, are capable of infecting humans while handling, cleaning and filleting fish.

Anisakis nematodes are common nematode worms, the larvae of which affect many species of locally caught fish. Anisakiasis in humans can be acquired by eating raw or partially cooked marine fish. 'Crayfish disease' is caused by many bacteria and can spread to humans while handling the marine organism. While most of these diseases causing bacteria are naturally found in the marine ecosystem, Anthropogenic activities and industrial effluents contribute to blooming.

Dinoflagellates bloom and the neurotoxins may also subsequently affect humans if they eat fish or shellfish containing the toxins. The resulting disease includes ciguatera(from eating affected fish) and paralytic shellfish poisoning or PSP (from eating affected shellfish like mussels, oysters).These diseases can be serious but are not usually fatal.

In addition to microbial contamination, anthropogenic chemical contamination of marine water has led to the increasing threat of heavy metals, PAHs and other environmentally persistent substances entering the food chain.

Humans can get exposed to heavy metals like copper. Copper toxicity can happen by eating copper contaminated fish. Even though the toxicity of copper to humans is relatively lower than the other metals like mercury, lead, and cadmium, exposure above essential levels can pose risk. As per research, the presence of heavy metals in fish can pose health risks particularly in foetus and young children.

Food poisoning and occupational exposure to the contaminated marine waters have been estimated to cost millions of dollars in health costs and loss of income worldwide.

**Way forward: policy suggestion-** In order to address the issue of marine pollution, we need to understand the underlying sources which in the first place are responsible for causing the problem. Some commonly talked about causes like oil spills are known to the masses and an endeavor is being made to tackle them, other lesser-known causes need Research and development(R&D). This, in turn, requires scholarship and political will to allocate a considerable percentage of revenue to the sector.

There is also a need to balance the economy versus ecology dichotomy so that the latter does not get affected. The recent amendment to Coastal Zone Regulation under Coastal Zone Notification 2018 has brought some changes crucial to the coastal ecology. The most important was the de-freezing of the FSI(Floor surface index) which was previously frozen as per the 1991 Development Control Regulation (DCR). This will now boost construction activities in CRZ II (Built-up urban area) rendering the area open to further pollution and littering. Secondly, The amendment has also categorized CRZ III (rural areas) into two parts based on population density. CRZ IIIA with a density above 2161 persons per square km will have No Development Zone(NDZ) of only 50 meters from High Tide Line(HTL). The issues of waste disposal, sewage treatment and ever-increasing bulk of plastic which ultimately finds its way to the animal's intestine need to be sorted out. Additionally, unlike before the clearance for project development by the Ministry of Environment will now be required only in cases of CRZ I (Ecologically sensitive



areas) and CRZ IV (Areas covered between low tide and 12 nautical miles seaward). This will give realtors easy access to other zones. Reconsidering the amendments especially for sensitive coastal regions like the Gulf of Kachchh is advisable.

The greater ease of clearance of forests for establishing industries and infrastructure projects under Compensatory afforestation fund management and planning authority (CAMPA) is also seen as a threat by environmentalists, which may affect marine fish due to changing temperature-salinity paradigm. However, Since the scheme has already been passed, judicious use of the fund for ensuring the treatment of industrial effluent and cleaning plastic debris along the line of "Ocean Cleanup" should be examined. Ocean cleanup is a passive clean up method that uses the natural oceanic forces to rapidly and cost-effectively clean up the plastic in the Pacific patch.

Remedial methods for cleaning oceans in the aftermath of marine operations which may cause an operational or accidental discharge of shipborne pollutants, oil spills due to maritime accidents, etc, have potential solutions in the upcoming innovative technologies like AI and big data to find the exact area affected and intensity of the impact and remedial measures in the inhospitable and remote areas off the Gulf of Kachchh. This too requires finances and technological know-how. Proper training and budgetary support become a requisite in such a case.

The new captive ports in the environmentally sensitive Gulf of Kutch area and the development of petrochemical industries coupled with the increasing movements of large crude carriers and other vessels make the coast of Gujarat highly vulnerable to pollution threats. Proper monitoring and regulations including the idea of "polluters pay" should be implemented to bring private companies on board. However, the implementation of regulations in the fishery sector for sustained production has to take into account its impact on the livelihood of the considerably poor fishing community.

Fisheries Management is an important practice which involves the integrated process of information gathering, data analysis, planning, consultation, decision-making on the allocation of the resources, implementation strategies for sustainable use, analyzing the present status of regulations or rules which govern fishing activities to ensure steady and sustainable harvest of the resources. Fisheries Management is not about managing fish but about managing people and related businesses. Fish populations are managed by regulating the actions of people. These management regulations should also consider its implications on the stakeholders.

In conclusion, as often reiterated, coastal populations and the states greatly depend on fish production to meet the domestic demand and to run their economy. Controlling marine pollution, therefore, becomes imperative not only for ecological implications and conserving biodiversity but also for the attached food chain wherein the morbidity at one trophic level passes through the chain to the other and may finally reach the humans in some way or the other. The recent hue and cry over the formaldehyde contamination in fish is a fresh reminder to the wide-scale impact the pollutants can have on human health, the economy and social rest. Hence collaborative international actions like the Minamata convention which was to contain the impact of mercury poisoning would be a good step to start with.

Since the marine debris often finds its origin in the beaches and boating tourism, endeavor to make the beaches and marinas eligible for Blue Flag Certification (by FEE) should be encouraged by giving some perks like a greater share in the divisible pool of taxes. Involving volunteers and cooperatives from the local fishing community should be encouraged. These steps would also boost trade in fish to qualify the sanitary and phytosanitary (SPS Agreement) norms of WTO, which sets basic rules for food safety and public health standard while also fulfilling the Sustainable Development targets (SDG-14). Addressing marine pollution will prove to be a win-win situation, in the long run, boosting trade, conserving marine biodiversity, ensuring sustained livelihood and will bring global repute to India.



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