Pakistan Journal of Marine Sciences, Vol.4(2), 159-174, 1995.

REVIEW ARTICLE

ECOLOGICAL IMBALANCES IN THE COASTAL AREAS OF PAKISTAN AND KARACHI HARBOUR

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ABSTRACT: The marine environment of Pakistan has been described in the context of three main regions : the Indus delta and its creek system, the Karachi coastal region, and the Balochistan coast. The creeks, contrary to concerns, do receive adequate discharges of freshwater. On site observations indicate that freshwater continues flowing into them during the lean water periods and dilutes the seawater there. A major factor for the loss of mangrove forests as well as ecological disturbances in the Indus delta is loss of the silt load resulting in erosion of its mudflats.

The ecological disturbance has been aggravated by allowing camels to browse the mangroves. The tree branches and trunks, having been denuded of leaves are felled for firewood. Evidence is presented to show that while indiscriminate removal of its mangrove trees is responsible for the loss of large tracts of mangrove forests, overharvesting of fisheries resources has depleted the river of some valuable fishes that were available from the delta area.

Municipal and industrial effluents discharged into the Lyari and Malir rivers and responsible for land-based pollution at the Karachi coast and the harbour. The following are the three major areas receiving land-based pollution and whose environmental conditions have been examined in detail: (1) the Manora channel, located on the estuary of the Lyari river and serving as the main harbour, has vast areas forming its western and eastern backwaters characterized by mud flats and mangroves. The discharge of industrial wastewater from the S.I.T.E. and municipal effluents from the northern and central districts into the Lyari has turned this river into an open drain. This, in turn, has caused a negative impact on the environment of the port, fish harbour, and the adjacent beaches. (2) The Gizri creek receives industrial and municipal effluents from the Malir river as well as from several industries and power stations. The highly degraded discharges from the Malir have negatively impacted the environment in this creek. (3) The coastline between the Manora channel and Gizri creek where the untreated municipal effluents are discharged by the southern districts of Karachi, is responsible for the degraded environment of the Chinna creek, and also of the beaches and the harbour.

The Balochistan coast is relatively safe from land-based pollution, mainly because of the lack of industrial, urban or agricultural activity, except the Hingol river system where some agricultural activities have been initiated.

The marine environment of Pakistan encompasses a coastline stretching from the eastern edge of the Indus delta to Gwatar Bay at Ras Fastah where the Dasht river discharges into the sea. It also includes the Exclusive Economic Zone extending over 320 Km into the Arabian Sea. A number of man-made processes have been initiated during the last 60 years causing an imbalance in the ecosystem of the coastline. The areas of concern with regard to marine pollution are the creek system, the Karachi coast, and the Balochistan coast (Ahmed, 1979; Beg, 1979; GOP, 1986).

THE INDUS DELTA

The creek system which in the past formed the channels of the Indus delta seems inactive now because the river has migrated to the east and has been dyked to flow in a fixed course. By all standards, the water in the creek system should be highly saline, but it is not. A large and intricate network of canals flows from the dyke. The water that flows into the fields from adjacent canals is also pumped by tube wells into the riverine area. The end of each channel is marked by a swamp where the water stagnates over a wide area and flows slowly into the sea. This stagnation is deliberate, but is uncontrolled. The result is extensive waterlogging all over the area between the terminal point of the channels and the sea.

This type of waterlogging that gives rise to swamps is advantageous as it is instrumental in lowering the salinity of the creek system. The net result is that the water in the creeks can bear the mangroves. There are only a few mangrove trees that have survived in Ketibunder and Guno, but they bear testimony to the observation that it is not the reduced flow of freshwater but overgrazing or overharvesting that has depleted the mangrove cover.

IMBALANCE IN THE COASTAL ECOSYSTEM

The balance in the ecosystem of the deltaic and coastal region of Pakistan has undergone major shifts due to changes in the river regime to meet development requirements of the agriculture, municipal and industrial sectors. Imbalances in the ecology of the river regime have been affected by: (1) diversion of water into canals by construction of barrages, thus making it perennially available in the command areas but much less for the delta itself, (2) storage of water in dams to meet agricultural requirements during the Rabi (winter) season and also for the power needs of the country, and (3) channelizing the flow of floods by raising embarkments along the Indus as it enters the province of Sindh to protect property and land from the vagaries of the floods (Beg, 1977a).

ECOLOGICAL IMBALANCES DUE TO DIVERSION OF WATER INTO BARRAGES

The management of water resources, particularly the aspects related to diversion through the barrages - laying of a network of canals to make water available on a perennial basis - has run into unforeseen problems that appeared many years after the projects were operational. The diversion has impacted the environment in the following manner. (1) It has partially reduced the waterflow downstream Kotri, the last barrage on River Indus, and located approximately 200 km upstream. (2) It has substantially reduced the silt load of river water flowing towards the coast to a bare subsistence of the natural habitat, including the mangroves. (3) It has caused the erosive action of the sea to dominate over sedimentation. (4) It has given rise to excessive use of water, causing waterlogging and increase in salinity of the soil, thus facilitating its losses through evaporation as a result of an increase in surface area. (5) It has caused seepage from canals and distributaries that are mostly unlined (Beg, 1977a, 1994; Meynell, 1994).

The first three consequences are concerned with the marine environment and will be discussed here.

REDUCTION IN VOLUME OF STREAMFLOW

The process of water diversion has reduced the streamflow to a few thousand cubic meters from mid-November to the end of March. In the past this water may or may not have been available but now its availability is restricted because of the priorities attached to its requirements for agriculture during the Rabi season for growing wheat, the staple crop. When there were no barrages, annual floods would bring upwards of 120 Million Acre Feet (MAF) to the delta, which would discharge through a large and

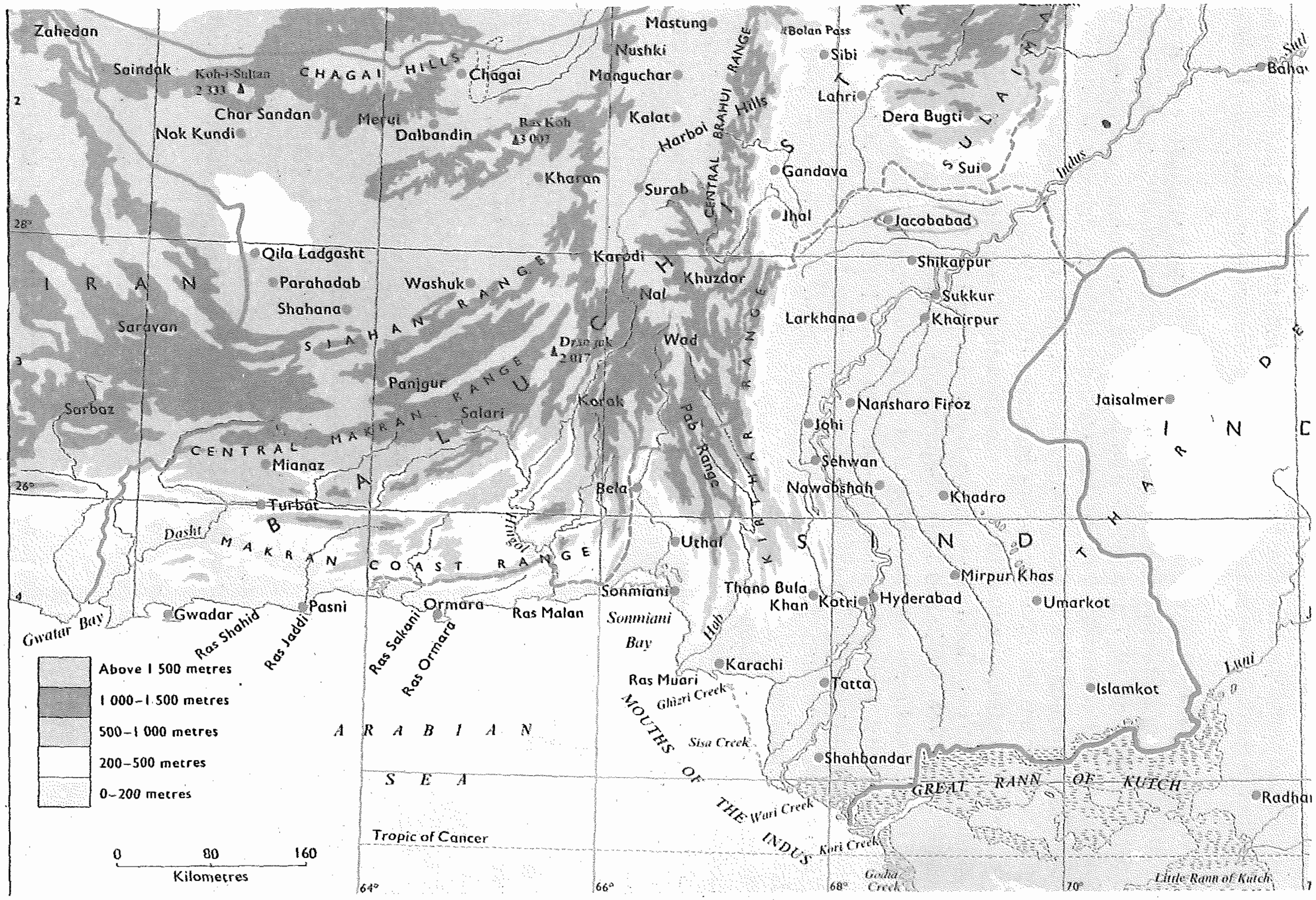

Fig.1. Map showing coastal areas of Pakistan.

intricate system of deltaic channels into creeks and onwards to the sea. The discharge was reduced to 100 MAF after 1932 when construction of the Sukkur Barrage was completed. The delta started shrinking hereafter not only because of this construction but also because embankments were being raised all along the river. The flow volume passing through the delta was reduced to 80 MAF on construction of the Kotri Barrage in 1956.

The volume of water flowing into the sea on an year-to-year basis has been reduced from 120 MAF to an average of 33 MAF ranging from a minimum of 9.7 to a maximum of 80.6 MAF between 1977 and 1992. The change in flow volume downstream of Kotri is due to the construction of the barrages, not the high dams at Mangla and Tarbela. The pattern of flow has not changed as peak discharges still occur from July to September, nor has the flood frequency increased (Beg, 1994).

The flood flows thus continue to be the same as before from April to late October. It is usual to have two flood flows in the rivers: one in late July and the other in September as in 1988, 1992, and 1994. September is marked by heavy floods since the land in the catchment and adjoining areas is already saturated and has lost its absorption capacity, giving rise to high runoff. In 1973, 1988, 1992 and 1994 when there was heavy precipitation in the catchment areas of the Indus and its tributaries, large areas were inundated. Numerous floods of varying intensity have similarly occurred in the territory.

The changes brought about by construction of embankments from Kashmore to the sea, and reduction in the flow volume downstream of Kotri are responsible for changes in the deltaic ecosystem. Channels from the Kalri Baghar Feeder and the Pinyari system from the Kotri Barrage offer a perennial supply to some of the creeks. This coupled with the enhanced flow during the April-July period and massive flood flow thereafter make up for the freshwater requirement of the deltaic region. The large delta is now restricted to only two small channels, instead of an intricate networks of rivulets and creeks. The reaches of freshwater to the creeks may be reduced during dry periods but it is available in the winter, especially if it has been preceded by a massive flood flow, as was the case in 1992 and 1994.

The availability of water in the creeks keeps the salinity level within optimum limits. The electrical conductivity of the samples of seawater collected from the root zone of a few mangrove trees in Keti Bunder and Guno near Gharo, indicates that the salinity in the region is in the range of 33-35 parts per thousand (ppt). A similar range of values was noted for the seawater at the Hajamro Creek near the high water line about 15 km to the southwest of Keti Bunder. These values are lower than those observed for the creeks near Karachi, 38 to 40 ppt. A salinity of 35 ppt suggests that adequate interaction of seawater with freshwater is taking place to impart the much needed dilution. It should be noted that in the past the water would also flow through the creeks only during the floods, would inundate the deltaic zone, and would then restrict itself to streamflow during the winter months from November to March.

REDUCTION IN SILT LOAD

The flow in the deltaic region is now reduced to a few hundred instead of a few thousand cubic meters per second, depending on the flood intensity during the monsoons. The difference lies in the amount of silt load carried by the Indus. The

Indus and its tributaries carry detritus in suspended and bed loads varying from 0.5 to 500 million metric tons (MT). It has been estimated that some 675 MT of sediment was being discharged by the Indus prior to the construction of the dams and barrages, 60% of which used to be deposited in the river channels and approximately 250 MT reached the estuary where there has been a 9 m accretion in the flood plain during the past 5,000 years and a seaward growth of 80 km in the delta during the last 2,000 years. The barrages have provided obstacles in the flow of water, which have led to selective settlement of detritus there, or to their diversion into canals and onwards into the farms (Milliman, *et al.* 1984).

Sediment load is also reduced during the low flow period, from November to March because the river streams are undisturbed and there is no inflow from the catchment areas, which undergo freezing during this season. Rains in the winter in the catchment areas bring in the sediments but these are confined to the northern parts and not much travels downstream of Kotri.

FACTORS CONTRIBUTING TO DESTABILIZATION OF THE COASTLINE

Erosion initiated by camel grazing: The coastal area on the Ochito-Ketibunder-Hajamro section lying adjacent to the Jangh, which is the mouth of the Indus, was visited in mid-January 1993. There were some interesting findings. The entire stretch of marshy land, which until recently was covered with mangrove forests, has been converted into a desert, with stumps of the once tall trees still standing in some places. The process of degradation may have started because of lack of sustainable management of the mangrove forests. Camels are sent to the forest for grazing. This animal is a voracious eater of the mangrove leaves. The large animals pluck and eat the leaves and twigs directly and also feed them to their young. In addition the young browse the seedlings which might still be firming up (Beg, 1993).

The camels remain there in the forest continuously. Because they need plenty of fresh water for drinking, this precious commodity is transported by boat at a fixed time. The animals are so trained that as soon as they see the boat they rush for their share of water. Camel farming has thus become an organized business. The demand for camels is said to be high, as the animal sells for more than Rs.15,000. No one, therefore, cares for the loss of the leaves and twigs from the trees. Overgrazing continues unchecked and the natural consequence is that the forest has been denuded.

The problem is further compounded as mangrove trees growth is stunted due to the loss of leaves by the grazing. The same individuals who bring the camels to graze, fell the branches of the trees indiscriminately to sell the leaves and twigs for fodder, and trunks for construction materials for huts, or for firewood. The felling operation is quite systematic and seem to be carried out with appropriate tools, that is, the saw and not an axe. The cutting of the tree trunks to a uniform height also suggests an organized undertaking.

Cutting the trees to trunk level constitutes the second phase of mangrove forest denudation. At a much later date, the stumps are removed when the trunks and roots have dried and when the tree soil interface is cut off.

This incidentally is an outline of the process whereby the forces consolidating the soil become ineffective. The marshy soil is soon destabilized and with the removal of the trunk it becomes vulnerable to erosion (Beg, 1993). Much of the mangrove forests have thus disappeared in only a few years.

Erosion of the coastline: The ecology of the entire Indus Basin has changed as a consequence of reduced sediment load in the stream flow. There is on the one hand, a gain of silt and nutrients in areas that receive irrigation water diverted from the barrages, and on the other hand there is a loss of soil on the coastline. The losses are apparently due to the domination of the erosion processes over sedimentation and deposition. It is known that with a reduced sediment supply but the same flow volume, an estuary of a river is degraded. Conversely the same sediment load with reduced flow volume causes accretion of the river estuarine area.

Accretion and retrogression of the river bed and the coastline have both been observed in Pakistan. In the deltaic area there has been a loss of land while in the river bed upstream of Sukkur there has been a gain. There has been so much erosion at Keti Bunder that the old town has lost its grandeur. In Karachi the land has advanced by at least two kilometers towards the sea from the Clifton beach within 40 years. However, this is totally unrelated to the river flows and is due to construction of the groyne (sea wall).

The seawater encroachment is particularly noticeable from Gharo to Keti Bunder which was a prominent town in the past. The port of Keti Bunder was stabilized when the port of Shah Bunder became too silted for traffic. The British found Shah Bunder in this condition when they occupied Sindh in 1843. This port had important links with the port of Ghorabari, which is on Hajamro, the main discharge channel of the Indus delta. Keti Bunder itself is located on the Ochito River which was a deltaic channel in the past. It has now stretched on both sides to become a major tidal creek and Keti Bunder, the once prosperous town, is submerged under water and dwarfed to a island. The graveyards of the town, which were located away from the Ochito, are now becoming submerged. The roads and linkages constructed in the past have become vulnerable to inundation by the tides. Kobar Dhora, which used to link Tursian with the Jangh River through Babar Creek, has also widened. The Jangh River is now a very large creek at the mouth of the Indus. The relationship with the tidal rivers becomes visible during the high floods when muddy water flows through this channel. The widening of the creeks seems to be related to the lack of soil stability on the coastline. It appears that the reduced sediments in the Indus has allowed erosion to dominate over sedimentation (Beg, 1993).

There has been a reduction in the availability of nutrients at the coastline but this is the consequence of redistribution at the command areas of the barrages. The soil of the Indus Basin as well as the coastline used to receive their annual share of nutrients, in the past, from the silt brought along with the floods. The redistribution of the silt along with the diverted river water into the command areas has now restrained their flow to the sea and, hence, the nutrients supply is also proportionately restricted. A field visit to the coastline 13 and 16 weeks after the massive floods of September 1992 indicated that the area is still marshy and that the diversity of aquatic animals inhabiting the mudflats in Hajamro Creek is still being maintained. This suggests that the nutrients supply is still quite adequate for the growth of mangrove and aquatic animals. This is supported by the surveys in 1985 of Hajamro Creek (Rabbani *et al.*, 1986; Rizvi, *et. al.* 1986).

In 1993, samples of soil and seawater were collected from the root zone of the mangrove trees in Keti Bunder and from the open sea at the end of Hajamro Creek approximately 15 km away (Beg, 1993). The pH of the soil from the root zone of the mangroves at Hajamro Creek was 8.8 while that of the seawater in the creek was 8.2. The former is, as expected, not very much different from the latter. The salinity of the seawater at Hajamro Creek was only 34 ppt compared with 36 to 38 ppt near the open sea (Rabbani *et al.*, 1986; Rizvi, *et. al.* 1986). This apparently indicates dilution of the seawater by freshwater. In October 1985, the salinity of a point in the same creek but near the Indus estuary, was found to be 27.6 ppt.

The pH and salinity of the soil samples do not seem to have changed between 1985 and 1992. This suggest that the chemistry of the microenvironment of the mangrove area of Hajamro Creek has not changed much as a result of the reduction in the flow of freshwater and the accompanying sediments. The slightly low salinity of the seawater at Hajamro Creek taken in mid-January shows that sufficient freshwater was still flowing into the Indus estuary to effect the observed dilution. The situation with regard to the availability of sediments and nutrients may, however, not continue for long because the coastal environment is fast degrading as a result of human activities.

Erosion of coastal soil: The soil on the coastline has succumbed to the erosive action of tides and waves. This has, as was observed during the field visit, resulted in the replacement of the mud by fine sand on such coasts or in the loss of mudflats areas. There has been a tremendous loss of soil from the creeks, which is borne out by satellite imageries. The creeks have, as noted earlier, become much wider than before. Large boats fitted with inboard motors have been operating in these creeks. They move in and out of the creeks causing wave actions that splash the seawater onto the coastal soils. The destabilized nature of the soil provides no resistance to the erosive action of the waves, which is meandering the coastline leading to widening of the creeks.

Destabilization of the coastline and the consequent meandering of the creeks are common all along the three metre wide shoreline, starting from the coast at Keti Bunder to Ochito Creek and onward to Hajamro Creek and in the Gharo-Guno Creek. The water is muddy as a result of wave action. The process initiated by tree felling, followed by mudflat erosion, seems to have rendered permanent damage to the ecology of the deltaic area, the creeks, and the once lush green and dense mangrove forest.

LAND BASED POLLUTION IN THE KARACHI COASTAL REGION

The coastline of Karachi is 135 Km in length. The marine environment most vulnerable to pollution is located close to the large metropolitan centre, but extends from Phitti Creek, which receives discharges from the Steel Mills, to Cape Monze, which receives effluents from the Hab Industrial Area. This region is faced with serious threats to its marine environment from the various operations comprising industrial, municipal, transportation and port activities. They have all compounded the problem to give rise to pollution of the highest order and to an imbalance in the ecosystem of the Karachi coastline (Beg *et al*, 1975a, 1975b; Beg, *et al.*, 1979).

There are three major coastal areas in Karachi that receive land based pollution: (1) Manora Channel, located on the estuary of the Lyari River, (2) Gizri Creek on the estuary of the Malir River and (3) the coastline between the Manora Channel and Gizri

Creek (Beg, 1979).

A considerable amount of research on marine pollution has shown that it is the effluents from the Lyari and Malir Rivers that are largely responsible for the degradation of the marine environment (Beg, *et al.*, 1975a,b; 1978a,b;1984;1992; Beg 1977b, 1979). The Lyari discharges into the Manora Channel, a highly polluted mixture of sewage from the north and west of the city, and industrial effluents from Sindh Industrial Trading Estate (S.I.T.E.) on Manghopir Road and the industrial areas of North Karachi and Federal Area. The Malir River receives sewage from the Korangi and Landhi Industrial Areas. The coastline from Manora Channel to Gizri Creek, on the other hand, receives the municipal effluents from the central business districts through two main channels that discharge them into the Chinna Creek.

The water supply to the industrial areas in Manghopir, Landhi and Korangi has only marginally increased from the previous amount of 40 MGD (KDA, 1972; Nizami, 1981; KWSB, 1991), but it has been augmented by delivery through tankers, which constitute a brisk trade in this water depleted megapolis. The quantity of the sewage generated has, on the other hand, increased from 14 MGD in 1951 to 216 MGD as at present. Two sewage treatment plants with capacity of 20 MGD each were installed in S.I.T.E. and Mahmoodabad in 1966 for primary and secondary treatment, but neither their capacity has been increased nor has any other plant been installed. On the contrary the two plants have not been able to function to the desired level. Most of the 176 MG of untreated sewage and the entire 40 MG which receives only primary treatment, if at all, flows daily into the sea from the Manora Channel, Chinna Creek, Clifton Beach, and the Gizri, Korangi and Phitti Creeks. Accordingly the concentration of industrial pollutants has decreased due to dilution by municipal effluents (Beg *et al.*, 1984b).

The amount of domestic sewage in the total wastewater is estimated at 12 to 14% while that of industrial wastes from the industrial areas of Karachi is 86 to 88% (KDA, 1972; Nizami, 1981). The coastline of Karachi receives water-borne pollution at the rate of 375 gm BOD per capita per day (KDA, 1972; Nizami, 1981). Assuming the population of Karachi to be 10 million, the BOD load discharged into the Karachi marine environment can be put at 3,750 tonnes/day or 1.368 million tonnes each year.

IMPACT OF DISCHARGE OF INDUSTRIAL AND MUNICIPAL EFFLUENTS ON MANORA CHANNEL:

Five salt works are located on the right bank and the port and the fish harbour are on the left bank of the Lyari, which empties into the Manora Channel. This channel occupies 7.17 sq km of the estuarine area of the Lyari. The entrance to the channel is through the narrow 'brackwater wall' on the western side and the 'sea wall' on the eastern side. Approximately 3.5 million cubic metre of seawater circulates into the channel daily through the tidal flow, which is ineffective in flushing out the pollution load brought by the Lyari. The pollution load in the channel thus remains stagnant for sometime (Haq, 1976; Ahmed, 1979; Beg *et al.*, 1984).

With a tidal range of 3.0 metres, the high tide fills the backwaters and creeks of the harbour area, covers the intertidal zones of the small islands and mudflats in the estuary and, going past the mangroves, reaches the salt pans. Recession during low tide is in a clockwise direction towards Clifton and Gizri which is the pattern followed by the currents from early March to late December. It moves in an anticlock-wise direction during the remaining period towards Sandspit and Cape Monze (Beg *et al.*, 1975a; Haq, 1976; Ahmed, 1979).

Sindh Industrial Trading Estate covers an area of 4000 acres. There were, in 1974, some 500 major industrial units discharging their wastewater into the Lyari (Beg *et al.*, 1978a). The number has increased to at least 1,200 units if not more. It has the largest conglomeration of a wide range of industries such as those producing food and beverages, tobacco, paper and paper products, textile, plastics, rubber products, chemicals, non-metallic minerals, coal, petroleum products, basic metals, and machinery. The construction of factories on plots not meant for the existing production and even on channels and nallahs has created hazards for the safe discharge of effluents from the S.I.T.E. The wastewater discharged from S.I.T.E. accounts for more than 80% of the pollution load carried by the Lyari to the sea (Nizami, 1981).

The Lyari, according to 1974 estimates, discharged 130,000 tons of dissolved solids every year. These include 16,000 tons of organic matter, 800 tons of nitrogen compounds, 90 tons of phosphate compounds and 12,000 tons of suspended solids (Beg *et al.*, 1975a).

Siltation is one of the main problems faced by the port authorities. They must keep dredging over 450,000 cubic metre of silt every year to maintain the channel depth. The dredge spoils are dumped 5 Km away in the southwest (Ahmed, 1979). The water, which used to be crystal clear in the harbour during the 1950s, is now turbid mainly due to the dredging spoils and the more than 34 tons of suspended solids carried by the Lyari every day (Beg *et al.*, 1992).

The Lyari water is invariably grey to black except during the rainy season. Its perennial flow and he sediments carried by it have turned the channel water black and hence the designation: 'kala pani' or 'black water' (Beg *et al.*, 1975a). The water at Lyari outfall contained 0.1 to 0.3 ppm of lead in 1985 but ten times this quantity, 1 to 3 ppm, in the locality immediately past the outfall and near the fish harbour (Beg *et al.*, 1992).

The adverse effects of 'black water' fall directly on the fisheries catch brought in by fishermen after spending at least two to three nights in the open seas. Firstly the ice used by the fishermen is contaminated with bacteria that pass on into the fish catch when placed into ice chests. Secondly the catch receives a full dose of bacteria on landing when the fishermen give it a dip into the 'black water' to make it look fresh.

This is borne out by the microbiological studies carried out in 1980 on the seawater in the channel and the spill over from it onto the beaches. High faecal counts were found at a number of study sites (Beg *et al.*, 1984b). This suggests that the beaches are also bearing the impact of contamination in the Manora Channel.

The salt works mentioned earlier have also been damaged as a result of pollution in the channel where the water remains stagnant. Analysis of brine collected from some of these salt works indicates that their input is sufficiently putrescible and that it contains a substantial quantity of volatile matter. This has been attributed to contamination of the seawater by the industrial and municipal effluents brought by the Lyari (Beg *et al.*, 1984a).

The quantity of bicarbonates flowing through the Lyari alone was estimated in 1974 to be 14,000 tons annually (Beg *et al.*, 1975a). This ingredient is not acceptable either for the calcarious rocks or for the shellfish population. Bicarbonates are even otherwise being formed as a result of interaction of seawater with the carbon dioxide produced by fossil fuel combustion. It was further noted that the pH of the harbour water was 7.5 rather than the usual 8.2 for seawater and that there were 200 ppm of bicarbonates instead of 140 ppm. This was attributed to the interaction of carbon dioxide in the nearshore region with the seawater (Beg *et al.*, 1984a). It is no wonder therefore that the shellfish have lost their biodiversity in the Karachi coastal region and that the rocks in the region have slowly been eroded within the memory of the present generation.

IMPACT OF DISCHARGE OF INDUSTRIAL AND MUNICIPAL EFFLUENTS ON GIZRI CREEK:

The second major coastal area exposed to the hazards of land based pollution is the Gizri and Korangi Creeks system. It occupies the extreme northerly portion of the saltwater creeks. This system is swampy and once had a luxuriant growth of mangroves which have now been thinned out. Extensive biodegradation has taken place in the swamps where incidentally some molluscs, including those that bear black pearls, have managed to survive. This creek system used to serve as the nursery for the young and juveniles of the fishes, shrimps oysters and other marine bottom communities. However, the bio-diversity of the creeks has largely been reduced during the last two decades, the time when Port Qasim and the Steel Mills facilities were constructed, for which millions of tons of bottom soil had to be removed to deepen the channel.

Siltation is just as problematic here as in the Manora Channel, since dredging has to be carried out continuously to keep it operational. This is an essential requirement because Port Qasim has to handle bulk cargo including iron ore, coal, steel mill exigencies, cement, fertilizers and rice.

The marine environment of Gizri Creek is under serious stress due to the discharge of industrial and domestic effluents from the metropolitan area as well as from the fishing villages, the port and shipping activities in Port Qasim and the fishing boats in the Ibrahim Haideri fish harbour. The Malir River is the principal recipient of industrial effluents from the Korangi Industrial Area and the Landhi Industrial Trading Estate, and municipal effluents from Mahmoodabad sewage treatment plant and a number of channels that have been constructed for carrying sewage from large and small residential localities, such as KDA Scheme No.1, Administration Society, Shah Faisal Colony and conglomeration of colonies and societies in Malir, Landhi and Korangi.

THE MALIR RIVER BED:

The river bed itself has been extensively degraded by excavating millions of tons of sand from it. Sand transportation is a brisk business and the transporters are not concerned with the degradation of the environment. The indiscriminate excavation has exposed the rock bottom with the result that the river has lost its absorption capacity and flash floods are commonplace. A protective embankment had to be raised all along its bank after the devastating floods in 1977. The construction of this embankment stopped the flow of wastewater from several channels used by the industries to discharge their effluents which started accumulating in pond and lagoons (Beg, 1982). This, in turn, has resulted in the accumulation of pollutants in well waters (Beg *et al.*, 1990).

The degraded environment of the river bed is being further exploited for growing vegetables by using the freely available wastewater. Pumping of wastewater is a commercial activity in the Korangi Industrial Area where water is pumped into fields located all along the river bed, starting south of the Landhi bridge to almost the end of the industrial area. Several hundred acres of the otherwise useless land has thus been reclaimed for growing vegetables, but by using highly hazardous wastewater. This is perhaps the reason that the waterflow in the river is very nominal compared to wastewater drains that discharge the effluents. The heavy impact of pollution on the marine environment thus appears to have been considerably reduced, in contrast with that in the Manora Channel. The silt load which is otherwise barely visible because of extensive excavation of the river bed, has been further lowered by the flow through the farm areas.

INDUSTRIAL EFFLUENTS:

The large and small industrial units in the Landhi and Korangi Industrial areas discharge their wastewater into Korangi nallah which terminates into the Malir River at Gizri Creek. But for the disposal into the stormwater drains,which are poorly maintained, the wastewater handling in these industrial areas is not as unsystematic as in the S.I.T.E. Here, the major polluting units pertain to textile and leather goods production but other diversified industries producing pharmaceuticals, food products, glass, refractories, ultramarine blue, and refineries processing petroleum are also carrying out their activities equally effectively.

Textile factories consume a large amount of freshwater and generate 12.5 MGD of effluents. Their wastewater contains organic matter comprising degraded cellulosic material, unused chemicals, dyes and auxiliaries and hence the high BOD load of over 10,000 tons per year (Driver, 1987). The wastewater containing toxic materials is degraded during its flow in the channels outside the factory by biological factors that have developed during the course of time. Whatever reaches the coastal area is, therefore, less toxic than the discharges from the factories.

Tanneries are next to the textiles industry in terms of volume of water consumed but they are major polluters in this industrial area with regard to their discharged pollution load. They are bulk users of water, all of which does not have to be fresh. The use of groundwater which has a total solids content exceeding 1% is quite common. This high salinity suits them since they do not have to use salt which is needed in their beamhouse operations. Their wastewater is estimated to be over 5 MGD but it is of no interest to the tanners in terms of recycling. However, since the groundwater level is slowly going down, it is quite likely that they will have to regenerate some of the process water. The estimates of the Karachi Water and Sewerage Board (KWSB, 1991), also suggest that the tanneries must attend to chrome recovery urgently, even if they do not wish to recycle all the wastes. The total dissolved solids present in the wastewater is of the same order as that contained in the Lyari effluents in 1974. All of the solids, whether suspended or dissolved, do not seem to reach the sea because, as noted earlier, there is a substantial reduction in flow volume as the stream approaches Gizri Creek.

The refineries have been generating 0.2 MGD of wastewater (Beg, 1990) even though there are treatment facilities. A soda ash factory discharges 0.3 MGD of its effluents (Beg *et al.*, 1990) containing calcium chloride and some carbonates, besides some solid wastes, into the Korangi Creek at a distance from the salt works in the area.

The Steel Mills were in 1985 generating 2 MGD of wastewater, but they have adequate arrangements for its treatment and recycling. Some process residues or washings are, however, discharged into the Phitti Creek outfall. This is, perhaps, the reason for the occurrence of heavy metals at the disposal site (Beg *et al.*, 1990).

The Steel Mills and the Port Qasim thermal power stations use seawater for cooling purposes and they discharge the hot water into the Phitti Creek. The Korangi thermal power station and the one on the premises of the Sind Alkalis discharge their hot water into the Korangi creek. The hot water has a temperature 4°C to 10°C higher than seawater and does not seem to have disturbed the ecological balance in any way.

The Korangi Creek area also has some well established salt works, that have been producing some good quality seasalt since early 1940s. These units, unlike the ones in the Manora Channel, receive uncontaminated input from the intake channel constructed for that purpose. These open into the creek whose water has the higher salinity required for salt production. The salt works, however, do not use bittern, the waste product that is higher in ionic concentration than seawater and they discharge it into the sea. This output is low and hence the salt works are not considered as polluting industries. Their input is also not considered to be polluted by industrial effluents e.g. by the soda ash factory, because the wastewater from latter is sufficiently diluted to have any adverse effect on the process of crystallization, which is all that this industry is concerned with.

The Korangi Creek receives strong sewage from the cattle colony in Quaidabad which holds more than 50000 buffalos, and also from the slaughter house in the vicinity (Driver, 1987). The discharge of wastewater is 0.8 MGD containing biodegradable organic matter having a BOD value of 15,000 tons per annum. The cattle owners also make extensive use of agrochemicals to protect their animals and the products. These ultimately find their way into the creek.

The amount of domestic sewage flowing into the Gizri-Korangi creek system appears to have been underestimated by the rapid assessment survey in 1987 (Driver, 1987) because the population involved is nearly 50% of the megapolis and not just 0.9 million. Similarly, the total flow has also been underestimated at 35 MGD because the localities discharging the wastewater are equally large. Accordingly the volume should be half of the total, *i.e.*, approximately 100 MGD.

POLLUTION OF BEACHES

The third area receiving land-based pollution is the one that constitutes the open beaches of Karachi, stretching from Keamari, Chinna Creek to Clifton and Gizri. The quality of wastes flowing through the various streams into the area has not been estimated but judging from data analysis, it is possible to say that they comprise a strong sewage mixed with oils and greases from automobile workshops, and wastes discharged by small industries located in residential areas. They have spoiled the recreational value of these beaches to the extent that the initiation of water sports at

Chinna Creek, had to be halted.

Chinna Creek, according to estimates, receives effluents equivalent to 1600 to 2000 cubic ft. per second (cusecs) from two channels, one discharging beyond the Cotton Committee Building and the other beyond the offices of Dawn Daily into the Railway Colony. This creek appears to be the worst polluted as faecal debris, oil film, plastic wastes and rags are easily visible floating in to and out of the port area.

The beaches in the Manora and Sandspit area also receive faecal contaminants from the discharges of the Lyari and the outflow from the Manora Channel. The pollution is, however, neither of high degree nor very outspread. It nevertheless poses health hazards to those seeking recreation.

OIL POLLUTION

The Manora Channel is highly affected by oil pollution because of its close location to the oil terminal, the wharves, the fish harbour, and Chinna Creek. Oil pollution is also found at the Gadani ship breaking yard, Port Qasim, and the fish harbour, at Ibrahim Haideri. At all these places the oil is in such large quantities that the water is black and bears a metallic shine on the surface. The oily discharges were estimated to be 20000 tons annually (Mian, 1979). While these figures, appear to be on the high side, conditions did look bad during the 1980s. The position has improved considerably after the construction of the oil piers and also after restraining the ships from taking too much liberty in discharging their tank washings on Pakistani shores. It may be noted that this is not the result of local legislations but more due to international conventions to which the shipping nations are signatories.

The indication of improvement ensues from the observations that the incidence of tar balls reaching the shores has been considerably reduced in recent times. Tar balls are formed when the volatiles from the oil spill evaporate-off, leaving the oil film to float and to oxidize slowly. The floating film drifts into the Manora Channel and outwards into the open sea. It is at this stage that the oxidized film assumes a semisolid form and on coming into contact with silt and other floating bodies settles to the bottom during low tide. Tar balls can still be found on the beaches, particularly when there are disturbances in the Gulf region, e.g., during the Gulf War.

IMPACT OF POLLUTION ON MANGROVES

The mud-flat of the Manora Channel where the Lyari discharges the wastewater and that of the Gizri Creek where the Malir terminates, are the areas that show visible signs of degradation of the mangrove habitat. *Avicennia marina*, the most predominant species is considerably dwarfed or occurs as an occasional or isolated plant at the points where these rivers enter the sea. The plant, however, grows as a thick forest only a few kilometers away where the effects of pollution are reduced to the extent of acceptability to its internal system. The mangroves enjoy a luxuriant growth due to the availability of nitrogen, phosphates and organic nutrients as well as freshwater which is their major requirement for survival.

THE PRESENT STATUS OF THE KARACHI COASTAL AREA AND HARBOUR

The total quantity of dissolved solids discharged into the sea was estimated in 1974 to be 262000 tons annually of which 50% passed through the Lyari while the rest was discharged through the Malir and other channels. The pollutants from the Korangi area tanneries alone have now been estimated to be more than 131000 tons per year (Meynell and Tharwani, 1992). However, since a substantial quantity of wastewater is being intercepted by the vegetable growers, it is quite likely that the pollution load is not very heavy and is perhaps of the same order as estimated earlier.

The contribution of sewage has increased during recent years. The estimated discharge of 216 MGD includes industrial effluents. This large quantity of sewage is generated by using not only the 350 MGD freshwater supplied to the city but also from wells and bore holes. The total BOD load carried by the wastewater reaching the marine environment has been estimated as 1.368 million tonnes each year, that is, quite high by all standards and calls for immediate attention to remedy the situation.

THE BALOCHISTAN COAST

The coastline of Balochistan stretches from the Cape Monze or Ras Muari at the Hab estuary to a little short of Ras Fastah on the Gwatar Bay where the Dasht River enters the sea and the Gwatar River from Iran also falls. This coast, more generally known as the Mekran coast is 550 km in length and is either rocky or sandy in nature. The entire coastline is sparsely populated mainly because of the lack of availability of freshwater.

No perennial river falls on the coastline. The Dasht has a large catchment area but its volume is low since it passes largely through an arid zone. The Hingol River basin constitutes the largest drainage system in Balochistan. The river is 664 km in length and has 65000 sq Km of catchment area which is larger than the other river valleys of Balochistan, viz. Porali, Dasht, and Kuddan (Mekran) (Ahmed, 1979a).

The valleys of Nal, Jhal Jhao and Sorab on the Hingol in southern Balochistan are being developed into mini-industrial estates. Agricultural wastes and some industrial wastes from the small cottage based industrial units are contributing, though very little, to the pollution of water.

The ports of Jiwani on the east of Gvatar Bay, Pishukun on the Gwadar West Bay, Gwadar on the Gwadar East Bay, Pasni at Ras Jaddi, Ormara at Ras Ormara, and Sonmiani and Gadani in the Sonmiani Bay are major fishing ports.

Gwadar, is the most populated among all the ports of Balochistan. Located close to the strategic Hormuz Bay, it is serving only as a fish harbour. The port is spread over 30 hectares. Its facilities include a 416 m long and 65 m wide jetty that can accommodate up to three vessels of 1000 dead weight (DWT). It has an approach channel that is 1.6 km long, 60 m wide and 3.5 m deep. Its jetty and mooring facilities can accommodate 500 fishing boats and gillnetters. This does not suggest a large pollution load from the port activities specially since the water and power supplies are limited. This excludes the fisheries sector. It is quite likely that the pollution load from the fisheries sector is substantial since the exportable catch from a small fleet of 500 boats is only 50% of the total.

Gadani has a well established ship-breaking industry, ranking the third largest in the world. It has become a source of metal wastes, and oily discharges. Some hazardous wastes have been dumped here, although this has not been adequately quantified.

In summary, the Balochistan coast, does not contribute much land based-pollution to the coastal environment.

CONCLUSION

The delta area in the coastal region has become very vulnerable to development oriented environment degradation, that has resulted in reduced flow of water below Kotri. Industrial discharges into the river streams from almost all over the country, amount to over 13 million tons per year. They flow into the farm land along with irrigation water, but at least one third of this amount flows into the coastal area with the flood waters.

The waterflow from the delta itself into the creeks is limited but there is considerable dilution of the seawater by the flow from irrigation channels. This process has created swampy condition in the creek area at Guno in the Gharo Creek. Similar conditions are prevalent elsewhere. Freshwater also keeps flowing from the Indus delta. It is strongly suggested that the reduction in the flow of freshwater is not the major cause for the reduction of the mangroves. The loss of mangrove forests is mainly due to the loss of the silt load since it is being diverted into canals. The loss of silt has given rise to an erosion process in the mudflats in the delta region.

The disturbance in the ecological balance in the mangrove forest environment has been aggravated by allowing camels to browse on the mangroves and by the indiscriminate removal of mangrove trees. Similarly it is the overharvesting of the fisheries resources and not reduced availability of water that has depleted the river of some valuable fish (*viz.* Palla and Baramundi), that were available from the delta area. Construction of a dam for the storage of flood water is likely to be adopted as a mitigation measures for making freshwater available for irrigation as well as for sustaining the fisheries resources in the coastal area.

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(Received: 8 February 1995)