IMPACT OF TWO SEMI-ENCLOSED SEAS ON NEIGHBORING SEA

The Arabian Sea is open to two semi-enclosed seas; the Red Sea and the Persian Gulf. The characteristics of the water masses of these seas are (Tchernia 1980):

Red Sea water:	T= 21.6 C, S= 40.6, $_t$ = 28.6, O_2 = 2-3 ml/l
Persian Gulf :	T= 20.5 C, S= 37.5, $_t$ = 26.6, O_2 = 2-3 ml/l

The Red Sea and Persian Gulf influence the circulation of the Arabian by transforming light surface waters into denser waters which flow out and sink at depth. The salinity of these waters in the Arabian Sea is nearly alike (37.5ppt) but the temperatures are different (Red Sea 18^0C, Persian Gulf 20.5^0C) and owing to this they find their density equilibriums at different levels; the Red Sea water near 700-800 m and the Persian Gulf water around 250-300 m. Both these water masses are rich in organic matter, increases the stratification because of their high salinities, and also help in depletion of oxygen (Salter and Kroopnick, 1984). The spreading of Persian Gulf water in the Indian Ocean is well known (Meera Pathmarjah, 1982) and extends to the bay of Bengal and Eastern Indian Ocean. Typical vertical profiles in the northern and southern Arabian Sea clearly indicate the salinity maxima due to Persian Gulf and Red Sea waters. The oxygen minima in the Arabian Sea also appear to be influenced by the Red Sea and Persian Gulf water masses.

The causes of the oxygen minimum in the Arabian Sea include: (a) the high productivity creating large oxygen demand on the water column; (b) strong stratification in the upper 200m which reduces the exchange of oxygen between the atmosphere and subsurface layers; (c) the seasonal reversal of the intermediate depth currents which lack trans-equatorial water transport to get.

OCEANOGRAPHIC CONDITIONS.

The oceanographic conditions in the northern Arabian Sea vary with the season. The euphotic zone of the northern Arabian Sea Ranges from 20 to 60 m. with an average depth of about 40 m. Surface temperatures range from 22.5^0 increasing from north to south. At 1,000 m the temperature is about 15^0C lower than at the surface. Maximum difference in temperature is found during the south- west monsoon. Salinity also decreases from north to south. High salinity in the northern region is probably due to the excess of evaporation over precipitation and to high salinity water coming from the Person Gulf. There is little seasonal effect on the salinity but there are large differences in the dissolved oxygen at the surface during the south-west monsoon. There are two oxygen minima, the first between 100 and 400 m and the second between 800 and 1,500 m. The formation of the first oxygen minimum is probably due to high organic production in the euphotic zone, sinking of a large amount of organic matter, the lack of horizontal advection due to the landlocked nature of the sea, and the presence of high salinity water in the upper layers. High oxygen at intermediate depths and the second oxygen minimum in the range 900 to 1,500 m probably occurs as a result of physical processes peculiar to this part of the Arabian Sea. The flow pattern consists of several eddies and meanders. Inorganic phosphorus is high in the surface layer and still higher at greater depths. Nitrate-nitrogen is low at the surface and increases with depth.

UPWELLING AND NUTRIENT REGENERATION

The thermal structure of the Arabian Sea is influenced by the south-west monsoon. In case of SST (sea surface temperature) the monsoon intensity appears to have reasonably good correlation. SST and temperatures depths are affected from the upwelling along the Somali and Arabian Coast and circulation of up welled water. Outflow and mixing of Red Sea and Persian Gulf water, intensive evaporation and cooling of the sea surface and mixing with deeper cool water result in the deepening of the mixed layer. The deepening of mixed layer of about 120 m at the peak of the south-west monsoon is well known. The nutrient concentrations in the salinity maximum underlying the mixed layer in some areas are quite low (below 1 microgram atom per liter (ug-at l^{-1}) nitrate in much of the Central Arabian Sea) and in some areas they are very high(above 10 ug-at / l nitrate, off Saudi Arabia and towards Karachi-Banse 1982).The seasonal salinity maximum at top of important source of nutrients to the mixed layer during the seasonal vertical convection. Thus there are high rates of primary production in the open sea from appreciable injection of nutrients into the mixed layer. Depth of 20^0C isotherm which is almost in the middle of the permanent thermo cline deepens to 180 meters. The deepening of 200C isotherms has also a reasonable correlation with the intensity of the South-west monsoon.

THE PAKISTAN COAST

The Pakistan coast can be divided into two main groups, namely Sindh and Baluchistan Coasts. The coasts have different climatic conditions, geographical location and socioeconomic factors. The Sindh coast can be further divided into two parts, namely the Indus deltaic coast and the Karachi coast, and, and the Baluchistan coast can be divided into Lasbela coast and the Makran coast. The coast in the vicinity of Karachi, about a 50- mile stretch, is redeveloped as compared to the rest of Pakistan coast, obviously the location of a big city such as Karachi, the availability of road rail links freshwater, and utility services are the main reasons.

HYDROMETEOROLOGY

(Temperature and salinity)

The average monthly temperatures of seawater for three different coastal areas (i.e. of Indus Delta, off Karachi and off Makran coasts) temperatures have range between 23.7^0C for the Indus Delta 23.5^0C and 29.1^0 C for off Karachi and 23.5^0C and 29.3^0C off Makran coast. The temperatures at a 100 meter depth are lower and generally have an annual range between 19.5^0C and 24.5^0C.the monthly distribution of average air and sea temperatures for the Indus Delta, Karachi coastal waters and Gawadar coastal waters is given in **table 1b**. The surface seawater salinities at Indus Delta, Karachi and Gawadar coastal waters are presented in the **table 1c**.the seawater surface salinities along the Pakistan coast have an annual range of between 36.02 to 36.74 ppt.

There is an acute shortage of water on the Baluchistan Coast. The local population depends on sweet from shallow wells, 10 to 15 feet deep dug in the foothills and at one or two places in the sand- dunes. During draught years, water in the wells turns brackish, casing much human suffering. During the dry season there is hardly any surface flow in the rivers. The availability of water in the river bed may well be attributed to stagnant water of seepage flow. The later could not be very large as the permeability of the river beds, which consists of the beds of silt, silty clay, fine sand and clay, is very low.

The major rivers which drain of the Baluchistan coast have reasonably large encashment areas. The average annual rainfall in the catchments area is not more then 7" with frequent draught years. Advantage of the occasional floods cannot be taken unless proper storage dams are built across the rivers. Sweet water potential, source and storage sites for the major rivers are given in Freshwater sources are dealt in detail in chapter 6.

THE STATE OF COASTAL ENVIRONMENT IN PAKISTAN

The cost of Pakistan, which borders the Arabian Sea in its north, extends for about 1000 km the border of Iran in the west to the border of India in the southeast. It is a subtropical coast where evaporation exceeds precipitation. The climate of the country and the hydrography of the Arabian sea is dominated by reversing monsoon winds, which blow more forcefully during the summer season (from the SW) than in the winter (from the NE).The surface currents also adopt a reversing pattern according to monsoon winds, flowing clockwise for the greater part of the year (summer season) and counter clockwise during the rest. The continental shelf for the country is wider (70-120 km) narrower and steeper in Baluchistan (16-42 km). The country has a territorial area of 23, 82 km2 and an EEZ area of 196,600 km2. The entire coastline of Pakistan is a very high energy coastline, with waves pounding the open coast beaches relentlessly year round, more in summer than in winter. This high wave energy results from the strong SW monsoon winds which blow almost diagonally to the coast for the greater part of the year Pakistan's Indus River delta is believed to receive more wave energy in one day than the Mississippi River of USA receives in one year. This high wave energy erodes the coastline and the deltaic beaches and suspends the resulting sediments in the water column. Sediments are thus being suspended in the water column constantly due to the erosion of the beaches. Had there been sediments coming through the Indus River These would have replenished the lost sediments from the beaches halting erosion and increasing the building of the beaches.

The presence of excessive quantities of sand the water column affects the biological cycle on the coast of Pakistan. It affects the production for phytoplankton (which serve as food for small marine organisms and some fish species), zooplankton, and fishes, affection the fish landings. This excessively high turbidity does not permit the formation of coral reefs and pearl oysters. Coral reefs are present in Persian Gulf, East coast of Africa and Gulf of Kutch (south of Pakistan, in India). Sediments in sea water have been considered the greatest of pollutants and Pakistani waters have them in abundance. Sediments also make waters murky and inestimable, and thus make beaches unattractive to tourists.

The man-made blocking of the Indus River flow to the sea (to boost agricultural output) for about ten months of the year deprives the Indus estuary and the delta of its normal supply of fresh water and sediments. Salinities in the sea are high, and they increase further in the Indus delta creeks during the period when the Indus discharge reaming blocked. The manmade stress to the Pakistani environment has resulted in the abandoning of red-rice cultivation in the delta. It strikes at the landing of estuarine fish species (for example Hilsa Tenualosa), and of the golden resources of shrimps, as well as reduces, in general, species diversity along Pakistan coast .The great reduction of the fresh water discharge of the Indus further striker at the mangroves and thus production of nutrients, which serve as food for the fish and shrimp population.

It is only the Greater Karachi region which experiences the urbanization phenomenon (and shows signs of anthropogenic eutrophication on the beaches of the tidal creeks) and industrial expansion. It is the Karachi area where exists, several power plants, a steel mill, the beaches of the tidal creeks and open coast of the Greater Karachi region which face maximum pollution loads anywhere in Pakistan.

In this it is then the Karachi Harbor which happens to be them most polluted area along the coast of Pakistan Port Muhammad Bin Qasim, although commissioned only about a decade or so ago, is fast pollution through it may not catch up with Karachi Harbour soon. The tidal creaks near Karachi may be placed on third position with regard to their pollution status, while Gadani beach along Baluchistan coast may be relegated to the fourth position. The rest of the coastal belt of Pakistan is lightly polluted or not at all. Areas like Gawader, Pasni and Ormara, where some industrial activity has been initiated recently in the form of is harbor construction .Would be next in line for pollution categorization.

Pakistan’s EEZ touches the oil-tanker routes from the Persian Gulf the Far East and may have oil slick and tar-ball pollution. The Pakistan EEZ is, however, not included in the high risk seas as far as oil spills are concerned. The nearness to the Persian Gulf does increase the possibility of tar- ball pollution on Pakistan coast, but such pollutants cause little damage compared to the oil spills which can decimate mangrove stands.

It is to be pointed out that although pollution is mounting considerable in the Greater Karachi area, steps for its mitigation are non-existent. The country is not prepared even to fight oil spills along its coast. After the recent inauguration of the OP-5 oil terminal in Karachi Harbour, the oil pollution load of the harbor has already started increasing.

There are three major areas in Karachi which contribute to land based pollution: (i) Manora Channel, located on the estuary of the Lyari river, serves as the main harbor and has waste areas forming western and eastern backwaters characterized by mud flats and mangroves, (ii) Gizri Creek which receives industrial and municipal effluents from the Malir river as well as several industries and power station, and (iii) the coastline between the Manora Channel and Gizri Creek where the untreated municipal effluents are discharged by the southern districts.

In has been established by the researches that it is the effluents from Lyari and Malir rivers which are largely responsible for the degradation of the marine environment. Luari discharges the highly contaminated mixture of sewage from the south and east of Karachi and industrial effluents from Korangi and Landhi Industrial Areas.

The coastline of Karachi is suggested to receive water-borne pollution at the rate of 375 gm BOD per capita per day. This includes a 12% share of the wastes from domestic sewage and 84% share of industrial wastes from industrial areas of Karachi. The population of Karachi is estimated to be 14 million. Accordingly the BOD load discharged into the marine environment of Karachi is approximately 5250 tones per day or 1.916 million tones each year. These effluents contain the high toxic wastes from the industries as well as municipalities and could be minimized if adequate treatment facilities are available with the industries.

Analysis of the sea water at the Manora nad Sandspit beaches, carried out suggested that the faecal contamination from the indiscriminate discharge of municipal effluents into and ultimately by the Lyari had reached recreation spots. The quality of wastes flowing through the various streams into the open Beaches of Karachi, stretching from Keamari, Chainna Creek to Clifton and Gizri, had not been estimated at the time, Judging from the recent analyses, mentioned earlier, it is possible to say the they comprise strong sewage mixed with oils and greases from automobile workshop, and wastes discharged by small industries located in residential areas. They have spoiled the recreational value of these beaches to the extent the institutionalization of water sports which was likely to be introduced at China Creeks has to be give
n a grinding half.

The natural China Creek, located at the entrance to the harbor on the Manora Channel, Passes under the Native Jetty Bridge and covers and area of 5 to 6 km. There is an island in the middle which has some mangrove trees still left on it. The rest of them have been removed by the fuel wood hunters in the Katchi Abadi. The sewage discharged by the city through their network and the chemicals coming along with it have caused an irreversible damage to the mangrove system. Gone are the days when it used to be the habitat some of the birds which use this region as their fly-way during their migration seeking warmth. The creek has now become dirty, stinky and unhealthy with filth floating when the tide is receding and oil film shining when it is swelling. There are two channels which carry raw sewage to the China Creek and are degrading the marine environment of the creed and the seaport. The two of them together have the capacity to transport over 1100 cusses of effluent. They are however, open drains at quite a few important locations.

The discharge of waste-water in both the channels is not the least environment friendly. They serve the open drain system to carry the sewage of the old city and the industrial effluents discharged by small / cottage industri9es e.g. the mechanical and auto workshops, dyeing, weaving and garment manufacturing units, much cattle wastes and waste from hospitals in the neighborhood. The two steams have no self-regeneration capacity since the pollution load is heavy and they carry nothing but a concentrate of pollutants. The China Creek has become highly polluted due to the indiscriminate discharge of untreated waste which may be highly hazardous and biologically active.

The Total BOD load carried by the wastewater reaching the marine environment is, accordingly to the above estimates 1.916 million tones each ear which is quit high by all standards. This calls for immediate remedial action besides emphasizing on the necessity to reduce the waste and recycle the wastewater.

The management of water resources, particularly the aspects related to the diversion through the barrages, laying of the network of canals and making the water available on a perennials basis, has run into unforeseen problems which cropped up many years after the projects went into operation. The diversion has (a) partially reduced the water flow downstream Kotri, (b) has substantially reduce the silt load of the river water flowing towards the coast to the bare subsistence of the natural habitat including the mangroves. (c) Given rise to the erosive action of the sea to dominate over sedimentation, (d) given rise to excessive use of water causing water logging and salinity of the soil and facilitating its losses due to evaporation because of increases in the surface area, and (e) caused seepage from canals and distributaries which are mostly unlined.

REMARKS

In view of this uncontrolled discharge of pollutants in the coastal zone from developing countries into seas is further degrading the sea water quality. Resultantly all efforts which are making to improve the sea would be useless till application of team work with neighboring countries located along the enclosed seas.

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