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Ecosystem Approach and Hydrological Potential Study of Port Qasim Industrial Coastal Zone of Karachi Pakistan

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Abstract
Extensive excavations for groundwater and rainfall diminish during past decades have disturbed water balance of Sindh Est extending over area between Indus and Kirthar Range towards west from District Dadu to the Coastal Zone and Indus Delta in the south. Groundwater exploitation without is determining hydrological potential of the region. This has increased the risk of seawater intrusion and of seismic events in the coastal areas.Groundwater depletion has been caused by the loss of infiltration capacity of surface soil due to sealing of top soil resulting from construction activities in urban areas and to salinization of soil in the canal command rural areas; both processes being responsible for reducing the capacity to recharge the groundwater aquifers. Excavation of silt, sand and gravel from bed of river and natural channels for construction activities in the urban areas of western Sindh has reduced the absorption capacity. Environmental Profile has discussed. Surface water, groundwater and wastewater, waste stream being discharged into the river and seawater along the coast has been determined with respect to several physical, chemical and biological parameters. For environmental hazards protection and handling of oil and molasses, PQA has adopted Environmental Management Plan. That was capable to avoid certain type of eco-disasters. Manage all environmental disasters and also including oil spill at KE Bin Qasim and PSO pumping station.
Keywords: Groundwater, sea water intrusion, salinization of soil, environmental hazards, environmental management plan

1. Introduction

Port Qasim Authority (PQA) has 4,900 hectare of land above high water mark for the purpose of industries and commercial establishments, 1080 ha in the north-western zone, 400 ha in the south-western and 3,420 ha in the eastern zone. Additionally it has 64,000 ha of forest area under mangroves. About 1,200 ha land was allotted for national and international industrial enterprises. Different agencies like KESC, Sui Southern Gas Company and Pakistan Telecommunication Limited have provided the corresponding infrastructure facilities to different entrepreneurs **[1]**.

Extensive excavation of groundwater by the industries and diminishing rainfall during the past decades have disturbed the water balance of Sindh West extending over the area between Indus and Kirthar Range in e east and from District Dadu to the Coastal Zone and the Indus Delta in the south. Industries, industrial estates, irrigation as well as tourism activities and municipalities have over-exploited the groundwater sources without confirming the hydrological potential of the region. This has increased the risk of seawater intrusion and of seismic events in the coastal areas.Depletion of groundwater potential has been caused by:

- Loss of infiltration capacity of the surface soil due to sealing of top soil resulting from construction activities in urban areas, and salinization of soil in the canal command areas; both processes being responsible for reducing the capacity to recharge the groundwater potential in the urban and rural areas respectively, and
- Excavation and transportation of silt, sand, and gravel from the river beds for construction activities in the urban areas of Sindh East have reduced the absorption capacity of the riverbeds thereby causing flash floods.

Diversion of Indus River water into irrigation canals and channels has on the one hand dried up the Indus Delta and on the other hand has waterlogged and salinized the land in the terminal zones of the irrigation system in the coastal areas of District Thatta in Sindh West. Furthermore, the creek channels are no longer hypersaline as is being maintained by several reports by concerned agencies. Contrarily the creek channels are hyposaline. Hypotheses just stated are being tested by applying the ecosystem approach comprising study of hydrologic processes and their interactions within the watersheds of the dry tributaries to the Indus in Dadu and

Thatta districts; the Hub, Lyari and Malir rivers in Karachi district; and the deltaic creeks into which the irrigation drainage effluents are being discharged. Ecosystem approach has taken into account the rainfall events, aggregate flow of water from the watersheds of the wadis and tributaries during, prior to and after the monsoons and the volumes estimated at the estuarine areas and confluence. Eosystem approach acknowledges that water availability in the ecosystem depends on the surface and groundwater resources just as much as on its components including interdependent interactions among topography, climate, geology, vegetation on the one hand and human modifications of these elements of the environment, comprising land use, water use, wastewater and saline effluent discharges on the other hand. Environmental audit has accordingly been adopted as the methodology for assessment of damages done to project induced modification of the environment and evaluation of current status of the concerned ecosystem. Hhypotheses stated above are being tested by environmental audit of performance of development projects including the irrigation and drainage system; industries, water supply and wastewater drainage system in Sindh West. For this purpose environmental profile of different ecosystems have been prepared and described hereunder.

PQA provides an alternative port facility to Karachi Port Trust, with the main landward navigational channel into Port Qasim/Phitti Creek passing through Ahsan Channel. The depth is maintained 12.4 m. Width of the channel from 400 m to 180 m. 180 m wide inner channel of Phitti Creek from Zulfiquar Bank to Hasan Point and of Kadiro Creek from Hasan Point to the Iron Ore and Coal Berth is maintained to a depth of 11.3 m. 11 to 13 m depth allows operation of vessels of up to 80,000 metric tons. Gharo Creek is maintained to a depth of 10m from the Iron Ore and Coal Berth to the Marginal Wharf, which allows vessels of up to 65,000 tons **[1]**.

The major land use of the area includes the establishment of four environmentally sensitive units Pakistan Steel Mills, KESC thermal power plant, Fauji Oil Terminal and Distribution Company. FOTCO Jetty located approximately 2 to 3 km on the west of the two units and the Industrial zone. Water outfall from Pak Steel Mill enters a tributary of Bakran Creek on the north of FOTCO Jetty. This comprises a channel that discharges seawater used as coolant whose temperature is over 10^{o}C higher than the ambient temperature **[1].**

2. Topography and Local Geography

There is no significant depression or elevated area and the terrain is more or less plane or flatland sloping towards the seashore. The elevation of land in this system is only a few metres above mean sea level. The land has been developed and its ground level has been raised by moving earth from a sand bar towards the area interfacing the seacreek. The Ghaggar Nallah delta has been impacted by the variations in the sea level and to a certain extent by the tidal effect of the sea **[1] [2]**.

The Chowdhry Creek is located between Ghaggar Nala and Ziarat Hassan Shah Island. The tidal prism of this creek has been cut down by the construction of causeway, which connects Ziarat Hassan Shah Island with the main land. There is very little water in the Chowdry Creek during low tides, particularly the extreme lows in the spring tides. The channel nevertheless is well defined throughout its length from the causeway to its south eastern end where it flows back into the Gharo Creek along the eastern margin of Ziarat Hassan Shah Island **[2]**.

3. Geology

Geological information of Port Qasim and its adjoining areas formed in the middle and upper Tertiary. Soil formations are fresh and slightly weathered with recent and sub recent shoreline deposits. These formations are derived from Gaj Manchhar formation of lower Miocene to middle Miocene and middle Miocene to Pliocene age. Similar deposits are found all along the coastal belt of Karachi and adjoining areas.

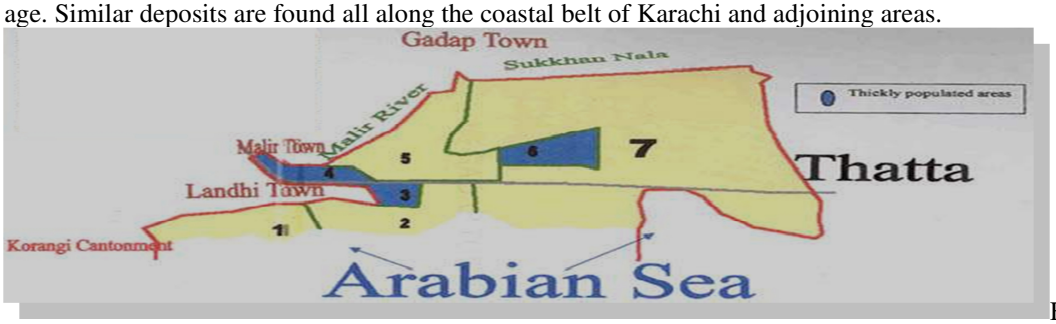

Figure 1: Map of Port Qasim Area

Gaj formation consists mostly of limestone with subordinate shale and sandstones. Limestone is hard, sandy and extremely fossiliferous. Overlies Nari formation which consists of harder limestone bed and shale. Overlying Gaj formation is Manchhar formation, which is composed of sandstones clay beds, cemented sand and gravel and shale concrete. Clays are of different colours such as grey, brown, chocolate and orange, widely occurring clays are light brown (khaki) and dark grey in colour. Clay is green and brown in shade.Similar Manchhar formations exist all along the coastal areas of Karachi. These are best exposed in Clifton, Ibrahim

Hyderi, Gizri, Korangi and Landhi areas in the coastal area to the south of this Far East zone **[3]**.

4. Environmental Profile

Far Eastern Zone that has large as well as small industrial units scattered over an otherwise largely barren land of Union Council #7 Ghaghar with very few human settlements and Union Council #6 Gulshane Hadeed, which houses the residential units of Pakistan Steel Mills employees. Union Council #7 Ghaghar now houses Pakistan Steel Mills and Port Qasim.

East zone are Port Qasim Authority (PQA) and Pakistan Steel Mills, PSM both established in 1973. PQA has during the course of time provided specialized port facilities for the exclusive use of PSM for bulk handling of imports of iron ore, coal and manganese ore at its premises, and provided environmental relief to the city of Karachi from congestion on road and atmospheric pollution caused by port traffic. Additionally it has provided land for location of such industries and commercial establishments whose imports/exports pass through the Port and generate cargo for it **[4][5][6]**.

Port Qasim includes units:

- Specialized berth designed to cater for vessels of 75,000 metric tons. Present handling capacity is for vessels 60,000 metric tons due to channel depths. This was constructed for bulk handling of iron ore and coal for Pakistan Steel Mills but is also catering coal for the cement industry and handles 70,000 dwt class vessels,
- Multipurpose Marginal Wharf area divided into seven berths of linear length 800 metre, to take vessels up to 45,000 dwt,
- 45 km of navigable channel for vessels of up to 85,000 dwt class,
- Procurement of dredger to undertake annual maintenance dredging work of the navigation channel (Planned),
- Liquid chemical terminal to operate in the private sector,
- Oil Terminal offering state-of-art port facilities to tankers up to 80,000 dwt,
- Two covered transit sheds each having an area of 10,000 sq. metres,
- Night Navigational facilities introduced initially to smaller ships to be further extendable to larger size vessels,
- Dedicated two berths container terminal catering for berthing facilities to 50,000 dwt class container vessel,
- Full range of floating craft and cargo handling equipment,
- Two Term Storage Areas with storage capacity of 118,000 sq. meters each,
- Access road to National Highway and connection to rail network,
- Infrastructure facilities and utilities are available,
- 12,000 acres of land above high water mark in the western and eastern zones for industrial development.

Fauji Oil Terminal & Distribution Company Limited, FOTCO development projects at FOTCO include an oil terminal berth, oil pipelines to the Buffer Oil Tank Farm and ancillary facilities including a fire-protection system. About 70 ha land of FOTCO Jetty is for storage of molasses. Several companies under the control of Pakistan Molasses operate in this area. Other major land uses include establishments such as FOTCO offices, PQA administration and operation units, some railway offices and the goths or villages. These establishments and settlements are located at a distance of 2 to 8 km from FOTCO Jetty.

FOTCO has the largest oil handling facility in Pakistan. It has been built in accordance with the highest international standards and capable of handling 9 million tons of oil per annum with a growth potential of more than 27 million tons. The berth is located on the North side of Kadiro Creek. There are three oil piers at Port Qasim, i) Marginal Wharf-1; ii) Oil pier belonging to FOTCO and iii) belonging to Engro Pak Tank Limited, EPTL-13. Berthing is carried out on first come first served basis. All berthing and sailing operations are carried out during daylight since there is no night navigation.

FOTCO terminal has been designed to meet the current and future petroleum handling requirements of the country. The terminal is equipped to cater for three additional berths and the following five additional product pipelines:

I. One 36”(900 mm) HFO or Crude Oil Pipeline,
II. One 30”(750 mm) HSD Pipeline,
III. One 24”(600 mm) Kerosene or HSD Pipeline,
IV. One12”(300 mm) Edible Oil Pipeline,
V. One 8”(200 mm) Liquid Chemical or LPG Pipeline.

Port Qasim International Container Terminal (PQICT) occupies berths 5, 6, and 7 and covers a total area of

240,000 m^2. Maximum holding capacity is 8,000 etu. It serves a fast growing industrial area having ICI-Dupont, EPZ, PSM, Toyota, Suzuki and Honda Motors, ETPL and FOTCO Terminal. The Terminal has been operational since August 1977. **Oil Terminal Comprises** mainly an all weather jetty capable of berthing ships of 25,000 to 75,000 DWT, a four km long trestle and two marine loading arms of 16" diameter. Trestle, which is designed to accommodate six product pipelines, allows vehicular access to the berth through a 3.5 meter wide road suitable for 12 tons axle load trucks. Only one pipeline has presently been laid for carrying HFO but Plans are underway for laying additional pipelines.

5. Environmental Management Plan

PQA has adopted its Environmental Management Plan in view of the environmental hazards inherent in the handling of oil and molasses. It has been able to avoid what could have been certain eco-disasters. Such facilities and contingency plans are, according to information available, an integral part of the facilities at the oil terminal. FOTCO has facilities to deal with environmental accidents and it was able to do so with two of them involving oil spills at KESC Bin Qasim and PSO pumping station in the Port Qasim area within a period of three weeks towards the end of year1999. It adopted the contingency measures to deal with the oil spill on December 15, 1999, which was caused by accidental opening of a gate valve at PSO pumping station outside FOTCO limits and did not involve FOTCO pipeline.

Contingency measures were immediately taken to divert the flow away from the sea by erecting earthen dykes and deploying heavy duty loaders and tractors to create reinforced bunds to contain the flow. 50 inch diameter hole in the PSO station boundary wall was plugged to stop further flow.

6. Ecosystem and important modifiers of the environment at PSM:

Pakistan Steel Mill (PSM*)* has been massive land use change at the site where PSM is presently located. Its huge complex and related facilities are spread over an area of 18,600 acres, or about Pakistan 75 km^2 as well as employment of over 40,000 workers daily during the peak construction period. Changes in the ecosystem started with the construction of the complex involving the use of 1.29 million m^3 of concrete, movement of 330,000 metric tons of machinery, steel structure and electrical equipment provide by Government of USSR and techno-financial assistance for construction of a coastal based integrated steel complex.

Ecosystem started with commissioning of coke oven battery and blast furnace in 1981, followed by the billet mill, two converters, one bloom caster, two slab casters of steel making department 1982- 1983, hot strip mill in 1983, second blast furnace in 1984, cold rolling mill in 1984, second coke oven battery in 1985 and the expansion project billet caster in 1989. Unloader & conveyor were constructed by Port Bin Qasim Authority exclusively for PSM. Entire raw material is transported for main plant through 4.3 kilometers long conveyor belt within half an hour. This unit contributes at least 50 tons of fugitive emissions into the ambient air every day. Very useful by-products like coke oven gas, ammonium sulphate, coal-tar etc. are being obtained besides coke which is consumed not only by the Steel Mills but also other units like soda ash production. Coke oven gas is being consumed in the Thermal Power Plant and Turbo Blower station to generate electricity for PSM. This unit generates considerable quantities of waste products like phenols, sulphides, oils and greases. PSM is equipped with a facility to treat the wastewater containing phenols. Performance of this unit has at times failed and has resulted in fish kill [1].

This unit, with a rated capacity of 970,000 tons is responsible for the emission of 2,425 tons of particulate matter, 2,813 tons of SO_2, 2,910 tons of hydrocarbons, 873 tons of CO and 191 tons of phenols. Iron *Making Plant* has two blast furnaces and each having a capacity of 1750 metric tons of molten iron per day. Blast furnaces also produce 250,000 metric tons of slag which use in production of slag cement, blocks and wool. Rated capacity of 1.23 million tons of molten metal responsible has generation of 19,544 tons of suspended solids per year.

Steel *Making Departmen*t has two converters and each having a capacity of 130 metric tons of steel. Steel for billets is melted in basic oxygen converter using high grade pig iron and latest techniques of oxygen blowing, to give high quality clean steel free from harmful elements. Billet Caster have 400,000 tons/year capacity Billet Caster set up in association with an Austrian firm has enhanced the production capacity of billets from 260,000 tons/ year to 660,000 tons/year. Share of billets of PSM has also increased in the overall domestic market and imbalance in its product mix has been reduced to a great extent... It has a designed capacity of 445,000 metric tons. Cold Rolling Mill has capacity of 200,000 tons out of which 100,000 tons is converted into galvanized sheets, 10,000 tons into cold formed sections leaving a balance of 90,000 tons. Cold rolled sheets are also utilized for production of galvanized sheets and black plates/tinplates. Thermal Power *Plant* has three turbo-generators and each having a capacity of 55 MW and four boilers. Gases produced by coke oven battery and blast furnaces, as well as coal-tar obtained from Coke Oven & By-Product Plant are used as fuel in Thermal Power Plant to minimize the use of natural gas and also to reduce the discharge of gaseous emissions into the air. This thermal power plant uses 350 m^3 seawater annually or about 225 MGD for industrial cooling. Temperature

difference between outfall and intake is 7°C to 8°C. Tonnage Oxygen *Plant* comprises two independent air separation units for the production of gaseous and liquid Oxygen and Nitrogen. Each unit is designed to produce 250 metric tons of Oxygen and 135 metric tons of Nitrogen /day. Designed production capacity of liquid Oxygen of the two units is 967 liters/hour/ unit while the cylinder filling capacity 100 metric tons/day each of Oxygen and Nitrogen.

7. Waste Teatment Facilities

Gulshan-e-Hadeed is a large residential area for the employees of PSM has a population of over 67,000. The area has its own sewage treatment plant. The treated wastewater is being recycled for horticultural purposes.Storage Depots for Rice Export Corporation of Pakistan (RECP) is close to the PSM. **The** environmental impact of this unit is in terms of air pollution caused by the emissions from large trucks and trailers and by the fugitive emissions due to unloading of the bags for storage and loading them for export [7]. FFC-Jordan Fertilizer Co. (FJFC) has manufacturing capacity is 0.445m metric tons Diammonium Phosphate, DAP and 0.551m metric tons urea and import of 0.4m metric tons phosphoric acid/ annum. Factory has installed units that cater to pollution control and waste minimization. According to information the performance of pollution control equipment is satisfactory. Pure Terephthalic Acid (PTA) plant set up by ICI Pakistan is spread over an area of 150 acres with annual capacity of 0.43m tons PPTA started commercial production in 1998. PTA is used for production of polyester fibre, PSF and PET bottles. Main raw materials for the manufacture of PTA are Paraxylene and Acetic Acid. Treatment facilities were provided to handle the industrial effluent from a new 400,000 ton-equivalent/annum PTA Plant being constructed at PQ. Plant is designed to handle a maximum of 230 m^3/hr of raw effluent utilizing Deep Shaft technology.

8. Environmental Assessment

Samples of Water were collected from latitude-logitude coordinates; meteorological data and water quality parameters viz. temperature, electrical conductivity, total dissolved solids (TDS), dissolved oxygen (DO) were recorded using portable instruments [8]. During the surveys ionic and trace metal concentration analyzed of surface and groundwater along river basins and around the wells as well as boreholes, besides the soil through which storm water permeates and the variation of different ions and trace metal concentration noted with each rainfall during year and at suitable intervals to evaluate and utilize the infiltration capacity of stream channels for regulating and upgrading quality of groundwater resources [8].

Table-1: Analysis of Surace Water, Groundwater & Wastewater

Sr. #	Description		RESULTS				
		Limits	1*	2*	3*	4*	5*
1	pH Value		8.79	8.75	8.98	8.76	8.4
2	Chemical Oxygen Demand(COD)	*No GL	9.5	9.4	61.3	4.7	234
3	Total Suspended Solids (TSS)		1286	<0.2	35	14.6	240
4	Total Dissolved Solids (TDS)	<1000 mg/l	190	310	670	110	2756
5	Chloride (Cl^-)	250 mg/l	32	44	136	28	80
6	Ca Mg Hardness	500 mg/l	116	224	336	116	258
7	Nitrate (NO_3^-)	<50 mg/l	4	2	2	BDL	8.0
8	Coliforms Organism 100/ml	-ve	12	8	8.6	0 colony	18
9	*Eschrichia Coli* (E-coli)	-ve	+ ve	- ve	+ ve	-ve	+ ve
*1- Kolachi Canal. 2-Dhamra Handpump (Besides Canal). 3- Lang Lake. 4- Filterd Tap Water (Sehwan). 5- Wastewater Sehwen Bridge. *NoGL (no guid line) **[9] [10] [11] [12] [13]**							

The filtered water supplied from the filter plant is ideally suitable for drinking. Analysis of canal water indicates that it is suitable for construction purposes. The canal water is, however, very turbid and has large amount of suspended solids. This water will have to be subjected to sedimentation if it is to be used for the drinking purpose. During site visit in the months of March-April 2009 standing water was observed at many places along the alignment. The following table shows the impact of seepage of water from the extensive canal network in the area. The level is as observed at site during the month of March and April 2009 **[14] [15]**.

Table-2: Water Table

Chainage Km	Observation of Water Table at Sites	
	Water Logging (Standing Water)	Water Table
0 – 25	Rare	Above 4m
25 – 50	Rare	1 to 4 m
50 – 75	Ponding	0 to 1 m
75 – 100	Ponding Excessive	0 to 0.75 m

Evalution physical features noted from Bajara along the slopes of the Kirthar Range to Super Highway were as follows:

Table-3: Physical Features along Slopes of Kirthar Range to Super Highway

Chainage	Section/ Station	Feature	Distance from Bajara (km)
0.0	Bajara	Crossing Jhangara - Bajara link road, cultivation is found on both sides, SSGC lock valves are present here	0
0.0		Aral Wah + Bajara link road and Rind Village, 20 houses, 1,100 watts WAPDA's electric crossing, PARCO line crossing Aral Wah with Sui gas pipeline, cultivation on both sides of RoW	0
01		Village Omer Khan Rind, link road crossing	1
06		PARCO- Post, cultivation both sides, water course crossing, 2 tube wells near village Bajara taluka Sehwan, deh Wanicha	6
06		Aral Wah crossing, sandy soil, fine sand, lift irrigation, small water course crossing 1 meter wide	6
52		Nadi, erosion	52
55		Arid and eroded land	55
62		Pokhan Nadi	62
63		Sui gas station, spring	63
66		PARCO's rest house, small village	66
70		Barani cultivation	70
72		Baran river	72
72.2		Karchat SSGCL Valve Assembly	72.2
76		PARCO-activity, cultivation	76
77		Cultivation, well	77
81		Cultivation, Farm	81
83		Small village Tube well and a mosque.	83
		PARCO-Activity (Corrosion Protection), small village and a mosque.	
85		Aral Dhoro, a bore nearby about 200 ft., pulai a tree bearing pink flowers only on nadis.	85
92		Trangol Dhoro, 300 meters crossing	92
94		Sui gas station	94
98		PARCO microwave station No. 3	98
102		Dadu - barani cultivation, forest trees, vadies, tube wells, wells	102
105	Karchat-Sari Section	Isar Nadi, near Ali Murad Barijo Goth, level of water aquifer 400ft., dry river comes from Kirthar catchment area and flows into Malir river system,	105
106		Mahal Kohistan check post	106
112		Village Ishaq at B.V-12, valve assembly, sparse population, sandy soils, 7 houses, 30 animals.	112
116		PARCO activity Desert area	116
120		Sand	120
121		Stones, rocks	121
122		OGDC station, OGDC camp, crossing, small mosque, few houses, sparse cultivation	122
126	Sari-Khadeji Section	PARCO, Sari goth, link road crossing, OGDC-PPL gas fields, bikik goth, gully erosion, sandy soil, occasional barani cultivation, plateau	126
		Arid lands	
140		Start of barren area	140
142		Khameso Khaskheli, wheat cultivation, guava orchard, one village of 35 houses and 200 animals, tube well	142
150		Dhoro	150
153		Mol nadi, sand and gravel excavation, Villages: Haji Khuda Baksh, Thana Bola Khan, 3 HT electric lines.	153
156		Petrol Pump at edge of Super Highway	156
157	Khadeji Mixing Plant-Karachi Terminal Section	Khadeji/Sui gas camp, Kandi, Khor, Khabar, wild berries, devi, wheat cultivation, HT wires	157
160		Malir/Khadeji confluence, cultivation, Village Noon, Edhi Village, poultry farms, HT wires, rock outcrops, proposed trucking station	160
161		SHW, vegetables, bushes, Sui Gas metering station. Pipeline route avoids houses or built structures.	161

According to the International Waterlogging and Salinity Research Institute Report on water table in October 1998 the water table north and northeastward of Karachi varies from zero to 300 cm in an irregular manner **[14]**.

Table-4: Depth to groundwater table North and Northeastward of Karachi, October 1998

Distance from Karachi Terminal (km)	Water table depth (m)
0-50	0-90
50-125	90-150
125-325	150-300

A map prepared by the Hydrogeological Directorate of WAPDA shows that along the Super Highway and Highway N55 the quality is generally poor; ranging from 1000 mg/l to 3000 mg/l. Along certain stretches the concentration of dissolved solids is 1000 mg/l which is barely suitable for drinking and irrigation purposes.

Table-5: Groundwater Salinity Information

Distance from Karachi Terminal (km)	Dissolved solids (mg/l)
0-25	3,000-1,000
200-210	1,000-3,000
210-360	3,000

Groundwater quality along the Sper Highway and Indus Highway N55 has, according to information from SSGCL, and also obtained during the site visit, not been impacted by natural ground conditions and/or poor irrigation practices so as to cause ground water logging, evaporation of groundwater from the water table and a consequent rise in soil and shallow groundwater salinity [16]. Leakage from faulty sewerage systems has, however, been found as the RoW enters the suburban areas and that may be causing pollution of groundwater in the vicinity [15]. The entire study area is largely rural in character, and people are engaged in cultivation of cash crops such as vegetables, fruits and lucerne or bersem. Although use farm machinery was not noticed during the survey, it is quite likely that some mechanical equipment are in use in the fields near irrigation systems such as those near Bajara, where farmers are engaged in grain crop production.

Pakistan's largest national park, and the only one in Sindh. It forms the core of a complex of protected areas (the Park, Wildlife Sanctuaries and Game Reserves) totalling 447,161 ha. The Park includes a nearly intact arid land ecosystem [17]. It comes under the IUCN category- II of protected areas and is the first of Pakistan's four national parks to be included in the 1975 United Nations list of National Parks and Equivalent Reserves. It was found during the visit with Sindh Wildlife Department (SWD) Officials (arranged after the Public Hearing for the EIA on April 25, 2006) that the RoW does not sideline the KNP and MKWS. It was also reported by the locals that there is still some wildlife activity along the existing RoW of the pipelines. Most wildlife activity except *Chinkara* and nocturnal animals is reported to be in the core habitat of mountain ranges to the east and west of the pipeline route. No water reservoirs or water holes, except the Pokhan irrigation channel, are situated within 500 meters of the pipeline routes. Rural population in the study area lives in small settlements of about 10 to 40 households. A list of villages visited on the way during the survey is given in table.

Table-6: List of villages visited and numbers of households

Village	Approx. Household/persons
Hussain Bux Rind-2km from Bajara	20 houses
Achar Khan Rind	15 houses
Jan Mohammad Shahani	15 houses
Haji Qasim Barecho	10 houses
Rahim Dad Aqlani- 10 km from Karchat	10 houses
Piyaro Khaskheli-20 km from Karchat	05 houses
Istiaque Lalani- 35 km from Karchat	07 houses
Qadir Bux Lalani-60 km from Karchat	10 houses
Pandhi and Darya Khan-near Sari	NA
Goth Haji Khuda Bux	100 persons
Khamiso Khaskheli Goth	35 houses
Sari Goth	20 houses
Ali Murad Barijo Goth	NA
Village Berhmani	35 houses
Village Khuda abad	NA
Punho Khan Punhwar Village	01 Middle School
Gohar Shah	15 houses
Ghulam Rasool Bijarani Village	40 houses
Chak Bangla Dhanghan	35 houses
Village Mauza Singh	NA
Mohammad pur	NA

9. Conclusion

It has been drawn from analysis of surface water, groundwater and wastewater and it has been noted that the fresh water being used marginally meets the drinking water quality standards, while treatment of wastewater remains unattended. The surveys and analytical data do support the hypotheses.

Extensive mining of ground water has dried up the aquifer and it is barely recharged once in three years and extensive excavation of sand and gravel from the riverine areas has dried up the aquifer and the flash floods are taking their toll, while excavation of sand from the coastal area has destabilized the coastline at several places and during the past decades disturbed the water balance.

Over- exploited without confirming the hydrological potential of the region by Municipalities the groundwater sources has been depleted and increased the risk of seawater intrusion and of seismic events in the coastal areas.

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