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# Assessment of hydrographic and oceanographic studies of right bank outfall drain, Gharo Creek Indus Deltaic Region

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**Key words:** Tide, Suspended Solid, Salinity, Bathymetry, Dissolved Oxygen.

**Abstract**

National Institute of Oceanography Pakistan was carried out the Hydrographic and Oceanographic studies of Gharo Creek for outfall structure designing.The proposed Right Bank Outfall Drain (RBOD) which is under construction is to carry Main Nara Valley Drain (MNVD) discharge from Karampur (near Sehwan) to Khuhi (near Kalri Lake) for the capacity of 3,525 cusecs and from Khuhi to Gharo Creek for the capacity of 3,975 cusecs. The proposed RBOD alignments will enroute Karampur near Sehwan RD 0+000 and outfall into Arabian Sea through Gharo Creek at RD 897.The focus of this study of Gharo Creek is on recording the Physical, Chemical and Geological Parameters such as, Tidal, Water Quality, Bathymetric survey, Sea bed sampling and tidal currents.The grain size data indicates calm depositional setting in the area of sampling. However, the presence of poorly to moderately well sort sand and the presence of shells (complete as well as broken fragments) indicates periodic events when the sea water encroaches to the upper part of the Gharo Creek. Dissolved oxygen is most important parameter to determine the water quality of the area. During the spring tidal cycle at station-1 > 6 mg/l and ranged between 6.6-8.43 mg/l, where high concentrations observed during low tide and low concentration at high tide . At station-2 dissolved oxygen during the Neap tidal cycle not follow the similar pattern of spring tide may be due to the high suspended particle cut the sun light and inhibit the photosynthesis and concentrations was in the range 4.5-8.7 mg/l. Surface seawater salinity at station-1 during the Spring tidal cycle noted was ranged between 4-6.5 ppt. Where low salinity recorded during the low tide which may be due to the input of fresh water from the Gharo stream.During High tide saline water from the creek area causes the higher salinity of Gharo creek area. During the Neap tidal cycle concentration ranges found higher than the Spring tide (3-10ppt) due to the mixing of fresh water from the Gharo fresh water Nallah.

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**Introduction**

The Indus, however, is by far the largest such river to be dammed, and also has a very high energy coastline and shelf(Tariq *et al.*, 2008). Due to recent human activities such as dam construction, sediment discharge has been sharply reduced, resulting in severe erosion and sea water intrusion along the entire delta coastline (Umitsu *et al*, 2001). The disposal of effluent into River Indus or Mancher has been a controversial issue and in the absence of any natural outfall outside the study area, it is essential to find out a satisfactory arrangement to dispose of the effluent. A major constraint to the drainage of the Right Bank of Indus River is the lack of outfall. The low flows in the River Indus downstream of Sukkur Barrage and high concentration of salt in drainage effluent precludes the disposal of effluent into River Indus as well Mancher Lake. The best alternation is carrying out the effluent along the Right Bank of river Indus through an extension of (MNVD) Main Nara Valley Drain and its connection with Kotri Barrage Right Bank drainage system. (NIO, 2004).The proposed RBOD is the extension of RBOD system existing on right bank upstream of Sehwan and being collected as MNVD is out flowing into Manchar. The salinity of the drainage water has contaminated Hamal and MancharLake. In order to maintain the salinity control, the drainage effluent being collected in MNVD is to be disposed off into sea rather than contaminating Manchar Lake or River Indus downstream Sukkur Barrage.The proposed RBOD which was under construction is to carry MNVD discharge from Karampur (near Sehwan) to Khuhi (near Kalri Lake) for the capacity of 3,525 cusecs and from Khuhi to Gharo Creek for the capacity of 3,975 cusecs. The proposed RBOD alignments will enroute Karampur near Sehwan RD 0+000 and outfall into Arabian Sea through Gharo Creek at RD 897. NIO carried out the Hydrographic and Oceanographic studies of Gharo Creek for outfall structure designing. The standard methods and protocols were followed during the collection of data. Data and information were collected by deploying state of the art equipment and by conducting original surveys in the area. The focus of this study of Gharo Creek is on recording the Physical, Chemical and Geological Parameters such as, Tidal, Water Quality, Bathymetric survey, Sea bed sampling and tidal currents.The procedure adopted for pre-treatment and dispersion of samples was according to British Standard 1377 (British Standard Institution, 1975).

Gharo Creek which is 35 miles from Phitti Creek entrance the tide are most half of the mean sea tides at the entrance with about 45 minutes lag.

*Discription of survey area*

The Indus River is a singular artery running through Sindh. Its delta at which Muhammad Bin Qasim Port is situated is built from the soil of a prehistoric continent and is a growth of alluvium from late tertiary period of earth's life. The delta region or river Indus which is the largest river of Pakistan comprises of about two million acres of tidal and mud flats most of which are inundated during flood tide. It has also been observed that about 2,300 years ago one of the main tributaries of the Indus was flowing close to Karachi, i-e from GHARO, KADIRO, PHITTI and other branch falling in the Sea through Koree; but since then there had been continuous South East ward migration of its principal discharge.

Gharo Creek which is 35 miles from Phitti Creek entrance the tide are almost half of the mean sea tides at the entrance with about 45 minutes lag.

**Methodology**

The sea water current observation and data of the study area collected from Gharo creek using survey boat facility. The standard method and protocol were followed during the collection of data. Data preserved in the field for further analysis carried out in NIO Laboratories.Data and information were collected by deploying state of the art equipment. The focus of this study of GharoCreek is on recording the PhysicalParameter "watercurrents". The study work covers the area of Gharo Creek location shown in the Figure-1&2 up to 3km upstream.


**Fig. 1.** Location Map.

The specific details of the survey observation techniques and procedures adopted are described undersection. The water quality data collection from two locations in the creek for one tidal cycle (25 hrs.) and continues salinity-recording profile at one location during tidal recording. The following oceanographic parameters were observed:

1. Suspended Load
2. Salinity of water
3. $p^H$ of water
4. Dissolved Oxygen
5. Transparency of water
6. Grain Size Analysis of the Sediments

NIO established a permanent camp at Gharo Creek for recording the tidal levels continuously and other oceanographic parameters from 21-10-2004 to 27-11-2004.

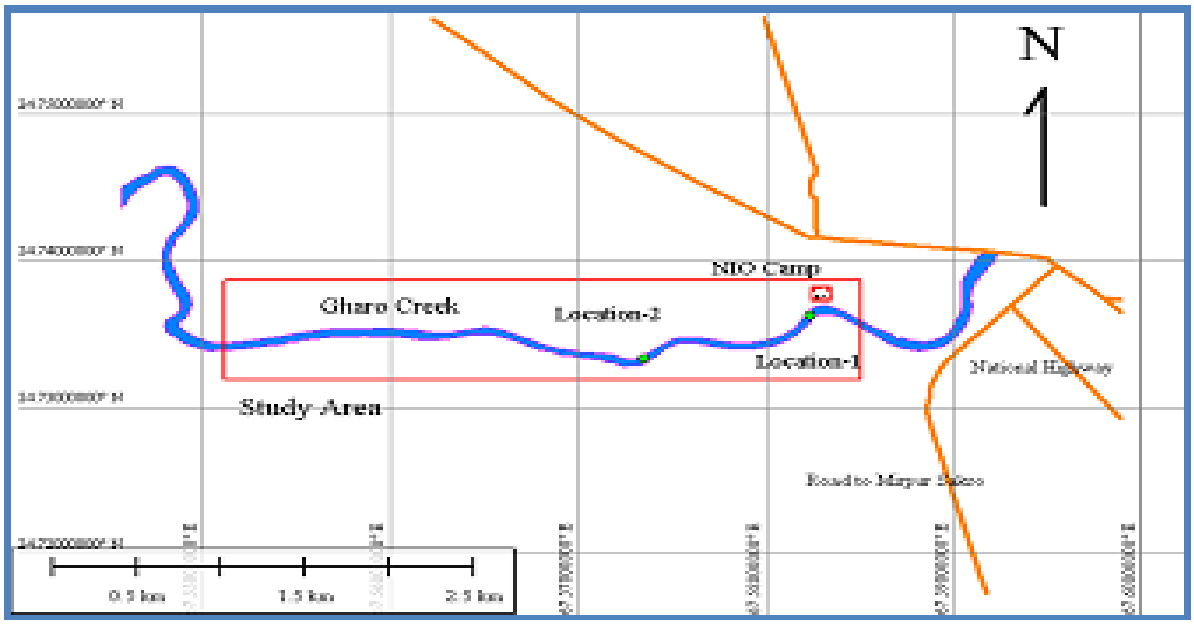


**Fig. 2.** Study Area.

The water levels were recorded using staff gauge and manual recording on hourly basis. The tide pole was calibrated by using the local Bench Mark value.

A number of equipment and Instruments were used during the survey period to achieve the objectives successfully and accurately.

**Observations and results**

*Tidal Levels Observations*

A graduated Tide Pole was installed in Gharo Creek for continuous tidal data recording at one hour's interval started from 22-10-2004 and closed on 27-11-2004. The locations of tidal station are shown in Figure 2 and tidal graph are placed in Figure 3 to 6. A tide pole was calibrated by using the local benchmark value. The graph shows that at Gharo Creek tides fall down rapidly due to frictional effects and gradual weakening of the tidal forces. Tidal waves entering in the creek show peculiar changes due to decrease in the water depth increase in frictions.

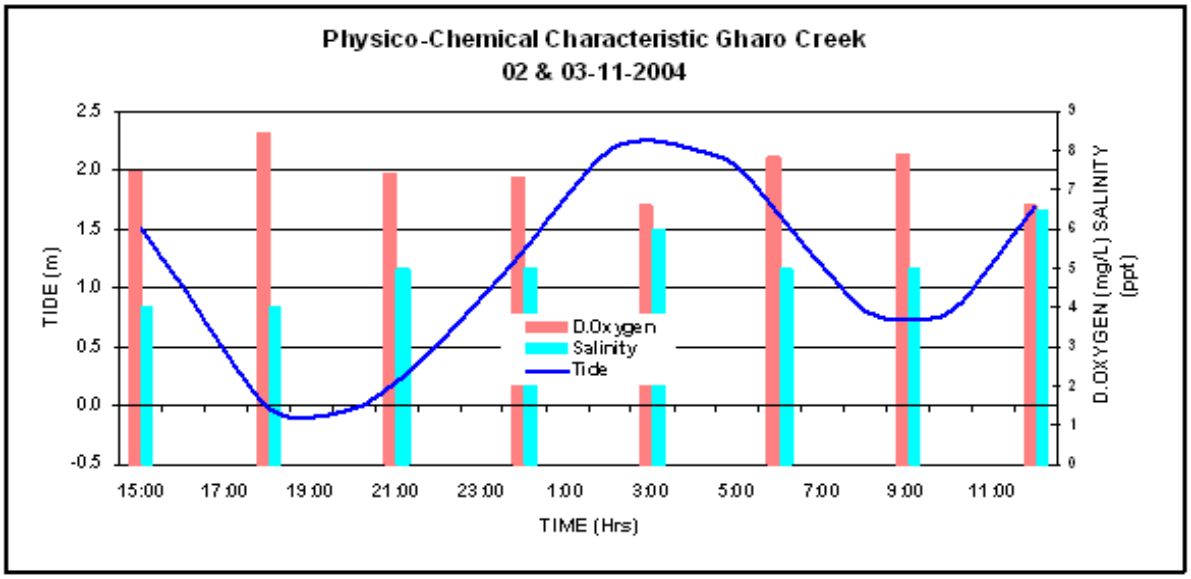


**Fig. 3.** Tidal variation with Physico-Chemical Characteristic Gharo Creek water.

In the open sea in front of a creek, the tides are symmetrical, but in the creek or river they become asymmetrical, namely the duration of flood becomes shorter than that of ebb. This asymmetry becomes remarkable as going up stream. At Gharo 35 miles from the Phitti Creek entrance the tide are almost half of the mean sea tides at the entrance with about 45 minutes lag. The tidal readings were checked to remove errors to obtain smooth data, the tidal constituents were computed using tidal harmonic analysis programme.

*Mean tidal levels*

Mean tidal levels have been calculated at Gharo Creek based on Tidal Harmonic constants using separate computer programme.These levels are shown in the table below:

| H.A.T(m) | M.H.H.W(m) | M.L.L.W(m) | L.A.T(m) |
|---|---|---|---|
| +3.50 | +2.55 | -0.49 | -0.7 |

*Mean Sea Levels (MSL)*

Mean High Water Spring (M.H.W.S)= +3.00 m

Mean High Water Neap (M.H.W.N) = +2.10 m

Mean Sea Level (M.S.L) = +1.18 m

Mean Low Water Spring (M.L.W.S) = -0.33 m

Mean Low Water Neap (M.L.W.N) = -0.03 m

The Mean Sea Level (MSL) computed at Gharo Creek is 1.18m.

*Physico-Chemical Characteristic Gharo Creek*

*Dissolved Oxygen*

Dissolved oxygen is most important parameter to determine the water quality of the area.). During the spring tidal cycle (2-3 Nov. 2004) at station –1, most of time recorded > 6 mg/l and ranged between 6.6-8.43 mg/l, where high concentrations observed during low tide and low concentration at high tide (Figure-3). At station –2 dissolved oxygen during the neap tidal cycle (24-25 November, 2004) not follow the similar pattern of spring tide probably due to the high suspended particle cut the sun light and inhibit the photosynthesis and concentrations was in the range 4.5-8.7 mg/l.

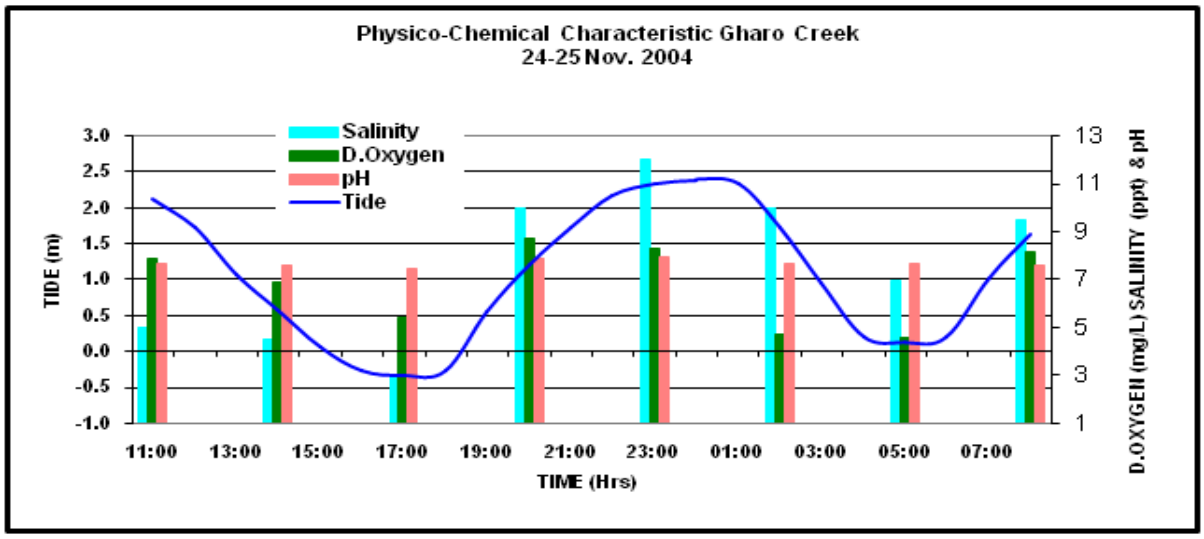


**Fig. 4.** Tidal variation with Physico-Chemical Characteristic Gharo Creek water.

*Salinity*

Surface seawater salinity at station-1 during the spring tidal cycle noted in ranged between 4-6.5 ppt. Where low salinity recorded during the low tide which may be due to the input of fresh water from the Gharo stream (Figure-4). During High tide saline water from the creek area causes the higher salinity of Gharo creek area. During the Neap tidal cycle (24-25 November, 2004) concentration ranges found higher than the spring tide (3-10ppt) due to the mixing of fresh water from the Gharo fresh water Nallah.

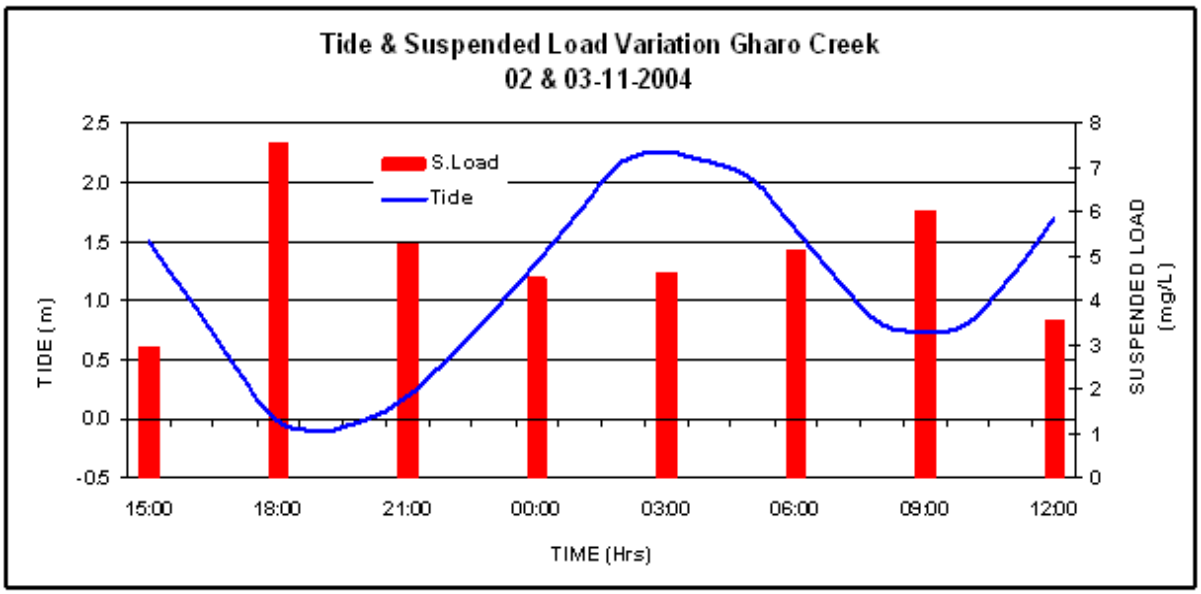


**Fig. 5.** Tide and suspended Load Variation of Gharo Creek water.

*Water pH*

The pH of water described the water quality and buffering capacity of seawater. Generally at surface water lower pH recorded during the low tide 7.88 (Neap tidal cycle**)**, whereas higher values at surface reported during the high tide 8.45 (Figure-4). Lowest pH caused by the influx of the fresh water.

*Suspended Load*

Suspended Load plays an important role removal of any organic and inorganic pollutant. Highest concentration recorded during low tide 172 ppm during the Neap tidal cycle (24-25 November, 2004) high concentration recorded probably due to the wave action eroded the sediment and re-suspended in the water column its concentration found in ranged 24-172 ppm. During the spring tide (2-3 November, 2004) similar pattern observed but its concentration ranges were lower 29-75ppm (Figure-5 and Figure-6).

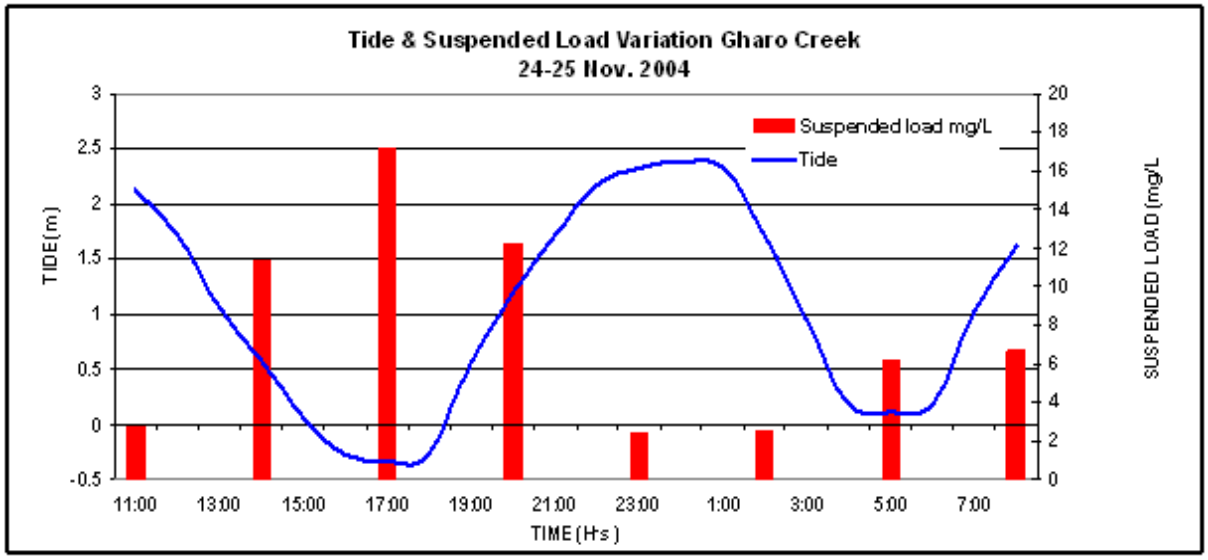


**Fig. 6.** Tide and suspended Load Variation of Gharo Creek water during 24-25 , November, 2004.

*Water Current Observations (Tidal Currents)*

Water current recording were made to cover two unequal tidal cycles (25 hrs) using Aandereaa Recording Current Meters (RCM-8). The RCM-8 (Current meter) was deployed for 25 hours recording at monitoring station at mid depth. The locations of RCM-8 meter are shown in Figure 2. The tidal currents are the flow caused by movement of sea water associated with the tidal phenomenon, and it changes periodically its direction and velocity. The RCM-8 current meter records data of current speed and direction at half-hour intervals. The analog signals obtained from RCM are digitized on computers using dedicated wave software, the current observations are plotted in the vector diagrams by using modern software, and these diagrams give the direction and velocity of currents at mid depth of the Gharo creek.

Location-1, which is very close to NIO Camp during spring tide the maximum current speed, was 33 cm/sec and minimum current speed was 2 cm/sec. The vector diagram is shown in Figure 7. The water current at Location-2, which is 1Km away from Location-1 towards Inside, are stronger than the current at Location-1. The water current in flood tide is 35 cm/sec and in ebb tide 68 cm/sec.

In Gharo creek Ebb current is much stronger than the flood currents.

The continues water salinity was observed during the study period from 23-10-2004 to 27-11-2004 . The water salinity was observed to vary between 2ppt (parts per thousand) to 10ppt. the 10ppt was found only 4 times during the study period, monthly below

10ppt was found. The data demonstrate comparatively lower water salinity in the study area due to the fresh water input from the different source into creek. It was generally observed that lower water salinity observed at ebb tides and higher salinity at flood tides due to the sea water increased in the creek,

*Salinity Profile*

During study period a long salinity profile was also recorded from NIO Camp to Harjina Bridge (near Bhambhor). The data shows that the increase in salinity continuously moving towards P.Q.A. It is observed that near bridge the salinity was 30ppt and at the camp only 5 ppt.

*Sea Water Temperature (°C)*

The sea water temperature was also recorded during water quality observations and water current recording. The average water temperature was observed very between 18°C to 22°C.

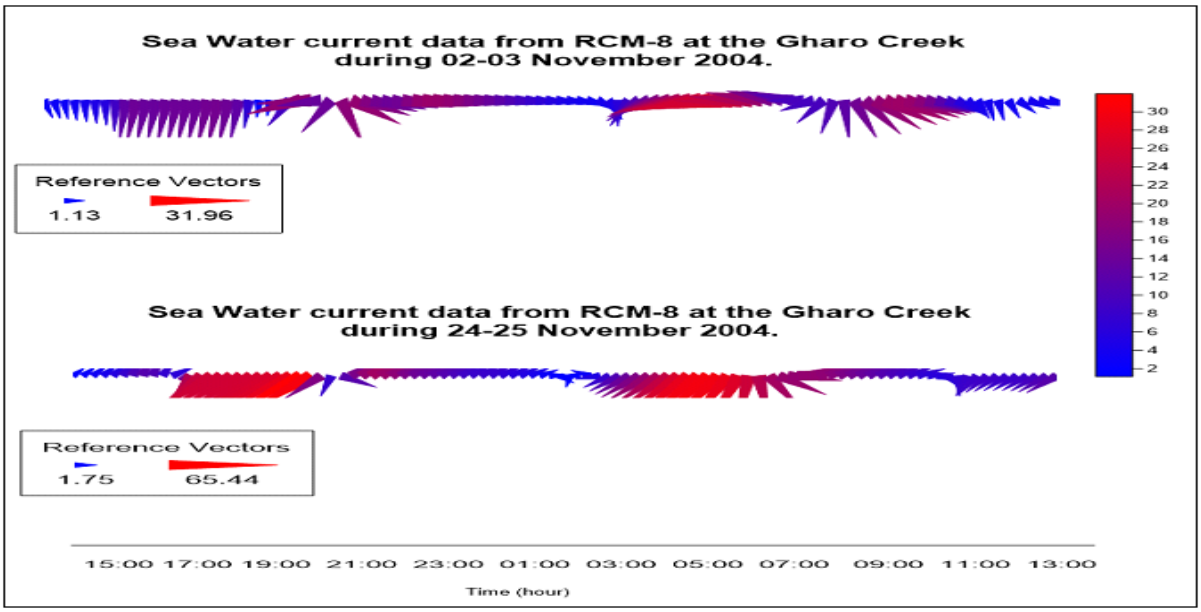


**Fig. 7.** Shows Water Current Speed and Direction vector diagram.

*Meteorological Observations*

Wind speed (m/sec) and wind direction was observed continually every day at 08:00, 11:00, 14:00, 17:00, 20:00 and 23:00 hrs during the study period from 23-10-2004 to 27-11-2004. At the site the highest wind speed was recorded is 7.4 m/sec and the lowest wind speed is 1 m/sec with mostly N and NE direction.

*Textural Analysis of Sediment Samples from Gharo Ceek*

*Particle size analysis*

The procedure adopted for pre-treatment and dispersion of samples was according to British Standard 1377 (British Standard Institution, 1975). Pre-treated samples were sieved through a 0.063mm (63 µm) sieve. The finer fraction that passed through the sieve was collected in 500ml. flasks for pipette analysis. A solution of 0.05% Sodium hexametaphosphate was used for particle dispersion. The sand fraction retained on the sieve was dried in the oven for dry sieving.

*Textural Classification*

The sediment classification adopted in this study (Table 34) is based upon that of Shepard (1954). Sand, silt and clay boundaries are based upon the Wentworth scale (1922).

**Discussion**

The sediment samples analysed for their grain size distributions are generally fine-grained as their

Graphic Mean averages 0.08mm . Poorly to moderately well sorted sand content in the sediment samples (averaging 30%) was generally restricted to fine to very fine sand size category . Among the sampled NIO RD's the NIO-10 and NIO-15 are dominantly. The silt size fraction averages 14% as it ranges from 9.5% to 19%. According to the Shepa NIO RD's textural classification of 1954, the general texture of these sediments can be defined as silty sandy clay except at sites NIO-10 and NIO-15.

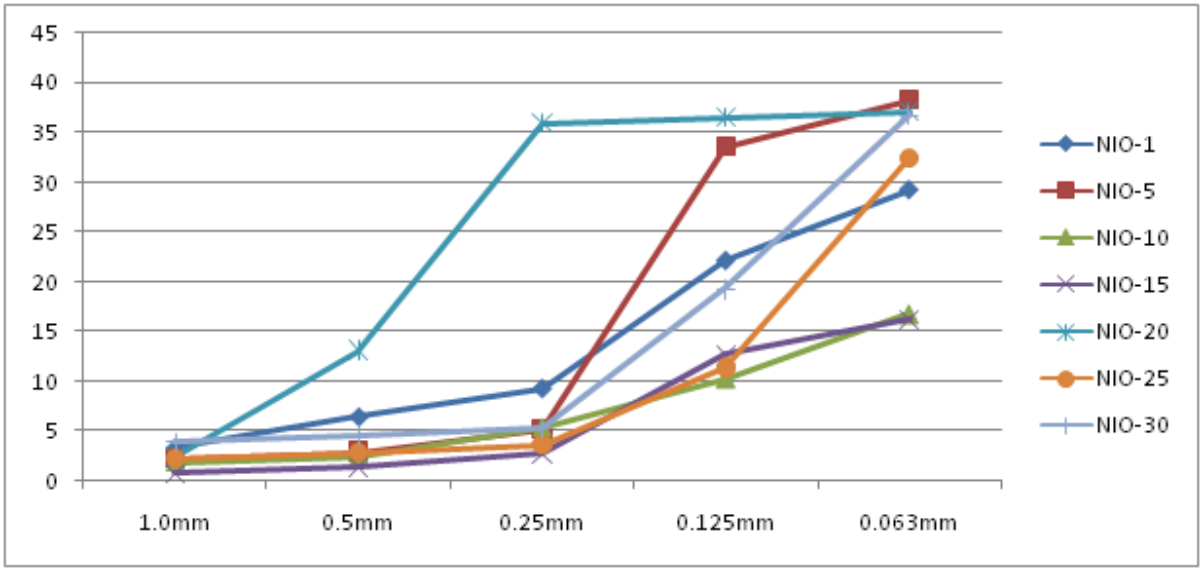


**Fig. 8.**

The grain size data indicates calm depositional setting in the area of sampling. However, the presence of poorly to moderately well sorted sand and the presence of shells (complete as well as broken fragments) indicates periodic events when the sea water encroaches to the upper part of the Gharo Creek.

*Water discharge*

The available data relating to the water movements at the end of Gharo Creek and the study area was used to prepare estimates for the flow and final discharge of water at the end of Gharo Creek. There is a net-discharge of about 0.578 $m^3/s$ at NIO-1 and 1.52 $m^3/s$ at NIO-10. By the time it reaches to at the end of Gharo Creek RD -896+00, RD -00, RD -1+00 and RD -5+00, the water volume/section (bank full) capacity average is 16888.88 $m^3$ and volume/section (wetted volume) capacity average is 7738.21 $m^3$ .The average bank full capacity volume from NIO -1 to NIO -30 is 8037.87 $m^3$ and average volume at MSL is 3051.74 $m^3$. By the time it reaches to at the end of Gharo Creek it is already under hydraulic resistance for downward flow because of the two Flood Tide waters per day on the other hand the two Ebb waters per day accelerate the downward flow of the Gharo Creek. Therefore, the resultant flow of water is dependent on the speed of water currents during Flood and Ebb Tides in the Gharo Creek. As the Ebb Tidal currents are stronger, therefore there is a net flow out to the Sea.

The observations on the water average water current speed, corresponding Tidal Levels and Bathymetry were used to calculate the discharge of water from the selected points at the Gharo Creek. The calculations also took into account the available information on the Gharo Creek.

The grain size data indicates calm depositional setting in the area of sampling. However, the presence of poorly to moderately well sorted sand and the presence of shells (complete as well as broken fragments) indicates periodic events when the sea

water encroaches to the upper part of the Gharo Creek.

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