

## **Research Article**

### **Dynamics of A Polluted Tidal Estuary, Gizri Creek During South West Monsoon**

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**Abstract:** A 25 hours study was conducted in a polluted Estuary, Gizri Creek in order to investigate how current speed, salinity and water temperature stratification behaves under the influence of a polluted freshwater source. Vertically lunar hourly profiles of salinity, water temperature and current speed were obtained and the results indicate that the estuary is forced by semi-diurnal tides. The profiles of current intensity indicates that the flood currents slightly higher than the ebb ones, with maximum values of about 33.45 and 31.51 cms-1, respectively. The major flooding velocity was enhanced by the strong tidal currents. The lunar hourly variations of salinity and water temperature reveal that during the ebb, the vertical stratification increases, decreasing during the flood period. The salinity ranges between 28 and 41 ppt (parts per thousand) and the water temperature between 30.2 and 33.7 °C. At surface and near the bed the salinity and water temperature increases during the flood periods, decreasing during the ebb. From the 25 hours observation of water column stratification or salinity vertical structure on the basis (Pritchard, 1955; Cameron and Pritchard, 1963) theory revealing that the estuary can be considered weakly stratified or vertically mixed.

**Keywords:** Salinity, Water column, Stratification, Classification, Gizri Creek

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#### **INTRODUCTION**

An estuary is a partially enclosed body of water along the coast where freshwater from rivers and streams meets and mixes with salt water from the ocean [1,2].

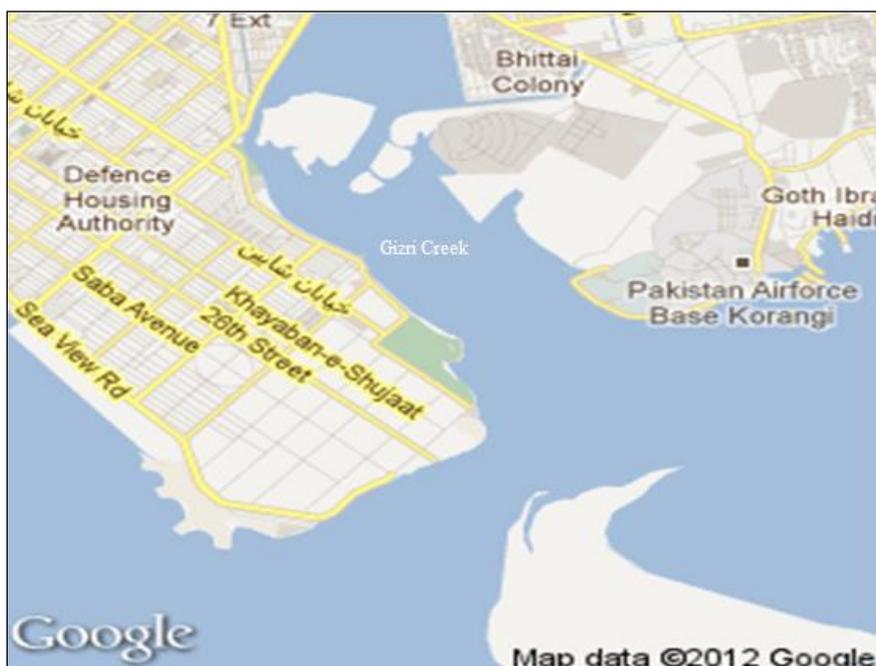
The Gizri Creek is located along the Karachi coast, the southern area of Pakistan in the North of Arabian Sea as shown in (fig. 1). Karachi coast is about 90 km long and on the basis of physiographic features it is divided into three different regions i.e. West Coast, South coast and Southeast coast [3]. Gizri Creek lies with a latitude of (24° 46' 28" N) and a longitude of (67° 06' 01" E) on the south coast of Karachi as shown in (fig 1), which is about 14 km along Clifton and Defence Housing Authority (DHA) beach extended from Kiamari to Korangi Creek [3].

The eastern part of Gizri Creek is connected to Korangi Creek. The mean depth of Gizri Creek is about 5 m and tides are mainly semi-diurnal and they represent the major driving force of circulation in the Creek. Gizri Creek receive the major source of polluted freshwater from Korangi Industrial area and residential areas of the Karachi city with catchment area about 2590 km<sup>2</sup> (*pr.hec.gov.pk/Chapters/2902H-3.pdf*).

It is estimated that 472 million gallons wastewater is being discharged per day, from which

26.5 % effluent drains into the Sea through Gizri-Korangi Creeks via Malir river [4]. During the monsoon rain the Malir River bring fresh water runoff to the Arabian sea through the Gizri Creek [5]. It is also reported that the coastal features of Clifton and DHA beach have been greatly modified and considerable area from Korangi - Clifton has been reclaimed by filling, low marshy lands [3]. Hence these environments are directly affected by human activities such as urban development and port-related activities [6]. however estuarine environment is characterized by temporal changes that occur due to hourly (tide) to seasonal variations (river discharge). It is believed that any modification to hydrological regime or sediment supply affects the estuarine evolution and alters the previously-achieved equilibrium system [7] and they can have a significant impact on human activities and structures. Therefore, the continuous research and monitoring of such processes is very important for the safety and well-being of coastal society [8,9].

The purpose of this study is to find out the stratification behavior of current speed, salinity and water temperature under the influence of fresh water source and classification of the estuary on the basis of [10,11] water column stratification or salinity vertical structure theory.

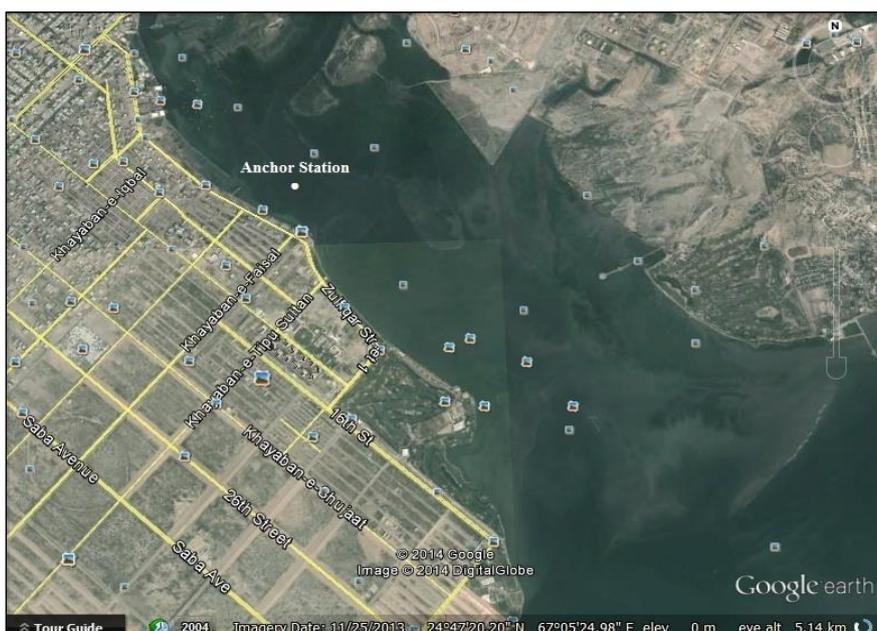


**Fig-1:**Location map of Gizri Creek

### METHODOLOGY

In order to investigate how water current speed, salinity and water temperature stratification behaves under the influence of a polluted water source, a lunar hourly vertical profile of water current speed was observed with a boat-mounted Acoustic Doppler Current Profiler (ADCP) a self recording Current meter model Flow Quest 1000 kHz, over one tidal cycle at an anchor station as shown in (fig. 2). Observations were undertaken at location (24° 47' 20.20" N, 67° 05' 24.98" E) in Gizri Creek during Spring tide. The depth of a

sampling site was about 5.5 meters during high tide. The water surface salinity and water temperature was observed , at the same time bottom water sample was collected by using Niskin Bottle for observing bottom salinity and temperature by using digital thermometer and refractometer respectively, in addition air temperature was recorded. All the observation was carried out on hourly basis. Salinity sensor was calibrated through standard saline seawater. The sampling period started at 16:00 of June 14th 2011 and ended at 16:00 on next day.



**Fig-2:** Study area with the location of the Anchor Station

**FIELD RESULTS**

**Tides**

Tides along Karachi Coast are semi-diurnal with two highs and two lows every day but significantly vary from each other in tidal heights in daily tidal cycle. These are categorized as Higher High Water (HHW), Lower High Water (LHW), Higher Low Water (HLW) and Lower Low Water (LLW). The tides move from

west to east i.e. the tides at Karachi Harbour arrive at about 10 minutes earlier than entrance of Port Qasim [3]. The tidal range varies from 1.8 m to about 3.2 m along the Pakistan coast [11]. During this study Karachi harbour predicted tides were used with tidal range between (-0.20 to 3.10) meters over a tidal cycle, during spring period, as shown in (fig. 3).

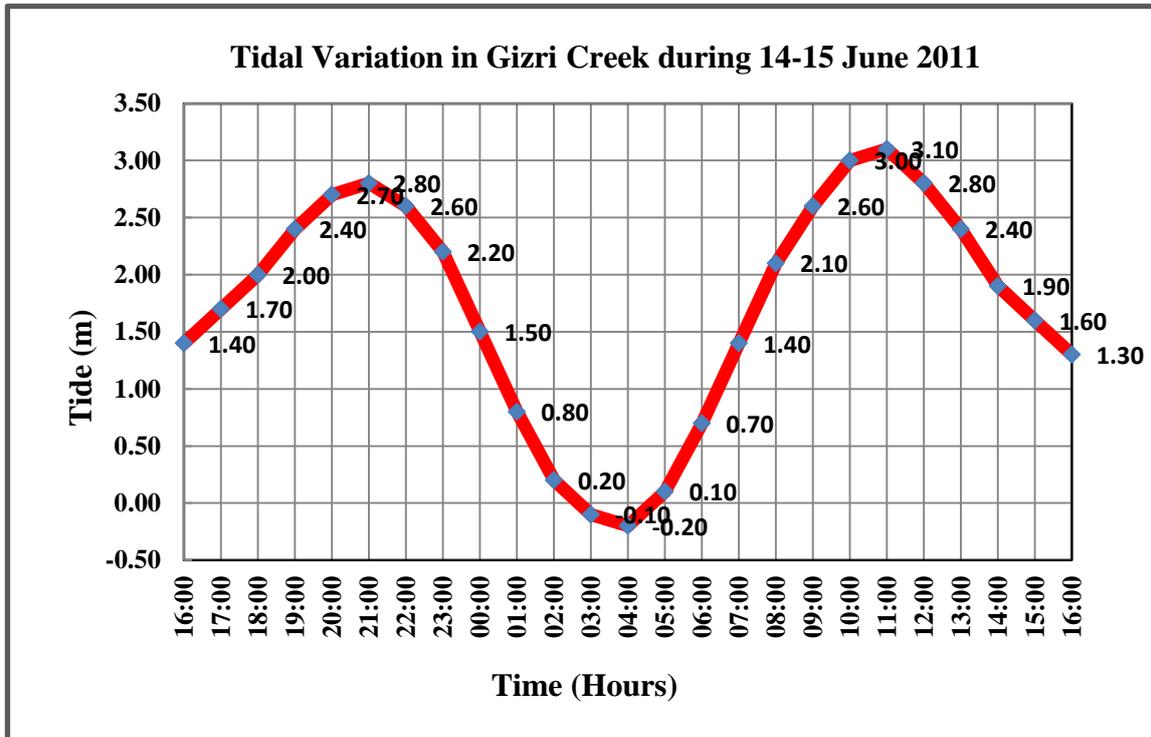


Fig-3: Tidal levels during a tidal cycle

**Metrological Observation**

The Gizri Creek is located along the Karachi coast. The climate of Karachi is controlled by the seasonal changes in the north Arabian Sea i.e. monsoonal system. The mean maximum temperature is 32°C while the mean minimum winter temperature is 10°C throughout the year. The average annual temperature during summer months is 26°C to 35°C, which may rise to above 40°C during day in May/June. During SW monsoon in July and August due to cloud cover the temperature is relatively moderate in Karachi but humidity is high varies from 74- 88 % during May to September. The mean summer relative humidity recorded by Meteorological Department at Karachi is 60-65% while the mean winter relative humidity is 25-30% [3].

Since Karachi is situated in a semi - arid climate zone therefore the annual rainfall is quite low, it varies between 150 - 250 mm during the year .The wind direction during the Southwest monsoon period is predominantly from the west and wind speed reaches up to 27 Knots and during northeast monsoon it is from the northeast and The wind speed rarely exceeds 15 knots [12].

During the sampling campaign the wind speed and air temperature recorded 5-15 knots and (31.3-33.8) °C respectively. Near the surface, the water temperature is influenced by the air temperature, increasing along the day but the surface and bottom water temperature also influenced by flood tide as shown in (fig. 4).

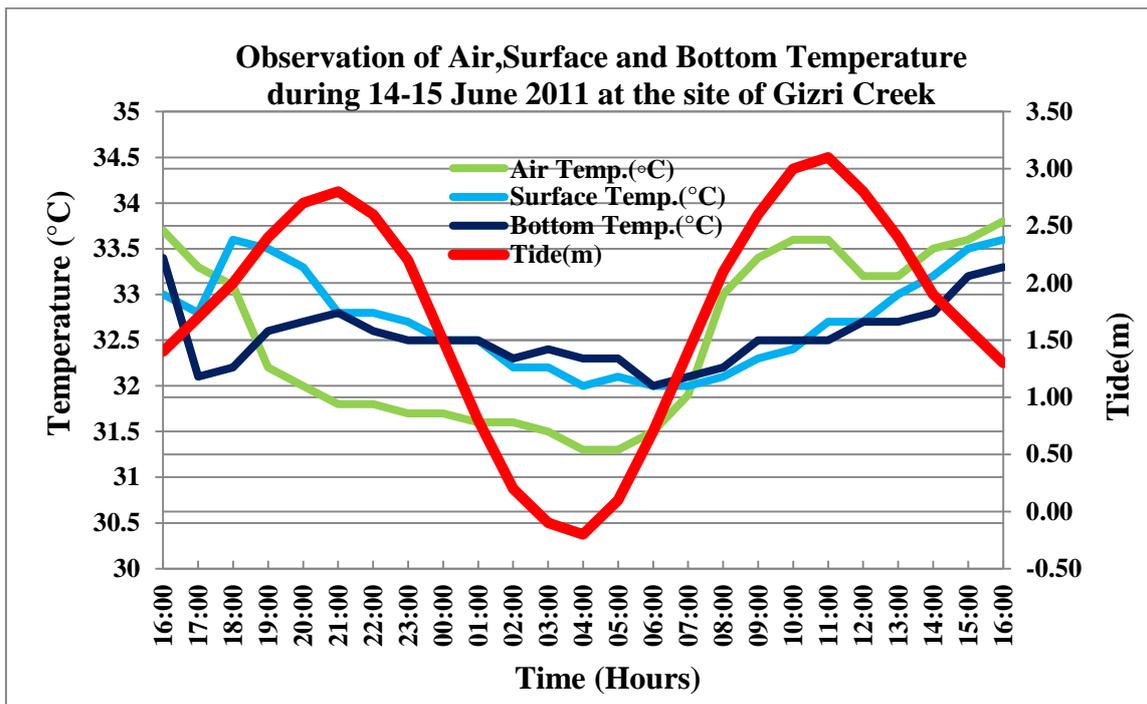


Fig-4: Metrological Observations during a tidal cycle

**Vertical Salinity Stratification**

The lunar hourly variations of salinity reveal that salinity ranges between 28 - 41 ppt (parts per thousand), the surface water salinity ranges between 28-40 ppt and bottom water salinity ranges between 34-41ppt. During the ebb, the vertical stratification slightly

increases due to the river runoff and decreasing during the flood period due to the tidal forcing and sea water influx from the open sea. This behavior is due to the high tidal current velocity associated with the spring tide. Fig. 5 shows the variation in bottom and surface salinity during a tidal cycle.

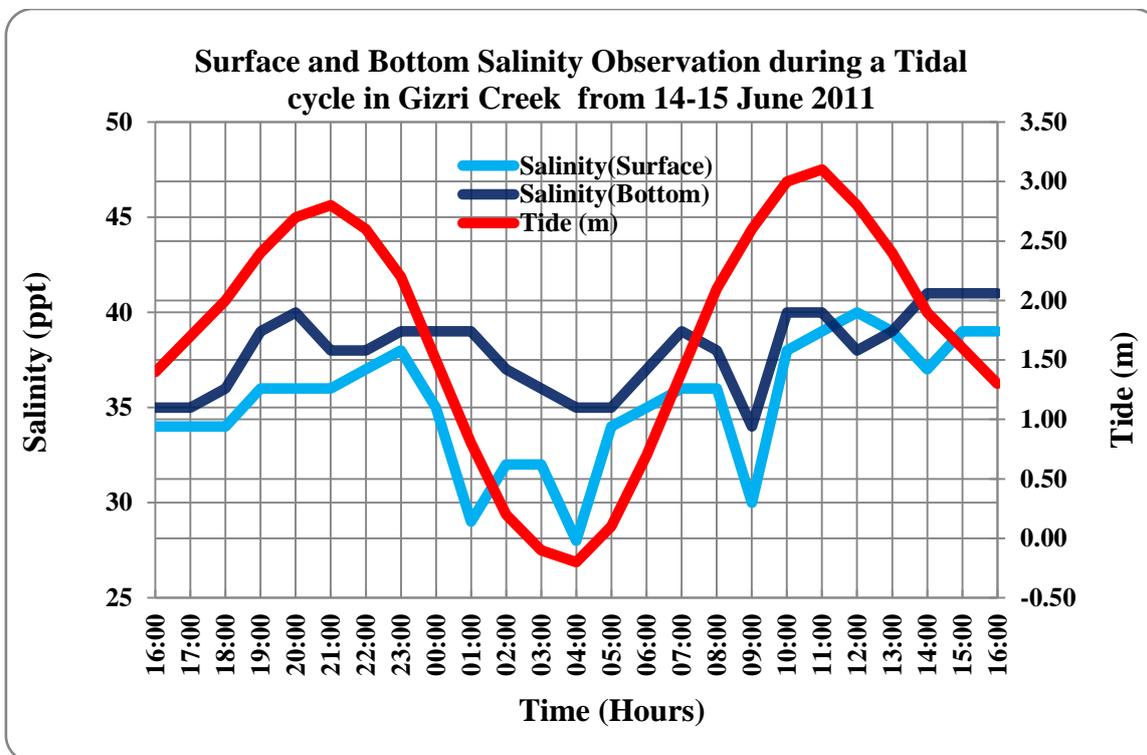
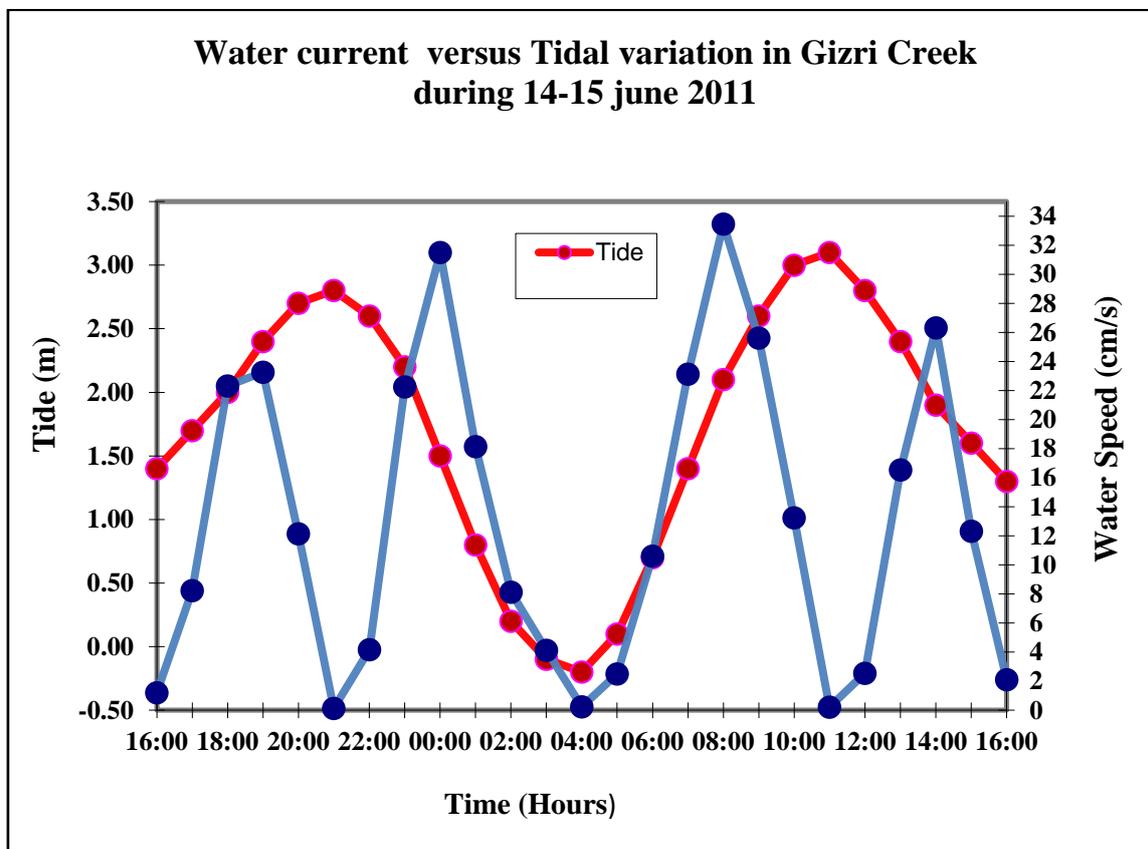


Fig-5: Water Salinity Observations during a tidal cycle

**Water Currents**

The profiles of current intensity indicates that the flood currents slightly higher than the ebb ones, with maximum values of about 33.45 and 31.51 cm s<sup>-1</sup>, respectively as shown in (fig. 6). The major flooding

velocity was enhanced by the strong tidal currents associated with the spring tide and low river runoff. This behavior is due to the predominant wind from SW monsoon.



**Fig-6: Water Current Observation during a tidal cycle**

**DISCUSSION**

The Gizri Creek is located along the south coast of Karachi, it receives the effluent from residential areas of Karachi through Malir River. Present study was conducted during SW Monsoon, during this period wind direction are prevailing from SW and they might affect the tidal currents. According to [13] the speed of the water current is not more than 25.52 cm s<sup>-1</sup> during NE monsoon but it reaches up to 51.44 cm s<sup>-1</sup> during SW monsoon. The similar results were found during present study. The profiles of current intensity indicates that the flood currents slightly higher than the ebb ones, with maximum values of about 33.45 and 31.51 cm s<sup>-1</sup>, respectively. The major flooding velocity was enhanced by the strong tidal currents. But according to [14] stronger currents were observed during the ebb tide compared to flood tide in Korangi Creek area adjacent to Gizri Creek. This variation may be occurred because, during the southwest monsoon winds are about 30 knots [15,14], hence Gizri and Korangi creeks are influenced by the influx of seawater from the open ocean during the semi-diurnal tidal regimes [14]. According to [16] the salinity varies from 35.5 to 36.9‰ in the inshore waters of Karachi and may rise as high as 41 to 42 ppt

in the tidal creeks, A similar trend was observed in the present study, The salinity ranges between 28 to 41 ppt. It is reported that a weak halocline with a difference of 4 ppt observed within a depth of 4-6 meter during ebb tide otherwise there was no difference between surface and bottom salinity in Gizri Creek [14].

The same results were found in present study of the lunar hourly variations of water column salinity and water temperature over a tidal cycle reveal that during the ebb, the vertical stratification slightly increasing, this behavior is due to the river flow and decreasing during the flood period due to the influx of seawater from open sea. The water temperature observed between 30.2 and 33.7 °C. Near the surface, the water temperature is influenced by the air temperature, increasing along the day. Also at surface and near the bed the salinity and water temperature increases during the flood periods, due to the influx of seawater from the open Sea but decreasing during the ebb.

## CONCLUSIONS

The results of lunar hourly profiles of salinity, water temperature and current speed exhibit that the estuary is forced by semi-diurnal tides. The major flooding velocity was enhanced by the strong tidal currents due to spring tide and prevailing wind from SW monsoon resulted influence of sea water influx from open sea.

Hence from the 25 hours observation of water column stratification profile obtained the classification of estuaries on the basis water column stratification or salinity vertical structure revealing that the estuary can be considered weakly stratified or vertically mixed.

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