INTERNATIONAL JOURNAL OF
COASTAL & OFFSHORE ENGINEERING

IJCOE Vol.4/No. 1/Spring 2020 (25-30)

Available online at: www. Ijcoe.org

Field data measurement in confluence of the Arvand and the Karun Rivers focusing on sediment, tidal and CTD study

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ARTICLE INFO

Article History:
Received: 31 May. 2020
Accepted: 21 Oct. 2020

Keywords:
The Arvand River
The Karun River
CTD
Tidal Current
Sediment, Field data

ABSTRACT

The Karun River is considered to be the longest Iranian river with 855 km length. The river is divided into two branches, 4 km away from the Arvand River, which is a branch of the Bahmanshir River in the north of Abadan, and another branch of the Namkarun River (the Azodi Channel) that flows into the Arvand River. The intersection of the Karun River and the Arvand River is important. Also, measuring and investigating of hydrodynamic phenomena have a vital role in recognizing and prediction the hydrodynamic changes in the region. Therefore, CTD and hydrographic studies were carried out for the Azodi Channel, which is the intersection of the Karun River and the Arvand River. These studies include measurements of marine phenomena such as tidal observations, water level changes, hydrography, topography, CTD and sedimentation. Studies have shown that floods of the Karun River have caused significant changes in the intersection of the rivers Karun and Arvand. Also, the sediment of the study area is fine-grained, but at the intersection of the rivers Arvand and Karun, it is coarse-grained. Sediment concentration is increased in depth, and the lowest and highest sediment concentrations are related to Karun station and Arvand Karun intersection respectively. Regarding the alignment survey, it was found that the current of the study area is mixed current, but mostly meridian. The flow of the Karun River is one of the parameters affecting the water level. So that if the current of the river is noticeable, it will prevent the tidal wave from spreading into the river.

1. Introduction

Karun, which is the longest river in Iran with a length of 855 km, is 180 km long from Khorramshahr to Ahvaz and is called Karun Sofla. This river is divided into two branches. One of them is Bahmanshir branch in the north of Abadan which runs parallel to Arvand and joins the Persian Gulf, and the other branch is Azodi canal which flows in the south of Khorramshahr and flows into Arvand. The Arvand River forms part of the Iran-Iraq border, joining the Tigris and Euphrates rivers in Iraq and joining the Karun River. The intersection of the Karun and Arvand rivers is of special strategic, economic, commercial and political importance due to the existence of various ports and shipbuilding complexes, as well as being located at the border point.

Investigating and studying coastal changes under the influence of hydrodynamic phenomena such as tides, sediment transportation, and salinity changes requires a deep understanding of these phenomena. Predicting and carefully examining the changes in these phenomena will play a significant role in reducing the costs and sustainability of the constructed structures. According to the importance of the study area, some researches have been done which mention below. Ajabpour examined the changes in direction and flow velocity at the confluence of the Arvand River and Karun. In this study, quantities such as water level changes, flow velocity, temperature, salinity, and water depth during a complete tidal period were measured. Studies show that the average flow of water in neap-spring period is towards the sea [1]. Sarvestani and Sadri Nasab studied the structure of a plum at the entrance to the Arvand River in the Persian Gulf, which is an inverted estuary. In this study four tidal components including H2, S2, K1, and O1 used. The results showed that Plum went to the left at the entrance of the Arvand River and turned to the right due to Coriolis force, creating an anticyclone rotation in the northwestern part of the Gulf and a floating coastal current around Qatar and Saudi Arabia [2]. Etemad Shahidi et al. examined the influence of saltwater due to the increase in seawater level in Bahmanshir. The results showed that sea levels increased from 30 to 90 cm in 2100, and the duration of salinity infiltration increased inversely with discharge and directly with increasing sea level [3]. Khosravi et al. presented the results of Karun river field measurements during one month in spring, 2013. The results indicated that the maximum measured current by a current-meter was 70.6 cm/s, in a seaward direction, and unexpectedly corresponded with the neap tide. The high river discharges concurrently with the neap tide, cause this maximum velocity [4].

As studies have shown, the confluence of the Karun and Arvand rivers is important. Also, the measuring and study of hydrodynamic phenomena will play a very important role in recognizing and predicting hydrodynamic changes in the region. Therefore, measuring the flow parameters and hydrography survey was performed for the Azodi Canal. Studies include measuring marine phenomena such as one-month tidal observations, water level changes, hydrography, flow metering, and sedimentation granulation. In this paper, the parameters measured in the connection range of Karun and Arvand rivers are presented.

2. Methodology and Measuring

Parameters such as salinity, temperature, flow velocity, and water level changes were measured at four stations (1 station on the Karun River and 3 stations on the Arvand River) for four days. The location of the measurement stations shows in Figure 1 and descriptions of measuring present in Table 1.

Figure 1. Study area

Table 1. Descriptions of measuring stations

Type of Station	No. Station	Location X	Location Y	Me. conditions	Me. Parameters
Current	1	229295.78	3370041.1	Measuring of parameters 13h/day, 4 days, from depth 0.1, 0.5 and 0.9	Salinity, Temperature, Velocity etc.
	2	227160.38	3369906.5		
	3	227667.17	3369471.6		
	4	227972.13	3368974.9		
Sediment	1	228654	3369903	The weight of samples is 5 Kg	Grading of samples
	2	227378	3369702		
	3	227699	3369448		
	4	227858			
Suspended Sediment	1	229209	3370018	Sampling from depths of 0.1, 0.5 and 0.9 meters	Weight of suspended sediment
	2	227285	3369789		
	3	227653	3369489		
	4	227917	3369050		

The specifications of the measuring devices are given in Table 2.

Table 2. Specifications of the measuring devices

Row	Equipment	Model	Measurement parameters
1	Tide Gage	RBR	Tide
2	Echo sounder/built on DGPS	CEEDUCER/Hemisphere	Positioning Echo sounding
3	Current Meter	Sea & Sun	Speed & Direction Current
4	GPS Dual frequency	Boif M85	Positioning
5	Grap	Metal	Sea bed
6	Water Sampler	Neskin	Water
7	Lap Top	HP	Hypack
8	Handy GPS	Garmin	Positioning
9	Theodolite	Nikon	Vertical Datum
10	CTD	EC Meter	Salinity, Temperature, Conductivity

3. Results and Discussion

In this section, the measured data analyzed. Hydrographic analysis, sediment sampling, water level changes, and flow velocity are the most important results of this section. Analysis and explanation of the field data provide an overview of the physical processes.

3.1. Hydrography

Examining the depth changes in different parts of the study area can determine the approximate pattern of the dominant flow. Therefore, in the first step, hydrography has been studied in the study area. A very deep area has developed at the confluence of the Arvand and Karun rivers. These hydrographic changes show flood currents in Karun that act like water jets. It due to the Om al-Rasas Island is located in front of the exit jet from the mouth of Karun; this island will be like a compression plate in front of the exit stream and will cause the formation of a wall jet.

Previous studies in the area have shown the process of river formation at the confluence of rivers, leading to drastic morphological changes in the area. Gohari and Amraei showed that sedimentation will occur in the flow separation area and erosion within the maximum current velocity [5]. This is in line with the sedimentation pattern at the confluence of the Arvand and Karun rivers. Therefore, one of the issues that should be considered in the analysis of this area is the flood currents of Karun, which can cause significant changes in the bed of the intersection of Karun and Arvand rivers.

3.2. Sediment Sampling

Sediment sampling includes sampling of riverbeds and suspended sediments. Table 3 and Figure 2 show the results of bed sediment sampling. Most of the sediments in the study area are fine-grained. Therefore the grading of sediments has been done with laser. Evaluation of the results shows that the volume of sand materials at stations in the Karun and the Arvand Rivers is about 10 per cent, and at the intersection of these rivers, about 30 per cent. Due to the drastic changes in depth at the intersection, the relative size of the materials has not been unexpected.

Also, the concentration of suspended sediments obtained at different depths from the water surface is shown in Figure 3. As it is known, sediments become denser with increasing depth. The concentration of sediment at Karun station has the lowest, and the station located at the intersection of the Arvand and the Karun Rivers shows the highest concentration of suspended sediments. The results show that the sediments of the region are fine-grained and the complexity of the flow in the confluence of the Arvand and the Karun is very significant.

Table 3. Results of bed sediment sampling

No. Station	Location of Station	Results of Grading	
		Bigger than 40μ (sand)	Smaller than 40μ (fine-grained)
1	Karun	4%	96%
2	North of Arvand	12%	88%
3	Confluence of Rivers	30%	70%
4	South of Arvand	12%	88%

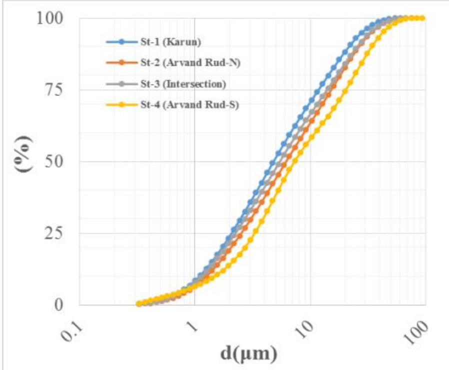


Figure 2. Results of bed sediment sampling

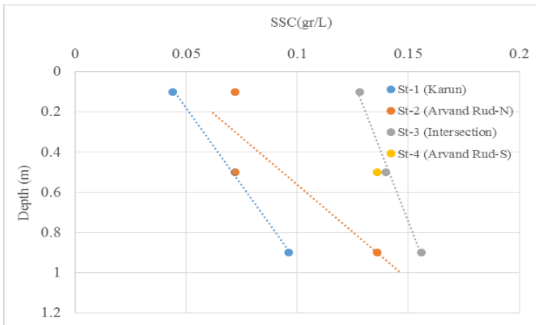


Figure 3. The concentration of suspended sediments obtained at different depths

3.3. Tide

In this section by considering the level measurement in the study area, the tide has been analyzed. Figure 4 shows the measured data of water level changes. As shown in Figure 5, there are significant changes in the water level at the beginning of the data that need to be considered.

The first step in analyzing tidal data is to find the appropriate amplitude and phase of the component with the least squares. IOS Tidal Package has been used to differentiate between water level changes caused by tides and other factors [6]. The range of tidal level changes compared to the measured levels in Figure 5 and the range and phase values of tidal components are presented in Table 4.

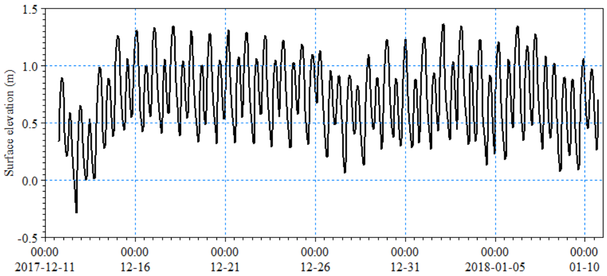


Figure 4. Changes in the water level in the area of Shahid Mousavi Shipbuilding Complex

Table 4. The amplitude and phase of tidal components based on the analysis of water level changes

O1		K1		S2		M2		Z0	
Amp.	Phase	Amp.	Phase	Amp.	Phase	Amp.	Phase	Amp.	Phase
0.02	0.0606	0.2077	20.77	0.0551	146.45	0.3086	73.51	-	0.72

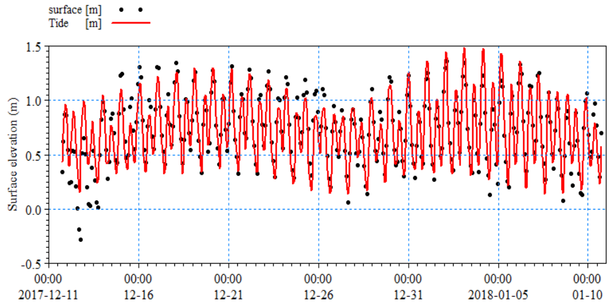


Figure 5. Changes in the water level in the area of Shahid Mousavi Shipbuilding Complex

The value of F is approximately equal to 0.74, which indicates that the tide type is mixed but is mostly semi-diurnal. Therefore, it is expected that two peaks and two bottoms with different intensities will be observed every day [7].

$$F=\frac{K_1+O_1}{M_2+S_2}=\frac{0.2077+0.0606}{0.3086+0.0551}\approx 0.74 \qquad (1)$$

Another parameter that is considered is the difference between measured values and tidal values, which shows the effect of environmental factors such as wind set-up, interaction of tidal components, flow phase difference in two different environments, and upstream river flow. Figure 7 shows the residual value of the water level and its positive and negative values. By considering the geographical location of the study area, one of the impressive parameters in the water level is the Karun River which seems to prevent the spread of tides inside the river whenever the flow rate is significant. Considering that the measurements were made in the winter, a sharp difference in the initial range could be the result of a significant flow in the Karun River. However, due to the construction of a dam upstream of the river, the amount of dam overflow reduced so can cause the significant influence of tide and salty water in the river, the remaining positive value confirms this.

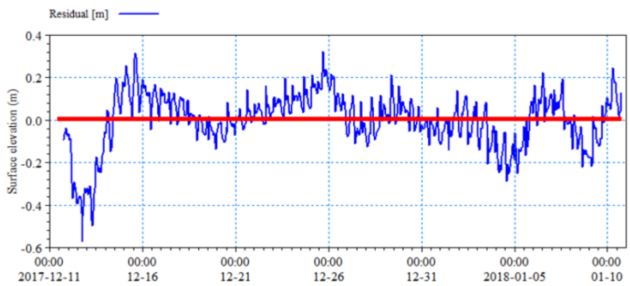


Figure 6. The difference between the level changes of the measured water level and the tidal values

3.4. CTD

In this part of study examined the result of measurements. The components of flow velocity in x and y direction, salinity, heat, and salinity are measured in three depths. Water level changes have also been measured at the same time as some of these measurements. Figure 8 shows the time interval of the measurements. As is clear, measurements were made in two periods, minimum and maximum tides.

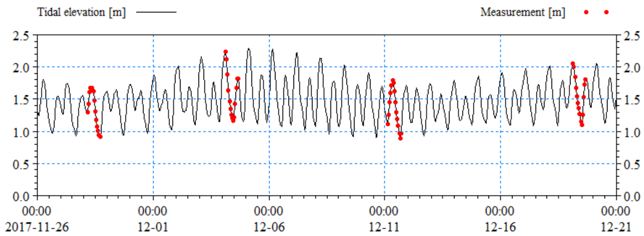
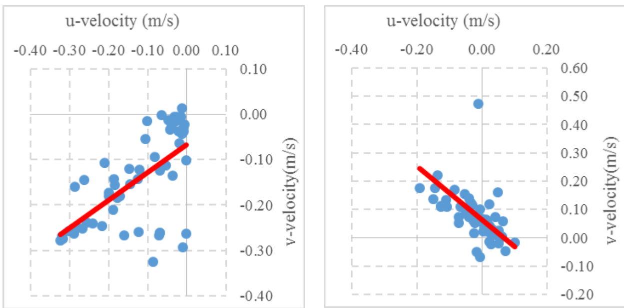


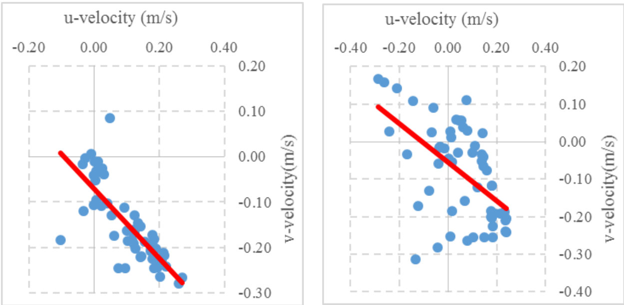
Figure 7. Measurement period (red dots)

3.4.1 Flow pattern examination

The velocity pattern in measured stations 1 to 4 is shown in Figure 8. It shows the flow velocity in different positions with the red line. Measurements made in Karun show that the prevailing flow rate in this area is towards Arvand, and the Arvand tide can only reduce the flow rate of this river locally. The direction of the flow at the station is to the north, which, considering its location, indicates the canalization of the tidal current in this area. At the intersection of the Arvand and Karun rivers, the flow is affected by the speed of the Karun Rivers. At Station No. 4, which is located south of the area, the direction of north-south flow and the amount of flow velocity are diffused, indicating that the impact of the Karun River in this area is decreasing and the tidal effect is visible.



Station No. 1 (Karun) Station No. 2 (North of Arvand)



Station No. 3 (Intersection) Station No. 4 (South of Arvand)

Figure 8. Current velocity at measuring station

3.4.2 Determination salinity and temperature pattern

The salinity and heat patterns can be examined in two ways. The first is to examine the pattern of salinity and temperature changes at a station and at different time intervals. Accordingly, the trend of salinity and temperature changes at Station 1 shows that the salinity rate at this station increased during the measurement period while the temperature decreased. In the first period, we see a decrease in the measured salinity at Station 1, which indicates that the inflow of low-salinity water source (Figure 9 and Figure 10). The sources of low-salinity water are typically rivers, lakes or aquifers associated with meteoric water.

The second way to check the salinity and temperature pattern is to compare the results of different stations over a period of time. According to this issue, the study of salinity pattern in the first period shows that the changes in this parameter in station 1 are different from stations 2 and 4, so that in station 1 the salinity decreases with increasing water level, but in Stations No. 2 and 4 increases in salinity. Examination of temperature changes shows that the process of change of this component in three stations is close to each other, so that increasing the water level increases the temperature in all three stations (Figure 11).

In the second period, the trend of salinity changes in the three stations is very close to each other (correlation coefficient between the result of station 4 and 2 is 0.81, and between station 2 and 1 is 0.93), so that in all three stations, the salinity decreases with increasing water level. Also, temperature changes in the three stations are very similar to each other (correlation coefficient between the result of station 4 and 2 is 0.93, and between station 2 and 1 is 0.88), so that with increasing water level, the temperature decreases (Figure 12).

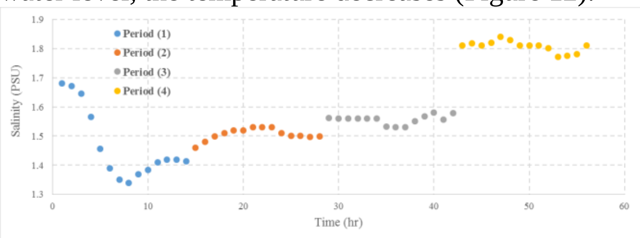


Figure 9. Salinity changes at Station 1 (Karun) at different periods

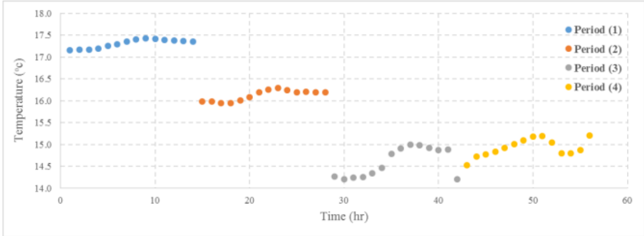


Figure 10. Water temperature changes at Station 1 (Karun) at different periods

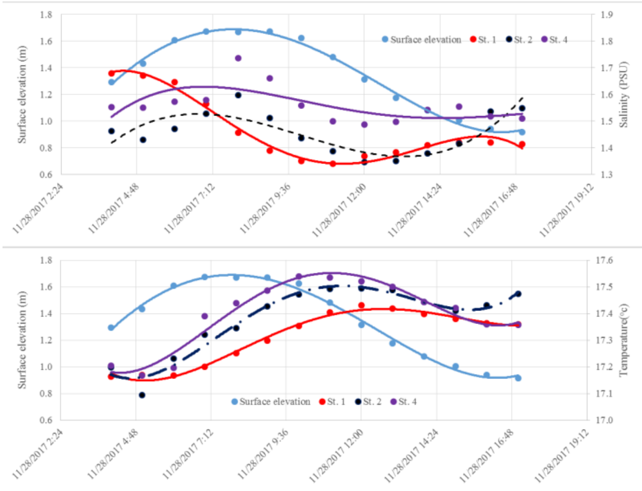


Figure 11. Changes in salinity and temperatures in different stations compared to changes in water level (tide) in the period 11/28/2017

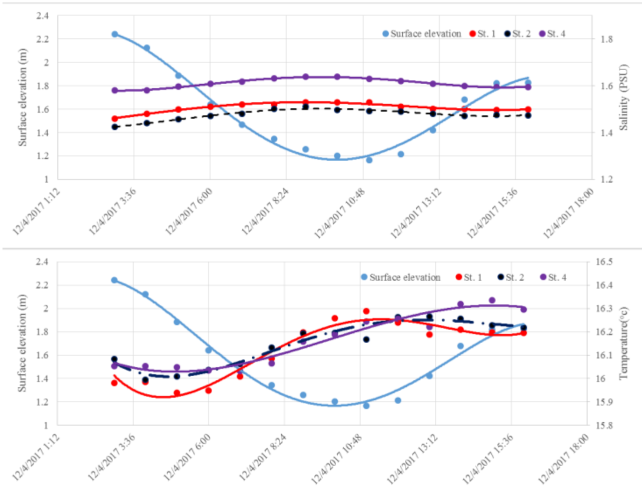


Figure 12. Changes in salinity and temperatures in different stations compared to changes in water level (tide) in the period 04/12/2017

4. Conclusions

In this study, a month-long analysis of the measured data of marine phenomena at the collision of Karun and Arvand rivers has been analyzed. These studies include tides, changes in water level, hydrography, and granulation, sedimentation and flow. Studies show that Karun flood currents have caused significant changes in the bed of the intersection of Karun and Arvand rivers, and most of the sediments in the study area are fine-grained, and at the intersection of Arvand and Karun rivers due to drastic changes. Depth of sediment is greater than that of other coarse-grained areas, and the concentration of sediment increases with depth of motion, and the lowest and highest sediment concentrations are related to Karun stations and Arvand Karun intersection, respectively. According to the measurement, it was determined that the flow regime is mixed but mostly half daily and two peaks and two depths with different intensities are expected to be observed daily and Karun river flow is one of the influential parameters in the water level. So that whenever the river flow is significant, it will prevent the tidal wave from spreading inside the river. The construction of a dam at the top of the river and the reduction of the dam's headwaters into the river cause a significant infiltration of tides and salinization of river water.

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