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DETERMINATION OF HYDRODYNAMIC RESISTANCE COEFFICIENT (MANNING'S COEFFICIENT) IN SHATT AL ARAB RIVER, SOUTHERN OF IRAQ-BASRAH

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Abstract: Shatt al-Arab River is considered one of the systems affected by the phenomenon of tides and has the economic, environmental and historical significance of the city of Basra in southern of Iraq. Manning or roughness coefficient (n) is considered an important bases in the hydraulic studies of river's flow. Experimental methods are used to calculate the value of (n) depending on the field's measurements for six measuring stations (Fao, Seehan, Aboflos, Al-Ashar, Ektiban, and Al-Sharash). It is concluded that n-value is varying along the Shatt al-Arab river, ranging between (0.0115- 0.06) along the river course. The highest value is recorded in Al-Sharash station (0.06) where many factors are interfere, including the velocity of currents, the nature and size of the sediment surface and shape of the river bottom (level, or zigzag).

Keywords: - *Manning's roughness coefficient, Shatt al-Arab River, Open channel.*

حساب معامل المقاومة الهيدروديناميكي (عامل مانك) لنهر شط العرب، جنوب العراق-البصرة

الخلاصة: شط العرب من الانظمة النهرية المتأثرة بظاهرة المد والجزر وله من الاهمية الاقتصادية والبيئية والتاريخية لمدينة البصرة جنوب العراق. يعتبر معاملماننك او معامل الخشونة من الاسس المهمة في الدراسات الهيدروليكية لجريان الانهار، استخدمت الطرق التجريبية لحساب قيمة المعامل (n) وذلك بالاعتماد على القياسات الحقلية لستة محطات قياس (الفاو و سيحان و ابو فلوس و العشار و كتيبان و الشرش). استنتج من الدراسة بان قيمة معامل الخشونة الهيدروديناميكي متغيره على طول نهر شط العرب اذ تراوحت ما بين (0.06 -0.0115) في المناطق التي يمر فيها النهر، أذ سجلت اعلى قيمة في محطة الشرش (0.06) حيث تتدخل فيها عوامل كثيرة منها سرعة التيارات وطبيعة وحجم الرواسب السطحية وشكل قاع النهر (مستوي او متعرج).

1. Introduction

Shatt Al-Arab River is one of the important world's river systems affected by the tides phenomenon. This river arises from the confluence of the Tigris and Euphrates Rivers at Al-Qurna (70Km) north of the city of Basra and its length is (204 Km). It conveys Tigris and Euphrates Rivers waters to the Arabian Gulf.

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Its width varies depending on the areas passing through which it ranges between (200 -2250m) [1]. Shatt al-Arab River is affected by the phenomenon of the tide coming from the Arabian Gulf. The prevailing tide is Mixed-Semi-diurnal dominated. Features a presence of two upper tides and two lower tides [2]. The upper tide varying spatially between the upper and bottom reaches of the southern part of the river. It is of considerable importance from the point of economic, environmental, and this because of the presence of many vital structures built on both sides such as ports, water desalination plants, an oil refinery, and others.

The bed rivers are considered as one of the transition surfaces. The friction that occurred is because of the roughness of the bed river. This characteristic causes change in the longitudinal or accidental cross sections of the rivers. Figures (1-a) to (1-e) show the topography of the Shatt al-Arab river bottom.

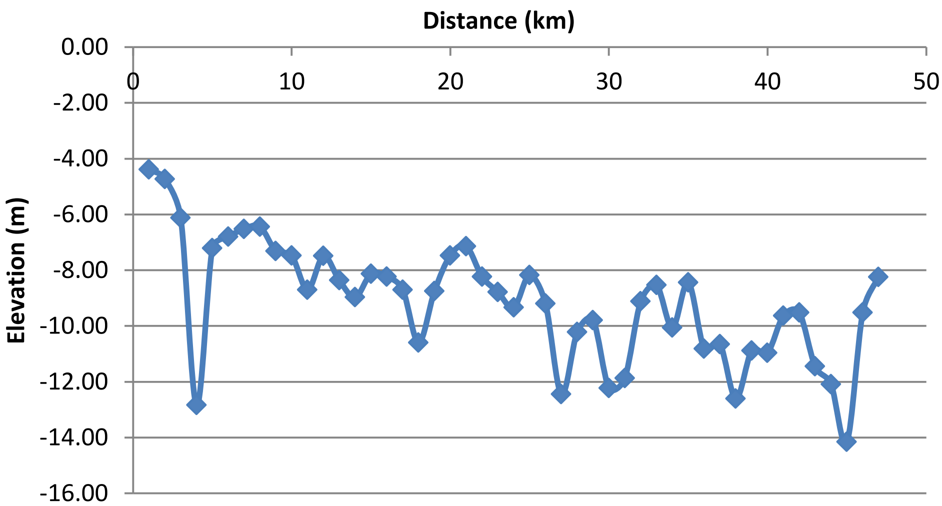

Figure (1-a) Longitudinal Section of Bed Level from Al-Sharash to Ektiban

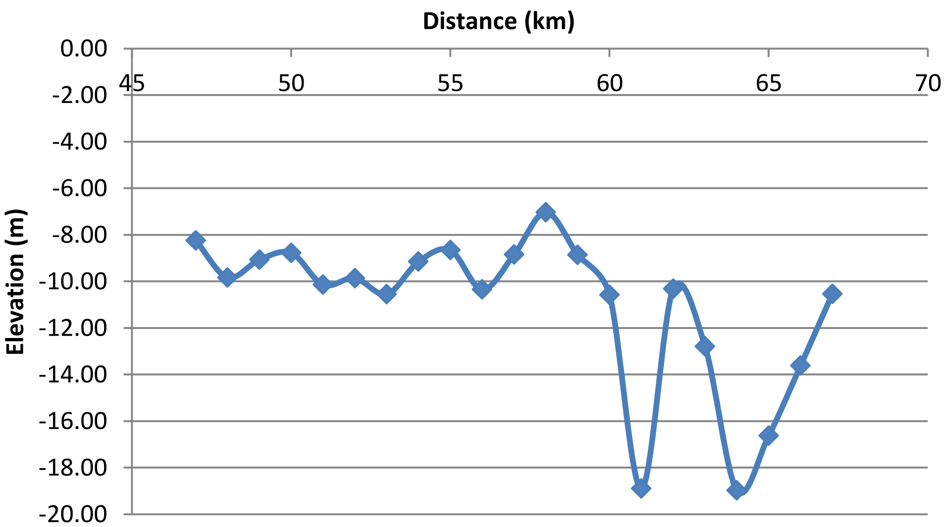

Figure (1-b) Longitudinal Section of Bed Level from Ektiban to Ashar

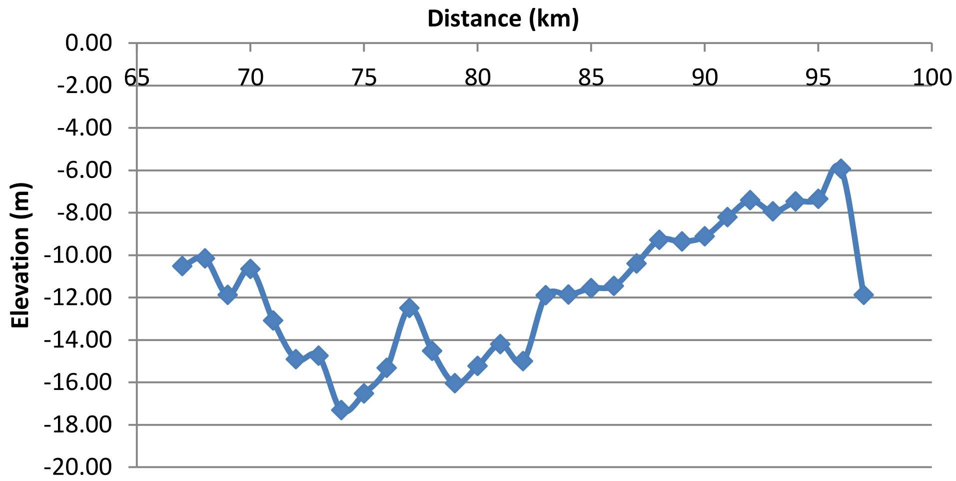

Figure (1-c) Longitudinal Section of Bed Level from Ashar to Aboflos .

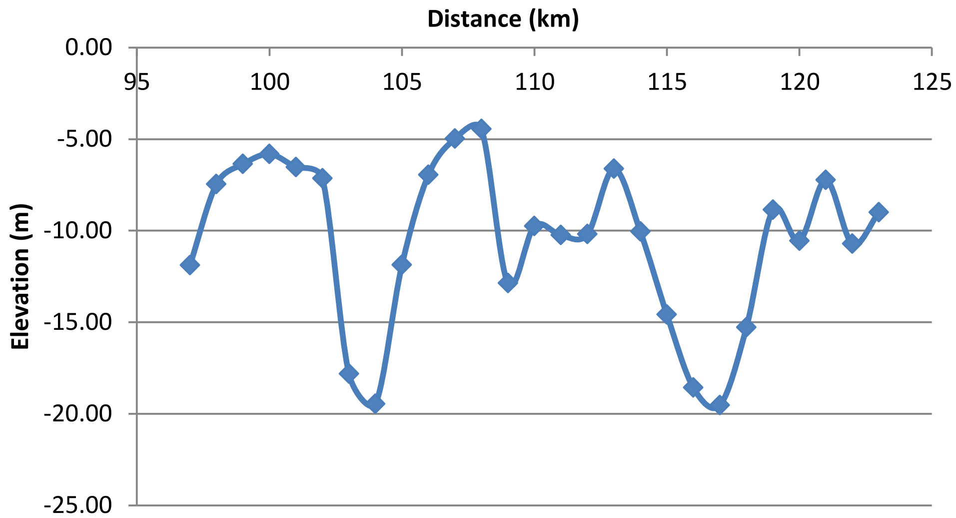

Figure (1-d) Longitudinal Section of Bed Level from Aboflos to Seehan

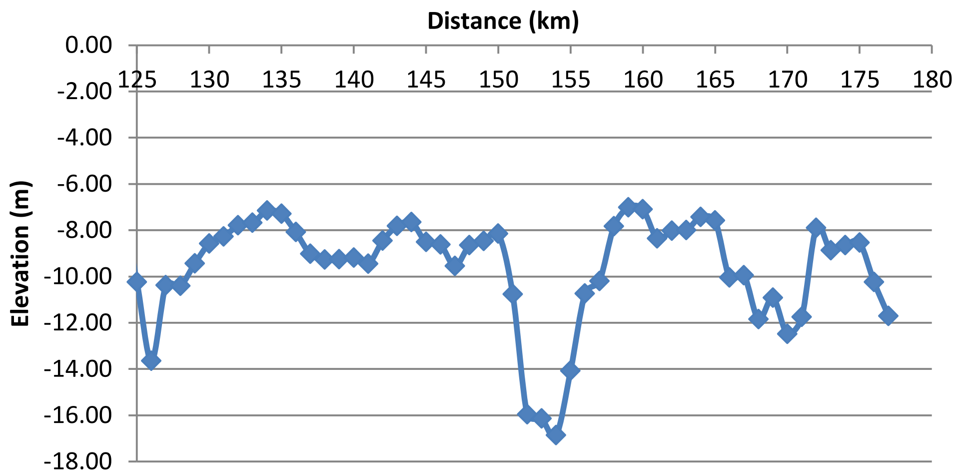

Figure (1-e) Longitudinal Section of Bed Level from Seehan to Al- Fao

The main reason for the occurrence of the friction is the roughness of these surfaces. Manning equation is one of the most commonly equations which used for calculating the roughness coefficient. This coefficient changing due to many factors. The most important of these factors are surface roughness, channel geometry variation of the cross sections of the river, the direction of the channel, and sedimentation and erosion.

A study was conducted in 1960 by [3], for the benefit of the Iraqi Ministry of Agriculture to determine the value of the Manning roughness coefficient for Iraqi rivers and found that their values is between (0.02- 0.03).

This study is considered as the first study conducted for decades to calculate the hydrodynamic resistance coefficient of the Shatt al-Arab river and determine its value. The n-value is considered as one of the most important coefficient that should be assessed. The design calculation of any hydraulic structure on the river will affected by this coefficient.

2. Methodology

The study period started from 01/12/2013 until 12/01/2014. Six measuring stations were chosen (Fao, Seehan, Aboflos, Al-Ashar, Ektiban, and Al-Sharash). Table (1) illustrates the selected measuring stations along the river extending from Al-Sharash area north of Basra city center and to the city of Fao, as shown in Figure (2). The Acoustic Doppler Current Profiler (ADCP) is used to measure cross sectional area, discharge and flow velocity of the river for full cycle of tidal 13 hours.

Also, the Van Veen Grab Sampler is used to collect bed sediment sampled of the above six stations. It is collected 18 samples, three samples for each station, along the cross-section of the river and these samples are preserved in plastic envelopes until transported to the laboratory. Volumetric analysis is performed to determine particle size distribution of the samples using pipette analysis method [5].

Table (1) The Hydraulic Properties of Stations under Consideration

Name of Station (1)	Distance (km) (2)	Width (m) (3)	Average velocity (m/sec) (4)	d90 (mm) (5)	d50 (mm) (6)	Area (m^2) (7)	Wetted Perimeter (m) (8)	Hydraulic Radius (m) (9)=(7)/(8)
Fao	0	560	0.645	0.0035647	0.0270058	3819	761	5.02
Seehan	54	330	0.587	-	-	2857	363	7.87
Aboflos	80	528	0.300	0.0033970	-	3110	607	5.12
Al-Ashar	110	370	0.228	0.0014117	0.0156000	3506	476	7.36
Ektiban	130	198	0.183	0.0016475	0.0248350	1238	212	5.84
Al-Sharash	177	201	0.155	0.001540	0.024100	1121	225	4.98

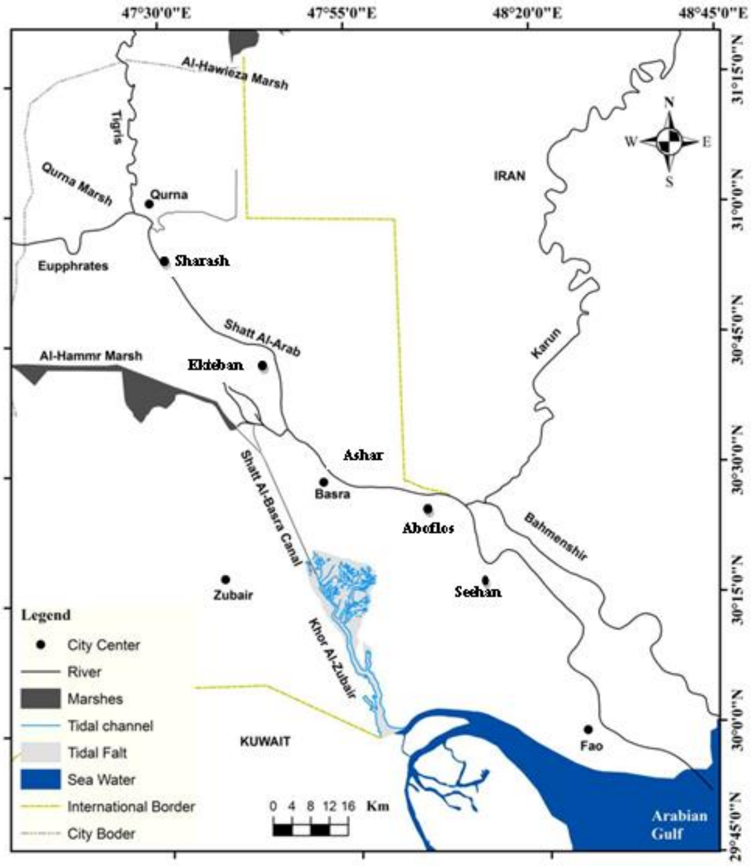

Figure (2) Map of Shatt Al Arab and Measurment Stations

Several methods are used to determine the Manning's roughness coefficient, such as: -

1. Using Cowan method [6]. In this method the relationship proposed by Cowan is

$$n = K (n_0 + n_1 + n_2 + n_3 + n_4)$$

Assuming that the channel bottom surface is uniform, smooth and straight channel and K represents the correction factor for meandering channel.

n_0 = Basic value of roughness coefficient and choosen according to the types of components of the bottom of the channel material; n_1, n_2, n_3, n_4 represent, respectively, the correction factor for the bottom surface irregularity, the values of the change in the shape and size of the cross section of the channel, obstacles and plants that cover the bottom of the channel, the values of runoff values conditions.

2. Using the standard tables to determine the value of n.

These tables are designed depending on constituent materials of the channel bottom. These materials may be natural (such as stones, sand, silt, and clay) or construction materials (such as cement, wood, metals) as well depending on the vegetation of the bottom of the channel [7].

3. The use of pictures and slides to determine the value of n.

The pictures and slides are collected by different ways, like including satellite imagery and through geological surveys (US Geological Survey (USGS) in 1957 and the US

Agriculture 1967). Then by using the data above, the explanations and interpretations are obtained and used to determine the value of n for the channels under consideration [8].

4. The use of experimental methods to find the value of n.

i- Strickler (1923) [9]

$$n = \frac{d_{50}^{\left(\frac{1}{6}\right)}}{21} \tag{1}$$

ii- Julien (2002) [10]

$$n = 0.038 d_{90}^{\left(\frac{1}{6}\right)} \tag{2}$$

iii- Handerson (1966) [11]

$$n = 0.034 d_{50}^{\left(\frac{1}{6}\right)} \tag{3}$$

iv- Julien (2002) [10]

$$n = 0.062 d_{50}^{\left(\frac{1}{6}\right)} \tag{4}$$

v- Limerinons (1970) [12]

$$n = \frac{0.11 R^{\left(\frac{1}{6}\right)}}{0.35 + 2\, log_{10}\left(\frac{R}{d_{50}}\right)} \tag{5}$$

vi- (Chow, 1959) [8]

$$n = \frac{R^{\left(\frac{2}{3}\right)}\, S^{\left(\frac{1}{2}\right)}}{v} \tag{6}$$

Where;

R = The hydraulic radius (m).

S = Slope of Shatt al-Arab river, which is equal to (0.015m / Km) [13].

d_{50} =Soil particles distribution less than (50%).

d_{90}= Soil particles distribution less than (90%).

ν = Flow velocity of the river (m/sec).

(Bajorunas, 1952) [14] concluded that the value of the Manning roughness coefficient consists of two main parts, as in the following equation:

$$n = n' + n'' \quad (7)$$

The value of (n') in the above equation represent Manning roughness coefficient due to the bottom granules, whereas (n '') value represents Manning roughness coefficient due to the shape of the topography of the river bed and is calculated from figure(3), which represents Bajorunas curve, as Ψ is calculated from the following relationship:

$$\Psi = \frac{1.65\ d_{50}}{R\ .\ S} \quad (8)$$

where, R and S are as defined above.

It is observed from figure (3) that as the value of Ψ increases the value of 1/Ψ decreases and then n'' increases. Also, equation (8) shows that hydraulic radius and slope of the channel gives inverse relationship whereas d50 is proportional to the n''-value.

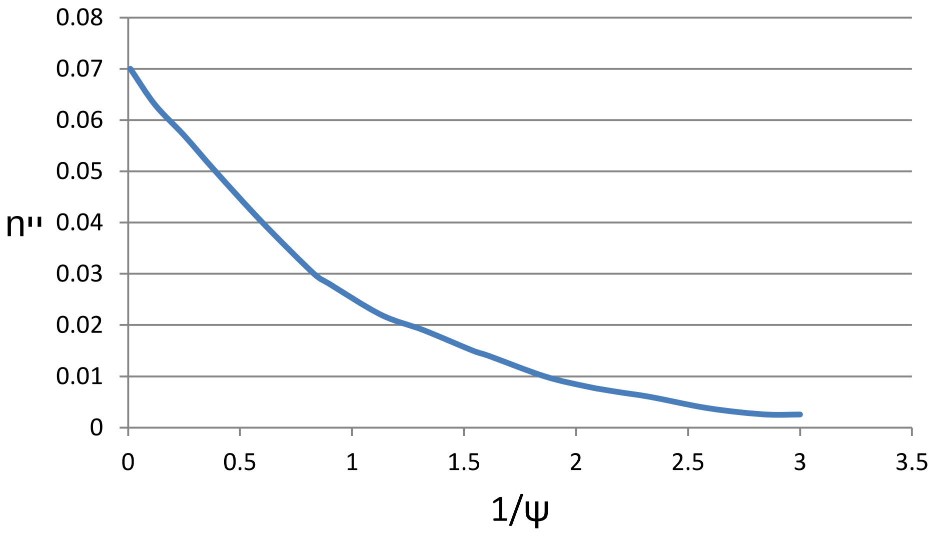

Figure (3) Bajorunas Curve for Flow Resistance (14)

The value of n that was estimated using the equations 1 to 6 explained above will give different values for the same measurement station. In order to represent each station by one value of n, the harmonic mean of the above values for each station is determined using the following equation:

$$X_h = \frac{k}{\sum_{i=1}^{k}(\frac{1}{n_i})} \quad (9)$$

where, X_h is the harmonic mean of manning coefficient at any measurement station, ni represents the value of manning coefficient by using different methods, and k represents the number of methods available in each station.

3. Results and Discussion

Equations (1 to 5) depend primarily on the particle size of the benthic sediments were used to calculate the bottom roughness coefficient (Manning coefficient) (n') of the Shatt al-Arab River in measuring stations after determining the values of (d50, d90). Figure (4) represents the cumulative particle size distribution curve of granular sediments of the measurement stations (Fao, Seehan, Aboflos, Al-Ashar, Ektiban, and Al Sharash). This curve is used to determine the values of (d50, d90) of the above stations. In addition, using of equation (6) to calculate Manning coefficient (n'), which depends on velocity and cross-sectional area of the river. It is observed from the volumetric analysis of the bottom sediment of the Shatt al-Arab river in measurement stations (Seehan and Aboflos) absence of (d50). This is due to that the alluvium deposits of Aboflos area between silt and sand, while it is found in the station (Seehan) that granular size is greater than (d90). This is due to the sandy deposits of this area results from the impact of sediment transported from the Karun River in the case of the lower tide.

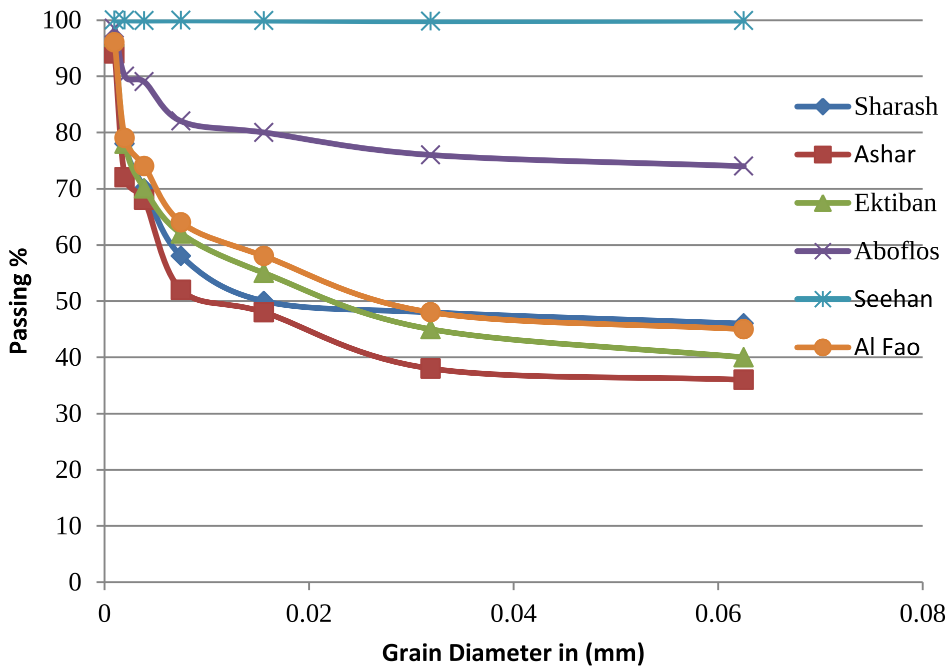

Figure (4) Accumulative Curve of Study Area

The value of Ψ is computed by subistituting the values of d50, R and S from table (1) in equation (8) for each measurement station. Then the value of (1/ Ψ) is calculated and from figure (3) n" is determined. Having determine the values of n' and n", the value of n is calculated using equation (7).

It is found in other measuring stations (Fao, Al-Ashar, and Ektiban) that there is a compatibility in grain size distribution. This indicates the similarity of benthic sediment quality in terms of particle size as shown in figure (4), as well as the velocity of currents in the stations is somewhat regular. Tables (2 to 7) show the results of calculations when applying equations (1 to 5), which considers the granular size, as it is based on the nature of the roughness on the river bed. The study found that the value of the Manning coefficient ranges (0.0115-0.046), while it is observed that equation (6) recorded values for the Manning coefficients ranges (0.0177-0.06), because the equation depends on the velocity and high velocities are recorded at Al Fao and Seehan.

Table (2) Manning Coefficient of Al Ashar

Equation No.	n'	n''	n
1	0.0075	0.004	0.0115
2	0.0127	0.004	0.0167
3	0.0170	0.004	0.0210
4	0.0310	0.004	0.0350
5	0.0130	_	0.0130
6	0.054	_	0.054
Harmonic Mean (X_h)=			0.0188

Table (3) Manning Coefficient of Ektiban station

Equation No.	n'	n''	n
1	0.0081	0.0065	0.0146
2	0.0130	0.0065	0.0195
3	0.0184	0.0065	0.0249
4	0.0334	0.0065	0.0399
5	0.0133	_	0.0133
6	0.0580	_	0.0580
Harmonic Mean (X_h)=			0.0216

Table (4) Manning Coefficient of Aboflos Station

Equation No.	n'	n''	n
2	0.0147	_	0.0147
6	0.0385	_	0.0385
Harmonic Mean (X_h)=			0.0319

Table (5) Manning Coefficient of Seehan Station

Equation No.	n'	n''	n
6	0.0262	_	0.0262
Harmonic Mean (X_h)=			0.0262

Table (6) Manning Coefficient of Al Fao

Equation No.	n'	n''	n
1	0.0082	0.012	0.0202
2	0.0148	0.012	0.0268
3	0.0186	0.012	0.0306
4	0.0340	0.012	0.0460
5	0.0132	_	0.0132
6	0.0177	_	0.0177
Harmonic Mean (X_h)=			0.0218

Table (7) Manning Coefficient of Al Sharash

Equation No.	n'	n''	n
1	0.0081	0.01	0.0181
2	0.0129	0.01	0.0229
3	0.0182	0.01	0.0282
4	0.0333	0.01	0.0433
5	0.0130	_	0.0130
6	0.0600	_	0.0600
Harmonic Mean (X_h)=			0.0239

4. Conclusions

1. Sediments of Seehan area is of sandy type and this result from the impact of the discharge of the Karun River sediments in the case of the lower tide; therefore, there is no (d_{50}, d_{90}) because particle size of the sand will be of large size.
2. Sediments of Aboflos area is of an alluvial type and mixed of silt and sand. This is due to the shipping traffic in the port of Aboflos in addition to the effect of sandy sediments transmitted from the Karun River in the state of the upper tide; therefore, there is no (d_{50}).
3. There is no constant value for the coefficient of roughness, because of the variation of the bottom sediments and physical factors for each station along the study area.
4. The study area can be divided into two parts, the southern (lower reaches), South of Karun River, and north of the stations, from Aboflos to Qurna (uper reaches). The harmonic mean values of Manning coefficient ranged from 0.0188 to 0.0319 at the down of the Karun River, while at the city of Basra ranged from 0.0218 to 0.0262.
5. It is found that roughness coefficient of the downstream the river (south of the Karun River) lower than that one of the upstream. This is due to the velocity of water currents in the region. Also, the large number of bends in the river in Sebah area, Al-Dorah and Al- Fao increased currents and hydraulic pressure of the river and thus decrease Manning coefficient.
6. There is no clear effect of the cross-sections area of Shatt al-Arab river on the variation of roughness coefficient values. The main influencing factor is the velocity of the currents.

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