

Salinity Intrusion in Shatt Al-Arab River, Southern Iraq

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Abstract

The factors influencing the salinity intrusion in Shatt al-Arab river estuary are as follows: the river mouth shape, the discharge, the sea level variation, the wind and its direction, etc. The observed data (2009 to 2012) show that when the upstream runoff decreases, the salinity observed in the rivers increases, and vice versa. The salinity intrusion results from natural and human factors. The intensity of salinity intrusion is mainly controlled by the tide activity and upstream runoff. Prevention of the salinity intrusion and solution of the problem of water resources in the Shatt al-Arab River must be based on the discharge and reasonable arrangement of water resources in the whole river. In order to reduce salinity intrusion effectively and protect the water supply in the Shatt Al-Arab River, some effective measures must be taken to control the increase of water consumption and water pollution. To solve the problem of water supply in Shatt Al-Arab river, the hydraulic engineering construction in the river shall be strengthened, which can adjust the upstream runoff in different seasons. The mechanism of salinity intrusion in the Shatt al-Arab River shall be studied further and the early warning system of salinity intrusion shall be established, to provide the scientific support for preventing salinity intrusion and ensuring a reliable water supply.

Introduction

The Shatt Al-Arab River surrounded by a large population, developed industry and high-level urbanization. As a result of the population growth, the quick industrialization and urbanization, the water supply demand is continuously expanding. However, due to the weak adjusting ability of local water resources, the salinity intrusion became longer.

The salinity intrusion in recent years (from 2004 to 2012) is getting more active. Since October 2009, the strong salinity intrusion seriously threatens the quality of the water supply in the Shatt Al-Arab river. The salinity intrusion results in serious economic and negative social effects to the Shatt Al-Arab river. In order to solve the salinity intrusion problem, and protect the safety of drinking water, we must examine the factors affecting the salinity intrusion in Shatt Al-Arab river Estuary and exploring the effective measures for utilizing the water resources of the whole river have a very important to ensure the sustainable development of water resources and the social stability in the Shatt al-Arab River .

The salt intrusion mechanism is generally divided into three types:

- a) the saline wedge,
- b) the partially mixed, and
- c) the well mixed type.

A stratification estuary occurs when the fresh water discharge in an estuary is large compared to the tidal owns. A well-mixed estuary occurs when the fresh water discharge is small compared to the tidal owns [1]. Suggests that in stratification, partially mixed and well mixed estuaries, the intrusion length reaches equally far and that it can occur at the same river discharge. In contrast, a saline wedge only occurs close to the mouth and during a period of high river discharge. The well mixed estuary occurs during low owns, resulting in a much deeper salt intrusion.

During the dry season, when water availability is lowest, water requirements are highest. At these times, when the problems of maintaining an acceptable water quality are most pronounced, the salt intrusion is generally of the mixed type. As the water consumption increases, the salt intrusion becomes even more strongly mixed [2].

Seawater intrusion is typically detrimental to an environment. When saltwater enters areas unadjusted to saline conditions, it leads to habitat loss. Because most plants grow in freshwater conditions, many of the plants in once-freshwater marshes will die. When freshwater is drawn faster than it can be replenished, seawater will inevitably be drawn from the water table (layer of ground water), which is harmful to people's health [2].

The behavior of the salt tide is mainly controlled by the upstream runoff and the downstream tidal current. When the high saline tidal water mass in the continental shelf flows into the estuary during the flood tidal period, the salt water diffuses and mixes with the fresh water coming from upstream, which makes the water in upstream rivers salty. This causes a salinity intrusion. When the chlorine content in the water exceeds 250 mg/l, the water quality will not meet the drinking water standard [4]. The factors influencing the salinity intrusion in the Shatt al-Arab River estuary are as follows: the river mouth shape, the rivers topography, the sea level variation, the wind and its direction, etc., in which the effect of the astronomic tide is relatively stable and periodic. The tidal current in the Shatt al-Arab River estuary is semidiurnal.

Usually, on the first day and the fifteenth day of each lunar month, the water level during the flood tide period reaches maximum, and the effect of the salinity intrusion is also relatively large.

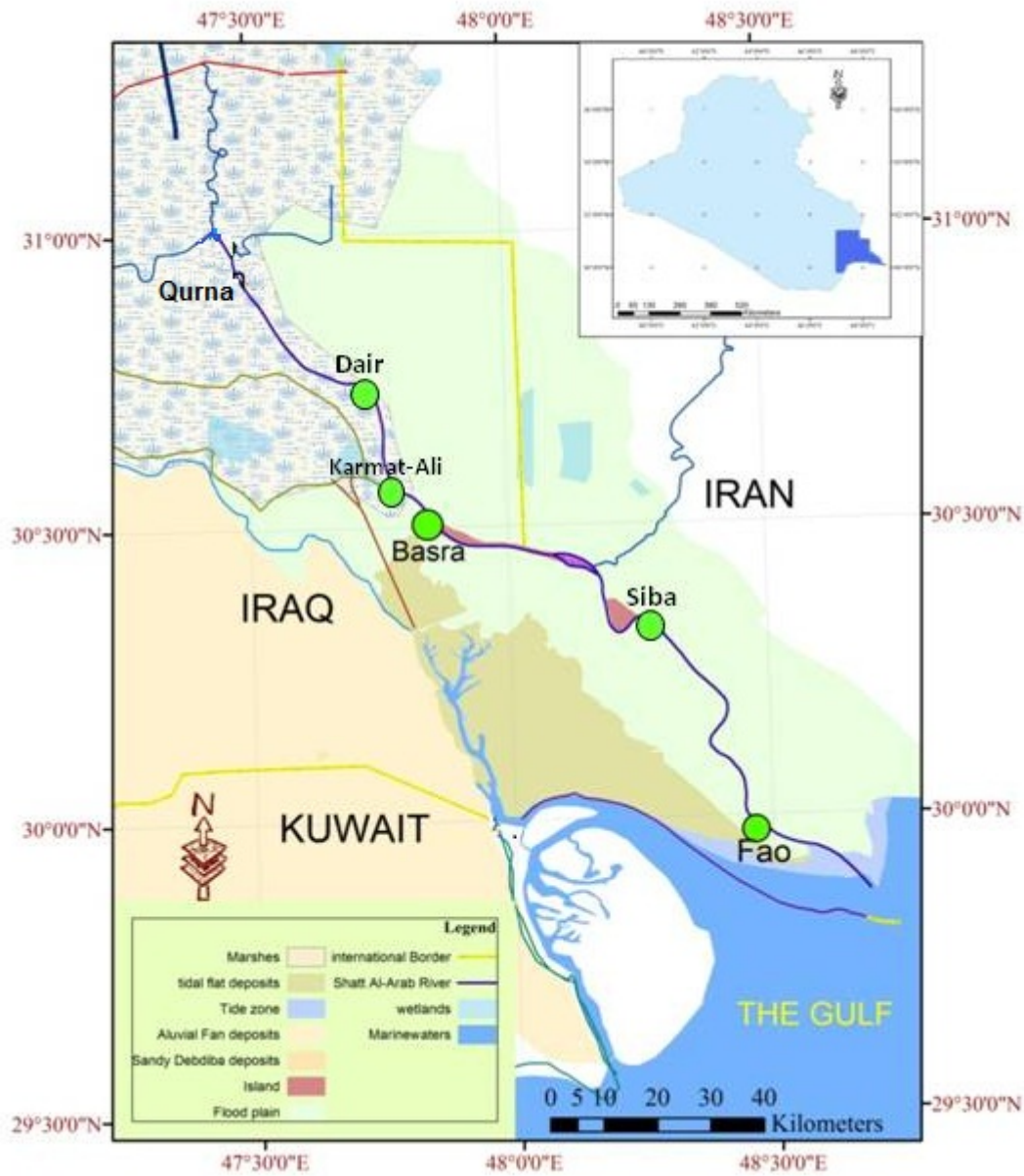


Fig. (1): study area show locations station (O)

Method

During the course of the tidal work measurements of salinity were made at one meter intervals through the water column every hour over complete tidal cycles nine stations along Shatt Al-Arab river (Fig. 1) by using Digital Salinometer (OSK 3288 Model: E-202). The work has done over a year Sep. /2012 for different periods (spring-neap) of the tide at low discharge and for the year 8, 9/2009 [3].

Results & Discussion:

The upstream runoff is an important factor influencing the salinity intrusion. The larger the fresh water amount flowing upstream is, the shorter the distance of the salinity intrusion will be and the less the effect of the salinity intrusion will be. The salinity intrusion often occurs in dry seasons. The observed data (table 1) show that when the upstream runoff decreases, the salinity observed in the rivers increases, and vice versa [2].

Table 1: shows salinity and discharge for many regions

year	Region	Salinity ‰	Discharge m ³ /sec
1988	Tigris	---	89000000
1988	Euphrates	---	48000000
1993 - 1994	Fao	0.85	1200
9/2006	Silo	1.27	---
7/2008	Karun (52%)	---	000000
8/2008	Silo	3.2	---
3/2009	Fao	30.56	---
3/2009	Seebah	23.67	---
10/2009	Ashar	12.14	---
11/2009	Al Muhmadia	7.96	---

Since 2004s, there are more and more such human activities as dredging sand from rivers, navigation channel dredging, and so on, which leads to the riverbed level getting down in the Shatt al-Arab River Estuary area and

hence, makes the major tidal channels deep. But according to statistics the average velocity current will not exceed 0.6m/sec approximately [5], which is small then this velocity cannot get riverbed down.

The region with a long summer, very hot and lack of rain, while winters are short and has a rain very little, and drought conditions passers make the area a reality under the influence of highland air surrounding the epicenter of the wind in the most active months of the year, especially during the summer months. Characterized the region winds speeds (15 km/h) in most months of the year, especially during the summer months, and it happens as a result of the lack of symptoms terrain, are also increasingly repeat northwest wind during the summer months, and also increasing rates of speed during these months, while increasing repeat Wind South and South-East and rates of speed during the transitional seasons [6].

In an estuary of the well mixed type the variation of the salinity along the longitudinal axis of the estuary is gradual. This implies that if a continuous survey is done along an estuary, e.g. by a moving boat or by simultaneous observations along the estuary, a smooth curve can be tested through the observed cross-sectional averaged salinities. Figure 2 shows average salinity effect, where reach up to areas far beyond of Sindbad Island because of the influence of south east winds in the case of its velocity 40 km/h(6/Sep./2012).In Figure 3 the average salinity decrease in the previous regions when the wind velocity was 5 km/h in the south east direction(12/Sep./2012) .

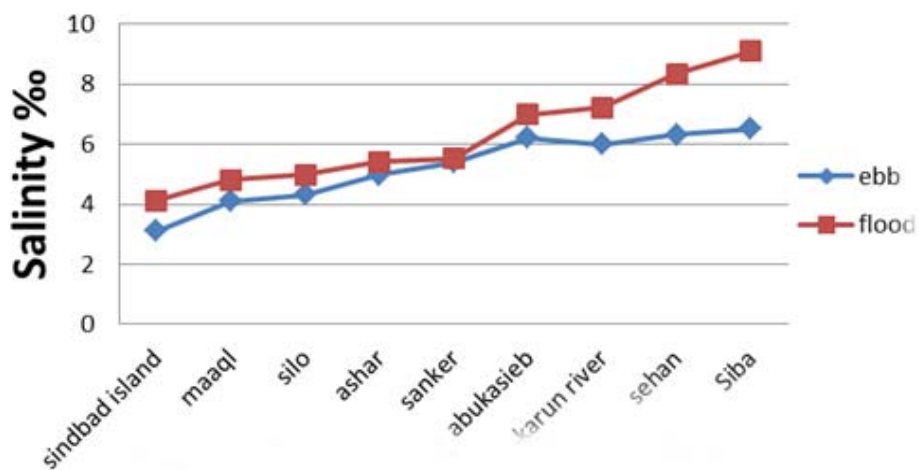
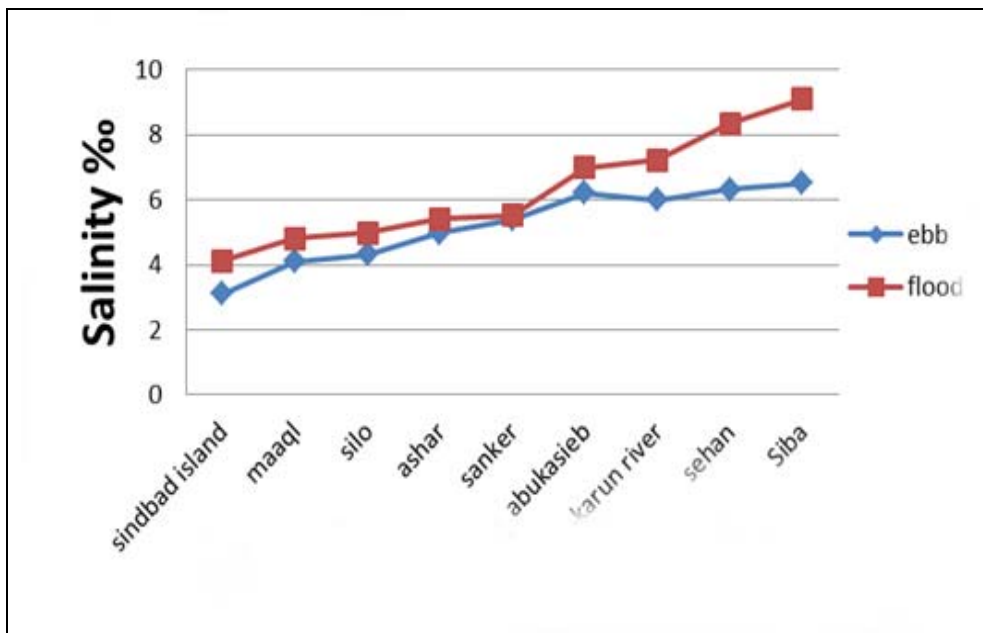


Fig. (2): Average Salinity for tidal cycle to many regions (wind speed 40km/h SE) 2012

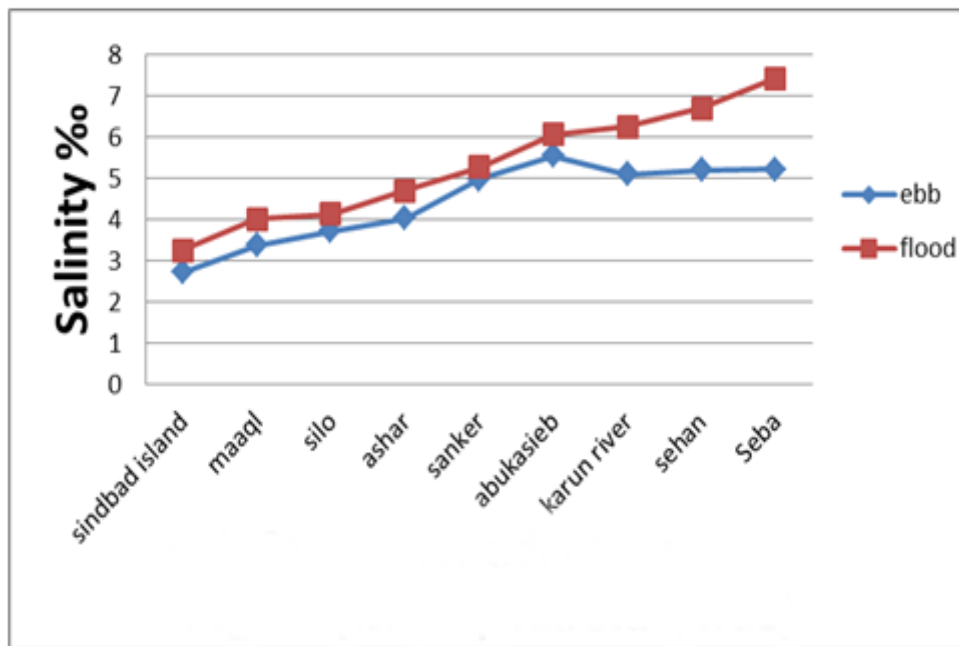


Fig. (3): Average Salinity for tidal cycle to many regions (wind speed 5km/h SE) 2012

Sustainable Utilization of Water Resources in Shatt al-Arab River

The salinity intrusion results from natural and human factors. The intensity of salinity intrusion is mainly controlled by the tide activity and upstream runoff. The tide activity is a natural phenomenon, which can be adjusted by human beings in a very limited degree. The reduction of the upstream runoff in recent years was caused and large water amount consumption which belongs to both human and natural factors. However, the upstream runoff can be adjusted by human to a certain extent. In fact, the water-holding capacity of the existing reservoirs in the upstream of the Shatt al-Arab river cannot ensure the water supply of the Shatt al-Arab River.

There are three main fresh water sources into Shatt Al-Arab (Fig. 1) the Tigris and the Euphrates rivers, that meet in the Qurna to form the Shatt al-Arab and the Karun river, where the contribution of the Karun river from the discharge of the Shatt Al-Arab is about 52%, was observed in the last ten years decreased discharge of the Shatt Al-Arab and the output of decline in annual revenue to the Tigris, Euphrates and Karun rivers as the latter cut fed Shatt Al-Arab almost completely since the month of July 2008. The greatest revenue for the Tigris and Euphrates rivers in 1988, which was 89 and 48 billion m^3 , respectively [9], while decreased this revenue in 2000 to 19 billion m^3 for both of them as a result of such a decline in revenue and inventory led to a decline in the discharge of the Shatt al-Arab, and thus led to the progress of salts in the Shatt Arabs.

Total discharge of the Shatt al-Arab in (18/3/1993) in the Fao was 1200 m^3 / s [7] and the rate of the surface salinity 0.76 ‰ for the tidal cycle in the Fao city. While in 2009 the discharge of the Shatt Al-Arab is decline, where the annual discharge of the river in the Basra city was less than 50 m^3 and this made salts progress along the mouth of Shatt Al-Arab. I've averaged salinity of surface and bottom of the tidal cycle in the Fao city was 30.56 ‰ and 31.53 ‰, respectively (9/3/2009), and in the Syba city the highest rate of salinity of surface and bottom was 23.67 ‰ and 24.28 ‰ respectively (15/8/2009). As well as the Basra city, the highest values of the rates of the surface and bottom salinity 12.14 ‰ and 13.55 ‰, respectively (11/11/2009), also provides salts did not stop at this point, but passed north of the city toward the Karma. Muhammadiyah Island, where the salinity rates of surface and bottom 7.96 ‰ and 9.93 ‰, respectively (4/11/2009).

From the above description is clear that the salinity of the waters of the Arabian Gulf transmitted in a manner of advection and sometimes in a manner diffusion until it reaches the Fao city, then continues to advance in a diffusion manner towards to the downstream, and this case

with in the area of the Al-Dear city where the rates of the surface and bottom salinity 1.3 ‰ and 1.39 ‰ , respectively (3/12/2009), and the water column is fully mixed along the tidal cycle. It also did not observe a wedge front (from Fao until the Basra city) because the lack of sufficient amounts of fresh water needed to create such a wedge front. Provide salts towards the top of the river was change the shape of estuary, where it was the head of the estuary during the high discharge period extends to a distance not to exceed 5 km north of the Fao city, while critical discharge created another division where it became the head of the estuary in the north of Basra city and mouth downstream in the Fao city.

The deterioration of the salinity of the Shatt al-Arab in 2009 lead to rating the Basra city and its southern suburbs cities plagued by environmentally which left of environmental risks to human health , animals and plants as well as weakness facilities, industrial life Vary values water discharge contained to Iraq from Tigris , Euphrates and Karun rivers involves more than two, and is shown in Figure (Fig. 1) the size of the TTM water to the Tigris and Euphrates in Iraq with the passage of time , especially in recent years(before 2003) in the southern part of the Tigris and Euphrates dramatically , which did not meet with the increasing demand on the waters , has reflected a lack of drainage of rivers southward discharge and salinity of the Shatt al-Arab river[8]. So increased rates of salinity in the Shatt al-Arab during the year (2009) from the extreme south (Fao station) compared to the north (Al-Dear Station) , which reflect the most high indicators of positive and negative ions in the river , which reflects the rising pollution in the waters.

Prevention the salinity intrusion and find solution to the lack of water resources into the Shatt Al-Arab river must be based on the discharge and reasonable arrangement of water resources in the whole river. According to increase

salinity, the decrease of upstream runoff in dry period has a great influence on the fresh water supply, but the runoff can be adjusted by the upstream key reservoirs to a certain extent. For the river bands change some measures can be taken, such as bumpers for protection against corrosion [9]. The influencing factors, such as effect of wind and its wind direction on salinity intrusion, can be adjusted by human beings to a very limited extent, but the influence of the tide activity can be controlled by the engineering construction. A fundamental method is to construct a water-saving anti-polluting society. In recent years, the demand of urban and rural water supply has increased quickly in Shatt al-Arab River, due to the rapid economic and social development and the quick urbanization.

The amount of industrial pollution recorded in 2009 was high, due to the increase in population and the large number of factories. Many studying was carried out during months 2006 to 2007 [10].

The hydraulic engineering construction shall be speeded up. The hydraulic engineering is the basis of water resources arrangement and water quantity dispatching. To solve the problem of water supply in Shatt al-Arab River, the hydraulic engineering construction in the basin shall be strengthened, which can adjust the upstream runoff in different seasons, and there exists serious shortage of water. So we shall speed up the pace of the comprehensive planning of water resources in the river and the water supply planning of cities in the Shatt al-Arab River, consider the safety of water supply in the river and adjust the geographical distribution of urban water supply. To clear the way for the construction of key hydro-projects, meanwhile, shall build more water gates, pumping stations, reservoirs, water treatment plants, etc., enlarge the emergent water supply capacity, carry out the dredging, enlarging, maintaining and enforcing of the existing works, enhance the capacity of transferring and storing fresh water, and increase the guarantee of water supply[11].

Concluding Remarks

In recent years, due to successive dry seasons, the upstream runoff, the effect of wind its direction, on the Shatt Al-Arab river estuary, the salinity intrusion becomes more serious. The drinking water is endangered in this area, which has negative effects on the social and economic development. It is predicted that in the future the economy of the Shatt al-Arab River will be increasing continually and stably. The population, the industry and urbanization will also increase. The demand of water resources will increase in both quantity and quality. Thus, the stress created from the economic development on the regional resources and environment will be even larger. Therefore, the measures for preventing the salinity intrusion should be put forward; and, the sustainable utilization of water resources should be ensured to support the sustainable development of the economy and society.

In order to resist salinity intrusion effectively and protect the water supply in the Shatt Al-Arab river, some effective measures must be taken to control the increase of water consumption and water pollution. In the long term, the Shatt al-Arab River shall construct a water-saving anti-polluting society center, establish a management system of water resources adaptable to the water rights index control by executing a reform of the water utilization system, establish an economic structural system adaptable to the carrying ability of regional water resources by adjusting the economic structure , industrial structure and establish a hydraulic engineering system adaptable to the optimizing arrangement of water resources by constructing water resources arrangement and water-saving projects. Only by these can the efficiency and benefit of water resources utilization be increased and the sustainable development is realized [12].

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