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# Analysis of Water Quality Using Physico-Chemical Parameters in the Shatt AL-Arab Estuary, Iraq

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**Abstract** Six sampling stations, Al-Qurna, paper factory, Al- Sindebad, AL-Ashar, Al-Sebah and Al-Fao , representing different sectors of Shatt AL-Arab estuary were selected to the distribution of the Physical and chemical parameters. Water sample analyzed from August 2008 to July 2009,Dissolved Oxygen (DO), Turbidity, Total Suspended Solids (TSS), Total Dissolved Solids (TDS), Electrical Conductivity (EC) , temperature, salinity and pH as well as nutrients were also analyzed . The mean range of the following parameters were recorded: pH (7.56-7.84), EC (1.29-3.22 mmohs/cm$^2$), Ca (87.18-130.26 mg/l), Mg (60.35-111.17 mg/l), Cl (304.7-753.31 mg/l), TSS (11-38.58 mg/l), TDS (891-2040.42 mg/l), DO (5.16-10.05 mg/l), turbidity (4.57-39.03 FTU), water temperature (21.09-22.47 ℃), air temperature (23.54-35.26 ℃), $SO^{2-}$ (285.73-663.89 mg/l), $HCO_3$ (204.39-255.22 mg/l), and Nutrient($NO_2$, $NO_3$ ,$PO_4$). Also the seasonal variation of all the parameters were monitored during this study and the result showed some fluctuation in some of them during different seasons at different locations of the estuary The results indicate that the water is no-polluted and can be used for domestic, irrigation and fisheries.
**Keywords** *Shatt AL-Arab estuary*; *Physico-Chemical Parameters*; *Monthly variation*

## Introduction

As water is one of the most important compounds of the ecosystem, but due to increased human population, industrialization, use of fertilizers in the agriculture and man-made activity, all these factors effect on water quality. The natural aquatic resources are causing heavy and varied pollution in aquatic environment leading to pollute water quality and depletion of aquatic biota. It is therefore necessary that the quality of drinking water should be checked at regular interval, It is difficult to understand the biological phenomena fully because the chemistry of water revels much about the metabolism of the ecosystem and explain the general hydro - biological relationship (Basavaraja et al., 2011). The Shatt al Arab River is formed after the confluence of the Euphrates and the Tigris Rivers near the city of Qurna in southern Iraq. The southern part of the river constitutes the border between Iran and Iraq until it discharges into the Arabian Gulf, with a total length of 192 km, the Shatt al Arab widens over its course, expanding from a width of 250-300 m near the Euphrates-Tigris confluence to almost 700 m near the city of Basrah and more than 800 m as it approaches the river mouth. An area of 145,190 km2 drains directly to the Shatt al Arab region downstream of the Euphrates-Tigris confluence (excluding the Euphrates and Tigris Basin areas). Several tributaries join the Shatt al Arab during its course, most importantly the Karkheh and the Karun Rivers. The Shatt al Arab Delta area is classified as estuarine-deltaic because the river's sediment seeps into a shallow, narrow part of the Arabian Gulf. The Shatt al Arab Delta is 140 km wide and splits into more than 10 branches. The landscape is characterized by green marshy areas, lakes, lagoons and estuaries, bordered by irrigated lands and date palm plantations and surrounded by desert (UN-ESCWA and BGR2013).

Shatt AL-Arab depends on some water sources tributaries for feeding. These tributaries are Al-Hammar, Al-Huyaza and Al-Qurna marshes and Al-Karoon River which flows in its left side. Shatt AL-Arab also affected by the climate tide comes from Arabian Gulf which reduces discharge of Shatt AL-Arab water to the sea. Shatt AL-Arab's two banks are characterized to be low in its flow area reaching Basrah , its full with water channels which are used for irrigation agriculture land (Hussain et al., 1991) studies on water quality and different land use to prevent the salinization in this soil which irrigated with Shatt Al-Arab water.

Water quality characteristics of an aquatic environment are of great significance for the proper understanding of distribution, growth and physiological function of the biotic community inhabiting the area. Understanding of water quality is also a very important factor in the semi-enclosed systems where nutrients and pollutants may be concentrated and where the growth and proliferation of plankton is largely dependent on the environmental and physico- chemicals variables which can either support or limit their production capacities. Although scientific measurements are used to define water quality, it is not simple to say that water is good or bad. So the determination is typically made, relative to the purpose of the water.Whether it is for drinking or to wash a car or for some other purpose, poor water quality can pose a health risk for people and ecosystem.

As described by (Tabari et al., 2011) that one major goal of surface water quality data collection may be the estimation of magnitude of changes in the concentration of various constituents. Such estimates may be to determine water quality impacts over time due to human activities, changes brought about by regulations, improvements to waste water treatment facilities, or land use changes. Also, the goal of water quality assessment includes: accurately assessing pollution level identifying the key pollutants' effect on the quality of water and future development trend (Al-Hejuje 2015 ).

This field study was initiated to assess the extent and magnitude of water quality threats of the Shatt AL-Arab-estuary. Six sampling locations were selected to cover the distribution of the pollutants in this estuary. The physical and chemical aspects of the water were assessed which will provide valuable indications of the overall health of the ecosystem of the Shatt AL-Arab estuary.

## Materials and Methods

Water sampler were used to collected water samples monthly, from August 2008 to July 2009. from 6 fixed stations as shown in Figure. (1).The stations on different sectors of Shatt Al-Arab, are Al-Qurna, paper factory, Al- Sindebad, Al-Ashar, Al-Sebah and Al-Fao (indicate the number - station 1-6) .The air and water temperatures were measured by simple thermometers with a range of 10-100˚C graduate at 0.2˚C,; pH was measured using pH meters model HANNA HI-9821,and Electrical Conductivity (EC) was measured using portable digital conductivity meters (WTW 3301).The TDS, TSS, $HCO_3$ and $SO^{2-}$ and DO, Mg, Ca and Cl were analyzed according to APHA (2005) standard method. Nutrient (NO3, NO2, PO4,) were measured by using Parson et al. (1984) methods.

## Result and Discussion

Water is a natural resource with limited and uneven distribution in time and space. All forms of life and all human activities are dependent on water. Water resources in Shatt al-Arab estuary are of great importance to human life and economy and are the main source of meeting the demand for drinking water, for irrigation of lands and industries. Lack of water is considered as a limiting factor of socio-economic development of a country. The rates of biological and chemical processes depend on temperature. Aquatic organisms from microbes to fish are dependent on certain temperature ranges for their optimal health. Optimal temperatures for fish depend on the species: some survive best in colder water, whereas others prefer warmer water. Benthic macro invertebrates are also sensitive to temperature and will move in the stream to find their optimal temperature. If temperatures are outside this optimal range for a prolonged period of time, organisms are stressed and can die.

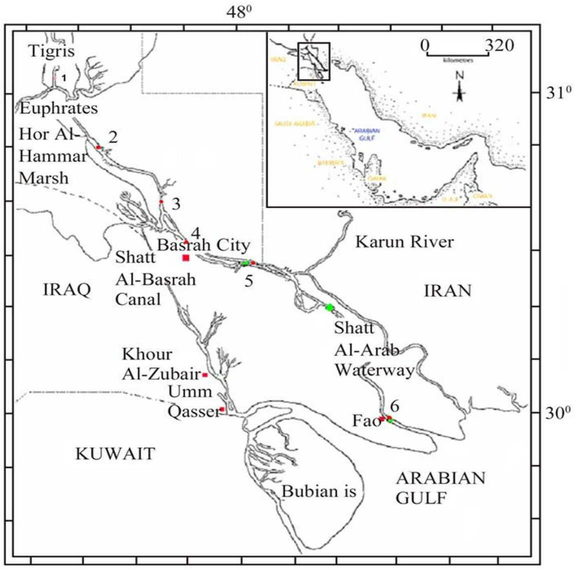


Figure 1 .Map of the Shatt Arab Estuary showing the sampling locations

Results of the present study showed that the air temperature in all stations were high during summer and low during winter. Temperature at Al-Qurna ranged from 12.0 to- 38.8℃. paper factory ranged was from 14.8-36.4℃, Al- Sindebad ranged from 14.0-33.0℃, Al-Ashar ranged from 12.0-34.0℃, in Al-Sebah ranged from 16.5-40.3℃ and in Al-Fao ranged from 17.4 -39.0℃ .

Water temperature varies in accordance with ambient air temperature. The spatial variations in water temperature among stations may be due to the variation in the sampling time at each station, or the depth of water at each station .The minimum (12℃) and maximum (45℃) water temperature were recorded during winter and summer months respectively, with a mean water temperature of (27.83℃) (Tables.2). The seasonal mean values of water temperature during winter and summer were (13.6℃) and (44℃) respectively. The highest variations in water temperature between winter and summer was depending mainly on the variations in the air temperature , which was the highest in summer because of the long day period , and the lowest in winter because of the short day period. A significant correlation (r = 0.926 , p<0.01) was found between water and air temperatures. These results agree with 13-33.4℃ obtained by Al-Hejuje 2015 .

The value of pH in natural water is affected by geological shed water and balance of $CO_2$, $H_2CO_3$ and $CO_3$. It ranged from 4.5-8.0 (Gems 1997), effected by processes which can be changed the concentration of dissolved $CO_2$. pH value effected on transpiration process between nutrient type and mineral it affection pollution toxic , which containing basic and acidic compound because of the ionization process (Gems, 1977). PH affects many chemical and biological processes in the water. For example, different organisms flourish within different ranges of pH. The largest variety of aquatic animals prefers a range of 6.5-8.0. pH outside this range reduces the diversity in the stream because it stresses the physiological systems of most organisms and can reduce reproduction. Low pH can also allow toxic elements and compounds to become mobile and "available" for uptake by aquatic plants and animals. This can produce conditions that are toxic to aquatic life, particularly to sensitive species of fish. Changes in acidity can be caused by atmospheric deposition (acid rain), surrounding rock, and certain wastewater discharges Variations in pH were very large during the study period .The minimum (7. 0) and maximum (8.91) pH was recorded during autumn and winter months respectively, with a mean pH of 7.92 . The mean values of pH during winter and summer were 7.92 and 8.21, respectively This result agrees with Al- Kazaeh (2014)(7.4-7.9) and Al-Hejuje (2015) (7.4-8.52) .

DO levels fluctuate seasonally and over a 24-hour period. They vary with water temperature and altitude. Cold water holds more oxygen than warm water and water holds less oxygen at higher altitudes. Thermal discharges, such as water used to cool machinery in a manufacturing plant or a power plant, raise the temperature of water and lower its oxygen content. Aquatic animals are most vulnerable to low DO levels in the early morning on hot summer days when stream flows are low, water temperatures are high, and aquatic plants have not been producing oxygen since sunset. Fluctuations in DO were wide along Shatt Al-Arab during winter and summer. The minimum (5.3 mg/L) and maximum (9.3 mg/L). DO were recorded during summer and winter months, respectively, with a mean DO of 7.63 mg/L . The mean values of DO during summer and winter were 6.37 and 8.57 mg/L, respectively. The dissolved oxygen content of water is influenced by the sources, raw water temperature and chemical or biological processes taking place in the aquatic system. The reduction of dissolved oxygen at some stations (especially at Al-Ashar ) during Summer and Autumn seasons can be due to the increasing in the untreated domestic sewage which polluted the water with reducing substances (such as nitrite) or due to organic pollutants which fasten the consumption of dissolved oxygen in water during warm months Low levels of dissolved oxygen in some stations are a sign of pollution and then , it is an essential parameter to be taken into consideration when the objective is to assess the water quality (ALHejuje ,2015).

Total solids suspended levels varied over wide range of 2.50-332.00 mg/L (Table 1). The minimum (4 mg/L) and maximum (187 mg/L) levels were recorded during summer months, respectively, with a mean value of 59.26 mg/L. The seasonal mean values of total solid suspended during winter and summer were 33 and 73.83 mg/L, respectively (Table.2). Fluctuation

Table 1 Regional distributions of physical and chemical parameters in six stations of Shatt AL-Arab Estuary during Aug.2008-Jul.2009 (All parameters determine in mg/L, while Turbidity in FTU, and EC in dS/m)

| Season | Station | Month | PH | EC | TDS | TSS | Turb. | Ca | Mg | Cl | $HCO_4$ | $NO_2$ | $NO_3$ | $PO_4$ | $SO_4$ |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Summer | 1 | Aug.08 | 7.60 | 2.15 | 1930 | 60 | 63 | 80 | 59 | 355 | 58 | 1.03 | 10.32 | 2.74 | 340 |
| Autumn | 1 | Sep.08 | 7.10 | 2.3 | 2510 | 96 | 40 | 128 | 44 | 2057 | 183 | 0.58 | 8.85 | 1.58 | 467 |
| Autumn | 1 | Oct.08 | 7.20 | 2.38 | 1568 | 48 | 17 | 80 | 413 | 390 | 268 | 0.12 | 17.74 | 2.49 | 369 |
| Autumn | 1 | Nov.08 | 7.70 | 2.12 | 2588 | 62 | 26 | 248 | 194 | 660 | 366 | 0.98 | 3.2 | 2.40 | 459 |
| Winter | 1 | Des.08 | 8.18 | 2.78 | 1334 | 46 | 18 | 160 | 112 | 638 | 305 | 5.39 | 36.81 | 2.84 | 591 |
| Winter | 1 | Jan.09 | 8.28 | 2.7 | 1596 | 20 | 2 | 360 | 753 | 851 | 976 | 2.57 | 37.75 | 1.82 | 947 |
| Winter | 1 | Feb.09 | 8.18 | 2.75 | 1992 | 48 | 22.6 | 160 | 49 | 532 | 305 | 1.37 | 18.57 | 2.21 | 4227 |
| Spring | 1 | Mar.09 | 8.58 | 2.84 | 1948 | 42 | 12.7 | 176 | 78 | 496 | 183 | 2.55 | 41.78 | 2.38 | 378 |
| Spring | 1 | Apr.09 | 8.34 | 1.56 | 1432 | 72 | 1.36 | 160 | 24 | 241 | 183 | 0.47 | 78.6 | 3.88 | 137 |
| Spring | 1 | May-09 | 8.32 | 1.3 | 490 | 52 | 31.9 | 48 | 49 | 269 | 183 | 0.97 | 40.34 | 0.12 | 240 |
| Summer | 1 | Jun.09 | 7.87 | 1.47 | 1282 | 187 | 52 | 200 | 24 | 461 | 98 | 1.86 | 24.52 | 2.68 | 80 |
| Summer | 1 | Jul.09 | 8.05 | 1.14 | 1084 | 62 | 67 | 32 | 68 | 291 | 305 | 0.9 | 38.17 | 3.65 | 206 |
| Summer | 2 | Aug.08 | 7.30 | 4.07 | 2700 | 52 | 42 | 120 | 48 | 638 | 83 | 1.24 | 12.38 | 13.63 | 505 |
| Autumn | 2 | Sep.08 | 7.00 | 2.46 | 1726 | 80 | 50 | 120 | 58 | 1702 | 244 | 1.18 | 8.32 | 3.93 | 404 |
| Autumn | 2 | Oct.08 | 7.10 | 2.47 | 1594 | 52 | 48 | 80 | 97 | 888 | 220 | 0.07 | 14.7 | 3.22 | 561 |
| Autumn | 2 | Nov.08 | 7.50 | 2.78 | 2852 | 62 | 17 | 176 | 126 | 589 | 286 | 1.68 | 3.66 | 9.75 | 492 |
| Winter | 2 | Des.08 | 8.03 | 2.79 | 966 | 34 | 17 | 104 | 268 | 674 | 268 | 6.6 | 31.69 | 4.00 | 653 |
| Winter | 2 | Jan.09 | 7.89 | 2.88 | 1826 | 18 | 3 | 240 | 899 | 496 | 915 | 1.93 | 23.38 | 6.37 | 534 |
| Winter | 2 | Feb.09 | 8.02 | 2.88 | 2056 | 50 | 21.2 | 120 | 170 | 355 | 610 | 1.35 | 19.26 | 2.86 | 4462 |
| Spring | 2 | Mar.09 | 8.38 | 2.95 | 2142 | 48 | 9.29 | 184 | 92 | 1028 | 183 | 3.52 | 43.78 | 7.85 | 314 |
| Spring | 2 | Apr.09 | 8.12 | 1.68 | 2748 | 152 | 0.8 | 80 | 49 | 262 | 183 | 0.47 | 78.54 | 7.53 | 186 |
| Spring | 2 | May-09 | 8.05 | 1.39 | 1044 | 50 | 27.1 | 64 | 24 | 284 | 220 | 1.31 | 39.71 | 0.18 | 193 |
| Summer | 2 | Jun.09 | 7.97 | 1.63 | 1150 | 52 | 32.8 | 200 | 49 | 425 | 85 | 1.57 | 24.98 | 7.81 | 80 |
| Summer | 2 | Jul.09 | 7.19 | 2.48 | 1370 | 75 | 50 | 64 | 40 | 815 | 390 | 0.48 | 22.83 | 18.92 | 245 |
| Summer | 3 | Aug.08 | 7.60 | 2.24 | 1557 | 4 | 37 | 96 | 64 | 383 | 87 | 9.11 | 81.61 | 6.46 | 602 |
| Autumn | 3 | Sep.08 | 7.30 | 2.37 | 1564 | 68 | 36 | 120 | 34 | 603 | 317 | 1.16 | 7.41 | 2.61 | 435 |
| Autumn | 3 | Oct.08 | 7.10 | 2.41 | 1536 | 104 | 163 | 160 | 316 | 568 | 195 | 0.49 | 21.31 | 2.65 | 480 |
| Autumn | 3 | Nov.08 | 7.60 | 2.49 | 1200 | 48 | 18 | 144 | 180 | 547 | 244 | 1.83 | 6.78 | 2.60 | 509 |
| Winter | 3 | Des.08 | 7.98 | 2.83 | 1826 | 22 | 11 | 152 | 268 | 674 | 268 | 7.26 | 42.34 | 5.33 | 620 |
| Winter | 3 | Jan.09 | 8.33 | 2.75 | 1748 | 18 | 2 | 160 | 899 | 461 | 732 | 1.77 | 22.72 | 2.60 | 377 |
| Winter | 3 | Feb.09 | 8.09 | 2.58 | 1984 | 68 | 16 | 160 | 146 | 355 | 610 | 1.32 | 10.33 | 1.43 | 523 |
| Spring | 3 | Mar.09 | 8.39 | 2.88 | 2200 | 68 | 27.2 | 184 | 83 | 567 | 146 | 2.25 | 39.68 | 3.97 | 383 |
| Spring | 3 | Apr.09 | 8.14 | 1.66 | 3092 | 36 | 0.84 | 80 | 49 | 262 | 183 | 0.54 | 78.58 | 7.13 | 178 |
| Spring | 3 | May-09 | 7.96 | 1.31 | 636 | 34 | 20.8 | 56 | 39 | 284 | 195 | 1.33 | 48.24 | 0.61 | 253 |
| Summer | 3 | Jun.09 | 8.12 | 1.5 | 910 | 136 | 24.7 | 120 | 73 | 390 | 61 | 0.81 | 43.57 | 4.88 | 110 |
| Summer | 3 | Jul.09 | 8.27 | 1.44 | 780 | 45 | 56 | 48 | 54 | 241 | 268 | 1.22 | 19.51 | 3.98 | 174 |
| Summer | 4 | Aug.08 | 7.60 | 2.31 | 1510 | 48 | 29 | 80 | 42 | 425 | 58 | 11.02 | 110.12 | 5.78 | 1256 |
| Autumn | 4 | Sep.08 | 7.30 | 2.34 | 766 | 62 | 46 | 104 | 53 | 815 | 183 | 1.19 | 8.58 | 3.10 | 435 |
| Autumn | 4 | Oct.08 | 7.10 | 2.42 | 1598 | 148 | 97 | 40 | 170 | 568 | 195 | 0.06 | 17.62 | 2.65 | 772 |
| Autumn | 4 | Nov.08 | 7.70 | 2.54 | 2668 | 68 | 24 | 160 | 272 | 490 | 244 | 0.88 | 3.54 | 2.85 | 409 |
| Winter | 4 | Des.08 | 8.05 | 2.85 | 1406 | 32 | 15 | 144 | 117 | 709 | 256 | 7.26 | 37.98 | 4.18 | 724 |
| Winter | 4 | Jan.09 | 8.65 | 2.75 | 1786 | 20 | 2 | 240 | 680 | 603 | 915 | 1.93 | 22.74 | 2.40 | 449 |
| Winter | 4 | Feb.09 | 8.27 | 2.81 | 1900 | 40 | 11.6 | 160 | 73 | 355 | 488 | 2.1 | 10.97 | 0.52 | 464 |

Continuing table 1

| Season | Station | Month | PH | EC | TDS | TSS | Turb. | Ca | Mg | Cl | $HCO_4$ | $NO_2$ | $NO_3$ | $PO_4$ | $SO_4$ |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Spring | 4 | Mar.09 | 8.59 | 2.83 | 2102 | 52 | 4.76 | 168 | 117 | 496 | 146 | 3.27 | 40.4 | 1.76 | 405 |
| Spring | 4 | Apr.09 | 8.33 | 1.79 | 3248 | 36 | 2.20 | 80 | 49 | 284 | 159 | 0.75 | 73.88 | 4.70 | 228 |
| Spring | 4 | May-09 | 7.97 | 1.33 | 926 | 30 | 11.2 | 48 | 44 | 248 | 195 | 2.00 | 48.28 | 0.43 | 284 |
| Summer | 4 | Jun.09 | 8.26 | 1.5 | 898 | 156 | 26.1 | 200 | 24 | 319 | 61 | 1.23 | 38.44 | 3.84 | 95 |
| Summer | 4 | Jul.09 | 8.09 | 1.46 | 732 | 92 | 27.37 | 56 | 44 | 241 | 281 | 2.46 | 23.73 | 3.74 | 178 |
| Summer | 5 | Aug.08 | 7.60 | 2.23 | 1594 | 78 | 35.0 | 96 | 67 | 425 | 53 | 7.89 | 78.86 | 2.98 | 1674 |
| Autumn | 5 | Sep.08 | 7.30 | 2.33 | 1426 | 128 | 47.0 | 96 | 53 | 638 | 244 | 1.18 | 7.270 | 3.10 | 413 |
| Autumn | 5 | Oct.08 | 7.10 | 2.45 | 1644 | 48 | 35.0 | 120 | 73 | 497 | 195 | 0.11 | 17.89 | 3.02 | 470 |
| Autumn | 5 | Nov.08 | 7.70 | 2.43 | 2706 | 62 | 28.0 | 160 | 253 | 518 | 244 | 0.81 | 4.120 | 2.20 | 407 |
| Winter | 5 | Des.08 | 7.93 | 2.87 | 1916 | 22 | 6.00 | 152 | 117 | 744 | 244 | 10.34 | 35.47 | 5.16 | 691 |
| Winter | 5 | Jan.09 | 8.46 | 2.8 | 1794 | 30 | 4.00 | 320 | 437 | 638 | 732 | 1.95 | 27.24 | 3.12 | 642 |
| Winter | 5 | Feb.09 | 8.26 | 2.97 | 1910 | 40 | 13.4 | 160 | 146 | 390 | 488 | 1.45 | 17.34 | 0.52 | 523 |
| Spring | 5 | Mar.09 | 8.59 | 2.85 | 5566 | 52 | 5.84 | 200 | 97 | 532 | 134 | 3.45 | 36.86 | 2.55 | 326 |
| Spring | 5 | Apr.09 | 8.18 | 1.74 | 3048 | 84 | 0.99 | 80 | 73 | 269 | 146 | 0.75 | 76.96 | 7.05 | 205 |
| Spring | 5 | May-09 | 7.97 | 1.3 | 142 | 34 | 16.5 | 56 | 15 | 262 | 183 | 1.62 | 41.41 | 0.43 | 230 |
| Summer | 5 | Jun.09 | 8.19 | 1.51 | 890 | 10 | 31.9 | 160 | 73 | 389 | 85 | 1.13 | 42.40 | 4.21 | 100 |
| Summer | 5 | Jul.09 | 8.07 | 1.48 | 704 | 36 | 59.0 | 56 | 44 | 262 | 317 | 2.02 | 28.29 | 3.82 | 200 |
| Summer | 6 | Aug.08 | 7.60 | 2.25 | 1540 | 26 | 52.0 | 96 | 75 | 425 | 58 | 6.99 | 67.40 | 2.27 | 2106 |
| Autumn | 6 | Sep.08 | 7.40 | 2.33 | 1388 | 54 | 41.0 | 112 | 49 | 532 | 244 | 1.09 | 8.400 | 3.23 | 301 |
| Autumn | 6 | Oct.08 | 7.20 | 2.44 | 1668 | 56 | 48.0 | 120 | 170 | 604 | 195 | 0.37 | 18.96 | 4.00 | 590 |
| Autumn | 6 | Nov.08 | 7.70 | 2.51 | 2600 | 62 | 26.0 | 200 | 97 | 483 | 232 | 0.80 | 3.700 | 4.15 | 477 |
| Winter | 6 | Des.08 | 7.91 | 2.86 | 1796 | 16 | 3.00 | 160 | 117 | 738 | 281 | 6.93 | 39.72 | 5.34 | 766 |
| Winter | 6 | Jan.09 | 8.91 | 2.81 | 1820 | 8 | 3.00 | 200 | 535 | 603 | 976 | 2.20 | 26.65 | 3.12 | 345 |
| Winter | 6 | Feb.09 | 8.27 | 2.86 | 1604 | 62 | 21.7 | 160 | 146 | 355 | 610 | 2.10 | 18.08 | 0.26 | 669 |
| Spring | 6 | Mar.09 | 8.54 | 2.82 | 2048 | 76 | 6.62 | 176 | 97 | 674 | 146 | 3.55 | 40.42 | 2.38 | 669 |
| Spring | 6 | Apr.09 | 8.36 | 1.78 | 3168 | 64 | 5.06 | 80 | 194 | 268 | 146 | 0.66 | 73.78 | 6.48 | 163 |
| Spring | 6 | May-09 | 8.01 | 1.35 | 2400 | 54 | 15.8 | 40 | 39 | 248 | 183 | 2.66 | 47.35 | 0.49 | 239 |
| Summer | 6 | Jun.09 | 8.16 | 1.51 | 890 | 142 | 23.42 | 200 | 122 | 425 | 85 | 1.69 | 39.15 | 3.78 | 150 |
| Summer | 6 | Jul.09 | 8.14 | 1.46 | 672 | 68 | 66.0 | 48 | 49 | 241 | 305 | 4.05 | 31.83 | 0.14 | 167 |

in NO3-N varied over a wide range of 3.2-110.12 mg/L (Table.1). The minimum (3.2 mg/L) and maximum (110.12 mg/L) NO3-N were recorded during autumn months with a mean NO3-N of 9.93 mg/L (Table.2). The seasonal mean values of NO3-N during winter and summer were 26.61 and 41.01 mg/L, respectively (Table.2).

Fluctuations in PO4-P (mg/L) values were similar to NO3-N. The minimum (0.12 mg/L) and maximum (18.92 mg/L) PO4-P levels were observed during summer months with a mean value of 5.30 mg/L (Table.2). The seasonal mean values of PO4-P(3.73 mg/L) during winter and summer were 3.00 and 5.3 mg/L, respectively as shown in Table. 2.

The E.C values in this study range from 1.14-4.07 dS/m..s while the EC values for natural water are between 0.5 – 1.5 dS/m (Gems 1997) , that is why Shatt AL-Arab is considered as a saline water in comparison with other rivers of the world. Previous studies show that EC. range from 1.469-2.364 dS/m during 1980 ( Polservice 1980) .while it range from 2.282-2.510 dS/m during 2004 (Al-Mayahi 2005). 1.53-5.3 dS/m (Al-Kazaeh 2014) ,1.57-10.85 dS/m Al-Hejuje (2015).

In stream water, dissolved solids consist of calcium, chlorides, nitrate, phosphorus, iron, sulfur, and other ions particles that will pass through a filter with pores of around 2 microns (0.002 cm) in size. Suspended solids include silt and clay particles, plankton, algae,

Table 2 Seasonal variations of physical and chemical parameters in Shatt AL-Arab Estuary

| | Station | Summer | Autumn | Winter | Spring |
|---|---|---|---|---|---|
| Water temp-rature (⁰C) | 1 | 30.00 | 19.00 | 9.00 | 22.00 |
| | 2 | 31.00 | 18.00 | 10.00 | 23.00 |
| | 3 | 32.00 | 20.00 | 10.00 | 23.00 |
| | 4 | 33.00 | 21.00 | 11.00 | 24.00 |
| | 5 | 33.00 | 22.00 | 12.00 | 24.00 |
| | 6 | 34.00 | 22.00 | 14.00 | 25.00 |
| D.O mg/L | 1 | 5.30 | 6.30 | 9.30 | 8.40 |
| | 2 | 5.90 | 7.80 | 8.50 | 8.30 |
| | 3 | 6.20 | 6.50 | 8.70 | 7.60 |
| | 4 | 6.80 | 6.80 | 8.10 | 8.50 |
| | 5 | 6.90 | 7.90 | 8.30 | 8.90 |
| | 6 | 7.10 | 8.10 | 8.50 | 8.40 |
| PH | 1 | 7.99 | 7.33 | 8.21 | 8.41 |
| | 2 | 7.48 | 7.20 | 7.98 | 8.18 |
| | 3 | 7.99 | 7.33 | 8.10 | 8.16 |
| | 4 | 7.98 | 7.36 | 8.32 | 8.29 |
| | 5 | 7.95 | 7.36 | 8.55 | 8.24 |
| | 6 | 7.96 | 7.43 | 8.36 | 8.30 |
| E.C mS/cm | 1 | 1.58 | 2.26 | 2.71 | 1.90 |
| | 2 | 2.72 | 2.57 | 2.85 | 2.00 |
| | 3 | 1.72 | 2.42 | 2.72 | 1.95 |
| | 4 | 1.75 | 2.43 | 2.80 | 1.98 |
| | 5 | 1.74 | 2.40 | 2.88 | 1.96 |
| | 6 | 1.73 | 2.42 | 2.84 | 1.98 |
| TUR FTU | 1 | 60.60 | 27.60 | 14.20 | 15.32 |
| | 2 | 41.60 | 38.30 | 13.70 | 12.39 |
| | 3 | 32.50 | 72.30 | 9.06 | 16.28 |
| | 4 | 27.49 | 55.60 | 9.50 | 6.05 |
| | 5 | 41.90 | 36.60 | 7.80 | 7.77 |
| | 6 | 47.14 | 38.30 | 9.20 | 9.16 |
| TSS mg/l | 1 | 100.00 | 68.60 | 38.00 | 55.30 |
| | 2 | 59.60 | 64.60 | 34.00 | 83.30 |
| | 3 | 61.60 | 73.30 | 36.00 | 46.00 |
| | 4 | 98.60 | 92.60 | 30.60 | 39.30 |
| | 5 | 41.30 | 79.30 | 30.60 | 56.60 |
| | 6 | 78.60 | 57.30 | 28.60 | 64.60 |
| TDS mg/l | 1 | 1432.00 | 2222.00 | 1640.60 | 1290.00 |
| | 2 | 1740.00 | 2057.30 | 1616.00 | 1978.00 |
| | 3 | 1082.00 | 1433.30 | 1852.60 | 1976.00 |
| | 4 | 1046.00 | 1677.30 | 1697.30 | 2092.00 |
| | 5 | 1062.00 | 1925.30 | 1873.30 | 2918.60 |
| | 6 | 1034.00 | 1885.30 | 1740.00 | 2538.60 |

| | Station | Summer | Autumn | Winter | Spring |
|---|---|---|---|---|---|
| Ca | 1 | 104.00 | 152.00 | 226.60 | 128.00 |
| | 2 | 128.00 | 125.30 | 154.60 | 109.30 |
| | 3 | 88.00 | 141.30 | 157.30 | 106.60 |
| | 4 | 112.00 | 101.30 | 181.30 | 98.60 |
| | 5 | 104.00 | 125.30 | 210.60 | 112.00 |
| | 6 | 114.60 | 144.00 | 173.30 | 98.60 |
| Mg | 1 | 50.58 | 217.18 | 304.56 | 50.22 |
| | 2 | 45.31 | 93.96 | 445.86 | 55.08 |
| | 3 | 63.36 | 176.58 | 437.76 | 56.70 |
| | 4 | 36.77 | 165.20 | 289.98 | 69.66 |
| | 5 | 58.34 | 126.36 | 233.28 | 57.22 |
| | 6 | 81.62 | 105.26 | 265.68 | 110.16 |
| Cl | 1 | 368.68 | 1035.51 | 673.55 | 335.71 |
| | 2 | 626.28 | 1059.46 | 508.11 | 524.66 |
| | 3 | 337.93 | 572.45 | 496.30 | 371.04 |
| | 4 | 268.50 | 624.41 | 555.38 | 333.68 |
| | 5 | 361.92 | 551.46 | 590.83 | 354.50 |
| | 6 | 363.95 | 539.35 | 562.08 | 369.70 |
| HCO3 | 1 | 153.60 | 272.46 | 528.66 | 183.00 |
| | 2 | 186.14 | 250.00 | 597.80 | 195.20 |
| | 3 | 138.96 | 252.13 | 536.80 | 174.80 |
| | 4 | 133.30 | 207.40 | 553.06 | 166.73 |
| | 5 | 152.02 | 227.70 | 488.00 | 154.53 |
| | 6 | 149.57 | 223.60 | 622.20 | 158.60 |
| SO4 | 1 | 208.63 | 431.55 | 1921.88 | 251.50 |
| | 2 | 276.77 | 485.49 | 1852.89 | 230.75 |
| | 3 | 295.40 | 474.63 | 506.46 | 271.49 |
| | 4 | 509.66 | 538.71 | 545.62 | 305.49 |
| | 5 | 658.19 | 430.01 | 618.49 | 253.40 |
| | 6 | 807.60 | 456.03 | 593.56 | 337.28 |
| NO3 | 1 | 24.34 | 9.93 | 31.04 | 53.57 |
| | 2 | 20.07 | 8.89 | 24.78 | 54.01 |
| | 3 | 48.23 | 11.83 | 25.13 | 55.50 |
| | 4 | 57.43 | 9.91 | 23.90 | 54.19 |
| | 5 | 49.85 | 9.75 | 26.68 | 51.74 |
| | 6 | 46.13 | 10.35 | 28.15 | 53.85 |
| PO4 | 1 | 3.03 | 2.16 | 2.29 | 2.12 |
| | 2 | 13.45 | 5.63 | 4.41 | 5.19 |
| | 3 | 5.11 | 2.62 | 3.12 | 3.90 |
| | 4 | 4.45 | 2.87 | 2.37 | 2.30 |
| | 5 | 3.67 | 1.77 | 2.93 | 3.34 |
| | 6 | 2.06 | 3.79 | 2.91 | 3.12 |

fine organic debris, and other particulate matter. These are particles that will not pass through a 2-micron filter. Higher concentrations of suspended solids can serve as carriers of toxics, which readily cling to suspended particles. A high concentration of total solids will make drinking water unpalatable and might have an adverse effect on people who are not used to drinking such water. Levels of total solids that are too high or too low can also reduce the efficiency of wastewater treatment plants, as well as the operation of industrial processes that use raw water. Total solids also affect water clarity. Higher solids decrease the passage of light through water, thereby slowing photosynthesis by aquatic plants. Water will heat up more rapidly and hold more heat; this, in turn, might adversely affect aquatic life that has adapted to a lower temperature regime. Sources of total solids include industrial discharges, sewage, fertilizers, road runoff, and soil erosion. TDS range from 900 – 5965 mg/L during (1975 – 2000) (Hasan and Mahmood 2003) for Shatt AL-Arab water and within the study period from (142 and 5566.00) in Al Fao and paper factory respectively. High concentrations of TDS in spring and autumn seasons as compared with that in the winter season may be due to the addition of solids from runoff water and sewage effluents which increase the TDS values in the river. This result was in agreement with Hassan et al. (2010) and Al-Hejuje (2015) who found that TDS values in the Euphrates and Shatt Al-Arab river respectively increased in winter months and decreased in summer months.

The total suspended solids (TSS) values range between (11-18 mg/L) during (1978) which considered as a low value that may be because of the sedimentation process in marshes. These result can be observed during the study period, the mean value of TSS (66.25, 60.42, 54.25, 65.33, 52, 57.33) mg/L for six station respectively .value in Tigris (turbid water) 64 mg/L and in Al-Qurna location is 13 mg/L rising in Sibah to 44 mg/L and 147 mg/L in Al-Fao this location effected with Karone sediment and sea tide.

Higher turbidity increases water temperatures because suspended particles absorb more heat. This, in turn, reduces the concentration of dissolved oxygen (DO) because warm water holds less DO than cold. Higher turbidity also reduces the amount of light penetrating the water, which reduces photosynthesis and the production of DO. Suspended materials can clog fish gills, reducing resistance to disease in fish, lowering growth rates, and affecting egg and larval development. As the particles settle, they can blanket the stream bottom, especially in slower waters, and smother fish eggs and benthic macro invertebrates. Sources of turbidity include: Soil erosion, Waste discharge Urban runoff, eroding estuary banks, Large numbers of bottom feeders (such as carp), which stir up bottom sediments, excessive algal growth. One of the important light parameter which is of well relation with clearness of water that considered as an indication to suspended mater in water , it values range between (0.80-163.00) FTU for study area Shatt Al-Arab river has high turbid water which exceeded the permissible value (5 NTU) in aquatic ecosystems.

Calcium & Magnesium (Ca , Mg) elements exist widely in water. In natural water Ca concentration range between (10 – 100)mg/L causing water hardness. Mg concentration Range between (5-50)mg/L , and if exceed 125 mg/L causing diarrhea and also softening hardness. during (1968-2000) (Hasan and Mahmood , 2003). Ca concentration ranges from1 36 mg/L to 160 mg/L Mg concentration Range from 96 mg/L to 223 mg/While the range between (212.1-280) mg/L for Ca and (67.4-691.4) mg/L for mg during 2004 (Al- Mayah, 2004). In this study Ca concentration range from 32.00 to 360 mg/L while Mg concentration range from 14.58 to 899 mg/L .Ca and mg concentrations Considered as a high value but they are still within the standard of WHO (2011), in Shatt Al-Arab river.

Bicarbonate ($HCO_3$) Alkalinity of the most natural and treated water are Ca , mg bicarbonate when pH degree for this water does not exceed 8.3. during (1988-2000) HCO3 conc. Ranges (183-244) mg/L and during 2004 it ranges (133.8-131.2)mg/L. in this study its conc. Range (53.46-976) mg/L. this rising in HCO3 concentration Is accompanied by rising in pH and Ca, Mg conc. That refer to an expected in the chemical constitution of Shatt Al-Arab water which may be a result of water pollution.

High concentration of Cl is caused by the geological components which contain chloride. Except that high concentration of Cl is an indication for high pollution of sewage water , some industrial waste , because of tide see or any saline water which have a bad effect on modern pipes, agriculture and factories. during (1988 – 2001) Cl range between (137 – 1060) mg/L ,and during the study period range (241.06-2056.6) mg/L for Qurna and Al-Ashar and that refer to the increase of industrial waste in river water (Table.1)

Nitrates are a form of nitrogen, which is found in several different forms in terrestrial and aquatic ecosystems. These forms of nitrogen include ammonia (NH3), nitrates (NO3), and nitrites (NO2). Nitrates are essential plant nutrients, but in excess amounts they can cause significant water quality problems. Together with phosphorus, nitrates in excess amounts can accelerate eutrophication, causing dramatic increases in aquatic plant growth and changes in the types of plants and animals that live in the stream. This, in turn, affects dissolved oxygen, temperature, and other indicators. Excess nitrates can cause hypoxia (low levels of dissolved oxygen) and can become toxic to warm-blooded animals at higher concentrations (10 mg/L) or higher) under certain conditions. It is the most oxidized from of nitrogen, it come from chemical fertilizers, agriculture lands, industrial water and sewage water. Nitrate estimation helps in the observation of thee from and oxidization degree in stream and ground water. In natural water (un polluted) contain low nitrate, in case of increasing it conc. Caused (methaemoglobinamia) for ting childe and also caused Eutrophication; which caused secondary pollution.

Nitrate conc. Range (3.2-110.12) mg/L during study period which considered higher values compare to the study result during 2004 which ranges from (3 -10) mg/L in Shatt AL-Arab water. Results found that most of downstream stations of Shatt AL-Arab river showed higher nitrogen compound compared with the upstream stations because they are more impacted by pollutants from domestic sewage released from Basrah city center. Also, climatic changes as well as reduction in water income to the river have resulted in alteration in nitrogen compounds concentrations, this conclusion was in agreement with Hameed and Aljorany (2011) and Al-Hejuje (2015).

Phosphorus ($PO_4$) has a complicated story. Pure, "elemental" phosphorus (P) is rare. In nature, phosphorus usually exists as part of a phosphate molecule ($PO_4$). Phosphorus in aquatic systems occurs as organic phosphate and inorganic phosphate. Organic phosphate consists of a phosphate molecule associated with a carbon-based molecule, as in plant or animal tissue. Phosphate that is not associated with organic material is inorganic. Inorganic phosphorus is the form required by plants. Animals can use either organic or inorganic phosphate. Both organic and inorganic phosphorus can either be dissolved in the water or suspended (attached to particles in the water column).It come from the weathering and process on pH degree. When pH range (6-8) the boundary forms 10% $H_2PO4^{-1}$ and 90% $HPO4^{-2}$ this form is the mean nutrient for organisms. Phosphate compounds more in the natural and sewage water and cause a secondary pollution that make basic nutrition for increasing organisms growth which depends on light with un desirable amounts some times. Phosphate concentration range (0.07 -3.67) mg/L during (2004) and in Al-Qurna reach (0.193) mg/L to (5.15) mg/L for Tigris before joining Euphrates. The concentrations were range from 0.12 mg/L at station 1 to 18.92 at station 2 .The decrease of phosphorus concentrations, which is more distant from the discharge points of effluents, may be due to the self-purifier capacity of the receiving stream. Nitrates and Phosphates appear with gradual increases especially during the months of April and May when fertilizers in lands around the river are used and accidentally spill into water.

Sulfate ($SO_4$) is formed from earth crust and organic compounds containing sulfate, which come from the industrial waste its conc. Range from several grams to some thousand grams. WHO considered (400) mg/L as the highest limit for drinking water. In Shatt Al-Arab water sulfate conc. Ranges from (80.15- 4462.23) mg/L being the lowest in Al-Sebah and the highest in paper factory. While it reached (674) mg/L for Shatt Al-Arab water during 2004 (Al-Mayahi, 2005).and High concentrations of sulfate recorded in Winter may be due to high petroleum compounds used as fuel and released sulfate compounds to the environments , or may be due to wet precipitation during Winter season . High concentration of sulfate may be due to electrical power plants (Al-Najebbia power plant and Turkish power plant) that released sulfate compound to the environment, also the agricultural activities at these areas have a role in the increasing sulfate compounds (Al-Hejuje ,2015**).**

As conclusion results showed some fluctuation in some of the data during different seasons at different locations of the estuary, also the results indicate that the water is Non-polluted and can be used for Domestic, Irrigation and Fisheries.

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