G.J.B.A.H.S.,Vol.5(3):43-53 *(July-September,2016)* **ISSN:2319 – 5584**

GLOBAL JOURNAL OF BIOLOGY, AGRICULTURE & HEALTH SCIENCES
(*Published By: Global Institute for Research & Education*)

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Appraisal of Some Water Quality Criteria of the Shatt Al-Arab River by Applying Geographical Information System (GIS)

Abdul-Razak M. Mohamed[1]*, Sadek A. Hussein[1] & Laith F. Lazem[2]

[1]Department of Fisheries and Marine Resources, College of Agriculture, University of Basrah, Iraq.
[2] Departments of Science, Open Educational College, Basrah, Iraq

Abstract

The present work illustrates the potential application of geographic information systems (GIS) and spatial analysis techniques to classify spatial and temporal distribution and predictions of some water characteristic. The study extended from December 2011 to November 2012. To execute the work three stations were selected based on the nature of the areas. Water samples were collected on monthly basis, from the three stations. Results revealed that water temperature ranged between 11.3-35.7 ˚C, salinity varied from 1.37 to 3.13 ‰, the pH ranged from 7.33 to 8.33. TDS differed from 1985 to 7131 mg/L, the dissolved oxygen 6.1-9.5 mg/L. Transparency fluctuated from 38.3 to 72.3 cm.

Key words: GIS, water quality, Shatt Al-Arab River, Iraq

1. Introduction

It is well known that water is the best of all things. It is of a substantial importance to all forms of life on earth and has no known alternatives (Kumar *et al.*, 2005; Williamson *et al.*, 2008). Although plenty amount of water is exist on earth, most of it is unfit to satisfy human usage and consumption. Approximately, out of 71% of water present on earth surface, less than 3% is potable and easily accessible to human (Naithani and Pande, 2012). Rivers play an important role in connecting aquatic ecosystems and terrestrial environments. However, river basins are highly populated locations due to the availability of vast productive land and water to fulfill various sources of human uses and consumption (Vega *et al.*, 1998). Therefor, few of them are now in their natural (Ngoye and Machiwa, 2004).

Due to the enormous development in various fields of science, it may become necessary to adopt new techniques to study water environments and fish communities. One of the most important techniques is the geographical information system (GIS) (Greene, 2010).It is therefore, the GIS has become an integral part of aquatic sciences (ESRI, 2007).

However, Burrough (1986) defined GIS as an organized collection of computer hardware, software, geographical data, and personnel designed to efficiently capture, store, update, manipulate, analyze, and display all forms of geographically referenced information. Fazal (2008) explained GIS as a system for capturing, storing, checking, integrating, manipulating, analyzing and displaying data that are spatially referenced to the earth. GIS allows users to view, understand, question, interpret, and visualize data in ways that reveal relationships, patterns, and trends in the form of maps, globes, reports, and charts (ESRI, 2009).

GIS can be applied to investigate water quality in rivers, river basin management, national and international protected areas and sanctuaries to assess the suitability of the environment (Da Silva and Fulcher, 2006; Yasmin *et al*., 2012). Kumar *et al*. (2005) declares that to assess river water, to manage and restore water resources, temporal and spatial data of the whole water body and more importantly a computer database to store, analyze and manipulate the collected data is required. Over the last 30 years, GIS have been internationally exploited to gather information needed to monitor various water bodies across the world (Naithani and Pande, 2012). Several studies were executed to apply GIS to evaluate water quality in different ecosystems included streams, rivers, lakes and groundwater (Assaf and Saadeh, 2008; Al Bassam, 2009; Selcuk, 2009; Diamond, 2011; Meixler and Bain, 2012).

Only few studies applied GIS to evaluate water quality in Iraq, namely, Salih *et al*. (2008) investigated water quality of Haditha Dam Lake applying remote sensing and GIS techniques. Sail *et al*. (2008) studied water quality of Habania, Abbas and Ziboon (2010) used remote sensing and GIS technique to study physical properties of Al-Hammar marsh soil. Jaber (2012) employed GIS facilities to construct map for water resources in Iraq. This study, however, aims to apply GIS to describe some water characteristics of the Shatt AL-Arab River, southern Iraq.

2. Materials and Methods

The Shatt Al-Arab River is located at the lower part of the Mesopotamian basin and flows at east south towards the Arabian Gulf. It is about 204 km, and 250m wide at Al-Qurna to more than 2 km at Fao district. Its depth fluctuate from 4.2m at Al-Qurna, 8.2m in Ad Dayr, 9.2m in Al-Hartha, 15m in Basrah to 7m in Al-Fao. From both sides of the river several irrigation canals are penetrating. Their approximate number is 637 (Al-Lami, 2009).Many small islands are located on both sides of the River from Garmat Ali downward to the Gulf. The River is affected by tidal current penetrating from the Arabian Gulf twice a day. Water level varies from 3m near estuary to one meter at Al-Maqal region and 0.5 m at Al-Qurna (Abdullah, 1990).

To execute the work three stations were selected (Fig. 1), based on the nature of the areas. Station 1 is located near Al-Dayr Bridge (746907 E, 3410824 N meters), station 2 is sited near Ashalha island north of the Sindbad Island (764452 E, 3386729 N meters) and station 3 is located near Al-Sahel Land in Abu Al-Khasib district (786725 E, 3373365 N meters).

Water samples were collected on monthly basis, from the three stations, manually from mid river by dipping sampling bottle at approximately 15-25 cm below the water surface, using a 1.5 L. plastic bottle for the period from December 2011 to November 2012. Samples were kept in a cooling box to move to the laboratory for analysis. The instrument (YSI 556 MPS)multiple meter models 2005was used to measure water temperature (WT), salinity (Sal), pH, total dissolved solid (TDS) and dissolved oxygen (DO). Transparency (Tran) of water was estimated by Secchi disk of 25cm in diameter. At each location, the GPS waypoint (location is record and store in the device) was collected for spatial reference using GPSMAP 78s model 2010 type Garmin.

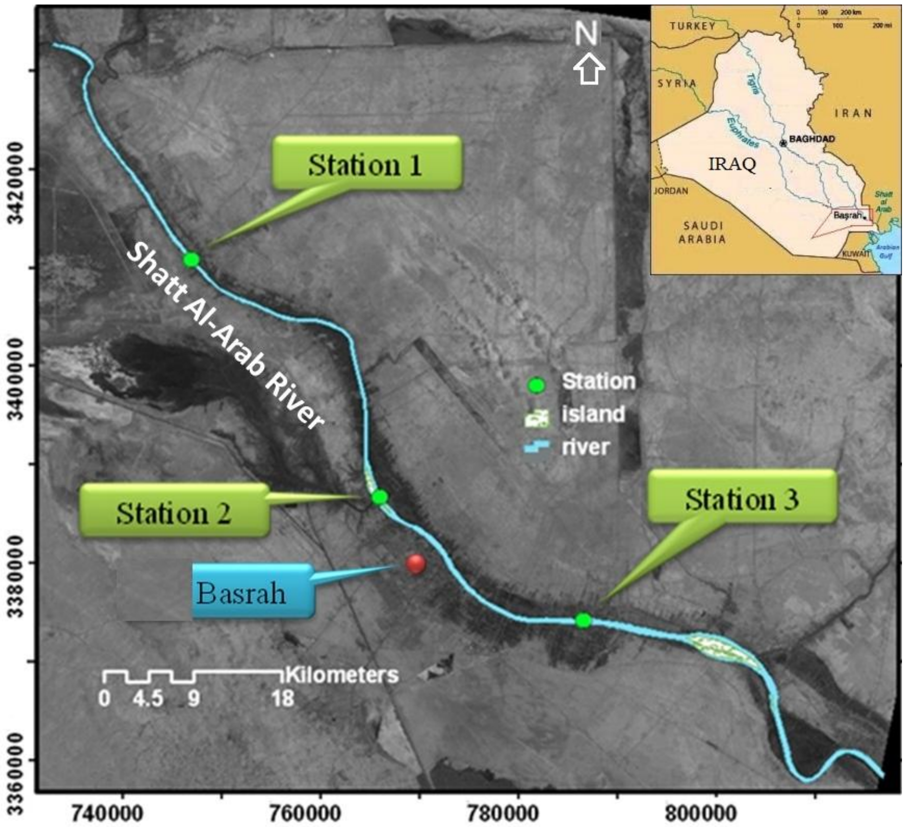

Fig. 1: Satellite image of study area in Shatt Al-Arab River captured by satellite Land sat 7, date of capture 2010

3. Results

3.1 Water Temperatures

Monthly and spatial variations in water temperatures are presented in Figure 2. This parameter revealed a gradual rise from February to achieve its highest value in August 2012. Values in station 1 ranged from 11.3°C in January to 34.4°C in August. In station 2, values varied from 11.8°C in January to 35.7°C in August and from 10.9°C in January to 36.9°C in August in station 3. Insignificant differences ($P>0.05$, $F= 0.073$) in water temperatures among stations were detected. The overall value of water temperature in the river varied from 11.3°C in January to 35.7°C in August.

3.2 Salinity

Monthly and spatially changes in water salinity are shown in Figure.3. Salinity values ranged from 0.75‰ in July to 1.48‰ in February in station 1, from 1.09‰ in July to 2.27‰ in August in station 2 and from 1.4‰ in March to 6.19‰ in September in station 3. Significant differences ($P<0.05$, $F=15.65$) in salinity values were found between station 3 and the other stations. The overall value of water salinity in the river differs from 1.37‰ in March to 3.13‰ in September.

3.3 Hydrogen Ion concentration (pH)

Slight monthly and locally fluctuations in pH values were observed (Fig. 4). Values of pH ranged from 7.41 in December to 8.51 in July in station 1, from 7.33 in December to 8.51 in February in station 2 and from 6.99 in February to 8.28 in March in station 3. Insignificant differences ($P>0.05$, $F= 0.202$) in pH values among stations were detected. The overall value of pH in the river ranged from 7.33 - 8.32.

3.4 Total dissolved solid (TDS)

Figure.5 illustrates the monthly and spatial changes in values of total dissolved solids. This parameter showed a gradual increase from July 2012 to attain its highest value in October 2012. TDS ranged from 1188 mg/L in June to 1789 mg/L in February in station 1, from 1626 mg/L in July to 3012 mg/L in October in station 2, and from 1985 mg/L in January to 7131 mg/L in October in station 3. TDS in station 3 found to be significantly different ($p < 0.05$, $F= 11.89$) from others. The overall values of TDS in the river differed from 1816 mg/L in January to 3914 mg/L in September.

3.5 Dissolved oxygen (DO)

Monthly and locality fluctuations in concentration of the dissolved oxygen are shown in Figure 6. Highest values of DO are encountered during winter (December-February). DO values ranged from 6.11 mg/L in June to 9.92 mg/L in January in station 1, differed from 5.55 mg/L in June to 9.5 mg/L in December in station 2 and fluctuated from 5.76 mg/L in August to 9.55 mg/L in January in station 3. Insignificant differences ($p > 0.05$, $F= 0.162$) in DO among stations were detected. The overall value of DO in the river differed from 6.05 mg/L in June to 9.46 mg/L in January.

3.6 Transparency (Tran)

Figure 7 explained the monthly and locality changes in the Transparency values. This parameter is fluctuating, and achieved its lowest value in July 2012. Values varied from 34cm in July to 76cm in January in station 1, from 38cm in August to 81cm in April in station 2 and from 35cm in August to 71cm in January in station 3. Variations were insignificant ($P > 0.05$, $F= 0.074$) among stations were detected. The overall value of transparency in the river varied from 38.3cm in August to 72.3cm in May.

4. Discussion

The quality of a biotic factors provides vital information about the health of a water body. These parameters are used to find out if the quality of water is good enough for drinking purposes, recreation, irrigation, and to support aquatic life (Selcuk, 2009). The temperature of water is one of the most important characteristics that determines, to a considerable extent, the trends and tendencies of changes in the river water quality. Increased water temperature decreases the solubility of dissolved oxygen and water temperatures above 32^0 C it would be considered unfit for public use (Chapman, 1992). Temperature plays a vital part in chemical and biochemical reactions and is an important factor influencing self-purification in streams (Mohd *et al*., 2012). Variations among stations were not evident, and the range of Temp. (11.3 - 35.7^0 C) are coincided with the results of similar studies (Hammadi, 2010; Moyel, 2010).

Salinity gradually increased towards station 3. This caused by several factors, including shortage in discharge of the Shatt Al-Arab, due to decline in water levels fed by the Tigris and Euphrates. In addition, obstruction of the Karun River, which used to be an important source of fresh water to the Shatt Al-Arab, serving as a barrier to reduce the progress of salty water from the Gulf upstream (Hassan *et al*., 2011). While remarkable increase in salinity was detected in station1 compared with other stations and the reason was attributed to a lack of salty seafront penetrating from the Gulf during ebb through the collection of the samples. The present study deduced that values of salinity in the Shatt Al-Arab were lower than those lately recorded by researchers in the same region (Hammadi, 2010). This may related to increase in water levels provided by the Tigris and Euphrates compared with former studies.

pH plays a critical role in the chemistry of rivers. The pH of water is influencing living organisms and the usage of the water. The pH level is a measure of the hydrogen ion in the water (Thanapalasingam, 2005). It is evident that although rarely fluctuated, pH values were generally within the alkaline limit. This is a common feature of the Iraqi waters (Hussein and Attee, 2000; Mohamed *et al*., 2010; Hammadi, 2010). The highest values recorded in July which strongly associated with chlorophyll-*a* ($r= 0.73$), and negative correlation with water transparency ($r= -0.45$). This was attributed to photosynthesis rises by aquatic plants that decrease of carbon dioxide in water that acts as buffer (Oakes *et al*., 2005).

The principal anions comprising TDS include carbonates, bicarbonates, chlorides, sulfates, phosphates, and nitrates (CCME, 2003).Monthly changes in this parameter reveal that value, in general, were relatively low from December to July. This may explained by the rise in water levels provided by the Tigris and Euphrates. Different conclusions were suggested by Hussein and Attee (2000) and Hammadi, (2010). The highest values were recorded in October at station 3 which strongly associate with salinity ($r= 0.95$). TDS increased gradually towards the river mouth, which coincide with increased salinity, this agreed with the results obtained by Al-Lami (2009).

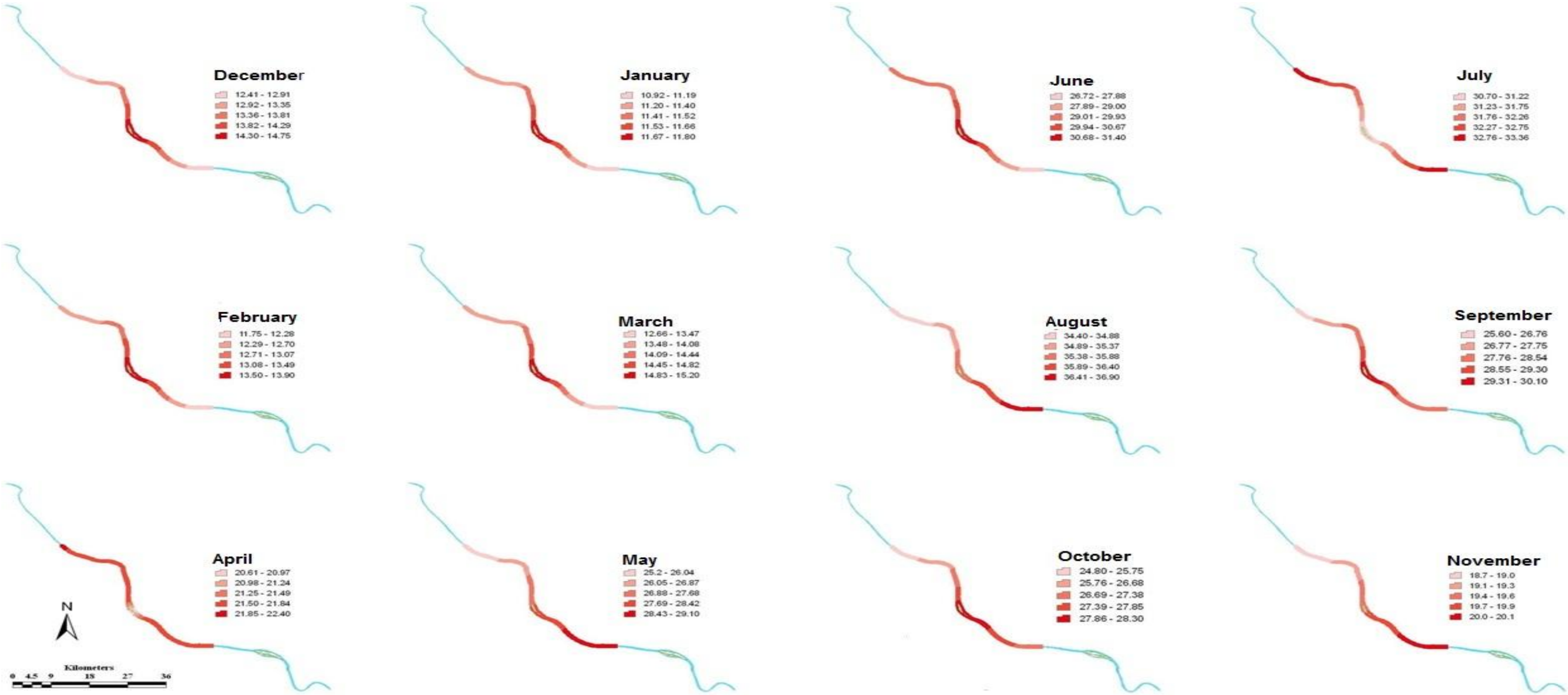

Fig. 2: Distribution of water temperature (°C) in the Shatt Al-Arab River from December 2011 to November 2012

Fig. 3: Salinity (‰) distributions in the Shatt Al-Arab Rive from December 2011 to November 2012

Fig. 4: pH distributions in the Shatt Al-Arab Rive from December 2011 to November 2012

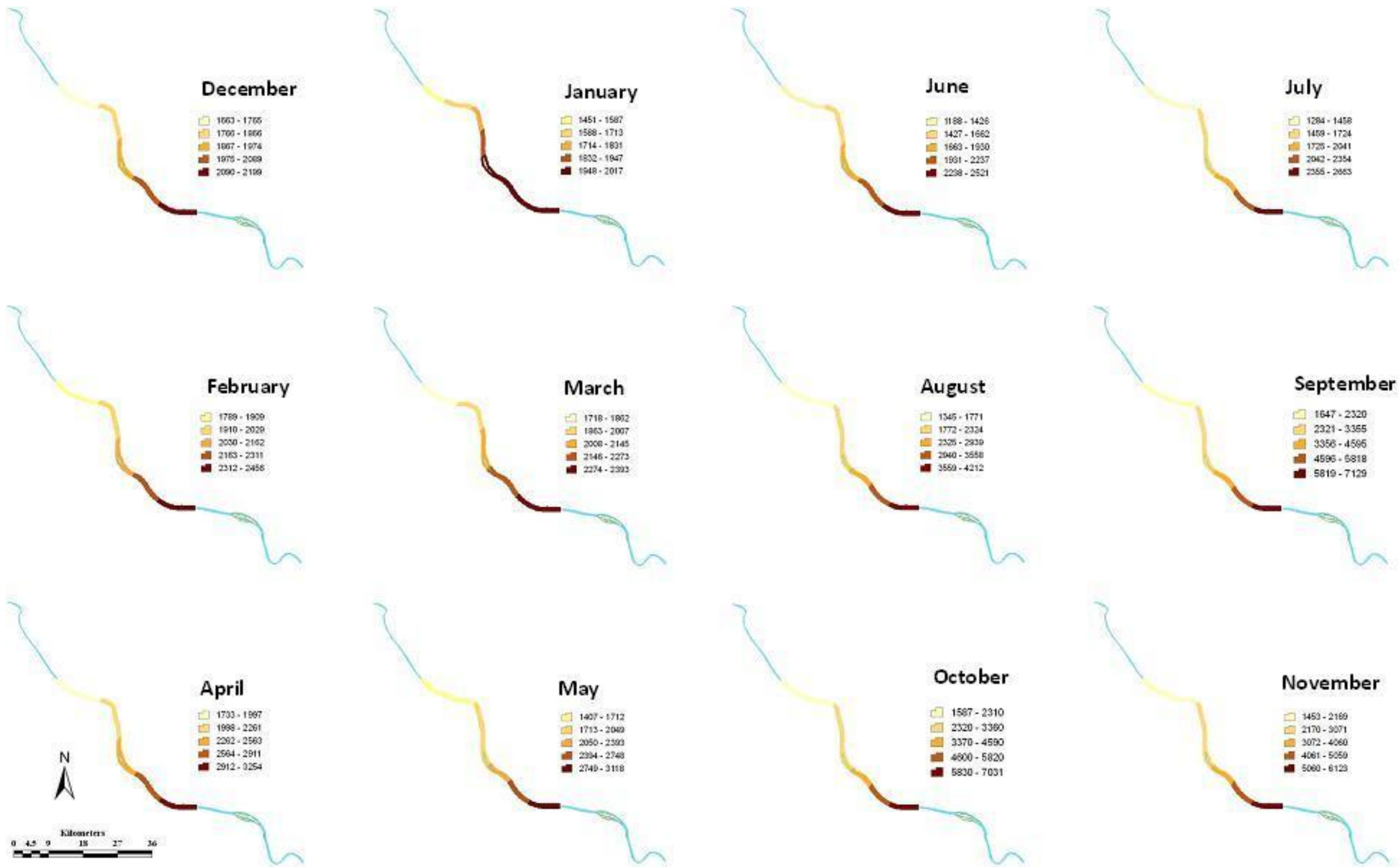

Fig. 5: TDS (mg/L) distributions in the Shatt Al-Arab Rive from December 2011 to November 2012

Fig. 6: Dissolved oxygen (mg/L) distributions in the Shatt Al-Arab Rive from December 2011 to November 2012

Fig. 7: Transparency (cm) distributions in the Shatt Al-Arab Rive from December 2011 to November 2012

Dissolved oxygen (DO) content is considered as pollution indicator of a water body (Basavaraddi *et al.*, 2012). DO levels depend on several factors, including rainfall, water salinity, decomposition and vegetation density, type of rock in riverbed and presence of pollutants. Oxygen contents plays important role, when evaluating the habitat conditions (Thanapalasingam, 2005). Dissolved oxygen concentrations obtained in the present study were generally adequate to support aquatic life (i.e., > 4 mg /L) and were generally high. This was due to the thorough mixing of water masses due to turbulence and current speed serving to increase gas solubility in the main River. DO values in the study area, in general, were high during the period from December to March. Lowest values were measured in summer (June - August), and may be due to rise in the ratios of consumption and decomposition associated with decline in gas solubility. This coincides with the most of findings as Moyel (2010) and Hammadi (2010).

Angle of light incidence and variation in light intensity both greatly affect transparency (Keithan and Lowe, 1985). This may explain local differences in light penetration, which is a vital parameter for photosynthesis and primary productivity (Horne and Goldman, 1994). Low values encountered in July may be related to dense algal growth and miner organic solids entering the river (Hammadi, 2010). Also to discharge of drainable water masses loaded with a huge quantity of suspended matters (Al-Bahely, 1997). Abundance of phytoplankton and chlorophyll-a may explain the decline in transparency recorded in the warmer periods (Al-Saadi *et al.*, 1996). Transparency exhibited relatively higher values during colder periods. This coincided with results obtained by other workers including Hussein and Attee (2000), Hammadi (2002) and Mohamed *et al.* (2010).

5. Conclusions

The results revealed that GIS was a good and efficient technique to assessment the water quality of the Shatt Al-Arab River, due to high response of GIS to every temporal and spatial change in water quality during the study period.

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