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Assessment of Trophic status for Shatt Al-Arab River using trophic state index (TSI)

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ABSTRACT

Shatt Al-Arab River receives considerable loads of nutrients, and other compounds, resulting from anthropogenic activities within its catchment. The main aims of this first line research in trophic state index in Shatt Al-Arab River were to evaluate spatial and seasonal trends in waer nutrients and also to compare data with trophic state index (TSI), identifying and assessing the impact of the loads to the environment. Ten stations were sampled within northern parts of Shatt Al-Arab River. Field measurements (water temperature, pH, Dissolved Oxygen and secchi disc transparency) and laboratory water analysis (total phosphorus and chlorophyll-a) were carried on the sampling stations monthly. The results explained that the secchi disc transparency was negative correlated with chlorophyll-a , although there were exceptions in some individual stations. The analysis of the data suggested that the relationship between transparency and total phosphorus was negative and slightly curvilinear. Positive correlation was found between Chl-a and total phosphorus. Trophic state index calculations (44.3) indicated mesotrophic conditions of Shatt Al-Arab River. The relationship of TSI with the diversity of different aquatic organisms is more beneficial to study in the future programs in this study area.

Keywords: Shatt Al-Arab River; trophic state index

1. Introduction

The evaluation of water quality in developing countries has become a serious problem in recent years, especially due to the concern that fresh water will be limited resource in the future. Whereas water monitoring for different purposes is well defined, the overall water quality is sometimes difficult to evaluate from a large number of samples, each containing concentrations for many parameters.

Rivers are dynamic systems and may change in nature several times during their course because of changes in physical conditions such as slope and bedrock geology [1]. They carry horizontal and continuous one-way flow of a significant load of matter in dissolved and particulate phases from both natural and anthropogenic sources. This matter moves downstream and is subject to intensive chemical and biological transformations [2].

Generally, Aagricultural activities have been the most important non-point source of water pollution. This mainly concerns nutrients, which are transported from fertilized agricultural land to surface waters via runoff and erosion and increase of the eutrophication process [3]. However, this diffuse pollution is also the most difficult to control. This is making environmental protection require serious of monitoring and accurate assessment of water quality in rivers. In environmental management and research, water quality data become very important to assess the water quality status; to \study the controlling processes of water pollution; to define and apply environmental objectives to restore or improve water quality; to assess the effects of best management practices in a watershed and to calibrate hydraulically and water quality models [4].

Reference [2] reported that the North and Middle Basin areas of Kizilirmak River receive considerably higher pollutant loads, due to the fact that these areas are highly populated and the domestic wastewater, as well as effluents from most of the industries is discharged into the river or its tributaries without any treatment. The presence and operation of high-capacity dams significantly contribute to the natural assimilation capacity of the river since the population density of the area is over the average of Turkey population.

Human activity has an enormous influence on the cycling of nutrients due to the extensive use of inorganic fertilizers [5], and this direct impact is reflected to Shatt Al-Arab River water quality as well. So, environmental quality indices are a powerful tool for processing, analyzing and conveying raw environmental information to decision-makers and managers. Different studies on the quality of nutrients were carried in Shatt Al-Arab River from a long time [6] [7] [8] [9] that can be collected in a database and be easily informed.

Numerous methods have been proposed and used to measure the trophic state (TS) of lakes. These range from single nutrient (phosphorus or nitrogen)or physical (secchi disc) measurements to increasingly more complex approaches such as trophic state indices (TSIs) employing multiparameter measurements. Carlson’s Trophic State Index (TSI) is a common means for characterizing a lake’s trophic state and associating Secchi disc, Chl-a and phosphorus measurements [10][11][12][13]. Phosphorus is an essential plant nutrient. In large quantities, they can encourage the growth of nuisance aquatic plants such as algal blooms. Chl- a is the green pigment in plants used for photosynthesis. It is a good indicator of the total quantity of algae in a water body [14].

The aims of this research line were to evaluate spatial and seasonal trends in water nutrients and also baseline study for further work with certain quality index (Trophic State Index (TSI), identifying and assessing the impact of the loads to the environment.

2. Method

2.1. The study area

The study area, Shatt Al-Arab River is the most important river in southern region of Iraq; it supplies drinkable water and is being used for a variety of agricultural and industrial activities, with a length of 190 km. It transports large quantities of water annually to the Arabian Gulf. The agricultural lands of Shatt Al-Arab River are widely irrigated from the canals. The ecosystem of the Shatt Al-Arab River area is rich in biological diversity [8]. River water samples were collected from the ten sites along Shatt Al-Arab River. The sampling stations were given in Figure 1. The sampling stations were selected according to the point and non-point pollution load possibilities of the basin mainly from agricultural and minor industrial.

2.2 Trophic state Index calculation

Carlson's Trophic State Index was calculated depending on the equations below [10]:

$TSI\ (TSI_{TP})=14.42*[\ln(TP\ average)]+4.15$

$TSI\ (TSI_{Chl\text{-}a})=9.81*[\ln(Chl\text{-}a\ average)]+30.6$

$TSI\ (TSI_{SD})=60-(14.41*[\ln(Secchi\ average)])$

As:

TP:Total phosphorus, Chl-a:Chlorophylla and SD: Secchi disc

Total phosphorus and Chl-a were measured in micrograms per liter and Secchi disc transparency was measured in meters.

The TSI scale ranges : 0 ultra- oligotrophic,

<40 oligotrophy (low producitivity),

40-50 mesotrophy (moderate productivity),

>50 eutrophy (high productivity) and

100 hypereutrophic.

2.3 Water measurements

The samples collected from each site consisted of 3-4 composite samples. Water was collected in 5 liter plastic bottles. This sampling program was run through the year of 2010 monthly. Water samples were collected, preserved and analyzed in accordance with Standards Methods [15]. Routine field analysis such as temperature (C), pH, Dissolved oxygen (mg/l) was done by multimeter instrument (model Lovibond) and Secchi desk transparency (m). Laboratory analysis such as total phosphate and Chl-a were measured by [15].

2.4 Statistical analysis

SPSS software program was used in data analysis.

3. Results and Discussion

Water temperature in Shatt Al-Arab River varied significantly with time, but not with station. Temperature ranged from 2.6 to 27.3 °C. The results from table 2 showed seasonal changes in water temperature caused by the light intensity and the length of the day, it was noted that no significant differences were among the stations. Values of pH showed little variation among the stations that generally classified within Iraqi waters, the water of a few Alkalinities [8] [16] and the highest pH values was during summer. Dissolved oxygen plays an important role in the metabolic processes of all living organisms [17] notes the high values of dissolved oxygen due to good diffusion, continuous mixing and the role of . aquatic plants

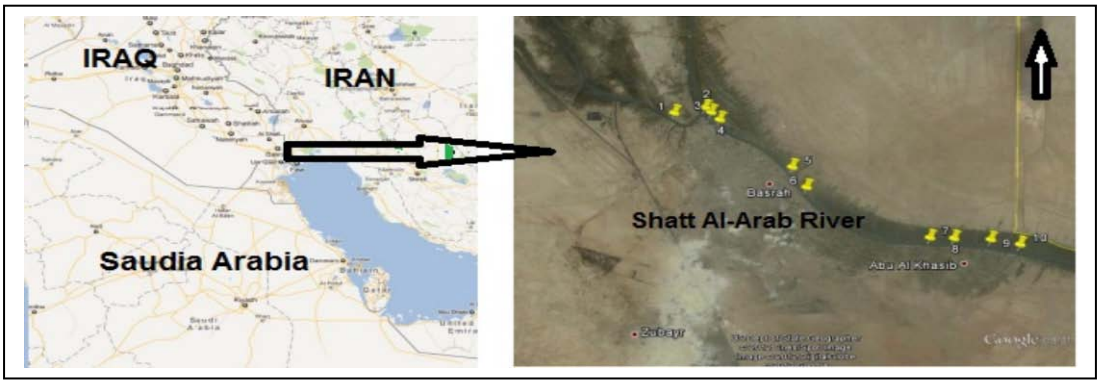

Figure 1. Map shows the Study area

Table 1. Position of Shatt Al-Arab River stations during study period.

Station name	Station number	GPS positions
Qarmat Ali	1	N 30 34 31 E 47 44 39
Al-Sindbad	2	N 30 34 49 E 47 46 10
Al-Najibia	3	N 30 34 36 E 47 46 28
	4	N 30 34 15 E 47 46 55
Al-Ashar	5	N 30 31 45 E 47 50 28
	6	N 30 30 40 E 47 51 09
Abu Al-Khaseeb	7	N 30 28 00 E 47 57 15
	8	N 30 27 56 E 47 58 26
	9	N 30 27 51 E 48 00 15
	10	N 30 27 37 E 48 01 41

Table 2. Mean values of water temperature, Dissolved oxygen and pH of Shatt Al-Arab River from Jan. 2010 to Dec. 2011

Season	water temperature (C)	DO (mg/l)	pH
winter	13.9±2.3	10.7±1.4	7.80±5
spring	18.6±2.7	8.2±2.8	7.71±2
summer	32.6±3.2	8.39±2.5	7.48±2
autumn	16.5±2.9	9.94±1.8	7.75±4

The highest values of Dissolved Oxygen were during winter due to low water temperatures and decrease of photosynthesis processes. Low values of DO during summer can be attributed to the relatively high water temperature, higher oxidation rate of NH_4 and other biodegradable organic materials which consumes oxygen during its oxidation.

Although not directly related to trophic status, water temperature, pH and Dissolved

oxygen are important water quality parameters with respect to the ability of a river to support healthy aquatic communities. Figure 2 indicates that the total phosphorus concentration (TP) ranged between 0.24 and 5.95 µg/l, with a grand mean value of 2.32µg/l, with highest values in station 9 . Seasonally, the distribution of total phosphorus was in the following order winter > autumn > spring > summer (Fig. 3).
Municipal wastewater and Agricultural activities within Shatt Al-Arab River in some stations particularly station 5 and 6 contributed to the decline of Shatt Al-Arab River water quality. Major causes of concern may from the fertilizers and chemicals from the north parts of Qarmat Ali (station 1) as same as of Abu Al-Khaseeb (station 7-10). Run-off from agricultural generally contains chemical residues and fertilizers, which may pollute the water, and depending on loads may result in various hazards to the aquatic life and other lives depending on the river as a habitat and source of water supply.

Phosphorus enrichment may stimulate algal growth directly in the water column, where Chl-a was measured [18]. Seasonally, higher total phosphorus were recorded during winter can be explained by Reference [19] who suggested that the rainfall during winter is able to carry soil erosion products and agricultural waste. Total phosphorus concentrations in spring and summer were reduced due to active phosphorus uptake by phytoplankton and algae during these periods. There was a noticeable pattern of higher phosphorus in the river in the non-growing season and lower concentrations in the growing season in most study stations (Figure 3). The average chlorophyll-a concentration (Chl-a) ranged between 200 and 3380 µg/l, with a grand mean value of 1000.6 µg/l (Fig. 4). Seasonally, the distribution of chlorophyll-a was in the following order spring > autumn > summer > winter (Fig. 5). Even a small increase in the amount of phosphorous in a river can cause nuisance algal blooms which, when they die, lead to a lower amount of dissolved oxygen (DO) in the water. This is caused by bacteria that consume large amounts of oxygen when they feed on the dead algae. The decrease in the amount of DO can lead to the death of fish, invertebrates, and other aquatic animals. Excessive phosphate from some wastes encourages the growth of plankton, algae and higher plants [20] led to increasing of Chlorophyll-a in the water.

The average Secchi disc transparency ranged between 0.19 and 2.73 m, with a grand mean

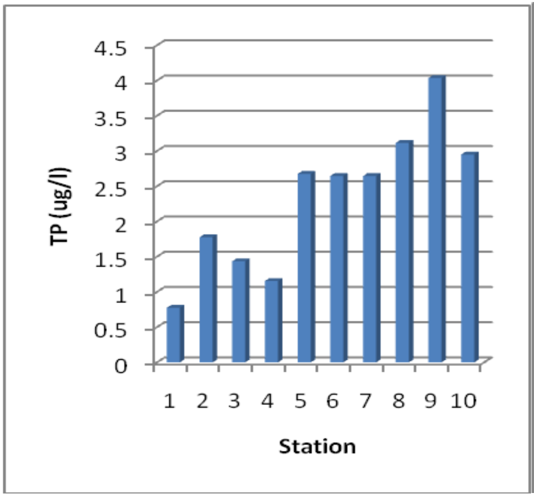

Fig.2. Mean of all stations of total phosphorus (TP) for Shatt Al-Arab River from Jan. 2010 to Dec. 2010

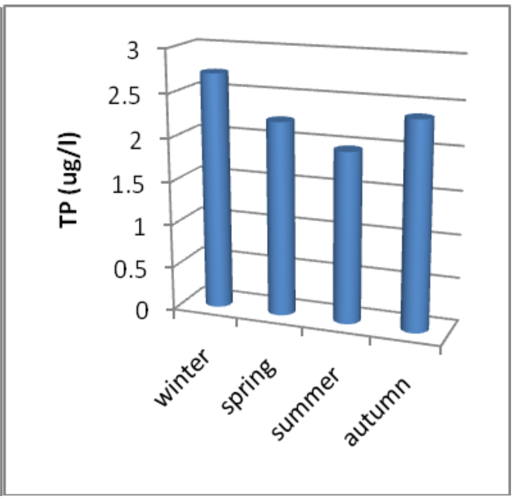

Fig.3. Seasonal changes of total phosphorus (TP) for Shatt Al-Arab River from Jan. 2010 to Dec. 2010

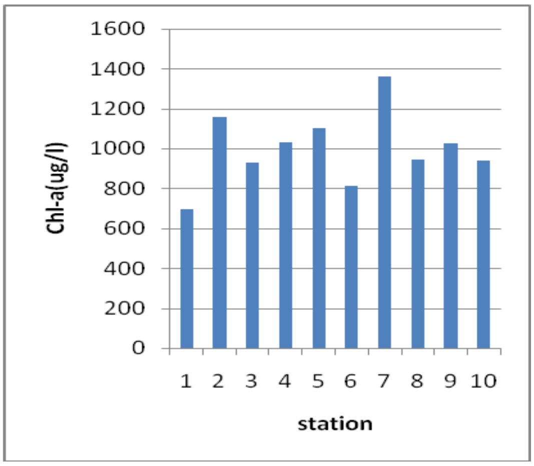

Fig.4. Mean of all stations of Chlorophyll a (Chl-a) for Shatt Al-Arab River from Jan. 2010 to Dec. 2010

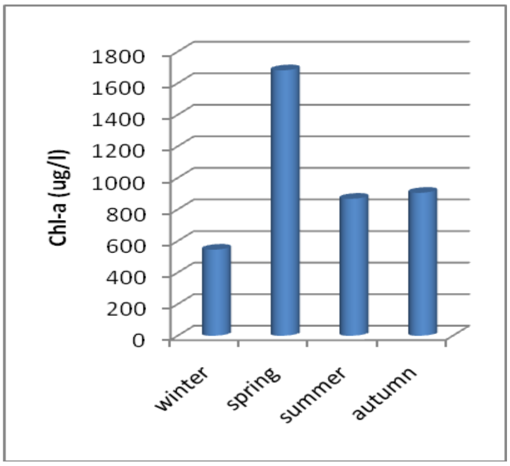

Fig.5. Seasonal changes of Chlorophyll a (Chl-a) for Shatt Al-Arab River from Jan. 2010 to Dec. 2010

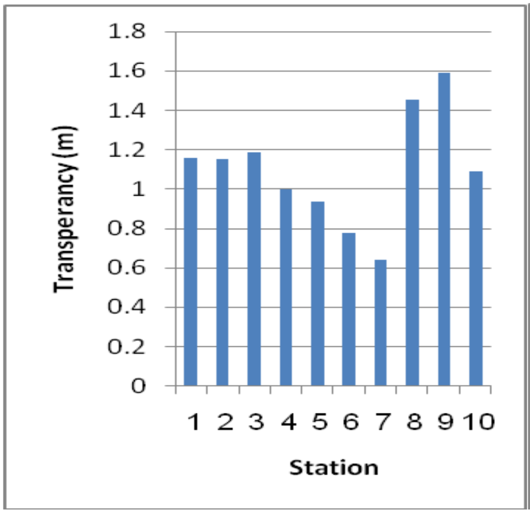

Fig.6. Mean of all stations of Transparency (m) for Shatt Al-Arab River from Jan. 2010 to Dec. 2010

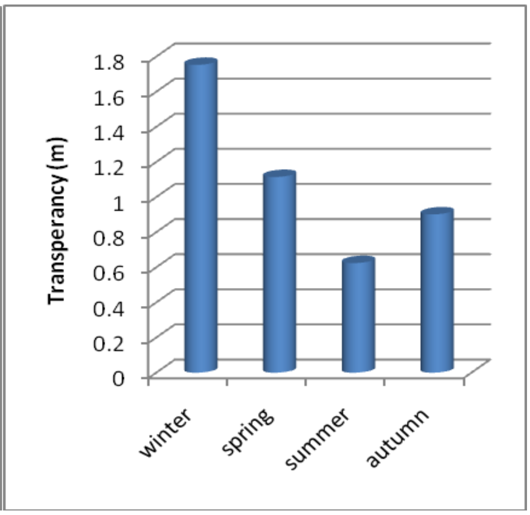

Fig.7. Seasonal changes of Transparen-cy(m)for Shatt Al-Arab River from Jan. 2010 to Dec. 2010

value of 1.09 m (Fig. 6). Seasonally, the ditribution of Secchi disc transparency was in the following order winter > spring > autumn > summer (Fig. 7).

Figure 8-10 explained that The secchi disc transparency was negative correlated with chlorophyll-a , for this Shatt Al-Arab River as a group the chlorophyll a concentration largely determines the water transparency, although there are exceptions in some individual stations. The analysis of data suggested that the relationship between transparency and total phosphorus was negative and slightly curvilinear**.** Positive correlation was found between Chl-a and total phosphorus.

In several instances, authors presented data on nutrients and chlorophyll levels, but did not perform a regression. In these cases, we independently estimated best fits using simple linear regression on the present data. The values of R^2 did not exceed 0.076.

The resulting numbers from the three measurements (TP, Chl-a and transperancy) cover different units and ranges and thus cannot be

directly compared to each other. To standardize these three measurements to make them directly comparable, converting them to a trophic state index using an equation must be done. TSI index can be used for regional classification of all surface water, including streams and rivers [10]. Shatt Al-Arab River, trophic state index calculations was performed (Table 3). According to those calculations, trophic state index at which only 58 based on concentration of Chl-a, 16 based on concentration of TP and 59 based on secchi disc parameter were considered, the average quality of the Shatt Al-Arab River was determined as "mesotrophic". However, average trophic state index was 44.3. Mesotrophic means with an intermediate level of productivity, greater than oligotrophic, but less than eutrophic. This River is commonly with beds of submerged aquatic plants and medium levels of nutrients.

TSI value described trophic state of Shatt Al-Arab River, while there were other indices could explain its water quality. In fact, Reference [2] explained that a trophic state index is not the same as water quality index. The term quality implies a subjective judgment that is best kept separate from the concept of trophic

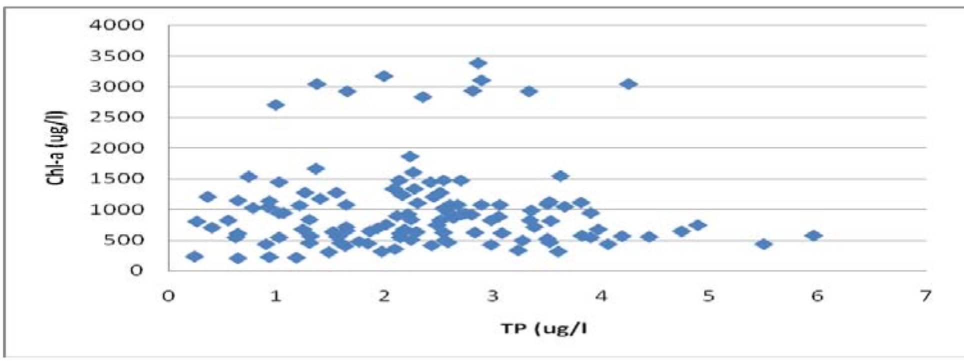

Figure 8: A Scatter plots illustrates relationship between Chl-a and total phosphorus within Shatt Al-Arab River.

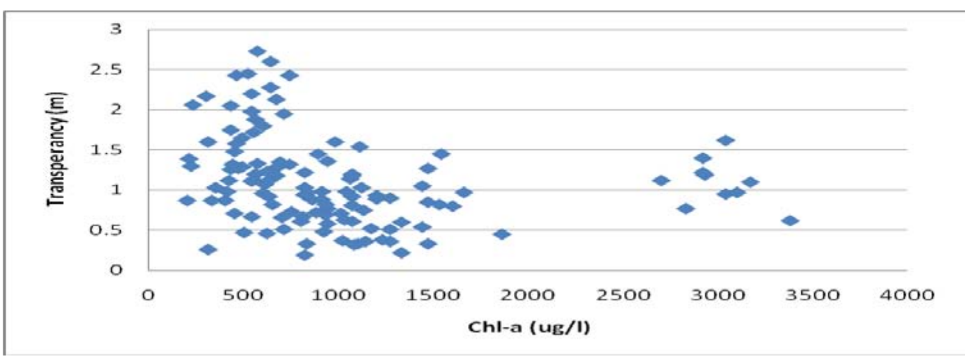

Figure 9: a Scatter plot illustrates relationship between Secchi disc transparency and Chl-a within Shatt Al-Arab River.

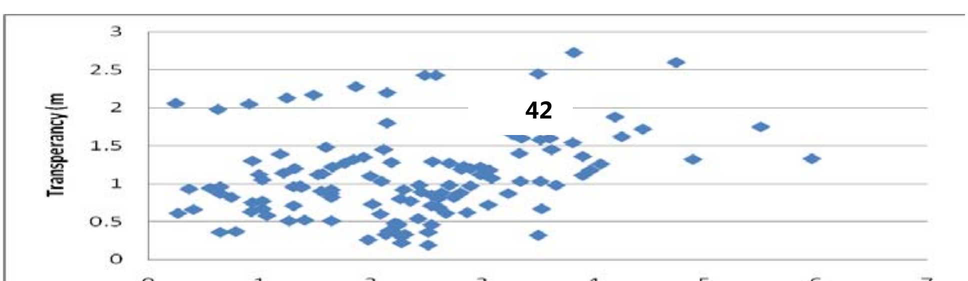

Figure 10: A Scatter plots illustrates relationship between Secchi disc transparency and total phosphorus within Shatt Al-Arab River.

Table 3. Average trophic state index calculations of Shatt Al-Arab River (2010)

Parameter	**unit**	**TSI**	**Trophic state**
Secchi disc transperancy	m	59	eutrophic
Total Phosphorus	ug/l	16	oligotrophic
Chlorophyll-a	ug/l	58	eutrophic
Average		44.3	mesotrophic

state. Another study of Reference [9] focused on the use of diatom indices for the assessment of Shatt Al-Arab River water quality. The component parameters used in the TSI calculations, secchi disc transparency, concentrations of chlorophyll-a, and total phosphorus, have been examined over periods of record for which data are available. Continued monitoring and specific evaluations o fect of each component on tł encouraged. Relative productivity studies, based on one of several accepted analytical techniques, will also be beneficial to understanding the trophic condition of the study area.

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