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Environmental Impact Assessment Study for Shatt Al-Arab River Receiving Industrial Wastewater

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Abstract

Shatt Al-Arab river has been used as the raw material for the drinking water, irrigation and fish purposes in Basrah city. Concurrently, this river has been polluted by domestic, farming and industrial waste. Three main factories lie on the bank of Shatt Al-Arab river: Al-Hartha Paper Mill, Hartha Power Station and Al-Najibia Power Plant. All these consume water from the river and return their wastewater back to it. The aim of this study is to assess the water quality of Shatt Al-Arab river and its suitability for drinking, irrigation and aquatic life through physicochemical analysis temperature, pH, EC, Total Dissolve Solid (TDS), Cl^-, Na^+, K^+, Ca^{+2}, Mg+2, HCO_3 total hardness, Biological Oxygen Demand (BOD5), Dissolved Oxygen (DO), Chemical Oxygen Demand (COD). BOD5 concentration near factories showed polluted water, unsafe and requiring costly treatment to use for drinking water. Sodium concentration is a key factor for irrigation, which represent by SAR and SSP. As SSP exceed 75.73 % in water near these factories, this could breakdown soil structure and can damage agriculture area. The high concentrations of BOD5 and COD could pose a threat to aquatic life and fishes. As Shatt Al-Arab river is used for different purpose, the result in this study showed polluted water near industrial areas. Therefore, it is recommended to have regular data on water quality for this river near these areas.

Keywords: Environmental impact assessment, Industrial wastewater, Physicochemical properties, Shatt Al-Arab river.

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1. Introduction

Water is one of the essential natural sources for all lives from microorganisms to human. Rivers are considered to be used as source of fresh water. Recently, this fresh water is being subjected to pollution by human habit due to development of industries, agriculture, and urbanization. Consequently, this polluted water would be used for irrigation and can badly affect flora and fauna as well as human population through the food chain. On the other hand, rivers water quality has become a vital and complex issue in many developing countries, this may be because of concern that this fresh water could become a scarce resource in the future. Thus, the water quality needs to be controlled and maintained to ensure protection of freshwater resources [1].

Shatt Al-Arab river is the main source of surface water in Basrah city. This river has economic and social values as it uses for various purposes such as potable water supply, irrigation and fisheries. Therefore, it is important to have reliable information on the quality of river water as this river is receiving several pollution activities that put directly into the river. These pollutant activities mostly come from domestic waste discharge, industrial waste and agricultural area [2].

Three main factories lie on the bank of Shatt Al-Arab river: Al-Hartha Paper Mill, Hartha Power Station and Al-Najibia Power Plant, as these factories require large quantities of water for their activity then their untreated wastewater find its way to the Shatt Al-Arab river. These industrial wastes usually contain specific and readily identifiable chemical compounds. Therefore, it is required to have regular monitoring programmes for reliable estimates of the Shatt Al-Arab river quality [2]. These monitoring programmes include study of physical, chemical and biological properties which are considered as measurements of water quality [3].

Aboodi et al. [4] study on the quality of the Shatt Al-Arab river near Hartha Power Station and Al-Najibia Power Plant. They also mentioned the impact of this quality on the on both drinking and agriculture for the environment surrounding these factories. In current study, the data matrix obtained during one-year monitoring program at three different pointes near the three factories (Al-Hartha Paper Mill, Hartha Power Station and Al-Najibia Power Plant) over the Shatt Al-Arab river. The objective of this study is to explore the exceeding value of physicochemical properties of Shatt Al-Arab river from standard quality and how it would affect on drinking water, irrigation and aquatic life.

2. Methods and Methodology

2.1. Study area

Shatt Al-Arab river is located in Basrah city, southern of Iraq. It is formed by the convergence of the two main rivers Tigris and Euphrates at Qurna town. The width of this river ranges from 232 meters to 800 meters in center of Basrah city and its mouth, respectively. While the total length of this river is about 192 km [4]. This river within Basrah city has a variety of uses, including irrigation in agricultural lands, drinking water and several different industries. Along the bank of this river, many industrial factories have been built, and the return flow from these industrial factories is directly discharged into the river. These factories are two power plants Hartha and Najibia as well as Al-Hartha Paper Mill. Hartha Power Stations located about 28 km from the center of Basrah city as shown in Fig. 1. This plant consists of four thermal units, and consumes about 74000 m^3/h of water [4]. Al-Najibia Power Plant which also consists of four thermal units, is located in Qarmat Ali about 10 km from the center of Basrah city and consumes about 34000 m^3/h of water [4]. While, Al-Hartha Paper Mill located about 33 km from the center of Basrah city and its water consumption is approximately 20 ton of water for ton of paper.

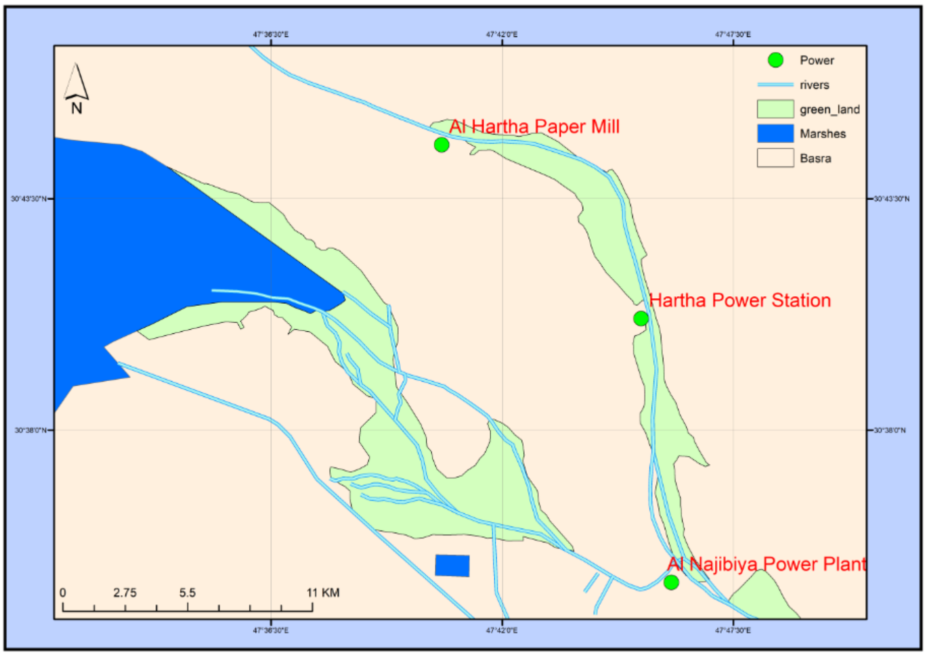

Fig. 1 Location of industrial area on Shatt Al-Arab river.

2.2. Sample preparation and analytical procedures

Samples of water were collected from the Shatt Al-Arab river from November 2016 to October 2017. The water samples were collected monthly from the Shatt Al-Arab river near the industrial area using plastic bottles. These bottles were fully filled and transferred to the laboratory after being stored in a refrigerated box. Portable multi meter was used to measure Temperature (T), pH, Electric Conductivity (EC) and Total Dissolved Solid (TDS). Chemical Oxygen Demand (COD) was measured used Hanna photometer.

Dissolved Oxygen (DO), Biological Oxygen Demand (BOD5) and Chloride (Cl^-) were measured according to the APHA (2005) [5]. The concentrations of Na^+, Mg^{+2}, K^+, Ca^{+2} were measured using flame photometry. HCO_3 and TH were measured by titration method.

For irrigation purposes, sodium concentration in the water is a key factor where high concentration of sodium and salinity in water can increase the exchange ratio of soil (the total capacity of a soil to hold exchangeable cations) [6]. The *SAR* is calculated as below:

$$SAR = \frac{Na^+}{\sqrt{\frac{Ca^{+2} + Mg^{+2}}{2}}} \quad (1)$$

The content and concentration of sodium in water sample were found through soluble sodium percentage (SSP), which applied to classify irrigation water. Usually, the increasing of *SAR* lead to increase the percentage of sodium exchange where there is a linear relation between them.

$$Na\,\% = \frac{Na^+ + K^+}{Mg^{+2} + Ca^{+2} + Na^+ + K^+} \times 100 \quad (2)$$

Where all cations expressed in meq/l.

3. Result and Discussions

3.1. Assessment of river water for drinking purpose

Table 1 represent the physicochemical properties of river water near the factories (Al-Hartha Paper Mill, Hartha Power Station and Al-Najibia Power Plant). pH average value ranges from 6.99 to 7.2, actually pH should be less than 8.0 according to WHO for drinking water. Water with pH more than 8 has a greater tendency to cause corrosion of pipes [7].

Water with BOD5 levels > 10 mg/l are considered as a contaminated water. As shown in Table 1 an average BOD5 range between 134.46 and 268.49 mg/l, which is, indicate polluted water and it is unsafe, costly treated to use as drinking water.

The high concentration of TDS in drinking water may causes cancer [8], coronary heart disease [9] and arteriosclerotic heart disease [10]. In current study, TDS value range from 1398 mg/l to 3911 mg/l as shown in Fig. 2.

Hardness in drinking water more than 200 mg/l may increase soap consumption. In contrast, hardness should keep out less than 100 mg/l to prevent pipes corrosion, resulting in the presence of certain heavy metals, such as cadmium, copper, lead, and zinc, in drinking water (2). In this study, an average value of total hardness was 1170 mg/l, 1027 mg/l and 1130 mg/l for industrial water from respectively, Al-Hartha Paper Mill, Hartha Power Station and Al-Najibia Power Plant as shown in Table 1.

Table 1. Water quality parameters values of Shatt Al-Arab river near industrial area and comparative guidelines for drinking, aquatic life and agriculture.

Variable	Industrial factory (means ± SD)			Drinking water WHO (2008) [14]	Aquatic life CCME (2007) [1-1]	WHO Agriculture [11-1]
	Al-Hartha Paper Mill	Hartha Power Station	Al-Najibia Power Plant			
Temperature	27.79 ± 7.70	34.75 ± 6.97	31.10 ± 6.50	-	-	-
pH	7.20 ± 0.36	7.04 ± 0.52	6.99 ± 0.30	6.5 - 8.5	6.5 - 9	6 - 8.5
TDS (mg/l)	2230.70 ± 688	1974.01 ± 430.87	2270.01 ± 488.49	1000	-	450
EC (dS/cm)	3.49 ± 1.075	3.08 ± 0.67	3.547 ± 0.76	-	-	7
DO (mg/l)	3.70 ± 0.84	3.8 ± 0.91	4.22 ± 0.77	-	-	2
$BOD5_5$ (mg/l)	134.46 ± 21.40	234.59 ± 60.85	268.49 ± 80.57	6	-	-
COD (mg/l)	138.33 ± 35.90	350.79 ± 74.79	206.19 ± 42.34	10	-	-
Na^+ (mg/l)	372 ± 28.6	375 ± 26.7	532 ± 19.6	200	-	66
K^+ (mg/l)	14.85 ± 10.94	18.88 ± 20.97	16.48 ± 7.21	-	-	-
Ca^{+2} (mg/l)	90.32 ± 45.17	63.48 ± 49.55	86.92 ± 58.45	-	-	-
Mg^{+2} (mg/l)	107.22 ± 53.19	127.75 ± 94.11	142.97 ± 80.91	150	-	-
Cl^- (mg/l)	431 ± 21.6	324 ± 18.9	574 ± 29.2	250	120	105
HCO_3^- (mg/l)	371 ± 51.5	391 ± 39.4	375 ± 43.6	-	-	-
TH (mg/l)	1170 ± 121.3	1027 ± 112.5	1130 ± 102.2	200	-	-

3.2. Assessment of river water for irrigation purpose

According to Jenson and Zahng (1990) [11], the irrigation water quality depends on amount of dissolved salts in water and the amount of sodium adsorption ratio (SAR). However, dissolved salts could be affected by pH value. From this point of view, the normal pH value ranges from 6.5 to 8.4. pH in this study (6.99-7.2) is considered suitable for agricultural irrigation. However, most plants can tolerate a wide range of pH where soil tends to buffer the water pH.

In this study and as shown in Table 2, the effect of Na is representing by SAR and SSP. Although, sodium has direct effect on salinity and could be toxic to the sensitive plant such as fruit trees. The main problem with a high SAR value is its effect on the physical structure of the soil. Continued irrigation soil with a high SAR leads to a breakdown of this structure. This could result in the dispersion of soil and as a result the soil becomes hard and compacted when dry and impervious to water penetration when wet. Therefore, the value of SAR is recommended to not exceeding 10. If the SAR value range between 10 and 18, sodium rate is moderate and irrigation by this water for long periods must be avoided [12]. SAR in this study exceed 40 and 50 in Al-Hartha Paper Mill, Hartha Power Station and Al-Najibia Power Plant respectively. The water near these plants considered not suitable for irrigation purpose and could breakdown soil structure.

On the other hand, SSP needs to be observed for salt that can accumulate in the root zones especially when SSP value above 60 % [12]. In this study, Na % range from 40.8 % to 85.5 %, as shown in Table 2.

The presence of high concentration of bicarbonates in irrigation water can increase SAR. Because, calcium carbonate ($CaCO_3$) and magnesium carbonate ($MgCO_3$) tend to precipitate at high concentration of HCO_3, and through evapotranspiration, the soil solution becomes concentrated. The concentration of HCO_3 in this study range between 284 mg/l to 437 mg/l, as shown in Fig. 3.

Moreover, there is interactive effect between SAR and EC on soil-water intake rate, maintain salt balance in root zone of the plant and on soil permeability [13]. High EC water can promote physiological drought phenomenon, which means inability of the plant to compete with ions in the soil solution for water, thus result its effect on crop productivity.

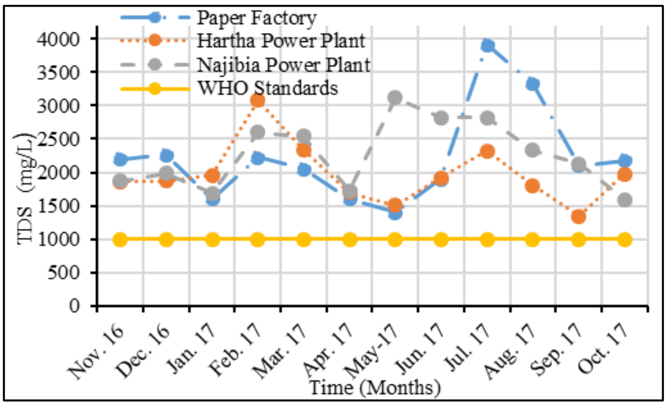

Fig. 2 The amount of TDS concentration in industrial water.

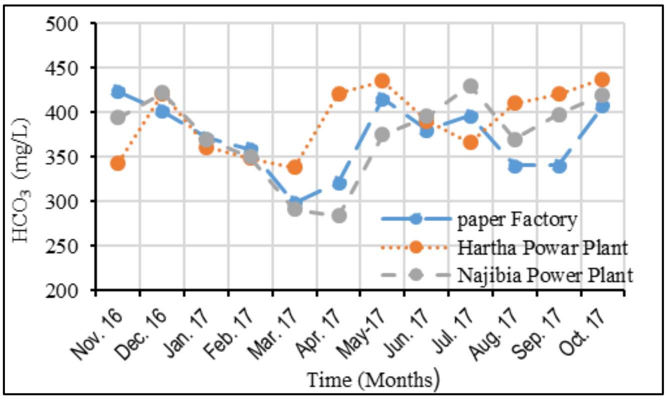

Fig. 3 The amount of HCO3 concentration in industrial water.

Table 2. Assessment of quality parameters in water near industrial area for agricultural purpose.

	Al-Hartha Paper Mill		Hartha Power Station		Al-Najibia Power Plant	
	SAR	Na %	SAR	Na %	SAR	Na %
Nov. 16	3.56	40.31	3.78	38.91	4.64	42.17
Dec. 16	3.69	41.96	3.82	40.74	4.55	42.34
Jan. 17	4.75	46.40	4.80	44.05	4.93	47.00
Feb. 17	2.35	26.42	7.05	65.88	6.24	58.51
Mar. 17	4.04	46.10	6.53	59.06	4.53	49.20
Apr. 17	4.34	42.02	4.18	45.56	4.10	40.37
May-17	6.20	59.29	6.78	66.29	5.52	58.07
Jun. 17	7.24	70.73	8.01	74.78	9.39	75.73
Jul. 17	4.93	54.03	8.88	74.67	4.64	42.97
Aug. 17	4.84	50.94	6.65	61.33	5.65	50.37
Sep. 17	6.50	64.94	4.56	39.42	5.25	53.22
Oct. 17	4.56	45.50	3.56	36.96	3.88	34.55

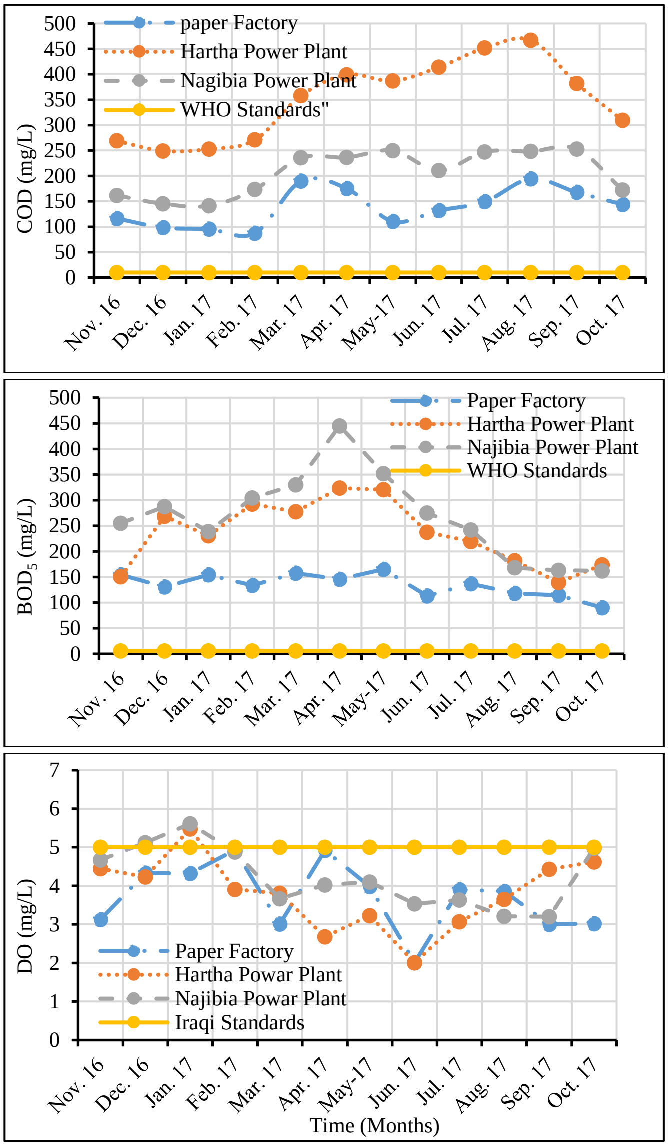

Fig. 4 The amount of Oxygen concentration in industrial water.

Furthermore, high EC could concentrate toxic ions to sensitive crops such as Na, Cl, HCO_3 [13].

In this study EC of water near factories range as average from 3.547 to 3.08 dS/cm as shown in Table 1, while most of the irrigation waters present salinity levels when EC is higher than 2.250 dS/cm [14]. This may be because, the higher EC, the less water is available to plants, even if the soil appears wet [15].

3.3. Assessment of river water for aquatic life purpose

Physiochemical properties such as pH, DO, BOD5 and COD are directly influence the growth of planktons (phytoplanktons and zooplanktons). These planktons are directly affecting the growth of other herbal and animals because it is considered as the main producers of any aquatic BOD5. The favorable conditions for plankton's growth are alkalinity where optimal pH value range from 6.5-8.2 [16], DO over 6 mg/l, BOD5 less than 15 mg/l and COD less than 50 mg/l, consequently, fish production can increase [17]. Low DO can create lacking swim bladder for fishes, which led to increase in mortality. Not only fishes breathing can relate to DO concentration, but also fishes feeding can relate to DO concentration. This because fishes in area with low DO become lethargic and stop feeding [18].

High fish mortality can also be related to high concentration of BOD5 and COD. These High concentrations can interfere with respiratory and metabolism [19].

In the present investigations, an average value for pH was 6.9-7.2 while values for DO, BOD5 and COD were 2.01-5.48 mg/l, 90.1-445.1 mg/l and 87.43-467.2 mg/l respectively as shown in Fig. 4, which indicated a polluted water and could, pose a threat to aquatic life and fishes.

4. Conclusions

This study used data collection from Shatt Al-Arab river near industrial area to identify the type of pollution that affecting water quality. As this river used for various purposes such as public water supply and drinking, irrigation and fishing. The status of water quality concluded that:

1. The high concentration of BOD5, TDS and TH made the river water not suitable for bathing and drinking.
2. The effect of Na concentration represents by SAR and SSP. When SAR > 18 lead to a breakdown the soil structure. In this study, SAR was less than 10 while SSP range from 26.42 % to 75.73 %. When SSP value above 60 %, the salt can accumulate in the root zones.
3. The soil solution becomes concentrated as HCO_3 concentration increase due to precipitate of $CaCO_3$ and $MgCO_3$ at high concentration of HCO_3.
4. At EC > 2.250 dS/cm, irrigation water identify as salinity water and less water is available to plants, even if the soil appears wet. In this study EC of water reach to 3.57 dS/cm.
5. The amount of oxygen concentration represents by DO, BOD5 and COD are directly influence the growth of all life in river water. Low DO, high BOD5 concentrations could increase fish mortality.

From above it is recommended to have regular study work on water quality of Shatt Al-Arab river as this river receiving different pollution through industrial area.

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Appendix

Fig. 5 Location of Al-Najibia Power Plant on Shatt Al-Arab River.

Fig. 6 Location of Hartha Power Station on Shatt Al-Arab River.

Fig. 7 Location of Al-Hartha Paper Mill on Shatt Al-Arab River.