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WATER QUALITY EVALUATION OF THE SHADEGAN AND HAWR AL AZIM WETLANDS FROM IRAN

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ABSTRACT

In this study the water quality of the Shadegan and Hawr Al Azim wetlands from October 2011 to September 2012 was evaluated. Data from the analysis of the water quality parameters showed that the salinity, hardness, total dissolved solids, turbidity, electrical conductivity and total suspended solids of their waters of these wetlands were higher than the Environmental Protection Agency or World Health Organization standards indicated that the wetlands had a poor quality condition which threatens their lives. However its severity in the Hawr Al Azim wetland compared to the Shadegan wetland was milder due to its healthier and intact environment. Since the aquatic organisms and wildlife especially the endangered or threatened species are dependent to the water quality of their habitats, encountered to serious threats. In overall currently the water quality of these wetlands have a poor condition and will be forecasted to be continued and gotten worse in the future.

KEYWORDS : Evaluation, Hawr Al Azim, Shadegan wetland, Water quality, Wetland

Wetlands such as Shadegan and Hawr Al Azim (Hawr Al Hawizea) have characteristics that identify them as distinct (Ramsar Convention Secretariat 2011) and the most productive ecosystems (EPA 2010). They naturally generate an array of vegetation and other ecological products that they are applied for personal and commercial uses (EPA 2012a). Really wetlands create significant economic benefits that are extremely valuable to human society including water quality improvement, removing pollutants from water, flood protection, erosion control, shoreline protection, recharge groundwater, wildlife habitat providing, recreational and cultural serving and aesthetic appreciation. Furthermore, wetlands are tourism sites and bear many socioeconomic advantages for local residents. They have also eco-environmental condition to prevent dust phenomena, a regional and interregional complex problem in Iran and the neighbor countries, that are extremely important in recent decades (Constanza et al. 1997; Nasirian et al. 2013; Nasirian et al. 2014a; Nasirian et al. 2014b). Therefore make us protect them. In fact it is protecting of our safety and welfare (EPA 2012a).

The healthy water resources are the main prerequisite for sustaining the environment, economic, political, social and cultural developments of the countries. Water resource protecting, recreational activity encouraging and wildlife survival keeping, needs the water high quality of the rivers, wetlands and other water resources (USGS 2001). As mentioned the above the Shadegan and Hawr Al Hawizea wetlands are very important but discharge of waste into the waters produce condition which can lead to emergence of the high density of mosquitoes. It may cause human long-lasting nuisance and distribute mosquito-borne diseases (WHO 2004) that can prevent wetland tourist activities.

In another respect, our country water quality such as Shadegan and Hawr Al Azim wetlands must be tried to maintain at the standard criteria which are undeniably key to protecting the quality of our Nation's waters (EPA 2003), and lead to maintaining recreation activities, agricultural irrigation, or protecting and maintaining of aquatic life (USGS 2001). In an evolving scientific arena, adequate protection of aquatic organisms and wildlife, recreational uses, and sources of waters depends on having well crafted standards and criteria in place for our waters for example, assuring adequate dissolved oxygen for aquatic organisms and wildlife, and installing wastewater treatment systems for basic sanitation. Protection of threatened and endangered species also is important in the standard

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development (EPA 2003).

In recent years, water resources of the countries are threatened by the various contaminants such as industrial sewages, fertilizers, pesticides, and wastewaters. So, possessing a plan and strategy for the water conservation and quality control is as a subject in the country's infrastructure. Urban and industrial development, farming, mining, combustion of fossil fuels, stream-channel alteration, animal-feeding operations, and other human activities can change the quality of natural waters (USGS 2001) such as wetlands. Although natural water quality varies from place to place, with the seasons, climate, and the types of soils and rocks through which water moves. When water evaporates from streams, lakes and wetlands dissolved minerals are more concentrated in the water that remains. Each of these natural processes changes the water quality and potentially the water use (USGS 2001). Since the aquatic organisms and wildlife are dependent to the water quality of their habitats especially dissolved oxygen, they encountered to the serious threats especially the endangered or the threatened species such as insects or other organisms.

Wetlands need to be monitored over the time in order to evaluate their water pollution (EPA 2012a). However measurement of the water quality pollution needs to qualify water that can be taken by regular environmental surveys. The goals of the water quality program are to prevent and clean up water pollution and to help communities make sustainable choices that reduce and prevent water quality problems. As an example of the effects of human activities on water, is considering the water quality parameters including temperature, electrical conductivity (EC), dissolved oxygen (DO), pH, hardness, total dissolved solids (TDS), total suspended solids (TSS), turbidity, and salinity that are applied likely to determine water quality. In this regard various research studies must be allocated annually. However, few studies in this context have been conducted about our country wetlands. Razedar el al. (2009) and Navabian el al. (2012) studied the water quality of Anzali wetland (Razedar el al. 2009; Navabian el al. 2012). Karimzadegan (2010) in a review study considered the water quality of Shadegan wetland from 1969 to 2003 according to the limited water quality parameters which measured previously by researchers (Karimzadegan 2010). Also Makvandi (2006) studied the water quality of Hawr Al Azim wetland limitedly (Makvandi 2006). Recently in a very small and short time scale study, Nasirian et al. (2013) considered the Shadegan wetland water quality. Whereas in this study the trend of the wetland water quality would not be evaluated. But it seems it would be better the study is taken in a large and long time scales to evaluate the trend of the wetland water quality. Thus a study designed to evaluate the water quality of the Shadegan and Hawr Al Azim wetlands in Khuzistan province, south west of Iran.

MATERIALS AND METHODS

Geographical Information

This study was conducted in the Shadegan and Hawr Al Hawizea (Hawr Al Azim) wetlands in Khuzistan province, south west of Iran. The Shadegan wetland is the largest wetland in Iran and covers an area of 537,700 hectares, located 52 km from Abadan and 40 km from Ahvaz and extends from north to Shadegan City and Khor Doraq, south to the Bahmanshir River, west to Darkhovien and Abadan Road and east to Khure-Musa. The Shadegan wetland area coordinates are: 48o 17'- 48o 50'E and 30o 17'- 30o 58'N (Nasirian et al. 2013). Hawr Al Azim or Hawr Al Hawizeh is situated in the North Azadegan Plain, 80 km south west of Ahvaz, near the border between Iran and Iraq. The area is about 56,654 hectares, being located between 47° 20´- 47° 55´E and 30° 58´- 31° 50´N (Mirzaei et al. 2010).

Site Selection

Samples were collected from six selected sites of the Shadegan and Hawr Al Azim (Hawr Al Hawizeh) wetlands (Fig. 1).

Water Quality Parameter Measurement

The water quality parameters which assessed were temperature, electrical conductivity (EC), dissolved oxygen (DO), pH, hardness, total dissolved solids (TDS), total suspended solids (TSS), turbidity, and salinity from October 2011 to September 2012. The temperature, EC, DO, pH, TDS and salinity were measured by the HQ40d Portable Multi-Parameter Meter. Whereas the hardness and TSS, and turbidity were measured in the laboratory by following the titration method and the turbidity meter, respectively.

Statistical Analysis

Data from the assessed water quality parameters between the sites, months, and sites and months were analyzed by One-way ANOVA and Post Hoc tests (Tukey HSD) using PASW Statistics 18. One-sample t-tests were used for comparing the water quality parameters with the Environmental Protection Agency (EPA) or the World Health Organization (WHO) standards (EPA 2012b; WHO 2008).

RESULTS

In this study the water quality parameters including temperature, electrical conductivity (EC), dissolved oxygen (DO), pH, hardness, total dissolved solids (TDS), total suspended solids (TSS), turbidity, and salinity were measured in the six sample sites of the Shadegan and Hawr Al Azim wetlands from October 2011 to September 2012. Table 1 and Fig. 2 show water quality parameters which were measured in the sample sites of the Shadegan and Hawr Al Azim wetlands, from October 2011 to September 2012.

Water Temperature

The temperature ranges of the water from the sample sites of the Shadegan and Hawr Al Azim wetlands were 16.5 (minimum) in March to 31.2 ˚C (maximum) in June in the SW5 and in the SW2 sites, respectively (Table 1 and Figure 2). Generally, the temperature of the water was decreased from October to December and with low swing from December to April whereas was increased from April to June and decreased from June to July then increased from July to September in the sample sites of the Shadegan and Hawr Al Azim wetlands (Table 1 and Figure 2).

Water pH

The pH ranges of the water from the sample sites of the Shadegan and Hawr Al Azim wetlands were 6.5-8.5 and were at the EPA standard ranges (EPA 2012b). The minimum (6.43) and the maximum (7.8) pH of the water were observed in the SW1 in the July, and in the SW1, SW2 and SW5 sample sites in the December and HH in the March, respectively (Table 1 and Figure 2).

Water dissolved oxygen (DO)

The DO ranges of the water from the sample sites of the Shadegan and Hawr Al Azim wetlands were 1.72 (minimum) in the April to 41 (maximum) mg/L in the December and both were in the SW5 sample site. The DO of the water was increased from October to December and reached to the highest ranges where the mean of the air and the water temperature were at the lowest of the annual ranges whereas was decreased from December to March, then with partial fluctuations was gradually decreased from March to July with increasing of the air and water temperature and reached to the lowest ranges in the September (Table 1 and Figure 2).

According to the EPA standard, the DO of the water must not be less than the 5 mg/L (EPA 2012b). The DOs of the water was less than the EPA value standard in some sample site of the month samplings (Table 1 and Fig. 2). Significant differences were found between the mean DOs compared to the EPA value standard ($P<0.05$) (Table 2). One-way analysis of variance (ANOVA) showed significant differences between the mean DOs of the month samplings ($P=0.0001$) (Table 3). Followed by Post Hoc tests were observed significant differences between the October with the December, April, July and September, and the December with the March, April, June, July and September ($P<0.05$) (Table 5) without any significant differences between the mean DOs of the site samplings ($P=0.257$) (Table 3)

Water Salinity

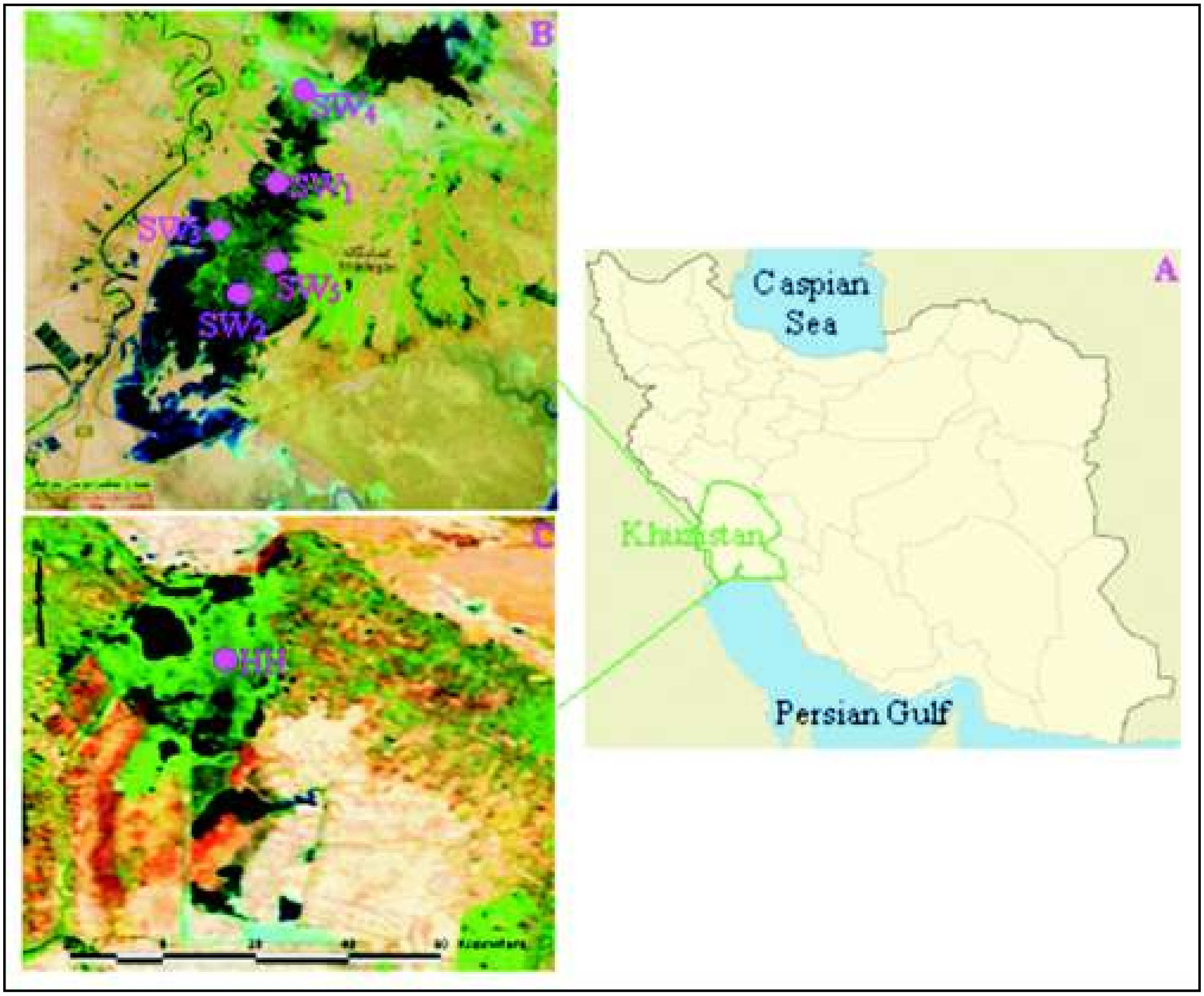
The salinity ranges of the water from the sample sites of the Shadegan and Hawr Al Azim wetlands were 30.54 (minimum) in the March to 386.7 mg/L (maximum) in the October in the HH and SW5 sites, respectively. The salinity of the water was decreased from October to March (The lowest ranges) with decreasing of the evaporation and the air and water temperature, and increasing the rain; whereas was gradually increased from March to September with partial fluctuation and with increasing of the evaporation and the air and water temperature, and decreasing the rain and reached to the highest ranges in the October (Table 1 and Figure 2).

One-way analysis of variance (ANOVA) showed significant differences between the mean salinity of the site

Table 1. Water Quality Parameters Measured in the Shadegan and Hawr Al Azim Wetlands, October 2011 to September 2012

Site	Season	Month	Tem	pH	DO	Sal	Hard	TDS	TSS	Tur	EC	Res
			(ºC)		(mg/L)					(NTU)	(µs/cm)	(Ωcm)
SW1	Autumn	October	25.2	7.7	10	186.01	2303.7	600	1	4	11232	-
		December	19.5	7.8	12	169	2110.3	6280	8.1	8	12590	-
	Winter	March	18.3	7.51	8.11	100.23	2024	6225	15	10	11825	-
	Spring	April	23.9	6.98	6.45	60.69	2220	6195	10.2	4	11820	86.2
		June	30	7.2	6.45	130.85	2070	6825	17.9	13	13005	79.9
	Summer	July	22.4	6.43	6.83	60.62	2360	6390	19.3	1	11590	85.9
		September	29.5	6.96	6.56	100.40	1916	5150	7.3	8	9460	105.1
SW2	Autumn	October	25.9	7.6	10	205.6	3823.7	915	1	5	17140	-
		December	22.3	7.8	14	231.5	3477.6	8570	14	3	17170	-
	Winter	March	22	7.72	13.54	90.29	2835	8980	19	45	15980	-
	Spring	April	22.9	7.46	8.56	100.49	2330	9395	28	17	17605	56.2
		June	31.2	7.28	12.31	120.94	2284	12580	11.6	11	21630	46.3
	Summer	July	22	6.46	2.75	300.3	4840	18130	104	7	30200	33
		September	29	6.82	2.61	280.6	4770	15720	15.2	8	26500	37.8
SW3	Autumn	October	26.8	7.6	10	215.38	2826.2	676	3	14	12650	-
		December	24.2	7.6	12	226	2787.5	6980	8.2	8	14000	-
	Winter	March	20.8	7.02	9.12	80.41	2490	8050	14.7	10	14715	-
	Spring	April	22.5	6.77	7.72	160.47	2366	8690	4.6	18	15850	61.2
		June	31	7.30	8.36	200.26	2200	9120	13.3	11	17050	58.1
	Summer	July	26.2	6.74	3.88	210.90	3240	12330	70.4	7	21330	47.2
		September	28.9	6.91	2.79	170.37	3088	9080	9.5	6	16100	62.1
SW4	Autumn	October	26.6	7.6	10	225.17	2066.2	526	12	11	9530	-
		December	17.4	7.5	13	198	2390	6390	8.5	11	12800	-
	Winter	March	21.6	7.24	8.71	70.46	1987	7175	9.1	30	13445	-
	Spring	April	22	7.53	8.03	100.09	2024	5615	4.4	9	10760	94.6
		June	27.7	7.01	6.73	110.79	2130	6680	38.7	17	12715	87.2
	Summer	July	24.9	7	7.09	100.61	2020	5630	27.5	5	10310	96.7
		September	29.1	7.09	6.60	100.13	1912	5060	5.8	8	9320	107
SW5	Autumn	October	23.6	7.4	10	386.7	5225	6290	21	47	25260	-
		December	21.5	7.8	14	181	1343.5	3860	14.7	21	7740	-
	Winter	March	16.5	7.45	12.66	50.69	2280	515	27.3	25	10580	-
	Spring	April	20	6.98	1.72	110.86	2444	6505	13	15	12345	80
		June	30.6	7.39	12.64	240.8	2346	13000	53	80	22200	44.6
	Summer	July	27	7.03	4.05	130.84	2620	7420	46.9	7	13420	75.1
		September	28.8	7.12	4.92	220.7	4520	12210	1.6	40	21200	47.5
HH	Autumn	December	20.1	7.5	12.5	174	2021.8	4030	8.8	4	8060	-
	Winter	March	20	7.80	8.56	30.54	1558	6045	9.9	9	6550	-
	Spring	April	22.5	7.48	6.31	40	1738	3695	6.2	8	7155	137.8
		June	29	7.75	4.09	60.48	1862	4110	17.9	8	8005	137.9
	Summer	July	26	7.29	2.32	70.13	1820	4130	26	3	7700	130.4
		September	27	7.18	2.75	80.79	2080	4690	3.3	4	8690	115.2

Note: The values higher than the EPA or WHO standards are shown in bold. Tem= Temperature, Sal= Salinity, Hard= Hardness, Tur= Turbidity and Res= Resistivity.



SW_1 to SW_5=Shadegan wetland and HH= Hawr Al Azim wetland sample sites.
Source adapted from A (Iran): wikimedia.org 2014, B (Shadegan wetland): khouznews.ir and C (Hawr Al Azim wetland): persianblog.ir 2014.
Figure 1 : Areas studying of the Shadegan and Hawr Al Azim wetlands, from October 2011 to September 2012.

and month samplings (P=0.004 and P=0.0001, respectively) (Table 3). Followed by Post Hoc tests were observed significant differences between the mean salinity of the HH with the SW_2, SW_3 and SW_5, and between the salinity of the October with March, April, June and December with March and April ($P<0.05$) (Table 4 and 5).

Water Hardness

The hardness ranges of the water from the sample sites of the Shadegan and Hawr Al Azim wetlands were 1343.5 (minimum) in the December to 5225 (maximum) mg/L in the October which both was in the SW_5 sample site. The hardness of the water was decreased with partial fluctuation from October to March 2011 (The lowest ranges) with decreasing of the evaporation and, air and water temperature, and increasing the rain; whereas was increased from March 2011 to September 2012 with increasing of the evaporation and air and water temperature, and decreasing the rain due to excess minerals and reached to the highest ranges in the October (Table 1 and Figure 2).

According to the WHO standard, the hardness of the water must not be higher than the 500 mg/L (WHO 2008). The mean hardness of the water was higher than the

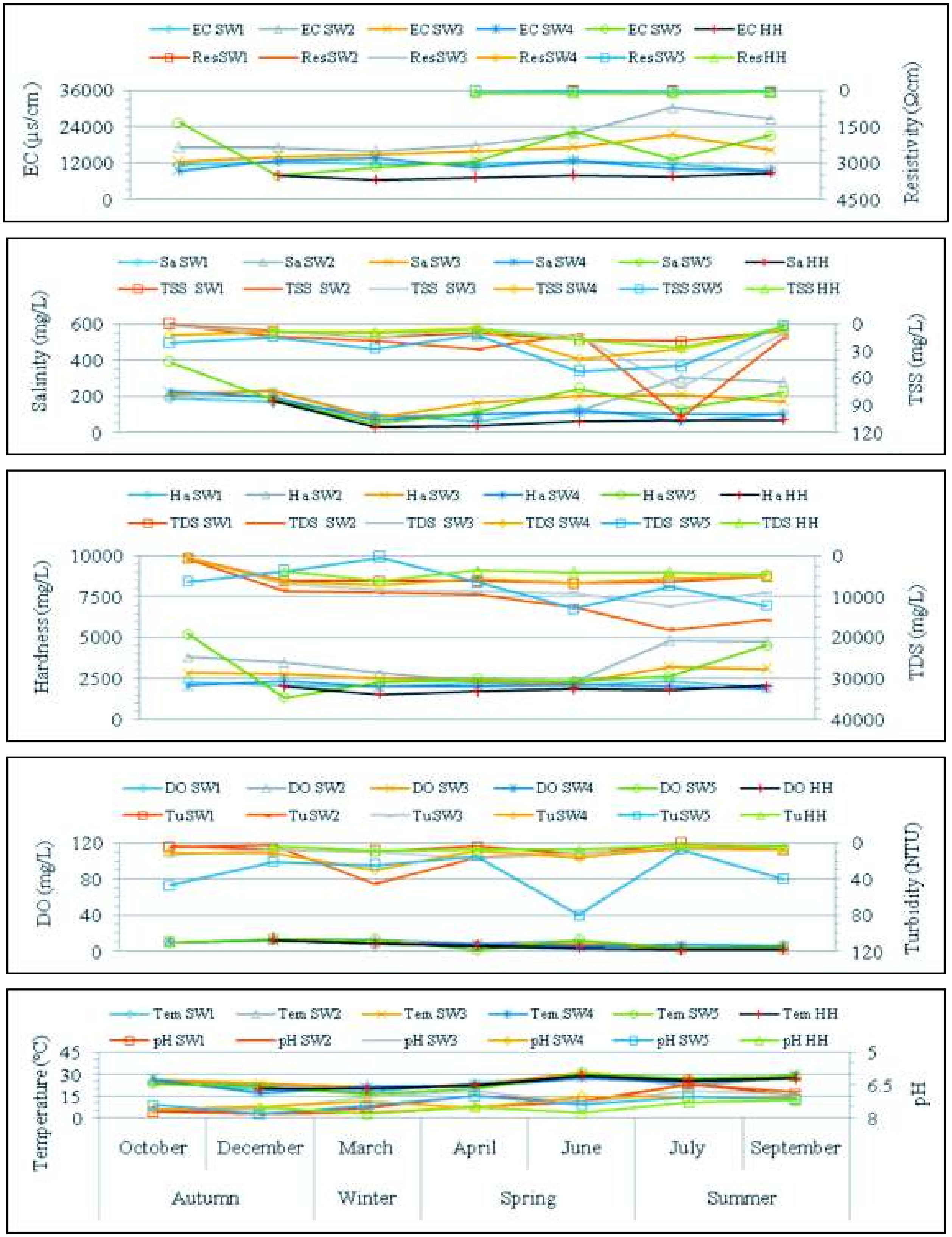


Figure 2 : Water quality parameters trend in the Shadegan and Hawr Al Azim wetlands, October 2011 to September 2012. Tem= Temperature, Tu= Turbidity, Ha= Hardness, Sa= Salinity and Res= Resistivity.

Table 2 : One-Sample T-Tests Analysis Between Observed Water Quality Parameters and EPA or WHO Standards.

Water quality parameter	Rate									
	Standard	Observed			Site			Month		
		t	df	P	t	df	P	t	df	P
DO	5	4.2	40	<0.0001	5.6	41	<0.0001	3.2	41	0.003
Hardness	500	14.6	40	<0.0001	1861.5	41	<0.0001	1588.1	41	<0.0001
Turbidity	5	3.9	40	<0.0001	5.6	41	<0.0001	3.2	41	0.003
EC	2000	13.9	40	<0.0001	7485.4	41	<0.0001	6390.3	41	<0.0001
TDS	500	10.4	40	<0.0001	1861.5	41	<0.0001	1588.1	41	<0.0001
TSS	150	42.4	40	<0.0001	549.3	41	<0.0001	467.4	41	<0.0001

Table 3 : One-Way ANOVA Analysis Between Site and Month Samplings of Observed Water Quality Parameter Rates.

Water quality parameter	Site			Month		
	F	df	P	F	df	P
DO	1.39	5	0.257	17. 11	6	<0.0001
Salinity	4.53	5	0.004	6.33	6	<0.0001
Hardness	5.39	5	0.001	2.28	6	0.063
Turbidity	5.10	5	0.002	1.83	6	0.128
EC	9.75	5	<0.0001	1.14	6	0.363
TDS	5.55	5	0.001	5.31	6	0.001
TSS	1.68	5	0.171	6.49	6	<0.0001
Resistivity	30.38	5	<0.0001	0.88	3	0.473

WHO standard in the all sample sites of the all month samplings (Table 1 and Figure 2). One-sample t-tests showed significant differences between mean hardness of the site and month samplings compared to the WHO value standard (P<0.0001) (Table 2). One-way analysis of variance (ANOVA) showed significant differences between the mean hardness of the site samplings (P=0.001) (Table 3). Followed by Post Hoc tests were observed significant levels between the mean hardness of the SW_2 with SW_1, SW4 and HH (P<0.05) (Table 4) without any significant differences between the mean hardness of the month samplings (P=0.063) (Table 3).

Water Turbidity

The turbidity ranges of the water from the sample sites of the Shadegan and Hawr Al Azim wetlands were 1 (minimum) in the July to 80 (maximum) NTU in the June in the SW1 and SW5 sample sites, respectively. The water turbidity of the sample sites of the Shadegan wetland was increased in the March (The highest ranges) because of the arrival of the rain runoff to the Shadegan wetland and was increased also in the June due to sever evaporation. The water turbidity of the SW_5 had many fluctuations and was increased in the June due to sever evaporation which has been reached to the highest ranges. The turbidity ranges of the Hawr Al Azim waters from December 2011 to September 2012 had low fluctuations and more uniformity due to its intact and original ecosystem compared to the sample sites of the Shadegan wetland (Table 1 and Figure 2).

According to the EPA or WHO standards, the turbidity of the water must not be higher than the 5 NTU (EPA 2012b; WHO 2008). The mean turbidity of the water was higher than the EPA or WHO standards (>5 NTU) in some sites of the month samplings (Table 1 and Fig. 2). One-sample t-tests showed significant differences between the mean turbidity of the site and month samplings compared to the EPA or WHO standards (P<0.0001 and P=0.003, respectively) (Table 2). One-way analysis of variance (ANOVA) showed significant differences between the mean turbidity of the site samplings (P=0.002) (Table 3). Followed by Post Hoc tests were observed a significant differences between the mean turbidity of the SW_5 with

Table 4 : Tukey HSD Analysis Among Observed Water Quality Parameters of Site Samplings After One-Way ANOVA Significance.

WQP	Site	SW_1			SW_2			SW_3			SW_4			SW_5		
		MD	**SE**	**P**	**MD**	**SE**	**P**	**MD**	**SE**	**P**	**MD**	**SE**	**P**	**MD**	**SE**	**P**
Sal	SW_2	74.56	27.69	0.107	-	-	-	-	-	-	-	-	-	-	-	-
	SW_3	65.14	27.69	0.206	9.42	27.69	>0.999	-	-	-	-	-	-	-	-	-
	SW_4	13.92	27.69	0.996	60.64	27.69	0.273	51.22	27.69	0.452	-	-	-	-	-	-
	SW_5	73.41	27.69	0.117	1.16	27.69	>0.999	8.26	27.69	>0.999	59.48	27.69	0.292	-	-	-
	HH	39.41	28.82	0.745	113.97*	28.82	0.005	104.55*	28.82	0.013	53.33	28.82	0.451	112.81*	28.82	0.006
Hard	SW_2	1336.61*	361.72	0.011	-	-	-	-	-	-	-	-	-	-	-	-
	SW_3	570.53	361.72	0.619	766.09	361.72	0.306	-	-	-	-	-	-	-	-	-
	SW_4	67.83	361.72	>0.999	1404.44*	361.72	0.007	638.36	361.72	0.503	-	-	-	-	-	-
	SW_5	824.93	361.72	0.234	511.69	361.72	0.718	254.4	361.72	0.980	892.76	361.72	0.167	-	-	-
	HH	296.8	376.49	0.967	1633.41*	376.49	0.002	867.32	376.49	0.225	228.97	376.49	0.990	1121.72	376.49	0.058
Tur	SW_2	6.86	6.32	0.883	-	-	-	-	-	-	-	-	-	-	-	-
	SW_3	3.71	6.32	0.991	3.14	6.32	0.996	-	-	-	-	-	-	-	-	-
	SW_4	6.14	6.32	0.923	0.71	6.32	>0.999	2.43	6.32	>0.999	-	-	-	-	-	-
	SW_5	26.71*	6.32	0.003	19.86*	6.32	0.040	23.0*	6.32	0.012	20.57*	6.32	0.031	-	-	-
	HH	0.86	6.58	>0.999	7.71	6.58	0.846	4.57	6.58	0.981	7.0	6.58	0.891	27.57*	6.58	0.003
EC	SW_2	9243.3*	2044.2	0.001	-	-	-	-	-	-	-	-	-	-	-	-
	SW_3	4310.43	2044.2	0.311	4932.9	2044.2	0.185	-	-	-	-	-	-	-	-	-
	SW_4	377.4	2044.2	>0.999	9620.7*	2044.2	0.001	4687.9	2044.2	0.229	-	-	-	-	-	-
	SW_5	4460.4	2044.2	0.276	4782.9	2044.2	0.211	150.0	2044.2	>0.999	4837.9	2044.2	0.201	-	-	-
	HH	3952.7	2127.7	0.447	13195.95	2127.7	<0.0001	8263.1*	2127.7	0.007	3575.2	2127.7	0.555	8413.1*	2127.7	0.005
TDS	SW_2	5232.1*	1441.3	0.013	-	-	-	-	-	-	-	-	-	-	-	-
	SW_3	2465.9	1441.3	0.636	2766.3	1441.3	0.411	-	-	-	-	-	-	-	-	-
	SW_4	84.1	1441.3	>0.999	5316.3*	1441.3	0.011	2550.0	1441.3	0.50	-	-	-	-	-	-
	SW_5	1733.6	1441.3	0.832	3498.6	1441.3	0.180	732.3	1441.3	0.995	1817.7	1441.3	0.803	-	-	-
	HH	930.7	1500.1	0.989	6162.9*	1500.1	0.004	3396.6	1500.1	0.241	846.6	1500.1	0.993	2664.3	1500.1	0.496
Res	SW_2	45.95*	8.2	0.001	-	-	-	-	-	-	-	-	-	-	-	-
	SW_3	32.1*	8.2	0.014	13.8	8.2	0.558	-	-	-	-	-	-	-	-	-
	SW_4	7.1	8.2	0.949	53.05*	8.2	<0.0001	39.2*	8.2	0.003	-	-	-	-	-	-
	SW_5	27.5*	8.2	0.041	18.5	8.2	0.269	4.65	8.2	0.992	34.6*	8.2	0.008	-	-	-
	HH	41.05*	8.2	0.002	87.0*	8.2	<0.0001	73.2*	8.2	<0.0001	33.95*	8.2	0.009	68.5*	8.2	<0.0001

*The mean difference is significant at the 0.05 level. WQP= Water quality parameter, MD= Mean difference, SE= Standard error, Sal= Salinity, Hard= Hardness, Tur= Turbidity and Res= Resistivity.

Table 5 : Tukey HSD Analysis Among Observed Water Quality Parameters of Month Samplings After One-Way ANOVA Significance.

WQP		October			December			March			April			June			July		
		MD	SE	P	MD	SE	P	MD	SE	P	MD	SE	P	MD	SE	P	MD	SE	P
DO	Decem	12.03*	3.3	0.015	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	March	7.7	3.3	0.255	19.72*	3.1	<0.0001	-	-	-	-	-	-	-	-	-	-	-	-
	April	11.3*	3.3	0.024	23.37*	3.1	<0.0001	3.65	3.1	0.899	-	-	-	-	-	-	-	-	-
	June	8.7	3.3	0.144	20.74*	3.1	<0.0001	1.02	3.1	>0.999	2.63	3.1	0.978	-	-	-	-	-	-
	July	13.3*	3.3	0.005	25.35*	3.1	<0.0001	5.63	3.1	0.554	1.98	3.1	0.995	4.61	3.1	0.754	-	-	-
	Septem	13.4*	3.3	0.005	25.46*	3.1	<0.0001	5.7	3.1	0.531	2.09	3.1	0.993	4.7	3.1	0.733	0.115	3.1	>0.999
Sal	Decem	47.2	31.4	0.740	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	March	173.3*	31.4	<0.0001	126.2*	29.9	0.004	-	-	-	-	-	-	-	-	-	-	-	-
	April	148.3*	31.4	0.001	101.2*	29.9	0.03	24.997	29.9	0.979	-	-	-	-	-	-	-	-	-
	June	99.8*	31.4	0.048	52.6	29.9	0.585	73.6	29.9	0.211	48.6	29.9	0.668	-	-	-	-	-	-
	July	98.2	31.4	0.054	51.02	29.9	0.618	75.1	29.9	0.192	50.1	29.9	0.636	1.55	29.9	1.0	-	-	-
	Septem	84.9	31.4	0.132	37.8	29.9	0.863	88.4	29.9	0.079	63.4	29.9	0.368	14.8	29.9	>0.999	13.3	29.9	>0.999
TDS	Decem	4216.9	1632.8	0.168	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	March	4363.6	1632.8	0.142	146.7	1556.8	>0.999	-	-	-	-	-	-	-	-	-	-	-	-
	April	4881.1	1632.8	0.074	664.2	1556.8	>0.999	517.5	1556.8	>0.999	-	-	-	-	-	-	-	-	-
	June	6917.8*	1632.8	0.004	2700.8	1556.8	0.600	2554.2	1556.8	0.658	2036.7	1556.8	0.843		-	-	-	-	-
	July	7203.6*	1632.8	0.002	2986.7	1556.8	0.485	2840.0	1556.8	0.543	2322.5	1556.8	0.747	285.8	1556.8	>0.999	-	-	-
	Septem	6850.3*	1632.8	0.004	2633.3	1556.8	0.627	2486.7	1556.8	0.685	1969.2	1556.8	0.862	67.5	1556.8	>0.999	353.3	1556.8	>0.999
TSS	Decem	2.8	8.8	>0.999	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	March	8.2	8.8	0.963	5.45	8.4	0.994	-	-	-	-	-	-	-	-	-	-	-	-
	April	3.5	8.8	>0.999	0.68	8.4	>0.999	4.8	8.4	0.997	-	-	-	-	-	-	-	-	-
	June	17.8	8.8	0.419	15.02	8.4	0.561	9.6	8.4	0.909	14.33	8.4	0.613	-	-	-	-	-	-
	July	41.4*	8.8	0.001	38.63*	8.4	0.001	33.18*	8.4	0.007	37.95*	8.4	0.002	23.6	8.4	0.105	-	-	-

*The mean difference is significant at the 0.05 level. WQP= Water quality parameter, MD= Mean difference, SE= Standard error and Sal= Salinity.

SW_1, SW_2, SW_3, SW_4 and HH (P<0.05) (Table 4) without any significant differences between the turbidity of the month samplings (P=0.128) (Table 3).

Water Electrical Conductivity (EC)

The EC ranges of the water from the sample sites of the Shadegan and Hawr Al Azim wetlands were 6550 (minimum) in the March to 30200 (maximum) µs/cm in the July of the HH and SW_2 sample sites, respectively. The water EC of the SW_1 and SW_4 sample sites of the Shadegan wetland had a partial fluctuation compared to the SW_2 and SW_3 and reached to the highest ranges in the July due to sever evaporation. The water EC of the SW_5 sample site had many fluctuation and reached to the lowest in the December due to rain and low evaporation, and reached to the highest in the October due to sever evaporation. The EC of Hawr Al Azim waters had low fluctuation and was healthier due to its intact and original ecosystem compared to the sample sites of the Shadegan wetland indicated that Hawr Al Azim was less polluted (Table 1 and Fig. 2).

According to the EPA or WHO standards, the EC of the water must not be higher than the 2000 µs/cm (EPA 2012b; WHO 2008). The mean EC of the water was higher than the EPA or WHO standards in the all sample sites of the all month samplings (Table 1 and Figure 2). One-sample t-tests showed significant differences between mean EC of the site and month samplings compared to the EPA or WHO standards (P<0.0001) (Table 2). One-way analysis of variance (ANOVA) showed significant differences between the mean EC of the site samplings (P<0.0001) (Table 3). Followed by Post Hoc tests were observed significant differences between the mean EC of the SW_2 with SW_1, SW_4 and HH, and the EC of the HH with SW_3 and SW_5 (P<0.05) (Table 4) without any significant differences between the mean EC of the month samplings (P=0.363) (Table 3).

Water Total Dissolved Solids (TDS)

The TDS ranges of the water from the sample sites of the Shadegan and Hawr Al Azim wetlands were 515 (minimum) in the March to 18130 (maximum) mg/L in the July in the SW_5 and SW_2 sample sites, respectively. The water TDS of the sample sites of the Shadegan wetland (except SW_5) was increased in the October to December 2011 and was increased from December 2011 to September 2012 and reached to the highest ranges in the September due to sever evaporation. Whereas the water TDS of the SW_5 had many fluctuation and reached to the lowest in the March because of the occurring the rain and reached also to the highest in the June and September due to sever evaporation. The TDS of Hawr Al Azim waters had low fluctuation and were healthier due to its intact and original ecosystem compared to the sample sites of the Shadegan wetland indicated that Hawr Al Azim was less polluted. The TDS of the water Hawr Al Azim with a low amount increasing reached to the highest in the March because of the occurring the rain (Table 1 and Figue 2).

According to the EPA standard, the TDS of the water must not be higher than the 500 mg/L (EPA 2012b). The mean TDS of the water was higher than the EPA standard in the all sample sites of the all month samplings with low intensity in the Hawr Al Azim wetland (Table 1 and Fig. 2). One-sample t-tests showed significant differences between the water mean TDS of the all site and the month samplings compared to the EPA standard (P<0.0001) (Table 2). One-way analysis of variance (ANOVA) showed significant differences between the mean TDS of the site and month samplings (P=0.001) (Table 3). Followed by Post Hoc tests were observed significant differences between the mean TDS of the SW_2 with SW_1, SW_4 and HH, and the October with the June, July and September (P<0.05) (Table 5).

Water Total Suspended Solids (TSS)

The TSS ranges of the water from the sample sites of the Shadegan and Hawr Al Azim wetlands were 1 (minimum) in the October to 104 mg/L (maximum) in the July in the SW_1 and SW_2, and in the SW_2 sample sites, respectively. The water TSS of the sample sites of the Shadegan wetland (except the SW5) and Hawr Al Azim was gradually increased in the December 2011 to July 2012 (The highest ranges) with fluctuation due to sever evaporation, however reached in September the same as in the initial, December. Whereas the water TSS of the SW_5 had many fluctuation and reached to the lowest in the September and to the highest in the July due to sever evaporation. The TSS of Hawr Al Azim water had low fluctuation and was healthier due to its intact and original ecosystem compared to the sample sites of the Shadegan wetland indicated that Hawr Al Azim was less polluted. The TSS of Hawr Al Azim water with a low ranges compared to the sample sites of the Shadegan wetland reached to the lowest in the July and to the highest ranges in the March (Table 1 and Figure 2).

According to the EPA or WHO standards, the TSS of the water must not be higher than the 150 mg/L (EPA 2012b; WHO 2008). The mean TSS of the water was less than the EPA or WHO standards in the all sample sites of the Shadegan wetland and with a low intensity in the Hawr Al Azim (Table 1 and Figure 2). One-sample t-tests showed significant differences between the mean TSS of the site and the month samplings compared the EPA or WHO standards ($P<0.0001$) (Table 2). One-way analysis of variance (ANOVA) showed significant differences between the mean TSS of the month samplings ($P<0.0001$) without any significant differences between the mean TSS of the site samplings ($P=0.171$) (Table 3). Followed by Post Hoc tests were observed significant differences between the mean TSS of the July with October, December, March, April and September ($P<0.05$) (Table 5).

Water Resistivity

The resistivity of the water was measured by HQ40d Portable Multi-Parameter Meter from April to September 2012. The resistivity ranges of the water from the sample sites of the Shadegan and Hawr Al Azim wetlands were 33 (minimum) in the July to 137.9 (maximum) Ωcm in the June in the SW2 and HH sample sites, respectively. The water resistivity of the sample sites of the Shadegan and Hawr Al Azim wetlands were uniform without any fluctuation (Table 1 and Figure 2).

One-way analysis of variance (ANOVA) showed significant differences between the mean resistivity of the site samplings ($P<0.0001$) without any significant differences between the mean resistivity of the month samplings ($P=0.473$) (Table 3). Followed by Post Hoc tests were observed significant differences between the mean resistivity of the SW_1 with the SW_2, SW_3, SW_5 and HH; the SW_2 with the SW_4 and HH; the SW_3 with the SW_4 and HH; the SW_4 with the SW_5 and HH; and the SW_5 with the HH ($P<0.05$) (Table 4).

DISCUSSION

In the present study we evaluated the water quality of the Shadegan and Hawr Al Azim (Hawr Al Hawizea) wetlands in Khuzistan province, south west of Iran. According to the EPA standard, the DO of the water must not be less than the 5 mg/L (EPA 2012b). In this study the mean DO of the water was less than the EPA standard in the SW_5 and HH in the April, July and September and in the SW_2 and SW_3 in the July and September (Table 1 and Figure 2) which one-sample t-tests showed significant differences between the months and were less than the EPA standard ($P<0.05$) (Table 2). Since the aquatic organisms and wildlife are dependent to the dissolved oxygen and in the April, July and September the dissolved oxygen was less than the EPA standard, they encountered to the serious threats especially the endangered or the threatened species such as insects, however the ecologists, environmental experts and regional managers must be find ways for solutions.

As indicated by the ecologists, environmental experts and regional managers, and showed in the table 1 and Figure 2. It seems that the water salinity of the Shadegan and Hawr Al Azim wetlands are increasing and phenomena such as reducing of the wetland water volumes, droughts in the recent decades, reduced the input water flow due to damming on the upstream of the river's water supply have increased the salinity waters of the wetlands and threatens their lives.

According to the WHO standard, the hardness of the water must not be higher than the 500 mg/L (WHO 2008). The mean hardness of the Shadegan and Hawr Al Azim waters were higher than the WHO standard in the all sites of the month samplings (Table 1 and Figure 2) and were observed significant differences between the mean hardness of the site and month samplings compared to the WHO standard ($P<0.0001$) by one-sample t-tests (Table 2). The TDS of the water, according to the WHO standard must not be higher than the 500 mg/L (EPA 2012b). The mean TDS of the water was higher than the EPA standard in the all sample sites of the Shadegan wetland and with a low intensity in the Hawr Al Azim of the all month samplings (Table 1 and Figure 2), as one-sample t-tests showed a significant differences between the mean TDS of the site and month samplings compared to the EPA standard ($P<0.0001$) (Table 2). So the hardness and the TDS of the Shadegan and Hawr Al Azim waters indicated that their water polluted as shown in the table 1 and Figure 2. However the severity of the pollution in the Hawr Al Azim wetland compared to the Shadegan wetland was milder and had low fluctuation due to its intact and original ecosystem.

The turbidity, EC and TSS of the Shadegan and Hawr Al Azim waters were higher than the EPA or WHO standards (EPA 2012b; WHO 2008) in the all or some sites of the all or some month samplings (Table 1 and Figure 2) which were confirmed by the one-sample t-tests (Table 2), indicated that the Shadegan and Hawr Al Azim wetlands were polluted and had a poor water quality condition. However the severity of the pollution in the Hawr Al Azim wetland compared to the Shadegan wetland was milder and had low fluctuation due to its intact and original ecosystem. It is interesting that these results have been confirmed by an evaluating water quality study used insect biological indices (Nasirian 2014).

In a old previous study (Farrokhian et al. 1997) the water turbidity and DO of the Shadegan wetland were higher than the EPA or WHO standard indicated that the Shadegan wetland had been polluted as confirmed also by this study. Then Karimzadegan (2010) in a review study showed that the water quality of the Shadegan wetland were polluted and had a poor and bad water quality trend by comparing the limited water quality parameters which measured in the past 36-year periods of the 1969 to 2003 (Karimzadegan 2010). However currently it seems that the water quality of the Shadegan wetland compared to the previous study has been worse as confirmed by the present study and will be forecasted to be continued in the future. In a limited study, Makvandi (2006) also reported that the water of the Hawr Al Azim wetland were polluted (Makvandi 2006) as indicated by the present study, however the severity of the pollution in Hawr Al Azim wetland compared to the Shadegan wetland was milder and had low fluctuation due to its intact and original ecosystem.

CONCLUSION

The hardness, TDS, turbidity, EC and TSS of the Shadegan and Hawr Al Azim (Hawr Al Hawizea) waters were higher than the EPA or the WHO standards (EPA 2012b; WHO 2008) in the all or some sample sites of the all or some month samplings (Table 1 and Figure 2) which were confirmed by one-sample t-tests (Table 2), indicated that the Shadegan and Hawr Al Azim wetlands were polluted and had a poor water quality condition. However the severity of the pollution in the Hawr Al Hawizea wetland compared to the Shadegan wetland was milder and had low fluctuation due to its intact and original ecosystem. Since the aquatic organisms and wildlife especially the endangered or the threatened species such as insects are dependent to the water quality of their habitats especially dissolved oxygen, they encountered to the serious threats though they have compensatory mechanisms to resist the threats, however the ecologists, environmental experts and regional managers must be find ways for solutions.

As indicated by the ecologists, environmental experts and regional managers, and observed in the current study it seems that the water salinity of the Shadegan and Hawr Al Azim wetlands are increasing and phenomena such as reducing of the wetland water volumes, droughts in the recent decades, reduced input water flow due to damming on the upstream of the river's water supply have increased the salinity water of the wetlands and threatens their lives.

In overall currently it seems that the water quality of the Shadegan and Hawr Al Azim wetlands compared to the previous study have a poor water quality condition and has been worse than the past as indicated by the ecologists, environmental experts and regional managers, and confirms by the present study and will be forecasted to be continued in the future. However the severity of the pollution in the Hawr Al Azim wetland compared to the Shadegan wetland is milder and has low fluctuation due to its intact and original ecosystem.

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