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Impact of Syrian Civil War on Water Quality of Turkish Part of Orontes River

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ABSTRACT: Surface waters become more and more polluted, depending on human activities around them. The current study has been conducted to evaluate the impact of Syrian civil war on water quality of the Turkish part of Orontes River. For so doing, it has obtained monitoring data between 2006 and 2014 from state of Hydraulic Works of Turkey, analyzing them via Water Quality Index (WQI) and Principal Component Analysis (PCA). WQI reveals that water quality in Orontes River has dropped sharply after 2011 and slightly improved by 2013. This time interval overlaps with Syrian civil war when conflicts between regime forces and dissidents occurred densely. Therefore, it can be concluded that Syrian civil war has impacted the water quality of Turkish water's with potential causes of water quality degradation identified as polluters from conflicts and immigration activities. In addition, this research has conducted PCA to investigate indicator parameters, representing the water quality variation as a result of war. Results showed that NO_2^- and NO_3^- concentration in the surface water can be used as main indicators of Syrian civil war's impact on water quality. Finally, it may said that anthropogenic activities happening in the Turkish part of the watershed also contribute to the pollution level of river, especially domestic and industrial discharges.

Keywords: Orontes River, Syrian civil war, water pollution, water quality index

INTRODUCTION

Water is the most crucial compound for human survival. Lakes and rivers are the main freshwater resources to provide easily-accessible water, yet they are vulnerable to anthropogenic activities, taking place around them, since they serve as a carrying element for domestic or industrial discharges as well as surface runoff (Singh et al., 2005). Because surface runoff carry all the residuals of human activities to water bodies, every human action, taking place around the river, affect water quality. Among this actions, war is the most undesired and harmful one for the environment.

The damage to the ecosystem, caused by war, can be examined in two different categorizes as direct and indirect effects. The former includes the destruction of cities, agricultural areas, and dams from bombing and armed conflicts (Mannion, 2003). On the other hand, indirect impacts of war are usually more difficult to detect, being more crucial for the ecosystem. For example, after the Gulf War, marine environment was heavily polluted with oil, resulting in decreased biodiversity of the area (İz, 2009). Fallujah and Basrah, two

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heavily bombarded cities in Iraq, suffered from lead and mercury toxicity which caused variety of diseases like congenital birth defects, miscarriages, premature births, infertility, sterility, leukemia, and cancer (Dahr, 2013). Alternatively, war forces lots of people to immigrate to other countries, which in turn affects the land use and ecological structure of both countries. These examples indicate that in order to assess any negative impact of Syrian civil war on the Turkish part of the Orontes Basin, proper management practices and monitoring studies should be carried out.

Water Quality Index (WQI) is a practical tool to monitor water quality and can be used to implement water management practices. The main purpose of WQI is to change complex water quality data into simple information that is both comprehensive and usable by policy makers and the public (Alam & Pathak 2010). In other words, WQI reflects the composite influence of different water quality parameters (Ramakrishnaiah et al., 2009; Yisa & Jimoh 2010). Water Quality Index was proposed by Horton in 1965 and has been used to investigate water quality in rivers ever since (Dojlido et al., 1994; Liou et al., 2004; Akoteyon et al., 2011; Tyaji et al., 2013). Since WQI gives a single value to represent water quality, it makes it easy to compare water quality between different sampling stations or events. This situation is especially important when trans-boundary rivers like Orontes River is concerned, because it helps managers compare before and after status of events as management strategies of different countries may not coincide (Bordalo et al., 2006).

Orontes River is a trans-boundary one, whose water is shared among Lebanon, Syria, and Turkey. Water quality of Orontes River has been evaluated by many researchers (Taşdemir & Göksu, 2001; Ödemis et al., 2007; Ağca et al., 2009; Kılıç & Can, 2017). However, these studies did not contain time-series data, being insufficient to determine the time-dependent change in water quality. Also, these studies did not investigate whether or not water quality changed after Syrian civil war.

Syrian civil war started as an impact of Arab Spring. At first, small protesting groups appeared in 2011. Following the first big protest on March 15, 2011, the government started to send troops against the protesters in order to regain the control, which resulted in a conflict between the regime forces and dissidents. Orontes Basin suffered from these conflicts severely, since most of the important settlements like Humus and Hama were located around it. During 2012 and 2013, there were intense conflicts between the regime forces and the dissidents, especially in Humus, Hama, Er-Rastan, and Telbise in order to regain authority in city centers and official buildings. After that, conflicts were drawn from rural centers to urban areas. In the beginning of 2014, regime forces took control of big cities such as Humus and Hama, trapping the dissidents in a small area between these two cities.

The present study has been conducted to evaluate water quality variation from 2006 to 2014, using monitoring data obtained from state of Turkish Hydraulic Works by means of water quality index and principal component analysis. It will show the impact of recent industrial developments, anthropogenic activities, and Syrian civil war on the quality of Turkish part of Orontes River.

MATERIAL AND METHODS

Orontes River is a trans-boundary river, whose water is shared by Lebanon, Syria, and Turkey. The river rises in Lebanese mountains, flowing 40 km in Lebanon to enter Syria and flow for a further 325 km. After leaving Syria, it flows 88 km until its final destination at Samandağ district of Hatay, Turkey (FAO, 2009). The basin is located in the Mediterranean climate zone which experiences hot and arid summers along with warm and rainy winters. The Turkish part of Orontes Basin enjoys an average annual precipitation of 816 mm, an average temperature of 16.8°C, and an annual total flow of 1.17 km³ per year (Anonymous, 2013). Its main anthropogenic activities involve agriculture, animal husbandry, and agricultural industries. Therefore, the river suffers from a variety of pollution sources in addition to domestic wastewater discharges. Also, it should be noted that since Orontes River is a trans-boundary river, its water quality depends on water management practices of beneficial countries.

Water quality monitoring data cover 11 different parameters, viz. Biological Oxygen Demand (BOD), Chemical Oxygen Demand (COD), Dissolved Oxygen (DO), temperature (T), pH, nitrite (NO21-), nitrate (NO31-), ammonia (NH4+), sulfate (SO42-), sodium (Na+), and Total Dissolved Solids (TDS), measured seasonally at four different stations along the main stream of Orontes River. Figure 1 represents the monitoring stations with CORINE 2012 land use map.

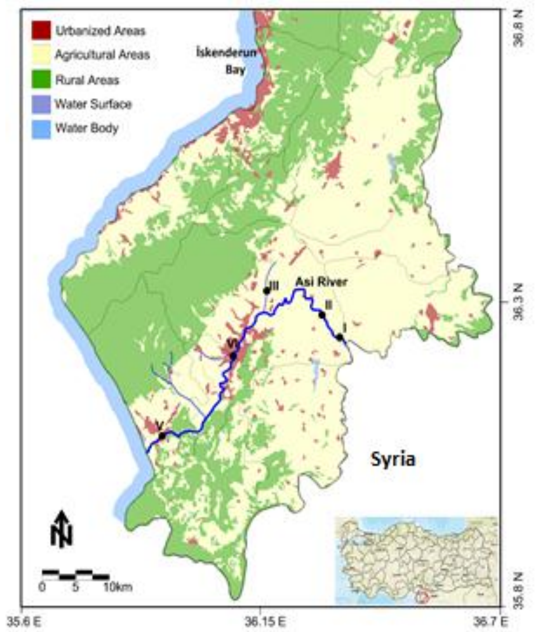

Fig. 1. Land use map with monitoring stations (I: Demirköprü Station, II: Küçük Asi Station, III: Antakya Station, and IV: Samandağ Station)

Water Quality Index (WQI) was calculated, using Weighted Arithmetic Index method (Yisa & Jimoh, 2010). Initially, quality rating scale (q_i) was determined for each parameter by dividing annual average concentration (C_i) of each parameter by its respective standard (S_i) and multiplied by 100. Respective standard was determined according to the standards, set by Water Pollution Control Regulation of Turkey (Official Bulletin No: 25687, 2004). Regulation divide inland water sources into four different categories, depending on their water quality. Respective standard values used in this paper was determined according to quality standards of Class-1 type inland waters (Table 1). Calculation of quality rating scale can be seen below in Equation 1:

$$q_i = \frac{C_i}{S_i} * 100 \tag{1}$$

Secondly, relative weight (W_i) was calculated by a value, inversely proportional to the recommended standard (S_i) of the corresponding parameter:

$$w_i = \frac{1}{S_i} \tag{2}$$

Afterwards, quality rating scale was multiplied by relative weight of each parameter and the results were added up to obtain the weighted sum.

$$weighted\ sum = \sum_{i=1}^{n} w_i q_i \tag{3}$$

Finally, Water Quality Index was calculated by dividing the weighted sum into the total relative weight.

$$WQI = \frac{\left(\sum_{i=1}^{n} w_i q_i\right)}{\sum_{i=1}^{n} w_i} \tag{4}$$

Table 1 gives a calculation example for Antakya station in 2006. Similar procedure was followed for each station in each year. All calculations was carried out using Microsoft Office Excel 2010.

Table 1. Sample WQI calculation for Antakya station in 2006

Parameter (Unit)	C_i	S_i	q_i	w_i	$w_i \times q_i$
T (^oC)	20.75	25	83	0.04	3.32
pH (-)	7.85	8.5	92.35294	0.117647	10.86505
DO (mg/L)	6.65	8	83.125	0.125	10.39063
SO_4^{2-} (mg/L)	174.48	200	87.24	0.005	0.4362
NH_4^+ (mg/L)	3.96	0.2	1980	5	9900
NO_2^- (mg/L)	0.109	0.002	5450	500	2725000
NO_3^- (mg/L)	3.5025	5	70.05	0.2	14.01
Na^+ (mg/L)	31.05	125	24.84	0.008	0.19872
BOD (mg/L)	7.8	4	195	0.25	48.75
COD (mg/L)	23	25	92	0.04	3.68
TDS (mg/L)	709	500	141.8	0.002	0.2836
			Total	505.78	2,734,992
			WQI	5,407.39	

Further statistical analyzes were conducted to evaluate water quality variations, depending on the year and the season. Two-way ANOVA test determines the factors which have a significant effect on depended variables. So, WQI scores were examined using two-way ANOVA test to evaluate the existence of any variation depending on either year or station.

Principal Component Analysis (PCA) provides information pertaining to the most significant parameters which describe the whole dataset without the loss of any information (Helena et al., 2000). Therefore, PCA was conducted to understand parameters responsible for most variations in the dataset. This allows identifying the way in which civil war affected water quality as well as the latent factors behind this variation. To satisfy PCA assumptions, the dataset got normalized, using log-transformation. Barlett sphericity test and Kaiser-Meyer-Olkin (KMO) applied on the normalized dataset to evaluate applicability of PCA. KMO and Barlett sphericity test results turned out to be 0.647 and 0.00, respectively, indicating that PCA is suitable and could achieve a significant data reduction.

RESULTS AND DISCUSSION

Table 2 indicates the descriptive statistic of 11 selected parameters. There is a high standard deviation and high change interval for all parameters, which reflects that water quality in Orontes River is changing both temporally and spatially. So, it can be concluded that both anthropogenic and natural processes are effective in the watershed. When mean concentrations of water quality parameters were examined according to Water Pollution Control Regulation of Turkey (Official Bulletin No: 25687,2004), Orontes River was categorized as Class-1 type surface water in terms of T, pH, DO, SO_4^{2-}, NO_3^-, and Na^+; Class 2 in terms of COD and TDS; Class 3 in terms of NH_4^+ and BOD; and Class 4 in terms of NO_2^- Therefore, it can be said that NO_2^-, NH_4^+, BOD, COD, and TDS were key parameters to represent water pollution status in Orontes River.

Temperature and pH are important parameters that represent water quality, since both of them affect physical and biological reactions within water ecosystem. Minimum and maximum values obtained for T and pH were 4^{o}C -34^{o}C and 7.20-9.80, respectively. Low dissolved oxygen usually represents microbiological activity and organic pollution in water bodies (Oram, 2014). DO concentration varied between 1.30 mg/L and 10.60 mg/L, depending on the station and the season (Table 2). It can be said that variations in

Table 2. Mean concentrations of water quality parameters with their standard deviations (Mean ± S.D) at four stations during 2006-2014, 2006-2011 (pre-war years), and 2012-2014 (war years), compared to Water Pollution Control Regulation

			Station				Water Pollution Control Regulation			
			Antakya	**Demirköprü**	**Küçük Asi**	**Samandağ**	**Class 1**	**Class 2**	**Class 3**	**Class 4**
T (°C)	2006-2014	Mean±Std	20.94±6.84	20.81±6.24	19.26±7.06	20.94±7.51	25.00	25.00	30.00	>30
		Min-Max	6.0-32.0	8.0-31.0	4.00-28.00	6.00-34.00				
	2006-2011	Mean±Std	20.67±0.87	20.38±1.40	19.42±2.65	20.88±0.81				
	2011-2014	Mean±Std	21.47±0.99	21.67±0.47	18.94±2.65	21.06±1.67				
pH (-)	2006-2011	Mean±Std	7.91±0.29	7.97±0.25	8.13±0.36	7.84±0.31	6.5-8.5	6.5-8.5	6.0-9.0	
		Min-Max	7.20-8.40	7.30-9.50	7.20-9.30	7.30-9.80				
	2006-2011	Mean±Std	7.81±0.17	7.91±0.17	8.03±0.19	7.58±0.76				Other than 6.0-9.0
	2011-2014	Mean±Std	8.04±0.14	8.07±0.04	8.31±0.19	8.36±0.09				
DO	2006-2014	Mean±Std	6.73±2.19	7.59±1.67	7.26±1.88	2.00±1.98	8.00	6.00	3.00	<3
		Min-Max	1.30-9.80	2.10-10.00	2.30-10.40	0.00-10.60				
	2006-2011		7.25±0.85	7.86±0.50	7.90±0.50	8.20±0.63				
	2011-2014		6.19±1.21	7.05±1.03	5.96±0.50	6.53±1.18				
SO_4^{2-}	2006-2011	Mean±Std	147.61±76.76	168.09±77.92	207.15±177.56	130.13±64.85	200.00	200.00	400.00	>400
		Min-Max	18.24-286.50	15.20-339.30	9.60-1100.00	11.80-301.92				
	2006-2011		142.59±26.88	169.88±32.53	213.72±14.14	126.37±35.83				
	2011-2014		147.88±23.27	164.53±23.74	194.01±14.14	137.65±14.73				
NH_4^+	2006-2014	Mean±Std	3.67±3.43	0.90±1.06	0.47±1.39	1.07±1.00	0.20	1.00	2.00	>2
		Min-Max	0.19-12.58	0.10-3.60	0.12-6.97	0.19-3.60				
	2006-2011		3.74±0.13	1.18±0.90	0.19±0.71	1.23±0.59				
	2011-2014		2.44±1.93	0.35±0.21	1.04±0.71	0.75±0.45				
NO_2^-	2006-2011	Mean±Std	0.48±1.36	0.43±1.82	0.50±1.39	0.55±1.53	0.002	0.01	0.05	>0.05
		Min-Max	0.0-7.60	0.01-10.64	0.01-6.97	0.01-8.52				
	2006-2011		0.13±0.02	0.04±0.01	0.19±71	0.22±0.27				
	2011-2014		1.22±0.56	1.18±1.13	1.04±0.71	1.20±0.75				
NO_3^-	2006-2014	Mean±Std	2.47±1.66	2.95±2.11	2.58±2.40	2.42±2.21	5.00	10.00	20.00	>20
		Min-Max	0.10-7.50	0.20-11.50	0.15-14.70	0.10-12.80				
	2006-2011		2.42±1.26	2.43±0.94	1.89±1.17	1.86±0.39				
	2011-2014		2.66±0.17	3.99±0.96	3.96±1.17	3.55±1.17				
Na^+	2006-2011	Mean±Std	52.03±23.47	48.40±15.68	66.04±45.74	40.37±17.38	125.00	125.00	250.00	>250
		Min-Max	24.84-150.19	15.18-95.45	16.04-239.20	7.82-97.33				
	2006-2011		50.48±13.25	50.39±7.55	65.66±10.65	35.58±8.69				
	2011-2014		53.30±5.10	45.09±1.78	66.81±10.65	49.96±9.46				
BOD	2006-2014	Mean±Std	10.13±9.14	3.91±22.00	4.91±21.00	7.38±24.00	4.00	8.00	20.00	>20
		Min-Max	1.7-40.00	1.00-22.00	1.00-21.00	2.00-24.00				
	2006-2011		10.78±5.49	4.03±2.15	4.03±2.12	7.57±5.23				
	2011-2014		6.25±5.25	3.67±0.92	6.67±2.12	7.00±3.47				
COD	2006-2011	Mean±Std	37.22±33.40	14.50±18.46	25.64±38.00	21.00±16.67	25.00	50.00	70.00	>70
		Min-Max	3.00-150.00	4.00-80.00	4.00-167.00	8.00-73.00				
	2006-2011		39.00±24.44	10.83±4.26	13.64±13.98	17.33±11.11				
	2011-2014		40.08±20.47	21.83±17.58	49.64±13.98	28.33±11.31				
TDS	2006-2011	Mean±Std	677.99±142.73	730.44±211.06	810.71±386.26	585.19±128.66	500.00	1500.00	5000.00	>5000
		Min-Max	469.00-1102.00	503.00-1530.00	265.00-2593.00	314.00-862.00				
	2006-2011		694.65±27.69	791.38±105.51	866.13±59.35	611.58±44.53				
	2011-2014		622.72±12.16	608.56±31.71	699.89±59.35	532.42±42.09				

(All parameters are given in mg/L unit, with the exception of T in °C and pH, which is without any particular unit)

these three parameters seemed to depend on season, as since they did not change temporally. In other words, there were no remarkable change among the stations for physico-chemical parameters. Agca et al. (2009) also investigated the spatial and temporal change in Orontes River, finding no statistically-significant change among the stations. Similarly, the study by Yılmaz & Doğan (2007) confirmed these results.

Sulfate is an essential micronutrient for water ecosystem; however, excessive amount of SO_4^{2-} accelerate the dissolution of nutrients, found in sediment, and may be toxic for aquatic environment (Orem, 2011). SO_4^{2-} concentration varied from 9.60 mg/L to 1100.00 mg/L (Table 2). During rainy seasons, sulfate got dissolved in mineral-containing soils to reach to Orontes River through surface runoff, resulting in high temporal variation in water quality (Kılıç, 2017).

Sodium is one of the most common alkali metals, found in surface water (Gałczyńska, 2013). Even though mean Na^+ concentration fell below regulation standards, there was a high concentration variation, depending on season and station, from 15.18 mg/L to 97.33 mg/L, mainly from the dissolution of sodium in the rocks during seasons with high amount of precipitation (Kılıç, 2017).

BOD and COD are water quality parameters that represent biodegradable and total organic content of surface water, respectively, being also an indicator of organic pollution from industrial and domestic discharges (Kazi et al., 2009). Annual mean BOD and COD concentration in Orontes River showed similar fluctuations until 2011 (Figure 2a-2b, Table 2). After that, COD concentration in the river increased regularly, in contrast to BOD. Increase in COD concentration had been most likely caused by rapid development of small-scale factories in the watershed. Similar to this case, Taşdemir & Göksu (2001) also found high BOD concentration near Antakya city center. It is unlikely that this increase was due to the Syrian civil war; since the increase was more significant in Antakya and Küçük Asi stations, where urbanization and industrialization were dense (Kılıç, 2017). Thus, organic pollution in the river had resulted from anthropogenic activities, mainly discharges of wastewater treatment plant and industrial zones, located near Antakya station.

TDS indicates soil erosion occurring as a result of seasonal storms (Kowalkouskia et al., 2006). The highest and lowest TDS concentrations were 265 mg/L and 2,593 mg/L, respectively (Table 2). High concentrations in dissolved solids was an indicator of intense anthropogenic activities along the river course (Chapman, 1996). Kılıç (2017), found that TDS is one of the major parameters that reflect water quality variation within the stations.

Nitrogenous compounds in surface water are usually related to excessive use of fertilizers, thus linking them to agricultural activities (Sing et al., 2005; Ogwueleka, 2015). However, they are also used in explosives in great amounts (Graham, 2003), so they may also indicate the effect of war on water quality. Figure 2d represents the annual mean NO_2^- concentration in Orontes River from 2006 to 2014, showing that after 2010, nitrite concentration soared in all stations (Table 2). Similarly, annual mean NO_3^- concentration was increased drastically after 2010 (Figure 2e, Table 2). Even though agricultural activities can increase the concentration of nitrite and nitrate in surface waters, such a sharp increase could not be explained by agricultural activities, alone. Ammonium nitrate has been used to produce explosives since 1935 (Ataman, 1965). As ammonium nitrate is highly soluble in water, the residuals of explosives solve in water during storms, reaching the surface water through surface runoff. Since periods, in which concentration of nitrogenous compounds increase in the water, were similar to those in which conflicts between regime forces and dissidents began, it can be said that this increase was a result of Syrian civil war.

Water quality index was used to understand the impact of Syrian civil war on the quality of Orontes River by using water quality monitoring data between 2006 and 2014 (Figure 2f).

Two-way ANOVA test was conducted to understand whether or not there was a significant variation in WQI score, depending on both the stations and the years. Even though WQI scores at Antakya Station were slightly greater than other stations (Table 3), it was found that there were no meaningful statistical variation among the stations ($p>0.05$). Similarly, two-way ANOVA test revealed that water quality score changed significantly between years ($p<0,05$).

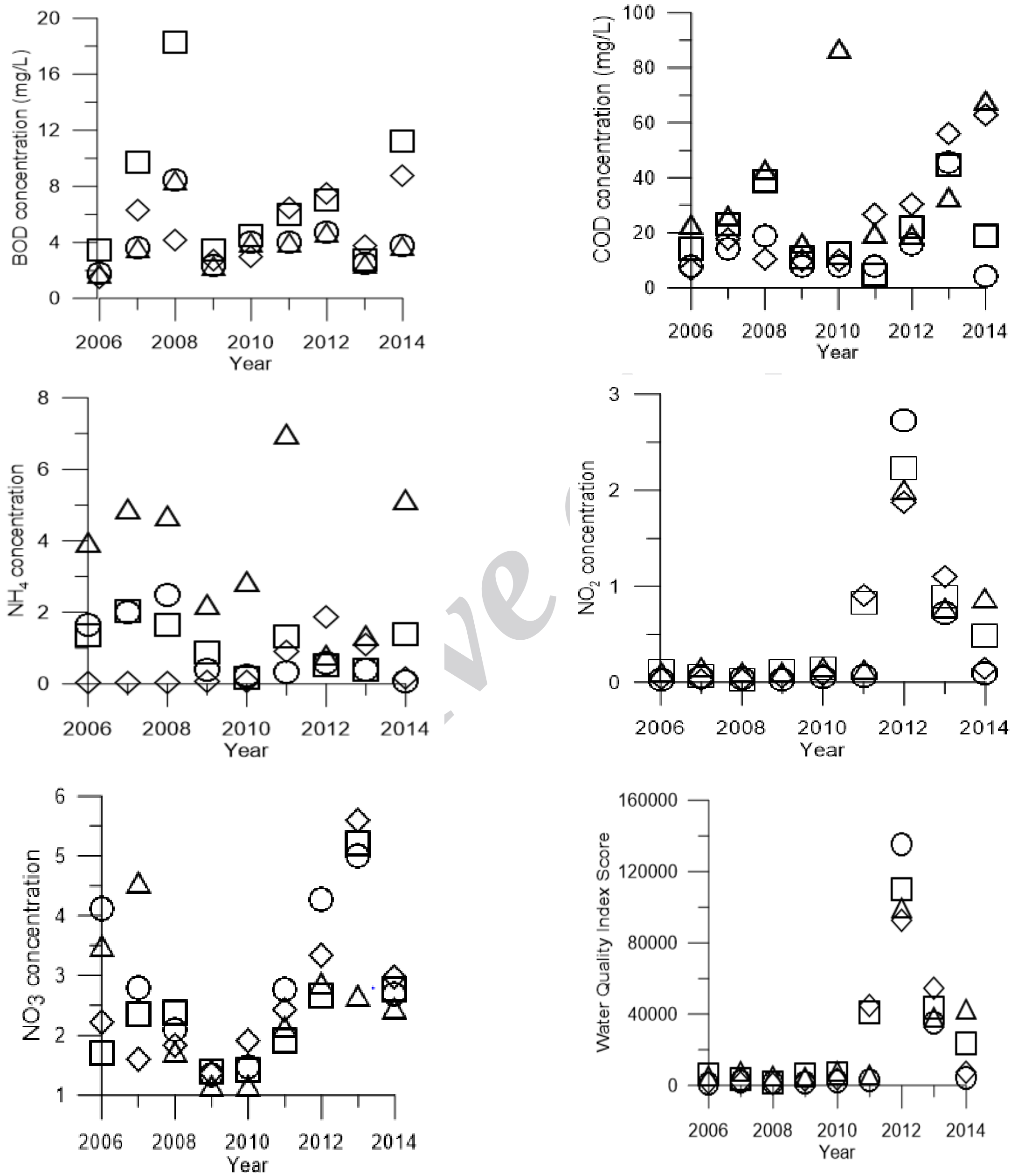

Fig 2. (a) Annual biological oxygen demand, (b) chemical oxygen demand, (c) ammonium, (d) nitrite, (e) nitrate concentration in mg/L, and (f) water quality index variation (∆: Antakya Station, o: Küçük Asi Station, ◊: Demirköprü Station, and □:Samandağ Station)

Table 3. WQI scores of stations from 2006 to 2014

	Antakya	Demirköprü	Küçük Asi	Samandağ
2006	5,407.39	1,070.93	1,878.41	6,024.24
2007	7,982.34	2,543.06	1,618.97	3,222.80
2008	5,473.05	1,865.81	1,054.62	1,404.61
2009	5,126.89	1,311.70	2,681.65	6,145.43
2010	8,021.77	2,361.28	3,620.82	6,846.28
2011	6,299.89	3,103.07	44,758.53	40,707.82
2012	99,403.59	134,907.1	92,816.31	110,009.2
2013	38,090.9	35,365.35	54,261.33	43,829.18
2014	43,143.3	4,267.45	7,447.57	23,714.34

Table 3 indicates water quality index scores of Orontes River from 2006 to 2014. It can be said that water quality in the river was similarly stable until 2011, but its index soared, by more than 15 folds, in 2012. This much of increase could not explained by natural causes or domestic, industrial discharges. The drop in water quality showed a similar trend with the occurrence of violent conflicts. It might be said that pollutants, occurring during Syrian civil war and arriving at the Turkish side beyond Syrian borders, may contribute to the point and diffuse pollution within Turkey's borders. Their combination led to a drastic decrease in water quality of Orontes River.

It is known that nearly half of Syrian population immigrated to other countries, because of the civil war, and Turkey hosts most of Syrian refugee community in world (İçduygu, 2015). Several refugee camps was established in Turkey to provide food and shelter to the refugees; however, these camps do not have any sewer system to remove the generated waste from camp areas. Therefore, effluents from Yayladağı, Altınözü, and Reyhanlı refugee camps, which are situated near Orontes River (Sahlool et al., 2012), may reach the river by surface runoff. This situation could also explain the drastic drop in water quality after 2011.

Refugee immigration also altered the land use, water use, and water management practices in Syria. Total irrigated area in the Syria declined, water allocation practices become insufficient, and reservoir storages decreased. As a result of these activities, Müller et al. (2016), stated that trans-boundary surface flow increased drastically after 2012, which in turn affected water quality in two different ways: Firstly, increase in the trans-boundary flow raised mass transport activities (advection, diffusion, etc.) which increased the ions and salts in water. Secondly, it also caused a dilution and decrease the pollution load of river. Second case may also explain the improvement of water quality after 2012 (Figure 2f).

Even though WQI score tarted to decrease after 2012, it was still quite higher than the pre-war years (2006-2010). This phenomena could also be explained by differentiation of fronts where conflict was observed between regime forces and dissidents, indicated by the decrease in amount of pollutants reaching the river by surface flow. Additionally, after the capture of city centers by regime forces, some infrastructure works might have been carried out in the cities. Hence, the small enrichment in water quality could be explained by these war-related factors.

PCA was applied to evaluate indicator parameters, reflecting the impact of Syrian civil war between 2006 and 2014. PCA produced 4 variance factors (VFs) with eigenvalues greater than 1 and explained 75% of total variance (Table 4). Liu et al. (2003) classified the loadings greater than 0.75 as strong, the ones between 0.50 and 0.75 as moderate, and the ones smaller than 0.3-0.5 as weak. Table 5 indicates the factors and corresponding loading scores.

Table 4. Eigenvalues and corresponding values of variance percentage

Component	Initial Eigenvalues		
	Total	% of Variance	Cumulative %
VF1	3.067	27.880	27.880
VF2	2.523	22.937	50.816
VF3	1.632	14.836	65.652
VF4	1.095	9.953	75.605
VF5	0.670	6.091	81.695
VF6	0.514	4.668	86.364
VF7	0.475	4.318	90.682
VF8	0.411	3.740	94.422
VF9	0.271	2.463	96.884
VF10	0.201	1.827	98.711
VF11	0.142	1.289	100.000

Table 5. Loadings of water quality parameters on significnt priciple components

Parameter	VF1	VF2	VF3	VF4
T	0.118	-0.183	0.172	0.879
pH	0.630	0.280	-0.383	0.221
DO	-0.696	-0.171	-0.378	-0.066
SO_4^{2-}	0.085	0.817	-0.269	-0.237
NH_4^+	0.141	-0.228	0.757	0.055
NO_2^-	0.859	-0.198	0.169	0.112
NO_3^-	*0.696*	-0.070	0.125	-0.482
Na^+	0.238	0.838	0.201	0.005
BOD	-0.073	0.016	0.819	0.348
COD	0.362	0.106	*0.705*	-0.138
TDS	-0.299	0.881	-0.090	-0.019

VF1 explained 27.9% of the total variance, having strong positive loading on NO_2^- and moderate loading on NO_3^-. Since these compounds are usually used in explosives, this factor represents the impact of Syrian civil war on Orontes River. It should also be noted that nitrogenous compounds in surface waters also indicate agricultural actives, yet given the impact of war, this case may be omitted. Second variance factor explained 22.9% of total variance, having strong positive Na^+ and TDS loading. Minerals and dissolved solids reached the surface water during rainy seasons after dissolution from soils or rocks (Kowalkouskia et al., 2006). Therefore, these loadings indicated that the change of water quality also depends on seasonal, natural processes. VF3 had a strong BOD and NH_4^+ loading, explaining 15% of variation. Both loadings usually indicate industrial and domestic discharges (Kazi et al., 2009). Lastly, VF4 had a strong positive T loading and explained 10% of total variance. Thus, this loading was again related to natural processes.

Therefore, PCA results showed that concentrations of NO_2^- and NO_3^- in the surface water can be used as an indicator of Syrian civil war's impact on water quality of Orontes River. As aforementioned, these indicators also indicated diffuse pollution, coming from anthropogenic activities. In this case, the main anthropogenic activity to degrade water quality was war, itself. It is known that nitrogenous fertilizers are generally used for the production of explosives, sending great nitrogenous load to the environment. So, it may be said that residuals of this explosives reached the river by surface runoff. Also, it should also be noted that natural processes might have been effective in this water quality degradation, though were not as significant as anthropogenic causes.

CONCLUSION

This study was conducted to evaluate the impact of Syrian civil war on the quality of Turkish part of Orontes River. For that purpose, the monitoring data, which included 11 different water quality parameters, got evaluated. It seemed that physical parameters, (mainly pH, T, and DO) did not reflect the impact of Syrian civil war, while erosion-induced ones (like Na^+, TDS, and SO_4) were strongly season-depended; their concentration rising during rainy periods, regardless of the war, itself. On the other hand, concentrations BOD, COD, NO_3, NO_2, and NH_4 increased drastically, following Syrian civil war. Also, it was found that water quality index score soared after 2011, proving the degradation of water quality in Turkish borders after Syrian civil war. Afterwards, principal component analysis was used to determine indicator parameters, reflecting the impact of Syrian civil war. It was found that the increase in NO_2^- and NO_3^- concentration may be used as an indicator since it was related to the use of explosives. In addition, refugee immigration affected water quality management practices, increasing diffuse pollution sources, which in turn declined water quality. Thus, to put it in a nutshell, Syrian civil war affected water quality of the Turkish part of Orontes River in different ways.

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