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Evaluation of seasonal variations in physico-chemical parameters of Taleghan River, northern Iran

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Abstract. In this study an experiment on water quality of Taleghan River between August 2008 and July 2010 was conducted. Twenty four samples from 6 stations along the river were taken monthly. Parameters like temperature, dissolved oxygen, pH, electrical conductivity, BOD_5, COD, nitrate, nitrite, ammonium and orthophosphate rates were considered in order to determine the water quality. Results show that there is no serious problem regarding the parameters checked in this study. So, the water can be used as drinking water for Tehran city without any serious problem.

Key words: water quality, Taleghan River, physico-chemical parameters, drinking water, Iran.

Introduction. Water quality performs an important role in health of humans, animals and plants. The quality of surface water within a region is governed by both natural processes (such as precipitation rate, weathering processes and soil erosion) and anthropogenic effects (such as urban, industrial and agricultural activities and the human exploitation of water resources) (Jarvie et al 1998; Liao et al 2007; Mahvi et al 2005; Nouri et al 2008). A variety of methods are used to display the information which is concealed in the quality variables observed in a water quality monitoring network (Mazlum et al 1999). The quality of a river at any point reflects several major influences, including the lithology of the basin, atmospheric inputs, climatic conditions and anthropogenic inputs (Bricker & Jones 1995; Shrestha & Kazama 2007). The anthropogenic discharges constitute a constant polluting source, whereas surface runoff is a seasonal phenomenon, largely affected by climate within the basin (Karbassi et al 2007; Najafpour et al 2008; Singh et al 2005). Seasonal variations in precipitation, surface run-off, ground water flow, interception and abstraction strongly affect river discharge and, consequently the concentrations of pollutants in river water (Khadka & Khanal 2008; Mtethiwa et al 2008; Vega et al 1998). Human activities are a major factor determining the quality of the surface and ground water through atmospheric pollution, effluent discharges, use of agricultural chemicals, eroded soils and land use (Niemi et al 1990). These land use changes increase the amount of impervious surface resulting in storm runoff events that negatively affect stream ecosystems and water quality (Paul & Meyer 2001).

Rivers in watersheds with substantial agricultural and urban land use experience increased inputs and varying compositions of organic matter (Sickman et al 2007) and excessive concentrations of phosphorus and other nutrients from fertilizer application and watershed releases (Easton et al 2007). Natural and synthetic estrogens, other pharmaceuticals and disease-causing bacteria are entering streams through the release of wastewater from sewage treatment plants and effluent from septic systems (Gross et al 2004; Kinzelman et al 2003; Williams et al 2003). Therefore, the effective, long-term management of rivers requires a fundamental understanding of hydro-morphological, chemical and biological characteristics (Shrestha & Kazama 2007).

However, due to spatial and temporal variations in water quality (which are often difficult to interpret), a monitoring program, providing a representative and reliable estimation of the quality of surface waters is necessary (Dixon & Chiswell 1996). The application of different multivariate statistical techniques, such as cluster analysis (CA), principal component analysis (PCA) and factor analysis (FA) helps in the interpretation of complex data matrices to better understand the water quality and ecological status of the studied systems, allows the identification of possible factors sources that influence water systems and offers a valuable tool for reliable management of water resources, as well as rapid solution to pollution problems (Lee et al 2001; Reghunath et al 2002; Vega et al 1998; Wunderlin et al 2001). Also in recent years, the PCA and FA methods have been exerted for a variety of environmental applications, containing evaluation of ground water monitoring wells and hydrographs, examination of spatial and temporal patterns of surface water quality, identification of chemical species related to hydrological conditions and assessment of environmental quality indicators (Bengraine & Marhaba 2003; Ouyang et al 2006; Perkins & Underwood 2000; Voutsa et al 2001).

Material and Methods. This study was undertaken during the period August 2008 until July 2010 by monthly sampling of physic-chemical parameters of Taleghan River water.

The Taleghan River is located in a 150 kilometer distance of Tehran Northwest; Talegan region is a pretty high area in the heart of the Alborz Chain. We have 6 stations for data collection in this River (Figure 1, Table 1).

Samples were analyzed to determine temperature, dissolved oxygen, pH, electrical conductivity, BOD_5, COD, nitrate, nitrite, ammonium and orthophosphate. To achieve this, standard methods were taken into consideration (APHA 1998; Clesceri et al 1998).

Figure 1. Location of the Taleghan river in Iran (original).

All data were transformed to logarithm scale and then analyzed using split-plot that the seasons were assumed as main factor and the stations as plots. Duncan's test was applied to determine significant difference between all season and years as well as their combination. Data present as mean ± SD. All analyses were performed using MSTATC software.

Table 1

Spatial characteristics of the sampling stations

Stations		*UTM*		*Elevation*	*Distance from upstream*
Number	*Name*	*X*	*Y*	*(m)*	*(km)*
S1	Gatedeh	3610480	05059160	2858	0
S2	Bayzan	3610927	05054325	2394	18
S3	Joyestan	3610963	05052928	2261	29
S4	Mongolan	3610550	05050867	2142	34
S5	Befor Shahrak	3610215	05046380	1910	47
S6	Glinak	3610007	05044880	1780	51

Results and Discussion

Temperature (T). There was not a significant difference between temperature values during the two years. Comparison of T during different seasons shows a difference in significance level of 0.01. Consequently, the summer season shows the highest amount of T during the two years and the spring and autumn seasons together do not show a significant difference in term of the amount of this factor. Also there is no any reciprocal effect between year and season (Table 2, Figure 2).

Table 2

Analysis of variance for T values in different years and seasons

Variance source	*Degree of freedom*	*Sum of square*	*Mean sum of square*	*F-Statistics*	*P-value*
Year	1	0.253	0.253	0.017	0.895
Season	3	4261.589	1420.530	97.966	0.000**
Year-Season	3	47.200	15.733	1.085	0.358
Error	130	1885.022	14.500		
Total	138	20020.035			

**Significance level of 0.01

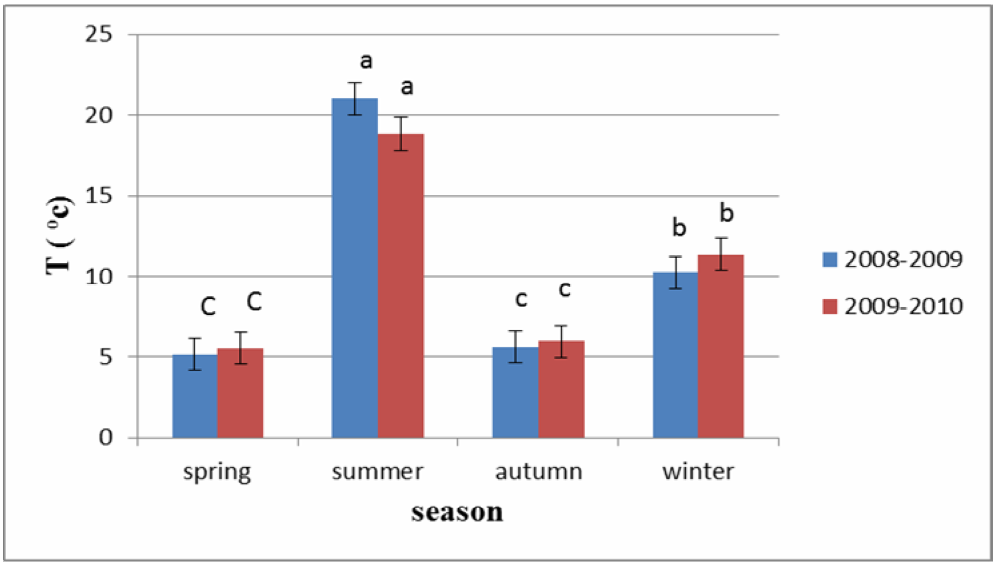

Figure 2. Seasonal changes in temperature values.

Dissolved oxygen (DO). Comparison of DO in the two years of sampling shows that there is no any significant difference between the two years in term of this factor. Comparison of DO in different seasons shows that, there is a significant difference in level of 0.01. Consequently, the spring season shows the highest DO value in both years while the winter season shows the least one. Such difference may be justified by more flow in spring due to more flood currents compared to winter. Both spring and summer seasons, in term of this factor, do not show a significant difference. Also there is not an observable mutual effect between year and season (Table 3, Figure 3).

Table 3

Analysis of variance for DO values in different years and seasons

Variance source	*Degree of freedom*	*Sum of square*	*Mean sum of square*	*F-Statistics*	*P-value*
Year	1	0.109	0.109	0.176	0.676
Season	3	23.171	7.724	12.414	0.000**
Year-Season	3	0.126	0.042	0.067	0.977
Error	130	80.884	0.622		
Total	138	4425.836			

**Significance level of 0.01

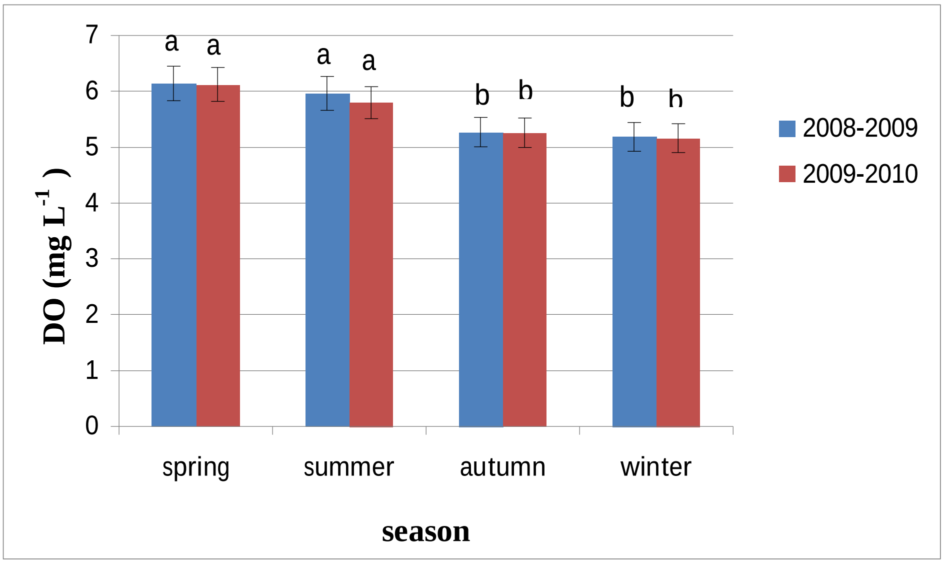

Figure 3. Seasonal changes of dissolved oxygen values.

pH. Comparison of pH in both years of sampling shows that there is no significant difference between the two years in term of this factor. Comparison of pH in different seasons shows that there is a significant difference in level of 0.01 in term of this factor. Consequently the spring season shows the highest amount of pH during both years, and summer season shows the least pH. Seasons of autumn and winter together do not show a meaningful difference in term of this factor. Also, there is not any observable reciprocal effect between year and season (Table 4, Figure 4).

Table 4

Analysis of variance for pH values in different years and seasons

Variance source	*Degree of freedom*	*Sum of square*	*Mean sum of square*	*F-Statistics*	*P-value*
Year	1	0.020	0.020	0.266	0.607
Season	3	10.869	3.623	47.784	0.000**
Year-Season	3	0.004	0.001	0.018	0.997
Error	130	9.856	0.076		
Total	138	9189.001			

**Significance level of 0.01

This result might suggest that the wastewater and runoffs that are introduced to the river are approximately neutralized in the case of pH, or the tampon power of the river is high enough to neutralize the acidic or basic wastewater drainage. The changes in pH in relation to seasons are related to photosynthesis intensity, if the effect of wastewater drainage be neglected. Thus, since there is no phytoplankton assemblages in Taleghan River (due to high turbulence and turbidity), it is not surprising that pH values were similar and stable during different seasons for two years.

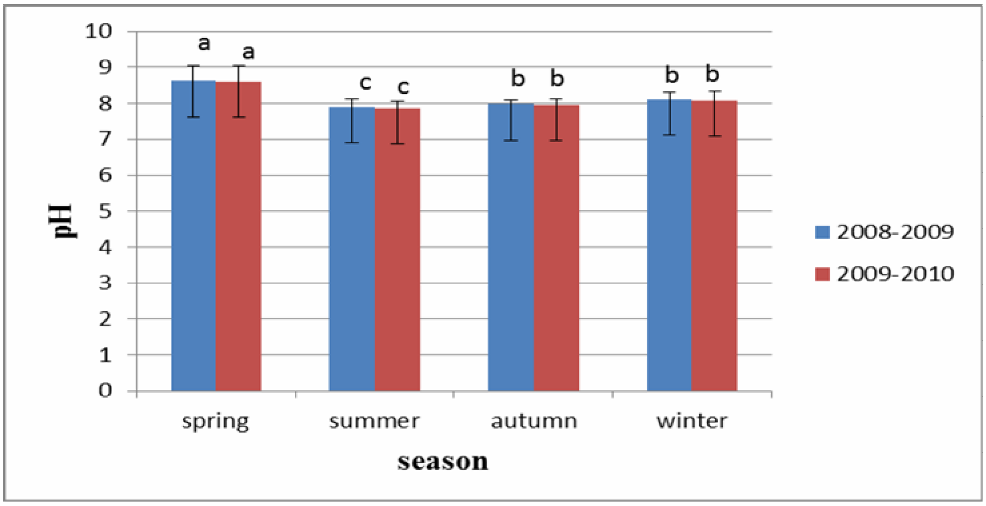

Figure 4. Seasonal changes of pH values.

Electro conductivity (EC). Comparison of EC in the two sampling years show that there is no significant difference between the two years. Comparison of EC in the different seasons shows that there is a significant difference in level of 0.01 in term of this factor. Consequently the spring season shows the highest EC in the two years. The winter season shows the least EC in both years. The winter season shows the least EC. Also, there is not any observable reciprocal effect between the two years (Table 5, Figure 5).

Table 5

Analysis of variance for EC values in different years and seasons

Variance source	*Degree of freedom*	*Sum of square*	*Mean sum of square*	*F-Statistics*	*P-value*
Year	1	6667.320	6667.320	0.830	0.364
Season	3	2814201.439	938067.146	116.843	0.000**
Year-Season	3	17896.491	5965.497	0.743	0.528
Error	130	1043701.778	8028.475		
Total	138	5.657			

**Significance level of 0.01

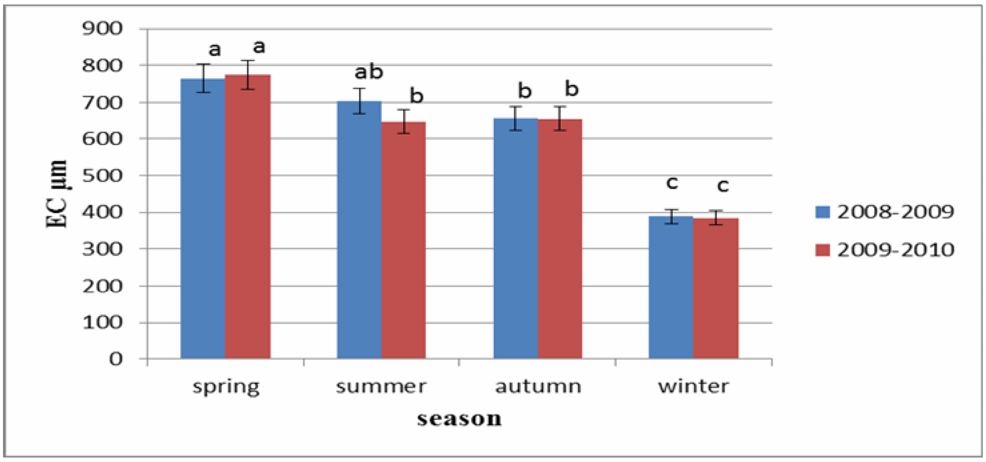

Figure 5. Seasonal changes of EC values.

Biochemical oxygen demand (BOD_5). Comparison of BOD_5 in the two sampling years shows that there is no significant difference between the two years. Comparison of BOD_5 in the difference season shows that, in term of this factor, there is a significant difference in level of 0.05. Consequently, the winter season shows the highest BOD_5 in the two years, while summer season shows the least one. There is not any significant difference between spring and autumn results. Also, there is not any observable reciprocal effect between year and season (Table 6, Figure 6).

Table 6

Analysis of variance for BOD_5 values in different years and seasons

Variance source	*Degree of freedom*	*Sum of square*	*Mean sum of square*	*F-Statistics*	*P-value*
Year	1	1.512	1.512	0.020	0.889
Season	3	554.580	184.860	2.400	0.037^{**}
Year-Season	3	3.329	1.110	0.014	0.998
Error	130	10014.622	77.036		
Total	138	65512.310			

**Significance level of 0.05

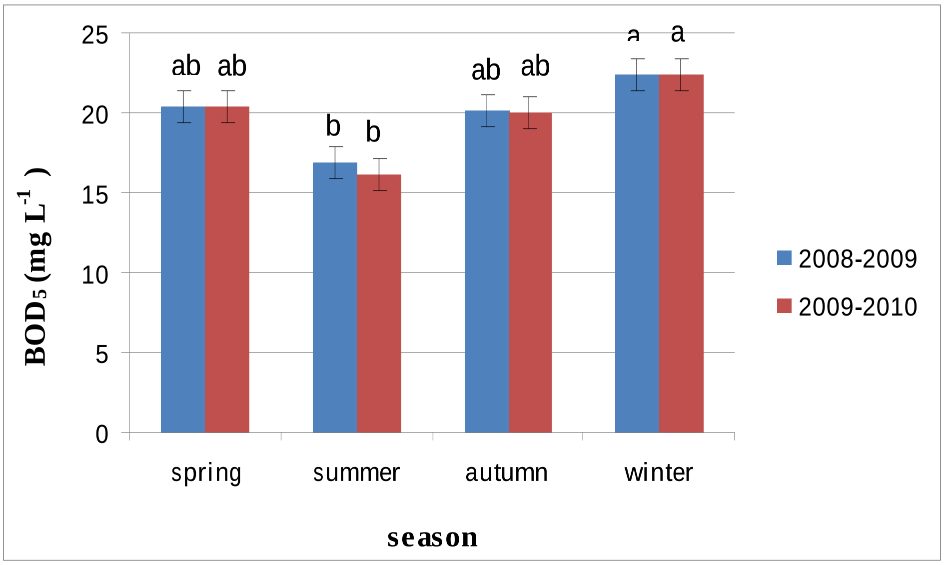

Figure 6. Seasonal changes of BOD_5 values.

Chemical oxygen demand (COD). Comparison of COD in the two years of sampling shows that there is no significant difference between the two years. Comparison of COD in different seasons shows that there was a significant difference in level of 0.01. Consequently, the winter season shows the highest COD in the two years, while summer season shows the least one. Also there is not any reciprocal effect between year and season (Table 7, Figure 7).

Table 7

Analysis of variance for COD values in different years and seasons

Variance source	*Degree of freedom*	*Sum of square*	*Mean sum of square*	*F-Statistics*	*P-value*
Year	1	1.038	1.038	0.004	0.950
Season	3	5563.583	1854.528	7.008	0.000^{**}
Year-Season	3	3.674	1.225	0.005	1.000
Error	130	34404.070	264.647		
Total	138	225275.840			

**Significance level of 0.01

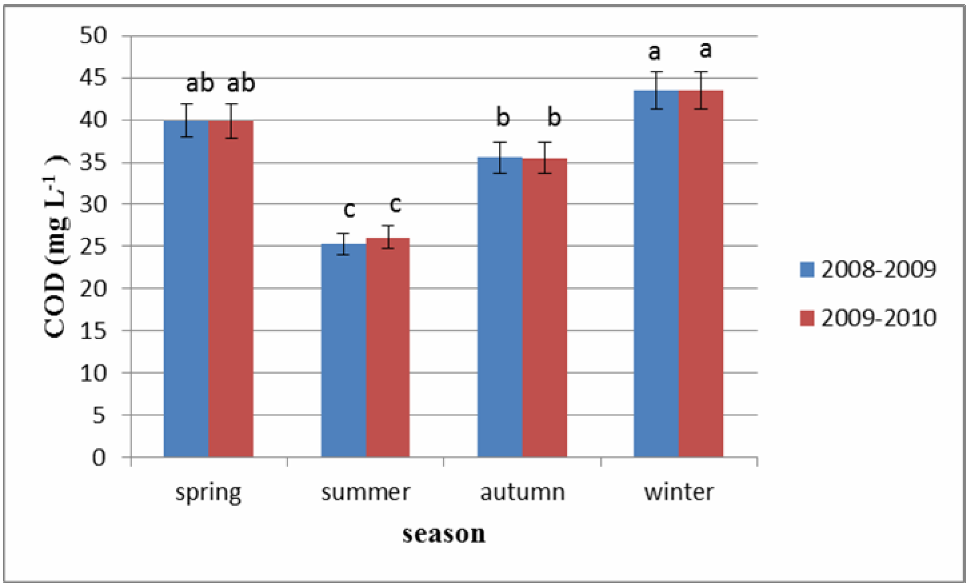

Figure 7. Seasonal changes of COD values.

Nitrate (NO_3^{2-}). Comparison of N (NO_3^{2-}) during the two years of sampling shows that there is no significant difference in term of this factor. Comparison of N (NO_3^{2-}) within the different seasons shows that there is a significant difference in term of this factor between seasons at level of 0.01. Consequently, autumn shows the highest N (NO_3^{2-}) values during the two years while summer shows the least one during 2008-2009. Winter and spring seasons do not show a significant difference in term of this factor. Also, there is not an interaction between the year and season (Table 8, Figure 8).

Table 8

Analysis of variance for N[NO_3^{2-}] values in different years and seasons

Variance source	*Degree of freedom*	*Sum of square*	*Mean sum of square*	*F-Statistics*	*P-value*
Year	1	2.238	2.238	0.849	0.358
Season	3	54.101	18.034	6.843	0.000**
Year-Season	3	6.981	2.327	0.883	0.452
Error	130	342.614	2.635		
Total	138	1759.869			

**Significance level of 0.01

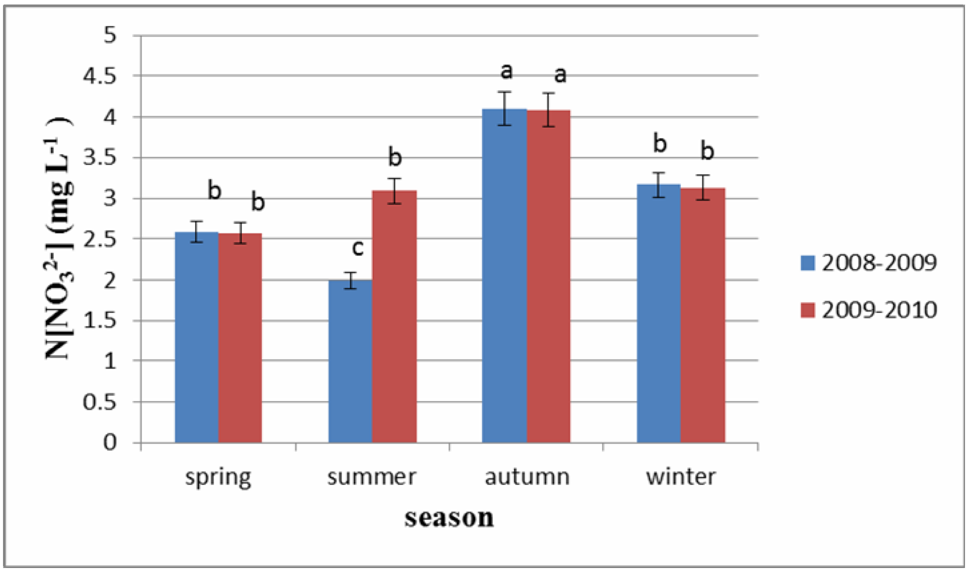

Figure 8. Seasonal changes of N [NO_3^{2-}] values.

Nitrite (NO_2^-). Comparison of NO_2^- within the two year of sampling shows that there is no significant difference in term of this factor. Comparison of NO_2^- within different seasons shows that there is a significant difference among seasons at level of 0.05. Consequently, spring and winter show the highest NO_2^- in 2009-2010, while autumn shows the least NO_2^- within 2008-2009. Also, there is not any observable interaction between the year and season (Table 9, Figure 9).

Table 9

Analysis of variance for NO_2^- values in different years and seasons

Variance source	*Degree of freedom*	*Sum of square*	*Mean sum of square*	*F-Statistics*	*P-value*
Year	1	0.005	0.005	0.195	0.659
Season	3	0.118	0.039	1.572	0.019**
Year-Season	3	0.010	0.003	0.136	0.938
Error	130	3.242	0.025		
Total	138	5.108			

**Significance level of 0.05

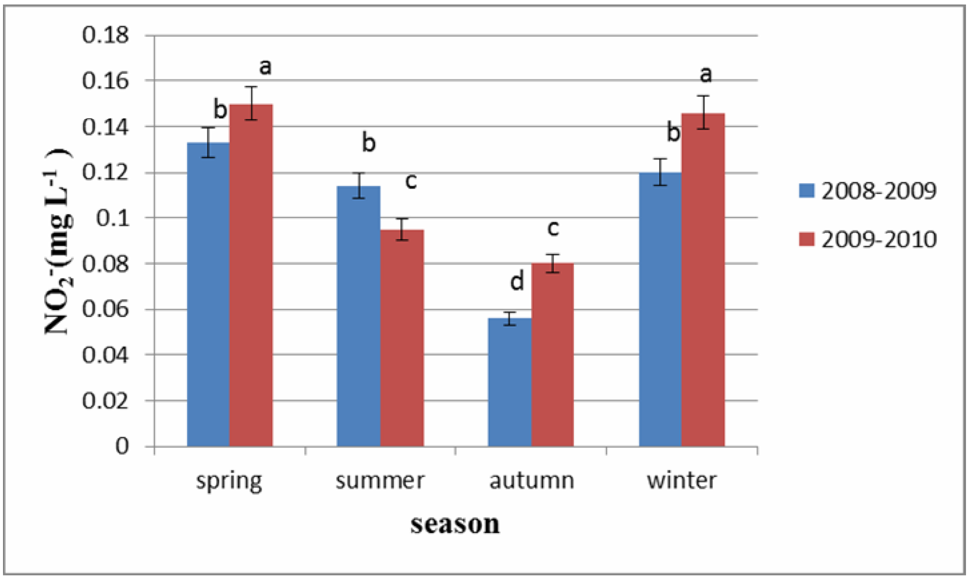

Figure 9. Seasonal changes of NO2$^-$ values.

Ammonium (NH_4^+). Comparison of NH_4^+ within the two years of sampling shows that there is no significant difference between the two years. Comparison of NH_4^+ within the different seasons shows that there is a significant difference in term of this factor at level of 0.01. Consequently, the winter within both years shows the highest NH_4^+. On the other hand, autumn shows the least NH_4^+ in 2008-2009. There is no significant difference between the spring and summer during 2008-2009 in terms of NH_4^+. Also, there is not any observable interaction between the year and season (Table 10, Figure 10).

Table 10

Analyze of variance for NH_4^+ values in different years and seasons

Variance source	*Degree of freedom*	*Sum of square*	*Mean sum of square*	*F-Statistics*	*P-value*
Year	1	0.039	0.039	1.678	0.197
Season	3	1.354	0.451	19.442	0.000**
Year-Season	3	0.028	0.009	0.397	0.755
Error	130	3.018	0.023		
Total	138	6.529			

**Significance level of 0.01

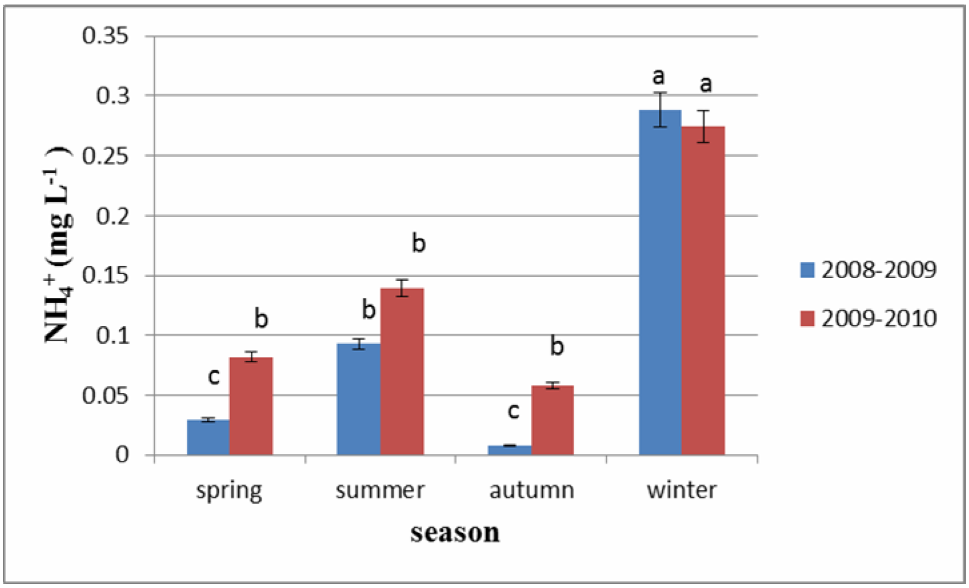

Figure 10. Seasonal changes of NH4$^+$ values.

Phosphate (PO_4^{3-}). Comparison of PO_4^{3-} within the two years of sampling shows that there is no significant difference between the two years. Comparison of PO_4^{3-} within difference seasons shows that there is a significant difference in term of this factor at level of 0.05. Consequently, summer shows the highest PO_4^{3-} in 2008-2009 while there is no significant difference between other seasons during both years. Also, there is not any observable interaction between the year and season (Table 11, Figure 11).

Table 11

Analyze of variance for PO4^{3-} values in different years and seasons

Variance source	*Degree of freedom*	*Sum of square*	*Mean sum of square*	*F-Statistics*	*P-value*
Year	1	0.000	0.000	0.080	0.778
Season	3	0.065	0.022	3.498	0.017**
Year-Season	3	0.023	0.008	1.254	0.293
Error	130	0.802	0.006		
Total	138	2.342			

**Significance level of 0.05

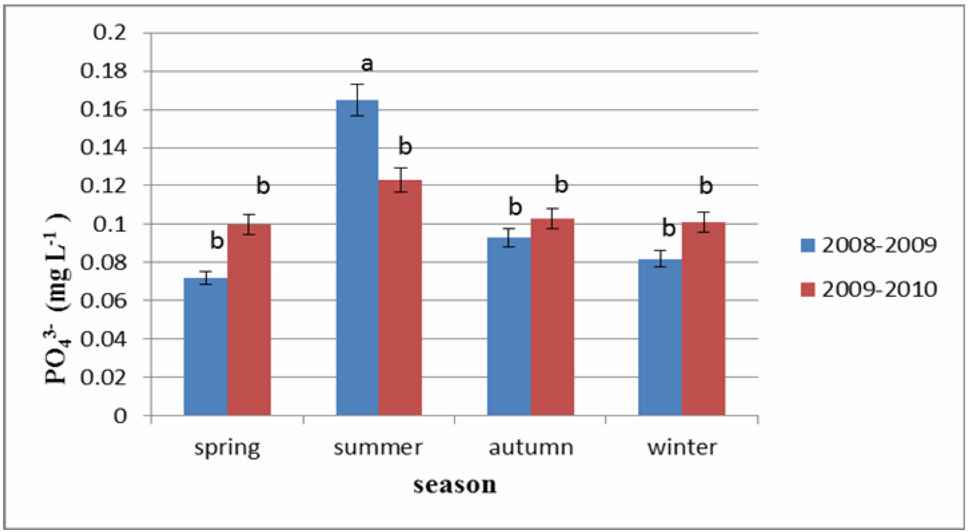

Figure 11. Seasonal changes of PO4^{3-} values.

The mean values of hydro-chemical characteristics of river water within the study area are shown in Table 12.

Table 12

Hydro-chemical characteristics of river water (Mean ± SD) in different years and seasons

Year	*Season*	*T*	*DO*	*pH*	*EC*	BOD_5	*COD*	$N[NO3^-]$	$NO2^-$	$NH4^+$	$PO4^{3-}$
1	spring	5.1±4.5^{c}	6.1±1.04^{a}	8.6±0.41^{a}	765.05±81.7^{a}	20.33±7.53^{ab}	39.8±12.8^{ab}	2.5±0.58 ^{b}	0.13±0.20^{b}	0.029±0.015^{c}	0.07±0.05^{b}
1	summer	21.0±2.5^{a}	5.9±0.67^{a}	7.8±0.21^{c}	703.6±50.2^{ab}	16.91±7.39^{b}	25.3±8.9^{c}	1.9±1.6^{c}	0.11±0.15^{b}	0.093±0.097^{b}	0.16±0.12^{a}
1	autumn	5.6±4.0^{c}	5.2±0.36^{b}	7.9±0.12^{b}	656.44±124.9^{b}	20.06±12.11^{ab}	35.5±17.2^{b}	4.09±2.2^{a}	0.05±0.03^{d}	0.008 ±0.007^{c}	0.09±0.05^{b}
1	winter	10.2±2.7^{b}	5.1±0.75^{b}	8.1±0.18^{b}	389.0±56.6^{c}	22.38±7.30^{a}	43.5±22.0^{a}	3.1±1.43^{b}	0.12±0.20^{b}	0.288±0.261^{a}	0.08±0.04^{b}
2	spring	5.5±4.6^{c}	6.1±1.02^{a}	8.5±0.45^{a}	775.0±81.7^{a}	20.31±7.50^{ab}	39.8±12.8^{ab}	2.56±0.57^{b}	0.15±0.20^{a}	0.082±0.765^{b}	0.10±0.06^{b}
2	summer	18.8±4.3^{a}	5.7±0.92^{a}	7.8±0.19^{c}	647.5±93.6^{b}	16.13±6.34^{b}	26.1±7.6^{c}	3.08±2.12^{b}	0.09±0.13^{c}	0.139±0.132^{b}	0.12±0.11^{b}
2	autumn	5.9±3.8^{c}	5.2±0.37^{b}	7.9±0.16^{b}	655.44±124.4^{b}	20.05±12.10^{ab}	35.5±17.2^{b}	4.08±2.23^{a}	0.08±0.04^{c}	0.058±0.037^{b}	0.10±0.05^{b}
2	winter	11.3±2.6^{b}	5.15±0.78 ^{b}	8.09±0.23^{b}	385.0±56.6^{c}	22.35±7.33 ^{a}	43.5±22.2^{a}	3.12±1.42 ^{b}	0.14±0.17^{a}	0.274±0.279^{a}	0.10±0.09^{b}

Different letters above the values show significance ($p < 0.05$), Duncan’s test. Year 1: 2008-2009, year 2: 2009-2010.

Conclusions. Taleghan River is used for different aims such as drinking water, local economic, irrigation and eco-tourism. Of course, inlet waters were limited at this period and wastes were introduced to the river, however, examined parameters didn't show critical points and no serious problem seems to be existed in the aspect of the water quality. Results show that there is no serious problem regarding the parameters checked in this study. So, the water can be used as a drinking water supply for Tehran city without any serious problem. Results of this analysis show that, a parameter that can be significant in contribution to water quality variations for a specific season, may not necessarily be significant for others. Accordingly it is required that, when selecting water quality parameters for implementing environmental monitoring plans in river basins, the seasonal variations of parameters in assessment of water quality should be considered.

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