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Use of Water Quality Index to evaluate the groundwater characteristics of villages located in Edirne Province

Cem Tokatlı[1,*]

[1]Laboratory Technology Department, Trakya University, İpsala, Edirne, Turkey

[*]Corresponding Author: tokatlicem@gmail.com

Abstract

In this research, water quality of groundwater of some villages located in Edirne Province of Turkey were evaluated by using Weighted Arithmetic Water Quality Index (WAWQI). Groundwater samples were collected from ten villages in winter season of 2019. Thirteen parameters including total dissolved solids – TDS, oxygen saturation – OS, salinity, pH, dissolved oxygen – DO, turbidity, nitrate – NO_3, electrical conductivity – EC, nitrite – NO_2, sulphate – SO_4, oxidation – reduction potential – ORP, phosphate – PO_4 and chemical oxygen demand – COD were measured in groundwater samples. According to detected data, groundwater of the region has 1. Class quality for dissolved oxygen, pH, nitrite, sulphate and COD parameters in general and has 2. Class quality for oxygen saturation, EC, nitrate and phosphate parameters in general. It was also determined that any investigated water quality parameter has not exceeded the drinking water standards. As a result of WAWQI, the values of overall WAWQI were recorded within the permissible limits (<100) and the groundwater quality of the region was found as "A grade" water quality characteristic.

Keywords: Edirne Province, Groundwater quality, Water Quality Index

Introduction

Water quality assessment has become an important mandatory on all over the world, because of increasing population and need of freshwater. One of the main points on an effective management of freshwater resources is monitoring quality of aquatic habitats (Solak et al., 2007; Çiçek et al., 2013; Tokatlı et al., 2014; 2016; Köse et al., 2014; 2016; Ustaoğlu et al., 2017; Atıcı et al., 2018; Onur and Tokatlı, 2020).

Water quality assessment indices are known as an effective tool to determine and evaluate the quality of water ecosystems. Weighted Arithmetic Water Quality Index (WAWQI), which is one of the most commonly used drinking water quality indices, is calculated from the perspective of suitability of drinking water for human consumption (Tyagi et al., 2013; Akter et al., 2016; Mukatea et al., 2019; Tokatlı, 2019; Ustaoğlu and Tepe, 2019; Ustaoğlu et al., 2020).

Edirne Province of Turkey is one of the most productive land because of nice soil structure and rich freshwater resources. But as in many aquatic ecosystems, surface and groundwater of the region is being adversely affected from agricultural and domestic discharges. The aim of the present investigation was to determine the groundwater quality of the villages located in the Edirne Province by determining some water quality parameters and evaluate the detected data according to Turkish Regulations Water Quality Classes and apply the WAWQI in order to assess the water quality in terms of drinking purposes.

Material and Method

Sample collection

In this research, groundwater samples were taken from ten villages located in the Edirne Province in winter season of 2019. The coordinate information of the stations is given in Table 1 and the map of study area and selected stations are given in Figure 1 and.

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Table 1. Coordinate information of villages

Villages	North	East
Büyükdöllük	41.759	26.601
Menekşesofular	41.763	26.640
Küçükdöllük	41.756	26.668
Kayapa	41.775	26.689
Korucu	41.791	26.655
Sinanköy	41.814	26.697
Çömlekakpınar	41.839	26.645
Hanlıyenice	41.870	26.695
Lalapaşa	41.839	26.736
Hıdırağa	41.738	26.661

Physical – chemical and statistical analysis

DO, OS, pH, EC, TDS, ORP and salinity variables were determined by using a multiparameter device (Hach Lange – HQ40D) during the field studies; turbidity variable was determined by using a portable turbidimeter device (Hach Lange – 2100Q) during the field studies; NO_3, NO_2, PO_4, SO_4 and COD variables were determined by using a colorimeter device (Hach Lange – DR890) and a spectrophotometer device (Hach Lange – DR3900) during the laboratory studies.

Cluster Analysis (according to Bray Curtis) was used in the present research by using the "PAST" statistical package program in order to classify the investigated locations according to similar water quality characteristics.

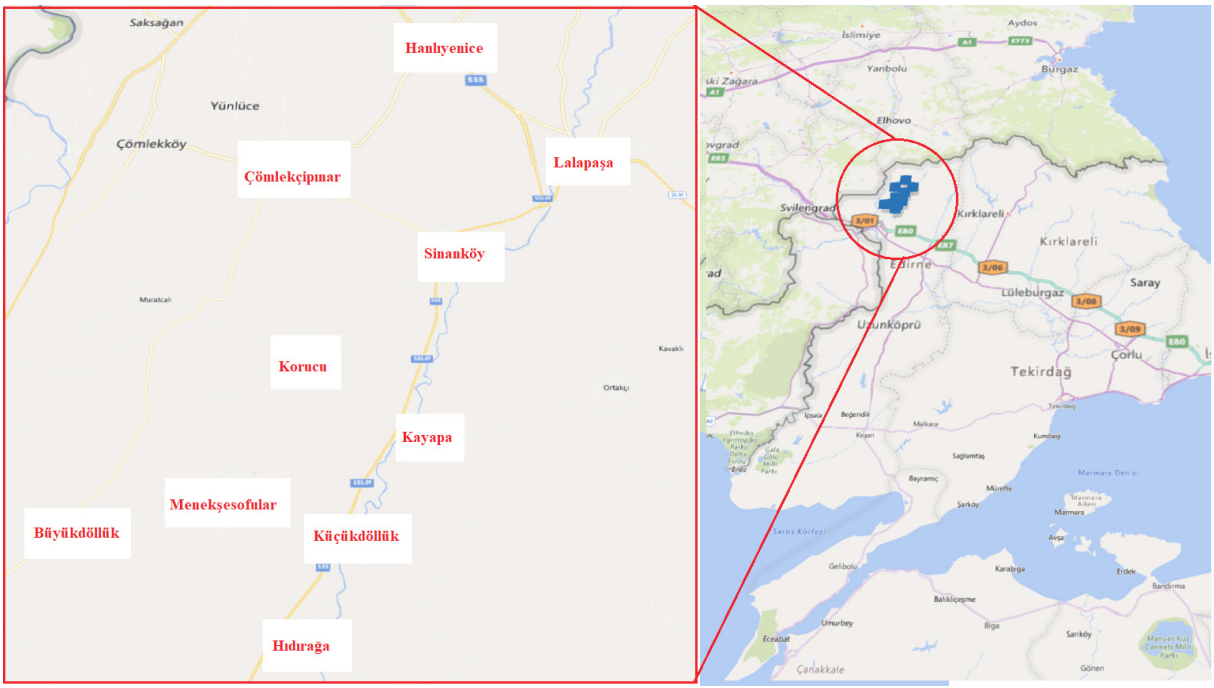

Figure 1. Study area and selected stations

Calculation of Weighted Arithmetic Water Quality Index

WAWQI calculation was made by using the following formula:

$$\text{WAWQI} = \sum QiWi / \sum Wi$$

The following formula was used to calculation of Quality rating scale (Qi):

$$Qi = 100[(Vi - Vo)/(Si - Vo)]$$

"Vi" is estimated accumulation of i^{th} variable, "Vo" is the best value of this variable, "Si" is recommended value of i^{th} variable.

The following formula was used to calculation of "Wi":

$$Wi = K/Si$$

The following formula was used to calculation of "K":

$$K = \frac{1}{\Sigma(1/Si)}$$

The quality classes of WAWQI is given in Table 2 (Brown et al., 1972).

Table 2. Water quality rating for WAWQI

WAWQI Value	Rating of Water Quality	Usage Possibilities	Grading
0 – 25	Excellent	Drinking, irrigation, industrial	A
25 – 50	Good	Drinking, irrigation, industrial	B
50 – 75	Poor	Irrigation, industrial	C
75 – 100	Very Poor	Irrigation	D
> 100	Unsuitable	Proper treatment is required	E

Results and Discussion

Results of detected physical – chemical parameters in villages located in the Edirne Province are given in Table 3. According to the Turkish Regulations (2004; 2015), groundwater of the region has 1. Class quality for dissolved oxygen, pH, nitrite, sulphate and COD parameters, in general and has 2. Class quality for oxygen saturation, EC, nitrate and phosphate, in general (Uslu and Türkman, 1987). Küçükdöllük village has 3. Class quality for nitrate parameter and Büyükdöllük village has 3. Class quality for nitrite parameter. It was also determined that any investigated station did not exceed the drinking water standards in terms of these parameters (TS266, 2005; EC, 2007; WHO, 2011).

The nitrate in water is caused by the oxidation of ammonia, which occurs as a result of the decomposition of proteins contained in animal and vegetable wastes, and especially nitrate fertilizers used in agricultural areas. A small amount of nitrate in clean waters is the most common form of nitrogen in streams (Wetzel, 2001; Manahan, 2011). Nitrite is an intermediate in biological oxidation from ammonium to nitrate, and it may have oxidized to nitrate or reduced to ammonia. It is mostly low in natural waters. Nitrite can reach high densities in low oxygenated waters with organic pollution and suggests sewage contamination if it is found in high amounts. The most important sources of nitrite in soils and waters are organic substances, nitrogenous fertilizers and some minerals (Wetzel, 2001; Manahan, 2011). The reason of the quite high nitrate and nitrite values detected in drinking water of some villages may be applied intensive agricultural fertilizers in the basin.

Table 3. Results of detected parameters

Villages	Parameters*												
	DO ppm	O_2Sat %	pH	ORP mV	EC mS/cm	TDS ppm	Sal ‰	Tur NTU	NO_3 ppm	NO_2 ppm	PO_4 ppm	SO_4 ppm	COD ppm
Büyükdöllük	9.33	81.6	7.47	206.3	568	404	0.41	0.42	7.90	0.081	0.059	22.0	1.00
	1. Class	2. Class	1. Class	-	2. Class	-	-	-	2. Class	**3. Class**	2. Class	1. Class	
Menekşesofular	9.52	84.3	7.66	202.3	598	416	0.42	1.50	3.99	0.003	0.047	21.7	0.03
	1. Class	2. Class	1. Class	-	2. Class	-	-	-	1. Class	1. Class	2. Class	1. Class	
Küçükdöllük	8.64	79.4	7.32	201.8	853	579	0.58	0.48	11.50	0.004	0.094	123.0	0.69
	1. Class	2. Class	1. Class	-	2. Class	-	-	-	**3. Class**	1. Class	2. Class	1. Class	1. Class
Kayapa	9.85	89.1	7.82	210.3	389	263	0.26	0.70	6.09	0.003	0.058	21.9	1.61
	1. Class	2. Class	1. Class	-	1. Class	-	-	-	2. Class	1. Class	2. Class	1. Class	1. Class
Korucu	9.71	87.5	7.47	192.6	448	305	0.31	0.41	2.29	0.005	0.036	30.4	0.59
	1. Class	2. Class	1. Class	-	2. Class	-	-	-	1. Class	1. Class	2. Class	1. Class	1. Class
Sinanköy	8.59	77.4	7.32	189.3	454	311	0.31	0.67	2.34	0.002	0.030	34.7	0.24
	1. Class	2. Class	1. Class	-	2. Class	-	-	-	1. Class	1. Class	2. Class	1. Class	1. Class
Çömlekakpınar	10.44	92.9	7.82	194.2	331	227	0.23	0.78	5.44	0.006	0.038	15.6	2.11
	1. Class	1. Class	1. Class	-	1. Class	-	-	-	2. Class	1. Class	2. Class	1. Class	1. Class
Hanlıyenice	9.26	82.4	7.58	168.4	711	498	0.50	3.29	0.90	0.008	0.066	127.0	2.03
	1. Class	2. Class	1. Class	-	2. Class	-	-	-	1. Class	1. Class	2. Class	1. Class	1. Class
Lalapaşa	9.83	86.6	7.84	187.3	374	261	0.26	0.48	7.83	0.006	0.035	26.9	3.64
	1. Class	2. Class	1. Class	-	1. Class	-	-	-	2. Class	1. Class	2. Class	1. Class	1. Class
Hıdırağa	10.47	92.8	7.96	176.5	582	405	0.41	0.65	7.18	0.001	0.104	38.6	2.27
	1. Class	1. Class	1. Class	-	2. Class	-	-	-	2. Class	1. Class	2. Class	1. Class	1. Class
min	8.59	77.4	7.32	168.4	331.0	227.0	0.23	0.41	0.90	0.001	0.030	15.6	0.03
mak	10.47	92.9	7.96	210.3	853.0	579.0	0.58	3.29	11.50	0.081	0.104	127.0	3.64
ort	9.56	85.4	7.62	192.9	530.8	366.9	0.36	0.93	5.54	0.012	0.057	46.1	1.42
SD	0.64	5.3	0.22	13.1	164.0	113.5	0.11	0.88	3.23	0.024	0.025	42.1	1.11

DO: Dissolved oxygen; O2sat: Oxygen saturation; Sal: Salinity; Tur: Turbidity
*3. – 4. Class water qualities are given in bold

Cluster Analysis (CA) was applied to detected data to determine the similar groups among the investigated villages according to water quality characteristics. The diagram of CA is given in Figure 3. According to the results of CA, 2 clusters were identified, which were named as "moderate contaminated zones" and "less contaminated zones". The moderate polluted cluster (C1) was formed by the locations of Hıdırağa, Mnekşesofular, Büyükdöllük, Küçükdöllük and Hanlıyenice; and the lower polluted cluster (C2) was formed by the locations of Kayapa, Lalapaşa, Çömlekakpınar, Korucu and Sinanköy.

Monomial and multinomial risks of electrical conductivity, turbidity, nitrate and nitrite parameters in groundwater of the region were determined by using WAWQI. The quality rating scale values (Qi), which means the results of monomial WAWQI, calculated unit weights (Wi) of investigated parameters and the data of overall WAWQI, which means the results of multinomial WAWQI are given in Table 2.

According to the results of WAWQI, the values of overall WAWQI were within the permissible limits (<100), and the investigated villages located in the Edirne Province were found as "A grade" water quality characteristic. It was also determined that the risk sequence of the investigated parameters in groundwater of the region used in the Weighted Arithmetic Water Quality Index as follows; electrical conductivity > turbidity > nitrate > nitrite in general.

In a study performed in the same region, groundwater quality of Ergene River Basin was evaluated by using WAWQI. According to the results of this research, the majority of investigated element concentrations in groundwater of the basin have been found to be in the range of human consumption standards (Tokatlı, 2019). In another study performed in the city of Pogradec (Albania), drinking water quality assessment was made by using the water quality index. According to the results of this research, the drinking water quality in the city of Pogradec was found as "good" level and as similar of the results of the present investigation, turbidity parameters was found as one of the main problem on drinking water quality (Damo and Icka, 2013).

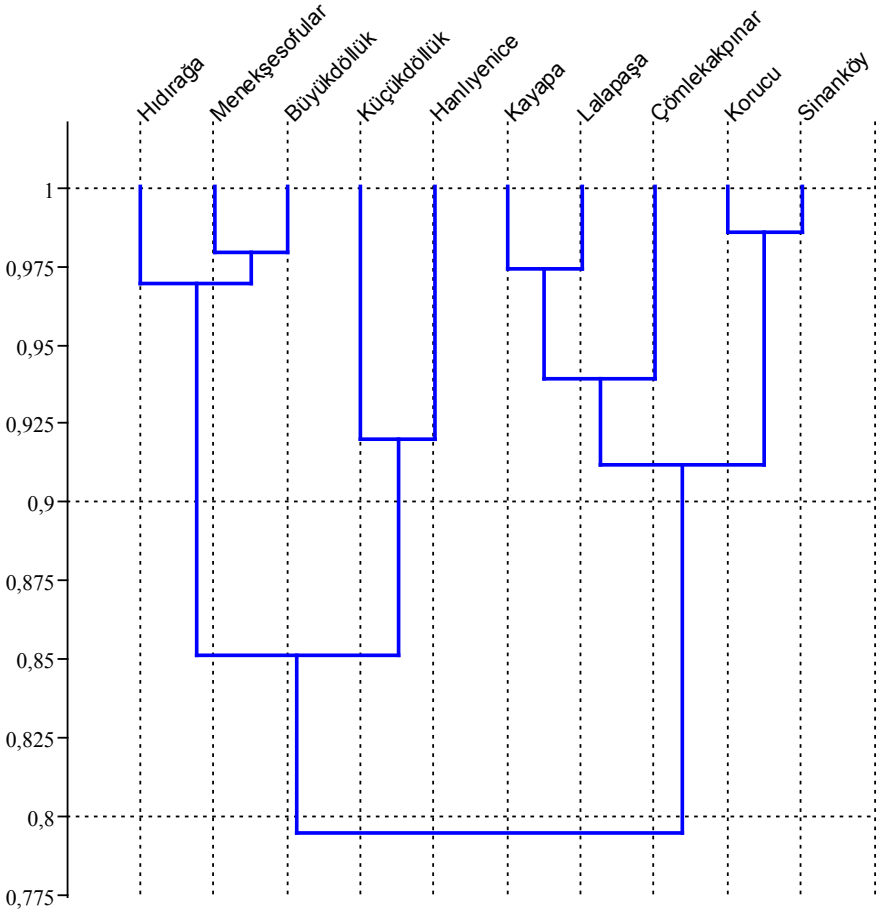

Figure 3. CA diagram of villages

Monomial and multinomial risks of electrical conductivity, turbidity, nitrate and nitrite parameters in groundwater of the region were determined by using WAWQI. The quality rating scale values (Qi), which means the results of monomial WAWQI, calculated unit weights (Wi) of investigated parameters and the data of overall WAWQI, which means the results of multinomial WAWQI are given in Table 2.

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Table 2. Quality rating scale values (Qi), unit weights (Wi) and overall WAWQI

Stations	Parameters used in WAWQI				Overall WAWQI
	EC	Turbidity	NO_3	NO_2	
	Wi				
	0.00007664	0.03832	0.0038	0.958	
	Qi				
Büyükdöllük	22.72	8.4	15.8	40.5	21.864369
Menekşesofular	23.92	30	7.98	1.5	15.856795
Küçükdöllük	34.12	9.6	23	2	17.187365
Kayapa	15.56	14	12.18	1.5	10.814634
Korucu	17.92	8.2	4.58	2.5	8.3035581
Sinanköy	18.16	13.4	4.68	1	9.3139911
Çömlekakpınar	13.24	15.6	10.88	3	10.684578
Hanlıyenice	28.44	65.8	1.814	4	25.024223
Lalapaşa	14.96	9.6	15.66	3	10.809632
Hıdırağa	23.28	13	14.36	0.5	12.790481
min	**13.24**	**8.2**	**1.814**	**0.5**	**8.3035581**
max	**34.12**	**65.8**	**23**	**40.5**	**25.024223**
mean	**21.232**	**18.76**	**11.093**	**5.95**	**14.264963**
SD	**22.72**	**8.4**	**15.8**	**40.5**	**21.864369**

Conclusion

In the present research, groundwater qualities of 10 villages in Edirne Province were assessed by using Weighted Arithmetic Water Quality Index (WAWQI). As a result of this study, the quality of groundwater in the region was found as 1. - 2. Class, in general and any investigated variable has not exceeded the drinking water standards. It was also determined that the values of overall WAWQI were recorded within the permissible limits (<100) and the groundwater quality of the region was found as "A grade" water quality characteristic.

In conclusion, although levels of some of the investigated parameters in some villages of the region were determined as quite high levels, the majority of investigated variables in drinking water of the region have been found to be in the range of human consumption standards.

The detected data reveals that agricultural runoff is the main risk factor for the groundwater of the region and if such contamination persists in especially around the Büyükdöllük and Küçükdöllük Villages, concentrations of nitrogen compounds in drinking water may reach the critical levels and may adversely affect the human health in the near future.

Compliance with Ethical Standards

Conflict of interest

The author declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

Author contribution

The author read and approved the final manuscript. The author verifies that the Text, Figures, and Tables are original and that they have not been published before.

Ethical approval

Not applicable.

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Data availability

Not applicable.

Consent for publication

Not applicable.

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