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Research Article

FLUORINE ACCUMULATIONS IN DRINKING WATER OF HAVSA DISTRICT (EDIRNE, TURKEY) AND ASSESSMENT OF WATER QUALITY IN TERMS OF TEETH HEALTH

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ABSTRACT

This study was carried out to determine the fluorine accumulations in groundwater of Havsa District, where is located in the Edirne Province of Turkey in Thrace Region. Drinking water samples were collected from 15 stations including almost all the residential areas of the Havsa District in winter season of 2016. Fluorine concentrations of water samples were determined by using a spectrophotometer and Cluster Analysis (CA) was applied to detected data in order to classify the groundwater of investigated residential areas according to fluorine contents. Geographic Information System (GIS) was also used in order to make a visual explanation by presenting distribution map of fluorine contents and detected data were evaluated according to national and international quality criteria. And also the detected data were evaluated in terms of teeth health of local people, who constantly drinks this water. According to data observed, the fluorine concentrations in the Havsa District were determined between 0.006 ppm (Bakışlar Village) – 0.567 ppm (Hasköy Village). According to the results of CA, 2 statistically significant clusters were formed as “Updistrict Cluster” with higher fluorine contents and “Downdistrict Cluster” with lower fluorine contents.
Keywords: Havsa District, fluorine, drinking water quality, cluster analysis, geographic information system (GIS), teeth health.

1. INTRODUCTION

Groundwater is the most significant source of drinking water supply for many settlement areas, but it is known that many pollutants sourced from natural and anthropogenic activities have been identified as strong contaminants found in groundwater (Canter, 1987; Hudak, 1999; Çiçek et al., 2013; Tokatlı, 2014; 2017). Therefore assessment groundwater quality has a great importance for human health especially in rural areas like villages.

Fluorine is a naturally occurring, widely distributed element and a member of the halogen family. However, the elemental form of fluorine is so chemically reactive that it rarely occurs naturally in the elemental state. Fluorine occurs in ionic forms, or combined with other chemicals in minerals. Fluorides are properly defined as binary compounds or salts of fluorine and another element. Examples of fluorides include sodium fluoride and calcium fluoride (ATSDR, 2003). Fluoride enters hydrosphere by draining away from soil and minerals into groundwater and

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groundwater may show variations in fluoride content depending on the presence of fluoride-containing formations at different depths (Mullane et al., 2016). Drinking water is known as the main source of fluoride. When fluoride is ingested, it accumulates mainly in calcifying tissues such as bone and dental tissues. Long term intake of fluoride during enamel formation results in continuum of clinical change of the enamel that is called dental fluorosis and the severity of these changes depends on the amount of fluoride ingested during the period of tooth formation. The pathological changes in enamel are dose dependent (Fawell et al., 2006). In humans, mottled enamel is an obvious clinical manifestation of dental fluorosis, when the fluoride level in drinking water is more than 1.5 ppm (Fejerskov et al., 1994). Many studies reported health benefits of the optimal amount of fluoride intake for preventing dental caries and a concentration of about 0.7 – 1.2 mg per liter in water supply is considered to result in maximum caries protection (Li et., 2001). However, health may be influenced adversely if excessive amount of fluoride is ingested (Brown et al., 2005). Briefly, fluoride content in drinking water makes possible to estimate the population exposed to levels of fluoride.

Havsa District, where contains very large and productive agricultural lands, is located in the Thrace Region of Turkey in Edirne Province. The aim of this study was to determine the fluorine content in drinking water of Havsa District and evaluate the detected data in terms of teeth health of local people.

2. MATERIAL AND METHOD

2.1. Study area and collection of samples

Havsa District with an altitude of about 30 meters has 49.635 square meters surface area and 27 km away from the Edirne Province city center. The land of the district is usually in the form of plain with no mountains, highlands, rivers and forests and also it is dominated by agricultural land (http://www.edirnekultur.gov.tr/; http://www.havsa.gov.tr/).

Table 1. Location properties of selected stations and capacities of water sources

Station Number	**Locality**	**Coordinates**		**Structural Information of Water Resources** (Anonymous, 2012)	
		North	South	Capacity (L/sec)	Source Type (wells)
S1	Bakışlar	41.458108	26.831325	-	Drilling
S2	Tahal	41.42818	26.856707	7	Drilling
S3	Naipyusuf	41.483062	26.904915	9	Drilling
S4	Yolageldi	41.518485	26.949749	10	Drilling
S5	Bostanlı	41.610994	26.97024	7	Drilling
S6	Köseömer	41.58754	26.888348	2	Drilling
S7	Havsa	41.549663	26.819859	-	Drilling
S8	Osmanlı	41.587715	26.835672	13	Drilling
S9	Hasköy	41.639331	26.858687	9	Drilling
S10	Arpaç	41.690341	26.880257	5	Drilling
S11	Habiller	41.669214	26.795204	7	Drilling
S12	Oğulpaşa	41.605067	26.752064	8	Drilling
S13	Abalar	41.546367	26.740826	16	Drilling
S14	Azatlı	41.502259	26.701552	6	Drilling
S15	Şerbettar	41.461724	26.759727	8	Drilling

In the present study, drinking w ater samples were collected in winter season of 2016 from 15 stations from the drill fountains of the villages located in the Havsa District. Water samples were then collected at the outflow of drill pump in polyethylene bottles. Coordinate information and localities of selected stations are given in Table 1 and the map of Havsa District is given in Figure 1. Also some structural information about the drinking water sources of Havsa District and connected villages are given in Table 1.

2.2. Chemical Analysis

Fluorine parameter was determined by using spectrophotometric method during the laboratory studies with a "Hach Lange DR 3900 Spectrophotometer" device (wavelength range 320 - 1100 nm). Cuvette Test LCK 323 was used in spectral photometer. This method provides fluoride ions react with zirconium to form a colorless zirconium fluoride complex. This causes the red zirconium lake which is present to lose color (https://tr.hach.com/).

2.3. Statistical Analysis and GIS Maps

Cluster Analysis (CA) was applied to detected data in order to classify the investigated villages according to fluorine contents by using the Past statistical package program. The distribution map (GIS Map) of fluorine parameter was made by using the "ArcGIS" package program.

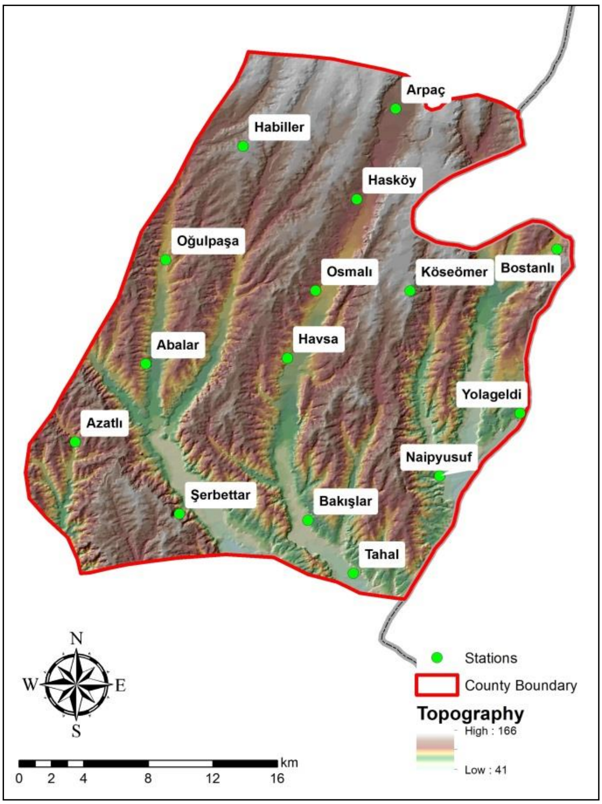

Figure 1. Map of Havsa District

3. RESULTS AND DISCUSSION

Results of investigated fluorine parameter in Havsa District with minimum, maximum and mean values and some national and international water quality standards are given in Table 2. Distribution map of fluorine accumulations in drinking water of Havsa District is given in Figure 2.

Table 2. Results of detected parameters and some limit values

Limit Values and the Results of Present Study		**F^-** (mg/L)
Water Quality Classes (SKKY, 2015)	**I. Class** (Very Clean)	1
	II. Class (Less Contaminated)	1.5
	III. Class (Much Contaminated)	2
	IV. Class (Extremely Contaminated)	>2
Drinking Water Standards	**TS266** (2005)	1.5
	EC (2007)	1.5
	WHO (2011)	1.5
Havsa District	Minimum	0.006
	Maximum	0.567
	Mean	0.185
	SD	0.174

TS266 – Turkish Standards Instıtute; EC – European Communities;
WHO – World Health Organization

As a result of this study, although fluorine parameter recorded in some villages of Havsa District were determined as quite high levels, fluorine contents in the drinking water resources of the region have been found to be in the range of drinking and human consumption standards specified by Turkish Standards Institute (TS266, 2005), European Communities (EC, 2007) and World Health Organization (WHO, 2011), in general. According to the Water Pollution Control Regulation criteria in Turkey (SKKY, 2015), Havsa District region has I. Class water quality in terms of fluorine parameter.

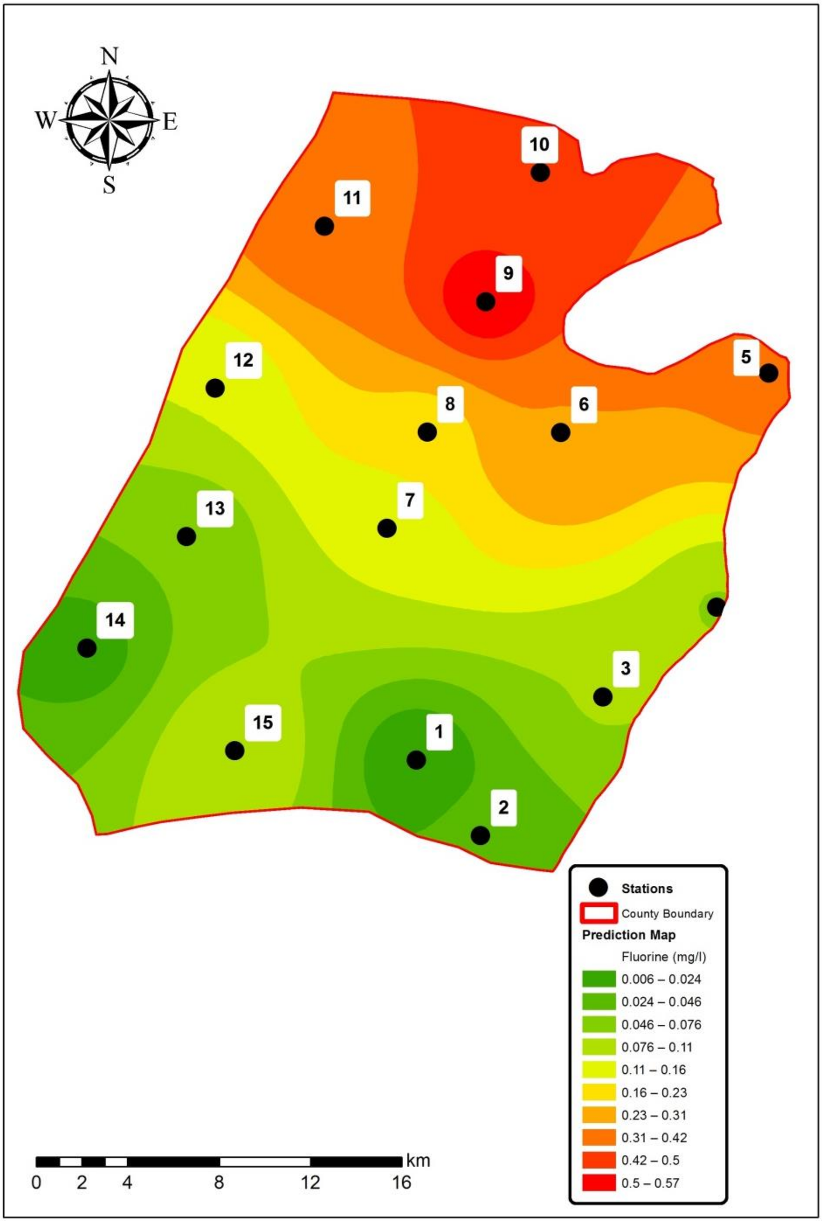

Figure 2. Fluorine distribution map of Havsa District

The diagram of CA calculated by using fluorine contents of villages is given in Figure 3. According to results of CA, 2 statistically significant clusters were formed: Cluster 1 named as "Updistrict Cluster" with higher fluorine contents corresponded to Hasköy, Bostanlı, Köseömer, Arpaç and Habiller villages; Cluster 2 named as "Downdistrict Cluster" with lower fluorine contents corresponded to Bakışlar, Tahal, Havsa, Osmalı, Oğulpaşa, Abalar and Azatlı villages.

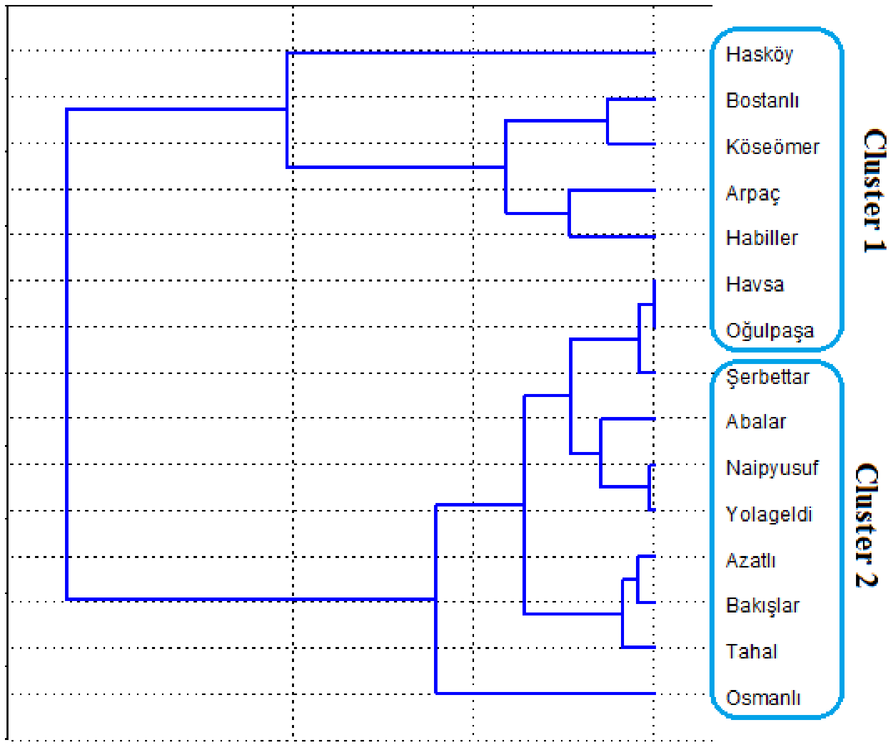

Figure 3. Diagram of CA

Human exposure to fluoride may occur through the food chain and drinking water is the main source of daily fluoride intake. Fluoride has a strong affinity for hard tissues and can easily get deposited in bones and teeth in the body (Taghipour, 2016) According to the studies fluoride in drinking water can be either beneficial or harmful depending on its concentration (GómezHortigüela, 2013; Guner, 2016; Taghipour, 2016). Low levels of fluoride intake might be beneficial for preventing dental carries, whereas chronic exposure to elevated levels of fluoride may lead to dental and skeletal fluorosis. It is more common in endemic areas of the world where fluoride naturally occurs in drinking water and its concentration is more than 1 ppm (Liu, 2014). Drinking excessive fluoride during mineralization of teeth results in dental fluorosis. In general, children drinking water with 1 ppm fluoride concentration may present a few small spots or slight discolorations on their teeth, whereas children drinking water with 4 ppm fluoride concentration may develop more severe forms of dental fluorosis (ATSDR, 2003).

In the present study, fluoride concentrations of the villages located in Cluster 1 were determined as close to optimal fluoride level of 0.7 ppm (Cruz, 2015), whereas fluoride concentrations of the villages located in Cluster 2 were determined as far below the optimal fluoride level in drinking water. The caries prevalence tends to decline with increasing fluoride level in the drinking water, thus indicating a positive effect of fluoride on prevention of dental caries (Horowitz et al., 2004).

In a preliminary study, the prevalence of dental caries and dental fluorosis in children of two districts of Edirne Province (Havsa and Süloğlu) were investigated. According to the results of this study, it was found that caries levels were lower in the optimal fluoride area (0.703 + 0.201

ppm) (Havsa District) than below-optimal fluoride area (0.357 + 0.053 ppm) (Süloğlu District) (Güner et al., 2017). According to the previous studies, drinking water containing fluoride concentration within the optimal fluoride range has a protective effect on caries incidence and prevalence (Fawell et al., 2006; WHO, 2011), thus the region in the Cluster 1 may result as decline in the prevalence and the severity of dental caries.

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