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Biogeochemistry in Akçakent Fluoride Deposits, Kırşehir, Türkiye

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Abstract: Fluoride (F) is the anion of hydrofluoric acid, a pungent acid in the halogen group, which evaporates at 194 ^{0}C. Fluoride (F^-) in the human body is absorbed from food and drink. The fluoride content of surface water is important for mineral exploration and human health. The reason for the low fluoride content in foods is water. Tomato plants and soil samples taken from the fluoride deposits of Akçakent (Kırşehir) and its surroundings are the main material of the study. The formation of fluorite deposits is associated with magmatic events. These deposits are found in the form of gangue minerals on the ceilings of the plutons. In rock-forming minerals (amphibole, mica, clay, apatite, and other water-containing minerals) F^- only replaces OH^-. F occurs in volcanic gases as HF. However, rocks in volcanic gas vents can be extremely altered. Hydrothermal solutions become acidic due to the absorption of fluoride. However, when they react with calcium and limestone, the pH value increases and basic fluorides are formed. Fluoride, CaF_2, is a transparent and translucent, purple, green, brown, yellow, red, blue and colorless mineral.

Keywords: fluoride, tomato, health, hydrothermal

Akçakent Florit Yataklarının Biyojeokimyası, Kırşehir

Özet: Flor (F), halojenler grubunda yer alan, keskin kokulu bir asit olan hidroflorik asitin 194 ^{o}C'de buharlaşan anyonudur. İnsan vücudundaki florür (F^-) yiyecek ve içecekler tarafından alınır. Yüzey sularının florür içeriği maden aramaları ve insan sağlığı açısından önemlidir. Gıdalardaki düşük florür içeriğinin nedeni sudur. Akçakent (Kırşehir) florit yatakları ve çevresinden alınan domates bitkileri ve toprak örnekleri çalışmanın ana materyalini oluşturmaktadır. Florit yataklarının oluşumu magmatik olaylarla ilişkilidir. Bu yataklar plütonların tavanlarında gang mineralleri şeklinde bulunur. Kaya oluşturan minerallerde (amfibol, mika, kil, apatit ve diğer su içeren mineraller) F-, yalnızca OH^-'in yerini alır. Volkanik gazlarda büyük miktarda florür HF formunda bulunur. Ancak volkanik gaz çıkışlarındaki kayalar aşırı miktarda alterasyona maruz kalabilir. Hidrotermal çözeltiler florür içemesiyle asidik hale gelir. Ancak kalsiyum ve kireçtaşı ile reaksiyona girdiklerinde pH değeri yükselir ve bazik floritler oluşur. Florit mor, yarı saydam, şeffaf, mavi, yeşil, sarı, kahverengi, kırmızı ve renksiz bir mineraldir.

Anahtar kelimeler: flor, domates, sağlık, hidrotermal

INTRODUCTION

The fluoride content of surface water is important for two different reasons: human health and mineral exploration. The level normally considered harmful is well below 1.5 ppm (Council Directive, 1998; Directive (EU) 2020; WHO, 1996; WHO, 2008; WHO, 2017). The formation and distribution of fluorite-

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bearing mineral deposits (Pirisi & Valera, 1974) and/or some types of volcanic activity, including thermal springs, and their products have a direct or indirect influence (Caboi et al., 1986; Calderoni et al., 1993; Yirgu et al., 1999; Edmunds & Smedley, 2013). F-bearing minerals occur as major constituents or in trace amounts in various ore associations. Fluorite is the most abundant and most widespread mineral. F-bearing compounds include fluorapatite, monazite, bastnaesite, topaz, etc., and related ore deposits may be located in a variety of settings (hydrothermal deposits, carbonatite complexes and kimberlites (fluorophlogopite: Plimer, 1984) (Serra et al., 2022).

This study is based on the dissertation entitled " Yeniyapan Köyü (Akçakent - Kırşehir) Florit Yataklarında Kirlilik Parametreleri ve Bölgedeki İnsanlarda İdrar Analizleri", completed in 2022.

GEOLOGY of The REGION

The Akçakent gabbros of the region crop out in the central parts of the study area and around Akçakent (Figure 1). They were first described as hornblende gabbro and fine crystalline gabbro by Önen and Unan (1988) and as isotrope and cumulate gabbro by Yılmaz and Boztuğ (1998). It was stated by Erler and Bayhan (1995) that it is a part of the Upper Cretaceous aged Ophiolitic Melange. Göncüoğlu and Türeli (1993) stated that Akçakent gabbro is part of the Izmir - Ankara ocean volcanic arc. These gabbros tectonically overlie the Çökelik Volcanites along north-south reverse faults in the western part. They are overlain by Upper Paleocene-Oligocene aged basin fills and Neogene age units. As the Akçakent Gabros were moved and deposited on the units in the study area, they entered into the intrusives in the form of large blocks during the uplift of the syenite intrusives. The syenites that cut the gabbros show a sharp contact relationship with the gabbros. It is represented mainly by isotropic and to a lesser extent cumulate gabbros. The dark green rocks are generally phaneritic and sometimes pegmatitic in texture. In addition, they have a cracked and fractured structure due to faults in the study area and as a result they have been subjected to alteration (Figure 2) (Deniz, 2016; Baba, 2022).

Figure 1. Location map of the Kırşehir - Akçakent study area.

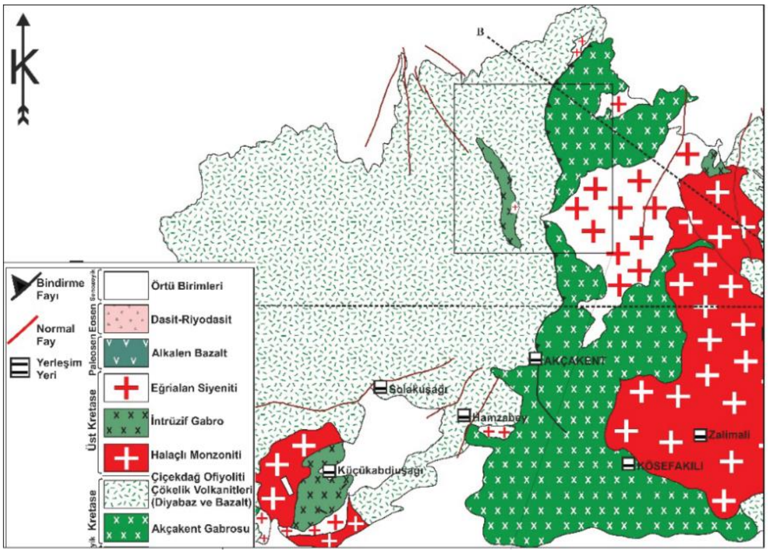


Figure 2. Geological map of the study area (Deniz, 2016; Baba, 2022).

MATERIALS and METHODS

Tomato plants and soil samples taken from the Akçakent (Kırşehir) fluorite deposits and their surroundings are the main material of the study (Figure 3). Soil and plant samples should be collected from open areas where the depositional environment is unlikely to be disturbed. Sampling the depth profile can provide a complete soil characterization. It is preferable to take conjugate samples of crops or vegetables growing in agricultural soils. Care should be taken to avoid soil particles adhering to the samples during plant preparation procedures (Barnekow et al., 2019; Baba, 2022).


Figure 3. A view of the study area and its surroundings.

The collected plant samples taken were prepared for analysis according to the method of Benton and Jones (1984) and Dunn (2007). Tomato plant samples (7) were first washed thoroughly in tap water. The plant was then separated into its organs (root and fruit), washed in pure water (Figure 4) and it was dried at room temperature in a laboratory environment. The dried plant samples were dried at 60 0C for 24 hours to remove moisture. These dried samples were burned in porcelain crucibles in a muffle furnace starting from 50 ^{0}C to 550 ^{0}C for 10 hours in a flameless environment. The ash samples were mixed with 5 ml of concentrated HCl and completed to 25 ml with deionised water (Demir & Özdemir, 2013). Soil samples were prepared for analysis considering the method suggested by Brooks et al. (1992) and Dunn (2007) (Baba, 2022)..

Soil samples from the region were collected by passing through a plastic sieve with a 2 mm aperture

(Kırat and Aydın, 2016a). After drying in an oven at 80 0C, these samples were passed through a -80 mesh sieve to obtain 0.1 g and placed in polyethylene containers (6 pieces) (Figure 4). These samples were evaporated after adding 10 ml of concentrated HF+HNO3 (1:1) mixture and 7 ml of concentrated HCl was added to these samples and evaporated again. The residual material obtained was dissolved in 7 ml of concentrated HCl and then immediately added to 25 ml of deionised water (Demir and Özdemir, 2013; Baba, 2022).

Figure 4. Tomato and soil samples from the study area.

RESULTS and DISCUSSION

In this study, the results of the analysis were statistically evaluated (minimum, maximum, standard deviation, mean, median, mode, skewness and Kurtosis) using SPSS 15.0 for Windows (Table 1).

The maximum limits for heavy metals in soil and plants as specified by the Food and Agriculture Organization (FAO), the World Health Organization (WHO) and the US Environmental Protection Agency (US EPA) are shown in Table 1 (Ediene and Umoetok, 2017; Onyedikachi et al., 2018; Özkan, 2017; Kul et al., 2021).

Seven tomato plants collected from the study area were analysed for elements by ICP-MS and F by IC. The statistical values of the analyzed elements were calculated in ppm. It was observed that the mean values of Mg, Mn, Co, Cu, Zn, Mo, Sn, Sb and Pb were greater than the standard deviation values. The fact that the mean and median values are close to each other shows that there is a normal distribution in the data. It is also observed that the median and mean values are greater than the mode value.

Kurtosis values between -2 and +2 indicate that there is a normal distribution among the variables (Eraslan et al., 2017). The Skewness values are between -1 and +3, while Kurtosis values are between -1 and +7. These values indicated that the Skewness and Kurtosis values have a non-normal distribution. Since the mean values are slightly larger than the median values, there is a positive Skewness (Table 2).

Accumulation of heavy metals in plants occurs when heavy metals in soil and water are transferred to plants during irrigation. In addition, heavy metals in the air can be transferred to the plant by dust particles and heavy metals can accumulate in the plant. The accumulation of heavy metals in soils prevents the uptake of nutrients needed by plants (Mengoni, et al., 2000; Jayakumar et al., 2007; Yerli et al., 2020).

Metal concentrations in plants vary between plant species. The transfer of heavy metals from soil to plants occurs either through the water they are supplied with or through transport across the plasma membrane of the root epidermal cell (Kirat & Aydin, 2015). Soil pollution, particularly from land use, is a major environmental problem in both developed and developing countries (Chen et al., 2009). Heavy metals are particularly important because they are toxic, carcinogenic and persistent in the environment (Kirat, 2020b).

Unlike organic pollutants, heavy metals are insoluble and non-degradable. Elements such as iron, cadmium, cobalt, lead, magnesium, nickel, tin, copper, zinc, chromium, silver and manganese, which are positively charged (cationic) in nature, and arsenic, molybdenum and fluorine, which are negatively charged (anionic) compounds, cause soil contamination (USDA 2000; Deniz Çiftçi, 2018).

Soils contaminated with heavy metals pose a risk to both for human health and the ecosystem, which has led to an increase in research on this issue in recent years (Asrari, 2014). As is found in the soil together with organic matter and enters into water and plants through the oxidation of these substances (Deniz Çiftçi, 2018). Cu is absorbed by, clays, oxides, carbonates and organic matter (Pendias, 2001; Kalender et al., 2009). Pb forms soluble complex ions with sulphates, bicarbonates and carbonates (Sposito, 1989). Zn is absorbed by organic matter, clay minerals and oxides (Kalender et al., 2009) or can be displaced by ion exchange (Wilson et al., 2008; Kirat & Aydin, 2016b).

The transfer from soil to plants varies with plant species, soil composition and the amount of acidity. Fe and Al oxides in soil adsorb and retain ionic As compounds in acid and neutral soils. As speciation in terrestrial plants showed that inorganic As species were more abundant (Ruiz-Chancho et al., 2008). In a study on tomato plants, it was determined that organic As species (Monomethyl arsonic acid (MMA) and dimethyl arsonic acid (DMA)) rather than inorganic As species were found to be transferred from soil to the plant and it was observed that plant growth slowed down and fruit yield decreased with the passage of these organic As species (Burló et al. 1999; Deniz Çiftçi, 2018).

While plants take up certain metals they need, some plants absorb many metals (Mganga et al., 2011). As they constantly accumulate elements in their bodies, plants either die or undergo physiological and morphological changes (Kirat, 2017).

Table 1. Maximum heavy metal limit values determined by WHO/FAO and US EPA (ppm) (Kul et al., 2021; Baba, 2022).

	WHO (ppm)		WHO (ppm)	US EPA (ppm)
Elements	**Edible plant**	**Plant**	**Soil**	
Mg	-	-	-	-
Cr	-	0.5	-	400
Mn	2	-	0.2	-
Fe	20	30	-	-
Co	-	-	-	-
Ni	-	5	5	-
Cu	3	5	12	200
Zn	47.4	50	60	300
Cd	0.21	0.5	0.5	400
Pb	0.43	2	10	300

Cr is a toxic element for plants and enters the plant body together with transporters during the uptake of other elements required for plant metabolism (Yıldız et al., 2011). In Table 1, the WHO value of 0.5 ppm for Cr in plants was found to be equal to and higher than the WHO values in plant root samples at sites T1, T3, T4 and T6. Soil levels were higher than those recommended by the WHO (0.2 ppm) and lower than those recommended by US EPA (400 ppm) (Table 2 - Table 4) (Baba, 2022).

Significant amounts of Cd pollution occur with the widespread use of phosphate fertilisers (Kırat, 2023), coal, flue gases from industrial production, refined petroleum derivatives and detergents (Kahvecioğlu et al., 2003; Okcu et al., 2009; Kul et al., 2021). Cd is not essential for plant growth (Allen, 1989). However, it is easily transported between plant organs. It can have high levels in the roots and leafs of the plant. The Cd value of plants growing in areas not affected by pollution is in the range of 0.01-0.3 ppm (Allen, 1989; Özmen & Koç, 2006). Table 1 shows that the WHO Cd level of 0.21 ppm in edible plants is low in plant roots and tomato samples. The soil values are lower than the values recommended by WHO (0.2 ppm) and US EPA (400 ppm) (Table 2 - Table 4) (Baba, 2022).

The element Mn is necessary for plants. The value of Mn in dry matter in the above-ground organs of the plant is in the range of 15- 25 ppm (Topbaş et al., 1998). When the Mn values obtained from the literature given in Table 1 and the Mn values obtained in this study were examined to determine the contamination, it was found that the Mn element in the edible plant (2 ppm by WHO in the literature) was higher than the normal value (8.78- 13.91 ppm) in the roots of the plant, while the highest Mn element in the soil in the region (not specified by WHO and US EPA in the literature) was 95.37 ppm. When the Mn element in the soil is compared with the literature (20-800 ppm), it is found that the soil in the region is not polluted in terms of Mn and is at normal values (Table 2 - Table 4) (Baba, 2022).

Since Pb has toxic properties in plants, it is not a factor for plant growth (Jones & Belling, 1967). Considering the Pb values obtained from the literature and this study given in Table 1, the Pb element in the edible plant (0.43 ppm by WHO in the literature) was found to be higher than the normal value in the roots of the plant (at sites K5 and K6). When the Pb element in the soil is compared with the literature (300 ppm by US EPA), it can be said that the soil in the region is not polluted with Pb (Table 2 - Table 4) (Baba, 2022).

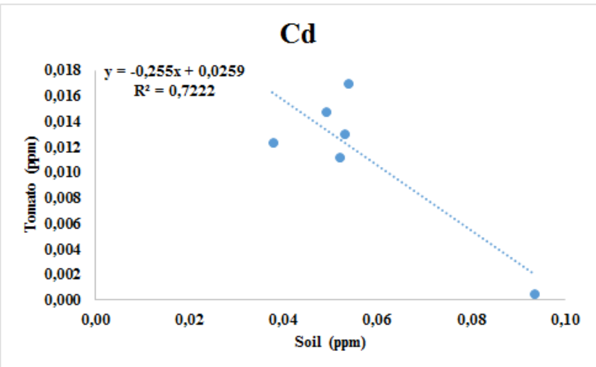
Cu and Zn are essential elements for plant growth and development (Kirat, 2020a). They are elements that can cause toxicity in humans, agricultural products and aquatic organisms even at low levels. Excessive levels of Cu, Zn, Cd, Ni and Pb elements cause toxic effects in plants (Okcu et al., 2009; Kul et al., 2021). Considering the Cu values obtained from the literature and this study given in Table 1, the Cu element in edible plant (3 ppm by WHO in the literature) was found to be higher than the normal value in the roots of the plant at all sites. When the Cu element in the soil is compared with the literature (200 ppm by USEPA), it can be said that the soil in the region is not polluted in terms of Cu (Table 2 - Table 4) (Baba, 2022).

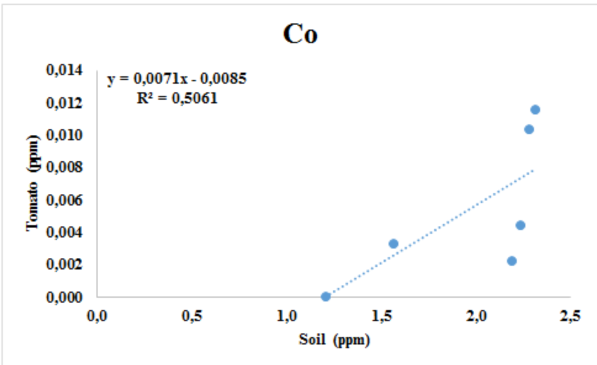
Table 2. Statistical analysis results of tomato samples taken from Akçakent region (Mg, Mn and Fe values %; other element values ppm) (Baba, 2022).

Elements	Samples	Minimum	Maximum	Std. Deviation	Mean	Median	Mode	Skewness	Kurtosis
Mg	7	1.300	78.4	27.9	**42.2**	**38.7**	1.3	-0.1	-0.9
Cr	7	0.000	0.60	0.20	0.19	0.10	0.10	1.97	4.51
Mn	7	0.000	0.60	0.22	**0.29**	0.20	0.20	0.25	-1.37
Fe	7	0.100	9.30	3.10	2.53	**1.40**	0.10	2.27	5.52
Co	7	0.000	0.01	0.00	**0.01**	0.00	0.00	0.86	-0.55
Ni	7	0.001	0.30	0.09	0.10	0.08	0.08	1.94	4.98
Cu	7	0.010	0.60	0.22	**0.29**	0.20	0.20	0.29	-1.37
Zn	7	0.030	1.50	0.53	**0.90**	**1.00**	0.03	-0.61	-0.52
As	1	0.000	0.00	*	0.00	0.00	0.00	*	*
Mo	7	0.000	0.13	0.04	**0.06**	0.06	0.00	0.48	0.76
Ag	5	0.000	0.00	0.00	0.00	0.00	0.00	0.00	2.00
Cd	7	0.001	0.02	0.01	0.01	0.01	0.00	-0.88	-0.15
Sn	7	0.200	26.60	8.00	**9.94**	**8.40**	0.20	1.67	4.39
Sb	7	0.002	0.11	0.04	**0.06**	**0.08**	0.00	-0.74	-1.29
Pb	7	0.002	0.15	0.05	**0.08**	0.10	0.11	-0.71	-0.81
F	7	0.003	6.90	2.51	1.22	**0.27**	0.00	2.63	6.92

(*values could not be calculated since they were below the detection limit).

When we look at the elemental correlation between the tomato of the studied plant and the soil on which this plant grows, it is observed that Cu, Co, Mg, Fe, Cd, Ni and Pb elements are highly correlated, i.e. Cu, Co, Mg, Fe, Cd, Ni and Pb are transferred from the soil to the tomato plant (Figure 5) (Baba, 2022).





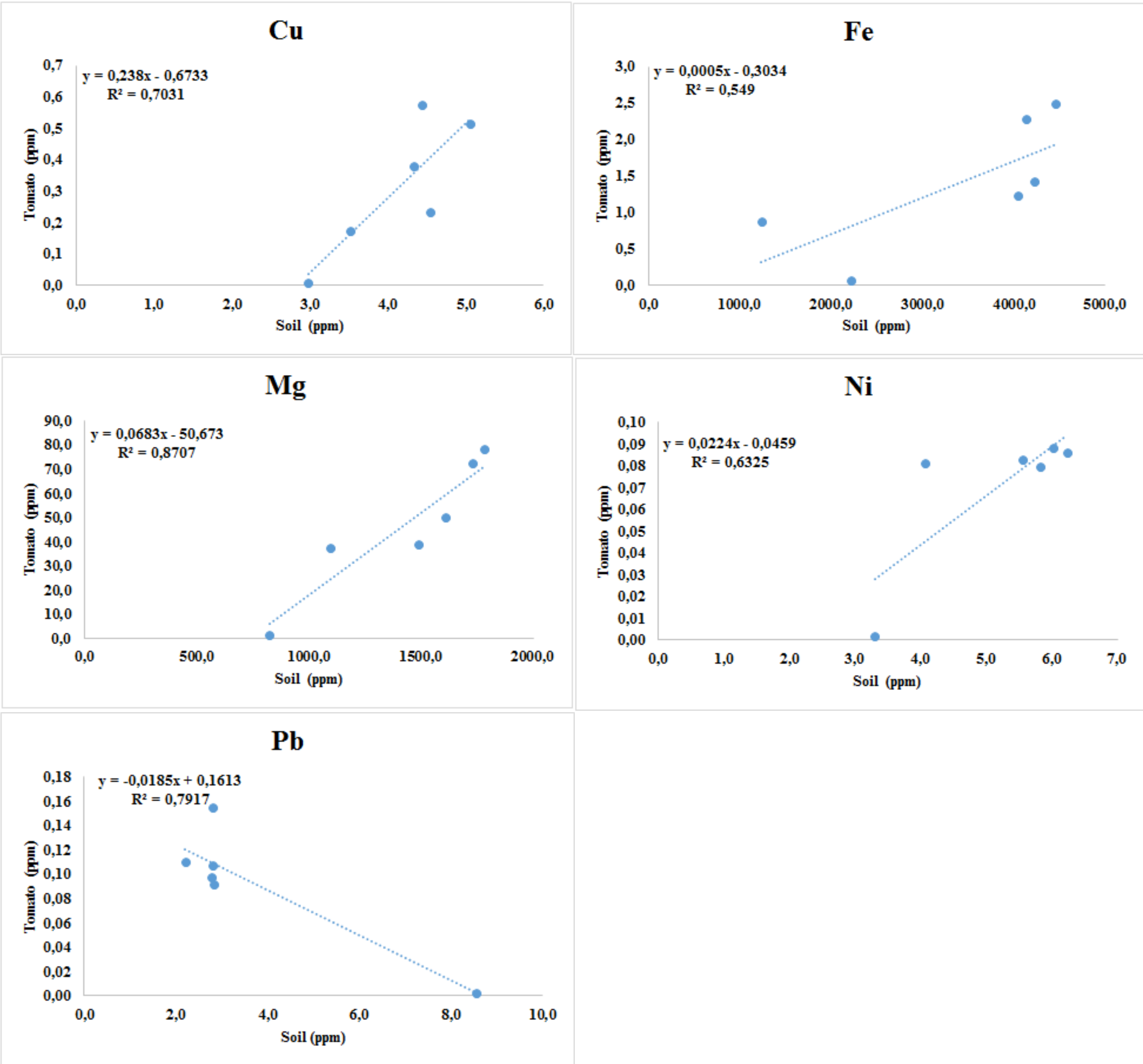


Figure 5. Element correlations between tomato and soil (Baba, 2022).

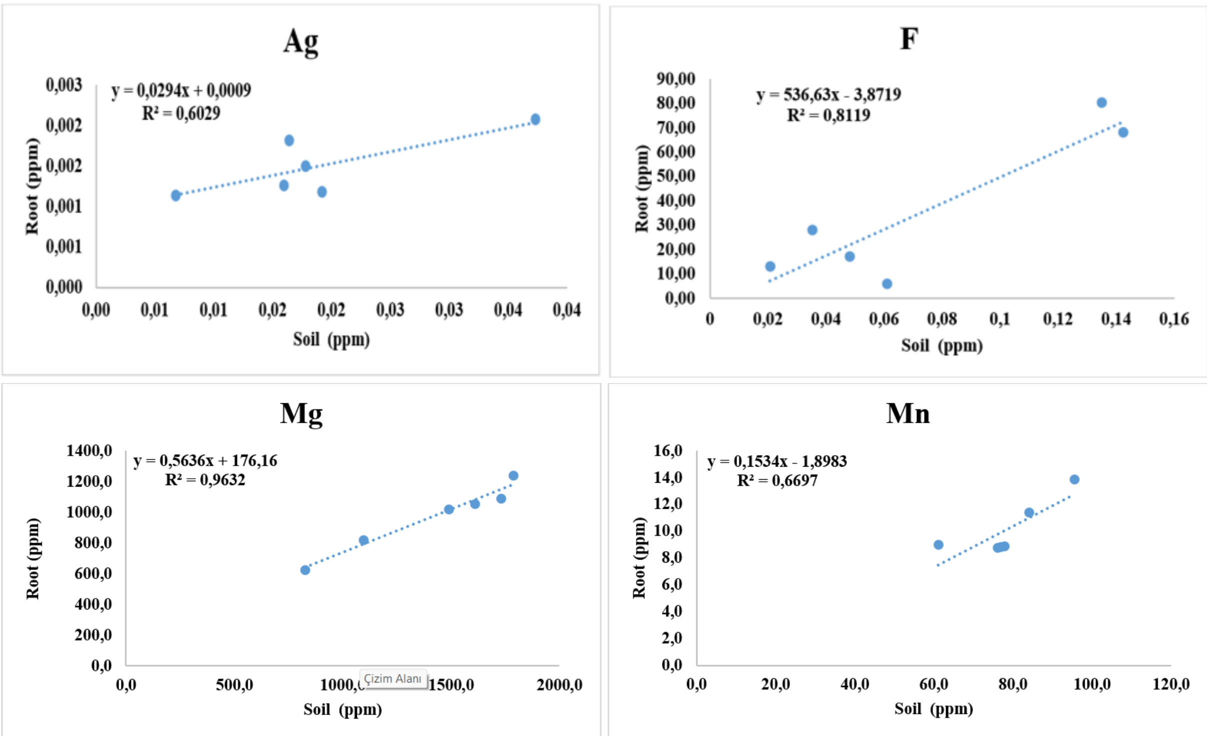
It was observed that the mean values of the elements studied in plant roots were greater than the standard deviation values. The fact that mean and median values are close to each other shows that there is a normal distribution in the data. In addition, the median and mean values are greater than the mode value. The Skewness values are between -1 and +2 while the Kurtosis values are between -1 and +3. These values show that the Skewness and the Kurtosis values have a distribution close to normal (Table 3) (Baba, 2022).

Looking at the Zn values obtained from the literature and this study given in Table 1, it was found that the Zn element in the edible plant (47.4 ppm by WHO in the literature) was lower than the normal value in the roots of the plant at all sites. When the Zn element in the soil is compared with the literature (300 ppm by US EPA), it can be said that the soil in the region is not polluted in terms of Zn (Table 2 - Table 4) (Baba, 2022).

Table 3. Statistical analysis results of root samples taken from the study area (Mg, Mn and Fe values %; other element values ppm) (Baba, 2022).

Elements	Samples	Minimum	Maximum	Std. Deviation	Mean	Median	Mode	Skewness	Kurtosis
Mg	6	625.2	1242.9	219.3	**977.2**	1040.2	625.2	-0.8	0.1
Cr	6	0.30	0.90	0.22	**0.55**	0.50	0.50	0.79	0.07
Mn	6	8.80	13.90	2.09	**10.15**	8.95	8.90	1.53	1.42
Fe	6	100.6	347.9	87.9	**195.4**	173.5	100.6	1.1	1.2
Co	6	0.10	0.40	0.10	**0.22**	0.20	0.20	1.44	3.60
Ni	6	0.30	1.30	0.33	**0.75**	0.75	0.80	0.62	1.88
Cu	6	3.20	3.60	0.15	**3.38**	3.35	3.30	0.42	-0.86
Zn	6	6.0	19.3	5.4	**12.4**	12.9	6.0	-0.1	-1.8
As	6	0.20	0.50	0.11	**0.30**	0.30	0.30	1.37	2.50
Mo	6	0.20	0.50	0.10	**0.33**	0.30	0.30	0.67	0.59
Ag	6	0.00	0.00	0.00	0.00	0.00	0.00	-0.31	-0.10
Cd	6	0.04	0.16	0.04	**0.08**	0.08	0.04	1.13	1.08
Sn	6	6.40	9.80	1.31	**8.60**	9.05	6.40	-1.13	0.30
Sb	6	0.06	0.12	0.02	**0.09**	0.08	0.07	0.63	-0.75
Pb	6	0.14	0.61	0.19	**0.31**	0.24	0.18	0.96	-0.43
F	6	6.3	80.5	31.0	**35.7**	22.9	6.3	0.8	-1.5

When the elemental correlation between the root of the tomato plant and the soil on which this plant grows was examined, it was observed that the elements Ag, F, Mg, Mn, Ni, Pb and Sn passed from the soil to the root of the plant, which showed high correlation (Figure 6) (Baba, 2022).



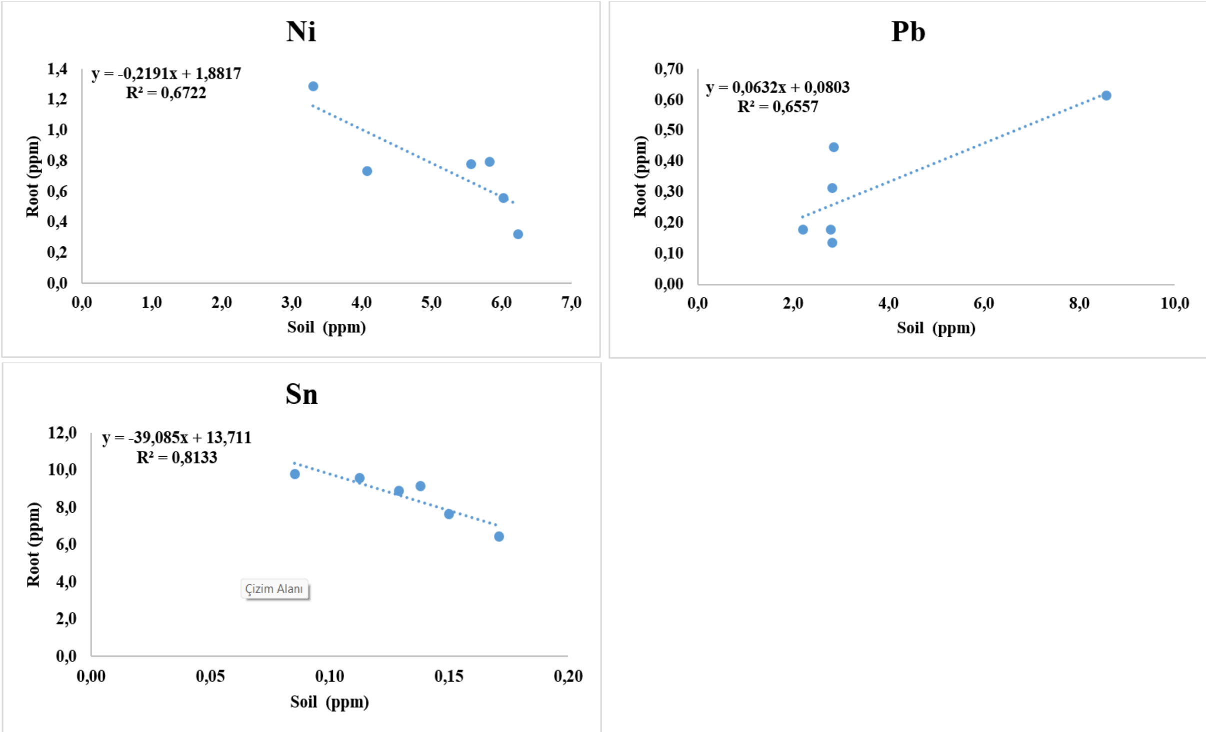


Figure 6. Element correlations between tomato root and soil (Baba, 2022).

It was observed that the mean values of the elements analysed in the soil samples were greater than the standard deviation values. The fact that the mean and median values are approximately similar indicates a normal distribution. It is also observed that the mode values are smaller than the median and mean values. The skewness values range between -1 and +3 while the Kurtosis values range between -1 and +6. These values show that the Skewness and Kurtosis values have a non-normal distribution (Table 4) (Baba, 2022).

As, Cd, Cr, Ni and Pb are the most abundant heavy metals in soils (Wuana and Okieimen, 2011). Heavy metals, which contaminates soils in different ways accumulate in the soil and cause heavy metal pollution. Soil texture, soil water content, organic carbon, soil temperature, clays, phosphorus, bicarbonates and carbonate cause the movement of heavy metals in the soil. Clay soils can adsorb heavy metals because they have high cation exchange properties. Furthermore, due to their high cation exchange properties, heavy metals accumulate in soils rich in organic matter and cause toxicity in plants (Montiel-Rozas et al., 2016). Since heavy metals are strongly bound to clays and organic matter, the accumulation of heavy metals in soil is higher especially in the upper part of soils (Yerli et al., 2020) (Baba, 2022).

Fluorine in soil is associated with micas and other clay minerals (Tylenda, 2011). While the F content of soils generally varies between 150-400 ppb, this value can reach up to 1000 ppm in clay soils (Chatterjee et al., 2020). The lowest F value in the soil samples in the study area is 0.02, the highest is 0.14 and the average is 0.07 ppm (Baba, 2022).

Table 4. Statistical analysis results of soil samples from the study area (Mg, Mn and Fe values %; other element values ppm) (Baba, 2022).

Elements	Samples	Minimum	Maximum	Std. Deviation	Mean	Median	Mode	Skewness	Kurtosis
Mg	6	824.9	1784.6	381.8	**1421.3**	1548.5	824.9	-0.9	-0.8
Cr	6	4.6	14.3	3.8	**11.5**	13.3	4.6	-1.6	1.8
Mn	6	61.2	95.4	11.2	**78.6**	77.4	61.2	-0.1	1.5
Fe	6	1237.8	4458.2	1329.3	**3387.7**	4089.5	1237.8	-1.1	-0.5
Co	6	1.20	2.30	0.46	**1.97**	2.20	2.20	-1.24	-0.03
Ni	6	3.30	6.20	1.18	**5.17**	5.70	3.30	-1.04	-0.76
Cu	6	3.00	5.10	0.77	**4.17**	4.40	3.00	-0.62	-0.67
Zn	6	8.1	20.4	4.3	**12.0**	10.7	10.7	2.0	4.6
As	6	1.70	3.60	0.74	**2.57**	2.80	2.80	-0.12	-0.92
Mo	6	0.07	0.26	0.07	**0.12**	0.10	0.10	2.27	5.42
Ag	6	0.00	0.04	0.01	**0.02**	0.02	0.02	0.44	1.33
Cd	6	0.04	0.10	0.03	**0.06**	0.05	0.05	0.93	-1.43
Sn	6	0.09	0.17	0.03	**0.12**	0.12	0.09	0.64	-0.30
Sb	6	0.36	0.48	0.04	**0.41**	0.40	0.40	1.36	3.13
Pb	6	2.20	8.60	2.43	**3.67**	2.80	2.80	2.39	5.81
F	6	0.02	0.14	0.05	**0.07**	0.05	0.02	0.70	-1.80

Spearman correlation coefficients were calculated to compare the elements analysed. These coefficients range between -1 and +1. If this correlation coefficient value is +1, it can be said that there is a positive linear relationship between the elements compared, if this value is -1, it can be said that there is a perfect linear relationship between the elements in the negative direction. If this coefficient value is 0 (zero), it can be said that there is no linear relationship between the elements (Baba, 2022).

While a very high positive correlation is observed between Fe-As, Fe-Co-As, Mo-Pb, Cu-As; Cr-Cu, , Fe-Co, Mn-Sb, Fe-Sb, Zn-Mo, Co-As, Zn-Pb, Cr-Ni, Mg-Cu, Cr-As, Fe-Cu, Mn-Zn, Co-Sb, Mo-Ag, Ni-Cu, Mo-Cd, Ag-Pb, Cd-Pb Ag-Sn high; Mg-Ni, Mg-Cr, Cr-Fe, Mn-Fe, Cr-Co, Mn-Mo, Mn-Pb, Mn-Ag, Fe-Ni, Zn-Ag, Co-Ni, Zn-Cd, Pb-Sn, Mo-Sn medium; Cr-Zn, Mn-Mg, Mn-Co, Mn-Sn, Mn-As, Fe-Sn, Ag-Sb, Cd-Sb, Zn-Sn weak; Cr-Mn, Mg-F, Mn-Cu, Fe-Cd, Fe-Zn, Cd-Sn, Co-Sn, very weak correlation is observed. Weak between Zn-F, Mn-F intermediate between Sb-F, Cd-F, Ag-F high between Sn-F and very high negative correlation is observed between Pb-F, Mo-F (Table 5) (Baba, 2022).

Table 5. Spearman correlation coefficient values between the analyzed elements (Mg, Mn and Fe values in %; other element values in ppm) (Baba, 2022).

	Mg	Cr	Mn	Fe	Co	Ni	Cu	Zn	As	Mo	Ag	Cd	Sn	Sb	Pb	F
Mg	1															
Cr	,543	1														
Mn	,429	,200	1													
Fe	**,943(**)**	,600	,657	1												
Co	**,971(**)**	,559	,353	,912(*)	1											
Ni	,600	,800	-,200	,500	,667	1										
Cu	,771	,886(*)	,200	,714	,736	,700	1									
Zn	-,058	,319	,754	,232	-,149	-,300	,116	1								
As	**,926(**)**	,802	,463	**,926(**)**	,890(*)	,632	**,926(**)**	,188	1							
Mo	-,169	,169	,676	,169	-,174	-,224	-,169	,857(*)	,000	1						
Ag	-,213	,030	,577	,030	-,125	-,224	-,213	,616	-,098	,718	1					
Cd	-,030	,213	,395	,213	-,125	-,224	-,030	,616	,098	,718	,032	1				
Sn	,086	,143	,486	,314	,235	,200	-,143	,319	,093	,676	,759	,213	1			
Sb	,754	Cr-Sb,	,899(*)	,899(*)	,702	,100	,406	,456	,705	,429	,308	,308	,464	1		
Pb	-,169	,169	,676	,169	-,174	-,224	-,169	,857(*)	,000	**1,0(**)**	,718	,718	,676	,429	1	
F	,200	,086	-,429	-,086	,147	,100	,429	-,464	,185	**-,845(*)**	-,516	-,698	-,771	-,319	**-,845(*)**	1

CONCLUSION

The Fluorine is present the Earth's crust at 0.03%. Fluorspar, fluorapatite, cryolite, mica, tourmaline and hornbled are minerals rich in fluoride. Fluorite, sirolite and fluor apatite found in volcanic rocks, mica minerals cause high amounts of fluoride in natural waters.

It was observed that the elemental values of Cd, Cu, Mn, Pb, Zn and F in tomato plants grown in Akçakent Yeniyapan village and the roots of this plant were lower than the literature data.

According to the analysis results, the distribution of F element varies in different locations of the study area varies. This indicates the presence of mineralisations with different characteristics in the study area. More detailed investigations should be carried out to determine the mineralisations in the region.

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Conflict of interest

There is no conflict of interest among the authors.

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