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Change of mineral element contents in the common shrubs of Mediterranean climatic zone: Non-nutrients

Akdeniz iklim kuşağının yaygın çalılarında mineral element içeriklerinin değişimi: Diğer elementler

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ABSTRACT

Mediterranean shrubs try to keep up their forage value year-round with their deep root penetrations and ever-green futures. Therefore, shrubs can serve a good source of nutrient for goats and may meet nutritional needs of goats. However, beside the nutrients, there are several other beneficial or harmful minerals in plants. This research was carried out in Marmara region of Turkey to investigate the amounts and variations of these kinds of elements. Variations of non-nutrient contents of shrubs and relevance with goats were evaluated. Experiments were carried out over two shrubby rangelands of Çanakkale province between the dates October 2006 and November 2007. Se, Co, Ni, Cr, Cd and Pb contents of kermes oak, mock privet, prickly juniper, gall oak, Christ's-thorn, pink rockrose, thyme and prickly burnet shrubs were determined. Annual variations of most of the minerals were found to be significant but irregular. Irregularity in variations was due to the fact that these elements are not essential for plants and present at trace amounts. Se contents of shrubs varied between 0.02-0.45, Co between 0.01-46, Ni 1.70-5.54, Cr 1.35-2.29, Cd 0.01-0.15 and Pb 0.72-1.93 mg kg^{-1}. None of these elements were found to be insufficient or redundant to create a problem either for plants or animals.

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ÖZ

Akdeniz kuşağı çalıları derin kökleri ve genelde herdem yeşil yapıları ile yem değerlerini yıl boyu korumaya çalışırlar. Bu durum keçilerin besin elementi ihtiyaçlarının büyük bir bölümünü buralardan karşılamalarına yardımcı olur. Ancak bitkilerde besin elementleri dışında yararlı ya da zararlı olabilen birçok mineral de bulunmaktadır. Bu tür elementlerin çalılardaki miktarları veya değişimleri konusunda Türkiye'nin Marmara ve Ege bölgelerinde araştırma yapılmamıştır. Bu nedenle bu araştırmada besin elementi olmayan minerallerin çalılardaki değişimi incelenmiş ve bunların keçilerle ilişkileri ortaya konmuştur. Deneme Ekim 2006 - Kasım 2007 tarihleri arasında Çanakkale'nin iki ayrı çalılı alanında yürütülmüştür. Araştırmada kermes meşesi, akçakesme, katran ardıcı, mazı meşesi, karaçalı, yapraklı laden, kekik ve abdestbozan çalılarının Se, Co, Ni, Cr, Cd ve Pb miktarları belirlenmiştir. İncelenen çalılardaki çoğu mineralin yıl boyu değişimi önemli, ancak düzensiz olmuştur. Bu düzensizlik genelde bu elementlerin bitkiler için mutlak gerekli olmadıklarından ve eser miktarlarda bulunmalarından ileri gelmiştir. Çalıların ortalama Se miktarları 0.02-0.45, Co 0.01-46, Ni 1.70-5.54, Cr 1.35-2.29, Cd 0.01-0.15 ve Pb 0.72-1.93 mg kg^{-1} arasında değişmiştir. Bu elementlerin hiçbiri gerek bitkiler gerekse hayvanlar için eksiklik veya fazlalık olarak herhangi bir sorun yaratacak düzeyde olmamıştır.

1. Introduction

Maquis lands of Mediterranean zone covering large areas in Turkey are good source of forage for goats. Evergreen shrubs are the most preferred species by goats as a nutrient source especially during the winter, end of spring and summer when the herbaceous species dry and lose the nutritive value (Perevolotsky et al. 1998; Rogosic 2000; Papachristou et al. 2003; Tolunay et al. 2009; Özaslan Parlak et al. 2011a). Goat can adapt severe conditions (Silanikove 2000) and meet almost

all of nutrient needs from shrublands where they grazed.

Plants and animals need nutrients for growth and development. Beside nutrients, there are some other non-nutrient elements beneficial for plants and animals at very low concentrations. There are also some heavy metals like Cd and Pb taken up from soil. These minerals pass to animals feed by plants. Heavy metals may have harmful impacts on plants and animals at concentrations above certain limits.

Concentrations of harmful or beneficial elements for plants and animals may vary significantly with regard to plant growth periods, plant, soil and climate conditions (Whitehead 2000). Serious variations occur especially with growth and maturation (Leano 1986; Bakoğlu et al. 1999; Ramirez-Orduna et al. 2005).

While Se, Co and Ni have positive impacts on physiological activities of some plants at low concentrations, they may have harmful or negative effects at high concentrations. Cr may have both plant growth stimulating effect and toxic effect. Se, Co, Cr and Ni are among the beneficial elements for animals at low concentrations. Cd and Pb have negative impacts both on plants and animals (Aydemir and İnce 1988; Whitehead 2000; Suttle 2010). However, trace amounts of Pb is required for animals (Kirchgessner 1985). In this study, variations in Se, Co, Ni, Cd, Cr and Pb like non-nutrient elements contents of different shrubs from Mediterranean were investigated.

2. Materials and Methods

The initial part of this research concerning about macro-nutrients was previously published (Gökkuş et al. 2011), the other part concerning about micro-nutrients was prepared for publication. Investigation of other non-nutrient mineral contents and evaluation with regard to needs of goat constitute the topics of current paper. Therefore, material and methods section of this paper was presented briefly.

The research was carried out over shrubby rangelands of Biga Ağaköy (ungrazed site) 85 km from Çanakkale Centrum and shrubby rangelands of Çıplak Village (grazed site) 30 km from Çanakkale between the dates October 2006 – November 2007.

Monthly average temperatures in both research sites during the research period were generally higher than the long-term averages. While there was severe precipitation in Ağaköy during the first month of the study, winter, spring and summer precipitation was lower than long-term averages. October, November and December 2007 precipitation was higher than long-term averages. In Çıplak village, total precipitations during the months of March, May, October and November 2007 were higher than long-term averages, and precipitations in other months were lower than averages. Soils of both rangelands are sandy-loamy, neutral, nonsaline with high organic material content, sufficient available P and sparse K content.

Since research sites are located within Mediterranean climate zone, zone-specific plant cover is dominant over the sites. Because Ağaköy rangelands are under exclosure for long time and have deeper soils, the site has dominant dense and high herbaceous vegetation cover. With regard to shrubs, generally deciduous gall oak and Christ's-thorn are dominant. Çıplak rangeland has shallow soils and is heavily grazed. Therefore, short annual plant cover is dominant over the site. Kermes oak, prickly juniper, prickly burnet and thyme shrubs, more resistant to grazing, among the shrub species, are dominant in Çıplak rangelands (Özaslan Parlak et al. 2011b). Therefore, evergreen shrubs of kermes oak (*Quercus coccifera* L.), mock privet (*Phillyrea latifolia* L.), prickly juniper (*Juniperusoxycedrus* L.), pink rockrose (*Cistus creticus* L.), thyme (*Thymus longicaulis* C. Presl.) and prickly burnet (*Sarcopoterium spinosum* (L.) and deciduous shrubs of gall oak (*Quercus infectoria* Oliv.) and Christ's-thorn (*Paliurus spina-cristi* Miller) were used as the plant material of this study.

Ağaköy rangeland is surrounded and preserved with fences. Çıplak rangeland is continuously and heavily grazed. Two plots of 20x50 m size were surrounded in grazed rangeland to prevent the grazing and to observe the normal growth of plants.

During the research period, plant samples were taken from the shrubs in the middle of each month. Leafy young (annual) shoots, grazable by animals, were cut at 10 cm size and collected. Ten samples were randomly taken from each shrub type. For defoliating shrubs, samples were not taken during the period from defoliation in fall to leaf-turn in spring.

Se, Co, Ni, Cd, Cr and Pb contents of samples were determined by using ICP-AES (Inductively Coupled Plasma Atomic Emission Spectrometer, "Varian- Vista", USA) device.

Se analyses are not realized by using ICP-AES (Inductively Coupled Plasma Atomic Emission Spectrometer, "Varian-Vista", USA) device. It necessitates that ICP-AES has hydrur system. Because the results of Se are confusing, the determination of Se has to be done with a more clear method.

Evaluation of results: Data were evaluated by SPSS statistical software according to repeatable measurement method (Winer et al. 1991). Duncan test was used to compare the means.

3. Results

Annual change of Se content was not found to be significant for shrubs except for mock privet. Variations of Co contents were found to be significant in kermes oak, mock privet and pink rockrose and were not significant in other shrubs. Variations in Ni contents during growth periods were significant in all shrubs. Significant variations of Cd contents were observed in only mock privet, pink rockrose and prickly burnet. Variations in Cr contents were found to be significant for all shrubs except for Christ's-thorn. Also, variations were significant in Pb contents of all shrubs.

For kermes oak, Se, Co, Cd and Pb ratios were below 1 mg kg^{-1}. Cr was high in winter and at the beginning of spring and lower values were observed in other months. Highest Ni levels (3.38 mg kg^{-1}) were seen in December 2006 and April 2007 (Table 1).

For mock privet, relevant minerals were observed at trace amounts. Generally, while increasing Se contents were observed at the end of summer and during fall seasons, highest values (2.73 mg kg^{-1}) for Ni was seen in November 2007, for Cr (1.81 mg kg^{-1}) in March 2007 and for Cd (0.15 mg kg^{-1}) in October 2007. Higher Pb rates were found between December 2006 and April 2007 (1.14-1.47 mg kg^{-1}) (Table 2).

For prickly juniper, Se, Co and Cd were observed at trace amounts (0.01-0.02 mg kg^{-1}). Cr significantly increased in January and the variations in other months were not significant. While the highest levels of Ni was observed in December, January and May, low levels were seen in other months. Pb was highest (1.87 mg kg^{-1}) in February (Table 3).

For gall oak, Ni, Cr and Pb were at low levels at the

beginning of growth (April, May), slight increases were observed in other months. Ni and Pb sustained their low levels during summer months (Table 4).

In Christ's-thorn, higher Ni contents were observed at the beginning of growth and higher Pb contents at the end of growth. Se, Co, Cd and Pb were at trace amounts (below 1 mg kg^{-1}) (Table 5).

For pink rockrose, Co content was low in fall and winter months of the year 2006 and high in spring, fall and winter months of the year 2007. Ni, Cd and Pb increased especially at the beginning of growth (spring). While the highest Cr was observed in January 2007, variations of Cr contents in other

Table 1. Amounts (mean ±SE) of non-nutrients of kermes oak (mg kg^{-1} DM) (n = 10)*.

Çizelge 1. Kermes meşesindeki diğer elementlerim miktarı (mg kg^{-1} DM) (n = 10)*, (ortalama ±SE).

Months	Se	Co	Ni	Cr	Cd	Pb
Oct. 06	0.07±0.07	0.06±0.04 cd	1.49±0.08 de	1.94±0.08 a	0.03±0.00	0.99±0.13 def
Nov. 06	0.11±0.05	0.35±0.38 a	1.66±0.09 cde	1.96±0.21 a	0.04±0.00	1.64±0.31 a
Dec. 06	0.15±0.07	0.08±0.04 cd	3.38±0.34 a	2.11±0.08 a	0.07±0.00	1.58±0.23 ab
Jan. 07	0.17±0.11	0.13±0.06 bcd	2.40±0.17 bc	1.90±0.13 a	0.05±0.00	1.11±0.05 cde
Feb. 07	0.09±0.05	0.08±0.06 cd	1.90±0.37 cde	1.55±0.04 bc	0.05±0.00	1.20±0.10 bcd
Mar. 07	0.05±0.03	0.25±0.01 ab	2.31±0.20 bc	1.82±0.04 ab	0.06±0.00	1.48±0.16 abc
Apr. 07	0.16±0.07	0.21±0.10 abc	3.38±0.39 a	1.39±0.07 c	0.05±0.00	0.74±0.08 efg
May 07	0.27±0.22	0.15±0.06 bcd	2.12±0.12 b-e	1.53±0.12 bc	0.04±0.01	0.66±0.08 fg
Jun. 07	0.15±0.08	0.09±0.05 bcd	1.42±0.15 e	1.35±0.07 c	0.02±0.00	0.45±0.06 g
July 07	0.18±0.10	0.07±0.03 cd	1.91±0.30 cde	1.36±0.16 c	0.02±0.00	0.51±0.05 g
Aug. 07	0.00±0.00	0.00±0.00 d	1.97±0.14 cde	1.52±0.05 bc	0.02±0.00	0.59±0.06 fg
Sep. 07	0.06±0.05	0.00±0.00 d	2.23±0.35 bcd	1.22±0.08 c	0.04±0.00	0.50±0.11 g
Oct. 07	0.00±0.00	0.00±0.00 d	2.81±0.27 ab	1.20±0.08 c	0.05±0.01	0.63±0.07 fg
Nov. 07	0.11±0.06	0.04±0.03 d	2.88±0.24 ab	1.38±0.04 c	0.06±0.01	0.63±0.11 fg
Mean	0.11	0.11	2.28	1.59	0.04	0.91
Sign. (*P*)	0.806	0.000	0.000	0.000	0.060	0.000

* Within columns, the values with different letters are significantly different at p< 0.01.

Table 2. Amounts (mean ±SE) of non-nutrients of mock privet (mg kg^{-1} DM) (n = 10)*.

Çizelge 2. Akçakesme çalısındaki diğer elementlerin miktarı (mg kg^{-1} DM) (n = 10)* (ortalama ±SE).

Months	Se	Co	Ni	Cr	Cd	Pb
Oct. 06	0.00±0.00 b	0.00±0.00 b	1.01±0.11 f	1.42±0.12 bcd	0.00±0.00 b	0.90±0.21 bcd
Nov. 06	0.00±0.00 b	0.00±0.00 b	1.04±0.08 f	1.34±0.06 b-e	0.00±0.00 b	1.06±0.16 bc
Dec. 06	0.05±0.03 b	0.00±0.00 b	2.55±0.11 ab	1.33±0.10 b-e	0.00±0.00 b	1.19±0.23 ab
Jan. 07	0.03±0.03 b	0.00±0.00 b	1.07±0.17 ef	1.59±0.05 ab	0.01±0.01 b	1.17±0.13 ab
Feb. 07	0.07±0.05 b	0.00±0.00 b	0.98±0.25 f	1.46±0.03 bc	0.00±0.00 b	1.18±0.06 ab
Mar. 07	0.01±0.01 b	0.00±0.00 b	1.29±0.05 def	1.81±0.06 a	0.00±0.00 b	1.47±0.12 a
Apr. 07	0.09±0.05 b	0.00±0.00 b	1.56±0.27 c-f	1.31±0.04 cde	0.00±0.00 b	1.14±0.09 ab
May 07	0.01±0.00 b	0.01±0.00 b	1.62±0.15 c-f	1.16±0.06 de	0.00±0.00 b	0.52±0.11 d
Jun. 07	0.00±0.00 b	0.00±0.00 b	1.90±0.12 bcd	1.08±0.02 e	0.00±0.00 b	0.68±0.08 cd
July 07	0.35±0.14 a	0.20±0.08 ab	2.17±0.24 abc	1.10±0.08 e	0.02±0.00 b	0.51±0.07 d
Aug. 07	0.01±0.01 b	0.14±0.08 ab	1.85±0.19 b-e	1.09±0.08 e	0.04±0.00 b	0.65±0.04 d
Sep. 07	0.19±0.13 ab	0.19±0.11 ab	1.93±0.24 bcd	1.31±0.05 cde	0.06±0.00 b	0.69±0.01 cd
Oct. 07	0.22±0.10 ab	0.26±0.07 a	2.04±0.22 a-d	1.41±0.12 bcd	0.15±0.07 a	0.56±0.05 d
Nov. 07	0.21±0.05 ab	0.34±0.15 a	2.73±0.61 a	1.42±0.06 bcd	0.03±0.00 b	0.67±0.05 cd
Mean	0.09	0.08	1.70	1.35	0.02	0.89
Sign. (*P*)	0.004	0.001	0.000	0.000	0.000	

* Within the same column, the values with different letters are significantly different at p< 0.01.

Table 3. Amounts (mean ±SE) of non-nutrients of prickly juniper (mg kg^{-1} DM) (n = 10)*.

Çizelge 3. Katran ardıcı çalışındaki diğer elementlerin miktarı (mg kg^{-1} DM) (n = 10)* (ortalama ±SE).

Months	Se	Co	Ni	Cr	Cd	Pb
Oct. 06	0.02±0.02	0.00±0.00	3.78±0.40 ab	1.79±0.08 b	0.00±0.00	1.11±0.03 bcd
Nov. 06	0.00±0.00	0.00±0.00	3.11±0.36 bc	1.60±0.08 b	0.01±0.00	1.01±0.13 bcd
Dec. 06	0.00±0.00	0.00±0.00	4.60±0.85 a	1.58±0.14 b	0.01±0.00	1.29±0.18 bc
Jan. 07	0.03±0.01	0.09±0.00	4.75±0.33 a	3.12±1.13 a	0.00±0.00	1.37±0.17 b
Feb. 07	0.00±0.00	0.08±0.00	2.49±0.15 bc	1.49±0.10 b	0.04±0.03	1.87±0.21 a
Mar. 07	0.02±0.01	0.00±0.00	2.72±0.91 bc	1.41±0.10 b	0.01±0.01	1.20±0.16 bc
Apr. 07	0.00±0.00	0.00±0.00	2.08±0.68 cd	1.31±0.06 b	0.00±0.00	1.02±0.16 bcd
May 07	0.04±0.02	0.00±0.00	4.84±0.77 a	1.93±0.21 b	0.05±0.02	0.90±0.08 bcd
Jun. 07	0.05±0.02	0.00±0.00	0.96±0.11 de	1.74±1.44 b	0.01±0.01	0.88±0.10 cd
July 07	0.01±0.00	0.00±0.00	0.86±0.13 de	1.62±0.15 b	0.00±0.00	0.64±0.08 d
Aug. 07	0.04±0.04	0.00±0.00	0.61±0.01 de	1.38±0.01 b	0.00±0.08	0.98±0.13 bcd
Sep. 07	0.00±0.00	0.00±0.00	0.76±0.09 de	1.61±0.06 b	0.00±0.09	0.86±0.16 cd
Oct. 07	0.01±0.01	0.00±0.00	0.54±0.10 de	1.49±0.19 b	0.00±0.00	1.09±0.12 bcd
Nov. 07	0.00±0.00	0.00±0.00	0.46±0.09 e	1.25±0.09 b	0.00±0.00	0.85±0.12 cd
Mean	0.02	0.01	2.33	1.67	0.01	1.08
Sign. (*P*)	0.651	0.319	0.000	0.050	0.265	0.000

*Within the same column, the values with different letters are significantly different at p< 0.01.

Table 4. Amounts (mean ±SE) of non-nutrients of gall oak (mg kg^{-1} DM) (n = 10)*.

Çizelge 4. Mazı meşesindeki diğer elementlerin miktarı (mg kg^{-1} DM) (n = 10)* (ortalama ±SE).

Months	Se	Co	Ni	Cr	Cd	Pb
Oct. 06	0.47±0.10	0.09±0,04	2.48±0.27 d	2.52±0.16 ab	0.08±0,01	1.64±0.05 c
Nov. 06	0.38±0.16	0.12±0,06	2.18±0.34 d	2.36±0.27 a-d	0.09±0,02	2.13±0.15 ab
Dec. 06	0.81±0.34	0.34±0,17	4.74±0.63 a	2.17±0.05 b-e	0.12±0,01	2.51±0.21 a
Apr. 07	0.39±0.23	0.10±0,40	2.65±0.13 cd	1.96±0.09 de	0.06±0,01	0.67±0.15 e
May 07	0.26±0.14	0.18±0,17	2.25±0.15 d	1.88±0.14 e	0.07±0,01	0.66±0.13 e
Jun. 07	0.45±0.22	0.39±0,37	2.51±0.16 d	2.61±0.17 ab	0.06±0,00	1.04±0.06 de
July 07	0.30±0.14	0.02±0,13	2.43±0.21 d	1.95±0.04 de	0.07±0,00	1.00±0.01 de
Aug. 07	0.32±0.12	0.35±0,09	3.44±0.27 bc	2.68±0.19 a	0.06±0,00	1.43±0.08 cd
Sep. 07	0.48±0.18	0.28±0,12	3.79±0.33 b	2.53±0.16 ab	0.10±0,01	1.57±0.18 c
Oct. 07	0.47±0.11	0.10±0,06	4.14±0.18 ab	2.44±0.19 abc	0.09±0,01	1.84±0.24 bc
Nov. 07	0.46±018	0.20±0,31	4.95±0.27 a	2.08±0.08 cde	0.09±0,01	1.86±0.13 bc
Mean	0.44	0.20	3.23	2.29	0.08	1.49
Sign. (*P*)	0.806	0.113	0.000	0.000	0.184	0.000

* Within the same column, the values with different letters are significantly different at p< 0.01.

Table 5. Amounts (mean ±SE) of non-nutrients of Christ's-thorn (mg kg^{-1} DM) (n = 10)*.

Çizelge 5. Karaçalı bitkisindeki diğer elementlerin miktarı (mg kg^{-1} DM) (n = 10)* (ortalama ±SE).

Months	Se	Co	Ni	Cr	Cd	Pb
Oct. 06	0.71±0.15	0.13±0.12	3.04±0.40 bc	2.10±0.11	0.02±0.01	1.08±0.17 b
Nov. 06	0.33±0.13	0.15±0.07	1.14±0.20 d	1.71±0.29	0.04±0.00	1.61±0.17 a
Apr. 07	0.41±0.19	0.46±0.17	6.85±0.41 a	1.93±0.31	0.06±0.00	1.02±0.18 bc
May 07	0.44±0.09	0.19±0.12	6.31±0.48 a	2.02±0.69	0.02±0.01	0.35±0.05 d
Jun. 07	0.34±0.09	0.26±0.14	3.63±0.32 b	1.28±0.10	0.03±0.01	0.35±0.02 d
July 07	0.38±0.20	0.12±0.10	2.26±0.47 cd	1.60±0.18	0.04±0.01	0.48±0.13 d
Aug. 07	0.64±0.16	0.07±0.07	2.49±0.28 bc	2.56±0.54	0.04±0.01	0.36±0.06 d
Sep. 07	0.29±0.14	0.08±0.05	1.95±0.31 cd	2.57±0.65	0.03±0.01	0.68±0.11 cd
Oct. 07	0.49±0.03	0.08±0.06	2.62±0.24 bc	1.70±0.22	0.04±0.01	0.57±0.04 d
Mean	0.45	0.17	3.37	1.94	0.04	0.72
Sign. (*P*)	0.374	0.314	0.000	0.429	0.651	0.000

* Within the same column, the values with different letters are significantly different at p< 0.01.

months were not found to be significant (Table 6). For thyme, Se, Co, Cd and Pb contents were below 1 mg kg^{-1}. Variations in Cr, Ni and Pb were significant and variations in other elements were not significant. Variations were not regular. Only Ni contents decreased especially in summer months (Table 7).

For prickly burnet, variations in Se and Co contents were significant and the others were not significant. Among these minerals, Se, Co and Cd levels were below 1 mg kg^{-1}. Cd decreased significantly during only summer months. Ni increased in winter months of the year 2006 and Pb exhibited a regular variation (Table 8).

4. Discussion

Se plays an important role especially for animals and average Se contents of shrubs vary between 0.02-0.45 mg kg^{-1}. Se contents of plants grown over soils poor in Se is usually below 0.05 mg kg^{-1} and this level is mostly depend on plant type and part of plant, soil conditions and variations in temperature (Macpherson 2000). Therefore, Se levels of shrubs were not at a level able to create a problem for plants. Since Se is not a nutrient, deficiency for plants cannot be mentioned. On the other hand, goats need 0.2 mg kg^{-1} DM Se and the level of 3 mg Se kg^{-1} DM is the toxic level for goats (Gasparotto 2010).

Table 6. Amounts (mean ±SE) of non-nutrients of pink rockrose (mg kg^{-1} DM) (n = 10)*.

Çizelge 6. Sistus çalısındaki diğer elementlerin miktarı (mg kg^{-1} DM) (n = 10)* (ortalama ±SE).

Months	Se	Co	Ni	Cr	Cd	Pb
Oct. 06	0.63±0.18	0.18±0.10 c	5.63±0.79 ab	2.08±0.38 b	0.04±0.00 d	1.91±0.17 bc
Nov. 06	0.27±0.18	0.20±0.06 c	5.05±0.68 abc	1.59±0.08 b	0.06±0.00 cd	1.25±0.16 def
Dec. 06	0.25±0.15	0.28±0.11 c	4.51±0.47 a-d	2.24±0.14 b	0.05±0.00 d	2.26±0.15 b
Jan. 07	0.33±0.22	0.37±0.15 bc	5.51±0.81 ab	4.32±0.59 a	0.12±0.01 bcd	2.27±0.29 b
Feb. 07	0.22±0.14	0.40±0.14 bc	3.48±0.45 cde	1.80±0.15 b	0.10±0.01 bcd	1.09±0.08 def
Mar. 07	0.18±0.08	0.45±0.15 bc	6.13±0.89 a	1.92±0.12 b	0.33±0.05 a	4.23±0.22 a
Apr. 07	0.34±0.14	0.76±0.19 ab	5.23±0.39 ab	2.03±0.18 b	0.34±0.03 a	2.25±0.25 b
May 07	0.33±0.10	0.91±0.08 a	4.28±0.49 bcd	1.95±0.08 b	0.17±0.03 bc	1.38±0.21 de
Jun. 07	0.25±0.11	0.35±0.14 bc	2.91±0.40 de	1.65±0.08 b	0.12±0.02 bcd	1.31±0.27 def
July 07	0.40±0.20	0.35±0.12 bc	3.00±0.23 de	1.77±0.06 b	0.11±0.01 bcd	0.82±0.12 ef
Aug. 07	0.27±0.07	0.64±0.19 abc	2.25±0.30 e	1.84±0.17 b	0.19±0.03 b	0.95±0.13 ef
Sep. 07	0.30±0.05	0.49±0.08 abc	3.30±0.18 de	1.99±0.11 b	0.14±0.01 bcd	1.36±0.13 de
Oct. 07	0.37±0.19	0.61±0.11 abc	5.91±0.43 a	1.89±0.08 b	0.09±0.01 bcd	1.63±0.09 cd
Nov. 07	0.46±0.13	0.47±0.07 abc	5.27±0.35 ab	2.15±0.22 b	0.17±0.03 bc	0.75±0.13 f
Mean	0.33	0.46	4.46	2.09	0.15	1.68
Sign. (*P*)	0.883	0.026	0.000	0.000	0.000	0.000

* Within the same column, the values with different letters are significantly different at p< 0.01.

Table 7. Amounts (mean ±SE) of non-nutrients of thyme (mg kg^{-1} DM) (n = 10)* .

Çizelge7. Kekik bitkisindeki diğer elementlerin miktarı (mg kg^{-1} DM) (n = 10)* (ortalama±SE).

Months	Se	Co	Ni	Cr	Cd	Pb
Oct. 06	0.23±0.16	0.13±0.08	2.86±0.19 efg	3.02±0.30 a	0.02±0.15	0.57±0.08 d
Nov. 06	0.14±0.10	0.24±0.13	7.52±1.24 abc	2.05±0.15 b-e	0.04±0.12	0.70±0.09 a-d
Dec. 06	0.20±0.12	0.14±0.08	6.64±1.01 bcd	1.76±0.06 def	0.03±0.18	0.80±0.07 a-d
Jan. 07	0.18±0.06	0.22±0.12	9.43±1.69 a	2.48±0.15 abc	0.03±0.08	1.03±0.07 a
Feb. 07	0.26±0.07	0.61±0.22	5.95±0.83 bcd	2.20±0.11 b-e	0.02±0.13	0.86±0.14 a-d
Mar. 07	0.30±0.21	0.23±0.10	5.33±0.53 cde	2.04±0.13 b-e	0.04±0.13	0.98±0.09 ab
Apr. 07	0.22±0.13	0.61±0.24	8.20±0.72 ab	2.41±0.16 bc	0.05±0.07	0.71±0.05 a-d
May 07	0.33±0.17	0.49±0.10	4.77±0.66 def	2.62±0.46 ab	0.08±0.23	0.80±0.15 a-d
Jun. 07	0.19±0.09	0.36±0.13	2.88±0.28 fg	2.39±0.17 bcd	0.03±0.11	0.59±0.16 cd
July 07	0.11±0.06	0.18±0.05	2.17±0.19 g	1.73±0.16 ef	0.03±0.12	0.56±0.26 d
Aug. 07	0.50±0.18	0.16±0.07	2.14±0.12 g	1.41±0.43 f	0.03±0.16	0.64±0.13 bcd
Sep. 07	0.35±0.10	0.33±0.09	4.89±0.58 def	2.05±0.05 b-e	0.05±0.25	0.75±0.31 a-d
Oct. 07	0.12±0.09	0.63±0.21	8.35±0.59 ab	1.94±0.14 c-f	0.06±0.13	0.93±0.12 abc
Nov. 07	0.10±0.06	0.45±0.12	6.48±0.81 bcd	2.22±0.06 b-e	0.05±0.01	0.98±0.06 ab
Mean	0.23	0.34	5.54	2.17	0.04	0.78
Sign. (*P*)	0.758	0.077	0.000	0.000	0.271	0.016

* Within the same column, the values with different letters are significantly different at p< 0.01.

Table 8. Amounts (mean ±SE) of non-nutrients of prickly burnet (mg kg^{-1} DM) (n = 10)*.

Çizelge 8. Aptestbozan çalısındaki diğer elementlerin miktarı (mg kg^{-1} DM) (n = 10)* (ortalama ±SE).

Months	Se	Co	Ni	Cr	Cd	Pb
Oct. 06	0.07±0.06	0.12±0.08	8.09±1.26 bc	2.16±0.08 ab	0.05±0.00 ab	2.17±0.25 abc
Nov. 06	0.05±0.03	0.18±0.12	10.87±1.83 a	2.07±0.02 abc	0.05±0.01 ab	2.75±0.27 a
Dec. 06	0.17±0.13	0.09±0.06	6.35±1.09 cd	1.58±0.09 d	0.04±0.01 abc	2.07±0.20 abc
Jan. 07	0.33±0.25	0.38±0.13	8.85±0.65 ab	2.37±0.21 a	0.03±0.00 abc	1.53±0.06 c
Feb. 07	0.31±0.23	0.16±0.09	5.65±0.75 de	2.06±0.09 abc	0.06±0.01 a	1.71±0.12 c
Mar. 07	0.26±0.17	0.05±0.04	3.67±0.12 ef	1.55±0.04 d	0.05±0.01 ab	1.79±0.13 bc
Apr. 07	0.57±0.35	0.04±0.04	3.22±0.58 ef	1.91±0.18 a-d	0.02±0.00 abc	1.92±0.24 bc
May 07	0.32±0.16	0.09±0.06	3.95±0.95 def	1.99±0.13 a-d	0.05±0.00 ab	2.49±0.27 ab
Jun. 07	0.62±0.16	0.11±0.06	1.70±0.19 f	1.74±0.04 bcd	0.01±0.01 abc	1.77±0.25 bc
July 07	1.11±0.40	0.02±0.01	1.47±0.07 f	1.97±0.11 a-d	0.00±0.00 c	1.92±0.27 bc
Aug. 07	0.20±0.17	0.05±0.02	1.53±0.07 f	1.76±0.10 bcd	0.01±0.00 bc	1.52±0.10 c
Sep. 07	0.22±0.09	0.09±0.09	1.37±0.15 f	1.68±0.08 cd	0.00±0.00 c	1.48±0.28 c
Oct. 07	0.54±0.19	0.00±0.00	1.67±0.12 f	2.11±0.14 abc	0.02±0.00 abc	2.19±0.25 abc
Nov. 07	0.15±0.10	0.08±0.04	1.50±0.16 f	1.95±0.11 a-d	0.00±0.00 c	1.67±0.25 c
Mean	0.35	0.10	4.28	1.92	0.03	1.93
Sign. (*P*)	0.086	0.135	0.000	0.005	0.033	0.005

*Within the same column, the values with different letters are significantly different at p< 0.01.

Se contents of all shrubs, except prickly juniper, were found to be sufficient during the sampling period and any toxic levels were not observed.

Co contents of grazable plant tissues did not exhibit a regular variation with regard to months. Increased ripening phase sometimes cause decrease in Co contents and higher levels may be observed during spring and fall (Macpherson 2000). Co plays a role in physiological process in plants (Mengel 1984). Therefore, an increase is expected in Co contents of plants during the active growth periods. However, since small amount of Co is sufficient, variations with growth is not distinctive. Sultan et al. (2008) reported Co contents of cereals as 0.023 mg kg^{-1} at the beginning of flowering, as 0.029 mg kg^{-1} during the maturation. Normally Co concentrations of plant dry matter vary between 0.01-0.4 mg kg^{-1}. Parallel to literatures, Co ratios in current study were determined as between 0.01 mg kg^{-1} and 0.46 mg kg^{-1}. Co is essential also for animals. It is the basic constituent of vitamin B_{12} (Kirchgessner 1985; Suttle 2010). Critical Co level for diets of goats is 0.06 mg kg^{-1} (Suttle 2010). With regard to this level, Co contents of shrubs were found to be sufficient in winter and spring for kermes oak, in summer and fall for mock privet, year-around for gall oak, Christ's-thorn, pink rockrose and thyme, in fall and winter for prickly burnet.

Although monthly variations in Ni contents of shrubs were found to be significant, the variations with regard to shrub types were irregular. However, higher Ni levels were observed in most types especially during fall and winter months. Ni contents vary between 0.1-5 mg kg^{-1} for plants over normal sites (Mengel 1984) and between 0.5-3.5 mg kg^{-1} for common rangeland plants (Underwood 1977). Ahmad et al. (2009) carried out a research over saline rangelands of Pakistan and recorded very high Ni ratios as between 37-84 mg kg^{-1}. Compared to these results, Ni ratios (1.81-5.54 mg kg^{-1}) of shrubs in current study may be thought as sufficient for plants. Ni is essential at low levels for animals. This element is essential in animals for growth, enzyme activities like urease enzyme in rumen and Fe absorption (Kirchgessner 1985; National Research Council 1992). Clinical and biochemical abnormalities occur in goats fed by fodders with Ni levels lower than 0.1 mg kg^{-1}. Beside this, ruminants can resist soluble Ni ($NiCl_3$) levels up to 50 mg kg^{-1} and non-soluble Ni ($NiCO_3$) levels up to 250 mg kg^{-1} (Suttle 2010). Considering these levels, all shrubs had sufficient Ni levels for animal during the growth periods. Ni contents of shrubs were not also at toxic levels.

Small amounts of Cr may be beneficial for some plants. Cr contents of three of the shrubs (prickly juniper, mock privet and pink rockrose) considered in this study reached to maximum levels in January. But variations in Cr were generally irregular. Since Cr does not play a significant role in plant metabolism

and present in plants at trace amounts, irregular variations might have been observed. Average Cr contents of shrubs varied between 1.35-2.29 mg kg^{-1}. Diaz and Massol Deya (2003) observed the Cr rates of forage crops as between 2.78-27.93 mg kg^{-1}. Clark and Baligar (2003) also reported Cr ratios of 0.75-1.34 mg kg^{-1}. Aydemir and İnce (1988) indicated Cr contents of dry plants as between 0.02-1 mg kg^{-1}. Considering all these findings, Cr contents of shrubs were found to be within allowable limits. Cr plays a role in glucose metabolism of animals and toxicity is random (Suttle 2010). Therefore, Cr contents of shrubs do not have any negative effects for animals and deficiency was not observed in this study.

Cd is harmful for both plants and animals. Monthly variations in Cd contents of shrubs were generally insignificant and variations in significant ones were irregular. Since Cd is not essential for plant metabolism, variations in Cd is not related to plant needs. Variations were mostly due to environmental factors. While forage crops grown under normal soils contain Cd levels <1 mg Cd kg^{-1}, toxic levels for ruminants start from >40 mg Cd kg^{-1} DM (Suttle 2010). In a research carried out in Patagonia over *Atriplex* and *Prosopis* shrubs, Cd levels of leaf and stem were below 1.79 mg kg^{-1}. Cd contents of shrubs considered in this study were at trace levels as between 0.01-0.15 mg kg^{-1} (Del Valle and Rosell 2000). These values are far away from harmful levels for both plants and animals fed with these plants.

Pb is a toxic element for plants, animals and humans. Monthly variations in Pb contents of shrubs were not similar to each other. Since it is not essential for plants, uptake varies based on soil conditions. Pb contents of shrubs were at trace levels as between 0.72 mg kg^{-1} (Christ's thorn) and 1.93 mg kg^{-1} (prickly burnet). Clark and Baligar (2003) observed Cd contents as between 0.40-1.88 mg kg^{-1}. Pb taken up by plants is accumulated at cell walls and protects plants from Pb toxicity (Aydemir and İnce 1988). Toxic Pb levels for livestock is given as >2000 mg kg^{-1} (Suttle 2010). Trace amounts of Pb levels observed in present study were away from being harmful for both plants and animals graze these plants.

5. Conclusions

Variations of mineral contents considered in this study carried out over shrubby lands of Mediterranean climate zone were generally found to be significant. However, the variations were irregular since these elements are not essential for plants and present at trace amounts in plants. None of the elements considered in this study were at levels to be considered excessive or deficient to create a harmful impact on both plants and animals.

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