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Trace element concentrations in animal feed samples from Thrace region, Turkey

Murat Belivermiş [1*], Önder Kılıç [1], Tulay Engizek [1], Saim Ergenç [1], Akın Çayır [2]

[1] *Istanbul University, Faculty of Science, Department of Biology, 34134 Vezneciler, Istanbul, Turkey*
[2] *College for Health Service, Çanakkale Onsekiz Mart University, 17100 Çanakkale, Turkey*
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Abstract

In the current work, Cd, Co, Cr, Cu, Fe, Ni, Pb and Zn concentrations were measured in the feed samples of the dairy cattle by means of atomic absorption spectrophotometer. For this purpose a total of 47 common vetch, hay, concentrate feed and wheat samples were collected from the villages of Thrace region. The average concentrations of Cd, Co, Cr, Cu, Fe, Ni, Pb and Zn were found as 1.15 ± 0.19, 3.22 ± 0.64, 4.51 ± 1.60, 3.46 ± 0.94, 90.6 ± 13.5, 7.1 ± 0.4, 9.2 ± 3.9, 42.2 ± 9.2 mg kg^{-1}, respectively, in dry matter. The highest concentrations of Cu, Fe, Zn were found in the concentrate feed samples while the highest concentrations of Cd, Co, Cr, Ni, Pb have been found in the hay samples. Factor analysis was performed in order to distinguish sources of measured elements. High positive correlation coefficients were observed among Cd, Co, Cr, Ni, Pb amounts of the feed. Average Cd concentrations of common vetch, hay and wheat samples were found higher than limit value recommended by dairy food organization.

Keywords: Dairy cattle, livestock feed, trace element.
***Corresponding author:** Murat Belivermiş (e-mail: belmurat@istanbul.edu.tr)
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Türkiye'nin Trakya bölgesinde hayvan yemlerindeki eser element konsantrasyonları

Özet

Bu çalışmada süthane ineği yemlerindeki Cd, Co, Cr, Cu, Fe, Ni, Pb ve Zn konsantrasyonları atomik absorpsiyon spektrofotometresi ile ölçülmüştür. Bu amaçla toplam 47 adet fiğ, saman, suni yem ve buğday örneği Trakya bölgesinin bazı köylerinden toplanmıştır. Ortalama Cd, Co, Cr, Cu, Fe, Ni, Pb ve Zn konsantrasyonları sırasıyla 1.15 ± 0.19, 3.22 ± 0.64, 4.51 ± 1.60, 3.46 ± 0.94, 90.6 ± 13.5, 7.1 ± 0.4, 9.2 ± 3.9, 42.2 ± 9.2 mg kg^{-1} kuru ağırlık olarak bulunmuştur. En yüksek Cu, Fe, Zn konsantrasyonları suni yemde bulunurken, en yüksek Cd, Co, Cr, Ni, Pb konsantrasyonları saman örneklerinde bulunmuştur. Ölçülen elementlerin kaynaklarını ayırt etmek için faktör analiz uygulanmıştır. Yemlerdeki Cd, Co, Cr, Ni, Pb miktarları arasında yüksek pozitif korelasyon katsayıları gözlenmiştir. Fiğ, saman ve buğdaydaki ortalama Cd konsantrasyonları süthane gıda organizasyonu tarafından tavsiye edilen limit değerlerden daha yüksek bulunmuştur.

Anahtar kelimeler: Süthane ineği, çiftlik hayvanı yemi, eser element.

Introduction

Although trace elements present in very low levels in human, animal and plant tissues, as compared to macro elements, some of them have fatal significance for growth and reproduction. Optimum levels of Cu, Fe and Zn are beneficial for living organisms while even very low levels of As, Cd, Hg and Pb may have toxic effects.

There are strong relationships among trace element levels of air, water, soil and plants. These strong relationships also continue in the cycle of plant (livestock feed)-livestock tissues-dairy products. Hay, wheat, pasturage, corn silage and soybean are some of the commonly used homegrown livestock feeds. Some soil properties such as cation exchange capacity, pH and salinity restrict the cycle of many heavy metals through the dairy food chain (Li et al. 2005). Trace elements penetrate to plant tissues via root, atmospheric accumulation, fertilizers and insecticides (Voutsinas et al. 1990; Tewett and Naidu 2000; Alberti-Fidanza et al. 2002), which indicates that properties of soil such as pH, texture and cation exchange capacity; properties of locality such as distance to highways and metal industry; and cultivation processes determine trace element levels of soil and homegrown feeds.

Deficiency of any nutrient of dairy cattle will decrease production of milk and milk components. However, excessive amounts of a nutrient in the diet of dairy cattle may decrease the efficiency of nutrient utilization and profits for dairy producers (NRC 2001). Therefore main nutrients and microelements should be balanced to provide the requirement of the dairy cattle.

Advanced organisms take trace elements mainly by respiration and digestion. Hazardous compounds and elements such as dioxin, pesticide and toxic metals can be accumulated in food chains which may also reach to the human body (Caggiano et al. 2005), and indicates the necessity of determining levels of the pollutant in livestock feed as well as in the human diet. The determination of essential and toxic elements in the homegrown feeds which can be used as a livestock feed is useful because of the fact that it reflects degrees of atmospheric deposition and soil pollution as well as essential and toxic element levels which may potentially enter into the food chains. There is limited data about the heavy metal levels of dairy feeds (McDonald et al. 1981; Nicholson et al. 1999; Farmer and Farmer 2000). The aims of the present study are; to determine trace element concentrations of the dairy cattle feed collected from Thrace region, and to assess the variability of trace element levels in respect of various feed types and different localities.

Material and Methods

The feed samples of dairy cattle have been taken into plastic bottles from villages of Havsa, Hayrabolu, Malkara and Uzunköprü towns in the summer of 2007. These towns are situated in the Thrace region which is a European part of Turkey. Milk demand of big cities such as İstanbul and Tekirdağ is mainly provided from dairy farms situated in Thrace especially in Havsa, Hayrabolu, Malkara and Uzunköprü towns, that is why these towns were selected for element analysis. Sampling stations were close to centers of the industrialized cities of Edirne and Tekirdağ.

A total of 47 feed samples were dried at 40^0C up to a constant weight. Approximately 100 g of each unwashed common vetch, hay, concentrate feed and wheat samples were powdered. The samples were digested with concentrated nitric acid in a microwave digestion unit. For this purposes, 0.5 g of the samples were put into teflon vessels and 8 ml concentrated nitric acid (65% HNO_3) was added. After appropriate dilution, final solutions were analyzed for Cd, Co, Cr, Cu, Fe, Ni, Pb and Zn using an atomic absorption spectrophotometer (Shimadzu AA 680, air–C_2H_2, background correction mode). The concentrations for each sample solution were measured three times. The reported concentrations (mg kg^{-1}) are mean values of three replicates. Blank solutions were prepared under the same conditions as the samples to control possible contamination during the preparation procedures of the samples. Individual results of each town were obtained by calculating average village values of that town. Accuracy of the digestion and measuring processes were checked by analysis of reference material from MAPEP (Mixed Analyte Performance Evaluation Program).

Pearson's correlation, factor analysis and Kruskal-Wallis H tests were performed using SPSS 11.0 for Windows in order to assess the relationship between measured trace element concentrations, studied areas and the feed types. Factor analysis was performed using principal component analysis extraction and Varimax rotation methods.

Results

Trace element concentrations of common vetch, hay, concentrate feed and wheat samples in Havsa, Hayrabolu, Malkara and Uzunköprü are reported in Table 1 and Table 2. Average trace element concentrations of the studied towns and those of other investigations are also presented in Table 3. The average concentrations of Cd, Co, Cr, Cu, Fe, Ni, Pb and Zn were found as 1.15 ± 0.19, 3.22 ± 0.64, 4.51 ± 1.60, 3.46 ± 0.94, 90.6 ± 13.5, 7.1 ± 0.4, 9.2 ± 3.9, 42.2 ± 9.2 mg kg^{-1} respectively, in dry matter. The concentrations ranges were found as 0.14-1.71 for Cd, 0.88-5.11 for Co, <LLD-10.33 for Cr, 1.01-8.89 for Cu, 35.9-135.2 for Fe, 5.4-8.6 for Ni, <LLD-25.8 for Pb and 16.0-99.0 mg kg^{-1} for Zn (Table 2). The highest concentrations of Cu, Fe, Zn were found in the concentrate feed samples while the highest concentrations of Cd, Co, Cr, Ni, Pb were found in the hay samples. The concentrations of Cd, Co, Cu, Fe, Ni and Zn were detected in all feeds while Cr and Pb were found as under the detection limit for some cases. Average trace element levels were found in decreasing order as: Fe > Zn > Pb > Ni > Cr > Cu > Co > Cd. Very high variation coefficients has been found except for Fe and Ni in accordance with results of Caggiano et al. (2005). All trace element concentrations displayed normal distribution ($p > 0.05$).

Discussion

It is known that Cu, Fe and Zn are essential elements for metabolic processes of plants. Plants may take higher amounts of Cu, Fe and Zn from the soil and accumulate them in the long term. In the studied area, common homegrown feeds are cultivated by farmers in their own farms and manure is added to the cultivation soil as a source of organic matter and minerals. On the other hand, concentrate feed is a commercial product and fabricated mainly by using mixtures of minerals and proteins. It is suggested to supplement the livestock feed Cu, Fe and Zn if the concentration values of livestock diet are lower than recommended (European Commission 2003a, 2003b). Hence, essential elements are expected to be added to concentrate feed at optimum levels in the meanwhile avoiding the inclusion of toxic elements. Excessive addition of trace elements to livestock feed may also be the reason for the high amount of those elements in the manure applied to farming lands (Li et al. 2005). Consequently, trace elements may reach humans via manure-soil-livestock feed-livestock tissues-dairy products.

As mentioned above, slightly higher levels of Cu, Fe and Zn were observed in the concentrate feed compared to the homegrown feeds (Table 1, 2). However, approximately 8 times higher Cu and 2 times higher Zn concentrations has been found by Li et al. (2005) in imported corn grain mix relative to homegrown feeds in their study. Chronic Cu poisoning is common in cattle which has diet supplemented with just 4-5 times higher Cu amount than the necessary (NRC 2001). In the present study, Cu value was slightly lower than the recommended value of the European Commission (2003a) for concentrate feed (Table 3). Average Fe concentration (90.6 ± 13.5 mg kg^{-1}) which was found in this study is reasonable since Fe exists in the environment

Table 1. Trace elements concentrations in the feed samples (mg kg^{-1})

Town	Village	Feed type	Cd	Co	Cr	Cu	Fe	Ni	Pb	Zn
Havsa	Bakışlar	Common vetch	1.45	3.96	<LLD*	1.35	71.4	8.88	2.85	20.3
		Hay	1.45	3.70	<LLD	0.52	74.8	8.05	22.03	24.9
		Concentrate feed	0.21	0.82	<LLD	7.62	120.1	7.48	2.94	97.8
		Wheat	1.26	3.19	0.12	1.25	34.1	7.66	5.68	25.5
	Çukurköy	Common vetch	1.33	4.54	<LLD	1.27	44.1	7.12	29.61	21.7
		Hay	1.27	3.64	<LLD	0.70	87.6	7.50	10.69	27.4
		Concentrate feed feed	0.13	1.11	<LLD	8.37	119.0	7.11	8.79	95.1
		Wheat	1.56	3.87	<LLD	1.05	35.5	8.16	30.70	23.1
	Tahal	Common vetch	1.81	5.67	<LLD	0.75	77.9	8.05	44.97	13.5
		Hay	1.24	4.39	<LLD	7.72	79.6	6.37	36.16	32.0
		Concentrate feed	0.07	0.94	<LLD	0.65	119.6	7.11	6.27	93.2
		Wheat	0.91	4.12	<LLD	1.80	38.0	6.52	31.00	26.8
Hayrabolu	Çene	Common vetch	0.23	1.08	2.50	5.54	90.4	1.41	0.36	27.4
		Hay	1.84	2.10	7.89	6.10	73.9	10.29	7.36	69.0
		Concentrate feed	1.65	2.16	12.21	7.10	72.9	10.08	6.04	91.5
	Haydere	Common vetch	1.45	3.00	1.68	2.97	116.6	7.11	4.96	43.9
		Hay	1.51	3.03	<LLD	2.40	58.2	6.52	11.16	40.8
		Concentrate feed	1.06	2.11	1.69	2.85	119.9	6.96	1.41	42.2
	Kabahöyük	Common vetch	1.60	1.71	5.74	5.65	119.9	9.06	3.54	55.9
		Hay	1.77	2.20	5.86	5.50	119.2	8.95	4.95	57.4
		Concentrate feed	1.50	1.84	1.98	3.05	118.8	6.40	5.19	44.4
		Wheat	0.28	0.88	1.39	2.97	119.4	5.43	1.05	43.2
Malkara	Aksakal	Common vetch	1.27	4.18	6.07	0.50	16.8	6.06	11.59	5.8
		Concentrate feed	1.45	4.50	10.14	1.57	119.7	8.17	8.80	24.2
		Wheat	0.14	0.54	1.04	10.83	271.8	1.90	0.15	43.1
	Ballı	Common vetch	0.20	0.52	3.50	6.81	123.6	2.20	<LLD	27.6
		Concentrate feed	1.57	3.37	4.87	4.12	58.5	9.58	16.0	53.6
		Wheat	1.44	2.82	3.90	3.57	59.9	6.87	8.8	44.9
	Emirali	Common vetch	1.47	4.95	5.56	2.32	118.1	7.54	11.32	29.8
		Concentrate feed	1.38	4.27	5.44	0.65	74.5	6.36	10.72	6.9
		Wheat	1.75	5.34	6.64	3.82	105.6	9.30	10.66	45.9
	Kavakçeşme	Common vetch	1.42	4.48	2.31	1.97	118.4	6.52	6.99	35.6
		Hay	1.44	4.68	10.33	3.67	117.5	8.47	12.27	48.7
		Concentrate feed	0.28	1.20	2.56	5.14	118.4	1.37	0.40	28.5
		Wheat	1.44	4.63	7.02	3.75	103.5	8.14	8.94	46.5
Uzunköprü	Malkoç	Common vetch	1.41	2.05	<LLD	1.87	86.7	7.62	2.43	23.1
		Hay	1.29	5.25	<LLD	1.15	89.1	7.54	2.11	18.4
		Concentrate feed	0.04	1.63	<LLD	8.77	120.1	9.25	<LLD	98.7
		Wheat	1.30	5.56	<LLD	1.17	35.6	8.46	2.02	25.1
	Karayayla	Common vetch	1.44	4.65	<LLD	1.37	42.1	8.53	3.34	20.4
		Hay	1.35	5.07	<LLD	1.07	66.8	5.85	2.68	16.1
		Concentrate feed	0.28	1.56	0.39	8.95	119.1	5.13	<LLD	96.2
		Wheat	1.47	4.38	<LLD	1.25	34.5	5.73	7.05	23.8
	Kavacık	Common vetch	1.65	5.89	<LLD	1.90	71.2	7.39	4.09	20.7
		Hay	1.42	5.02	<LLD	0.80	59.2	6.61	2.10	13.6
		Concentrate feed	0.12	2.02	<LLD	8.95	119.5	7.81	<LLD	102.0
		Wheat	1.32	4.96	<LLD	1.25	38.7	6.96	1.51	25.2

* Lower limit of detection

abundantly and is required in very small mounts by dairy cattle, thus Fe deficiency rarely occurs. At the same time, Fe content in the feeds is much lower than the value of 1000 mg kg^{-1} which is accepted as toxic by NRC (2001).

Cd, Cr, Ni and Pb concentrations appeared to be slightly higher compared to the literature values while Cu and Zn concentrations are close to the literature values except the mineral mix (Table 3). Average Cd value was found higher than the limit value given by the European Commission (2003c) as 1 mg kg^{-1} except for concentrate feed. Cd and Pb can be transported to long ranges in the atmosphere and accumulate in unpolluted areas by precipitation rather than soil enrichment (Pacyna et al. 2001). The studied area is close to industrial cities like Edirne and Tekirdağ, which may explain the high levels of Cd and Pb for the homegrown feeds. Pb is accumulated presumably by foliar uptake via atmospheric accumulation rather than root uptake. Elevated Cd, Cr, Ni and Pb content of soil which the homegrown feeds have been cultivated and/or deposition through atmospheric long range transportation may be the reasons for the comparatively high level of these metals. Caggiano et al. (2005) similarly have found the greatest metal concentrations in the farm close to anthropogenic sources. Also, Cd is more mobile than other contaminant elements measured in this study (Li et al. 2005).

Pearson's correlation and factor analysis results were displayed in Table 4 and Table 5,

Table 2. Average trace element contents in the feed samples (mg kg^{-1})

Town	Feed type	Cd	Co	Cr	Cu	Fe	Ni	Pb	Zn
Havsa	Common vetch	1.53 ± 0.14*	4.72 ± 0.50	< LLD**	1.12 ± 0.19	64.4 ± 10.4	8.0 ± 0.5	25.8 ± 12.3	18.5 ± 2.5
	Hay	1.32 ± 0.07	3.91 ± 0.24	< LLD	2.98 ± 2.37	80.6 ± 3.7	7.3 ± 0.5	23.0 ± 7.4	28.1 ± 2.1
	Concentrate feed	0.14 ± 0.04	0.96 ± 0.08	< LLD	5.55 ± 2.46	119.6 ± 0.3	7.2 ± 0.1	6.0 ± 1.7	95.4 ± 1.3
	Wheat	1.24 ± 0.18	3.73 ± 0.28	0.12 ± 0.35	1.35 ± 0.22	35.9 ± 1.1	7.4 ± 0.5	22.5 ± 8.4	25.1 ± 1.1
Hayrabolu	Common vetch	1.09 ± 0.43	1.93 ± 0.57	3.31 ± 1.24	4.72 ± 0.88	109.0 ± 9.3	5.9 ± 2.3	2.9 ± 1.4	42.4 ± 8.3
	Hay	1.71 ± 0.10	2.44 ± 0.30	5.29 ± 3.46	4.67 ± 1.15	83.7 ± 18.3	8.6 ± 1.1	7.7 ± 1.8	55.7 ± 8.2
	Concentrate feed	1.40 ± 0.18	2.04 ± 0.10	6.88 ± 1.02	4.33 ± 1.33	103.8 ± 15.5	7.8 ± 1.1	4.2 ± 1.4	59.4 ± 16.1
	Wheat	0.28 ± 0.53	0.88 ± 0.94	1.39 ± 1.18	2.97 ± 1.72	119.4 ± 10.9	5.4 ± 2.3	1.1 ± 1.0	43.2 ± 6.6
Malkara	Common vetch	1.09 ± 0.30	3.53 ± 1.02	4.36 ± 0.88	2.90 ± 1.36	94.2 ± 25.8	5.6 ± 1.2	10.0 ± 1.5	24.7 ± 6.5
	Hay	1.44 ± 1.20	4.68 ± 2.16	10.33 ± 3.21	3.67 ± 1.92	117.5 ± 10.8	8.5 ± 2.9	12.3 ± 3.5	48.7 ± 7.0
	Concentrate feed	1.17 ± 0.30	3.34 ± 0.75	5.75 ± 1.59	2.87 ± 1.05	92.8 ± 15.5	6.4 ± 1.8	9.0 ± 3.2	28.3 ± 9.6
	Wheat	1.19 ± 0.36	3.33 ± 1.10	4.65 ± 1.39	5.49 ± 1.78	135.2 ± 46.7	6.6 ± 1.6	7.1 ± 2.4	45.1 ± 0.7
Uzunköprü	Common vetch	1.50 ± 0.08	4.20 ± 1.13	< LLD	1.71 ± 0.17	66.6 ± 13.1	7.8 ± 0.3	3.3 ± 0.5	21.4 ± 0.9
	Hay	1.35 ± 0.04	5.11 ± 0.07	< LLD	1.01 ± 0.11	71.7 ± 9.0	6.7 ± 0.5	2.3 ± 0.2	16.0 ± 1.4
	Concentrate feed	0.56 ± 0.21	1.74 ± 0.14	0.39 ± 0.62	8.89 ± 0.06	119.5 ± 0.3	7.4 ± 1.2	<LLD	99.0 ± 1.7
	Wheat	1.36 ± 0.05	4.97 ± 0.34	< LLD	1.17 ± 0.03	36.3 ± 1.3	7.1 ± 0.8	3.5 ± 1.8	24.6 ± 0.5

* Standard deviation of mean
** Lower limit of detection

(Table 3). Average Fe concentration (90.6 ± 13.5 mg kg^{-1}) which was found in this study is amounts by dairy cattle, thus Fe deficiency rarely occurs. At the same time, Fe content in the feeds is much lower than the value of 1000 mg kg^{-1} which is accepted as toxic by NRC (2001).

Cd, Cr, Ni and Pb concentrations appeared to be slightly higher compared to the literature values while Cu and Zn concentrations are reasonable since Fe exists in the environment abundantly and is required in very small close to the literature values except the mineral mix (Table 3). Average Cd value was found higher than the limit value given by the European Commission (2003c) as 1 mg kg^{-1} except for concentrate feed. Cd and Pb can be transported to long ranges in the atmosphere and accumulate in unpolluted areas by precipitation rather than soil enrichment

Table 3. Trace elements concentrations of livestock feed samples in the current and other investigations (mg kg^{-1})

Reference	Feed type	Cd	Co	Cr	Cu	Fe	Ni	Pb	Zn
Farmer and Farmer 2000	Hay	0.23 (0.16-0.35)						5.4 (1.58-1.94)	34.7 (24.8-45.2)
	Pasturage	0.32 (0.10-0.72)						3.97 (2.80-5.85)	18.42 (9.8-27.7)
Li et al. 2005	Hay (alfalfa)	0.07		0.71	6.8 ± 2.1 (3-11.4)			0.19	23 ± 8 (13-54)
	Imported corn grain mix	0.34		1.83	38.2 ± 46.7 (3-232)			0.25	154 ± 122 (23-495)
	Mineral mix	1.58		69.3	560 ± 376 (4-1339)			2.85	3060 ± 2170 (45-6980)
McDonald et al. 1981	Grass silage				8				33
	Hay				7.3-13.4				
Nicholson et al. 1999	Grass silage	<0.1		0.21	6.2		0.8	<1	30
	Hay	0.11		0.28	6.8		0.8	3.6	29
Baranowska et al. 2005	Grass	0.11-0.63						0.16-136	35.2-55.9
	Cereals	0.20-0.31						1.05-5.47	14.9-28.8
European Commission, 2003 a	Hay				7.3-9.0				28
	Corn silage				7.6				27-29
Current study	Common vetch	1.30 ± 0.12*	3.60 ± 0.61	3.84 ± 0.53	2.61 ± 0.72	83.5 ± 10.9	6.8 ± 0.6	10.5 ± 5.3	26.7 ± 5.4
	Hay	1.46 ± 0.09	4.04 ± 0.59	7.81 ± 2.53	3.08 ± 0.77	88.4 ± 10.0	7.8 ± 0.5	11.3 ± 4.4	37.1 ± 9.2
	Concentrate feed	0.82 ± 0.29	2.02 ± 0.50	4.34 ± 2.00	5.41 ± 1.28	108.9 ± 6.5	7.3 ± 0.3	6.4 ± 1.4	70.5 ± 16.7
	Wheat	1.02 ± 0.25	3.23 ± 0.86	2.05 ± 1.35	2.75 ± 1.00	81.7 ± 26.5	6.6 ± 0.4	8.6 ± 4.8	34.5 ± 5.6
	Average	1.15 ± 0.19*	3.22 ± 0.64	4.51 ± 1.60	3.46 ± 0.94	90.6 ± 13.5	7.1 ± 0.4	9.2 ± 3.9	42.2 ± 9.2

* Standard deviation of average

(Pacyna et al. 2001). The studied area is close to industrial cities like Edirne and Tekirdağ, which may explain the high levels of Cd and Pb for the homegrown feeds. Pb is accumulated deposition through atmospheric long range transportation may be the reasons for the comparatively high level of these metals. Caggiano et al. (2005) similarly have found the greatest metal concentrations in the farm close to anthropogenic sources. Also, Cd is more mobile than other contaminant elements measured in this study (Li et al. 2005).

Pearson's correlation and factor analysis results were displayed in Table 4 and Table 5, respectively. Factor 1 explained 44.1% of total variance while Factor 2 and 3 explained 22.3% and 17.6%, respectively.

The high positive correlation coefficients were observed among Cu, Fe, Zn (Table 4). presumably by foliar uptake via atmospheric accumulation rather than root uptake. Elevated Cd, Cr, Ni and Pb content of soil which the homegrown feeds have been cultivated and/or Homegrown feeds take these elements via air and roots. Individual common vetch, hay and wheat samples display approximately equal levels of airborne trace elements since the towns are close to each other. Hence, the strong positive correlations may be expected among these elements. Cu, Fe, Zn are more available in soil for plants than other elements measured in this study because of the fact that intake of these elements by plants restrict vertical movement of them in soil. According to factor analysis result, Cu, Fe and Zn were also included in same group, Factor 1 (Table 5). These elements are necessary for plants and animals at optimum levels, although excessive levels may be toxic for some tissues and organs. Cu, Fe and Zn are mainly used in metabolic processes as metalloprotein and enzyme, they are also necessary trace elements for livestock growth.

Table 4. Pearson correlation coefficient among measured trace elements

Elements	Cd	Co	Cr	Cu	Fe	Ni	Pb	Zn
Cd	1	73**	64*	-.47	-.52*	.52*	.30	-.61*
Co	73**	1	.52	-.68**	-.62**	.29	.37	-.74**
Cr	.64*	.52	1	-.13	.29	.43	-.13	-.12
Cu	-.47	-.68**	-.13	1	75**	.03	-.29	89**
Fe	-.52*	-.63**	.29	75**	1	-.24	-.36	63**
Ni	.52*	.29	.43	.03	-.24	1	.36	17
Pb	.30	.37	-.13	-.29	-.36	.36	1	-.29
Zn	-.61*	-.74**	-.12	89**	63**	.17	-.29	1

* Correlation is significant at the 0.05 level (2-tailed)
** Correlation is significant at the 0.01 level (2-tailed)

The high positive correlations were also obtained between regional trace element contents of feed samples (Table 6). According to the Kruskal-Wallis H statistical test, there is no significant difference among the towns concerning the trace element levels ($p > 0.05$).

Cd, Ni and Pb were included in Factor 2 (Table 5). These elements are mainly released from mines, refineries, phosphate fertilizers, pesticides and motorized vehicles (Adriano

1986; Alloway 1995). It is known that As, Cd, Hg, Pb may be hazardous to organisms even at very low levels and are generally present in soil and plants at lower concentrations relatively to essential trace elements such as Fe and Zn. Concentrations of As, Cd, Hg, Pb may increase in manure as a result of ingestion of these elements by livestock (Li et al. 2005). Livestock tissues and dairy products generally do not contain toxic elements such as As, Cd, Hg and Pb at hazardous levels except in contaminated areas (Vreman et al. 1986 ;Kan and Meijer 2007). Cd and Pb are accepted as contaminant trace elements in the livestock feed (Li et al. 2005). These elements can accumulate in tissues of livestock and can return to livestock in the cycle of manure-soil-livestock feed. At the same time, these elements may reach humans through dairy products and veal. Blüthgen (2000) reported that average transfer ratio of Cd and Pb from livestock feed to milk as <0.05% and <0.1-1%, respectively. Cd accumulates in kidney and liver while Pb accumulates in bone, kidney and liver. Maximum tolerable concentrations of Pb in the feed of dairy cattle is 30 mg kg^{-1} (NRC 2001), which indicates that average Pb value of the present study (9.2 ± 3.9 mg kg^{-1}) is safe.

Table 5. Factor analysis Principal component analysis with Varimax Kaiser Normalization.

Elements	Component		
	1	2	3
Cd	-.660	.556	.369
Co	-.813	.367	.048
Cr	.063	.073	.958
Cu	.914	-.018	.222
Fe	.695	-.355	.490
Ni	.085	.952	.123
Pb	-.379	.547	-.212
Zn	.982	.079	.031

Table 6. Pearson correlation coefficient among regions

Towns	Hayrabolu	Malkara	Uzunköprü
Havsa	.81 **	.71 **	.97 **
Hayrabolu		.96 **	.82 **
Malkara			.69 **

** Correlation is significant at the 0.01 level (2-tailed).

Average Co, Cu, Fe and Zn concentrations in the feed samples were found as 3.22 ± 0.64, 3.46 ± 0.94, 90.6 ± 13.5 and 42.2 ± 9.2 mg kg^{-1}, respectively. Average Co, Cu, Fe and Zn concentrations of a dairy cattle diet should be 0.11, 15.7, 34 and 63 mg kg^{-1}, respectively, according to NRC (2001). Weiss (1996) has reported the same values as 0.1, 10, 50 and 50 mg kg^{-1}. It is seen that Cu and Fe concentrations of the feed samples of the Thrace region are also lower than recommended values.

Co is accepted as one of the main microelements for ruminant animals considering that it is a component of vitamin B_{12} (NRC 2001). Co is mainly released from petroleum and coloring industries as well as subtraction of Ag, Fe, Ni and Pb ores (Adriano 1986; Alloway 1995). In this study, Co was included in the same group with toxic elements Cd and Pb, Factor 2.

According to the factor analysis, Cr was included in Factor 3 (Table 5). Cr, used in carbohydrate and lipid metabolism, is considered as a beneficial trace element, but should be at low levels compared to Cu, Fe and Zn (Li et al. 2005). Very limited data is available investigating the acceptable level of Cr for dairy cattle feeds, though its tolerability has been shown even for elevated levels (NRC 2001).

Trace element concentrations measured in the feed of dairy cattle are generally close to those reported in the literature except for Cd. The elevated correlation coefficients were obtained among micronutrient elements. Comparatively higher Cu, Fe, Zn concentrations were observed in the concentrate feed, attributed to the supplementation, while higher Cd, Co, Cr, Ni and Pb in the homegrown feeds were mainly explained with both atmospheric deposition and root uptake.

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References

Adriano D.C. (1986) *Trace Elements in the Terrestrial Environment*. Springer-Verlag New York Inc., USA.

Alberti-Fidanza A., Burini G. and Perriolla G. (2002) Trace elements in foods and meals consumed by students attending to faculty cafeteria. *Science of the Total Environment*, 287: 133-40.

Alloway B.J. (1995) *Heavy Metals in Soils*. Chapman and Hall second edition. Blackie Academic and Professional, London, UK.

Baranowska I., Barchanska H. and Pyrsz A. (2005) Distribution of pesticides and heavy metals in tropic chain. *Chemosphere*, 60: 1590-1599.

Blüthgen A.H. (2000) Contamination of milk from feed. *Bulletin of the International Dairy Federation*, 356: 43-47.

Caggiano R., Sabia S., D'Emiliob M., Macchiatob M., Anastasioc A., Ragostad M. and Paino S. (2005) Metal levels in feed, milk, dairy products, and tissues sampled in ovine farms of Southern Italy. *Environmental Research*, 99 (1): 48-57.

European Commission (2003a). Opinion of the scientific committee on animal nutrition on the use of zinc in feedstuffs. European Commission, Health and Consumer Protection Directorate, Brussels, Belgium.

European Commission (2003b). Opinion of the scientific committee on animal nutrition on the use of copper in feedstuffs. European Commission, Health and Consumer Protection Directorate, Brussels, Belgium.

European Commission (2003c). Opinion of the scientific committee on animal nutrition on undesirable substances in feed. European Commission, Health and Consumer Protection Directorate, Brussels, Belgium.

Farmer A.A. and Farmer A.M. (2000) Concentrations of cadmium, lead and zinc in livestock feed and organs around a metal production centre in eastern Kazakhstan. *Science of the Total Environment*, 257: 53-60.

Kan C.A. and Meijer G.A.L. (2007) The risk of contamination of food with toxic substances present in animal feed. *Animal Feed Science and Technology*, 133: 84-108.

Li Y., McCrory D.F., Powell J.M., Saam H. and Jackson-Smith D. (2005) A survey of selected heavy metal concentrations in Wisconsin dairy feeds. *Journal of Dairy Science*, 88: 2911–22.

McDonald P., Edwards R.A. and Greenhalgh J.F.D. (1981) *Animal Nutrition*, 3rd ed. Longman, New York, USA.

Nicholson F.A., Chambers B.J., Williams J.R. and Unwin R.J. (1999) Heavy metal contents of livestock feeds and animal manures in England and Wales. *Bioresource Technology*, 70: 23-31.

NRC (2001) *Nutrient Requirements of Dairy Cattle*. 7th revised edition National Academy Press Washington DC, USA.

Pacyna E.G., Pacyna J.M. and Pirrone N. (2001) European emissions of atmospheric mercury from anthropogenic sources in 1995. *Atmospheric Environment*, 35 (17): 2987-96.

Tewett S.C. and Naidu A.S. (2000) Assessment of heavy metal pollution in red king crabs following offshore placer gold mining. *Marine Pollution Bulletin*, 4: 478-90.

Voutsinas L., Pappas C. and Kutsiari M. (1990) The composition of Alpine goats milk during lactation in Greece. *Dairy Research*, 57: 41-51.

Vreman K., Van Der Veen N.G., Van Der Molen E.J. and De Ruig W.G. (1986) Transfer of cadmium, lead, mercury and arsenic from feed into milk and various tissues: chemical and pathological data. *Netherland Journal of Agricultural Science*, 34 (2): 129-44.

Weiss J. (1996) Trace elements in dairy cattle feeding. *Milchpraxis*, 34 (2): 101-03.