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Trend Analysis of Pb Content of Soils and Plants Near The Roadside in Turkey
Türkiye'de Yol Kenarında Bulunan Bitki ve Toprak Örneklerinde Kurşun İçeriğinin Eğilim Analizi

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ABSTRACT
INTRODUCTION: Lead is one of the most common heavy metal which contaminate environment. People may be exposed to lead by inhaling the contaminated air droplets and dust particles, through drinking water, or eating contaminated foods such as vegetables grown in lead-contaminated soils. It is aimed to examine the change of lead levels measured in the plants and soils growing on the roadside which heavy traffic with years.
METHODS: 63 articles were scanned from different databases using keywords. 25 of the scanned articles were found suitable to determined criterias. Lead levels were evaluated according to measured Lead levels measured in plant and soil samples growing on the roadside were evaluated by years.
RESULTS: A decrease in lead accumulation in both soil and plant samples were seen in collected data through the years. Lead levels from industrial cities and metropolises were higher than in the countryside.
DISCUSSION AND CONCLUSION: It was foud out that lead levels mostly exceeded safety limits in earlier studies. This situation may be due to the lead added to the gasoline in the previous times, as well as the low sensitivity of the analytical methods used for measurement. The decrease over the years was interpreted as the use of unleaded gasoline after 2004, taking important measures to increase air quality and at the same time increasing the sensitivity of analytical methods.
Keywords: Heavy metal, Herbal, Plant, Highway, Roadside, Lead, Turkey

ÖZ
GİRİŞ ve AMAÇ: Kurşun, çevreyi kirleten yaygın elementlerden birisidir. İnsanlar, kontamine olmuş hava damlacıklarını ve toz parçacıklarını soluma yoluyla, içme suyuyla veya kurşunla kirlenmiş topraklarda yetişen sebzeleri yiyerek kurşuna maruz kalabilir. Trafik hareketliliğinin yoğun olduğu yol kenarlarında yetişen bitki ve topraklarda ölçülen kurşun düzeylerinin yıllara göre değişiminin incelenmesi amaçlanmıştır.
YÖNTEM ve GEREÇLER: Farklı veri tabanlarından anahtar kelimeler kullanılarak 63 makale taranmıştır. Taranan makalelerin 25'i belirlenen kriterlere uygun bulunmuştur. Yol kenarında yaşayan bitki ve toprak örneklerinde ölçülen kurşun düzeyleri yıllara göre değerlendirilmiştir.
BULGULAR: Yıllar içinde toplanan verilerde hem toprak hem de bitki örneklerinde kurşun birikiminde azalma olduğu görülmüştür. Sanayi şehirlerinden ve metropollerde kurşun seviyeleri kırsal bölgelere göre daha yüksek bulunmuştur.
TARTIŞMA ve SONUÇ: Daha önceki çalışmalarda, kurşun seviyelerinin çoğunlukla güvenlik limitlerini aştığı tespit edilmiştir. Bu durum, önceki zamanlarda benzine katılan kurşun nedeniyle olabileceği gibi aynı zamanda ölçüm için kullanılan analitik yöntemlerin hassasiyetlerinin düşük olmasıyla da ilişkilendirilebilmektedir. Yıllara göre azalmanın ise 2004 yılından sonra kurşunsuz benzin kullanılması, hava kalitesinin arttırılması için önemli tedbirlerin alınması ve aynı zamanda analitik yöntemlerin hassasiyetinin yükselmesi olarak yorumlanmıştır.
Anahtar Kelimeler: Ağır metal, Bitkisel, Bitki, Otoyol, Yol Kenarı, Kurşun, Türkiye

1.Introduction

Chemical substances form the core of our world for both the living systems and the environment. When they are produced, used and managed appropriately, chemicals take part in making things easy and benefit our everyday needs. However, in some circumstances, chemicals may also be a significant threat to the living systems and the ecosystem. In 2010, World Health Organization (WHO) published a report on ten chemicals or groups of chemicals considered as major public health concerns. WHO listed them as air pollution, arsenic, asbestos, benzene, cadmium, dioxin and dioxin-like substances, inadequate or excess fluoride, lead, mercury, and highly hazardous pesticides. As it is seen, there are several heavy metals on the list, including lead. (1)

Environmental pollution has been a primary global health concern since the early phases of the industry. This issue is getting more threatening and becoming much more critical day by day. Heavy metals are accepted as one of the primary sources of environmental pollution. Thanks to technological develoments, actions are being taken to diminish the hazardous effects of these pollutants by environmentally-friendly solutions, such as abandoning the use of lead in gasoline. (2)

Due to highly involvement of heavy metals in technological equipments, existence of them in living systems is inevitable. When the amount exceeds the acceptable ranges, they can be accumulated in organisms.

Heavy metal accumulation has become a predominant problem for the world, especially in developing countries, and it may cause several harmful effects on humans, animals, plant species, and the environment itself. (3) Contaminated soil can be a critical source for heavy metal exposure due to farming, agriculture, horticulture, and animal breeding. Moreover, roadside soils should also be considered a focus of attention because many people, especially in the rural regions, collect and consume plant substances growing on the roadside. Therefore, estimating the qualitative and quantitative content of harmful substances, particularly heavy metals in the soil, is a necessity. (4)

Heavy metal can be considered as the naturally occurring metallic elements with densities higher than 5 g/cm^3, equal to more than five times that of water, and relatively high atomic numbers. (2,5) Several definitions had been proposed for heavy metals. The Oxford English Dictionary indicates that the oldest definition in the scientific literature of heavy metal is 'those metals with an elemental density above 7 g/cm^3.' (6) More specific definitions have been published, but none of these have been widely accepted. Ali. H., & Khan, E defined heavy metals as naturally occurring metals having an atomic number greater than 20 and an elemental density greater than 5 g/cm^3. (6)

Heavy metal exposure result in toxicities and tissue damages with various symptoms. Toxic effects vary depending on several factors such as amount and route of exposure and personal characteristics like age, gender, hereditary characteristics, and eating habits of the exposed individual. (2, 5)

Heavy metal contamination is caused majorly by exhaust gases from industrial activities, motor vehicles, chemical and pharmaceutical manufacturings, and fertilizers and pesticides used for agricultural purposes, eventually leaking into the soil. The contamination of heavy metals in the soil is notable because of their non-biodegradable nature; they may persist in the soil for many years, ultimately causing their accumulation. Moreover, as the soil's heavy metal content increases, the amount taken by the plant also rises. (2,3) The United States Environmental Protection Agency (US EPA) and the International Agency for Research on Cancer (IARC) classify arsenic, cadmium, chromium, lead, and mercury as probable or known human carcinogens.

This study focused on the accumulation levels of lead throughout the years because of its high content in the roadside plants and soils. (5) Lead is naturally occurring in the environment and is one of the most important and commonly contaminated heavy metal. It has an atomic number of 82 and a molecular weight of 207.2 u. (5) According to the US EPA, lead is a naturally occurring element which is found at small amounts in the earth’s crust. It causes severe toxicities besides some beneficial impacts. (7)

People may be exposed to lead by inhaling the contaminated air droplets and dust particles, exhaling the household paintings, drinking contaminated water, or ingesting contaminated food such as vegetables grown in lead-contaminated soils. (5)

Lead shows its toxic effects by particular mechanisms after entering the systemic circulation in the body. It may interfere with the enzymes by binding their amide and sulfhydryl groups and inhibiting their action. It competitively binds to the sites of some essential elements like calcium, and alteres their activities. Also, it induces oxidative stress generating reactive oxygen species (ROS). Oxidative stress is widely known toxicity mechanism for its role in cellular damage. (5)

The central nervous system is the primary target for lead toxicity, which results in headaches, memory deficits, attention deficits, or confusions. Also, studies show that lead poisoning is reported to cause neurobehavioural and intelligence-related damages in children. Lead exposure is also a significant problem for pregnant women including possible preterm labor and post-natal complications in the child because it may cross the placental barrier. (5)

In this study, a literature review is conducted collecting data from a total of 25 studies regarding the lead accumulation in the roadside plants and soils from several different regions around Turkey between 2001 and 2020. Then, lead levels' changes through the years were examined, and possible reasons beneath them were ~~are~~ discussed.

2.Material and Method

In this study, 63 articles about heavy metal accumulation in plants and soil were scanned. All of the studies read about heavy metal accumulation included lead but other heavy metals varied. The study was focused on roadside plants and soil. Heavy metal, herbal, plant, highway, and roadside keywords were used while searching the articles. At first, articles from throughout the world were read, then narrowed down to studies from Turkey. After, articles that do not examine lead, not collected samples on the roadside, and not studied in Turkey were eliminated. 25 articles left to be put on the table. Table 1 shows lead accumulation in plants (fruit and leaves). Table 2 shows lead accumulation in soil. Tables 3 and 4 show Pb accumulation in parsley and *Rosmarinus officinalis* in order. These two plants were used because they had more data available. To make a correct comparison, we have to compare the same plants, since each plant species have their different bioaccumulation factors. To achieve a more accurate comparison, parsley and rosemary data were listed in different tables. Table 5 shows the exposure limits of five different natioanl and international authorities for lead including OSHA (Occupational Safety and Health Administration), NIOSH (National Institute for Occupational Safety and Health), WHO, ECHA (European Chemicals Agency), and the Ministry of Family, Labour and Social Services of Turkey. Permissible exposure limit of lead according to OSHA and NIOSH is 0.00005 ppm. (8) The safety limit of lead for soil and plants according to WHO are 85 and 2 ppm, respectively. (9) Occupational exposure limits of lead according to the Ministry of Family, Labour and Social Services of Turkey and ECHA are 0.00015 and 0.00003 ppm respectively. (10,11,12)

3.Results

3.1.Lead Accumulation in Roadside Plants

Table-1

During the research, a total of 60 results from different plants and places were collected. All plant data are listed in Table-1 according to the year. The safe level of lead in plants is 2 ppm according to WHO. Results varied in the range of 0.00 ppm to 866.0 ppm. 30% of plants were safe according to their lead level. Lead levels were higher in studies that were conducted in the early years. Before 2003, all data was higher than the safe limit. The highest values were found in a study conducted in 2002 in Elazığ, Turkey, and apple leaves had the most lead accumulated one. The second and third highest values were found in grape leaves, and parsley in the same study. The lowest values were found in Denizli, Turkey in 2010. In that study, researchers found 0.0 ppm accumulation in *Pinus nigra*.
The lethal dose of lead is 450 ppm in the lowest published data (36). Three of the 60 results collected were higher than the lethal dose. Lead values are mostly higher than 2 ppm but lower than the lethal dose.

3.2. Lead Accumulation in Roadside Soil

Table-2

During the research, 20 results were collected. All soil data are listed in Table-2 according to the year. The safe level of lead in the soil is 85 ppm according to WHO. Results varied in the range of 1.55 to 567.00 ppm. 55% of the samples were within the safe limit. The highest results were obtained in 2010 in Ankara, Turkey where the lowest value was found in 2006 in Edirne, Turkey.

3.3. Comparison of Lead Values in Parsley

Table-3

In Table-3, lead accumulation in parsley from different areas and dates are listed according to year. Four values were found. Values varied in the range of 0.95 ppm to 585 ppm. Fifty percent of these results are under the safe limit. After 2007 results are within safe limits even though results are from metropolises. The highest accumulation, in which lead accumulation was higher than the lethal dose, was seen in 2002 in Elazığ, Turkey.

3.4. Comparison of Lead in *Rosmarinus officinalis*

Table-4

In Table-4, accumulation in *Rosmarinus officinalis* leaves from different areas, and dates are listed according to year. Four values were found, and 2 of them were from the same study where they investigated differences in accumulation according to place (slope or refuge). Values varied in the range of 1.19 ppm to 10.01 ppm in which 25% of the collected data were under the safe limit. None of them were above lethal dose. The highest value was seen in 2014 in Hatay, Turkey in slope.

4.Discussion

Heavy metal accumulation is one of the primary health concerns in the world affecting millions of people and the ecosystem. Lead is a naturally occurring heavy metal that may accumulate within the soils and plant species through waste products and exhaust gases.

At the beginning of this study, articles on heavy metal accumulation in plants and soil were scanned. Then the study was limited to lead accumulation of roadside plants and soil. During the research, heavy metal, herbal, plant, highway, and roadside keywords were used. After finding the lead levels in plants and soil from various articles, the limit values of Turkish and International authorities were examined. Lead levels were evaluated with reference to the WHO data. Plants, which had more data, were made separate tables to make a more accurate comparison, with regards to their bioaccumulation factors.

In Table 1, accumulated lead values (ppm) for several plant samples from different locations are listed throughout the years with their safe limits and percentages.

All the lead values from the studies before 2003 exceeds the safe limits. This founding gave rise to thouht that this is probably resulting from the low sensitivity of the analytical methods using back then due to lack of the quality parameters of measurements. Analytical methods used for determining the heavy metal content in the plants can not be precise enough to give a correct measurement, eventually leading to inaccurate results.

On the other hand banning the use of lead in gasoline in 2004 had a positive impact on the accumulation rates, the lead content in the plant materials started to get generally diminished. This change may have resulted from both a more proper and accurate analytical system and the ban of lead in gasoline. However, results were still higher in metropolises and industrial cities.

Examining different studies conducted from diverse cities with different economic backgrounds and means of livings, it can be concluded that, in the industrially-developed cities, lead levels exceed the safe limits because of exhaust gases, heavy industry factories, waste products, and heavy traffic.

Also, the differences in the different plants' bioaccumulation factors affect the results, such as different accumulation rates of perennial and annual plants.

In Table 2, the lead contents in soil samples from the different regions around Turkey are listed through the years. Once again, lead content conducted from the studies of earlier years is much higher, probably because of the inaccuracy in the analytical methods and measurement systems. Also, mostly industrialized cities had exceeded the safe limits.

According to a study conducted in 2010, when lead accumulation in the highway soil is higher in Ankara compared to Bursa, the content in the central soil is more elevated in Bursa rather than Ankara. This contrast can result from the heavier traffic on the highways of Ankara and intense industrial activity in Bursa. As the capital, Ankara is the center for several routes, and lead can be quickly accumulated in the plants and soils near the highway. On the other hand, Bursa is a city known for its heavy industrial activity, especially the machinery industry. This industrialization is built up in the city center which may release high content of exhaust gases containing lead from the factories and cause accumulation in the central soil.

For Istanbul, lead contents were measured in the years 2008 and 2016, and we can see a significant decrease when comparing the results. Although the population has risen from 2008 to 2016 in Istanbul, which will also directly affect the heaviness of the traffic, the lead content in the soil is diminished from 191 ppm to 27.4-51.55 ppm. This change probably is due to the banning of lead from the use of gasoline in 2004. Even after the ban of lead in gasoline, lead levels in given data did not always decrease right away and took some time to be shown in the results. This indicates that it requires an amount of time to reduce the accumulation of lead in the soil.

In Table-3, lead levels in parsley samples conducted from the different regions of Turkey are listed. Earlier results seem to be much higher; this can be caused by improved measurement technologies and increased environmental awareness in the later years. For instance, the value measured in Elazığ in 2002 is within the lethal ranges. The cause of this high level may be explained with the technical problem or low sensitivity of methods or really high metal level.

According to data from 2006 and 2007, although samples were collected within almost the same year in Kayseri and İstanbul, lead accumulation in Istanbul is nearly one-tenth of Kayseri which may result from different industrial activities in those cities where Kayseri has a lot of heavy metal industrial applications releasing a high amount of solid waste to the environment.

In Table-4, Hatay has the highest values even though it is long after the ban of lead in gasoline. Air pollution can be the reason of this high amount. Also, the slope had higher accumulation than the refuge in Hatay. Mersin and Hatay are close cities geographically, and the accumulation rate is seen to be decreased from 2007 to 2014 which may be the result of unleaded gasoline use since 2004.

In conclusion, lead accumulation is a global concern which is also valid for Turkey. Although the soil and plant contents are generally decreasing as time passes, the environmental and health risks are still present. The banning of gasoline is one of the primary causes of reduced concentrations.

The studies conducted by far provide us an insight about the contamination status of lead in Turkey. The methods used for analyses can be more problematic in the earlier years due to lack of quality parameters of measurements in published studies; however, more accurate and precise results are given in recent studies. For a better analysis, further studies must be done, the concentration levels of lead should be followed more closely for different purposes, and researches can be widen for different areas of.

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Table 1: Lead level in different plants in different region of Turkey

Year	Sample	Pb level (ppm)	Pb in Portion (100 gram)	Safety Limits (ppm)	Percentage of safety limit (%)	Location	Reference
2001	*R. pseudo-acacia* (leaves)	72.69	7.27	2	3634	Denizli	Çelik, et.al, 2005
2002	Apple	180	18.0	2	9000	Elazığ	Bakirdere et.al, 2007
2002	Grape	213	21.3	2	10650	Elazığ	Bakirdere et.al, 2007
2002	Apple (leaves)	866	86.6	2	43300	Elazığ	Bakirdere et.al, 2007
2002	Grape (leaves)	547	54.7	2	27350	Elazığ	Bakirdere et.al, 2007
2002	Tomato	175	17.5	2	8750	Elazığ	Bakirdere et.al, 2007
2002	Bell pepper	139	13.9	2	6950	Elazığ	Bakirdere et.al, 2007
2002	Parsley	585	58.5	2	1170	Elazığ	Bakirdere et.al, 2007
2003	Grass	1.75	0.175	2	87.5	Konya	Onder et.al, 2007
2003	Lavender (flowers)	0.5	0.05	2	25	Western Anatolia	Divrikli et.al, 2006
2003	Laurel (root)	0.1	0.01	2	5	Western Anatolia	Divrikli et.al, 2006
2003	Chard (leaves)	0.2	0.02	2	10	Western Anatolia	Divrikli et.al, 2006

2003	Chard (root)	2.8	0.28	2	140	Western Anatolia	Divrikli et.al, 2006
2003	Lavender (leaves)	0.8	0.08	2	40	Western Anatolia	Divrikli et.al, 2006
2006	Parsley	9.9	0.99	2	495	Kayseri	Demirezen et.al, 2006
2006	Tomato	9.7	0.97	2	485	Kayseri	Demirezen et.al, 2006
2007	Cabbage	0.91	0.091	2	45.5	Istanbul	Osma et.al, 2012
2007	Parsley	0.95	0.095	2	47.5	Istanbul	Osma et.al, 2012
2007	Chard	0.99	0.099	2	49.5	Istanbul	Osma et.al, 2012
2007	*R.officinalis*	6,9	0.690	2	345	Mersin	Koç et.al, 2009
2008	Apple	2.21	0.221	2	110	Konya	Hamurcu et.al, 2010
2008	Cornelian	2.65	0.265	2	132	Konya	Hamurcu et.al, 2010
2008	Plum	2.82	0.282	2	141	Konya	Hamurcu et.al, 2010
2008	Rose	2.86	0.286	2	134	Konya	Hamurcu et.al, 2010
2009	*Pinus nigra*	0.35	0.035	2	17.5	Denizli	Keskin et.al, 2012
2010	*Pinus nigra*	0.00	0	2	0	Denizli	Keskin et.al, 2012

2012	Sweet cherry (leaves)	8.74	0.874	2	437	Aras Valley	Pehluvan et.al, 2015
2012	Sweet cherry (fruits)	1.75	0.175	2	87.5	Aras Valley	Pehluvan et.al, 2015
2012	Black mullberry (leaves)	3.48	0.348	2	174	Aras Valley	Pehluvan et.al, 2015
2012	Black mullberry (fruits)	1.62	0.162	2	81	Aras Valley	Pehluvan et.al, 2015
2012	White mullberry (leaves)	4.15	0.415	2	207	Aras Valley	Pehluvan et.al, 2015
2012	White mullberry (fruits)	2.15	0.215	2	107	Aras Valley	Pehluvan et.al, 2015
2012	Apricot (leaves)	10.23	1023	2	511	Aras Valley	Pehluvan et.al, 2015
2012	Apricot (fruits)	3.15	0.315	2	157	Aras Valley	Pehluvan et.al, 2015
2012	Plum (leaves)	15.47	1547	2	773	Aras Valley	Pehluvan et.al, 2015
2012	Plum (fruits)	3.42	0.342	2	171	Aras Valley	Pehluvan et.al, 2015
2012	Peach (leaves)	7.69	0.769	2	384	Aras Valley	Pehluvan et.al, 2015
2012	Peach (fruits)	3.15	0.315	2	157	Aras Valley	Pehluvan et.al, 2015
2012	Pear (leaves)	10.43	1043	2	52	Aras Valley	Pehluvan et.al, 2015
2012	Pear (fruits)	2.15	0.215	2	107	Aras Valley	Pehluvan et.al, 2015

2012	Hawthorn (leaves	8,67	0.867	2	433	Aras Valley	Pehluvan et.al, 2015
2012	Hawthorn (fruis)	3,1	0.31	2	155	Aras Valley	Pehluvan et.al, 2015
2012	Rosehip (leaves)	10,36	1,36	2	518	Aras Valley	Pehluvan et.al, 2015
2012	Rosehip (fruits)	2,85	0.285	2	142	Aras Valley	Pehluvan et.al, 2015
2012	Sweet cherry (leaves)	47,83806947	4,784	2	2392	Aras Valley	Pehluvan et.al, 2015
2012	*R.officinalis* (leaves)	1,19	0,119	2	59.5	Izmir	Çolak Esetlili et.al, 2014
2012	Parsley	1,14	0.114	2	57	Izmir	Çolak Esetlili et.al, 2014
2014	*P.coccinea*	8,94	0,894	2	447	Adana-Gaziantep Highway	Kirpik et.al, 2017
2014	*N.oleander*	4,86	0,486	2	243	Adana-Gaziantep Highway	Kirpik et.al, 2017
2014	*R.officinalis*	8,16	0.816	2	408	Adana-Gaziantep Highway	Kirpik et.al, 2017
2014	*R.officinalis* (refuge-stem)	9.48	0.948	2	474	Hatay	Bozdogan et.al, 2019
2014	*R.officinalis* (refuge-leaves)	9.70	0.97	2	485	Hatay	Bozdogan et.al, 2019
2014	*R.officinalis* (slope-stem)	11.21	1,121	2	560	Hatay	Bozdogan et.al, 2019

2014	*R.officinalis* (slope-leaves)	10.01	1.00	2	500	Hatay	Bozdogan et.al, 2019
2016	*Celtis australis* (leaves)	34	3.4	2	1700	Istanbul	Oztürk et.al, 2017
2017	Hollyhock (leaves)	2,59	0.26	2	129	Lake Van	Kaya et.al, 2018
2020	Pomegranate (fruits)	0.375	0.0375	2	18.75	Pirinçli Village-Siirt	Demirhan et.al, 2020
2020	Pomegranate (fruits)	0.351	0.0351	2	17.55	Kapılı Village-Siirt	Demirhan et.al, 2020
2020	Pomegranate (leaves)	0.614	0.0614	2	30.7	Pirinçli Village-Siirt	Demirhan et.al, 2020
2020	Pomegranate (leaves)	0.625	0.0625	2	31.25	Kapılı Village-Siirt	Demirhan et.al, 2020

Table 2: Lead level in soil samples in different places of Turkey

Year	Sample	Pb level (ppm)	Pb level in portion (100 gram)	Safety Limit	Percentage of safety limit (%)	Location	Reference
2001	Soil	336,55	33,66	85	395,9	Denizli	Çelik, et.al, 2005
2002	Soil	73	7,3	85	85,882	Tokat	Tüzen et.al, 2003
2002	Soil	26	2,6	85	30,588	Elazığ	Bakirdere et.al, 2007
2002	Soil	13,27730769	1,328	85	15.62	Elazığ	Bakirdere et.al, 2007
2003	Soil	2,6599	0.266	85	3,129	Konya	Onder et.al, 2007
2006-2007	Soil	1,55	0,16	85	1,82	Edirne	Aktaş et.al, 2010
2007	Soil	235,1	23,51	85	276,6	Bursa-Izmir Highway	Aydinalp et.al, 2010
2008	Soil	191	19,1	85	224,7	Istanbul	Guney et.al, 2009
2009	Soil	31.50	3,15	85	37,05	Eskişehir	Malkoc et.al, 2010

2009	Soil	1,72	0,172	85	2,02	Fatsa	Ozkutlu et.al, 2009
2010	Central soil	401	40,1	85	471,764	Ankara	Akbulut et.al, 2014
2010	Highway soil	567	56,7	85	667,05	Ankara	Akbulut et.al, 2014
2010	Central soil	442	44,2	85	520	Bursa	Akbulut et.al, 2014
2010	Highway soil	405	40,5	85	476,47	Bursa	Akbulut et.al, 2014
2012	Soil	124,36	12,436	85	146,305	Gümüşhane	Vural et al, 2013
2013	Soil	102,8514	10,285	85	121	Sakarya	Celenk et.al, 2015
2014	P.coccinea (soil)	33.70	3,37	85	39,647	Adana-Gaziantep Highway	Kirpik et.al, 2017
2014	N.oleander (soil)	25.56	2,556	85	30,07	Adana-Gaziantep Highway	Kirpik et.al, 2017
2014	R.officinalis (soil)	35.76	3,576	85	42,07	Adana-Gaziantep Highway	Kirpik et.al, 2017

2016	Soil	27,4-51,55	2,74-5,155	85	32,235-60,647	Istanbul	Ozturk et.al, 2017

Table 3: Lead level in parsley samples in different places of Turkey

Year	Pb level (ppm)	Pb level in portion (100 gram)	Safety Limit	Percentage of safety limit (%)	Location	Reference
2002	585	58.5	2	1170	Elazığ	Bakirdere et.al, 2007
2006	9,9	0.99	2	495	Kayseri	Demirezen et.al, 2006
2007	0.95	0.095	2	47,5	Istanbul	Osma et.al, 2012
2012	1,14	0.114	2	57	Izmir	Çolak et.al, 2014

Table 4: Lead level in *Rosmarinus officinalis* samples in different places of Turkey

Year	Pb level (ppm)	Pb level in portion (100 gram)	Safety Limit	Percentage of safety limit (%)	Location	Reference
2007	6,9	0.690	2	345	Mersin	Koc et.al, 2009
2012	1,19	0,119	2	59,5	Izmir	Colak et.al, 2014
2014	9.70	0.97	2	485	Hatay-refugee	Bozdogan et.al, 2019

2014	10.01	1,001	2	500,5	Hatay-slope	Bozdogan et.al. 2019

Table 5: Exposure limits of lead according to different national and international authorities

Exposure limits of lead (ppm)					
OSHA PEL	NIOSH REL	WHO		Ministery of Family, Labour and Social Services	ECHA
0.0005[a]	0.0005[b]	Soil 85[c]	Plant 2[d]	0.00015[e]	0.00003[f]

a. Permisible exposure limit of lead according to OSHA (Occupational Safety and Health Administration)
b. Recommended exposure limit of lead according to, NIOSH (National Institute for Occupational Safety and Health),
c. Safety limit of lead for soil according to WHO (World Health Organization),
d. Safety limit of lead for plants according to WHO (World Health Organization)
e. Occupational exposure limit of lead according to the Ministry of Family, Labour and Social Services of Turkey
f. Occupational exposure limit of lead according to ECHA (European Chemicals Agency).