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RESPONSE OF HEAVY METAL CONTENTS IN APRICOTS TO DIFFERENT TRANSPORTATION MODES

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ABSTRACT

In order to evaluate the effects of different transportation hubs on cultivated soil and apricots, macro and micro elements and heavy metal contents of fruit, leaf, kernel and soil samples collected from apricot orchards located at the border of the railroad, the motorway, the airport, and an orchard far from transportation modes were detected by ICP/OES (inductively coupled plasma / optical emission spectrometry). The results indicated the highest Cd, Pb and Ni contents of soil, fruit, and kernel samples under impacts of railroad transportation modes, whereas the highest contents of leaf were found under motorway side. All fruit samples contained higher amounts of Cd and Pb compared to permissible limits of FAO/WHO, and contents differentiated between sampling locations. There were no correlative relations found between transportation modes and macro-micro element contents. As a conclusion, in terms of heavy metal contamination, the orchards located at railway sides have the highest risk and this was followed by motorway side.

Key words: heavy metal, roadsides, modes of transportation, apricot

INTRODUCTION

The global world population increased rapidly and intends to be about 9.4 billion by 2050 [Lal 2001]. The rapid growth of the world population arose many environmental problems related to uncontrolled urbanization and industrialization [Yan et al. 2016]. Even though urbanization had been slow until the 1950s since then the process gained a rapid rising due to migrations from rural sites. The ratio between Turkish rural and urban population changed from 5.7 to 0.3 from 1950 to 2012, respectively [TUIK 2016]. One of the most important reasons for this striking change was developments and investments in the industry. Hence, the urban population increase became higher in industrially developed cities [Kapluhan 2014]. Turkey is a major producer of apricots in the world with respect to production area and its large share of income in Turkish national economy.

Industrialization is one of the main factors of rapid and also unorganized urbanization and source of heavy metal contamination in the environment. However, more important than industrial sources, transportation activities in the modes of the airway, rail-

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way, and motorway are the main sources of environmental contamination with heavy metals, which are known to have crucial toxic effects on human health. As the population grows, transportation activities increase and cities get wider, correspondingly agricultural production areas become more and more affected and surrounded by heavy metal contamination sources. Heavy metals are known to be significantly toxic to all living organisms and also for the humanity [O'Connell et al. 2008]. For that reason, contamination of fruits with heavy metals constitutes a serious threat to human health and also fruit quality [Kuno 1984, Sharma et al. 2008].

The apricot (*Prunus armeniaca* L.) is one of the most important fruits with a high nutritional value, and it has been cultivated for many years. Together with the apricot fruit, which is consumed both fresh and dry, its kernels are also used in many ways such as snacks, material for confectionery and pharmaceutical industries. Turkey is the top apricot producer country worldwide and particularly Malatya city provides more than half of the national production [TUIK 2016]. The city is surrounded by apricot production areas and even in the city center, it is possible to see apricot orchards. In this respect, Malatya constitutes a convenient example for the above-described situation of contaminated agricultural products with heavy metals, especially for apricots. There are many apricot orchards very close to airport, railroads, and motorways. In spite of the importance of apricot for Malatya and the increasing threats to its production areas, the fruit and apricot orchards have not yet been investigated in terms of heavy metal contamination.

For all those reasons, this study was conducted to examine the level of trace elements and heavy metal concentrations in soil, fruit, and leaf and kernel samples taken from apricot orchards close to the airport, railroad and motorway in Malatya region in Turkey.

MATERIALS AND METHODS

Sites description

The experimental sites were located at the border of the motorway, railroad, and airport. The airport (Malatya Airport) has been actively used since 1984 at the current location in Malatya, Turkey [DHMI 2017]. The study sites were established in nearly flat areas with the slope and elevation of 3–5%, and 750–850 m, respectively. The study sites were characterized by a continental climate having relatively warm, arid summers and cold, snowy winters with a mean annual air temperature of 1°C in winter and 25.8°C in summer, respectively. The mean annual precipitation is about 376.4 mm [MGM 2017].

Sampling and analysis

Soil, fruit, leaf and kernel samples were collected from one orchard located at the border of each transportation mode. Control samples were collected from an orchard located far from any transportation facility. A total of 3 replicated samples per sites were collected.

Soil samples were collected from 0–10 cm depths at all study sites using a push probe auger from orchards in summer of 2016. Soil samples were composited for each site and sieved and passed through 1 mm sieve pending analysis in 4°C until the analysis performed. Cultivars, tillage practices, and tree ages were standard in all sampled orchards. Fruit, leaf and kernel samples were collected from trees nearest to transportation mode. From each orchard, 50 fruits and their kernels and 200 leaves were sampled from different parts of three trees. Fruits were dried at ambient temperature and after drying, the seeds were separated from dried fruits. After separation of kernels, fruits were cleaned by drying at 65°C. Leaves were dried at 65°C.

All samples were analyzed in order to determine the contents of N, P, K, Ca, Mg, Na, Fe, Cu, Mn, Zn, B, Cd, Pb, and Ni. Samples weighing about 0.5 g were digested in concentrated HNO_3-H_2O_2 acid mixture (2 : 3, v/v) in three step (first step: 145°C, 75% radio-frequency power (RF), 5 min; second step: 180°C, 90% RF, 10 min and third step: 100°C, 40% RF, 10 min) in microwave (Berghof speedwave microwave digestion equipment MWS-2) [Mertens 2005a]. Contents of N, P, K, Ca, Mg, Na, Fe, Cu, Mn, Zn, B, Cd, Pb and Ni in collected samples were determined using an inductively couple plasma, optical emission spectrophotometer (Perkin-Elmer, Optima 2100 DV, ICP/OES, Shelton, CT 06484-4794, USA) [Mertens 2005b].

Standard stock solution (1000 mg L^{-1}) of each element was used for the preparation of standard solution in 2% HNO_3. The standard stock solution was diluted with 2% HNO_3 and the following concentrations were prepared (mg L^{-1}): 0, 5, 10, 20, and 40 for

N, P, K, Ca, Mg, Na; 0, 1, 3, 5 and 10 for Fe, Cu, Mn, Zn, B; 0.1, 0.3, 0.5, and 1.0 for Cd, Pb, and Ni. Blank solutions were prepared in the same media. Calibration ranges were adjusted for each element according to the expected concentration range. The precision of the method was evaluated using the relative standard deviation of repeated determinations of the analytes. Sensitivity of the method with respect to each metal was evaluated using the resulted slope of the calibration curves. The correlation coefficients for all curves (digest solutions and diluted samples) were more than 0.990.

Statistical analysis

Statistical analysis was performed to evaluate the impact of transportation modes on soil, fruit, leaf, and kernel properties. An estimate for the statistical significance among transportation modes was obtained using analysis of variance as explained by Püskülcü and İkiz [1989]. Transportation modes were considered as fixed effects and replications (3) as random effect. The differences among treatments were calculated at the significant level of $\alpha = 0.05$.

RESULTS

Macronutrients concentrations in soil, fruit, kernel, and leaf

Results of the present study including macro nutrients contents of fruit, leaf, kernel and soil are tabulated (Tab. 1). The observations under impact of airway on the nitrogen contents of soil (10.6 mg kg^{-1}) and kernel (16.4 g kg^{-1}) were the highest values reported whereas soil N content influenced by control (8.65 g kg^{-1}) and kernel N content affected by motorway (11.7 g kg^{-1}) were the lowest observations. The nitrogen content in the fruit as impacted by motorway transportation mode (14.4 g kg^{-1}) and affected by airway (13.2 g kg^{-1}) represented the highest and lowest values, whereas railway (28.7 g kg^{-1}) and control (22.1 g kg^{-1}) reported as highest and lowest observations for N content in the leaf.

Table 1. Macro-nutrients in the soil, fruit, leaf and kernel as influenced by transportation around airway, railway and motorway under apricot of Malatya, Turkey

	Samples	N**	P	K	Ca	Mg
Soil (mg kg^{-1})	Control	8.65 ±0.12*	12.7 ±0.47	8.91 ±0.31	64.90 ±2.8	3.26 ±0.12
	Airway	**10.6 ±0.69**	**13.7 ±0.7**	8.95 ±0.16	65.20 ±2.9	**3.31 ±0.05**
	Railway	9.55 ±0.29	12.8 ±0.45	**9.72 ±0.31**	66.20 ±4.5	3.24 ±1.54
	Motorway	9.52 ±0.48	13.0 ±0.19	8.45 ±0.20	**68.90 ±5.5**	3.24 ±0.12
Fruit (g kg^{-1})	Control	13.9 ±0.40	2.02 ±0.30	13.49 ±3.42	10.79 ±0.43	2.06 ±0.56
	Airway	13.2 ±1.10	1.64 ±0.67	11.66 ±1.63	17.29 ±5.59	**5.95 ±0.13**
	Railway	13.3 ±0.50	1.80 ±0.44	**13.80 ±3.85**	**17.49 ±6.29**	5.49 ±0.12
	Motorway	**14.4 ±2.10**	**2.65 ±1.35**	10.48 ±5.25	11.74 ±0.85	1.41 ±0.79
Leaf	Control	22.1 ±0.80	2.30 ±0.15	22.90 ±3.09	21.50 ±9.36	5.07 ±4.28
	Airway	23.8 ±3.60	2.75 ±0.36	28.88 ±0.60	**26.46 ±9.76**	**8.74 ±0.14**
	Railway	**28.7 ±2.70**	**3.23 ±0.33**	16.64 ±11.03	14.86 ±1.69	1.95 ±1.39
	Motorway	28.0 ±2.00	2.86 ±0.31	**30.14 ±0.48**	21.75 ±9.17	6.74 ±3.62
Kernel	Control	15.1 ±0.40	1.80 ±0.21	16.58 ±0.54	18.20 ±5.86	**4.54 ±2.35**
	Airway	**16.4 ±3.70**	2.13 ±0.45	15.99 ±5.06	16.88 ±6.53	4.21 ±2.48
	Railway	15.6 ±3.30	**2.51 ±0.59**	**22.34 ±3.11**	**20.45 ±13.27**	4.12 ±0.77
	Motorway	11.7 ±0.50	1.87 ±0.30	12.97 ±2.78	20.49 ±6.16	3.99 ±2.05

* Mean values followed by standard deviations within each soil, fruit, leaf and kernel represent significant differences due to each transportation modes at $P < 0.05$

** N − nitrogen content; P − phosphorus content; K − potassium content; Ca − calcium content, and Mg − magnesium content

The data reported that soil phosphorus content under impacts of airway (13.7 mg kg^{-1}) revealed the highest values compared to those under motorway (13.0 mg kg^{-1}), railway (12.8 mg kg^{-1}) and control (12.7 mg kg^{-1}). However, airway (1.64 g kg^{-1}) was the least impacted on fruit phosphorus content, whereas motorway (2.65 g kg^{-1}) represented to be most affected. The phosphorus content as impacted by railway (3.23 g kg^{-1}, leaf; 2.51 g kg^{-1}, kernel) was highest observations, whereas those under control (2.30 g kg^{-1}, leaf; 1.80 g kg^{-1}, kernel) were lowest.

The potassium content in the soil, fruit, and kernel was impacted by railway (9.72 mg kg^{-1}, soil; 13.80 g kg^{-1}, fruit, and 22.34 g kg^{-1}, kernel) most and by motorway (8.45 g kg^{-1}, soil; 10.48 g kg^{-1}, fruit, and 22.34 g kg^{-1}, kernel) least. However, the potassium content under impacts of railway (16.64 g kg^{-1}) was lowest values, whereas those under influences of motorway (30.14 g kg^{-1}) represented the highest observations in the leaf.

Secondary element contents of fruit, kernel, leaf and soil

Soil calcium content under impacts of motorways (68.90 mg kg^{-1}) was higher compared to those under impacts of railway (66.20 mg kg^{-1}), airway (65.20 mg kg^{-1}) and control (64.90 mg kg^{-1}) by 4.1%, 5.6%, and 6.1%. The calcium concentrations of the fruits under influences of railway (17.49 g kg^{-1}) were the highest observations compared to those due to airway (17.29 g kg^{-1}), motorway (11.74 g kg^{-1}) and control (10.79 g kg^{-1}). Moreover, the calcium concentrations in the kernel under influences of railway (20.45 g kg^{-1}) were also highest observations in comparison to those under motorway (20.49 g kg^{-1}), control (18.20 g kg^{-1}) and airway (16.88 g kg^{-1}) influences. However, the railway (14.86 g kg^{-1}) the least impacted the leaf calcium concentrations compared to those under control (21.50 g kg^{-1}, 30.88%), motorway (21.75 g kg^{-1}, 31.67%) and airway (26.46 g kg^{-1}, 43.80%).

Magnesium contents under impacts of airway were the highest observations in soil (3.31 mg kg^{-1}), fruit (5.95 g kg^{-1}), leaf (8.74 g kg^{-1}), but not kernel (4.21 g kg^{-1}), whereas the lowest observations were monitored under impacts of motorway (3.24 mg kg^{-1}, soil; 1.41 g kg^{-1}, fruit; and also 3.99 g kg^{-1}, kernel), and railway (1.95 g kg^{-1}, leaf). Magnesium concentrations under airway were higher by 2.2% in the soil, 3.22 times in the fruit and 4.48 times in the leaf than the lowest observations, whereas magnesium content in the kernel was 13.78% higher under control than lowest observation.

Micro-nutrients concentrations in soil, fruit, kernel, and leaf

The soil, fruit, leaf and kernel micro-nutrient concentrations under impacts of different transportation modes are reported on Table 2. Soil sodium (Na) was significantly impacted by airway (0.85 mg kg^{-1}) compared to those under influence of railway (0.81 mg kg^{-1}), control (0.81 mg kg^{-1}) and motorway (0.76 mg kg^{-1}). A similar trend was observed for fruit Na content. However, all treatments negatively impacted the leaf Na concentrations. The lowest values were monitored under effects of motorway (1011 mg kg^{-1}) in comparison to airway (1044 mg kg^{-1}), railway (1082 mg kg^{-1}) and control (1101 mg kg^{-1}). Kernel Na content under impacts of railway (904 mg kg^{-1}) was higher than those under effects of airway (775 mg kg^{-1}, by 16.65%), motorway (667 mg kg^{-1}, by 35.53%) and control (633 mg kg^{-1}, by 42.81%).

Soil iron (Fe) content under impacts of railway (4.64 mg kg^{-1}) was higher than those under airway (4.58 mg kg^{-1}), motorway (4.53 mg kg^{-1}) and control (4.32 mg kg^{-1}). Similar trends were represented for fruit and kernel Fe content. However, all treatments negatively affected the leaf Fe content compared to the control. The lowest value under railway (169 mg kg^{-1}) was 3.40%, 5.05%, and 9.62% lower than those under motorway (175 mg kg^{-1}), airway (178 mg kg^{-1}) and control (187 mg kg^{-1}).

The soil copper (Cu) content under influence of railway (5.43 mg kg^{-1}) was the highest observations, whereas that under motorway (5.15 mg kg^{-1}) was the lowest. A similar trend was represented for leaf Cu content except from leaf Cu content under airway (21.73 mg kg^{-1}), which was the lowest. The fruit and kernel Cu contents were represented as highest observed values under impacts of control (23.41 mg kg^{-1}, fruit; 21.60 mg kg^{-1}, kernel), whereas the lowest were under railway (15.20 mg kg^{-1}) for fruit Cu content and motorway (13.92 mg kg^{-1}) for kernel Cu content.

Table 2. Micronutrients for the soil, fruit, leaf and kernel as influenced by transportation around airway, railway and motorway under apricot of Malatya, Turkey

	Samples	Na**	Fe	Cu	Mn	Zn	B
Soil ($mg\ kg^{-1}$)	Control	0.81 ±0.07*	4.32 ±0.23	5.37 ±0.12	6.18 ±0.37	**3.89 ±0.40**	0.26 ±0.02
	Airway	**0.85 ±0.05**	4.58 ±0.20	5.38 ±0.26	6.33 ±0.19	3.51 ±0.17	0.25 ±0.03
	Railway	0.81 ±0.09	**4.64 ±0.08**	**5.43 ±0.1**	**6.59 ±0.15**	3.71 ±0.05	0.25 ±0.05
	Motorway	0.76 ±0.07	4.53 ±0.18	5.15 ±0.56	6.47 ±0.17	3.39 ±0.22	**0.28 ±0.05**
Fruit ($mg\ kg^{-1}$)	Control	598 ±60	65 ±11.2	**23.41 ±10.6**	14.87 ±2.66	**26.43 ±3.7**	**13.75 ±2.64**
	Airway	**709 ±46**	85 ±5.14	18.01 ±1.84	23.18 ±4.27	21.65 ±2.4	9.52 ±5.19
	Railway	584 ±69	**87 ±7.32**	15.20 ±2.08	**36.39 ±16.5**	19.6 ±2.97	7.16 ±6.65
	Motorway	592 ±125	66.6 ±6.5	19.57 ±4.07	33.41 ±14.9	23.82 ±2.01	9.63 ±3.51
Leaf ($mg\ kg^{-1}$)	Control	**1101 ±115**	**187 ±59**	30.36 ±0.49	41.82 ±45.8	38.50 ±5.56	20.14 ±2.2
	Airway	1044 ±37	178 ±13	21.73 ±8.19	**50.86 ±19.1**	33.93 ±10	16.32 ±5.95
	Railway	1082 ±70	169 ±26	**35.07 ±9.26**	23.15 ±7.71	**48.41 ±3.37**	21.26 ±3.85
	Motorway	1011 ±108	175 ±45	27.16 ±11.5	45.04 ±28.7	44.99 ±14.1	**24.86 ±10.5**
Kernel ($mg\ kg^{-1}$)	Control	633 ±82	83 ±15	**21.60 ±11**	40.95 ±25.2	23.37 ±8.93	7.22 ±4.06
	Airway	775 ±171	108 ±32	19.54 ±7.43	29.20 ±20.5	25.82 ±7.4	**12.55 ±8.23**
	Railway	**904 ±129**	**120 ±41**	18.53 ±3.34	**57.99 ±15.9**	**26.27 ±6.52**	10.19 ±3.41
	Motorway	667 ±73	74 ±3.7	13.92 ±1.61	33.54 ±6.75	20.28 ±0.69	5.51 ±0.88

* Mean values followed by standard deviations within each soil, fruit, leaf and kernel represent significant differences due to each transportation modes at $P < 0.05$

** Na − sodium content, Fe − iron content, Cu − cupper content, Mn − manganese content, Zn − zinc content and B − boron content

The values for manganese (Mn) concentrations were significantly impacted by railway (6.59 mg kg^{-1}, in soil; 36.39 mg kg^{-1}, in fruit; and 57.99 mg kg^{-1}, in kernel) for soil, fruit and kernel, whereas the least values were represented under impacts of control (6.18 mg kg^{-1}, in soil and 14.87 mg kg^{-1}, in fruit) for soil and fruit, but under airway (29.20 mg kg^{-1}) for kernel. The highest observations were represented under impacts of airway (50.86 mg kg^{-1}), which was 12.92% higher than those under motorway (45.04 mg kg^{-1}), 21.62% than those under control (41.82 mg kg^{-1}) and 1.20 times than those under impacts of railway (23.15 mg kg^{-1}).

The soil zinc content (Zn) under control (3.89 mg kg^{-1}) was higher than those under railway (3.71 mg kg^{-1}), airway (3.51 mg kg^{-1}) and motorway (3.39 mg kg^{-1}). A similar trend was represented for fruit Zn content. However, the highest zinc contents for leaf and kernel were represented under railway (48.41 mg kg^{-1}, leaf, and 26.27 mg kg^{-1}, kernel), whereas the lowest values were represented under airway (33.93 mg kg^{-1}) for the leaf and under motorway (20.28 mg kg^{-1}) for the kernel.

The soil boron (B) content under motorway (0.28 mg kg^{-1}) was higher than those under railway (0.25 mg kg^{-1}), control (0.26 mg kg^{-1}) and airway (0.25 mg kg^{-1}). A similar trend was represented for leaf B content. However, fruit B content under control (13.75 mg kg^{-1}) was 42.78%, 44.43% and 92.04% higher than those under motorway (9.63 mg kg^{-1}), airway (9.52 mg kg^{-1}), and railway (7.16 mg kg^{-1}). Moreover, airway (12.55 mg kg^{-1}) impacted the kernel B content most, whereas motorway (5.51 mg kg^{-1}) influenced the least.

Heavy metal contents of soil, fruit, kernel, and leaf

The soil, fruit, leaf and kernel cadmium (Cd) concentrations under impacts of different transportation modes are reported on Figure 1. Soil, fruit and kernel Cd concentrations were highest impacted by railway (0.017 mg kg^{-1}, soil; 4.45 mg kg^{-1}, fruit; and 9.99 mg kg^{-1}, kernel). The least impacted Cd contents under transportation modes were represented by the control

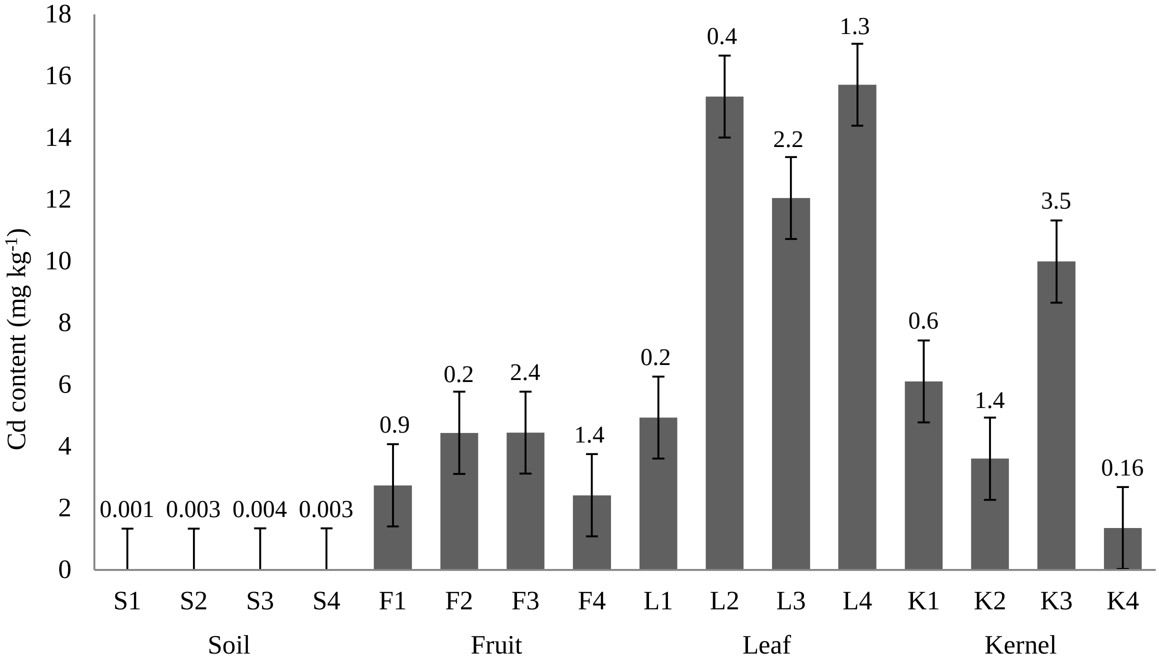

Fig. 1. Cd contents for the soil, fruit, leaf and kernel as influenced by transportation around airway, railway and motorway under apricot of Malatya, Turkey (S1, F1, L1, K1 − control; S2, F2, L2, K2 − airway; S3, F3, L3, K3 − railway; S4, F4, L4, K4 − motorway)

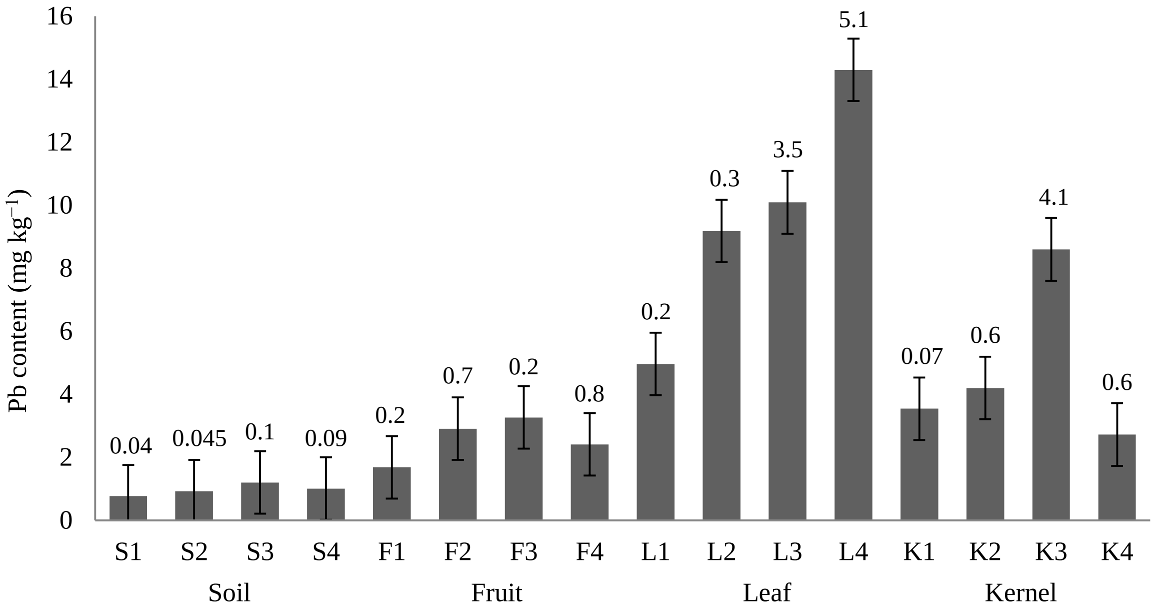

Fig. 2. Pb contents for the soil, fruit, leaf and kernel as influenced by transportation around airway, railway and motorway under apricot of Malatya, Turkey (S1, F1, L1, K1 − control; S2, F2, L2, K2 − airway; S3, F3, L3, K3 − railway; S4, F4, L4, K4 − motorway)

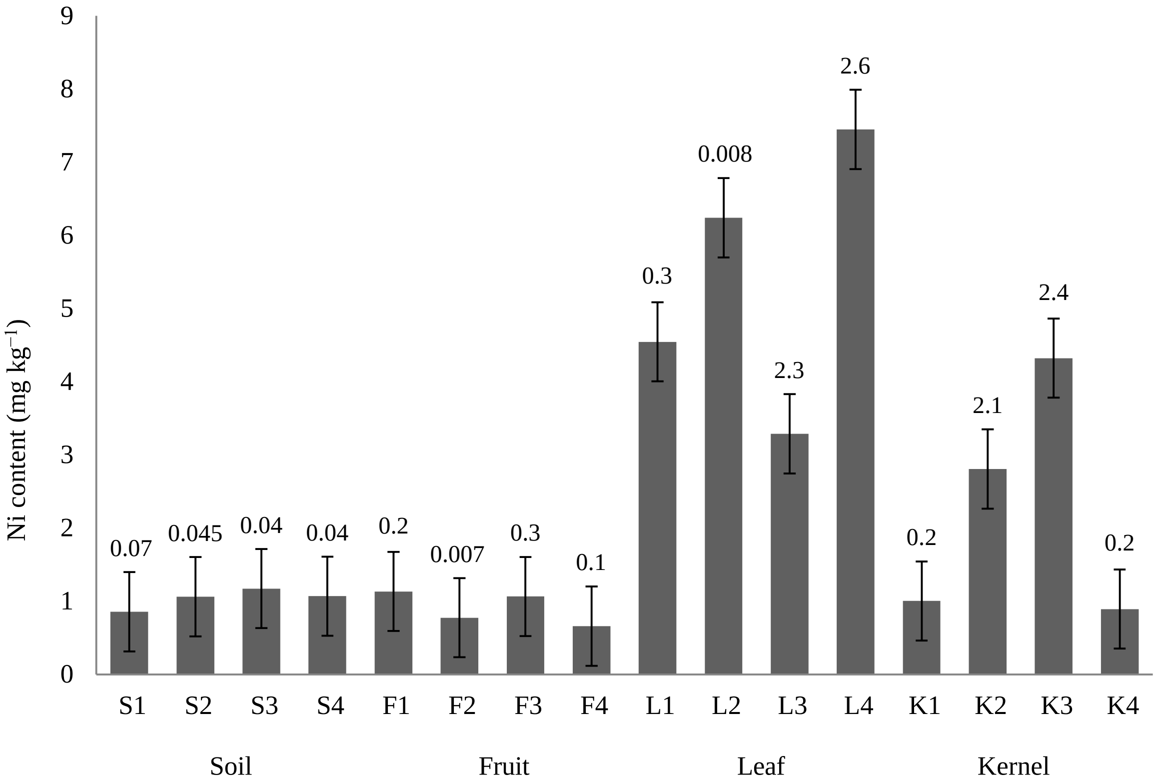

Fig. 3. Ni contents for the soil, fruit, leaf and kernel as influenced by transportation around airway, railway and motorway under apricot of Malatya, Turkey (S1, F1, L1, K1: control; S2, F2, L2, K2: airway; S3, F3, L3, K3: railway; S4, F4, L4, K4: motorway)

(0.003 mg kg^{-1}, soil and 4.93 mg kg^{-1}, leaf) for both soil and leaf, but not fruit (lowest values, 2.74 mg kg^{-1} under motorway) and kernel (lowest value, 1.35 mg kg^{-1} under motorway). Leaf Cd content under motorway (15.71 mg kg^{-1}) was highest value, whereas it was 2.5%, 30.42%, and 2.19 times higher than those under impacts of airway (15.33 mg kg^{-1}), railway (12.049 mg kg^{-1}) and control (4.93 mg kg^{-1}). Similar trends were observed for soil, fruit, leaf and kernel lead (Pb) contents (Fig. 2). The soil, fruit, leaf and kernel nickel (Ni) concentrations under impacts of different transportation modes are reported on Figure 3. The soil Ni content under impacts of railway (1.17 mg kg^{-1}) was higher than those under motorway (10.07 mg kg^{-1}), airway (1.06 mg kg^{-1}) and control (0.86 mg kg^{-1}) by 9.60%, 10.35%, and 36.71%. Similar trends were represented for fruit and kernel Ni content. However, motorway most impacted on the leaf Ni content compared to those under airway (6.24 mg kg^{-1}), control (4.55 mg kg^{-1}), and railway (3.29 mg kg^{-1}).

DISCUSSION

Macro-element contents of fruit, kernel, leaf and soil

Apricot (*Prunus armeniaca* L.) is one of the most important fruits with a high nutritional value, that has been cultivated for many years. Impact of different transportation hubs resulted in significant increase in soil nitrogen, phosphorus, and potassium concentrations, whereas higher impacts of airway was monitored for N concentrations in soil and kernel and also P concentration in the soil only. However, accumulation of N in the leaf was monitored under impacts of railway and motorway, whereas insignificant differences were observed in the fruit. Air contains 80% nitrogen, but macronutrients are most often limiting factors. Nitrogen is the mineral that the plant can get only from microbial reactions. Nitrogen fixation is an example that is the conversion of N_2 in air to NH_3 by microbial organisms. Therefore, transportation modes impact on the soil and crop N contents due to their impact on soil microbial reactions are important [Park et al. 2010].

Parallel of these observations, it was revealed that railway transportation mode increases the soil P content in the leaf, kernel and fruit in comparison to other transportation hubs. The differences in soil P concentrations showed that P was not taken by crops and fruits under airway impacts, whereas railways had more impacts on P uptake by crops.

Result of the present study reported that airway transportation hubs had significant impact on secondary nutrients (Ca and Mg) except from soils under motorway impacts showing higher values compared with other transportation means. Results of present study indicate that soil and crop under impacts of airway had higher accumulation of Ca and Mg, whereas uptake of Ca by crops was lower under impact of motorways. Some macro-micro elements and heavy metal contents in apple, cornelian, plum and rosa fruits under influence of roadsides in different regions of Turkey were examined by Hamurcu et al. [2010] and they indicated similar results to current study.

Micro-element contents of fruit, kernel, leaf and soil

In the current study, airway impacts on soil and crop Na contents were significantly higher than those under impacts of other transportation modes, except there were not any significant differences in Na content of leaf (Tab. 2).

All fruit Fe and Mn concentrations in the present study were within the international standards; however, fruit Cu contents were higher than the international standards. Leftover total heavy metal concentrations in the soil may cause toxicity for crops [Li et al.2007]. The maximum legitimate limits of international standards are within 425 mg/kg and 500 mg/kg for Fe and Mn according to FAO/WHO [2011], 10.00 mg/kg for Cu according to FAO/WHO [1994], 8 mg/kg for Cu according to Davidescu et al. [1988] and Ozkutlu [2009]. Even though, the maximum legitimate limits of national standards are 5 mg/kg for Cu concentration according to Turkish Food Codex [2002]. There is not any information about Mn levels in soil. According to Paschke et al. [2005], phytotoxicities of soil have generally been related to 41.53–120.03 mg kg^{-1} of total Mn and to 60–125 mg kg^{-1} of total Cu [Ross 1994]. In detail, impacts of railroad transportation hubs significantly increased Fe, Cu and Mn concentration of the soil, kernel and fruit compared to other transportation modes and control. However, there were not any significant impacts from transportation modes on leaf Fe, Cu and Mn concentrations. In addition, soil, apricot leaf and apricot fruit heavy metal contents were different under impacts of different transportation hubs. Pehluvan et al. [2015] also supported these findings according to a study focused on impacts of different transportation modes on apricot production.

Data of present study stated that railroad transportation mode was significantly effective on leaf and kernel zinc content. However, any of these transportation modes did not show significant differences in terms of soil and fruit zinc concentrations. The additional concentration of soil Cd, Cu, Zn and Ni is a reason of inhibition in growth [Kuno 1984]. In addition, only significant impacts on soil B content was monitored under impacts of airway hubs for kernel B content. The maximum tolerable level of soil available Zn is 43 mg kg^{-1} [Davidescu et al. 1988, Ozkutlu 2009]. However, there is not any information about national standards of Zn, Mn, Co or Cr levels in fruit in Turkey. In the present study, the fruit Pb and Ni concentration went beyond maximum permissible limits referring Turkish standards limits of Food Codex. Liu et al. [2009] studies upon surface soil Cu, Mn, Pb, Zn, Cd concentrations from three certain distances to railroad track reported that a decline in heavy metal concentrations were equal with the distance from the track in Sichuan, China. Morton-Bermea et al. [2009] also supported the investigations of present study by reporting surface soil heavy metal contents with an enhancement of Pb, but not Ni, closer to the airport.

Heavy metal contents of fruit, kernel, leaf and soil

Heavy metals are well documented to be significant hazard to fruit quality [Kuno 1984, Sharma et al. 2008] and toxic to biodiversity and humanity [O'Connell et al. 2008]. Under these considerations, apricot is a suitable instance of heavy metal contaminated agricultural products in Malatya. Thus, the present study focused on to determine the soil, fruit, leaf, and kernel heavy metal concentrations under influences of the airport, railroad and motorway in this region. Growth media, nutrients, agro inputs, pesticides, chemical fertilizers, composts, and wastewater supply are some of the conditions that may influence the soil and crop heavy metal contamination. However, emissions from transportation modes are major components for present study to aim determination of their impacts on heavy metal contamination.

Hamurcu et al. [2010], Nookabkaew et al.[2006] and Arnaudova [2003] reported higher concentration of trace elements and heavy metals in leaves and fruits in comparison to those in edible parts. Data from the present study indicates significant impact of railroad transportation hubs on soil, fruit, and kernel Cd, Pb, and Ni concentrations, whereas motorway significantly impacted on the increase in Cd, Pb, and Ni concentration of leaves. Pehluvan et al. [2012] reported a study on mulberry production and cultivated soils indicating high pollutions due to accumulation of Cd, Pb, Cu, Mn and Zn heavy metals under impacts of different distances from roads.

The maximum permissible Ni concentration for foods were determined as 10 mg/kg according to SEPA [2005]. According to these standards, results of the present study were found within the safe limits. FAO/WHO expressed the maximum permissible level of foods Cd and Pb concentration as 0.05 and 0.1 mg/kg [FAO/WHO 1995]. It has been reported that the Pb, even at low amounts, is toxic and may be carcinogenic for human metabolism [Trichopoulos 1997]. Also, results of present study indicated comparable outputs with those previously reported [Kumar and Soni 2007, Duran et al. 2008, Ozkutlu 2009, Hamurcu et al. 2010].

In general, Cd and Pb as part of heavy metals, indicate greater densities than 5 mg/kg [Khan et al. 2008, Oves et al. 2012] and when they are dissolved in the water, soil and air, crops can bio-accumulate them [Fu et al. 2008, Xiu-Zhen et al. 2009] causing potential risk of exposure. For instance, bio-accessible Pb makes a potential risk exposure, which indicates lead contamination in urban soils owing to its interactions and absorption by organisms [Obrycki et al. 2016]. Other examples were also well documented by previous studies on soil heavy metal pollution [Fu et al. 2008, Li et al. 2014, Yu et al. 2012]. The potential risk of heavy metal accumulation in soils, crops, and fruits is crucial to monitor and minimize even if it is in small amount. It is realistic to assume the potential health risk of high heavy metal accumulation [Pan et al. 2016].

CONCLUSIONS

The highest heavy metal contents of soil, fruit, and kernel samples were found under impacts of railroad transportation modes, whereas the highest contents of leaf were found under motorway transportation mode. Fruit Cd, Pb, and Ni contents differentiated between sampling locations. There were no correlative relations between transportation modes and macro-micro element contents. This suggests that the contents of those elements in soil, fruit, leaf and kernel are independent of transportation activities. According to the results, it was concluded that in terms of heavy metal contamination, the orchards located at railway sides have the highest risk and this was followed by motorway side.

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