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DETERMINATION OF THE EFFECT OF DISTANCE TO HIGHWAY ON THE ACCUMULATION OF SOME HEAVY METALS IN APPLE ORCHARDS

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Abstract
In this study, which was carried out in Yeşilhisar/Kayseri, it was aimed to determine the heavy metal accumulation in soil, leaves and fruits in apple orchards located on the Kayseri-Niğde highway. In the study carried out in 2021, samples were taken from rows 0, 100 and 200 meters from the highway in orchards at 3 different locations. According to the results of the study, Aluminum (Al), Cadmium (Cd), Cobalt (Co), Chromium (Cr), Nickel (Ni) and Lead (Pd) contents of the samples at 0 meters distance from the road in the orchards were higher than those at 100- and 200-meters distance. A similar trend was observed between samples at 100 meters distance and samples at 200 meters distance. In general, it was determined that Al content was higher in leaf sample, Cr content was higher in fruit sample, and other metals were higher in soil sample. Element contents in fruit sample were listed as Al > Pd > Ni > Co > Cr > Cd. Although fruit sample at 0 meters from the highway accumulate higher heavy metal elements than at other distances, they are still within acceptable limits. The results obtained can give an opinion on the new orchard establishment, especially in the lands close to the highways.

Keywords: apple, fruit, heavy metals, highway.

1. INTRODUCTION

Türkiye has an important position in terms of fruit growing due to its different climatic and soil conditions (Ercisli, 2004). An important part of fruit species and varieties can be grown commercially in Türkiye (Yıldız and Perdahçı, 2019). Apple (*Malus communis* L.), one of these fruit species, has spread over wide areas around the world and can easily adapt to many regions. Due to the suitable ecology of Anatolia, it has allowed the apple production amount to be high and the cultivation regions to be widespread (Kaşka, 2001). In Türkiye, apple cultivation is leading in Isparta, Karaman, Niğde, Antalya, Kayseri, Denizli and Çanakkale. These provinces make up 68% of our country's apple production. In general, apple cultivation is carried out intensively in the transition areas between the Black Sea coastal region and the Central Anatolia and Eastern Anatolian plateaus and in the lake's region in the south in recent years (TUİK, 2021).

One of the biggest problems of today is environmental pollution, which increases in parallel with technology and negatively affects life. Elements that make up the environment such as soil, water, and air; It is polluted by the effects of plants and animals, especially humans. Toxic heavy metals have become an important issue in recent years due to the potential risk they may pose on living

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things. Industrial activities, exhaust gases of motor vehicles, mineral deposits and operations, volcanic activities, fertilizers, and pesticides used in agriculture and urban wastes are some of the factors that cause heavy metals to spread to the environment (Kılınç, 2006). Soil pollution factors caused by heavy metals threaten food safety, pose a risk, and deteriorate soil flora and soil composition. It causes a decrease in microorganisms and earthworms in the soil, and a decrease in the biotic ability of the soil (Çağlarırmak and Hepçimen, 2010).

Industrial activities, motor vehicle exhausts, mineral deposits and operations, volcanic activities, fertilizers, and pesticides used in agriculture, and urban wastes are the leading factors that cause heavy metals to spread to the environment (Stresty and Madhava Rao, 1999). Continuous and usage-related pollution causes quite a lot of heavy metal content and density in the environment. As a result of this density, the plants found in nature are adversely affected and the products obtained are extremely dangerous in terms of health. In Türkiye, Ekinci-Kulu (2006) in Kemalpaşa/İzmir, Hamurcu et al. (2010) in Konya, Pehluvan et al. (2015) in the Aras Valley, Dağ (2015) in Aydın, and Pehlivan (2016) in the region between Trabzon and Giresun city centers, it has been reported that heavy metal accumulation in some fruit species and varieties is at levels that threaten health. In this respect, the fact that the western border of the Develi Plain, where 90% of apple cultivation is carried out in Kayseri, is formed by the Kayseri-Niğde highway and that there are orchards in the direction of this road brings along concerns. In this study, it was aimed to reveal the presence of a heavy metal-induced risk or contamination in apple trees located at different distances (0 m, 100 m, and 200 m) from the highway in apple orchards.

2. MATERIALS AND METHODS

The study area is in the Develi Plain, which is formed on a volcanic layer spread out by the volcanic movements of Mount Erciyes and has an area of approximately 1000 km², located in the southwest of this mountain. The plain, which is one of the widest plains of the Upper Kızılırmak region, has an east-west length of 30 kilometers between Develi-Yeşilhisar districts, and a north-south length of 32-33 kilometers between Develi-Yahyalı districts. The study was carried out in apple orchards in 3 different locations on the Kayseri-Niğde highway, which is approximately 40-45 km long, forming the western border of the plain (Figure 1). In the orchards located on the highway, rows at different distances (0 m, 100 m, and 200 m) were used, and soil, leaf and fruit samples were collected from these areas. The sampled orchards are located on the highway, approximately 32 km between the junction of Incesu district and Yahyalı district.

Soil, leaf, and fruit sampling from apple orchards on the Kayseri-Niğde highway was carried out in September 2020. In the study, the relevant rows at 0, 100 and 200 m distances parallel to the highway were used in each orchard. A total of 6 trees in the rows were taken as a basis for sampling, and each 2 tree was considered as a replication.

While the soil sample was taken from 0-30 cm depth within the tree crown projections, the leaf sample was taken as 20-25 leaves from the completed leaves on the fruitless shoots, and the fruit sample was taken as 10 fruits in total from each side of the trees.

Soil samples taken from the orchards were air-dried and sieved with 2 mm sieves. All samples taken are kept in glass jars with screw caps in the laboratory environment. Heavy metals such as Aluminum (Al), Cadmium (Cd), Cobalt (Co), Chromium (Cr), Nickel (Ni) and Lead (Pd) extractable with DTPA of soil samples were determined in the ICP-OES device in the filters obtained (Lindsay and Norvell, 1978).

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Leaf and fruit samples were washed with distilled water, dried in an oven at 65-70 ^{o}C until constant weight. The samples were ground to be less than 0.5 mm in size. The samples were thawed by dry combustion method (Kacar and Katkat, 2010) and heavy metal concentration of the samples were read in the ICP-OES instrument (Kacar and İnal, 2008).

Figure 1. Satellite image of the research areas (source: earth.google.com)

Data Analysis

Analysis of variance was applied to the obtained data in accordance with the Random Plots Trial design and the differences between the averages were determined at the 5% significance level according to the Tukey test.

3. RESULTS AND DISCUSSIONS

This study was conducted in the Develi Plain in which apple cultivation is mainly carried out in Kayseri (90 %of production). In this study, sampling was made to reveal the presence of heavy metal-based risk or contamination in the apple trees at different distances (0 m, 100 m, and 200 m) to the Kayseri-Niğde highway, which constitutes the western border of the plain. At the end of the trial, the data obtained for heavy metal contents are presented in Table 1. As can be seen from the table, the heavy metal content detected in the samples taken from different distances was statistical importance.

While the effect of distance on Al and Ni contents in soil samples was statistically insignificant, it was found significant on other parameters. The all-heavy metal contents of the soil samples at 0 meters distance from the road in the orchards were higher than those at 100- and 200-meters distance. A similar trend was also observed between the heavy metal contents of soil samples at 100 meters, except for Cr and Ni contents, and the heavy metal contents of soil samples at 200 meters.

The effect of distance on all heavy metal contents in leaf samples was statistically significant. In general, the heavy metal contents (except for Cd) of leaf samples at 0 meters distance from the road in the orchards were found to be higher than at other distances. On the other hand, Al, Co, Cr and

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Pb contents of leaf samples at 100 meters distance and 200 meters distance were found to be statistically similar.

Table 1. ***Heavy metal content (mg/kg) of soils, leaves and fruits sampled from different distances***

Sample	Distance	Al	Cd	Co	Cr	Ni	Pb
Soil	0 m	0.23	0.07 a(1)	0.40 a	0.02 a	0.70	1.33 a
	100 m	0.21	0.05 ab	0.35 ab	0.01 b	0.56	1.13 b
	200 m	0.19	0.03 b	0.27 b	0.01 b	0.56	0.90 c
Leaf	0 m	67.34 a	0.02 a	0.05 a	0.02 a	0.49 a	0.66 a
	100 m	52.06 b	0.02 a	0.02 b	0.01 b	0.42 ab	0.46 b
	200 m	48.82 b	0.01 b	0.01 b	0.01 b	0.36 b	0.50 b
Fruit	0 m	4.14 a	0.02	0.05	0.03	0.09 a	0.16 a
	100 m	3.89 a	0.01	0.04	0.02	0.08 ab	0.09 b
	200 m	2.22 b	0.01	0.04	0.02	0.07 b	0.06 b

(1): Differences in the column in each sample title are shown with separate letters

While the effect of distance on Al, Ni and Pb contents in fruit samples was statistically significant, it was insignificant on Cd, Co, and Cr. Among the heavy metal contents of the fruit samples at 0 meters distance from the highway, only the Pb content was statistically higher than the fruit samples at 100- and 200-meters distances. The Al content of the fruit samples taken from 0- and 100-meters distance was statistically higher than the fruit samples at 200 meters distance.
The contents of heavy metal at different samples and distances are examined separately in Figures 2-7.
Accordingly, it is seen that Al content is higher in leaf samples, Cr content is higher in fruit samples, and other metals are higher in soil samples. Considering the high levels of Pb, Ni, Co, and Cr metals in the soil, it is seen that Pb, and Ni contents are higher in leaves than fruits, and Co content is higher in fruits than leaves.

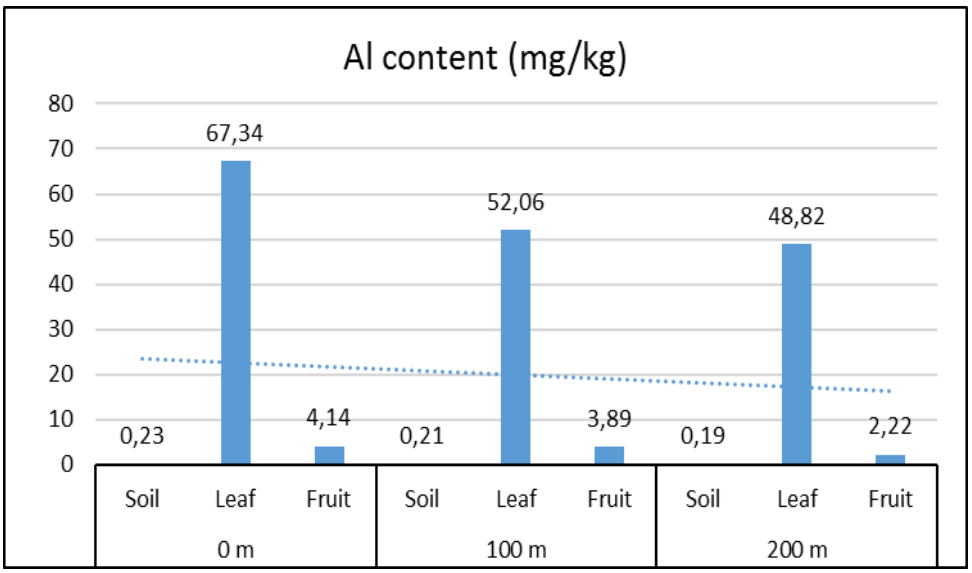

Figure 2. Aluminum content of the samples at different distances

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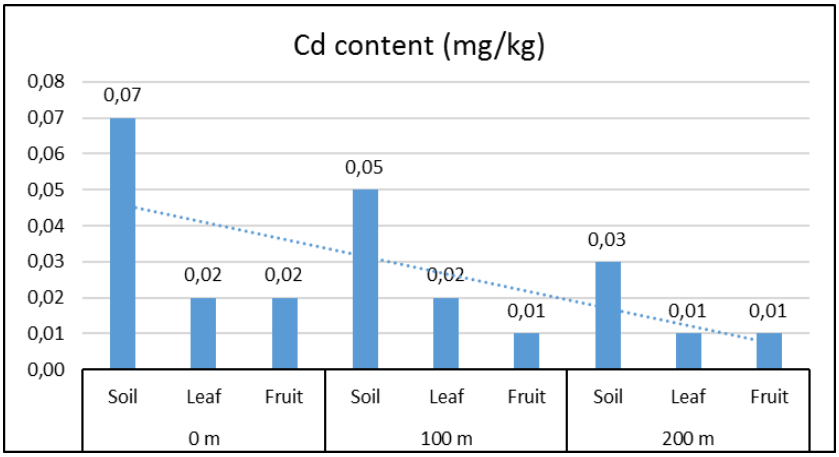

Figure 3. Cadmium content of the samples at different distances

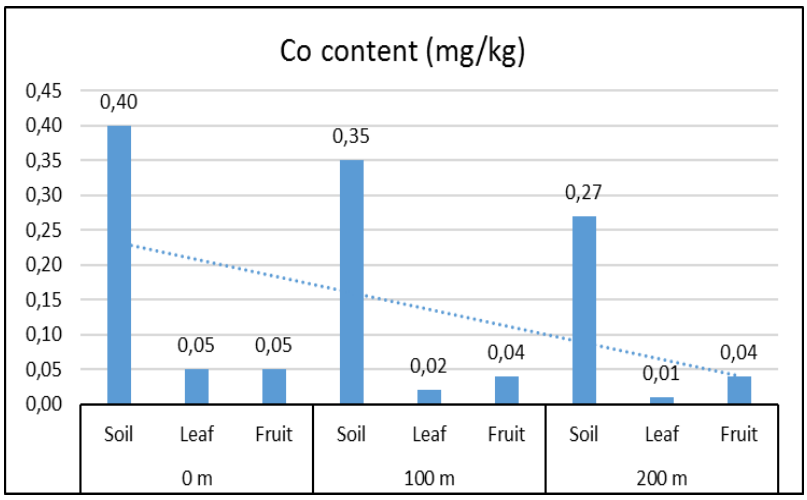

Figure 4. Cobalt content of the samples at different distances

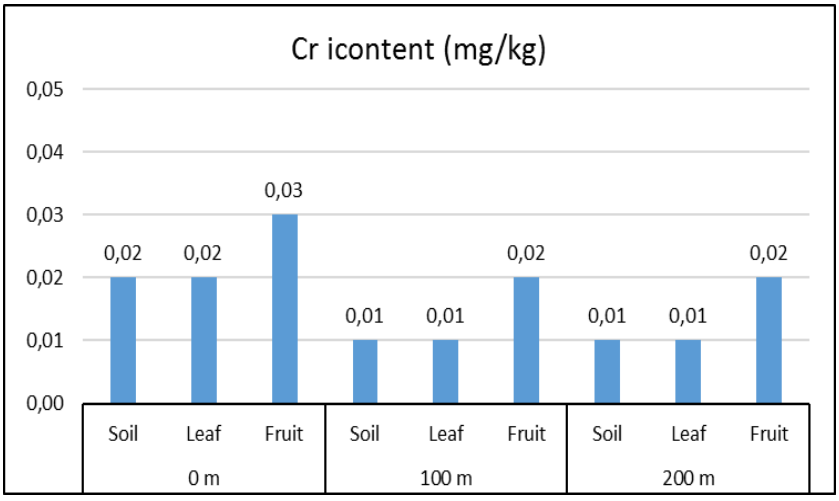

Figure 5. Chromium content of the samples at different distances

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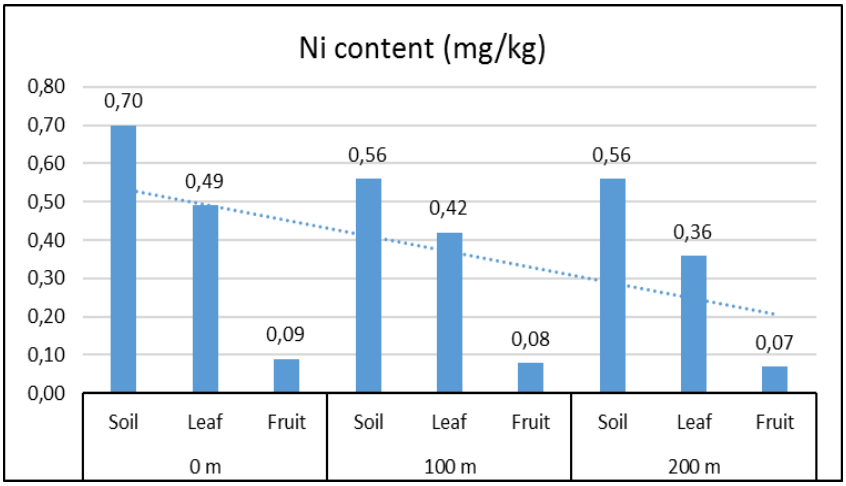

Figure 6. Nickel content of the samples at different distances

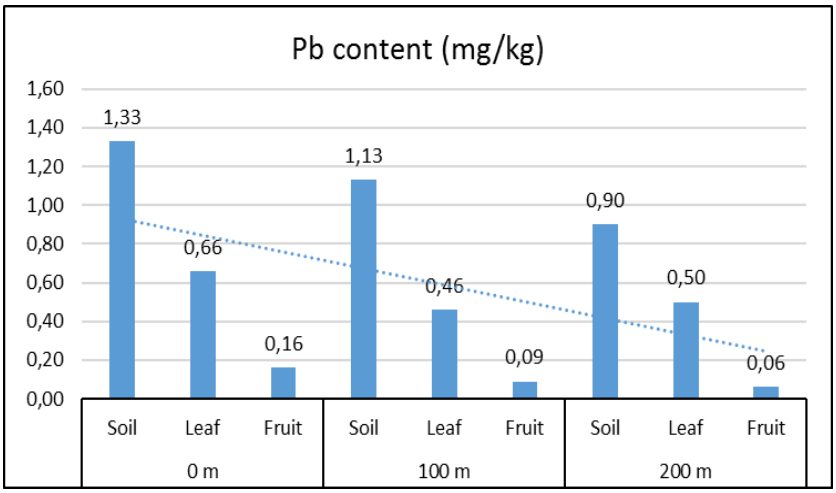

Figure 7. Lead content of the samples at different distances

4. CONCLUSIONS

Elemental contents were listed in soil samples as Pb > Ni > Co > Al > Cd > Cr; in leaf samples as Al > Pb > Ni > Co > Cr = Cd, and in fruit samples as Al > Pb > Ni > Co > Cr > Cd. Toxicity limit values for heavy metals in soil samples has been reported as 50 mg/kg for Ni, 100 mg/kg for Pb (Kloke, 1980), 75-100 mg/kg for Cr (Pendias and Pendias, 1984), 10 mg/kg for Co and 1 mg/kg for Cd (Yıldız, 2001). In our study, soil samples located at different distances to the highway were determined below the specified limit value, and no heavy metal pollution was observed.

In plant organisms, 0.5 mg/kg for Cd, 2 mg/kg for Cr (Scheffer and Schachtschabel, 1989; Stoeppler, 1991), 10 mg/kg for Ni, 6 mg/kg for Pb (Özbek et al. 1995), 0.6 mg/kg for Co (Allen, 1989) was reported as the toxic limit threshold. On the other hand, while the Turkish Food Codex reported the maximum Cd level as 0.05 mg/kg and the Pb level as 0.20 mg/kg in fruits, Herrick and Freidland (1990) informed the limit values for fruits and vegetables as 1-10 ppm for Ni, 0.02-0.5 ppm for Co and 0.1-1 ppm for Cr. Pehluvan et al. (2015) conducted a study to determine the heavy metal contents of temperate climate fruit species such as cherry, black mulberry, white mulberry, apricot, apple, plum, peach, pear and hawthorn grown in the Aras Valley. In the study, Cadmium

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(Cd), Lead (Pb), Nickel (Ni) and Chromium (Cr) contents of fruit samples were determined in the range of 1.12 - 5.89 mg/kg, 1.62 - 3.42 mg/kg, 0.36 - 1.36 mg/kg, and 0.01 - 0.09 mg/kg, respectively. At the end of the study, the researchers reported that all samples were contaminated with Cd and Pb metals. In our study, while the leaf values were below the standard values, it was observed that the Co and Pb contents of the fruits were at the upper limits at 0 meters from the highway.

Today, heavy metal pollution in soil is one of the important environmental problems. In this respect, in this study, it is aimed to reveal the presence of a heavy metal-related risk or contamination in apple orchards located on the 40-45 km long Kayseri-Niğde highway, which forms the western border of the Develi plain, where apple cultivation is carried out intensively. When the results were evaluated in general, it was observed that the proximity to the highway increased the accumulation of heavy metals in plants. To prevent the negative consequences of this situation, first of all, care should be taken to establish the newly established orchards 1-2 km from the roadside. Considering that the number of orchards established on the highway in the study area is too high to be underestimated, it would be appropriate to increase the number of these and similar studies. The findings obtained because of the study will contribute to revealing the extent to which the province of Kayseri, where apple cultivation increases every year, is faced with the effects of environmental pollution. In addition, the fact that the method applied in the study can be applied not only to apple species but also to other fruit species and varieties will guide our knowledge and researchers who will work on similar issues.

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