Carpathian Journal of Earth and Environmental Sciences August 2022, Vol. 17, No. 2, p. 235 – 244; DOI:10.26471/cjees/2022/017/217

THE IMPACTS OF LONG-TERM INTENSIVE FARMING APPLICATIONS ON THE HEAVY METAL CONCENTRATIONS IN SOILS

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Abstract: Intensive farming applications have been increasingly employed to balance the increasing world population and decreasing farming lands in the last half-century. The main purpose of these efforts is to obtain greater amounts of yield per area using modern agricultural methods. However, uncontrolled intensive farming applications (fertilization, irrigation, disinfection, etc.) disturb certain physical, chemical, and biological properties of soils. Especially the uncontrolled chemical fertilization applications increase the heavy metal concentrations in farming lands. The study compares certain properties of the soils from an active farming land (A-FL) in which intensive farming activities have been carried out since 1996 to those of the soils from a passive farming land (P-FL) with no farming activities. For this purpose, the study examines the changes caused by 25-year-long agricultural activities in the soils. The results revealed that the soils from the A-FL had higher levels of pH, electrical conductivity (EC), lime, nitrogen (N), phosphorus (P), potassium (K), arsenic (As), chromium (Cr), copper (Cu), iron (Fe), manganese (Mn), nickel (Ni), and zinc (Zn) than the soils from the P-FL. The negative impact of intensive agricultural activities on the soils is of great importance in terms of soil management and food safety. The uncontrolled agricultural applications indirectly and negatively affect human and animal health worldwide.

Keywords: Intensive farming, soil management, heavy metal accumulation, agricultural practices

1. INTRODUCTION

Organic and inorganic plant nutrients are applied to obtain more yield per area along with irrigation and agricultural pesticide applications to achieve optimal growth. However, applications such as uncontrolled fertilization and irrigation cause physical, chemical, and biological deterioration. Water is of vital importance for plants and soil organisms. Water is especially important in the chemical reactions in soils, the decomposition of organic matter (OM), and the transport of nutrients. The excessive application of water to soils, on the other hand, negatively affects soil productivity in the long term (Demir, 2021). The excessive application of water through flood irrigation can cause the removal of the mineral materials from soils and salinization of soils in dry areas due to surface flow and percolation (Bennie & Hensley 2004; van Rensburg, 2010; Doğan Demir et al., 2019; Drewry et al., 2020; Demir et al., 2021). In the same vein, the application of plant nutrients to soils using chemical fertilizers can lead to salinity and heavy metal accumulation in soils in the long term. For example, researchers have reported that non-water-soluble phosphorus fertilizers produced phosphate rocks that play an important role in the immobilization of metals, causing sedimentation (Bolan et al., 2003). Especially uncontrolled fertilization can cause the accumulation of heavy metals such as Cd, Pb, and As in soils (Nouri et al., 2008; Atafar et al., 2010; Demir, 2021). Various studies have associated the long-term heavy metal accumulation in soils and plants with the applications of chemical and organic fertilizers to soils (Parkpian et al., 2003; Wångstrand et al., 2007; Huang & Jin, 2008). Other researchers have reported that the accumulations of Cr, Ni, Cu, As, Cd, and Zn in soils were significantly affected by land-use models (Bai et al., 2010).

The objective of this study is to compare the heavy metal accumulation in an active farming land (A-FL) in which intensive farming applications (fertilization, irrigation, disinfection, etc.) are carried out to that in a passive farming land (P-FL) with no agricultural activities and to make some practical recommendations.

2. MATERIAL AND METHODS

2.1. Study Area

The study was carried out in a farming area that is located in the southeast of Şanlıurfa, Turkey, which is governed by semi-arid climatic conditions (36°42'N- 39°18'). According to the data from the Akçakale station, which is the closest station to the study area, the annual mean temperature is 17.7°C, annual precipitation is 320 mm, and total evaporation is 1848 mm in the region (Turkish State Meteorological Service, 2021). According to the soil taxonomy, the study area has a xeric soil moisture regime and thermic soil temperature regime (Yılmaz, 1999).

The soils from the two farming lands that are at the same location and topographically similar were examined (Fig. 1). One land is an active farming land (A-FL) in which intensive farming applications such as irrigation, disinfection, fertilization, and soil processing (Table 1) have been carried out since 1996, while the second land is an untouched passive agricultural land despite its availability for agricultural activities (P-FL).

2.2. Soil Sample Collection and Analyses

The soil samples were collected from the two lands from the depths of 0-30 cm using the grid method (100m x 100m) (Fig. 1). Thus, 11 soil samples were collected from the 80-da A-FL while 12 soil samples were collected from the 92-da P-FL. The clay content of the soils in the study area is high and generally has a clay loam texture. The soil samples were brought to the laboratory under the appropriate conditions and prepared for analysis. The particle size distribution of the samples was determined using the Bouyoucos hydrometer method (Gee & Bauder, 1986). Soil reaction and electrical conductivity were examined using soil saturation paste (Jackson, 1962; Horneck et al., 1989). The $CaCO_3$ content of the soils was determined using the Scheibler calcimeter (Allison & Moodie, 1965). The organic matter content was determined following the method proposed by Walkley & Black (1934) and the total nitrogen content was determined using the Kjeldahl method (Kacar, 2009). The phosphorus content of the soils was examined using the sodium bicarbonate method (Olsen, 1954), while the potassium content of the samples was investigated using the ammonium acetate method (Black et al., 1965). The Di-Acid-Microwave method as described by Estefan et al., (2013) was

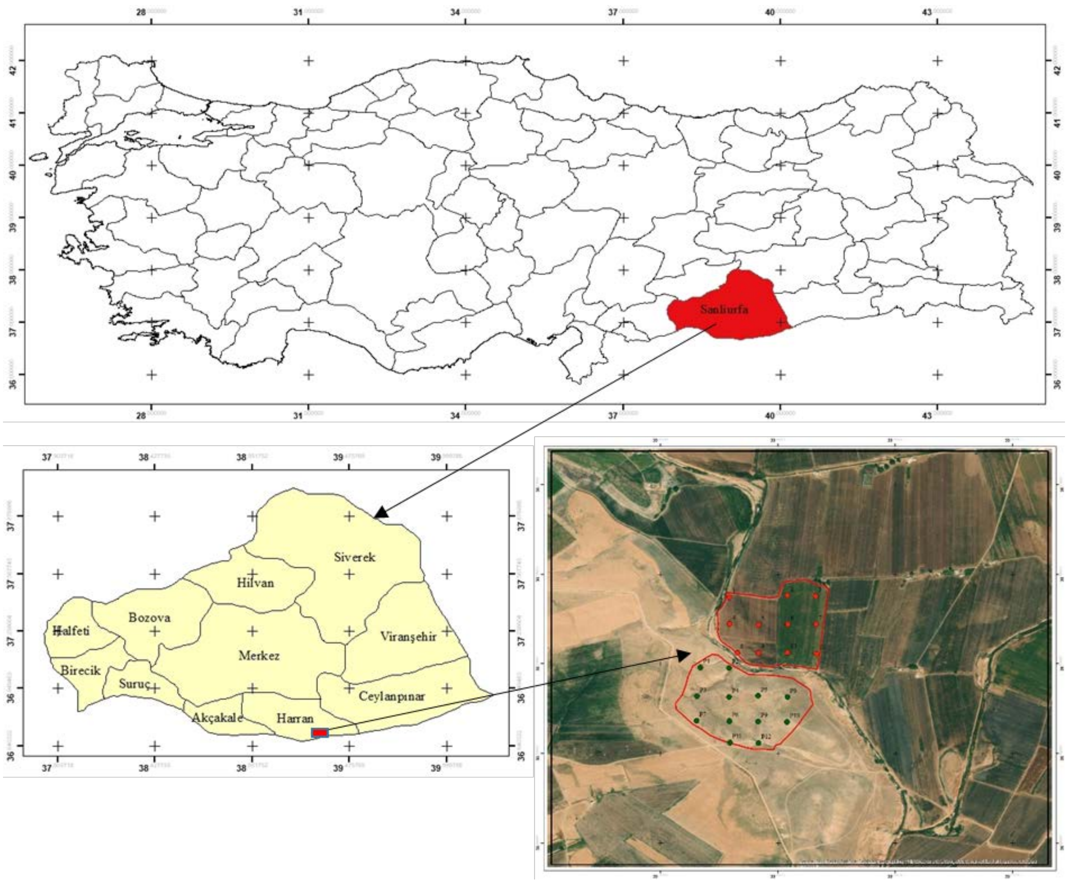

Figure 1. Location map of study area

Table 1. Agricultural pesticides and fertilizers applied to AFL soils in the study area between 1996-2021 (DAP: diammonium phosphate, CAN: calcium ammonium nitrate, AN: Ammonium nitrate, TSP: triple super phosphate, AS: ammonium sulphate)

Years	Plant type	Fertilizer	Fertilization Dose	Used pesticide (Active Ingredient)
1996	Cotton	DAP+AN	25 kg/da DAP + 20 kg /da AN	No record
1997	Cotton	DAP+CAN	30 kg/da DAP + 20 kg /da CAN	No record
1998	Cotton	DAP+CAN	25 kg/da DAP + 25 kg /da CAN	No record
1999	Cotton	DAP+AN	35 kg/da DAP + 20 kg /da AN	No record
2000	Cotton	DAP+AS	25 kg/da DAP + 20 kg /da AS	No record
2001	Cotton	DAP+AN	25 kg/da DAP + 20 kg /da AN	No record
2002	Cotton	DAP+AN	30 kg/da DAP + 20 kg /da AN	No record
2003	Cotton	DAP+CAN	25 kg/da DAP + 20 kg /da CAN	No record
2004	Cotton	DAP+AN	30 kg/da DAP + 25 kg /da AN	No record
2005	Cotton	DAP+CAN	25 kg/da DAP + 20 kg /da CAN	Emamectin benzoate + Chlorantraniliprole
2006	Cotton	DAP+AN	25 kg/da DAP + 20 kg /da AN	Afidopyropen
2007	Cotton	DAP+AS	40 kg/da DAP + 20 kg /da AS	Afidopyropen
2008	Cotton	DAP+AN	40 kg/da DAP + 25 kg /da AN	Emamectin benzoate
2009	Cotton	TSP+AN	25 kg/da TSP + 25 kg /da AN	Emamectin benzoate
2010	Cotton	DAP+AN	25 kg/da DAP + 20 kg /da AN	Etoxazole + Abamectin
2011	Cotton	DAP+AN	30 kg/da DAP + 25 kg /da AN	Etoxazole + Abamectin
2012	Cotton	DAP+AN	30 kg/da DAP + 20 kg /da AN	Emamectin benzoate + Chlorantraniliprole
2013	Zea Mays	DAP+AN	30 kg/da DAP + 30 kg /da AN	Emamectin benzoate + Chlorantraniliprole
2014	Cotton	DAP+AN	25 kg/da DAP + 20 kg /da AN	Etoxazole + Abamectin
2015	Zea Mays	DAP+AN	40 kg/da DAP + 20 kg /da AN	Etoxazole + Abamectin
2016	Cotton	DAP+AN	40 kg/da DAP + 30 kg /da AN	Bifenazate + Etoxazole + Abamectin
2017	Zea Mays	TSP+CAN	30 kg/da TSP + 20 kg /da CAN	Fluometuron+Etoxazole + Abamectin
2018	Cotton	TSP+AS	30 kg/da TSP + 30 kg /da AS	Pendimethalin + Etoxazole + Abamectin
2019	Zea Mays	DAP+CAN	30 kg/da DAP + 40 kg /da CAN	Pendimethalin + Etoxazole + Abamectin
2020	Cotton	TSP+CAN	35 kg/da TSP + 40 kg /da CAN	Pendimethalin + Etoxazole + Abamectin
2021	Zea Mays	DAP+CAN	30 kg/da DAP + 40 kg da /CAN	Pendimethalin + Etoxazole + Abamectin

employed in the determination of the total heavy metal concentration (As, Cd, Cr, Co, Cu, Fe, Mn, Ni, Pb, Zn). Using the method, the total heavy metal content of the soils that were digested in the microwave using nitric acid (HNO_3) and hydrochloric acid (HCl) was determined using inductively coupled plasma optical emission spectroscopy (ICP ES) and inductively coupled plasma mass spectroscopy (ICP-MS).

2.3. Data analysis

In this study, independent t-test was used to test the significance of the difference between the means obtained from two independent groups (AFL and PFL). These comparisons were performed using the statistical package SPSS (version 15.0, SPSS Inc., USA).

3. RESULTS AND DISCUSSION

Table 2 shows the descriptive statistics for the A-FL and P-FL soils. The two-way comparisons between the A-FL and P-FL for each parameter revealed significant differences between the two soils (Table 3). The chemical fertilizers that are added to soils with intensive farming applications deteriorate the soils in the long term. The higher N, P, and K levels, i.e., macronutrients, in the A-FL soils than those in the P-FL soils are attributable to chemical fertilization. The differences between the A-FL and P-FL soils in terms of the levels of these elements were statistically significant ($p<0.05$). The differences between the soils from geographically similar and physically adjacent lands are attributable to intensive farming applications. Intensive farming necessitates the use of high-mineral fertilizers, deteriorates the physical properties of soils, and causes intensive environmental pollution (Sezen, 2002). The mineral fertilizer applications to the soils in the A-FL since 1996 have led to high concentrations of N, P, and K in the soil solution. The organic matter content of the soils from the study area was below 1%, leading to the disruption of the food cycle in the soils by negatively affecting the microbial activity in the soils using mineral fertilizers (Geisseler & Scow 2014; Geisseler et al., 2017; Demir & Doğan Demir, 2021. The OM contents of both the A-FL and P-FL soils were considerably low. The soil processing applications in the A-FL led to lower levels of OM in the soils compared to those in the P-FL.

This was attributed to the non-homogeneity and rapid decrease in the organic carbon distribution

Table 2. Descriptive statistical data on analysis results determined in A-FL and P-FL soils

	N	Minimum	Maximum	Mean		Std. Deviation
				Statistic	Std. Error	
P-FL						
EC (µS/cm)	12	828.00	881.00	859.67	4.50	15.58
pH	12	7.71	7.86	7.81	0.01	0.04
OM (%)	12	0.94	1.21	1.05	0.03	0.09
$CaCO_3$ (%)	12	28.95	33.15	31.18	0.36	1.25
N (%)	12	0.01	0.03	0.02	0.00	0.01
P (mg/kg)	12	12.50	15.10	13.68	0.22	0.77
K (mg/kg)	12	324.70	462.00	393.93	10.86	37.60
As (mg/kg)	12	0.22	0.31	0.26	0.01	0.03
Cd (mg/kg)	12	0.00	0.00	0.00	0.00	0.00
Cr (mg/kg)	12	0.40	0.61	0.49	0.02	0.07
Co (mg/kg)	12	1.06	1.24	1.17	0.02	0.06
Cu (mg/kg)	12	0.89	1.23	1.05	0.03	0.09
Fe (mg/kg)	12	1756.18	1812.93	1797.03	4.99	17.29
Mn (mg/kg)	12	49.93	59.93	55.29	0.95	3.30
Ni (mg/kg)	12	4.64	6.01	5.53	0.10	0.35
Pb (mg/kg)	12	0.58	0.71	0.64	0.01	0.05
Zn (mg/kg)	12	1.45	2.04	1.68	0.05	0.19
A-FL						
EC (µS/cm)	11	1495.00	1625.00	1560.91	13.76	45.63
pH	11	8.05	8.37	8.20	0.04	0.12
OM (%)	11	0.29	0.59	0.45	0.03	0.09
$CaCO_3$ (%)	11	40.18	44.82	42.21	0.48	1.60
N (%)	11	0.01	0.07	0.05	0.00	0.02
P (mg/kg)	11	16.80	22.80	19.77	0.52	1.71
K (mg/kg)	11	505.50	689.50	589.28	21.07	69.87
As (mg/kg)	11	0.31	0.48	0.40	0.02	0.06
Cd (mg/kg)	11	0.00	0.00	0.00	0.00	0.00
Cr (mg/kg)	11	5.29	8.43	6.72	0.32	1.07
Co (mg/kg)	11	1.05	1.28	1.16	0.02	0.08
Cu (mg/kg)	11	1.45	1.71	1.57	0.02	0.07
Fe (mg/kg)	11	3399.79	3469.44	3433.87	7.78	25.80
Mn (mg/kg)	11	54.47	72.63	63.36	2.22	7.35
Ni (mg/kg)	11	6.49	8.13	7.38	0.15	0.50
Pb (mg/kg)	11	0.59	0.74	0.66	0.01	0.04
Zn (mg/kg)	11	2.04	3.28	2.85	0.11	0.37

Table 3. Comparison of analysis result for the means of AFL and PFL soils using independent t-test (Symbols "a" and "b" represent statistically significant differences between groups for $p<0.05$.)

Parameters type	Parameters	AFL	PFL
Minerals and Soil Properties	Texture	Clay Loam	Clay Loam
	EC (µS/cm)	1560.91±45.624a	859.67±15.584b
	pH	8.19±0.12a	7.81±0.04b
	OM (%)	0.44±0.09b	1.04±0.08a
	$CaCO_3$ (%)	42.21±1.59a	31.17±1.25b
	N (%)	0.051±0.015a	0.015±0.006b
	P (mg/kg)	19.77±1.708a	13.98±0.767b
	K (mg/kg)	589.28±69.87a	393.93±37.60b
Heavy Metals	As (mg/kg)	0.402±0.057a	0.265±0.028b
	Cd (mg/kg)	ND	ND
	Cr (mg/kg)	6.72±1.06a	0.49±0.06b
	Co (mg/kg)	1.16±0.07	1.17±0.05
	Cu (mg/kg)	1.56±0.07a	1.05±0.05b
	Fe (mg/kg)	3433.87±25.80a	1797.03±17.28b
	Mn (mg/kg)	63.36±7.35a	55.28±3.29b
	Ni (mg/kg)	7.38±0.501a	5.53±0.347b
	Pb (mg/kg)	0.66±0.043	0.64±0.045
	Zn (mg/kg)	2.85±0.371a	1.68±0.187b

due to soil processing in cultured lands (Shepherd et al., 2001). The comparisons revealed a significant difference between the OM contents of the soils ($p>0.05$). OM plays an important role in many physical, chemical, and biological properties of soils. OM are important in soil productivity because of their roles as the nutrient and energy source of microorganisms. Moreover, OM is an important source of N, P, and K, which are of vital importance for plants. However, the lack of OM in soils necessitates chemical fertilization especially in regions of intensive farming.

The electrical conductivity of the soils from A-FL and P-FL were significantly different from each other ($P<0.05$). This is mainly and undoubtedly attributable to the fertilization and irrigation activities in the A-FL. The quality of the irrigation water was extremely low. In their study, Demir et al. (2019) reported the use of high-salinity underground water for irrigation in the area. The researchers determined that the water quality was C_3S_1 (third-grade irrigation water for salinity and first-grade irrigation water for sodium content) by following the US Salinity Laboratory Staff (USSL, 1954) guidelines. This indicates that the A-FL soils will increasingly become more saline due to the current farming activities and, thus, their physical, chemical, and biological properties will be negatively affected. Various studies have reported the salinity problem in the region as a severe environmental and ecological issue (Tekinel et al., 2002; Sargın, 2010; Bilgili, 2013). Adaman & Ozertan (2007) attributed the salinization of the soils to the excessive and unproductive irrigation applications in the region. Our results revealed that the salt content of the A-FL was two-fold greater than that of the P-FL. The soils from both lands had high $CaCO_3$ content. Table 2 and Table 3 show that the $CaCO_3$ contents of the soils were 42.11% and 31.17% for the A-FL and P-FL, respectively, with a statistically significant difference. The insufficient amount of precipitation generally limits the removal of $CaCO_3$ from soils, which reflects the characteristics of vertisol soils (Atasoy, 2008). Öztürkmen et al., (2021) have also reported high $CaCO_3$ contents for the soils from the same region. Çakmaklı (2008) reported that the mean $CaCO_3$ content in the region varied between 14% and 38%, and the variability in the $CaCO_3$ content was due to the renewal of the main soil materials with new materials that are carried by waters. Thus, the higher $CaCO_3$ content of the A-FL soils than that of the P-FL soils is attributable to the use of calcium fertilizers and irrigation in the A-FL. The high $CaCO_3$ content in both lands can potentially affect other properties of the soils as well. The high $CaCO_3$ content of soils can lead to numerous problems in soil productivity. Calcareous conditions harm the availability of nutrients such as phosphor, iron, manganese, zinc, and copper (Zabunoğlu & Brohi, 1982; Saygan, 2007; Rengel, 2015), leading to yield loss in agricultural production. Various studies have shown that the use of sulfate fertilizers and certain acidic organic materials improved the yield parameters of soils (Khan et al., 2008; Katkat et al., 2009; Abouhussien et al., 2019; Demir et al., 2019). The pH values of the soils from both lands were greater than 7.5 with A-FL soils having a statistically significantly higher pH value than the soils from the P-FL. Soil pH is an indicator of numerous soil properties and affects the majority of the physical, chemical, and biological properties of soils (Karaman et al., 2007; Brady & Weil, 2008). The biological cycle in soils, availability of plant nutrients, and chemical reactions during soil formation are governed by the pH values of soils (Harter, 1983; Pietri & Brookes, 2008; McCauley et al., 2009; Neina, 2019). In addition, pH is an important soil property organizing the mobility and bioavailability of soil pollutants (Boekhold & Meeussen, 1993). Aluminum, manganese, and iron dissolve excessively under low pH conditions while the increasing bicarbonate (HCO_3) levels under high pH conditions reduce the availability of certain micronutrients in soils. The said (uselessness of some nutrients and excessive dissolution of some elements) problems mostly emerge when the pH values are lower than 6.0 or greater than 8.5. The pH values of the A-FL and P-FL soils were within the values of 6.0 and 8.5, thus not pointing to a problem. However, the pH value of the A-FL soils is still noteworthy for being greater than 8.0. The intensive farming activities in the A-FL soils with overfertilization (especially using calcium) and irrigation applications will lead to increasing pH values, which will further worsen the physical and chemical properties of the soils. In agricultural applications, various organic/inorganic materials are added to soils to obtain high-quality, resistant, and greater yield per area. The impact of these materials on the environment and dynamic properties of soils have been examined by numerous researchers for many years.

The studies are still ongoing, with most focusing on the heavy metal accumulation in soils. Atafar et al., (2010) reported that chemical materials are applied through fertilization and disinfection, leading to increased concentrations of Cd, Pb, and As each year. Martin et al., (2006) and Huang & Jin (2008) have indicated organic and inorganic fertilization as the main cause of the heavy metal accumulation in soils. Zwolak et al., (2019) stated that a certain level of heavy metals is mixed with soils when fertilizers containing both minerals and organic materials are used in addition to the natural sources of heavy metals in soils. Tian et al., (2021) determined a serious increase in the Cr, Cd, Pb, Zn, and Cu concentrations in soils irrigated with swine wastewater. The comparison of the two farming lands with and without intensive farming revealed differences in the heavy metal contents of the soils. The As, Cr, Cu, Fe, Mn, Ni, and Zn contents of the A-FL soils were greater than those of the P-FL soils. As shown in Table 3, the differences between the concentrations of these elements in soils were found to be statistically significant. However, the differences between the Co and Pb contents were not statistically significant, and Cd was not detected in any soil group.

Arsenic (As) is an important micronutrient for organisms (Ye et al., 2012; Stazi et al., 2015), but its high concentrations are classified as highly toxic (Agency for Toxic Substance and Disease Registry 2007). The most important As source of soils is the main material, but arsenic-containing herbicides, insecticides, phosphate fertilizers, and irrigation with As-polluted underground waters also cause anthropogenic As accumulation in agricultural soils (Stazi et al., 2015; Surucu et al., 2020). Although both lands in the study area are developed of the same main material, the intensive farming applications in the A-FL soils since 1996 have resulted in a greater As content in the soils. The Cr content in soils has many sources, with main materials, industrial chrome facilities, atmospheric content, and anthropogenic activities as the leading sources. The Cr accumulation in agricultural soils is most importantly due to fertilization, disinfection, and irrigation using underground water (Watanabe, 1984; Ertani et al., 2017; Borah et al., 2018). Various experimental studies have revealed agricultural fertilizers as the source of the Cr content of soils (Duan et al; 2012; Nacke et al; 2013; Li et al., 2020). In agreement with previous studies, the Cr content of the A-FL soils was greater than that of the P-FL soils. There are no industrial establishments near the study area and both lands contain the same main material; therefore, the increase in the Cr content is attributable to the agricultural applications. Although the Cr concentration in the A-FL soils was below the limit value (100 mg/kg) specified by the WHO (2020), the increase in the Cr content due to the agricultural applications is an important environmental issue. Studies have shown that industrial activities added to the Cr content of soils. İşleyen et al., (2019) reported a Cr content of 173.1 mg/kg in Sakarya, Turkey where industrial establishments are heavily concentrated while Yaylalı-Abanuz (2011) reported Cr values ranging from 7.87 to 725 mg/kg in the soils from Gebze, Turkey.

Although Cu, Fe, Mn, and Zn are heavy metals that can cause environmental pollution, they are also important plant nutrients. Zn helps plant growth hormones and enzyme systems and are needed for chlorophyll production and carbohydrate formation. Cu plays an important role in photosynthesis. It improves the taste of fruits and vegetables and can help prevent the formation of ergot in grains. Mn helps chlorophyll formation and contributes to the availability of phosphorus and calcium. Fe promotes chlorophyll formation and functions as an oxygen carrier. Thus, they are needed for the optimum development and growth of plants. However, their presence in excessive amounts harms and kills plants. They also negatively affect the microbiological activity in soils. Our results revealed that the concentrations of these elements in the A-FL soils were significantly greater than those in the P-FL soils. The soils worldwide are generally rich in Fe, but the levels of plant-available forms of soluble Fe (Fe^{2+}, Fe^{3+}, $Fe(OH)^{2+}$, $Fe(OH)^{2+}$) are considerably limited (Lindsay & Schwab, 1982). The increase in soil pH (pH>7.5) lowers the activity of Fe (Schulte, 2004). The pH values that are greater than 7.5 in both the A-FL and P-FL soils limited the availability of Fe to plants. The total Fe content of the A-FL soils was approximately two times greater than that of the P-FL soils. As revealed by the records, Fe-added fertilizers have not been used in the A-FL soils since 1996, but the difference might have been caused by irrigation with underground waters and the use of agricultural pesticides. The Zn, Mn, and Cu contents of the A-FL and P-FL soils were below the limit values specified by the WHO (2020). However, the statistically significant differences between the two lands in terms of their concentrations reveal the impact of intensive farming on the soils. As is with Fe, the soil properties affect the availability of these elements (Zn, Mn, Cu) to plants, with soil pH being undoubtedly the most important of them all. The availability of Mn, Cu, and Zn decreases with increasing soil pH (Rosas et al., 2007; Duffy, 2007; Wen et al., 2018). Researchers have reported that the mean Mn, Zn, and Cu concentrations of unpolluted soils in Turkey were 600 mg/kg, 45 mg/kg, and 20 mg/kg, respectively (Coşkun et al., 2006). The values determined in this study, however, were determined to be lower than the mean values in Turkey. The phosphate fertilizers (DAP, TSP) and agricultural pesticides that were commonly applied to the A-FL soils added especially to the Cu and Zn contents of the soils as Cu and Zn have a greater potential to accumulate in agricultural soils due to long-term use of fertilizers (Wang et al., 2020). Ni contents of the A-FL and P-FL soils were also significantly different. The sources of Ni in soils are the main material, anthropogenic accumulation, or both (Kabata-Pendias, 1993). The Ni concentration of agricultural soils rarely exceeds 50 mg/kg (McGrath, 1995). In Turkey, the allowable Ni concentration in soils at pH values below 6 is 75 mg/kg. In both lands, the Ni levels were below this value. Ni is mostly mixed with soils due to industrial wastes. Some phosphate fertilizers have also been reported to cause Ni pollution in soils (Kabata-Pendias, 1993; Chauhan et al., 2008). In addition, Raven & Loeppert (1997) reported that the triple superphosphate fertilizer contained Ni at concentrations of 15.6-25.2 ppm. Thus, the sources of Ni are possibly the main material and agricultural activities in the soils from the study area, which is located far away from industrial establishments. Moreover, the higher Ni content of the A-FL soils is attributable to the intensive farming applications (fertilization, disinfection, irrigation, etc.).

4. CONCLUSIONS

The results revealed that the A-FL had significantly higher levels of EC, pH, $CaCO_3$, N, P, and K than the P-FL. Similarly, heavy element concentrations (As, Cr, Cu, Fe, Mn, Ni, and Zn) of the soils were higher in the case of intensive farming. The statistically significant differences between the two farming lands from the same geographical location are attributable to the differences in agricultural activities. The use of phosphatic fertilizers and high-salinity irrigation waters was determined to be especially effective. The heavy metal contents of the soils were within the acceptable limits specified by the WHO, but the impact of agricultural applications on the accumulation of these elements attaches importance to sustainable soil management. In the soils from dry regions where irrigated farming is carried out, agricultural activities such as irrigation, fertilization, and disinfection should be carried out following certain programs (the application of the appropriate fertilizers at calculated doses, the use of pressurized irrigation instead of surface irrigation).

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Received at: 15. 04. 2022
Revised at: 10. 05. 2022
Accepted for publication at: 17. 05. 2022
Published online at: 26. 05. 2022