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RESEARCH PAPER

The effect of land use change on chemical forms and availability of iron and manganese in arid and semi-arid region of southwestern Iran

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Abstract

Changing land use from rangeland and forest to agricultural land and orchard can greatly affect the characteristics and fertility of the soil, especially in arid and semi-arid regions. In this study, seven major land-use types in Kohgiluyeh-and-Boyer-Ahmad province of southwest Iran were selected; these land types were orchards (grape), forests, rangelands, and agricultural lands which cultivated corn, beans, and rainfed and irrigated wheat containing five soil orders, namely Entisols, Inceptisols, Mollisols, Alfisols, and Vertisols. The samples were collected from the soil depths of 0-30 cm. Based on the results, the highest average content of organic carbon (OC) was detected in the forest (3.3%). It may thus be stated that there is a balance in forest soils between the rapid decomposition of soil organic matter and the rapid accumulation of litter due to plantation and also an abundance of litter. In all soil samples, the highest percentage of Fe and Mn were found in the residual (Res) fraction and the lowest percentage in the exchangeable (Ex) fraction. The highest and lowest amounts of Fe and Mn carbonate (Car) form were associated with forest and rangeland land uses. Different land uses had an important influence on the amount of the Fe form bound to organic compounds. In this way, the maximum amount of this form belonged to forest use which contained the highest amount of organic matter; the lowest amount of organic matter was related to rangeland use.

Keywords: land use, iron, manganese, arid and semi-arid, chemical forms of Fe and Mn

Introduction

Land use change is one of the most important human interventions in ecosystems and its processes, especially microbial mineralization of carbon and nitrogen. Nutrient losses due to leaching can occur under the cover of vegetated lands such as forests, plantations, and agricultural lands. Iron (Fe) and manganese (Mn) are micronutrients essential to plant life (Parjono, 2019). Soil erosion due to unsustainable land use change is the main cause of soil degradation in the world, particularly in semi-arid regions (Gugino *et al*., 2009). The change of land use for agricultural purposes and consequently, the addition of chemical fertilizers, limited disturbance of the soil, and removal of the plant can lead to changes in soil characteristics and fertility. Therefore, changes in soil characteristics and nutrient availability are to be considered in the management of agricultural lands and compensated for by the correct application of organic and inorganic fertilizers (Azadi and Shakeri, 2020). Cutting down forest trees and converting forests to farmlands destroy natural ecosystems, leading to a decline in soil quality and ultimately to the permanent destruction of soil fertility. Heavy metals are one of the important sources of environmental contamination, and they pose a threat to human health, wildlife, air quality, and other environmental components (Hajabbasi *et al*., 1997). These

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elements can influence the biogeochemical cycle and accumulate in the life of organisms as they cannot disappear by physical processes and remain stable in the long run (Burt, 2004). Micronutrients are the elements found in the earth's crust in amounts less than 0.1%by volume (Adriano, 2001). The most important elements of this kind include Fe, zinc, copper, Mn, lead, and cadmium. Most of these elements have a significant effect on the nutritional status of the soil. Elements such as zinc, copper, Mn, Fe, cobalt and chromium play an essential role in the life of most plants and soil microorganisms although the presence of high amounts of these elements can cause soil contamination (Alloway and Ayres, 1993).

The available Fe is mainly influenced by the organic phase of the soil, while Zn and Cu are influenced by the soil reaction (pH) and adsorption on the colloid surface. For Mn, the oxidation and reduction status in the soil and complex with natural chelating agents are more important (Havlin *et al*., 1999). Soil characteristics such as pH, amount and type of clay minerals, amount and type of organic matter, and moisture content determine the composition of the soil solution, sedimentation reactions, and availability of metals in the soil solution (Kumpiene *et al*., 2008; Shakeri and saffari, 2019). Changes in environmental conditions, such as land use change and climate change, and the soil saturation with metal beyond its buffering capacity can cause micronutrients to move in the soil (Huang and Jin, 2008). Simple organic acids secreted by the plant roots have a high potential to increase the mobility of metals in the soil profile through reduced acidity and complex with micronutrients (Renella *et al.*, 2004).

Different land uses with the mechanisms present in the type of land use significantly influence the chemical and physical properties of the soil. For different types of land use, altering the amounts and proportions of physical and chemical soil properties, considering the relationships between the properties and micronutrients, is expected to change the amount and availability of micronutrients. Micronutrients are deposited in calcareous soils with neutral to alkaline pH and are not available to plants under normal conditions (Xu *et al*., 2019; Shakeri and saffari, 2020). Organic matter can increase the number of exchangeable forms and thus higher uptake by plants, as chelates are formed with these elements and are degraded by microorganisms, leading to the acidification of the environment (Wei *et al*., 2010). Since one of the effects of different land uses is to change the amount of organic carbon, the effect of different land uses on arid and semi-arid regions can provide useful information on the potential availability of Fe and Mn based on the soil under each land use. The studies conducted heretofore on calcareous soils have mostly revolved around various forms of micronutrients and extraction methods for these forms, and no specific and coherent research has been conducted on the impact of land use on the forms of these elements. The investigation of these conditions may be important for long-term land management and prediction of undesirable changes caused by land use type in areas with similar land uses. Therefore, the objective of this study was to compare the availability and distribution of Mn and Fe forms in different land uses (including grape orchards, forests, rangelands, and agricultural lands where corn, beans and wheat are cultivated) of calcareous soils in arid and semi-arid regions of southwest Iran.

Materials and Methods

Study area

This research was conducted in southwestern Iran (Kohgiluyeh-and-Boyer-Ahmad province), with an area of 16,264 km^2 between 30° 9′ and 31° 32′ N latitude and 49° 57′ and 50° 42′ E longitude. This province is considered as mountainous with a relatively high altitude; the highest point of the province, Dena peak, has an altitude of 4409 m and the altitude of the lowest area, Lishtar, is less than 500 m above sea level. Due to the geographical conditions of the province, the height of the mountains and the amount of rainfall and humidity are significantly reduced from the northeast to the southwest along the main mountain range of Zagros. This natural condition has formed a double climatical characteristic and separates the province to two warm and cold areas. According to the climate conditions in the study area and the soil moisture conditions, the soils of the area have Xeric, Ustic, and Ustic-Aridic moisture regimes and Thermic and Hyperthermic temperature regimes.

Soil sampling and characterization

To study the effects of land use type on different soil characteristics and micronutrients, seven major land use types were selected, namely grape orchard, forest, rangeland, and agricultural land used for cultivating corn, beans, and rainfed and irrigated wheat belonging to five soil orders, namely Entisols, Inceptisols, Mollisols, Alfisols, and Vertisols. For soil sampling, only the surface samples were analyzed because the most impact of land use type generally occurs in the soil surface horizons. The experiment was conducted in a completely randomized design with seven factors (land use type) and three replications. Physical and chemical experiments performed on the samples. Soil particle size was measured using the hydrometer method (Gee and Bauder 1986) and soil organic carbon by the wet oxidation method of Walkley and Black (Nelson and Sommers 1982). The cation exchange capacity (CEC) by replacing cations with sodium acetate (Sumner and Miller 1996), electrical conductivity (EC) was measured in saturation extract of soils using an EC meter; pH was determined in 1:1 water-to-soil extract; calcium carbonate equivalent (CCE) was measured through volumetric measurements method by calcimetry (Loeppert and Suarez, 1996). Chemical forms of Mn and Fe were extracted by sequential extraction method (Sposito *et al*., 1982) (Table 1). In this method, the exchangeable, available, Organic (Om), Carbonate (Car), and Residual (Res) forms were extracted using 0.5M potassium nitrate, demineralized water, 0.5M sodium hydroxide, 0.05M ethylene diamine tetra acetic acid, and 4M nitric acid, respectively. The concentration of the elements extracted in each step was measured using the atomic absorption apparatus (AA-670, Shimadzu, Japan). The mobility factor was determined based on the sum of exchangeable and Car forms divided by the total chemical forms according to the following formula (Sipos, 2009):

$$MF = \frac{F_1 + F_4}{F_1 + F_2 + F_3 + F_4 + F_5} \times 100$$

whereF_1, F_2, F_3, F_4, and F_5 are the metal contents used indifferent parts of the sequential extraction method. A high mobility factor indicates a relatively high instability and bioavailability for the elements in the soil.

Table 1. Summary of the sequential extraction procedure (Sposito et al, 1982)

Extraction stage	Fraction	(hr) Shaking time	Temperature	Extracting solution	Soil solution
F_1	Exchangeable (Ex)	16	20℃	0.5M KNO_3	2:25
F_2	Sorbed*(Sor)	2	20℃	H_2O	2:25
F_3	Organic (Om)	16	20℃	0.5M NaOH	2:25
F_4	Carbonate (Car)	6	20℃	0.5M Na_2EDTA	2:25
F_5	Residual (Res)	16	80℃	4M HNO_3	2:25

*Three times extraction

Data processing

SPSS software was used for statistical data analysis, comparison of means was done via Duncan's test at5% level, and Microsoft Office Excel 2013 was utilized for plotting the diagrams.

Results and Discussion

Physical and chemical properties of soil in different land uses

Table 2 shows the statistical description of some physical and chemical properties of soil in different land uses. Some of the physical and chemical properties considered in this study were influenced by land use, and the statistical analysis of the data showed a significant difference between some different land uses. In general, the amount of CCE ranged from 8.1% to 90.7% with an average value of 47.6%. In addition, according to the results presented in Table 1, the highest average amount of CCE was observed in rangeland use (65.4%). Secondary sedimentation of calcium carbonate in the soil of arid and semi-arid regions is a common phenomenon. The calcium source for the secondary formation of calcium carbonate in soils is the release of calcium ions during chemical processes from primary calcium-bearing minerals (Shakeri and Abtahi, 2020). In fact, these rangelands are poor. Lack of organic matter caused by the reduced degradation and preservation of the initial structure of the soil, and the lack of irrigation and cultivation have lead to the poor development of soil solum and soil; as a result, its characteristics are similar to the parent materials with a large amount of calcium carbonate. Consequently, since the studied soils have calcareous parent material, there were no significant differences between different land uses regarding the amount of calcium carbonate equivalent, which is in line with the findings of Boostani *et al*. (2019). The pH levels varied from 7.4 to 8.2 with an average value of 7.8, which is in the range of alkaline soils. Although soil acidity may change due to different land management practices, according to Table 1, the average value of this parameter did not differ significantly between different land uses. The electrical conductivity of the soil ranged from 0.1 to 2.1 with an average value of 0.7 dS/m. Since the maximum salinity observed is generally related to the pedons of agricultural use (wheat), the use of fertilizers and other by-products may therefore increase the soil EC to some extent (Achiba *et al*., 2009). In this study, the organic carbon (OC) content ranged from 0.14 to 5.3 with an overall average of 1.1%, indicating that most of the soil in the study area had a low average OC. The highest average content of OC was observed in the forest land use (3.3%). It may thus be stated that there is a balance in terms of forest soils between the rapid decomposition of soil organic matter and the rapid accumulation of litter due to plantation and also abundance of litter. However, such a balance is not observed in other land uses such as farmland and orchard. Tillage is the most important factor affecting the accelerated loss of soil organic matter and increasing the decomposition of soil organic matter during plowing (Six *et al*., 2000). The high susceptibility of agricultural land to erosion is a factor contributing to the reduction of soil organic carbon since much of the soil OC in soluble form is removed with runoff by the erosion process. Additionally, tillage mixes the underlying soil layers with lower organic carbon content through the overlying soil layer with higher OC content, resulting in the reduced OC of the surface soil compared to its original state (Gregorich *et al*., 1998). The CEC varied from 5.5 to 39 with an average value of 19.6 cmol/kg. In general, the soil texture of all soil samples (seven land uses) was identified as clay, clay loam, and loam based on the US soil texture triangle. The amount of sand was different in different land uses as the amount of sand was at its highest in the grape orchard use, possibly due to the frequent irrigation of grape orchards by gardeners, selective leaching and erosion of finer particles, and retention of coarser particles. As shown in Table 2, the corn cultivation use had more silt than other uses with an average value of 40.3%. However, it was almost identical in the rangeland, rainfed, bean, and forest uses, and the lowest amount was observed in the grape orchard use. Ajami et al. (2008) also observed significant differences in silt content between different land uses, whereas Wu and Tiessen (2002) and Evrendilek *et al.* (2004) reported contradictory results, implying that there is no significant difference in silt content between different land uses. Nonetheless, it appears that processes such as erosion and tillage may affect the amounts of silt fraction. Moreover, since the undisturbed rangelands had a relatively low vegetation density, organic matter increased after the land use change, application of appropriate fertilizers, and planting with high vegetation density in the cultivated areas. Consequently, this influenced other chemical properties, such as pH, and ultimately the availability of micronutrients. However, in areas where rainfed wheat was cultivated, despite the addition of straw, organic matter showed a similar trend to poor rangelands because of the poor plowing and tillage.

Table 2. Some physico chemical properties of different land uses

	Sand	Silt	Clay	OC	CCE	SP	pH	EC	CEC
			%					(dSm^{-1})	(cmol$^{(+)}$Kg^{-1})
Bean									
Min	27.3	30.6	35.4	0.7	44.1	43.3	7.9	0.7	13.0
Max	34.0	36.0	36.7	1.2	65.9	48.3	7.9	0.8	15.6
Mean*	30.6ab	33.3ab	36.1ab	0.9b	55.0a	45.8ab	7.9a	0.8a	14.3bc
Corn									
Min	17.3	37.3	37.4	1.0	40.2	50.4	7.8	0.5	18.4
Max	19.3	43.3	45.4	1.1	45.4	54.2	8.0	0.7	21.7
Mean	18.3b	40.3a	41.4ab	1.1b	42.8a	52.3ab	7.9a	0.6a	20.1abc
Pasture									
Min	23.3	9.3	13.4	0.4	53.3	26.2	7.6	0.3	5.5
Max	77.3	44.6	34.7	1.3	90.7	52.6	8.2	2.0	17.0
Mean	45.3a	30.3ab	24.4b	0.8b	65.4a	40.2b	7.9a	0.9a	10.9c
Forest									
Min	34.7	32.0	31.0	1.4	37.3	47.2	7.4	0.3	22.0
Max	37.0	34.0	31.3	5.3	54.6	71.1	7.9	1.3	39.0
Mean	35.9ab	33.0ab	31.2ab	3.3a	46.0a	59.1a	7.7a	0.8a	30.5a
Irrigated wheat									
Min	9.3	32	37.4	0.4	9.7	27.7	7.6	0.1	15.0
Max	17.3	45.3	55.4	1.6	55.2	64.1	8	0.8	31.8
Mean	15.5b	38.1ab	46.4a	1.0b	32.9a	50.9ab	7.8a	0.4a	24.6ab
Garden									
Min	35.3	19.3	22.7	0.5	45.4	32.3	7.7	0.1	9.4
Max	58.0	30.0	34.7	3.1	67.8	57.6	8.0	0.6	25.9
Mean	48.9a	23.1b	28.1b	1.3b	56.8a	43.8ab	7.9a	0.4a	17.6bc
Rainfed wheat									
Min	11.3	8.6	13.4	0.14	8.1	36.1	7.6	0.2	5.5
Max	78	39.3	57.4	1.4	82.8	53.6	8.0	2.1	35.3
Mean	33.8ab	28.2ab	38.1ab	0.8b	37.1a	45.5ab	7.9a	0.8a	23.6abc

Forms of Mn and Fe in land uses

Figure 2 shows the relative percentage of various forms of Mn and Fe in different land uses studied. According to the results, the sum of Res and Car forms accounted for over 98% of the total Fe and Mn in all land uses, and other chemical forms comprised less than 2% of the total Fe and Mn. Figure 1 and Table 3 show the available form of Fe in different land uses. The Res form with an average of 0.31457 mg kg^{-1} and the sorbed form with an average value of 1.1 mg kg^{-1} had the highest and lowest amounts of chemical Fe forms in irrigated wheat cultivation concerning the samples studied indifferent land uses. Wei *et al.* (2010) studied the spreading of various forms of iron in China and showed that the lowest amount of iron was in the exchangeable fraction and the maximum amount belonged to the Res fraction. Based on the findings, the amount of Ex Fe in all samples studied was below the detection limit though insignificantly. The nonattendance of the exchangeable form of iron in soils with calcareous parent material might be dependent on the soil pH, the conversion of Fe^{+2} to Fe^{+3}, and the subsequent reduction of exchangeable Fe. In the sequential extraction method, since potassium nitrate was used to extract the exchangeable form, the higher valence of iron (Fe) compared with K caused the lower transfer of ions from the soil to the solution, which is additional cause for the lower amount of Ex fraction. Abollino *et al*. (2006) cited the strong tendency of Fe to change into hydroxide and oxide, leading to very little amounts of Ex iron. As can be seen, the carbonate form of iron in the studied land use had the highest Fe content after the Res form, which is due to the high proportion of calcium carbonate in calcareous soils. There was a significant difference between different land uses because the highest and lowest values were associated with forest and rangeland use, respectively. Different land uses had a significant influence on the amount of the Fe form bound to organic compounds. In this way, the maximum amount of the form belonged to forest use with the highest amount of organic matter; the lowest amount was related to rangeland use. Also, the small amount of Fe bound to organic compounds compared to the carbonate and residual fractions correlated with the difference between Om fractions and compounds of the soil and the lack of soil organic matter. Based on the amount of soil organic matter fractions (fulvic acid, humin and humic acid), different results were obtained regarding the relationship between Om fractions and the number of elements in the soil (Harter, 1991). Examining the amount of available Fe (extracted with DTPA) in the studied soil samples under different land uses showed that land use type had a significant influence on the amounts of this form of Fe. Consequently, the highest and lowest amounts of the Ex forms were obtained in the corn and rangeland uses, respectively, in the following order: corn> irrigated wheat> beans> forest> grape orchard> rainfed wheat> rangeland for different land uses.

According to the findings of the correlation between soil properties, the reason for the changes may have been the changes in the contents of clay, silt and organic matter of the soil. Sharma *et al*. (2003) reported similar results in terms of the correlation between Fe-DTPA and the amount of clay and organic matter. In other words, the amounts of Fe extracted by DTPA varied from 5 to 20 mg/kg (Table 3). Since the acceptable limit of this form of Fe in the literature (Malakouti and Gheibi, 2000; Kabata-Pendias, 2010) is between 5 and 25 mg/kg, the observed Fe-DTPA levels are consequently in an acceptable range. Although the amount of total Fe in the soil is high, the comparison of the Fe extracted by DTPA with the total Fe showed that the total of Fe in the soil was a very small part of the total Fe. Given the examination of the chemical fractions of Fe and the high amounts of the residual form, it can be concluded that iron is trapped into the structure of silicate clays (Connolly and Guerinot, 2003).

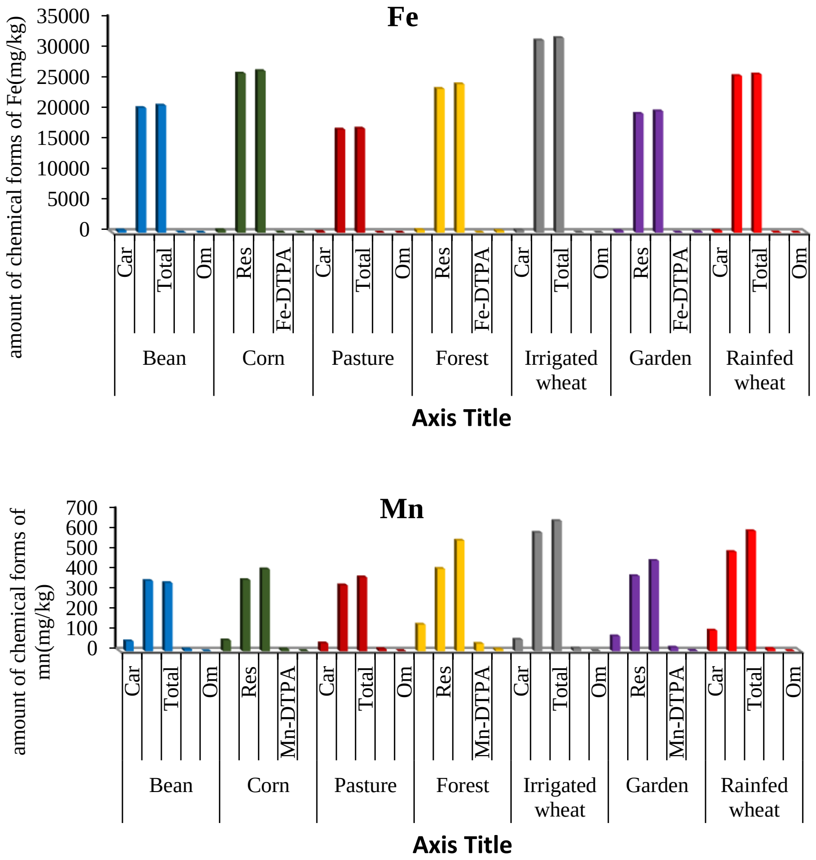

Figure 1. Chemical forms of various metals in different land uses in the study area

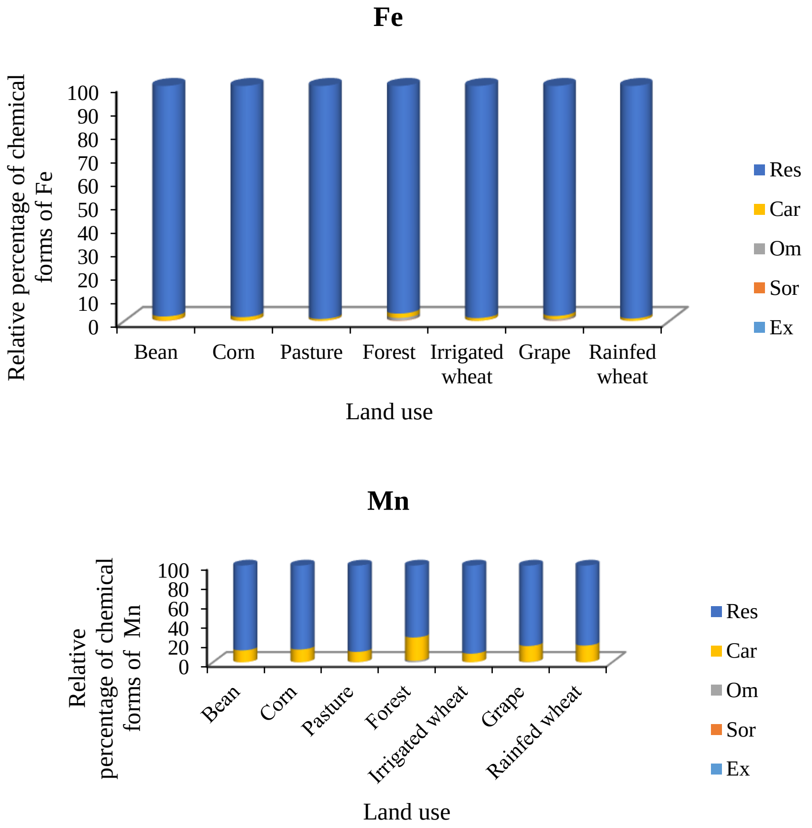

Figure 2. Relative percentage of the chemical forms of Fe and Mn in different land uses

The results of the Mn chemical forms showed that concerning irrigated wheat and bean cultivation land uses, the Res form with an average value of 648.2 mg kg^{-1} and the Om fraction with an average value of 0.3 mg kg^{-1} had the highest and lowest amounts, respectively. The sorbed and exchangeable forms of Mn had no contribution and the extraction degree of the forms was very low and indistinguishable by the atomic absorption apparatus. The investigation of the chemical fractions of manganese in the land uses indicated that the Om and available forms (extracted with DTPA) were affected by the type of land use or, in other words, the change in the type of land use.

Table 3. Status of different chemical forms of various metals in different land uses

Fe				**Land use**			
	Bean	corn	pasture	forest	Irrigated wheat	Garden	Rainfed wheat
Sor	29.2ab	5.7bc	10.8bc	37.1a	1.1c	26.0abc	2.4c
Om	3.4b	6.9b	2.6b	285.2a	4.0b	128.3ab	3.5b
Car	365.0ab	414.5a	127.6b	439.5a	384.6ab	267.3ab	258.5ab
Res	20383.5ab	26011.0ab	16861.4b	23517.0ab	31457.0a	19421.8b	25624.0ab
Total	20781.0ab	26438.0ab	17002.4b	24278.5ab	31847.0a	19843.3b	25889.0ab
Fe-DTPA	15.0ab	20.0a	5.0b	14.1ab	15.8ab	13.3ab	10.3ab

Mn				**Land use**			
	Bean	corn	pasture	forest	Irrigated wheat	Garden	Rainfed wheat
Om	0.3b	0.5b	0.7b	8.8a	0.5b	2.0b	0.7b
Car	49.0a	53.5a	39.0a	132.5a	57.5a	73.8a	102.8a
Res	350.0a	354.0a	327.9a	410.0a	590.1a	373.8a	494.43a
Total	399.0a	408.0a	367.8a	551.0a	648.2a	449.8a	598.2a
Mn-DTPA	9.2b	9.1b	10.4b	36.9a	14.0b	18.0b	11.2b

Therefore, the highest amount of organic content was related to the forest use and the lowest amount belonged to bean cultivation use. The highest and lowest amounts of available Mn were found in forest (36.9 mg/kg) and cultivation (9.1 mg/kg) land uses. As shown in Table 3, the amount of Mn extracted with DTPA ranged from 9.1 to 36.9 mg/kg. According to Malakouti and Gheibi (2000), regarding the critical limits of the elements in calcareous soils which showed the acceptable limit of this form of Mn in the range of 0.25 to 30 mg/kg, the observed Mn-DTPA levels in the studied land uses were in an acceptable range. Other forms of Mn had no significant difference in terms of different land uses. The amount of this element for the various land uses was in the following order: forest> orchard> irrigated wheat> rainfed wheat> rangeland> beans> corn. Walna *et al*. (2010) investigated the Mn forms in Polish forests and reported that the reducible forms had the maximum proportion of Mn forms compared to other ones. Najafi-Ghiri *et al*. (2013) studied the calcareous soils of Iran and demonstrated that numerous factors can affect the accessibility of micronutrients, including soil properties such as CCE, OC, pH, clay content, soil evolution, and soil moisture conditions. Since soil pH has a significant effect on the concentration and micronutrient availability, it can increase the amount of micronutrients in cultivated soil. Secretion of organic acids from plant roots also increases the solubility and available form of elements in the soil by chelating them with micronutrients. Light carboxylic acids are involved in many soil processes and chemical reactions. The function of these compounds as ligands increases the total amount of soluble cations(such as Fe and Al) dissolved in the soil by complexation with metal cations (Chorom and Rengasamy, 1997). The carbonate and exchangeable forms determine the environmental hazards. Therefore, assessment of changes in carbonate and exchangeable forms can be considered to study the effects of soil amendments on element immobilization. In this research, the mobility factor of Mn and Fe in different land uses was calculated(Figure 3). Metal mobility is divided in four categories: If $\%1 \leq MF \leq \%10$, the element isa low-mobility one, if $\%10 \leq MF \leq \%30$, it is a medium-mobility element, if $\%30 \leq MF \leq \%50$, it is a high-mobility element, and if $\%50 < MF$, it is a very high-mobility element (Rodriguez *et al*., 2009). Figure 3 shows the mobility factor of Fe and Mn in each land use. Accordingly, the mobility factor of Fe in the studied land uses was found to be less than 10%, indicating the low mobility of Fe in these soils. According to the values obtained, Mn had a medium mobility factor. Moreover, the mobility of Mn was higher than that of Fe in the studied land uses. In general, the highest mobility factor of both elements was 23% in forest use and the lowest amount was 0.8% in rangeland use. Soil characteristics such as pH, amount and type of clay minerals, amount and type of organic matter, and moisture content determine the composition of the soil solution, sedimentation reactions, and availability of metals in the soil solution (Kumpiene *et al*., 2008). Changes in environmental conditions such as land use and climate change, and the soil saturation with metal beyond its buffering capacity can cause micronutrients to move in the soil (Huang and Jin, 2008). Simple organic acids secreted by the plant roots have a high potential to increase the mobility of metals in the soil profile through reduced acidity and complexation with micronutrients (Renella *et al.*, 2004).

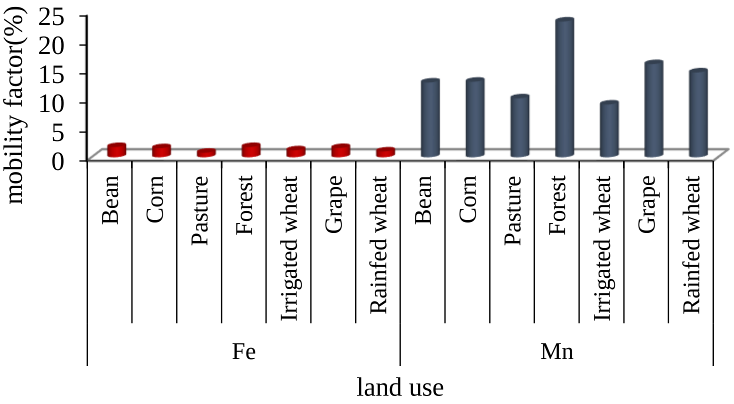

Figure 3. Percentage of mobility factor (MF) related to Fe and Mn in the studied land uses

Conclusion

Based on the results, more than 98% of the total Fe and Mn in the studied land uses was in Car and Res forms, while a very small proportion (less than 2%) was obtained in Om, Ex, and Sor forms. Among the physical and chemical characteristics of the soils under study, the factors affecting the distribution of different elements were found to be CEC, OC, and soil texture. The presence of calcium carbonate provides a mechanism for absorption and retention of metal with the chemical absorption of heavy elements, reducing the activity of the soluble form of Fe and Mn to be used in various land uses. The mobility factor was also different in the studied land uses. Consequently, the highest amount of mobility factor belonged to the forest use while the lowest amount was seen in rangeland use. Different land uses showed a significant influence on the amount of the Fe form bound to organic compounds. In this way, the maximum amount of the form was observed in the forest use with the highest amount of organic matter; the lowest amount also belonged to rangeland use. The amount of DTPA-extractable Fe and Mn was also affected by the land use type as the highest amount of each one was found in the corn and forest uses, respectively. Considering the impact of land use type on various characteristics of soil and capability of nutrients, it is suggested to specify the avail capability ability of lands for different land uses and to avoid land use change, regardless of these effects, especially in arid and semi-arid regions. The solubility and availability of the elements are also higher in acidic pH. In addition, pH is neutral to alkaline in calcareous soils due to the presence of calcium carbonate, and it is not possible to change the pH due to the buffering properties. It is therefore recommended that the availability of the elements be retained and enhanced through maintaining or adding organic matter to these lands.

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References

Abollino O, Giacomino A, Malandrino M, Mentasti E, Aceto M, Barberis R. 2006. Assessment of metal availability in a contaminated soil by sequential extraction. Water, Air, and Soil Pollution, 173(1-4); 315-338.

Achiba WB, Gabteni N, Lakhdar A, Laing GD, Verloo M, Jedidi N, Gallali T. 2009. “Effects of 5-year application of municipal solid waste compost on the distribution and mobility of heavy metals in a Tunisian calcareous soil”. Agriculture, Ecosystems and Environment, 130(3-4); 156-163.

Adriano DC. 2001. Trace Elements in Terrestrial Environments: Biogeochemistry, Bioavailability and Risks of Metal. 2nd Springer-Verlag. New York, Berlin, Heidelberg.

Ajami M, Khormali F, Ayobi Sh. 2008. Application of neural network for prediction of earthen dam peak breach outflow and breach time. Iranian Journal of Soil and Water Research, 39(1);15-30.

Alloway B, Ayres DC. 1993. Chemical Principles of Environmental Pollution. CRC Press.

Ammari T, Mengel K. 2006.Total soluble Fe in soil solutions of chemically different soils. Geoderma, 136; 876–885.

Azadi A, Shakeri S. 2020. Effect of different land use on Potassium forms and some soil properties in Kohgiluyeh and Boyer-Ahmad Province, Southwest Iran. Iran Agricultural Research, 39(1); 121-133.

Boostani H, Mehdi N, Mahmoodi A. 2019. Effect of Land Use Change on Potassium Chemical Fractions and Availability of Some Soil Nutrients in Darab Region, Fars Province. Applied Soil Research, 7(3); 180-191.

Burt R. 2004. Soil Survey Laboratory Methods Manual: Soil Survey Investigations, Report No. 42, Version 4.0, USDA, Natural Resources Conservation Service, Lincoln, NE, USA.

Chorom M, Rengasamy P. 1997. Carbonate chemistry, pH, and physical properties of an alkaline sodic soil as affected by various amendments. Australian Journal of Soil Research, 35; 149-161.

Connolly EL, Campbell NH, Grotz N, Prichard CL, Guerinot ML. 2003. Overexpression of the FRO2 ferric chelate reductase confers tolerance to growth on low iron and uncovers posttranscriptional control. Plant physiology, 133(3); 1102-1110.

Evrendilek F, Celik I, Kilic S. 2004. Change in soil organic carbon and other physical soil properties along adjacent editerranean forest, grassland and cropland ecosystems in Turkey, Journal of Arid Environments, 59; 743-752.

Gee GW, Bauder JW. 1986. Particle size analysis, hydrometer method: In Klute, A. et al., (Eds.), Methods of Soil Analysis, Part I. Madison, (WI); SSSA and ASA.

Gregorich EG, Greer KL, Anderson DW, Liang BC. 1998. Carbon distribution and losses: erosion and deposition effects. Soil and Tillage Research, 4; 291-302

Gugino BK, Abawi GS, Idowu OJ, Schindelbeck RR, Smith LL, Thies JE, Van Es HM. 2009: Cornell soil health assessment training manual. Cornell University College of Agriculture and Life Sciences.

Hajabbasi MA, Jalalian A., Karimzadeh KHA. 1997. Deforestation effects on soil physical and chemical properties, Lordegan, Iran. Plant and Soil, 190; 301- 308.

Harter RD. 1991. Micronutrient adsorption-desorption reactions in soils. Micronutrients in agriculture, 4; 59-87.

Havlin JL, Beaton JD, Tisdale SL, Nelson WL. 1999. Soil fertility and fertilizers an introduction to nutrient management, 6th ed. Prentice Hall, Upper Saddle River, NJ.

Huang S, Jin J. 2008. Status of heavy metals in agricultural soils as affected by different patterns of land use. Envvironment Assess, 317; 327-139.

Kabata-Pendias A. 2010. Trace Elements in Soils and Plants. CRC Press.

Kumpiene J, Lagerkvist A, Maurice C. 2008. Stabilization of As, Cr, Cu, Pb and Zn in soil using amendments–a review. Waste management, 28(1); 215-225.

Loeppert RH, Suarez DL. 1996. Carbonate and gypsum, In: Sparks D. L. (ed) Methods of soil analysis, SSSA Book Series, Part 3, Madison, WI.

Malakouti MJ, Gheibi MN. 2000. Determination of critical limit of effective nutritious elements in soil, plant and fruit. Karaj Agriculture. Training Press Center, Iran

Najafi-Ghiri M, Ghasemi-Fasaei R, Farrokhnejad E. 2013. Factors affecting micronutrient availability in calcareous soils of Southern Iran. Arid Land Research and Management, 27(3); 203-215.

Nelson DW, Sommers LE. 1996. Total carbon, organic carbon, and organic matter. In: Sparks D, editor. Methods of soil analysis part 3-chemical methods. Madison (WI). American Society of Agronomy.

Obrador A, Alvarez JM, Lopez-Valdivia LM, Gonzalez D, Novillo J, Rico MI. 2007. Relationships of soil properties with Mn and Zn distribution in acidic soils and their uptake by a barley crop. Geoderma, 137; 432– 443.

Parjono P, Anwar S, Murtilaksono K, Indriyati l. 2019. Fractionation of iron (Fe) and manganese (Mn) in the horizons of a forest soils, agroforestry, and dryland agriculture. Journal of Environmental Science and Sustainable Development, 2(1); 117-126.

Renella G, Landi L, Nannipieri P. 2004. Degradation of low molecular weight organic acids complexed with heavy metals in soil. Geoderma, 122; 315-311.

Rodríguez L, Ruiz E, Alonso-Azcárate J, Rincón J. 2009. Heavy metal distribution and chemical speciation in tailings and soils around a Pb–Zn mine in Spain. Journal of Environmental Management, 90(2); 1106-1116.

Shakeri S, Abtahi A. 2020. Potassium fixation capacity of some highly calcareous soils as a function of clay minerals and alternately wetting-drying. Archives of Agronomy and Soil Science, 66(4); 445-457.

Shakeri S, Saffari M. 2020. The Status of Chemical Forms of Iron and Manganese in Various Orders of Calcareous Soils and Their Relationship with Some Physicochemical and Mineralogical Properties. Communications in Soil Science and Plant Analysis, 51(15); 2054-2068.

Shakeri S, Saffari M. 2019. Distribution of zinc and copper chemical forms and their relationship with some physico-chemical properties and clay minerals in some calcareous soils. Iran Agricultural Research, 38(2); 71-82.

Sharma BD, Arora H, Kumar R, Nayyar VK. 2004. Relationship between soil characteristics and total and DTPA-extractable micronutrients in Inceptisols of Punjab. Communication in Soil Science and Plant Analysis, 35; 799–818.

Sharma BD, Jassal HS, Sawhney JS, Sidhu PS. 1999. Micronutrient distribution in different physiographic units of the Siwalik Hills of the semiarid tract of Punjab, India. Arid Land Research and Management, 13(2); 189–200.

Sharma RP, Singh M, Sharma JP. 2003. Correlation studies on micronutrients vis-à-vis soil properties in some soils of Nagaur district in semi-arid region of Rajasthan. Journal of the Indian Society of Soil Science, 51(4); 522-527.

Sipos P. 2009. Distribution and sorption of potentially toxic metals in four forest soils from Hungary. Central European Journal of Geosciences, 1(2); 183-192.

Six J, Paustian K, Elliott ET, Combrink C. 2000. Soil structure and organic matter, I. distribution of aggregate-size classes and aggregate-associated carbon. Soil Science Society of America Journal, l(64); 681-689.

Sposito G, Lund LJ, Chang AC. 1982. Trace Metal Chemistry in Arid-zone Field Soils Amended with Sewage Sludge: I. Fractionation of Ni, Cu, Zn, Cd, and Pb in Solid Phases 1. Soil Science Society of America Journal, 46(2); 260-264.

Sumner ME, Miller WP. 1996. Cation exchange capacity and exchange coefficients: Methods of Soil Analysis Part 3—Chemical Methods, Madison (WI). American Society of Agronomy.

Walna B, Spychalski W, Ibragimow A. 2010. Fractionation of iron and manganese in the horizons of a nutrient-poor forest soil profile using the sequential extraction method. Polish Journal of Environmental Studies, 19(5); 1029-1037.

Wei X, Shao M, Zhuang J, Horton R. 2010. Soil iron fractionation and availability at selected landscape positions in a loessial gully region of northwestern China. Soil Science and Plant Nutrition, 56(4); 617-626.

Wu R, Tiessen H. 2002. Effect of land use on soil degradation in alpine grassland soil, China, Soil Science Society of America Journal, 66; 1648-1655.

Xu CHEN, Xiaorong WEI, Mingde HAO, Jing ZHAO. 2019. Changes in soil iron fractions and availability in the loess belt of northern China after 28 years of continuous cultivation and fertilization. Pedosphere, 29(1); 123-131.