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Effects of land-use change from pasture to agricultural lands on several soil quality charactristics under different soil texture classes

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Key words: Land-use change, soil degradation, soil organic carbon, soil quality.

Abstract

Evaluation of the long term effects of the land-use change on soil quality indexes would supply valuable information for soil sustainable management and prevention of intensive soil degradation. In this regard, the current research was aimed to evaluate the effects of land-use change from pasture to agricultural lands on soil wet-aggregate stability (WAS) and organic carbon (OC). The study was carried out on Northwestern slopes of Mount Sahand, northwest of Iran. The study area including three soil texture classes of loam, sandy clay loam, and sandy loam was pasture land which is partially changed to either irrigated and rain-fed agricultural lands or bare soil. Results showed that regardless of soil texture, pasture conversion to agricultural lands resulted in reduction of soil OC which will deteriorate soil quality. The reduction was more considerable in pasture conversion to irrigated farmlands due to mismanagements which reduced soil OC content to the nearly half (0.54 *vs.* 0.98 %) and also led to 11 percent reduction in WAS of soil (WAS of 59 % *vs.* 70 %). The mismanagements also resulted in destruction of pasture and converted them to unprotected bare soils. It is concluded that appropriate and detailed surveys and investigations are needed to conserve studied pasture lands.

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Introduction

Recognizing managements which not only improve the quality and quantity of soil productivity in long term, but also conserve soil dynamic quality is one of the most important goals of land sustainable managements (Islam *et al.*, 1999). During recent decades, soil quality assessment in order to evaluate soil phico-chemical and biological yields of forest, pasture, and agricultural ecosystems was one of the main strategy to sustainable managements of lands (Karlen *et al.*, 1997). Soil quality refers to soil ability to sustain its biological yield beside water and air quality improvement which provides human, plants, and animal's health (Doran and Parkin, 1994). Different indexes are usually used to evaluate soil quality since its direct measurement is impossible. Therefore, appropriate and representative features selection is the most important step in soil quality assessments. Burger and Kelting (1999) believed that soil physical properties are the most appropriate measures for soil quality assessments and Romig *et al.* (1996) also reported that soil organic matter is a proper indicator for land health assessments.

Wet-aggregate stability (WAS) is one of the soil physical properties which is usually considered as representative indicator for soil quality (Muckel and Mausbach, 1996, Kiani *et al.*, 2004). Indeed, it is the suitable measure of the soil structure which is a key factor in soil fertility and productivity having high ecological importance, as well. Soil structure effects on soil crust, root developments, water and air movement through soil medium, CO_2 diffusion, soil erosion, water and nutrient holding capacity, and biological activity are well-known. Generally, soil structure is depend on soil type, soil formation factors, management, and environmental condition (Ciric *et al.*, 2012). Wet-aggregate stability (WAS) refers to soil aggregates which resist disintegration when disruptive forces associated with raindrop impact or wetting in wet sieving apparatus are applied. WAS is one of the crucial physical attributes of soil which affects soil productivity as well as its susceptibility for soil erosion and degradation.

Beside soil WAS, soil organic matter (OM) or soil organic carbon (OC) is another important characteristic of soil which influences soil quality and is referred as key factor for soil fertility and productivity. Soil OM should be retained in a proper level within soils in order to maintain soil fertility and productivity. Unfortunately soil OM of farmlands in Iran is usually lower than one percent which is caused by excessive chemical fertilizers (specifically nitrogenous ones) and less organic fertilizers applications during recent decades (Mohamadian and Malakouti, 2002). Soil carbon stocks is considered as a sensitive indicator to soil organic matter's trends (Sparling *et al.*, 1997). Relatively decomposed organic matter, although, assigns negligible contribution of soil volume, it is considered as an important soil quality index due to having short return period and rich soil nutrients and carbon contents (Haynes, 2005). Actually, the relatively decomposed organic matter of soil is considered as a temporary storage of soil nutrients.

It seems that each agricultural practice which affects soil properties and vegetation would affect soil microorganisms, too. Land-use and its change is one of the most important soil management practices which would influence soil OC as well as soil quality. Eskandari *et al.* (2006) by evaluating effects of two different land-uses including dryland agriculture and pasture on WAS's of Northern Karoun watershed showed that there were high significant differences (sometimes up to 100 percent differences) between WAS's of these two land-uses. Soil OM shortage is considered as one of the main reasons for the low WAS of the study area. Gajic *et al.* (2013) also evaluated the effects of two land-uses including grassland and farmland on soil WAS. They depicted that mean diameter of stable aggregates in grassland (0.92 mm) significantly was higher than one in farmland (0.81 mm). Abrishamkesh *et al.* (2011) also evaluated long term effects of forest and tea farm on soil WAS and OM. They reported that soil WAS and OM of tea farm significantly were lower than those of forest and soil bulk density of tea farm was significantly higher than that of forest. Dlapa *et al.* (2011) also investigated long term effects of grape garden and forest on soil WAS and OM. Their results showed that there were significant differences between measured WAS and OM of these two land-uses subjecting higher OM and WAS to forest. Moncada *et al.* (2014) investigated effects of two land-uses including permanent pasture and cereals monoculture farms under two different soil textures (silt loam and sandy loam) on soil WAS. Their results showed that regardless of soil texture, aggregates of permanent pasture were more stable than those of cereals monoculture farms.

In addition to evaluating different land-uses effects on soil structural quality indexes, several researches (Neufeldt *et al.*, 1999, Hoyos and Comerford, 2005, Williams and Petticrew, 2009, Abrishamkesh *et al.*, 2011, Dlapa *et al.*, 2011, Gajic *et al.*, 2013) have been carried out in order to investigate land-use changes effects on soil physical and structural properties. Zolfaghari and Hajabasi (2008) showed that land-use change from pasture and forest to farmlands decreased soil OM, mean weight diameter of aggregates (MWD), porosity, and hydraulic conductivity of soil and finally deteriorated soil quality. Gebremariam and Kebede (2010) also depicted that land-use change from forest to agricultural lands significantly increased soil bulk density and decreased soil OM. Ajami *et al.* (2012) also showed that land-use change from forest to agricultural land deteriorated soil quality and led to around 40 % and more than 70 % reductions in MWD (1.49 mm in surface soil of forest *vs.* 0.88 mm in agricultural lands) and soil OC, respectively. It also increased soil bulk density in agricultural land compared to forest.

Despite the abovementioned researches, land-use change and soil texture interaction on soil WAS rarely ever is investigated. For example, we can refer to investigation carried out by Moncada *et al.* (2014). However, prior research results show that soil management and soil type are key factors to interpret effects of different soil attributes on soil aggregate stability (Colazo and Buschiazzo, 2010). In this regard, the current research was aimed to investigate land-use changes effects on soil aggregate stability under three different soil texture classes.

Methods and materials

Study area

Study area having 76 km^2 area is located in northwestern slopes of Mount Sahand (46˙ 22' 23" E to 46˙ 28' 05" E and 37˙ 43' 07"N to 37˙ 50' 08"N).

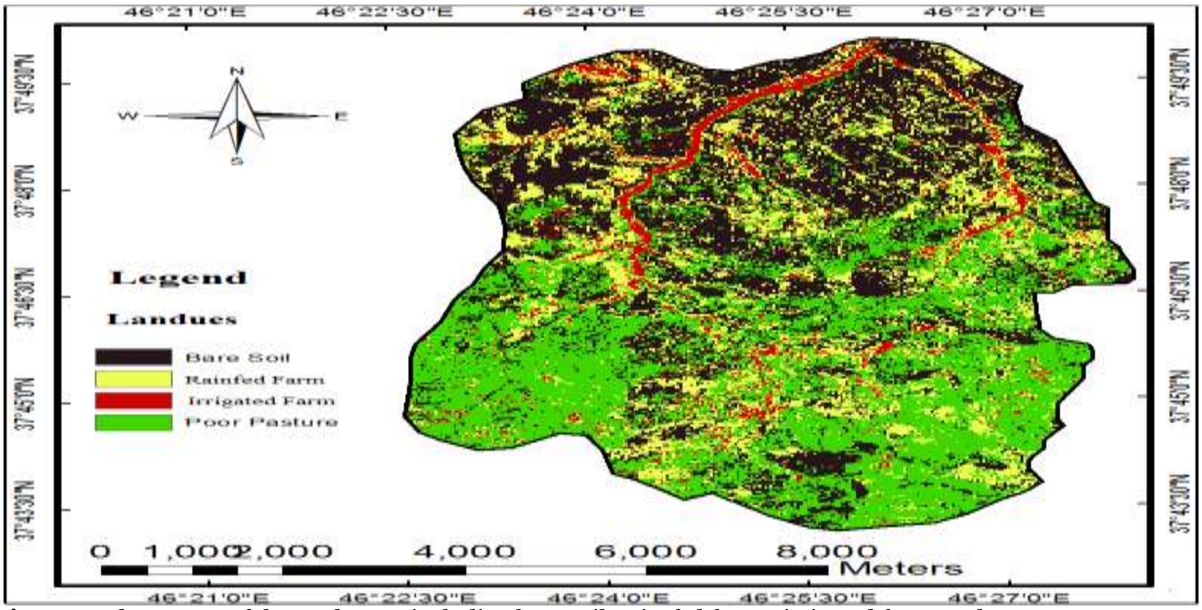

Fig. 1. Land-use map of the study area including bare soil, rain-fed farms, irrigated farm, and poor pasture.

Nearly all parts of study area had course-textured soils including loam, sandy clay loam, and sandy loam texture classes. Initial land-use of the study area was pasture which is partially changed to rain-fed or irrigated farmlands or converted to bare soils without any vegetal cover as a response to mismanagements during recent decades. Figure 1 depicts the current status of the study area considering existence land-uses.

Soil sampling and measurements

Generally, 220 soil samples were taken from study area. Soil texture was determined by hydrometer method (Gee and Or, 2002), soil organic carbon was determined by wet oxidation method (Nelson and Sommers, 1982), and wet-soil aggregate stability (WAS) was determined using wet sieving apparatus and aggregates with 1 to 2 mm sizes (Nimmo and Perkins, 2002).

Statistical analysis

A two-factor unbalanced factorial experiment on the base of the completely randomized design were applied to fulfil the current study.

First factor implies land-uses including irrigated farm (LU1), bare soil (LU2), rain-fed farm (LU3), and poor pasture (LU4) and second factor implies soil textures including loam (ST1), sandy clay loam (ST2), and sandy loam (ST3). Mean comparisons were carried out using T-test (LSD) in 1 and 5 % probability levels.

Results and discussions

Table 1 reports descriptive statistics of measured properties of soil within the study area. Table 1 shows that considerable part of the study area has coarse-textured soils and most parts of the study area contains low amount of soil OC.

Table 1. Descriptive statistics of soil properties within different land-uses in study area.

Variable	Irrigated farm		Bare soil		Rain-fed farm		Poor pasture	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD
WAS(%)	59.40	20.22	63.00	19.79	63.05	19.79	69.49	16.62
CC(%)	19.99	4.53	16.56	4.99	15.96	5.04	16.12	4.27
Si(%)	27.75	6.24	24.16	6.32	29.06	7.18	27.68	8.07
Sa(%)	52.26	9.67	59.23	8.28	54.98	8.93	56.19	9.56
OC(%)	0.54	0.24	0.73	0.22	0.84	0.56	0.98	0.48

WAS: wet-aggregate stability; CC: clay; Si: silt; Sa: sand; OC: soil organic carbon.

In this research, long term effects of land-use change on aggregate stability (WAS) and organic carbon (OC) under different soil texture classes were evaluated. Analysis of variances of measured characteristics are reported by Table 2. The results showed that land-use, soil texture, and their interactions had significant (P < 1 and 5 %) effects on WAS, OC, and soil separates. Mean comparison of the main factors and their interactions are reported by Tables 3 and 4.

Table 3 revealed that WAS of the poor pasture were significantly (P < 1%) higher than one of irrigated farm (69.49 % *vs*. 59.40%). Results also depicted that WAS of rain-fed farm and bare soil showed no significant differences with other land-uses. It seems that significant differences between WAS of poor pasture and irrigated farm is subjected to OC trends between these two land-uses. Because mean comparisons (Table 4) showed that OC of poor pasture (0.99 %) was significantly (P < 1%) higher than ones of irrigated farm (0.54 %). Initially a higher OC was expected for irrigated farm rather than others. However, the results was against to this expectation which seems to be due to the crop residuals mismanagement which are made by local farmers taking out and burning crop residuals.

Analysis of variances of soil separates also showed that there were significant difference of silt percent among different land-uses (Table 3). The lowest silt percent was subjected to bare soil (24.19 %) which was significantly lower than those of other land-uses especially poor pasture (27.65 %) as a reference. It seems that soil erosion is the main reason of the around 3 percent reduction in silt portion due to land-use change from pasture to bare soil. Because contrary to clay and sand, silt particles are more susceptible to soil erosion due to low adherence and weight.

Table 2. Analysis of variances of measured characteristics of soil.

Source of the variation	df	Sum of squares				
		WAS	OC	CC	Si	Sa
Land-use (LU)	3	1865.39^{**}	1.5052^{**}	0.0035^{ns}	0.0105^{**}	0.0030^{ns}
Soil texture (ST)	2	430.02^{ns}	0.6452^{**}	0.0662^{**}	0.2085^{**}	0.3972^{**}
LU × ST	6	1248.44^{**}	0.4511^{**}	0.0036^{*}	0.0027^{ns}	0.0023^{ns}
Error	208	287.24	0.1319	0.0014	0.0027	0.0036

WAS: wet-aggregate stability; CC: clay; Si: silt; Sa: sand; OC: organic carbon

** and *: significant at 1 and 5 percent probability levels, respectively; ns: insignificant.

Table 3. Mean comparison of the main factors using LSD test.

Factor	Level	Mean (%)				
		WAS	OC	CC	Si	Sa
	Irrigated farm	59.40 (b)	0.54 (c)	-	27.71 (a)	-
	Bare soil	63.00 (ab)	0.73 (b)	-	24.19 (b)	-
Land-use	Rain-fed farm	63.05 (ab)	0.84 (ab)	-	29.15 (a)	-
	Poor pasture	69.49 (a)	0.99 (a)	-	27.65 (a)	-
	Loam	-	0.63 (b)	19.44 (b)	36.22 (a)	44.40 (c)
Soil texture	Sandy clay loam	-	0.81 (a)	22.76 (a)	23.59 (b)	53.62 (b)
	Sandy loam	-	0.85 (a)	14.63 (c)	23.94 (b)	61.48 (a)

Mean comparisons of the interactions of land-use and soil texture on WAS showed that poor pasture × sandy clay loam had the highest WAS (77.45 %). Contrary, rain-fed farms × sandy clay loam, bare soils × sandy clay loam, and irrigated farm × loam had the lowest WAS with 29.87 %, 53.10 %, and 52.95 %, respectively. It seems that higher WAS's of poor pasture × sandy clay loam were subjected to higher OC (1.35 %) of this treatment. Interestingly sandy clay loam and loam soils under irrigated farm, rain-fed farm, and bare soils which had the lowest WAS's contained the highest amount of clay particles (around 23 %). It seems that despite of higher clay contents, their lower WAS's are depend on the type of the soil minerals which needs further investigations.

According to the topographic condition and potential suitability of the study area (being suitable for pasture), cultivation in these areas beside mismanagements (burning and removal of the crop residuals) which are made by local farmers would intensively deteriorate soils of study area. In this regard, it sounds the main reason of the insignificant differences of WAS or OC of the poor pasture and rain-fed farms may be due to less human interferences compared to irrigated farms. Because generally farmer's interferences in natural conditions in rain-fed farms are relatively lower than in irrigated farms.

The results also revealed that conversion of pasture to bare soils due to vegetal cover destruction decreased OC (0.73 % *vs.* 0.99 % of pasture) and deteriorated the soil structural quality with WAS of 63 % *vs.* 70 % of pasture (although it was insignificant). According to the classification of the studied area in poor pasture class, an appropriate and accurate attention is needed to prevent further destructions of this natural resource.

Table 4. Mean comparison of the interactions between land-use and soil texture.

Land-use	Soil texture	WAS	OC	CC
Irrigated farm	Loam	52.95 (d)	0.56 (def)	23.11 (a)
	Sandy clay loam	69.82 (abc)	0.47	20.75 (bc)
	Sandy loam	61.44 (cd)	0.54 (ef)	16.00 (de)
Bare soil	Loam	62.89 (cd)	0.31 (g)	21.67 (ab)
	Sandy clay loam	53.10 (d)	0.78 (cd)	23.47 (a)
	Sandy loam	64.96 (bc)	0.77 (cde)	14.62 (e)
Rain-fed farm	Loam	65.05 (bc)	0.83 (bc)	18.25 (cd)
	Sandy clay loam	29.87 (e)	0.44	23.50 (a)
	Sandy loam	66.56 (abc)	0.90 (bc)	14.16 (e)
Poor pasture	Loam	75.47 (ab)	0.71 (cde)	16.87 (de)
	Sandy clay loam	77.45 (a)	1.35 (a)	21.83 (ab)
	Sandy loam	65.05 (bc)	1.05 (b)	14.74 (e)

Results were in line with results from other researches. For example, Zolfaghari and Hajabasi (2008) also showed that land-use change from forest to agricultural lands led to 23, 55, 11, 40 percent reductions in soil OM, MWD, porosity, and soil hydraulic conductivity, respectively. They also reported that land-use change from pasture to agricultural lands led to 22, 40, and 9 percent reduction in soil OM, MWD, and porosity, respectively. Gebremariam and Kebede (2010) by evaluating land-use change from forest to agricultural lands also showed that this alteration increased soil bulk density, decreased soil OM, and deteriorated soil quality. Ajami *et al.* (2012) reporting the same results also showed that deforestation and farming decrease soil OM from 3.5 % to 1 % and MWD from 1.49 mm to 0.88 mm.

Conclusions

1) Pasture conversion to agricultural lands especially irrigated one reduced WAS and deteriorated soil structure.

2) Pasture conversion to rain-fed farms showed less affecting soil quality and OC than irrigated farms.

3) Vegetal cover destruction and converting pasture to bare soils intensively accelerate soil deterioration.

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