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Full Length Research Paper

Decline in soil quality as a result of land use change in Ghareh Aghaj watershed of Semirom, Isfahan, Iran

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Land use change, if not based on proper scientific investigation affects physical, chemical, and biological properties of soil and leading to increased destruction and erosion. The objective of this study was to investigate the effects of changing rangelands into farmlands on certain soil physical, chemical, and biological properties. Undisturbed soil samples were collected from a 10 cm depth of soil surface in Ghareh Aghaj watershed of Isfahan Province with following land uses: pasture with good vegetation cover, pasture with medium vegetation cover, abandoned dry land farming, and degraded dry land farming. The results indicated that soil organic matter, cation exchange capacity, microbial respiration, and available K decreased by 66.6, 38.8, 81.8, and 70 percent, respectively, from pasture with good vegetation cover to degraded dry land farming. Calcium carbonate content, however, showed changes in the reverse order. Total N showed its highest content in pasture with good vegetation cover but available P did not indicate any significant difference. The most aggregate stability was measured in pasture with good vegetation cover and degraded dry land farming. Based on the results obtained, it seems that land use change may lead to lower soil quality and increase its degradation with undesirable consequences.

Key words: Land use change, soil quality, soil degradation.

INTRODUCTION

From the advent of agriculture, there has been an innate interest in soil and land quality (Carter et al., 2004). Maintaining or improving soil quality can provide economic benefits in the form of increased productivity, more efficient use of nutrients and pesticides, improvements in water and air quality, and lessening of greenhouse gas emissions (USDA-ERS,1997). Karlen et al. (1997) proposed a complete definition for soil quality: they defined soil quality as “the capacity of a specific kind of soil to function, within natural or managed ecosystem boundaries, to sustain biological productivity, maintain or enhance water and air quality, and promote human heath’’. The general consensus is that the soil quality concept should not be limited to soil productivity, but should encompass environmental quality (Karlen et al., 2003). In response to increasing interest in the concept, numerous scientific articles and books have been published (Karlen et al., 1997; Mausbach and Seybold, 1998; Karlen et al., 2003; Andrews et al., 2004). Soil quality began to be interpreted as a sensitive and dynamic way to document soil conditions, as a response to management or as resistance to stress imposed by land use changes (Karlen et al., 2001).

An important feature of soil quality is the differentiation between inherent and dynamic soil properties (Carter et al., 2004). The dynamic soil nature describes the condition of a specific soil due to land use and management practices (Karlen et al., 2003). It is measured by using various chemical, physical and biological indicators (Karlen et al., 2003). For soil in

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Abbreviations: GP, Pasture with good vegetation cover; **MP,** pasture with medium vegetation cover; **ADF,** abandoned dry land farming; **DDF,** degraded dry land farming; **$CaCo_3$,** calcium carbonate; **SOM,** soil organic matter; **CEC,** cation exchange capacity; **TN,** total nitrogen; **AP,** available phosphorus; **AK,** available potassium; **MWD,** mean weight diameter; **MR,** microbial respiration.

natural conditions, reference values represent the inherent ability of a soil to function as defined by the soil forming factors and processes in its native state and can be used to compare effects of land use change or different management practices on similar soils (Mausbach and Seybold, 1998). Assessing soil quality involves measuring physical, chemical, and biological soil properties and using these measured values to detect changes in soil as a result of land use change or management practices (Adolfo et al., 2007).

The objective of this study was to investigate the impact of converting rangeland in to dry farmland on certain soil chemical and biological properties.

MATERIALS AND METHODS

Study area

For the purposes of this study, Ghareh Aghaj watershed, located in central Zagros (51° 36′ E, 31° 31′ N) in Isfahan Province, was selected as the study area (Figure 1). The soils in the study area were classified as Typic Calcixerepts according to key to soil taxonomy 2010 (Soil Survey Staff, 2010) and as Hypercalcic Calcisols according to WRB (IUSS Working Group, 2007) in all the land uses. Mean annual temperature and rainfall in the study area were 9.5° C and 362 mm, respectively. The dominant natural vegetation in the rangelands included *Astragalus sp.* and *Bromus tomentellus.* Because the study areas were selected quite close to each other, climate conditions and landforms were assumed to be identical.

Field study

Undisturbed soil samples were collected in a completely randomized design with four replications from a depth of 0 to 10 cm in the following land uses:

Pasture with good vegetation cover (GP), pasture with medium vegetation cover (MP), abandoned dry land farming (ADF) and degraded dry land farming (DDF).

Laboratory analysis

Soil samples were air dried in the laboratory and passed through a 2-mm sieve prior to analysis. Particle size fractions were determined by the pipette method (Day, 1965), pH by using a pH meter in a 1:1 soil/water ratio (Page et al., 1986), and soil organic carbon by the Walkley–Black oxidation method (Walkley–Black, 1934). The percent of soil organic matter (SOM) was calculated by multiplying the percent organic carbon by a factor of 1.724, following the standard practice that organic matter is composed of 58% carbon (Brady, 1985). Electrical conductivity (EC) was determined by using an EC meter in a 1:1 soil/water ratio (Page et al., 1986); Cation Exchange Capacity (CEC) was determined using sodium acetate at a pH of 8.2 (Rhoades, 1986), Total N (TN) was determined by the Kjeldahl digestion, distillation, and titration method (Bremner et al., 1982), available P(AP) was determined by the Olsen extraction method (Olsen et al., 1954), and available K (AK) was extracted with a solution of ammonium acetate (1 mol/L) adjusted to pH 7 and measured by flame emission (Chapman, 1965). The back titration method (Allison and Moodie, 1965) was used to determine calcium carbonate ($CaCO_3$). Microbial respiration (MR) was measured using the closed bottle method of Anderson (1982) and aggregate stability was determined by the wet sieving method (Van bavel, 1950) and expressed as mean weight diameter (MWD). Soil samples were passed through a 4.6 mm sieve, sprayed with water as a pretreatment and oscillated in water for 5 min using a set of sieves with 2, 1, 0.5, and 0.25mm apertures.

Statistical analysis

Data analysis was performed using a randomized complete design with four replications and comparison of means was accomplished by the Duncan test using SPSS program at 0.05 probability levels.

RESULTS AND DISCUSSION

Some of the physical and chemical soil properties in the studied land uses are presented in Table 1. Table 2 presents the values of mean comparisons.

Calcium carbonate ($CaCO_3$)

The results showed that this parameter had its lowest value (30.37%) in GP and its highest (85.25%) in DDF, indicating an increase of 58% (Table 2). This can be due to inappropriate management practices including tillage or severe soil erosion that cause the underlying soil containing more $CaCO_3$ to move to the surface.

Soil organic matter (SOM)

This parameter had its highest value (2.66%) in GP and its lowest (0.945) in DDF, showing a reduction of 66.6% (Table 2). The results indicated that land use change from pasture to dry land farming, degraded the soil and reduced its SOM content. Khademi et al. (2006) also compared some indicators of soil quality in different land management practices of Boroojen area in Iran to find out that, compared to preserved pastures, dry land farming and released pastures caused a significant decrease in SOM content. They claimed that this was because in conservational management, plant production rate exceeds that of respiration, which leads to the accumulation of carbon in biomass and eventually in soil. Chuluun and Ojima (2002) and Ross (1993) also have reported similar results. In dry land farming, tillage accelerates the decomposition rate of SOM and increases soil erosion and, consequently, wastes SOM. This is similar to the results reported in Mc Dowell and Sharpley (2003), Amsalu et al. (2007) and Akinola (1981) about the effect of tillage and management operations as well as to those reported in Ronggui and Tiessen (2002) about the effect of erosion on reducing SOM. Another cause of the significant decrease in SOM content in this land use type can be related to the decline of plant residues in the soil compared with that in pasture lands. Hajabbasi et al. (2007), reported that in weak and

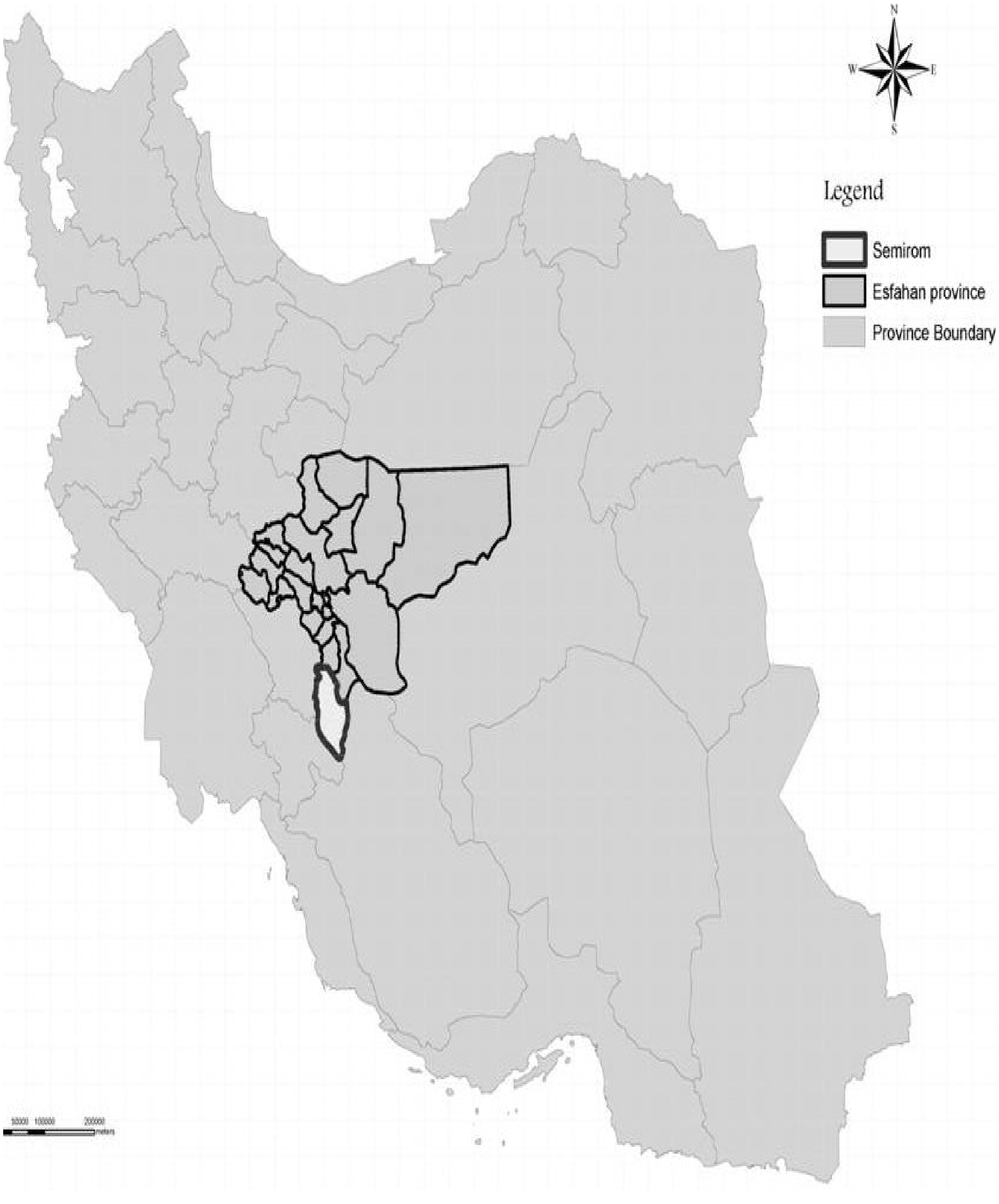

Figure 1. Location of the study areas in central Zagros, Semirom, Esfahan province Iran.

Table 1. Some soil chemical and physical properties in the studied land uses: pasture with good vegetation cover (GP); pasture with medium vegetation cover (MP); abandoned dry land farming (ADF); degraded dry land farming (DDF).

Land use	pH	EC (ds/m)	Clay (%)	Silt (%)	Sand (%)
GP	8	0 .54	31	62	7
AP	7 .6	0 .54	34	64	5
ADF	7 .6	0 .42	32	63	6
DDF	7 .7	0 .41	29	62	9

Table 2. Means comparisons of some physical, chemical, and biological soil quality indices.

Land use	$CaCO_3$ (%)	SO M(%)	CEC ($Cmol^+$/kg)	TN (%)	PÁ (mg/kg)	AK (mg/kg)	MWD (mm)	MR (mg CO_2/day/kg)
GP	^{d*}30 .37	^{a}2 .66	^{a}27 .26	^{a}0 .177	^{a}56 .65	^{a}21.623	^{a}33.0	^{a}11.0
AP	^{c}37 .37	^{b}1 .27	^{b}23 .45	^{b}0 .106	^{a}57 .97	^{a}596 .12	^{b}19.0	^{b}04.0
ADF	^{b}47 .12	^{b}1 .26	^{b}23 .32	^{b}0 .118	^{a}54 .05	^{a}07.525	^{b}16.0	^{bc}03.0
DDF	^{a}85 .25	^{c}0 .94	^{c}16 .74	^{b}0 .076	^{a}66 .64	^{b}15.187	^{a}32.0	^{c} 02.0

* Values in each column with different letters indicate significant differences at p *<0.05*. GP, pasture with good vegetation cover; MP, pasture with medium vegetation cover; ADF, abandoned dry land farming; DDF, degraded dry land farming; $CaCO_3$, calcium carbonate; SOM, soil organic matter; CEC, cation exchange capacity; TN, total nitrogen; AP, available phosphorus; AK, available potassium; MWD, and mean weight diameter; MR, microbial respiration.

abandoned dry land farming, the returning SOM to the soil decreased, thus land use change causes SOM to reduction.

Cation exchange capacity (CEC)

This parameter had its highest value (27.26 $Cmol^+$/kg) in GP and its lowest (16.74 $Cmol^+$/kg) in DDF, showing a reduction of 38.8% (Table 2). This maybe essentially due to the higher SOM content in GP. The values for CEC in these four land uses are related to the SOM content. It may, therefore, be concluded that changing land use from pasture to dry land farming reduced CEC. Sanchez-Maranon et al. (2002) reported that reducing CEC during land use change from Mediterranean pasture to dry land farming was 50%.

Total nitrogen (TN)

TN had its highest value (0.177%) in GP (Table 2). In DDF, intensive erosion occurred due to land use change which maybe the main reason for this reduction. Disturbing soil surface destroys its natural conditions and leaves negative impacts on soil structure and infiltration rate, increases runoff, and leads to the loss of large amounts of nitrogen from soil surface. Another reason for nitrogen loss is the removal of natural vegetation. In pastures with good cover natural vegetation and its return into soil increase the soil SOM content, which in turn increase TN content. Wang et al. (2009) studied NT changes under different land uses in China and found a positive relationship between total nitrogen and total soil organic carbon. SOM content also prevents soil erosion and nitrogen losses due to sedimentation. Removal of the vegetation cover and disturbance of the soil surface by land use change affect soil temperature and soil moisture and, thereby, accelerate biological decomposition of SOM, increase nitrogen mineralization and, ultimately, reduce TN. Unger (1997) reported the deterioration of soil fertility under cropping and concluded that the soils under various types of agricultural land uses contained less organic matter content, total nitrogen, exchangeable bases and cation exchange capacity(CEC) than similar soils under natural vegetation.

Available phosphorous (AP)

The results showed that land use change did not significantly affect AP (Table2). In pastures, vegetation cover and its return into soil increase the soil SOM content, which in turn increase AP content. In dry land farming crops are harvested; so phosphorus is not returned into the soil as a result of phosphorus uptake by crops. However, the concentration of this element increases in these land uses due to phosphorous fertilization during cultivation years; hence, no significant differences are observed in AP content between pastures and dry land farms. Hajabbasi et al. (2002) in their investigations also indicated no significant differences between undisturbed pasture and abundant dry land farming about available phosphorus in Boroojen soil.

Available potassium (AK)

The results showed that this parameter had its minimum value (187.15 mg/kg) in DDF with a reduction of 70% compared with GP (Table 2). The results also indicated that land use changes from pasture to dry land farming destroyed the soil and led to the loss of AK. High AK levels in pasture lands maybe due to enhanced weathering of minerals containing potassium. Similar conditions are observed in dry land farming, but leaching and lessivage of this element to the lower layers lead to the loss of potassium. Also increasing AK in pasture soil surface maybe due to the high ability of pasture plants to absorb potassium from the underlying layers of soil and releasing it by the plant residues to the surface layer. Kayser and Isselstein (2005) reported that continued nutrient export without K supply will lead to depletion in the soil that, depending on K storage, may take from 3 to10 years.

Aggregate stability

The Results showed that MWD had its highest values in GP and DDF land uses (Table 2). The reason for this can be the high levels of SOM content in GP and the high soil $CaCO_3$ content in DDF. Boix-Fayos et al. (2001) reported that in Mediterranean soils, Water stability of the macroaggregates depended on the organic matter. They also indicated that carbonate content was strongly correlated with aggregate stability. Dorioz et al. (1993) explained that strong rooting and extracellular polysaccharide production of pastures are especially effective in gluing soil particles together at the micro-aggregate 5 to 200 mm scale, although packing effects may also influence macro-aggregation up to 1000 mm.

Yadav and Girdhar(1981) and Shainberg et al.(1981) also realized the positive impact of $CaCO_3$ in increasing MWD of calcareous soils. $CaCO_3$ lead to gluing soil particles to gather and hence MWD will increase.

Microbial respiration (MR)

MR was found to have its highest value (0.11 mg CO_2/day/kg) in GP and its lowest (0.02 mg CO_2 /day/kg) in DDF, with a reduction of 81.8% (Table 2). MR is defined as the amount of carbon dioxide produced or the amount of oxygen consumed as a result of the metabolism in microorganisms such as bacteria and fungi. Thus, differences in soil MR are the result of differences in microbial activity. These differences seem to reflect changes in SOM content. In other words, the production of more biomass and, consequently, the accumulation of more organic matter in soil affect soil microbial populations, thus increasing the potential for MR in soil. Dube et al. (2009) in a study reported that soil microbial respiration was also correlated positively with microbial biomass C and SOC. In another study Mallik and Hu (1997) reported that soil organic matter is strongly related to soil microbial respiration and is one of the important factors controlling it. The different land uses affect the formation of organic matter, SOC and microbial biomass C, which in turn will affect soil microbial respiration.

Conclusion

The results of this research showed the effects of different management systems on agricultural and natural ecosystems. It was shown that it does not usually take a long time for the pasture land use changes to lead to significant changes in soil quality in the study region.

Chemical properties, especially SOM which is the most important indicator of soil chemical properties, had a very important role in soil sensitivity to destructive factors. This is because SOM content affects the main soil physical, chemical, and biological properties. This is evidenced by the fact that SOM content was found to have its highest value in GP due to the higher vegetation cover and a greater return of plant residues into the soil while it had its lowest value in DDF where tillage and increased soil erosion reduce its content.

MR index properly showed soil biological differences among the different land uses. It is, therefore, a valuable indicator in soil quality studies.

The overall result is that dealing with hardly renewable resources and sustainable use of them, which are the main factor of sustainable development of any society, must adjust with physical status and capacity of any long term activity in each region.

This means that the use of lands and other resources should be adapted to their natural conditions and that laws and regulations must be provisioned that protect the environment.

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