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The Comparison of Some Soil Quality Indexes in Different Land uses of Ghareh Aghaj Watershed of Semirom, Isfahan, Iran

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***Abstract*—**Land use change, if not based on proper scientific investigation affects other physical, chemical, and biological properties of soil and leading to increased destruction and erosion. It was imperative to study the effects of changing rangelands to farmlands on some Soil quality indexes. Undisturbed soil samples were collected from the depths of 0-10 and 10-30 centimeter in pasture with good vegetation cover(GP), pasture with medium vegetation cover(MP), abandoned dry land farming(ADF) and degraded dry land farming(DDF) land uses in Ghareh Aghaj watershed of Isfahan province. The results revealed that organic matter(OM), cation exchange capacity(CEC) and available potassium(AK) decreasing in the depth of 0-10 centimeter were 66.6, 38.8 and 70 percent and in the depth of 10-30 centimeter were 58, 61.4 and 83.5 percent respectively in DDF comparison with GP. Concerning to the results, it seems that land use change can decrease soil quality and increase soil degradation and lead in undesirable consequences.

***Keywords*—**Land use change, Soil degradation, Soil quality

I. Introduction

FROM the advent of agriculture, there has been an innate interest in soil and land quality [10]. 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 [33]. Karlen *et al.* [18], 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 [20]. In response to increasing interest in the concept, numerous scientific articles and books have been published (e.g. [18], [25], [20], and [6]). 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 [19].

An important feature of soil quality is the differentiation between inherent and dynamic soil properties [10]. The dynamic soil nature describes the condition of a specific soil due to land use and management practices [20]. It is measured by using various chemical, physical and biological indicators [20]. For soil in 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 [25]. Assessing soil quality involves measuring soil physical, chemical, and biological properties and using these measured values to detect changes in soil as a result of land use change or management practices [1].

So the objective of this study was to investigate the impact of converting range lands to dry farming land use on some chemical and biological properties of soils

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II. Materials and Methods

A. 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 (Fig. 1). The soils in the study area were classified as Typic Calcixerepts according to key to soil taxonomy 2010 [31] and as Hypercalcic Calcisols according to WRB [17] 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 land uses in the study area were selected quite close to each other, climate conditions and landforms were assumed to be identical.

B. Field Study

Undisturbed soil samples were collected in a completely randomized design with four replications from each depths of 0-10 and 10-30 cm in 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).

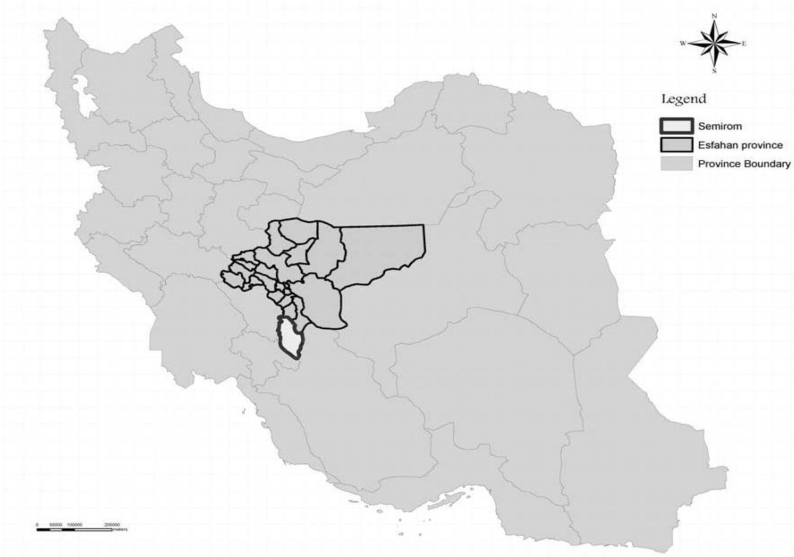

Fig. 1 Location of the study area in central Zagros, Semirom, Isfahan Province, Iran

C. Laboratory Analysis

Soil samples were air dried in the laboratory and passed through a 2-mm sieve prior to analysis. Soil organic carbon was determined by the Walkley–Black oxidation method [35]. 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 [8]. Cation Exchange Capacity (CEC) was determined using sodium acetate at a pH of 8.2 [27], Total N (TN) was determined by the Kjeldahl digestion, distillation, and titration method [9], available P (AP) was determined by the Olsen extraction method [26] and available K (AK) was extracted with a solution of ammonium acetate (1 mol/L) adjusted to pH 7 and measured by flame emission [11]. Calcium carbonate ($CaCO_3$) was determined by back titration method [3]. Microbial respiration (MR) was measured by the closed bottle method [5]. Aggregate stability was determined by the wet sieving method [34] 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.

D. 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.

III. Results and Discussion

A. Calcium Carbonate ($CaCO_3$)

Mean comparison of $CaCO_3$ in depths of 0-10 and 10-30 cm of soils appears in Table I and Table II respectively.

$CaCO_3$ in depth of 0-10 cm in AP, ADF and DDF land uses indicated 4.5, 24.2 and 58 percent increasing respectively compared with GP. Also this parameter in depth of 10-30 cm in AP, ADF and DDF land uses indicated 30.1, 45 and 70.5 percent increasing respectively compared with GP. 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.

B. Soil Organic Matter (SOM)

Mean comparison of SOM in depths of 0-10 and 10-30 cm of soils appears in Table I and Table II respectively.

SOM in depth of 0-10 cm in AP, ADF and DDF land uses indicated 55.5, 51.8 and 66.6 percent decreasing respectively compared with GP. Also this parameter in depth of 10-30 cm in AP, ADF and DDF land uses indicated 41.6, 50 and 58 percent decreasing respectively compared with GP. The results indicated that land use change from pasture to dry land farming degraded the soil and reduced its SOM content. Khademi *et al.* [22] 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 [12] and Ross [28] 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 in accordance with other researches about the effect of tillage and management operations[23], [4], [2]. 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.* [16] reported that in weak and abandoned dry land farming, the returning SOM to the soil decreased, thus land use change causes SOM to reduction.

TABLE I
MEANS COMPARISONS OF SOME PHYSICAL, CHEMICAL, AND BIOLOGICAL SOIL QUALITY INDICES IN DEPTH OF 0-10CM OF SOILS

Land use	$CaCO_3$	SOM	CEC	TN	AP	AK	MWD	MR
	(%)	(%)	($Cmol^+$/kg)	(%)	(mg/kg)	(mg/kg)	(mm)	(mg CO_2/day/kg)
GP	30 .37^{d}	2 .66^{a}	27 .26^{a}	0 .177^{a}	56 .65^{a}	623.21^{a}	0.33^{a}	0.11^{a}
AP	37 .37^{c}	1 .27^{b}	23 .45^{b}	0 .106^{b}	57 .97^{a}	596 .12^{a}	0.19^{b}	0.04^{b}
ADF	47 .12^{b}	1 .26^{b}	23 .32^{b}	0 .118^{b}	54 .05^{a}	525.07^{a}	0.16^{b}	0.03^{bc}
DDF	85 .25^{a}	0 .94^{c}	16 .74^{c}	0 .076^{b}	66 .64^{a}	187.15^{b}	0.32^{a}	0. 02^{c}

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.

TABLE II
MEANS COMPARISONS OF SOME PHYSICAL, CHEMICAL, AND BIOLOGICAL SOIL QUALITY INDICES IN DEPTH OF 10-30CM OF SOILS

Land use	$CaCO_3$	SOM	CEC	TN	AP	AK	MWD	MR
	(%)	(%)	($Cmol^+$/kg)	(%)	(mg/kg)	(mg/kg)	(mm)	(mg CO_2/day/kg)
GP	27 .6^{d}	2 .4^{a}	27 .7^{a}	0 .18^{a}	66 .7^{a}	652.4^{a}	0.35^{a}	0.05^{a}
AP	39 .5^{c}	1 .4^{b}	27 .3^{a}	0 .1^{b}	61 .9^{a}	560.2^{b}	0.19^{b}	0.02^{b}
ADF	50 .2^{b}	1 .2^{bc}	19 .9^{b}	0 .09^{b}	69 .2^{a}	504.1^{b}	0.19^{b}	0.02^{b}
DDF	93 .6^{a}	1 .01^{c}	10 .7^{c}	0 .08^{b}	83 .6^{a}	107.8^{c}	0.38^{a}	0. 01^{b}

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.

C. Cation Exchange Capacity (CEC)

Mean comparison of CEC in depths of 0-10 and 10-30 cm of soils appears in Table I and Table II respectively.

CEC in depth of 0-10 cm in AP, ADF and DDF land uses indicated 14.3, 14.6 and 38.8 percent decreasing respectively compared with GP. Also this parameter in depth of 10-30 cm in AP, ADF and DDF land uses indicated 1.4, 28.1 and 61.4 percent decreasing respectively compared with GP. This may be 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.* [29] reported that reducing CEC during land use change from Mediterranean pasture to dry land farming was 50%.

D. Total Nitrogen (TN)

Mean comparison of TN in depths of 0-10 and 10-30 cm of soils appears in Table I and Table II respectively. The results indicated that this parameter had its highest value in both study depths of GP. In DDF, intensive erosion occurred due to land use change which may be the main reason for this reduction. Disturbing soil surface and its natural conditions 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. Natural vegetation in pastures with good cover returns organic matter into the soil leading to a higher SOM content in soil. Wang *et al.* [36] 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 [32] 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.

E. Available Phosphorous (AP)

Mean comparison of AP in depths of 0-10 and 10-30 cm of soils appears in Table I and Table II respectively. The results showed that land use change did not significantly affect AP in both study depths. 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.* [15] in their investigations also indicated no significant differences between undisturbed pasture and abundant dry land farming about available phosphorus in Boroojen soils.

F. Available Potassium (AK)

Mean comparison of AK in depths of 0-10 and 10-30 cm of soils appears in Table I and Table II respectively. The results showed that this parameter had its minimum value in both study depths of DDF land use. 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 may be 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 soil surface may be 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 [21] 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.

G. Aggregate stability

Mean comparison of MWD in depths of 0-10 and 10-30 cm of soils appears in Table I and Table II respectively. The Results showed that MWD had its highest values in both study depths of GP and DDF land uses. 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*. [7] 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.* [13] explained that strong rooting and extracellular polysaccharide production of pastures are especially effective in gluing soil particles together at the micro-aggregate 5–200 mm scale, although packing effects may also influence macro-aggregation up to 1000 mm.

Yadav and Girdhar [37] and Shainberg *et al.* [30] also realized the positive impact of $CaCO_3$ in increasing MWD of calcareous soils. $CaCO_3$ lead to gluing soil particles to gether and hence MWD will increase.

H. Microbial Respiration (MR)

Mean comparison of MR in depths of 0-10 and 10-30 cm of soils appears in Table I and Table II respectively. The results showed that this parameter in both study depths of GP land use was found to have its highest value.

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.* [14], in an study reported that soil microbial respiration was also correlated positively with microbial biomass C and SOC. In another study Mallik and Hu [24], 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.

IV. Conclusions

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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