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Effect of Converting Forest to Rainfed Lands on Spatial Variability of Soil Chemical Properties in the Zagros Forest, Western Iran

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ABSTRACT The control of biological, hydrological and geochemical cycles of soil is the key part of the earth system. The objective of this research was to evaluate changes in soil chemical properties due to deforestation occurred in the Gazafolya Village, Merek Watershed, Kermanshah Province, Iran. Toward this attempt, 35 soil samples were collected from top soil layer using auger in early June, 2013. Soil analysis including pH, carbonate content, electrical conductivity (EC) and exchangeable sodium (Na), soil organic carbon (SOC) and cation exchange capacity (CEC) were made. The results showed that there were no significant differences between soil pH, carbonate content, EC and Na in the forest and rainfed areas while there was significant difference (P> 0.005) between SOC in the forest (2.10%) and rainfed (1.35%) areas. The semi-variance analysis also revealed that the spatial dependence class of SOC in the forest was strong, while it was mainly moderate in the rainfed areas due to improper plowing practices in the rainfed area there was moderate. In addition, the results showed the soil CEC in the forest and rainfed areas were 33.3 and 25.1 $cmol_c kg^{-1}$, respectively, indicating significant higher level in the forest area. Semi-variance analysis also revealed a strong spatial variation for CEC in the forest. Finally, there were no significant differences for EC and Na with moderate spatial variation in both areas. It was concluded that SOC and CEC significantly reduced by severe deforestation phenomenon of Zagros Forest.

Key words: *Crops Residue Burning, Human induced deforestation, Improper Tillage Practice, Kashkan Formation, Sustainable Land Management*

1 INTRODUCTION

The soil provide different services and resources for human. However, the dynamic interaction between vegetation, particularly forest, and soil helps renew both them. The global forests are about four billion hectares (FAO, 2012), but suffering from deforestation factors mainly shifting to arable lands. Converting forest involves the replacement of natural forests with other forms of landuse imposing serious problems, especially loss of plant and soil diversities associated with landuse and cover change, climate change and contamination (Berendse, *et al.*, 2015; Brevik, 2015). Forest conversion to rainfed lands has the concern of relevant experts and even decision makers in Iran due to its severe negative impacts.

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During 1972-2009 about 353000 ha (69%) of Zagros Forests (western Iran) are declined mainly due to converting to agricultural lands (Henareh Khalyani *et al.,* 2012) and subsequently subjected to inappropriate tillage practices, soil disturbance and permeability. In this converted forest, agricultural activities, especially tillage practice and agrochemicals application can lead to an accumulation of fertilizer residue, heavy metal and pesticides in soil, sediment and water as well as increasing soil erosion and siltation (Mohammad and Adam, 2010; Fallahzade *et al.,* 2011; Keesstra *et al.,* 2012). In addition, soil in the most parts of Zagros area comprises marl and shale depositions with dominant expanded clay mineral such as smectite (Karimi *et al*., 2008; Heshmati *et al.*, 2011).

Subsequently, impacts of these huge forest decline of soil quality particularly depletion of soil organic carbon (SOC), cation exchange capacity (CEC) and nutrients (N, P, K) are the main challenges for crops yield and sustainable agriculture in this region. Although soil nutrients affected by intrinsic factors (parent materials and soil texture), they are more vulnerable to extrinsic factors mainly anthropogenic deforestation, tillage, burning of crop residue and erosion. In Zagros area, crop residue brining and fire blowing in the forest are occurred mainly during September. The ash of burned vegetation affects soil physicochemical and biological properties, water repellency or wettability, which in turn, increase runoff and erosion by sealing the soil surface in the slope lands (Dlapa *et al.,* 2013; Pereira *et al.,* 2013; Hedo *et al.,* 2015).

Furthermore, the adverse effects of continuous up-down the slope tillage under moldboard plowing on soil properties and crops yield is at least four times more than across the slope (Quinton *et al*., 2006; Blanco and Lal, 2008), while Singh *et al.* (2014), reported that conventional tillage enhanced soil moisture storage and organic carbon in a sodic soil in other region (India). SOC at the slope arable lands of Mediterranean areas reach to depression areas such as drainage system through this tillage (Karlen *et al*., 2008). Depletion of SOC may affect soil biological properties via compaction, which in turn, cause aeration and oxygen providing for biological activities. The highest microbial density and activity is reported in tillage depth (Fterich *et al.,* 2014). In contrast, wise landuse practices and no tillage and crop rotation improve SOC and biochemical as well as gully erosion control compared to conventional tillage in the rainfed lands of semiarid regions (Rousta, 2010; Laudicina *et al.,* 2015).

Land use changes is more frequent in the highlands due to market demand, climate change and urbanization (Valentin *et al*., 2008). These processes occur in most parts of Zagros Mountains in Iran. Field observation in the several parts of these area showed that the recent rainfed farms in neighbored the forests are faced to severe erosion, crops yield decline and it is going to triggered desertification phenomenon mainly due to tillage practice and absence of vegetation cover during rainfall season.

Spatial dependence of soils variable can be quantified and modeled through geostatistics (comprise variography and kriging model). Variography uses semi-variograms to characterize and model the spatial variance of data whereas kriging uses the modeled variance to estimate values between samples base on nugget variance and total variance ratio (Cambardella, *et al.,* 1994; Yamagishi *et al.,* 2003). Spatial variation of soil properties could be well described by spherical model in the forest and exponential model in the cultivated and grazing lands (Jafarian Jeloudar *et al.*, 2014). The study on the impact of converting forest to arable lands can reveal ways to increase sustainability of natural resources and agriculture as well as public awareness. Toward this, the objective of this study was to evaluate spatial variability of soil chemical properties via conversion of forest to the rainfed farms during recent decade in the Gazafolya Village, Kermanshah Province, western Iran.

2 MATERIALS AND METHODS

2.1 Study Area

This research was conducted in the Zagros Forest and its vicinal rainfed areas of Gazafolya Village, located 35 km from sout Kermanshah City, Iran (693749 to 700368 E-longitude, 3767614 to 3771684 N Latitude) (Figure 1). It is one of the upper Watersheds of the Karkheh river basin (KRB) located in Zagros Mountain Range (western Iran) (Figure 1). This site comprises plains and hilly lands with forest and agricultural areas. The mean annual precipitation and temperature are 450 mm and 17 °C, respectively, indicating a semi-arid region (Kermanshah Meteorology Office, 2013). Zagros Oak Forests (*Quercuse persica*) with an area of five million ha, occupies Zagros Mountains Range, locating along the western of Iran (Sepahvand and Zandebasiri, 2014). These forests are facing accelerated human-induced deforestation features over the time. There were approximately 10 million ha during six last decades (Saeed, 2006).

The geological formations comprise sedimentary rocks including limestone, sandstone, shale and marls deposits of Pleistocene and Holocene eras. The soils are mostly clay and silty in nature with high amount of calcite. The *Quercus percia* occupies about 80% of central Zagros Forest, western Iran. The canopy cover of the forests in the degraded area is less than 50% (Gheitury and Tavakoli, 2008). The majority of the literature classifies the Zagros Forests in the Irano-Anatolian phytogeographic subregion (Zohary, 1973; Sabeti, 1993). This forest is subjected to deforestation phenomenon due to severe anthropogenic land degradation factors, especially forest clearance in the adjacent to agricultural lands. Land degradation in this area characterized by soil erosion (particularly inter-rill, rill, gully and landslide), improper and heavy tillage practices, overgrazing and misuse of chemical inputs in the agriculture lands (Milani *et al.*, 2006).

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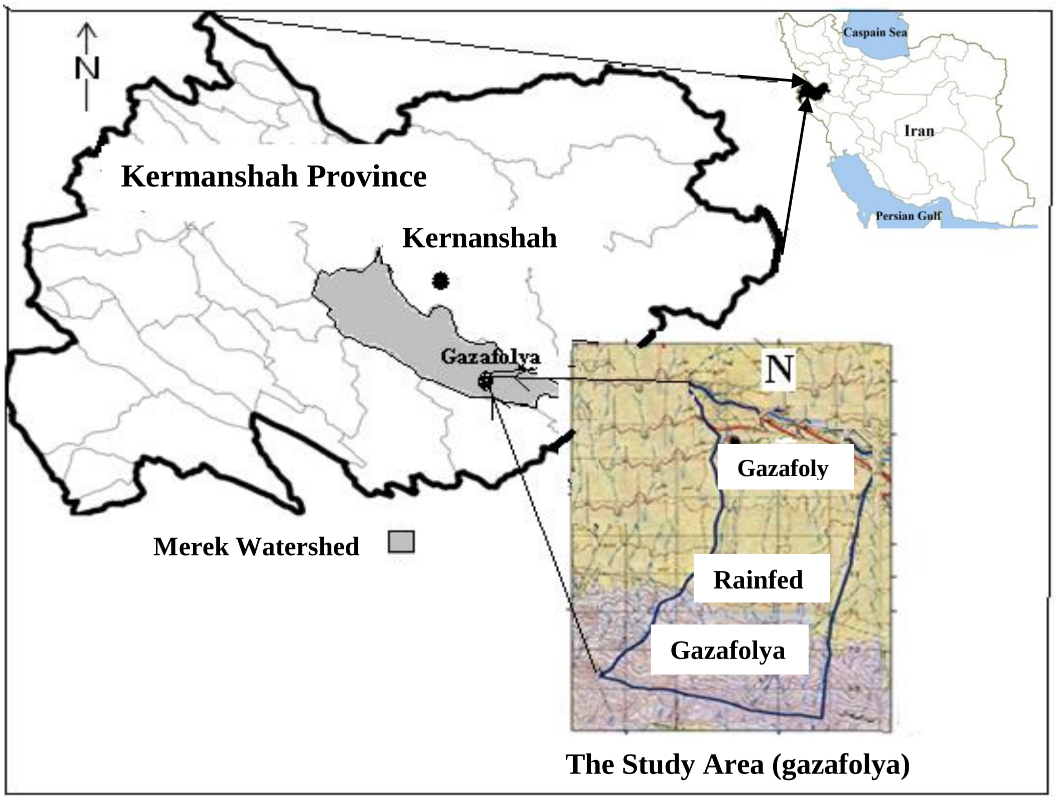

Figure 1 Location of the study area (Gazafolya Village) in the Merek Watershed, Kermanshah Province, Western Iran

2.2 Geomorphologic characteristics of selected sits

The selected rainfed and its upward forest have same characteristics in terms of geology, topography (slope gradient and direction, altitude range), soil group and erosion feature with different landuse practices. Each of them can be suppose as a geomorphological unit that is a homogenous area with specific characteristics of geology, topography, land use and erosion within a Watershed (Ahmadi, 2003). The geological sediment strata in the most part of Zagros Mountains comprise limestone, sandstone, shale and marls materials. The study area is located on the Kashkan Formation (given local name by geological survey of Iran). This geological formation is a marl deposit and its outcrop in the study area includes the presence of reddish claystone, siltstone and sandstone, inter-layered with limestone (Karimi-bavandpoor *et al.*, 1999). Field observations showed the limestone is shallower than fine grained layers of silt and clay. Landslide was found as the main degradation feature and initiated by piping and cracking. The slope steepness ranged between 15-20% with northern direction. The elevation above sea level is ranged from 1500-1600 m. soil is Entisols with A and C horizons (USDA, 2003). The alteration of forest to the rainfed was carried out approximately during recent decade by local inhabitants either gradually via plowing or direct forest clearance through limited arson fire and logging activities. The rainfed in the down ward of forest was selected using the topographic map, aerial photo and satellite images (landsat) and verified in the field.

2.3 Soil Sampling and Analysis

To conduct the research, 35 soil samples were collected from surface soil layer, using auger and

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followed by stratified random soil sampling and their coordinates were determined by global positioning system (GPS) (Figure 2). The dried soil samples were sieved through 2 mm mesh. Soil properties were determined at the laboratory. The pH of the saturated soil was measured by a pH meter as outlined by Ryan *et al.* (2001). Electrical conductivity (EC) of saturated soil sample was read by EC meter. SOC was determined by the Walkley and Black method (Nelson and Sommers, 1982). The carbonate in the soils was measured by the titration method using sodium hydroxide solution (Nelson and Sommers, 1982).

The samples were centrifuged and their extracted solution run by atomic absorption spectrophotometer (Perkin-ELMER). CEC and exchangeable sodium (Na) of soils was determines by the 1 M ammonium acetate at pH 7, as outlined by Van Reeuwijk and Vente (1993).

2.4 Statistical and Geo-statistical Analysis

Descriptive statistical analysis including mean, maximum, minimum, standard deviation (SD) and coefficient of variation (CV) as well as t-test carried out using SAS 6.12 software. The geo-statistical analysis including semi-variogram model (autocorrelation and interpolation) and kriging procedures cross validation) was performed to assess the degree of spatial variability of each soil characteristics using the GS$^+$ 9.0 software. The normality of data were also checked through this software based on skewness coefficient. The skewness between -1 to +1 indicates normality of data and no need to transform the data prior to using geo-statistical analysis (Virgilio *et al.*, 2007).

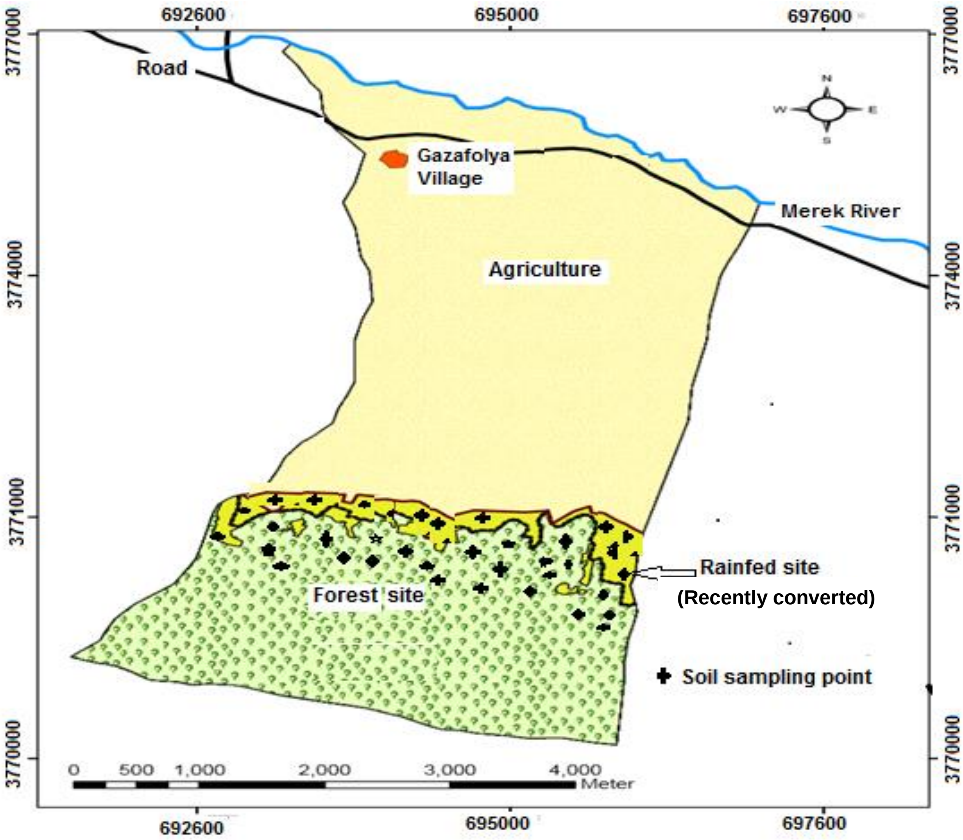

Figure 2 Soil sampling points in the study forest and rainfed areas, Kermanshah Province, Western Iran

3 RESULTS AND DISCUSSION

The results of descriptive statistical and geo-statistical analysis of soil characteristics in the forest and rainfed areas including soil pH, carbonate, EC, Na and SOC are shown in Tables 1 and 2. The mean soil pH in the study area was 7.6 and didn't have significant difference for soil pH between forest and rainfed areas, while coefficient of variance in forest was more than rainfed (Table 1). The geo-statistic parameters show high pH spatial variation in the forest, but moderate spatial dependence in the rainfed (Table 2) indicated no effects of landuse practices on pH variable which also confirmed by high level of regression coefficient of kriging model (Table 3).

Respective soil carbonate content in the forest and rainfed was 32.7 and 30.0 percent indicating a bit higher in the rainfed and no significant difference between them (Table 1). The semi-variograms model showed weak and random spatial variation for carbonate (Table 2) and kriging parameter is more variable for carbonate in the rainfed area (Table 3) The randomized distinct classes of spatial dependence showed the severe effects of both rill erosion and tillage practices on surface soil resulting in disturbance of carbonates with high sample variance in the rainfed area (Table 2). If the nugget equal sill, soil variable is described as spatial independence and completely random (Cambardella *et al.,* 1994). It is more influenced by soil erosion (Jabro *et al.,* 2010).

SOC in the forest and rainfed was 2.1 and 1.35%, respectively. Descriptive statistical analysis revealed significant difference for SOC between forest and rainfed lands ($p<0.05\%$). The geo-variance analysis also explored that SOC in the forest is strongly spatial variable (Table 2) with validated kriging model (Table 3). The spatial variability of SOC was more imposed by deforestation compared to the other soil properties in the Hyrcanian Forest (Kooch *et al.,* 2014). The higher value of SOC in forest associated with vegetation biomass, although faced to other deforestation agents such as grazing, charcoal and tree branch cutting.

Furthermore, lower variance and standard devotion of SOC in the forest shows lower soil disturbance compared to rainfed area. Adversely, SOC in the rainfed was found spatially independent affecting by external factors mainly erosion. Rill and gully erosion is reported in rainfed area due to improper agricultural activities delivering high value of suspended clay and silt sediments originates predominantly from the hill slopes (Keesstra *et al.,* 2009; Heshmati *et al.,* 2011) (Table 2). There was confirmed by other similar study (Cambardella *et al.,* 1994; Jafarian *et al.,* 2011). Tillage practice contributes to SOC loss in the agricultural areas, especially in the top-soils. The moldboard plowing system can expose and displace most of the top-soil resulting in SOC depletion. The study of Elberling *et al.* (2013), revealed that changes of forest to agriculture resulted in SOC flux and consequently adverse environmental changes such as salinization and desertification. Even converting forest to orchard or other permanent plant need to long term remediation measures for enhance soil chemical, biological and physical properties. The research by Costantini *et al.* (2015), showed lower SOC, N, C/N and EC in a yang vineyard compared to old vineyard. The study of Bravo-Espinosa *et al.* (2014), showed that soil aggregate stability, mechanical resistance to penetration and nitrate concentration in the topsoil layer affected by forest conversion to avocado orchards.

Spatial variability of SOC is controlled by plough system, soil texture and soil disturbance as well as climatic and topographic factors (Karlen *et al.,* 2008). Soil disturbance negatively affected SOC and subsequently crops yield (Miralles *et al.*, 2009). Kilic *et al.* (2012) explored that soil SOC, CEC, EC, clay and silt contents decreased significantly through tillage practice and variables of the cultivated soils had a lower nugget compared to the grassland. Finally, change in SOC is more evident with addition of plant residues causing stability of coarse soil aggregate in the agricultural lands (Kabiri *et al.*, 2015).

Farm management in terms of minimum machinery traffic, chisel plough, turnover of crops residue and precise agrichemical application are considered as the proper practices in these area (Hamza and Anderson, 2005). Soil compaction through agricultural machinery contributes to loss of SOC (Saeedifar and Asgari, 2014). Field verification explored that steep slope faced to severe erosion and should be reforested or protected for curtail sedimentation. Same reforestation leads to 45% of sediment since 1975 at the Watershed scale in Slovenia (Keesstra *et al.*, 2009). Understory vegetation at the degraded forest can also regarded for enhancement of soil quality and subsequently growing forest tree mainly due to moisture holding and significant increase in tree volume (Thomas *et al.*, 2015). In addition recently arson fire is more occurred for converting the arable lands. The effect of fire on soil properties, erosion, overland flow and hydrophobicity is more considered in the forest compared to herbs and shrubs (Cerdà *et al.*, 2005).

Soil carbonate content in the forest (32.7%) was a bit higher than rainfed lands (30.3%), while there was no significant difference between two values, but spatial dependence in surface soil of rainfed was random higher replacement due to disturbance agent such as erosion and tillage. This high level of soil carbonate derived from parent material of study area and can be affect soil properties and adverse availability of nutrients for plants. High soil carbonate and alkaline soil pH suppressed plant growth probably mainly by inhibiting uptake of phosphate, Ca and Mg (Wang *et al.*, 2009).

As shown in Table 1, mean EC of soil in the two landuse is 7 dS m^{-1}. This result is approximately similar to pH and carbonate content of soil as the intrinsic soil properties indicating lower effect of landuse practices, particularly in the semiarid regions. Respective level of Na in the forest and rainfed was 0.55 and 0.45 $cmol_c kg^{-1}$ and although there a bit higher in the forest, no statistically significant difference between two areas (Table 1). The geo-statistical analysis revealed a moderate spatial variation for both EC and Na in the study area. Low EC and Na are related to geological properties which comprise limestone, sandstone and claystone with absence of halite minerals (Karimi-bavandpoor, 1999).

Soil CEC in the forest and rainfed areas was 33.3 and 25.1 $cmol_c kg^{-1}$, respectively. The t-test analysis showed that CEC value in the forest was significantly ($p<0.05\%$) more than rainfed site (Table 1). Semi-variance parameters also revealed strong spatial variation for forest, whereas there was moderate in the rainfed area (Table 2). Moderate spatial variability for most of the soil chemical properties except SOC, is confirmed by study of Ayoubi *et al.* (2007) in the crop lands of North Iran. Moreover, Ayoubi *et al.* (2007) found high level of spatial variation for SOC. The moderate CEC value rated 12-25 $cmol_c kg^{-1}$, while high CEC class includes 25-40 $cmol_c kg^{-1}$. In contrast, soil with a low CEC value (<12 $cmol_c$ kg^{-1}) indicates a soil with little or no organic matter that could not hold considerable cations (Hazelton and Murphy, 2007).

Geo-statistical analysis indicated a moderate spatial dependence in the both areas with validate level of kriging model (Tables 2 and 3). At a result, significant reduction in soil CEC in the rainfed area (moderate compared to high class) occurred mainly due to low SOC, tillage and crops residue burning as dominant features of improper agricultural activities. Moalemi *et al.* (2009), showed that soil CEC mainly was related to clay particle, SOC and pH in the soil of Guilan Province, Iran confirming curtail of SOC through deforestation and subsequently negative effect on soil CEC stock. Tillage, contribute loss of SOC and also CEC and there are more vulnerable in the slope lands (Negassa *et al.,* 2015). Sharma *et al.* (2014) showed that the soil nutrients and CEC loss were significantly influenced by cultivation system. Furthermore, the fluxed SOC can be emitted to air within 100 days resulting in significant soil nutrients and CEC depletion (Barbosa *et al.,* 2009; Polyakov and Lal, 2008). This rainfed lands are suffering from uninterrupted cropping, conventional tillage practice and burning of crop residue. The positive effects of no-tillage on soil properties and crop yield has been evidenced, particularly higher yield for wheat in the semiarid region (Costa *et al.,* 2015).

Table 1 Descriptive statistics of soil nutrients variables in the forest and rainfed areas in the Gazafolya Village, Merek Watershed, Kermanshah Province, Iran

Variable	Landuse	Mean	SD	S. Var	Min.	Max.	N	Ske.	P
pH	Forest	7.70	0.236	0.05	7.20	8.32	19	0.44	0.051
	Rainfed	7.56	0.124	0.015	7.30	7.80	16	-0.80	NS
Carb. (%)	Forest	32.70	9.94	98.9	14.80	49.2	19	-0.69	0.388
	Rainfed	30.23	6.70	44.9	19.60	45.0	16	0.99	NS
SOC (%)	Forest	2.10	0.47	0.14	1.2	2.60	19	-0.05	0.0004*
	Rainfed	1.35	0.56	0.31	0.65	2.75	16	0.46	
EC (dS m^{-1})	Forest	0.71	0.20	0.042	0.46	1.10	19	0.45	0.973
	Rainfed	0.70	0.21	0.046	0.36	1.30	16	1.02	NS
Na ($cmol_c kg^{-1}$)	Forest	0.55	0.19	0.04	0.25	0.89	19	0.03	0.127
	Rainfed	0.45	0.15	0.02	0.23	0.68	16	0.01	NS
CEC (cmolckg-1)	Forest	33.3	3.50	12.27	26.0	38.6	19	-0.23	0.0001*
	Rainfed	25.1	5.96	35.5	14.0	38.2	16	-0.53	

Carb.= Carbonate, SOC= Soil Organic Carbon, EC= Electrical Conductivity, Na = exchangeable sodium, CEC= Cation Exchange Capacity, S. Var = Sample Variance, Ske.= Skewness,
* = Significant difference at 5% level and NS = Non significant difference

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Table 2 Coefficients of the theoretical semi-variogram models of soil nutrients properties variables in the forest and rainfed in the Gazafolya Village, Merek Watershed, Kermanshah Province, Iran

Variable		Co	Co + C	Co/(Co+C)	r^2	RSS	Spatial variation class*
pH	Forest	0.051	0.1026	0.49	0.080	1.48E-03	Moderate
	Rainfed	0.0048	0.0200	0.24	0.204	4.79E-04	Strong
Carb.	Forest	81.60	204.7	0.401	0.142	2103	Moderate
	Rainfed	37.96	37.96	1.00	0.417	2116	Random
SOC	Forest	0.018	0.131	0.14	0.367	0.0131	Strong
	Rainfed	0.316	0.316	1.00	0.065	0.162	Random
EC	Forest	0.037	0.074	0. 51	0.037	1.35E-03	Moderate
	Rainfed	0.037	0.074	0.51	0.0.29	3.7E-03	Moderate
Na	Forest	0.026	0.108	0.24	0.45	5.6E-04	Moderate
	Rainfed	0.022	0.047	0.50	0.017	1.9E-03	Moderate
CEC	Forest	8.53	21.0	0.40	0.20	172	Moderate
	Rainfed	25.4	50.8	0.50	0.45	1938	Moderate

*Co/(Co+C) <0.25= Strong spatial dependence, 0.25<Co/(Co+C) <0.75 = moderate spatial dependence, Co/(Co+C) >0.75= weak spatial dependence, If total variance is equal to the nugget variance [Co=(Co+C)], variable is described as spatially independent and completely random (Cambardella *et al.*, 1994)

Table 3 Parameters of kriging model validation for soil nutrients variables in the forest and rainfed in the Gazafolya Village, Merek Watershed, Kermanshah Province, Iran

variable	Land-use	Regression Coefficient	Standard Error (SE)	R^2	Y intercept	SE prediction
pH	Forest	0.69	0.98	0.03	2.35	0.23
	Rainfed	-1.58	0.69	0.27	19.53	0.11
Carb.	Forest	-0.60	0.54	0.07	53.18	9.60
	Rainfed	-15.00	0.54	1.00	483.70	9.59
SOC	Forest	1.015	0.26	0.48	-0.04	0.34
	Rainfed	-15.00	0.25	1.00	21.72	0.34
EC	Forest	-3.52	1.26	0.32	3.20	0.17
	Rainfed	-15.00	1.26	1.00	11.33	0.17
Na	Forest	0.18	0.75	0.004	0.44	0.19
	Rainfed	-3.14	1.45	0.25	1.90	0.13
CEC	Forest	1.96	1.19	0.14	98.53	3.25
	Rainfed	-15.00	1.19	1.00	402.60	3.25

Carb.= Carbonate

5 CONCLUSION

Deforestation phenomenon in the Zagros Forest is being accelerated seriously over time, but conversion of forest to rainfed lands is the background of this challenge affecting soil properties as well as environmental impacts. The results of this study based on classical and geo-statistical analysis revealed that some soil

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chemical properties are affected by forest converting practices. Some soil chemical properties including pH, carbonate, EC and Na did not significant change by this improper land use practices, while their spatial variations in the rainfed area were relatively more that forest area. In contrast, two other crucial soil chemical variables including SOC and CEC negatively reduced in the rainfed compared to forest area. This is occurred through improper tillage practices as well as crops residue burning. As evidenced by this research, converting Zagros Forests to rainfed lands and subsequently tillage and crop residue burning attribute to significant reduction in SOC and CEC indicating soil quality loss. Finally, changes of forest to agriculture should be public awareness among stakeholders (policy makers and social inhabitants) and they can be used for future sustainable management of land resources. These results suggest the importance of implementing strategies for mitigating the accelerated converting Zagros Forest to rainfed landsand implementation of programs for deforestation reduction should be a priority in the protection biodiversity and reclamation of steep slope croplands.

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اثرات تبدیل جنگل به دیم‌زار بر تغییرپذیری مکانی ویژگی‌های شیمیایی خاک در جنگل‌های زاگرس در غرب ایران

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چکیده خاک بخش کلیدی سیستم زمین است که چرخه‌های زیستی، هیدرولوژیکی و شیمیایی زمین را کنترل می‌کند. هدف از این تحقیق بررسی مهم‌ترین اثرات تبدیل جنگل به دیم‌زار بر مشخصات شیمیایی خاک بود که در محدوده‌های روستای گزاف واقع در سرشاخه حوزه مرک در استان کرمانشاه به‌عمل آمد. برای این منظور، نمونه‌برداری از لایه سطحی خاک جنگل و دیم‌زار به‌عمل آمد و مورد آزمایشات خاکشناسی قرار گرفت. نتایج حاصله و ارزیابی آماری آنها نشان داد که بین اسیدیته، آهک کل، هدایت الکتریکی و سدیم تبادلی در هر دو کاربری جنگل و دیم‌زار تفاوت معنی‌داری وجود نداشت. در مقابل، متوسط کربن آلی خاک جنگل و دیم‌زار به‌ترتیب ۲/۱۰ و ۱/۳۵ درصد به‌دست آمد که به‌طور معنی‌داری (p<۰/۰۵) با هم متفاوت بودند. هم‌چنین تغییرات مکانی ماده آلی خاک را با استفاده از زمین آمار به‌ترتیب در جنگل و دیم‌زار "متوسط" و "قوی" ارزیابی شد که مقدار قوی به‌دلیل شخم موازی شیب بوده است. هم‌چنین نتایج این تحقیق نشان داد که ظرفیت تبادل کاتیونی (CEC) جنگل و دیم‌زار نیز به‌ترتیب ۳۳/۳ و ۲۵/۱ سانتی‌مول بر کیلوگرم بود که به‌طور معنی‌داری در دیم‌زار کم‌تر از جنگل بوده و میزان وابستگی مکانی این عامل خاک در جنگل بیش‌تر از دیم‌زار به‌دست آمد. بنابراین، نتیجه‌گیری می‌شود که تبدیل جنگل به دیم‌زار موجب کاهش معنی‌دار ماده آلی و ظرفیت تبادل یونی خاک به‌عنوان پایه‌های اصلی حاصل‌خیزی خاک در منطقه شده است.

کلمات کلیدی: جنگل‌زدایی، سازند کشکان، سوزاندن بقایای گیاهی، شخم نامناسب، مدیریت پایدار سرزمین

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