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EFFECT OF EXCLOSURE ON RUNOFF, SEDIMENT CONCENTRATION AND SOIL LOSS IN EROSION PLOTS

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ABSTRACT

Nowadays watershed and rangeland management projects play the important role in water resources and soil management worldwide. Although watershed and rangeland management projects have the considerable importance as approaches to rural areas development and natural resources management, more studies have been focused on their effects on sediment and their effects on soil erosion have rarely been considered. The present study was conducted in two treated and control sub-watersheds with exclosure treatment and under grazing respectively, in Khamsan representative watershed with an area of 4337.27 ha in south of Kurdistan Province, Iran. Three plots were installed in each western, northern and eastern slopes for the runoff volume and coefficient, sediment concentration and soil loss measurement. The exclosure treatment was operated for installed plots in treated sub-watershed from 2007. Then, all the data of runoff volume and coefficient, sediment concentration and soil loss from USLE standard plots in both control and treated sub-watersheds for 52 events over the years 2009 to 2014 were compared and evaluated. Therefore, in order to the number of plots and sub-watersheds, 18 USLE standard plot data were finally recorded and analysed for each storm event. The results showed the significant ($p \leq 0.05$) decreasing effect of exclosure treatment on runoff volume, sediment concentration and soil loss at plot scale. Finally, decreasing rates of 15.68, 6.13, 16.67, 24.37 and 21.43% due to exclosure respectively for runoff volume and coefficient, sediment concentration, soil loss and sediment yield were obtained. The variables of runoff volume, soil loss and sediment yield had statistically significant differences ($p \leq 0.05$) in treated and control sub-watersheds. The sediment concentration variable had p value of 0.058 and therefore the effect of exclosure treatment on sediment concentration was also significant ($p \leq 0.06$).

Keywords: *Khamsan watershed, soil conservation, soil loss, vegetation cover, watershed management.*

INTRODUCTION

Erosion and sediment transport is not only the cause of an imbalance of natural rivers and streams, but also the cause of change in the river channel and sediment accumulation behind dams reducing their storage volumes (Sadeghi et al., 2014; Spalevic et al., 2014). Nowadays, watershed management projects especially in upstream of the dam reservoirs are essential because of increasing population and cultivated lands, drop in groundwater levels, freshwater shortages, lack of rainfall, reducing fertility and increasing soil loss and diminution of water quality (Eskandari et al., 2014). Therefore, in recent years, the extensive practices for soil and water conservation carry out as one of the most important goals of watershed management projects. Overgrazing as well as early and late grazing and continuous movement of livestock in rangelands lead to more soil compaction and degradation and decrease the vegetation role in runoff and flood control, especially in developing countries. Therefore, from the watershed management and soil conservation view, it can be stated that grazing management leads to decrease runoff severity and amount and consequently, soil loss. In this regard, one of the basic and fundamental tools is the evaluation of the effects of watershed management projects. Assessment of the impact of watershed management projects plays an important role to achieve a clear view about the practices efficiency, improvement of available methods, review of macro and micro policies and the innovation of new methods (Eskandari, et al. 2014). Many researchers have evaluated and assessed the effects of watershed management practices in the world (Kohnke, 1968; Busby and Gifford, 1981; Wood and Blackburn, 1981; Sadeghi, 1996; Radwan, 1999; Sadeghi et al., 2004; Goff and Gentry, 2006; Shahrivar and Molaii, 2006; Hayashi et al., 2008; Eskandari et al., 2014).

The management practices affecting soil and vegetation cover and consequently, affect runoff and soil loss control (Ghoddousi et al., 2006; Spalevic et al., 2013). Vahabi (1989) stated that the exclosure treatment in Iran could replace desirable forage species, so that the soil loss controlled with increasing vegetation density. Gharehdaghi (1997) studied the effect of rangeland exclosure on physical and chemical characteristics of soil in some rangelands of Iran and stated that this conservation operation could improve the soil physical and chemical characteristics and reduce soil loss. They also showed that the exclosure management had the direct impact on infiltration rates (about 52%) and prevented soil compaction. Ghoddousi et al. (2006) evaluated the exclosure impact on runoff and soil loss and revealed that the pastures exclosure could reduce soil loss and also help to water optimization in pastures surface. Mohammadpoor et al. (2010) studied the effect of short-term exclosure in some highland rangelands of Iran and showed that the exclosure application could decrease runoff amount. Shahid et al. (2014) also stated that the land use change is an important factor in increasing runoff and sediment amount in a small watershed in Pakistan.

The literature review showed that the exclosure can reduce surface runoff and soil loss by changing the vegetation species and also increasing vegetation density which lead to soil and water conservation. Therefore, evaluation of the effects of exclosure on runoff and soil loss is very essential (Lang, 1962; Slayback and Cable, 1970; Vallentine, 1971; Wood and Blackbur, 1981; Vahabi, 1989; Ghoddousi et al., 2006; Barovic et al., 2015). For this purpose, the present study was conducted in two treated and control sub-watersheds with exclosure treatment and under grazing respectively, in Khamsan representative watershed, located in west of Iran.

MATERIALS AND METHODS

Study area

The present study was conducted on the data of 52 events over the years 2009 to 2014 in two treated (with area of 107.54 ha) and control (with area of 110.54 ha) sub-watersheds with exclosure treatment and under grazing respectively, in Khamsan representative watershed, west of Iran Table 1 shows the physiographic characteristics of treated and control sub-watersheds. Fig. 1 shows the location of Khamsan Representative and treated and control sub-watershed in Iran.

Table 1. Physiographic characteristics of treated and control sub-watersheds

Physiographic characteristics	Khamsan representative watershed	Treated sub-watershed	Control sub-watershed
Area (km^2)	43.37	1.08	1.10
Perimeter (km)	30.25	4.06	4.56
Main River Length	5.18	1.11	0.83
Total river length	198.85	5.02	5.98
Slope (%)	42.95	48.23	40.09
Maximum elevation	2378	1817	1820
Minimum elevation	1580	1618	1610
Average elevation	1936.27	1698.73	1695.03

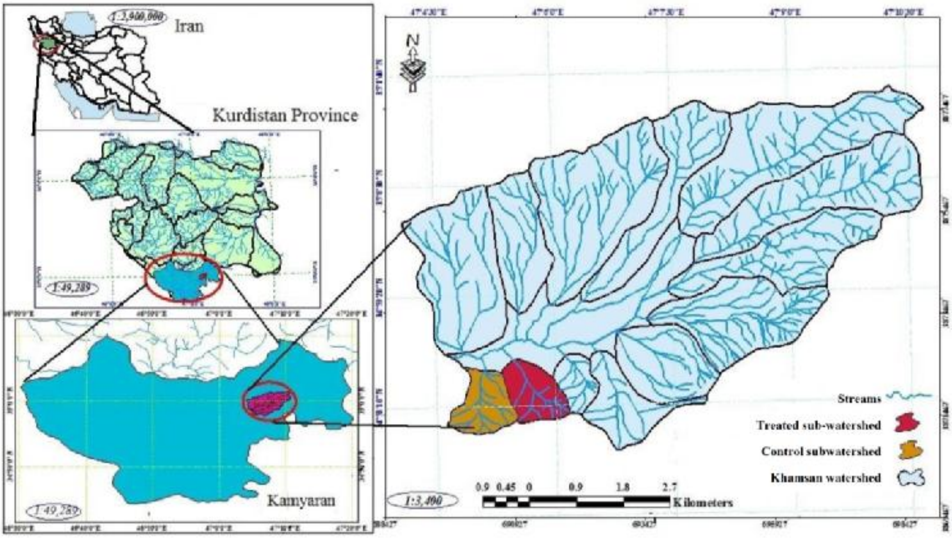

Fig. 1. Location of Khamsan Representative and treated and control sub-watersheds in Iran

The exclosure treatment was operated for installed plots in treated sub-watershed from 2007. Three USLE standard plots were installed in each western, northern and eastern slopes to measure the storm-wise runoff volume and coefficient, sediment concentration and soil loss. Then, all the data of runoff volume and coefficient, sediment concentration and soil loss from 18 plots in both control and treated sub-watersheds for 52 events over the years 2009 to 2014 were compared and evaluated. Fig. 2 shows the location of standard plots in treated and control sub-watersheds.

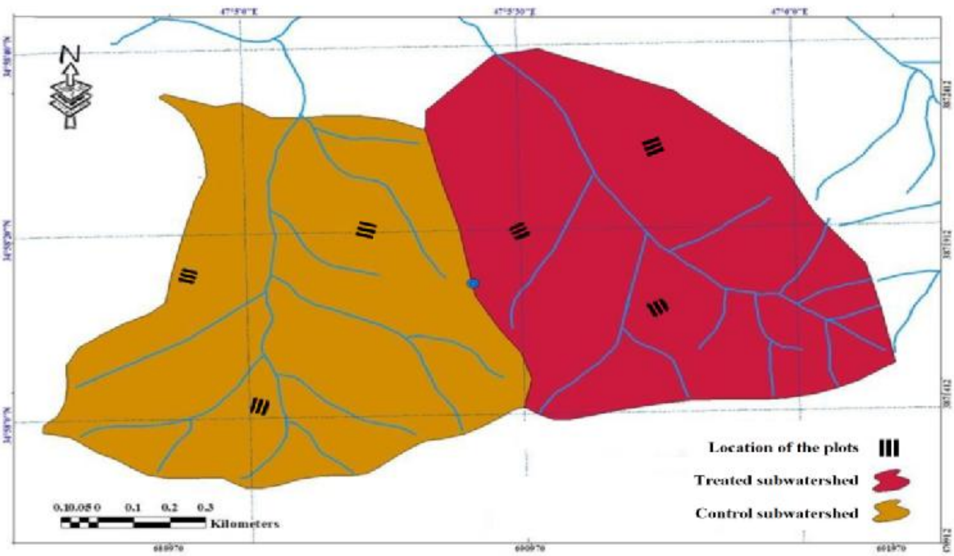

Fig. 2. Location of USLE standard plots in studied sub-watersheds

Methods

Three erosion plots with the area of 22.13 × 1.83 m (dimension of Universal Soil Loss Equation plots) were installed in each western, northern and eastern slopes of both control and treated sub-watersheds. The surface runoff and soil loss at the output of all 18 plots were collected and measured after each rainfall event which led to runoff (Fig. 3).

A

B

Fig. 3. A view of standard erosion plots (A) and a view of runoff and sediment collected in plot output reservoir (B).

All the data of runoff volume and coefficient, sediment concentration and soil loss from 18 USLE standard plots in both control and treated sub-watersheds for 52 events over the years 2009 to 2014 were then measured and evaluated. The collected runoff samples transferred to the laboratory and sediment concentration was measured using decantation procedure and oven drying at 105 °C for 24 h and weighed by high-precision scales (Gholami et al., 2014; Khaledi Darvishan et al., 2014).

RESULTS AND DISCUSSION

The results of runoff volume and coefficient, sediment concentration, soil loss and sediment yield in treated and control sub-watersheds are presented in Table 2. Table 3 also stated the average coefficient of variation due to exclosure in studied variables.

Table 2. Runoff volume and coefficient, sediment concentration, soil loss and sediment yield in treated and control sub-watersheds

Variable	Sub-watershed	Mean value	Mean standard error
Runoff volume (L)	Treated	34.78	1.05
	Control	41.25	1.18
Runoff coefficient (%)	Treated	3.52	0.18
	Control	3.75	0.21
Sediment concentration	Treated	0.65	0.05

($g L^{-1}$)	Control	0.78	0.06
Soil loss (g)	Treated	24.15	2.02
	Control	31.93	2.67
Sediment yield ($t ha^{-1}$)	Treated	0.011	0.001
	Control	0.014	0.001

Table 3. The average coefficient of variation due to exclosure in studied variables

Variable	Variation coefficient (%)
Runoff volume (L)	15.68
Runoff coefficient (%)	6.13
Sediment concentration ($g L^{-1}$)	16.67
Soil loss (g)	24.37
Sediment yield ($t ha^{-1}$)	21.43

Table 2 showed that the exclosure practice could decrease runoff volume and coefficient, sediment concentration and soil loss in treated sub-watershed. It can be stated that the exclosure practice as conservation method can increase the canopy cover which leads to decrease runoff and soil loss (Gholami, 1995; Sadeghi, 1996; Alidoost et al., 2006; Ghoddousi et al., 2006). The results also showed the decreasing rates of 15.68, 6.13, 16.67, 24.37 and 21.43% due to exclosure respectively for runoff volume and coefficient, sediment concentration, soil loss and sediment yield (Table 3). Table 4 presented the results of independent samples t-test between runoff volume and coefficent, sediment concentration, soil loss and sediment yield in treated and control sub-watersheds.

Table 4. The results of independent samples t-test between runoff volume and coefficent, sediment concentration, soil loss and sediment yield in treated and control sub-watersheds

Sources of variations	Significant level	Degree of freedom
Runoff volume (L)	0.028 *	887.754
Runoff coefficient (%)	0.166 ns	916.385
Sediment concentration ($g L^{-1}$)	0.058 ns	903
Soil loss (g)	0.020 *	903
Sediment yield ($t ha^{-1}$)	0.020 *	933

^{ns}, *: not significant and significant at $P \leq 0.05$, respectively.

The results showed the significant ($p \leq 0.05$) decreasing effect of exclosure treatment on runoff volume and soil loss at plot scale. In other words, the variables of runoff volume, soil loss and sediment yield had statistically significant differences ($p \leq 0.05$) in treated and control sub-watersheds which is in agreement with previous researches including Vahabi (1989), Kerr and Chung (2002), Ghoddousi et al. (2006) and Hematzadeh et al. (2009). The sediment concentration variable had p value of 0.058 and therefore the effect of exclosure treatment on sediment concentration was also relatively significant. The variables of runoff volume, sediment concentration, soil loss and sediment yield were significantly decreased in treated plots as well as treated sub-watershed due to exclosure. The exclosure was clearly an efficient method which led to increase the vegetation density and infiltration rate and consequently reduce runoff and soil loss which is in agreement with previous researches (Kohnke, 1968; Vahabi, 1989; Gholami, 1995; Akbarzadeh, 1996; Sadeghi, 1996, Rahmati et al., 2004; Alidoost et al., 2006 and Ghoddousi et al., 2006). Also, the splash erosion which is the first step of water erosion could decrease with the vegetation cover.

CONCLUSION

The present study was conducted in two treated and control sub-watersheds with exclosure treatment and under free grazing respectively, in Khamsan representative watershed in south of Kurdistan Province, Iran. Based on the results, it can be revealed that the exclosure treatment, because of increasing vegetation density and cover, caused the increasing infiltration and significantly decreased runoff, sediment concentration and soil loss.

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