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Comparison of Soil Erosion and Watercourse in Soils Covered by Pasture, Rainfed and Abandoned Rainfed in Different Slopes Using an Artificial Rainfall Simulator Device

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ABSTRACT

The purpose of this study was to evaluate and compare the watercourse land use of pasture, rainfed and abandoned rainfed which conducted in Bab Karafs watershed (Sarduyeh) in Jiroft County using the artificial rainfall simulator device. In this study three land uses with constant soil type and lithology have been considered and also, rainfall intensities have been created by using rainfall simulator device and in two intensities of 46 mm/hour and 88 mm/hour, and as well as considering the slopes of 5 percent and 15 percent, according to the three repeats in 36 stages of sampling. Also, from adjacent parts of the rainfall simulator device and from 0-20 cm depth of soil, the soil samples were taken for analysis in a soil laboratory. The results showed that the land use changes indicate dramatic impacts on watercourse and erosion amounts in different slopes; so that the maximum amount of watercourse is carried out in the abandoned rainfed use and slope of 15%. The minimum amount of watercourse is carried out in the rainfed use and slope of 5%.

1. Introduction

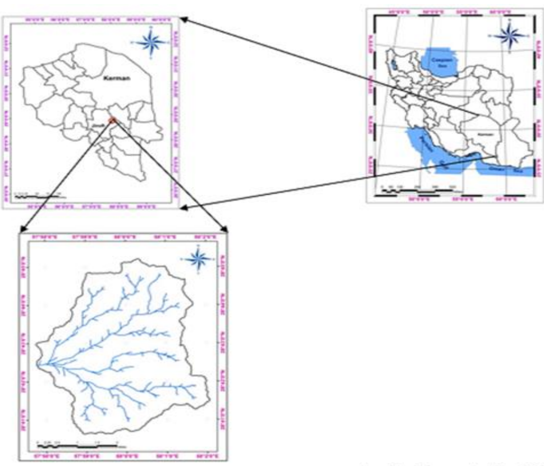
Soil is one of the most important natural resources and production factors. Soil erosion is one of the damaging and harmful phenomena in nature, which can lead to the elimination of the natural resources as well as degradation and increasing the possibility of floods and reducing the amount of vegetation [23]. Therefore, to reduce the amount of soil loss can try to estimate the amount of erosion and sediment in the watersheds by using various solutions and carry out solutions including the creation of structures reform as well as vegetation and ultimately preventing degradation of lands and changing their use [4]. On the other hand, soil erosion is one of the most important environmental challenges [3]. The soil properties are one of the important and studied variables on the process of watercourse and soil erosion [3]. There are different methods to calculate the amounts of watercourse and soil erosion that rainfall simulators are one of the most common used methods. In theory, this device not only saves time and money, but the amounts of watercourse and erosion, as well as more effective processes can be evaluated quantitatively and frequency through this device. However it should be noted that the use of rainfall simulators has some limitations, so that rainfall simulators can never completely prepare the natural conditions and facing some limitations in terms of creating cloudburst conditions and rainfall in small surface of plot [4]. According to the studies, we can find out that in general, several factors are involving in the occurrence and exacerbation of watercourse and soil erosion that considering conditions of each region the effects of one or more factors are more than the others.

In the meantime, the role of land use change is important due to the effect of this change on vegetation and soil properties and as a result the amounts of watercourse and soil erosion [10].

2. Materials and Methods

2.1. The study area

Bab Karafs watershed is located in the geographical coordinates of 42.9' 57' 57˚ and 12' 2' 58˚ eastern longitude, and 31.7' 40' 28˚ to 15.2" 45' 28˚ north longitude with an area of 3634.6 hectares. This watershed is located in about 12 km from Sarduiyeh District in Jiroft County. The maximum height of this area is 3270 meters and the minimum height is 2990 meters. Bab Karafs, Khardan, Ghanat Bid, Nahr Kamal etc are the most important villages of the area. Figure (1) shows the location of Bab Karafs watershed in Iran and Kerman Province.



2-2. characteristics of the rainfall simulator device

In this study, an artificial rainfall simulator device with rainfall level of 0.09 square meters (dimensions of 30×30 cm) was used.

2-3. methods of soil sampling and laboratory analysis

In this study, areas with a slope of 5 percent and 15 percent were tested. According to the research aim, the uses should be examined in such a way that all variables are fixed and only use changes on the amounts of erosion and sediment are evaluated and the effects of these changes on soil properties and the obtained results can be observed by removing the canopy. So, three uses of pasture, rainfed and abandoned rainfed in an area were studied and all of the sampling points in these uses specified and the sampling was performed (Figure 2).

After correct placing of the rainfall simulator device in the intended places and based on the region slope and adjusting height of the rainfall simulator foundations in order to rain on the intended surface, the amount of watercourse obtained from the sampling place, was taken. Then, the amount of sediment passed through Whatman filter paper No. 40 in the three repeats and the amount of sediment was separated from whole of the watercourse in the soil laboratory. Then, the sediments were placed in Oven for 24 hours at 105 ° C. In this study, first, normality of the data was examined by SPSS 17 software and after ensuring of the data normality which conducted by using Shapiro Kolomograve--Anderson and Kramer tests, the data were statistically analyzed by SAS software and mean comparison using Duncan test at 5% level.

Figure 2. Correct placing of the rainfall simulator device in uses of rainfed, pasture and abandoned rainfed.

3. Results

Results of the measured variables in the soil including watercourse volume, the amount of sediment, clay percentage, silt, sand, organic matter, lime, erodibility factor $EC, pH, SAR, ESP, (K)$ are presented in Tables (1), (2), (3), (4), (5) and figures (4) and (5). The significance level for figures (Charts) is based on analysis of variance results.

Table 1. Results of mean comparison of the land use effect on the measured variables.

Erodibility (gr)	Organic materials	Lime	SAR	ESP	pH	EC	Sand percentage	Silt percentage	Clay percentage	Sediment grams/liter	Watercourse liter	Land use
c14.0	**b**23.0	**a**46.17	**a**95.1	**a**60.1	**c**52.7	**a**88.1	**a**25.70	**c**83.28	**c**91.3	**c**18.1	**c**50.682	**rainfed**
a47.0	**c**077.0	**a**81.16	**b**81.1	**b**43.1	**b**75.7	**b**88.0	**c**08.38	**a**91.52	**a**00.9	**a**69.4	**a**83.1255	**abandoned rainfed**
b27.0	**a**52.0	**b**73.2	**c**20.1	**c**52.0	**a**85.7	**b**68.0	**b**41.51	**b**33.42	**b**25.6	**b**38.2	**b**08.932	**pasturage**

Table 2 . Results of mean comparison of slope effect on the measured variables.

Organic materials	Lime	SAR	ESP	pH	EC	Sand percentage	Silt percentage	Clay percentage	Sediment grams/liter	Watercourse liter	Slope
a27.0	a58.12	a67.1	a19.1	a69.7	a21.1	a61.54	b11.39	a27.6	b48.2	b17.876	5%
a27.0	a09.12	a64.1	a17.1	a73.7	a08.1	b88.51	a61.41	a50.6	a02.3	a44.1037	15%

Table 3. Watercourse correlation matrix in the use and slope.

	Slope		**Use**			
15%	5%	pasturage	abandoned rainfed	rainfed	Variable	
0/99	-0/90	0/29	-0/11	-0/25	Clay percentage	
-0/84	-0/61	0/003	-0/14	0/34	Silt percentage	
0/78	0/67	-0/07	0/14	-0/31	Sand percentage	
0/46	-0/08	0/78	0/60	-0/63	EC	
0/28	-0/81	0/71	0/07	0/004	pH	Watercourse
-0/94	0/81	0/55	0/18	0/62	ESP	
-0/75	-0/90	0/13	0/45	0/82	SAR	
0/86	0/65	-0/55	0/26	-0/91	Lime	
0/90	0/19	0/18	0/07	-0/61	Organic materials	
0/91	0/08	0/96*	0/88	0/88	Erodibility	

*significance level of 5%, ** significance level of 1%

Table 4. Sediment correlation matrix in the use and slope.

	Slope		Use			
15%	5%	pasturage	abandoned rainfed	rainfed	Variable	
-0/71	-0/68	0/52	-0/58	-0/014	Clay percentage	
0/94	-0/86	-0/39	-0/29	-0/07	Silt percentage	
-0/97	0/90	0/34	0/33	0/07	Sand percentage	
0/38	0/29	0/46	0/57	-0/50	EC	
0/55	-0/97	0/57	-0/39	-0/22	pH	Sediment
0/36	0/97	0/39	0/46	0/37	ESP	
0/98	-0/68	-0/27	0/79	0/56	SAR	
-0/93	0/88	-0/74	0/67	-0/65	Lime	
-0/90	0/54	0/34	-0/39	-0/44	Organic materials	
-0/26	-0/29	0/97*	0/57	0/99**	Erodibility	

*significance level of 5%, ** significance level of 1%

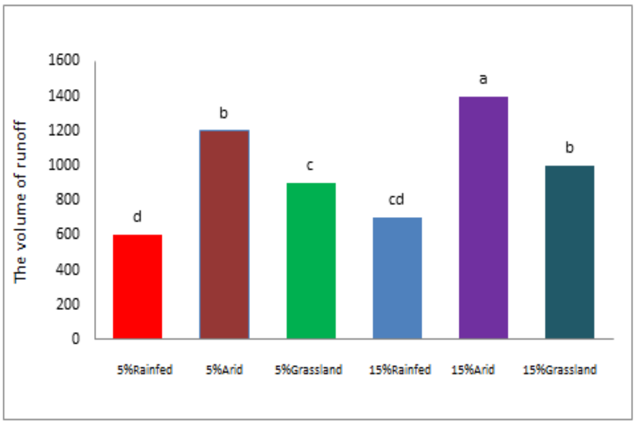


Figure 4. The mutual effect of land use in the slope on watercourse volume, the significance level of 1%.

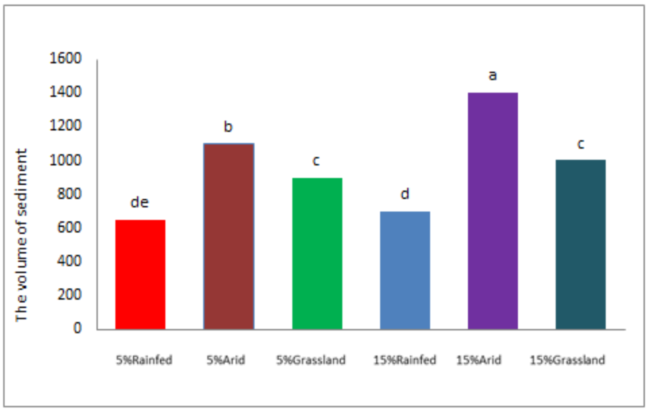


Figure 5. The mutual effect of slope in land use on the amount of sediment, the significance level of 1%.

Table 5. Correlation between different variables affected by the slope, land use and rainfall intensity.

*significance level of 5%, ** significance level of 1%

	Watercourse	Sediment	Clay	Silt	Sand	EC	pH	ESP	SAR	Lime	organic matter	erodibility
Watercourse	1											
Sediment	95**.0	1										
Clay	85**.0	81**.0	1									
Silt	82**.0	76**.0	89**.0	1								
Sand	84**.-0	78**.-0	92**.-0	99**.-0	1							
EC	63*.-0	54.-0	71**.-0	81**.-0	81**.0	1						
pH	52.0	41.0	62*.0	74**.0	73**.-0	95**.-0	1					
ESP	04.-0	06.0	10.-0	26.-0	24.0	71**.0	76**.-0	1				
SAR	05.-0	07.0	13.-0	25.-0	23.0	69*.0	75**.-0	98**.0	1			
Lime	03.0	13.0	01.0	16.-0	13.0	64*.0	70*.-0	98**.0	97**.0	1		
organic matter	4.-0	47.-0	35.-0	27.-0	29.0	27.-0	40.0	83**.-0	81**.-0	87**.-0	1	
erodibility	97**.0	90**.0	89**.0	83**.0	85**.-0	60*.-0	50.0	02.-0	03.-0	07.0	043.-0	1

4. Discussion

4.1. Watercourse

In this study, the study uses including pasture, rainfed and abandoned rainfed were evaluated in terms of the potential for creating watercourse and sediment in slopes of 5 percent and 15 percent. According to Table (1), the study use of abandoned rainfed has high watercourse volume, clay percentage, silt, lime, and erodibility compared to other land use. Land use converting to pasture, increased organic matter and soil pH which following this increase the amount of watercourse was significantly decreased [13,4]. Considering that rainfed use had maximum percent of sand, ESP, SAR, EC and lime, so, the amount of watercourse showed a significant decrease compared to the other two uses [3]. One of the main reasons for the existence of high volume of watercourse in the abandoned rainfed land use is the presence of clay and silt, as well as lime and the high amount of the soil erosion in the abandoned rainfed land use compared to the pasture and rainfed lands [12] (Table 1). By increasing the amount of sand, permeability rate increases and the amount of watercourse decreases [16]. Also the amount of sand showed a negative correlation with the watercourse [17]; the erodibility rate showed a positive correlation with watercourse so that, the amount of watercourse increases by increasing the soil erodibility factor [15].

4.2. Erosion and Sediment

According to the results presented in Table (1) the land use has significant effects on clay percentage, silt, sand, EC, pH, ESP, SAR, lime, organic matter and soil erodibility factor that all these properties will affect the amounts of erosion [7]. According to the results in Table (1) the amount of measured sediment in the abandoned rainfed land use significantly different from the other two land use. One of the main factors in increasing of sediment in this land use is related to more clay percentage and silt in the land use compared to other land use [1]. According to the correlation matrix (Table 5) the highest correlation of sediment is related to soil erosion in rainfed and pasture land use. The amount of sediment also showed a negative correlation with the amount of sand [14] which the amount of sediment decreases by increasing the percentage of sand [18]. In this study, increasing rate of clay showed completely different result due to the increasing amount of clay in the soils and increasing their resistance to erosion; which this different result is because of trampling of domestic animals imported to the abandoned rainfed use and the complete destroying of soil structure and its completely powder mode that increasing the amount of clay indicates a positive and significant correlation with the erosion rate.

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