Kurdistan Journal of Applied Research (KJAR)
Print-ISSN: 2411-7684 | Electronic-ISSN: 2411-7706

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Assessing Soil Tolerance Limit for Two Soil Orders Surrounding Sulaimani City

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Volume 4 – Issue 2
December 2019

DOI:
10.24017/science.2019.2.18

Received:
03 November 2019

Accepted:
27 December 2019

Abstract

This research was conducted to determined Soil loss tolerance limit (SLTL) which used for soil and water conservation projects and assessing the potential risk of soil erosion. In this study, two different sites were selected including Bakrajo and Qallachwalan were located 9.4 and 23.7 km far from Sulaimani city respectively. The soil orders in the two studied sites were determined through describing the soil profile properties which were known as Vertisols and Mollisols respectively. Each site was divided into 16 sub-sites using the grid point system. The dimension of each site was (2.5*2.5 km). The estimated soil tolerance limit for whole grid points except one grid point at Bakrajo site was equal to 12.5 (Mg/ ha/ yr), while at Qallachwalan in a wide range as 2.5-10 (Mg/ ha/ yr). The mentioned results of soil tolerance limit explained that the Bakrajo site is more resist to the risk of water erosion compared to Qallachwalan site which was known as a rugged area. Besides the most soil depth of the grid points at Qallachwalan was shallow did not exceed 50 cm. So the Qallachwalan site needs several processes conservation planning than the Bakrajo site which known as more deep and flatty soil.

Keywords: Soil loss tolerance limit, biophysical model, land degradation, soil erosion, soil erodibility factor, saturation hydraulic conductivity.

1. INTRODUCTION

Degradation can cause unacceptable land use for pasture, agricultural, industrial or urban purposes by reducing the yield potential and the soil quality[1]. In fact, a degradative process such as biological, chemical and physical leads to decrease soil productivity and quality. The food security and consequently the world population now and in the future depend on sustainability[2]. Sustainable land management practices are needed to avoid land degradation which typically occurs because of human development or land management practices that is not sustainable over a period[3].

In the many parts of the world, land degradation is rising in intensity and extent, as for grasslands, cultivated areas and forests, the rate of (10, 20 and 30)% has been reported subjected to degradation[4]. Erosion is one of the most recognized and dominant types of soil degradation causes remove the most nutrient rich and organic matter dense layer of the soil profile [5]. In various parts of the world, soil erosion is accelerated such as the area under study due to population density, deforestation, overgrazing, intensive land cultivation and higher demand for firewood as an energy source [6, 7].

In the developing counties especially in the tropics and subtropics areas subjected to soil degradation is a permanent issue and going to stay the same during the twenty- one century, whilst, soil degradation occurs by accelerated erosion [8]. Gabriels and Conelis [9] demonstrated that land degradation covers the soil, vegetation and water resources degradation and water erosion is the most important type of soil degradation occupying fifty six percent of the worldwide area. Conacher, [10] showed that salinization and waterlogging of irrigated areas are two closely related and perhaps the earliest forms of reported land degradation.

Soil erosion is a slow dynamic natural process which involves detachment, transportation and accumulation of productive surface soil across the earth's surface through water or wind action[11]. Pimentel [12] demonstrated that soil low organic matter content, medium to fine texture and weak structural development is very easy to erosion. Also, soils which have low water infiltration rate are subject to high rates of erosion by water and the soil particles are easily displaced by wind power. Gupta et al., [13] showed many other issues created by soil erosion such as deposition of unfertile materials on cultivated lands, harmful effects on water supply, sedimentation of canals and rivers and most important the destruction of the agricultural fertile lands. In addition, crop productivity decreases by soil erosion, due to either physical degradation or nutrient depletion[14]. Some index cause soil erosion such as soil surface crusts increasing, opened roots, the reduced topsoil thickness, apparent gullies or rills, opened subsoil at the soil surface and poor plant growth [15].

Determination of soil erosion can be helpful for improving the information about the extent of the areas influenced and consequently for developing measurement due to reduce the intensity of the issue by recognition of areas that are severely affected. As reported by [16, 17] appropriate land management along with technologies such as soil conservation methods cause increasing in land productivity, reducing soil erosion and sustain soil quality.

Duan et al., [18] discovered the determination of the soil loss tolerance limit (SLTL or T value) is one of the most important aspects of water and soil conservation projects leads to a criterion for controlling erosion rates. Mandal and Sharda [19] defined soil loss tolerance as the maximum rate of erosion at which the quality of a soil as a medium for plant growth can be maintained. On the other definition, SLT defined as the maximum amount of annual soil erosion that will permit a high level of crop productivity to be obtained economically over an extended period of time [20]. These authors suggested various criteria should be considered in the evaluating of SLT, including influence on water quality, grade or (class) of weathering and modify in soil quality. Method conserving the nonlinearities of soil growth or (progression) process and weathering of the rock should be displaced of a direct association between evolution of the soil profile and soil erosion by [21]. Therefore, Lal [22] suggested that the TSL concept should be extended involve the environmental influence of air quality and water on ecosystems and the greenhouse effect economic effects of onsite and offsite, the amount of soil erosion and the amount of new soil formation.

Mostly depends on the proficiency of the individuals included for determining soil loss tolerance limit (SLTL), despite the consequence of STL for soil conservation. For estimating SLT Duan et al.,[18] reported three major quantitative methods based on soil formation rate, soil thickness and soil productivity.
The SLT is based on favorable rooting depth as reported by [23]. Lenka et al., [24] recommended that SLTL estimation can be calculated based on soil functions. This is affects soil erosion process. In addition, the best approximation of SLT can be estimated by the root zone rather than the depth of the root [24]. However, SLTL of (13 ton/ha/yr) has been proposed for deep medium textured soils under moderate humid conditions at the time amount of soil loss is believed to take pace with the comparable amount of weathering [25].
The United State Department of Agriculture in 1956 reported ten factors which have an impact on SLTL. This is for special soil involving soil depth, likelihood of appear gully and rill, the formation of the soil from parent material, erosion cause to loss plant nutrients, reduction of crop yield by erosion, converts favorable soil properties for plant growth which caused by erosion, the rate topsoil formation from subsoil, delivery of sediment from the erosion site, over and above maintainable soil conservation practices on the availability of economic, practicable, artistic and socially tolerable [18].
Quantifying the acceptable soil loss without influencing is a major challenge for planner, researchers and conservationists [19]. Mandal et al., [26] elucidated that on shallow soils SLTL land productivity declines quickly when SLTL is 5 Mg/ha/yr. Conversely, crop productivity not affected in deep soils when soil loss tolerance limit (12.5 Mg/ha/yr). With a few exceptions, the SLTL for 12 sub-watersheds within Chamchamal main catchment was estimated at 10 Mg/ha/yr [7]. On the other hand, Hussein, [27] noticed that about 43% out of 49 sites within Bastora catchment had SLTL of 12.5 Mg/ha/yr on account of the sufficient soil depth and high soil resistivity to erosion.
The most important factor for determined soil loss tolerance limit refers to considered soil formation rate[28]. Therefore, standard SLTL value based on soil formation rates in most farmlands, but it's not reasonable to utilize[19].
Thus, the objective of the research was to find and compare permissible soil loss limit for two orders study sites in Sulaimani city.

2. METHODS AND MATERIALS

Two different sites were selected according to their different in soil orders in June-September 2018. The selected sites were Bakrajo (Vertisols) is located between N 35º 29' 45" and N 35º 31' 31" latitude and E 45º 21' 20" and E 45º 22' 05" longitude and Qallachwalan (Mollisols) located between N 35º 37' 51" and N 35º 38' 43" latitude and E 45º 34' 32" and E 45º 34' 58" longitude (Fig. 1).
A biophysical model described by Mandal and Sharda[19] was employed to STL for different grid points of a grid system (2.5* 2.5 km). For these reason five indicators, each representing a soil function related to soil erosion was selected including saturated hydraulic conductivity, soil erodibility, soil organic matter content, soil bulk density and soil pH. The calculated value of each index was converted to a unitless score ranged between zeros to one. Based on the relative importance of the indicator, weights were applied to the indexes. The weights to the five indicators that mentioned before were 0.35, 0.25, 0.10, 0.15 and 0.15 respectively[19]. Then the transformed values of the indicators scaled "0 to 1" scale were multiplied by (the weight) assigned to them.
A quantitative value (Q) indicating the aggregate score was obtained for the each grid point by collecting the values of the weighted parameters as described below:

$$Q = \sum_{i=1}^{n} qi\, wi \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots.. (1)$$

$$Q = q_{\mathrm{rir}}\, w_{wir} + q_{rk}\, w_{wk} + q_{rbd}\, w_{wbd} + q_{roc}\, w_{woc} + q_{rpH}\, w_{wpH}$$

Where: Q defines (the state or condition) of the soil in terms of (structural and functional) integrity, q_{rir} index for infiltration rate, q_{rk} the rating for(soil erodibility), q_{rbd} used for the bulk density, q_{roc} used for the organic carbon and q_{rpH} the rating for potential of hydrogen (pH) of soils and (W) indicates the weight factor for each function.
According to the Q value, there are three groups of soil: 1 (Q<0.33), 2 ($Q = 0.33 + 0.66$), and 3 (Q>0.66). The STL was computed for each grid point on the basis of soil group multiply depth matrix [29].
The soil erodibility at each grid points was estimated using the following equation [30].

$$K = 0.277\ 10^{-5}\ M^{1.14}\ (12 - \mathrm{OM}) +\ 0.043\ (\mathrm{SC} - 2)\ +\ 0.033\ (\mathrm{PC} - 3) \ldots\ldots\ldots (2)$$

Where:
K = soil erodibility in metric unit (hr m^{-1} cm^{-1})
M = (100- clay %) (silt % + very fine sand %)
OM = organic matter %;
SC = structure class code, showed in (Table 1).
PC = permeability class code, showed in (Table 2).
Also representative soil samples were obtained from the top (0.20 m) at each grid points. They were air-dried (at 48 hr. to take laboratory condition), grounded by plastic hummer and sieved with No, ≤ 2 mm due determine particle size distribution by using sieving method according to[31]. The structure was described visually after dropping representative clods from a height of about 1 m in the field. Constant head permeameter method used to determine soil hydraulic conductivity for undisturbed cores diameter was (10 cm) and the length was (10 cm), following the procedure reported by[31]. The soil bulk density was measured by clod method covering with paraffin wax as described by[32]. Wet oxidation method was applied for measuring soil organic carbon content as described by [33]. The pH of the soil saturation extract (soil to water ratio 1:1) was measured with pH-meter (Hanna pH 211, model) according to[34].

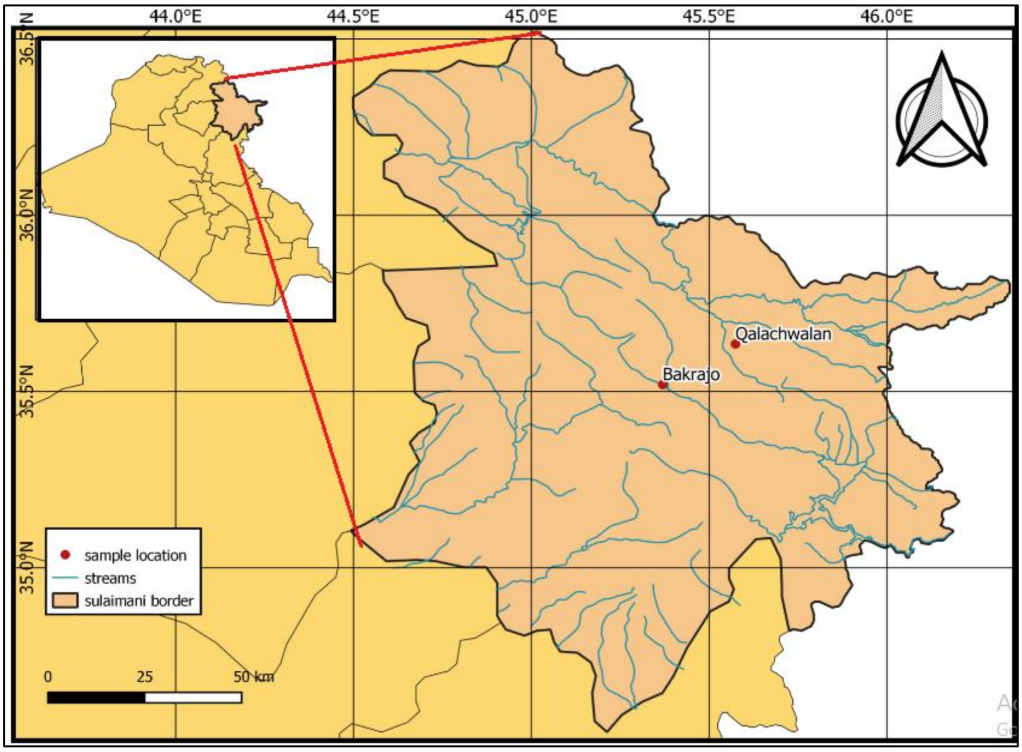

Figure 1: Location map showing study site

Table 1: Structure code (SC) for structure types

Type of structure	SC
Very fine granular structure	1
Fine granular structure	2
Medium or coarse granular structure	3
Blocky, platy or columnar structure	4

Table 2: Permeability code (PC) for permeability classes

Permeability (cm hr^{-1})	Permeability class	PC
<0.1	Very slow	6
0.1-0.5	Slow	5
0.5-2	Slow to moderate	4
2-6	Moderate	3
6-12	Moderate to rapid	2
>12	Rapid	1

3. RESULTS AND DISCUSSION

3.1 Soil erodibility estimation factor (K)

Value of the K-factor were computed for different grid points for Bakrajo and Qallachwalan sites according to the method which prepared by[35]. Table 3 shows the results. The K-values ranged from 0.249 to 0.483 for grid points 1 and 13 in Bakrajo respectively, for Qallachwalan ranged from 0.181 to 0.493 metric units at grid points 4 and 11 respectively. Results show that, even there was little variation in K-value at the study sites, but still at Qallachwalan was greater compared to Bakrajo site, due to topography of Qallachwalan had slope and rugged, while the other site was approximately flat. However, clay content ranged 32.33% and 46.99% for Bakrajo, and 15.08% and 61.08% for Qallachwalan and soil organic matter content which ranged between 1.35% and 3.11% at Bakrajo but 0.22% to 4.17% at Qallachwalan. It was also found that clay content and organic matter was linearly and negatively correlated with K-value, indicating that as clay content increases, the K-value decreases, and the greater the amount of organic matter, the lower will be the K-value. These results are closed were conducted in Chamchamal, Erbil and Sulaimani by [7, 27, 36] respectively.

Table 3: Soil erodibility factor for Bakrajo and Qallachwalan sites

Site	Grid point	Particle size distribution (%)			Organic matter content (%)	Very fine sand (%)	Structure class code	Permeability class code	Soil erodibility, K (Metric unit)
		Sand	Silt	Clay					
Bakrajo	1	8.00	45.01	46.99	2.21	1.54	4	2	0.249
	2	2.68	55.01	42.31	2.21	1.44	4	2	0.327
	3	7.74	55.94	36.32	1.69	2.15	4	4	0.482
	4	5.40	61.43	33.17	1.88	1.94	4	3	0.471
	5	8.41	55.74	35.85	3.11	3.15	4	3	0.379

	6	4.50	58.61	36.89	2.02	1.51	4	3	0.415
	7	7.04	55.89	37.07	1.49	2.78	4	2	0.389
	8	3.76	62.49	33.75	1.97	1.91	4	3	0.467
	9	3.76	50.25	45.99	1.99	1.61	4	3	0.326
	10	2.78	54.39	42.83	1.65	1.35	4	2	0.333
	11	5.22	56.81	37.97	1.75	2.11	4	2	0.381
	12	5.16	56.70	38.14	1.35	1.78	4	4	0.459
	13	4.36	63.31	32.33	1.82	1.99	4	3	0.483
	14	6.44	51.10	42.46	2.77	2.27	4	1	0.259
	15	4.69	60.84	34.47	1.67	2.01	4	3	0.468
	16	3.82	54.09	42.09	2.17	1.65	4	3	0.361
Qallachwalan	1	17.59	36.62	45.79	2.32	1.87	4	4	0.284
	2	11.37	37.14	51.49	1.69	3.02	4	4	0.284
	3	10.11	37.52	52.37	3.22	1.89	4	2	0.185
	4	31.59	28.78	39.63	3.99	4.09	4	2	0.181
	5	4.77	34.15	61.08	1.95	1.23	4	4	0.229
	6	14.57	37.32	48.11	3.82	3.87	4	3	0.225
	7	25.47	44.12	30.41	3.63	4.73	2	2	0.209
	8	10.99	45.36	43.65	4.07	2.06	4	2	0.228
	9	21.82	54.44	23.74	2.11	5.59	4	2	0.459
	10	9.91	53.14	36.95	2.05	2.11	4	3	0.382
	11	7.32	59.41	33.27	0.99	2.22	4	3	0.493
	12	42.17	40.07	17.76	0.22	13.59	3	2	0.469
	13	11.80	41.99	46.21	1.61	2.06	4	3	0.283
	14	8.25	57.11	34.64	0.48	1.94	2	4	0.425
	15	43.19	35.21	21.60	4.17	6.45	3	2	0.229
	16	61.38	23.54	15.08	1.33	9.38	4	1	0.276

3.2 Soil indicators used for assessing soil loss tolerance limit

Table (4) displays the measured values for four soil indicators at the grid points of the system which was established. These indicators were selected based on sensitivity analysis. Each indicator represents a soil function related to soil erosion.

According to the table 4 the saturated hydraulic conductivity varies from a minimum of 0.72 cm hr^{-1} at grid point 12 to a maximum of 14.40 cm hr^{-1} at the grid 14 at Bakrajo site, but in Qallachwalan site those values ranged from 0.90 and 18.36 cm hr^{-1} at grid points 5 and 16 respectively. The variation of saturated hydraulic conductivity may cause by variation in soil bulk density and soil texture. These results are in concord with the results obtained by [27] in Erbil.

It can also be noticed that the soil bulk density ranged from 1.41 Mg m^{-3} at grid point 1 and 1.69 Mg m^{-3} at grid point 12 within Bakrajo site, but at Qallachwalan site were 1.38 and 1.70 Mg m^{-3} at grid points 5 and 16 respectively.

A considerable difference in soil organic carbon content values can be observed across the entire both sites, which varied from 0.78% at grid point 12 to 1.80% at grid point 5 for Bakrajo site and in Qallachwalan ranged from 0.13% at grid point 12 to 2.42 at grid point 15. Overall the soils of the study areas are described by low soil organic matter. The soil of the majority sites fell in the high soil organic matter content class OM > 12.9 g kg^{-1}propsed by [37].

The results of the study sites also indicated that soil pH was ranged between 7.27 at grid point 1 to 8.08 at grid point 11 for Bakrajo site, but in Qallachwalan was ranged from 7.05 at grid point 4 to 7.85 in grid point 14. The pH of majority of the soil fell in neutral class (7.4-7.8), while the pH of the remaining soils fell in the moderately alkaline class (6.6-7.3) by [38].

Table 4: Soil indicators used for describing the resistance of soil to water erosion at the two study sites

Site	Grid point	Saturated hydraulic conductivity (cm hr^{-1})	Bulk density (Mg m^{-3})	Soil organic carbon (%)	Soil pH
Bakrajo	1	10.08	1.41	1.28	7.27
	2	8.28	1.52	1.28	7.92
	3	1.08	1.60	0.98	7.81
	4	3.60	1.54	1.09	7.80
	5	3.96	1.47	1.80	7.54
	6	3.24	1.51	1.17	7.92
	7	7.20	1.54	0.87	7.91
	8	2.16	1.64	1.14	7.87
	9	3.60	1.44	1.15	7.82
	10	6.12	1.47	0.96	7.83
	11	7.20	1.48	1.02	8.08
	12	0.72	1.69	0.78	7.89
	13	5.76	1.56	1.06	7.96
	14	14.40	1.42	1.60	7.88
	15	2.52	1.50	0.97	7.89
	16	3.60	1.49	1.26	7.86
Qallachwalan	1	1.80	1.50	1.35	7.46
	2	1.44	1.43	0.98	7.65
	3	8.64	1.47	1.87	7.48
	4	7.20	1.50	2.32	7.05
	5	0.90	1.38	1.13	7.51
	6	2.57	1.48	2.22	7.34
	7	8.64	1.49	2.11	7.27
	8	11.16	1.55	2.36	7.24
	9	8.28	1.54	1.23	7.40
	10	5.40	1.53	1.19	7.77
	11	4.32	1.58	0.57	7.78
	12	7.20	1.60	0.13	7.76
	13	5.76	1.48	0.93	7.57
	14	1.44	1.64	0.28	7.85
	15	10.8	1.56	2.42	7.16
	16	18.36	1.70	0.77	7.80

3.3 Soil tolerance limit

Table (5) shows the calculate of aggregate score from the attributed scores and the corresponding weights. It is obvious that the aggregate score is distributed in a wide range, and varied from 0.410 at grid point 12 and 0.900 at grid points 1 and 14 within Bakrajo site. With some exception the aggregate score of most grid points (1, 2, 4, 5, 7, 9, 10, 11, 13, 14, and 16) were exceed 0.66 q6 demonstrating soil good state as a result all of the these soils were placed in group 3 (Q > 0.66). But aggregate scores at grid points (3, 6, 8, 12, and 15) were ranged between 0.33 and 0.66 and placed in group 2 showing soils are in moderate state.

The aggregate scores for Qallachwalan site were ranged between 0.400 to 0.930 at grid points 14 and 3 respectively. With some exception, the aggregate scores of most grid points of (3, 4, 6, 7, 8, 9, 10, 13, 15 and 16) also were exceed 0.66 and were placed in group 3, but the remain aggregate scores at grid points of 1, 2, 5, 11, 12, and 14 were falling between 0.33 and 0.66 and placed in group 2.

Finally the STL for the two study sites was calculated based on soil group multiply by depth matrix. The STL for Bakrajo site at the all investigated grid points was estimated of 12.5 Mg ha^{-1} yr^{-1}, except grid point 1 which was 7.5 Mg ha^{-1} yr^{-1} (table 6). Soil loss tolerance limit at grid point 1 can be related to the soil depth which was about 25-50 cm, while the soil depth for remained grid points was above 150 cm. These results reflect that the existing soils over the study site are characterized by relatively low heterogeneity with respect to (infiltration rate, soil bulk density, soil organic carbon, soil pH, soil erodibility and soil depth).

The estimated STL in Qallachwalan site was distributed a wide range and varied between 2.5 Mg ha^{-1} yr^{-1} at grid points 12 and 14, to 10 Mg ha^{-1} yr^{-1} at grid point 1, 3 and 4. The main reason for existing a wide range of STL in Qallachwalan is that the study site had the different soil depth ranged between <25 cm to 150 cm. So Qallachwalan site needs special conservation practices than Bakrajo site such as afforestation, pasture management and preventing the trees and grasses from burning cutting, pasture management, preventing the trees and grasses from burning cutting. Similar results were reported by [27] in Erbil and [39] for three states of northern India.

Table 5: calculation of aggregate score from the individual rate for different attribute

Site	Grid points	Individual rate for					
		Saturated hydraulic conductivity (q1)	**Bulk density (q2)**	**Soil erodibility (q3)**	**Organic carbon (q4)**	**Soil pH (q5)**	**Aggregate score (q6)**
Bakrajo	1	1	0.8	0.8	0.8	1	0.900
	2	1	0.5	0.5	0.8	0.8	0.765
	3	0.3	0.3	0.5	0.5	0.8	0.455
	4	0.8	0.5	0.5	0.8	0.8	0.695
	5	0.8	0.8	0.5	1	0.8	0.755
	6	0.5	0.5	0.5	0.8	0.8	0.590
	7	1	0.5	0.5	0.5	0.8	0.720
	8	0.5	0.2	0.5	0.8	0.8	0.560
	9	0.8	0.8	0.5	0.8	0.8	0.725
	10	1	0.8	0.5	0.5	0.8	0.750
	11	1	0.5	0.5	0.8	0.5	0.720
	12	0.2	0.2	0.5	0.5	0.8	0.410
	13	1	0.3	0.5	0.8	0.8	0.745
	14	1	0.8	0.8	1	0.8	0.900

	15	0.5	0.5	0.5	0.5	0.8	0.545
	16	0.8	0.5	0.5	0.8	0.8	0.695
Qallachwalan	1	0.3	0.5	0.8	0.8	1	0.625
	2	0.3	0.8	0.8	0.5	0.8	0.580
	3	1	0.8	0.8	1	1	0.930
	4	1	0.5	0.8	1	1	0.900
	5	0.2	1	0.8	0.8	0.8	0.610
	6	0.5	0.5	0.8	1	1	0.725
	7	1	0.5	0.8	1	1	0.900
	8	1	0.5	0.8	1	1	0.900
	9	1	0.5	0.5	0.8	1	0.795
	10	1	0.5	0.5	0.8	0.8	0.765
	11	0.8	0.3	0.5	0.3	0.8	0.600
	12	1	0.3	0.5	0.2	0.8	0.655
	13	1	0.5	0.8	0.5	0.8	0.795
	14	0.3	0.2	0.5	0.2	0.8	0.400
	15	1	0.3	0.8	1	1	0.880
	16	1	0.2	0.8	0.5	0.8	0.765

Table 6: maximum permissible soil loss rate for the study soils based on soil depth and aggregate score

Site	Grid point	Soil depth (cm)	Aggregate score (Q)	Soil group	Maximum soil loss rate (Mg ha^{-1} yr^{-1})
Bakrajo	1	25-50	0.900	3	7.5
	2	> 150	0.765	3	12.5
	3	>150	0.455	2	12.5
	4	>150	0.695	3	12.5
	5	>150	0.755	3	12.5
	6	>150	0.590	2	12.5
	7	>150	0.720	3	12.5
	8	>150	0.560	2	12.5
	9	>150	0.725	3	12.5
	10	>150	0.750	3	12.5
	11	>150	0.720	3	12.5
	12	>150	0.410	2	12.5
	13	>150	0.745	3	12.5
	14	>150	0.900	3	12.5
	15	>150	0.545	2	12.5
	16	>150	0.695	3	12.5
Qallachwalan	1	100-150	0.625	2	10
	2	25-50	0.580	2	5
	3	50-100	0.930	3	10

4	50-100	0.900	3	10
5	25-50	0.610	2	5
6	25-50	0.725	3	7.5
7	25-50	0.900	3	7.5
8	25-50	0.900	3	7.5
9	25-50	0.795	3	7.5
10	25-50	0.765	3	7.5
11	25-50	0.600	2	5
12	<25	0.655	2	2.5
13	25-50	0.795	3	7.5
14	<25	0.400	2	2.5
15	<25	0.880	3	7.5
16	<25	0.765	3	7.5

4. CONCLUSION

Generally most of the estimated soil tolerance limit for Bakrajo site was greater than Qallachwalan site. Most of Bakrajo soils depth in exceeds 150 cm. So, it didn't need any conservation planning except continuous monitoring of the soil condition. In Qallachwalan site there was a large variety of the soils depth ranged from less than 25 cm to 150 cm. This is means that need for numerous different conservation planning to control the soil erosion. The estimated soil erodibility for the two studied sites was ranged between low to moderate due to high content of clay particles and organic matter. The most aggregate score in Bakrajo was excess 0.66 which described soils under group 3, but in Qallachwalan site it was ranged between 0.33 and 0.66 and the soil was described under as group 2. In general the soil of Bakrajo site is in a best condition respect to water erosion risks than Qallachwalan soil site.

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