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Comparison of the K factor in different areas on the slope

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Abstract — Erosion is among the leading factors threatening our sources of soil and water. The use of soil susceptibility indices to determine erosion and risk situations is vital, especially in erosion studies. The susceptibility of soil to erosion is the resistance of soil against decomposition due to some external forces. Carried out around Tokat-Tekneli village, the research aims to determine the erodibility factor (K) of the soil by its physical and chemical qualities in different slope segments of a field which is applied wheat-fallowing planting watch and has a convex slope in the study area. With this aim, three-times repeated deteriorated surface soil samples of 0-20 cm depth were taken from the peak, shoulder, ridge, face, and inch (finger) regions of the slope area, and they were analysed in the laboratory. With the formulation of the K factor, the soil erodibility value of each soil sample was calculated. The erodibility value of the region is between 0.07 and 0.12 t ha^{-1} Mj mm^{-1}, and it was determined that soils are classified in the soil class, which is sensitive to moderate erosion.

Subject Classification (2020):

1. Introduction

Today, soil erosion is considered one of the most critical factors leading to a decrease in agricultural land fertility [1]. Erosion, which causes environmental problems and land degradation, forms a coarse-textured soil structure by detaching fine particles from the soil [2]. It is stated that approximately 10 million hectares of agricultural land become undergo soil erosion every year [3,4]. In the agricultural lands where tillage practices are carried out for a long time, the crop yield decreases, and soil properties deteriorate as the fertile topsoil is eroded and moved [5]. Soil erosion in the world, especially in developing countries such as Turkey, leads to severe agricultural advancements and crop yield [6,7]. Therefore, the realistic estimation of soil loss in large areas is significant in conserving agricultural lands and increasing the yield [8].

Agricultural land is considered a rich source providing the necessary nutrients for the growth and development of plants [9]. This is because microbial activity, which allows the soil to be ventilated and the water to flow smoothly, is highly abundant in agricultural lands with high organic matter and humus content. This activity is deteriorated due to environmental and human factors, especially erosion. Soil

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erosion occurs due to the wearing away of the soil due to external forces such as wind, river or rainwater. The soil erodibility, which is expressed as abrasion, is defined as the resistance of the soil against decomposition and transportation [10]. Soils decomposed by precipitation or surface flow become convenient for erosion [11,12].

To raise the fertility of agricultural areas and ensure ecological balance, it is necessary to carry out agricultural research and develop state policies. A great many methods have been developed to estimate soil losses. USLE and its revised version, RUSLE, are the most widely used methods in the world today. USLE and RUSLE [13] are widely used in the whole world because they are easy to use, they require very little data and have a very reliable data set [14-16].

USLE [17] is one of the most advanced mathematical models used to predict the potential loss of soil likely to occur inland or basin due to surface erosion and gully erosion caused by precipitation [18]. It predicts soil losses by considering the rainfall erosivity factor, soil erodibility factor, the length and the slope factor of a hillside, the yield management factor, the soil conversion factor [19].

USLE is a model developed in line with the erosion data obtained from the uniform hillside lands divided into small parcels [20]. The K factor of USLE is widely used to determine and assess the soil losses occurring worldwide [17]. The K factor varies depending on the organic matter content of the soil, sand, very fine sand, silt and clay contents, soil structure, and permeability [21]. Also, erodibility is closely linked with soil texture, aggregate stability, shear stress, soil structure, infiltration capacity, soil depth, volume weight, soil organic matter content, and chemical composition [22]. Depending on the K value determined by these properties, it is ascertained how the soil affected by erosion can be improved or methods which can be taken to prevent soil losses [23].

In Tokat province, which generally shows arid and semi-arid climatic characteristics and where precipitation intensity-duration relationship and topographical condition are suitable for water erosion, the number of studies on the determination of soil loss is very limited [8]. Knowing the annual soil losses and tolerable soil erosion is essential in terms of taking effective erosion measures. This study aims to determine the value of the soil erosion occurring in different regions of a homogenously sloping hillside land where agricultural activities are carried out. The data obtained aims to guide the soil conservation studies to be carried out in the field in the future.

2.1. Material

The study was carried out in Tekneli village, 9 km away from Tokat province. Tekneli village is located between 36°30'13''E and 40°10'59''N and has an elevation of 1214m from the sea (Figure 1). In Tekneli village, where semi-arid climate conditions are present, the summers are hot and dry; winters are cold and rainy. The average annual rainfall is 492.1 mm, the average temperature is 8.1 °C, the highest snow depth is 86 cm, and the number of snow-covered days is 124. Considering the climate data of the Tokat region, the study area moisture regime is Ustic, and the soil temperature regime is Mesic. Tekneli village has shallow soil having A and C horizon and is formed on 10-12% sloping limestone. As the soil depth widens, the lime content increases and the amount of clay decreases. The dominant cations are Ca, and Mg and the pH vary between 7.70-7.86. The geological units of the basin are composed of magmatic, metamorphic and sedimentary rocks. Metamorphic rocks are composed of upper and lower cretaceous old schists, gneisses and limestones. Sedimentary units are represented by minerals such as Oligocene and Miocene aged gypsum, limestone, sandstone, shale. Volcanic units are seen as andesite, basalt and diabase rocks [24].

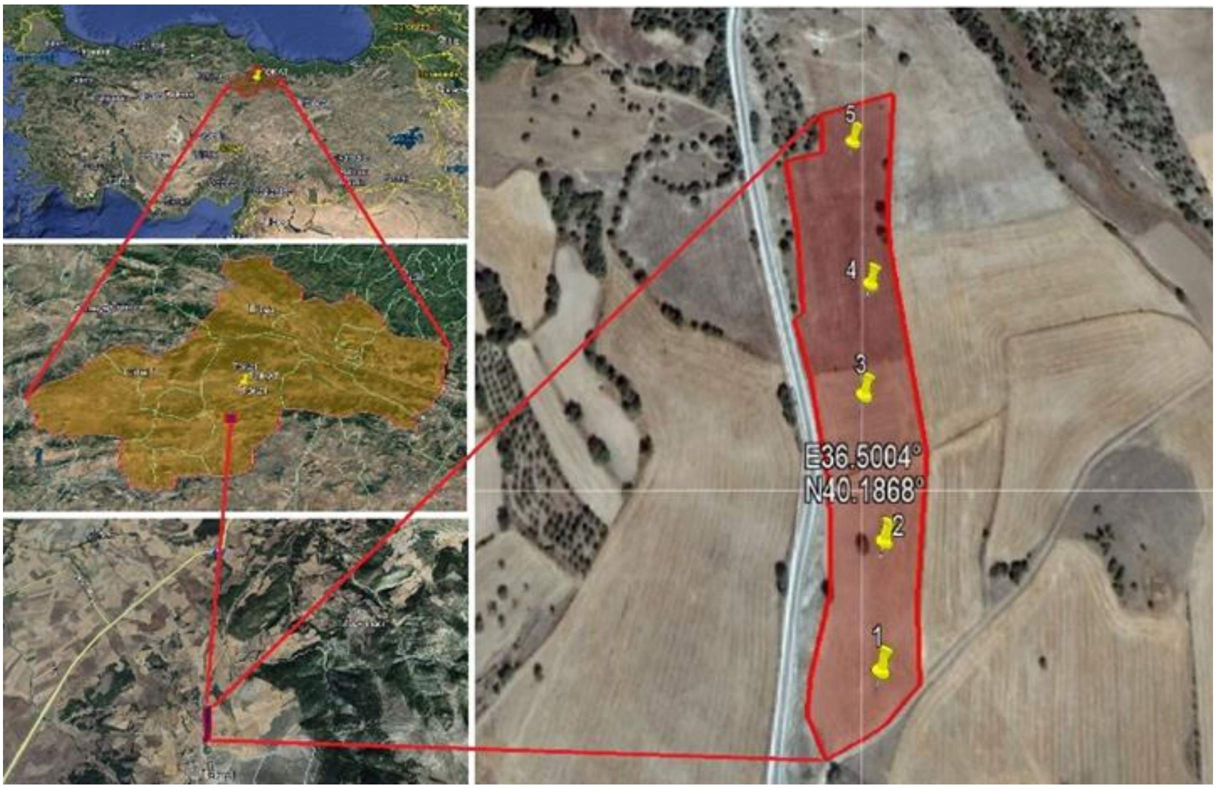

Figure 1. Site location map of the study area

2.2. Methods

To determine soil properties affecting soil erosion tendency, a total of 15 degraded surface soil samples (0-20cm) were collected from 5 different points of the slope segments of a field with a convex slope, where wheat-fallow crop rotation is carried out with three replications.

"Bouyoucos" hydrometer method was used in texture analysis of the soil [25]. The very fine sand fraction of the samples was determined by draining off the mechanical analysis suspension from a 0.105 mm sieve [26]. The organic matter was determined by the Walkey-Black method [27], and the hydraulic conductivity of the soils was found by the use of hydraulically permeable sets [28] where the water level was constant.

2.2.1. Determination of soil erosion susceptibility (Erodibility) K factor

The soil's erodibility (K) factor stands for the resistance of the soil to external erosive forces, and the probability of erosion occurs due to the physical and chemical properties of soils. Under the same external forces, this value is quite low in some soils; however, it is quite high in some others. The K factor value is calculated according to the empirical equation given below according to the results obtained from laboratory analysis:

$$100K = 2.1 \times 10^{-4}\ (12 - OM)M1.14 + 3.25(S - 2) + 2.5(P - 3)d \quad (1)$$

Here, OM=Organic matter %, S=Soil structure classification, P=Soil permeability code, M=Grain thickness distribution parameter, d = Metric system transformation coefficient, and d= 1.292.

The following equation was used in the calculation of the M factor:

$$M = (\text{Silt }\% + \text{Very Fine Sand }\%)(100 - \text{Clay }\%) \quad (2)$$

3.Results and Discussion

To determine the soil's erosion susceptibility in the study area, Equation 1 and K values were calculated by considering the textural and organic material content and water permeability values and structural characteristics of the samples in the study area. The results are presented in Table 1. The clay and sand content of soils of the study area was 50% and 35%, respectively, and the texture class was determined as Clay. The erodibility values of the clay-rich soils are very low. This is because the particles are bonded together in clay soils by various cement materials and show strong resistance to decomposition-transportation [29].

Table 1. Physical and chemical properties of soils in the study area

Location	Sample Point	Sand (%)	Clay (%)	Silt (%)	Classification	Organic Matter (%)	Very Fine Sand (%)	Hydraulic Conductivity (%)	Soil Erodibility (K) tha^{-1} Mj mm^{-1}
Summit	1	32	54	14	Clay	2.07	3.48	3	0.10
	2	26	60	14	Clay	2.40	3.78	7.8	0.09
	3	34	56	10	Clay	2.01	3.22	1.7	0.11
Shoulder	4	38	46	16	Clay	2.20	3.1	2.3	0.08
	5	34	52	14	Clay	2	2.6	8.4	0.07
	6	34	54	12	Clay	2.36	4.78	2.3	0.09
Back Slope	7	34	56	10	Clay	3.16	3.78	1.3	0.11
	8	28	56	16	Clay	3.02	3.36	3.5	0.10
	9	30	58	12	Clay	1.46	2.68	1.7	0.12
Foot Slope	10	38	46	16	Clay	3.20	3.78	8.3	0.08
	11	36	52	12	Clay	2.54	2.96	2.8	0.09
	12	40	46	14	Clay	1.93	3.62	7.2	0.08
Toe Slope	13	34	52	14	Clay	2.68	3.36	3.6	0.10
	14	38	50	12	Clay	1.74	3.02	3.6	0.09
	15	38	52	10	Clay	2.54	3	2.2	0.08

Erosion erodibility values of the samples taken from various locations of the sloping land are given in Table 2. The K values range between 0.07 and 0.12 tha^{-1} Mj mm^{-1}, and the study area soils fall into the slightly erosive class. The study conducted in China found that soil erosion values with the organic matter content ranging between 2.5 and 5.5% were between 0.02 and 0.04 [30]. Besides, in his study in which he investigated the erosion susceptibility of the clay soils in Nigeria, Okorafor [31] found that K values ranged between 0.060-0.067 investigated the erosion susceptibility of soils in the Yamchi basin in the north of Iran [32]. K values of the soils taken from 0-20 cm depth were found between 0.442 and 0.0076. The study results indicated that the erosion susceptibility of soils increased with the decrease of organic matter content. In this study, the organic matter contents of soils no. 9, 12, and 14 were determined as 1.46, 1.93, and 1.74, respectively. These values obtained resulted in an increase in the K value in these locations and were classified as moderately eroded soils (Table 2).

Table 2. Erosion susceptibility (erodibility) degrees of soils in the study area

Sample Location	K Value	Classification
1	0.10	Very low soil erodibility
2	0.09	Very low soil erodibility
3	0.10	Very low soil erodibility
4	0.09	Very low soil erodibility
5	0.07	Very low soil erodibility
6	0.09	Very low soil erodibility
7	0.10	Very low soil erodibility
8	0.10	Very low soil erodibility
9	0.12	Low soil erodibility
10	0.08	Very low soil erodibility
11	0.09	Very low soil erodibility
12	0.11	Low soil erodibility
13	0.10	Very low soil erodibility
14	0.11	Low soil erodibility
15	0.08	Very low soil erodibility

Statistical analyses were performed to determine the relationship between erosion susceptibility and soil properties. Results are presented in Table 3. When the standard deviation, skewness, and kurtosis values of the K factor are examined, it is seen that the results were close to the mean, and the data were normally distributed.

The relationship between the K factor and soil properties was determined by correlation analysis. There is a negative relationship (-0.658) between K and the permeability of the soil, and the relationship between them was significant (p<0.01). [33] found similar results in his study. Similarly, [33] found a negative (-0.882) relationship between the K-factor and the hydraulic conductivity of soils in the study, which investigated the erosion susceptibility of soils. A negative relationship was found between the K factor and the soil's clay content (-0.616) and the amount of organic matter (-0.249). Both soil properties have colloid binding properties. They increase the erosion susceptibility of soils. [33] found a negative relationship between clay content and k factor in their study.

Table 3. Descriptive Statistics

	K Factor	Clay %	Sand %	Organic Material %	Hydraulic Conductivity mm/hr	Very Fine Sand %
Mean	0.09	52	34.53	2.49	3.98	3.37
Standard Deviation	0.01	5.01	4.81	0.72	2.57	0.55
Kurtosis	-0.46	-.0.05	-0.2	1.64	-0.78	2.09
Skewness	0.38	-0.57	0.03	1.05	0.94	1.05

Table 4. Correlation analysis between the K factor and some soil properties

	K Factor	Clay %	Sand %	Organic Material %	Hydraulic Conductivity mm/hr	Very Fine Sand %
K	1					
Clay	-.616	1				
Sand	-.473	-.818	1			
Organic matter	-.249	.358	-.446	1		
Hydraulic Conductivity	-.632	-.832	.447	-.085	1	
Very Fine Sand	.006	-.023	-.148	.192	.042	1

4. Conclusion

The K factor of the USLE model is very closely related to soil losses and is a key factor used in predicting soil erosion. The soil erosion values of the hillside land of the Tekneli village were found in the moderately erosive soil group. As a result of the analysis, it was observed that the erosion value is closely related to the organic matter and clay content. The clay content of the study area soils is very high. Since clay particles form aggregates resistant to decomposition, the soil erosion value of the region is reduced. Erosion degree depends only on soil properties. It is not associated with slope, precipitation, vegetation, and management practices.

Author Contributions

All authors contributed equally to this work. They all read and approved the last version of the manuscript.

Conflicts of Interest

The authors declare no conflict of interest.

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