Mesopotamia J. of Agric. ISSN: 2224 - 9796 (Online) مجلـــة زراعـــة الرافديـــن
Vol. (47) No. (4) 2019 ISSN: 1815 - 316 X (Print) 2019 (4) العدد (47) المجلد

COMPARISON OF SOME DETACHABILITY INDICES IN RELATION TO SOIL ERODIBILITY (K_{USLE}) FOR CALCAREOUS SOILS

Khalid F. Hassan Guljehan A . Ibrahim
Mosul University, College of Agric. and Forestry / Dept. of Soil and Water Resources
Email: Khalid-a222@yahoo.com

ABSTRACT

The objective of this study was to use some indices related to soil aggregate instead of soil erodibility factor K_{USLE} of the universal soil loss equation (USLE) for a calcareous soils. Twelve composite calcareous soil samples from 0 - 15 cm depth were collected from 12 different locations at Nineveh provenance. The selected soils were analyzed and commonly used for five erodibility indices in order to identify soil erodibility. These indices are; Clay Aggregation Index (CAI), Clay Dispersion Ratio (CDR), Clay Flocculation Index (CFI), Dispersion ratio (DR), and Erosion Index of Bouyoucos (EIB) .

The results show a highly significant positive correlation (r = 0.891**) between EIB and K_{USLE} in comparison to the other criteria which pointed a weak correlation. Also, the results show through variance analysis that the mean of the criterion EIB values (3.651) was very close to the mean of the K_{USLE} values (3.839). These results mean that EIB is more reliable index for prediction the soil erodibility in calcareous soils.

Key words: Detachment, Water erosion, Calcareous soils.

Received: 5/8/2019, Accepted: 22 / 12 / 2019

INTRODUCTION

Soil erodibility (K_{USLE}) is actually defined as the quantitative measure of inherent soil susceptibility to erosion by susceptibility by water. Thus, the K factor for a specific soil can use an indicator of the detachment and transportation of soil particles by rainfall and runoff (Renard et al. 1997). Factors which affect soil erodibility are generally categorized into two groups, the first relates to the physical characteristics of soil which are easier dealt with compared to the second which is related to farming management or conservative actions (Chan et al.1994). It is basically related to the soil properties that include percentages of sand, silt, clay, and organic matter, structure, aggregation, and various interactions of these variables (Igwe et al. 1995). To allow estimation of soil erodibility from measurable soil properties, the soil erodibility Nomograph was published in the early 1978 (Wischmeier and smith. 1978). However, determination of soil erodibility under controlled field conditions by using Nomograph are tedious, time consuming and requires an elaborate experimental set up and therefore, can't be adopted for large scale investigations .Thus indices of soil erodibility can be worked out by measuring some properties .Various erodibility indices have been proposed by different workers for predicting the erosional behavior by computing the normal analytical data on soil physical properties. Some of erodibility indices that related to some of the efficient indices of soil erodibility are widely used in relation to be percentage-weight of water

---

The research is part of M.Sc. for 2nd researcher stable aggregates (WSA) and aggregate size distribution (Calero et.al.2008) to determine the soil erodibility of soil by water erosion.

The objective of this study was to use the most common indices related to soil aggregates to identify the susceptibility of calcareous soils for water erosion. Also this study was aimed to determine the most important index that can be used instead of soil erodibility factor K_{USLE} for this type of soils.

MATERIALS AND METHODS

Twelve composite calcareous soil samples were taken from 0 to15 cm depth around different locations at Nineveh provenance. The collected soil samples were analyzed to some physical and chemical properties which included:

1-Particle Size Distribution of the fine soil fractions was determined using the sieve and pipette method. Total clay (TC) and total silt (TS) obtained by the use of chemical dispersant. Water dispersion clay (WDC) and water dispersed silt (WDSi) were obtained by the same method.
2-Calcium carbonate determined by titration with Hydrochloric acid.
3- Organic matter determined by Walkly-Black method (Jackson 1958).
4- Sesquioxides determined by DCB method (Black 1965).
5-Soil reaction (pH), electrical conductivity (EC) measured in1:1soil extract (Richard 1954).

The soil erodibility factor K_{USLE} was estimated using the Wischmeier and Smith method by identifying some soil properties related to water erosion (sand%, very fine sand%, soil organic matter content, soil structure and soil Permeability. These determined properties were then plotted on special K-nomograph to get on soil erodibility factor (K_{USLE}).

$$\mathbf{K = [(2.1\times10^{-4}\ (M)1.14\ (12 - a) + 3.25\ (b - 2) + 2.5\ (c - 3)\ 1.292] / 100}$$

Where:
M =Particle size parameter (% silt + % very fine sand) × (100 - % clay).
a = Percentage of organic matter.
b = Soil structure code.
c = Profile permeability class (Wischmeier and Smith, 1978).

Commonly, five erodibility indices were used for identifying the susceptible of soil to erosion instead of K_{USLE} were selected. Methodologies for estimation of the indices are described in Table (1).

Table (1): The selected indices and their formulas used in this study.

Index	Models	References
Clay Aggregation Index (CAI)	CAI = %TC - %WDC	Mbagwu (1986)
Clay Flocculation Index (CFI)	CFI = % (TC - WDC) / %TC	Igwe et. (1995)
Clay dispersion ratio (CDR)	CDR= % WDC / %TC	
Dispersion ratio (DR)	DR= % (WDSi + WDC) / % (TS + TC)	
Erosion Index of Bouyoucos (EI)	EIB= % (WDSa + WDSi) / % (WDC)	

Where:
TC = % Clay after remove of calcium carbonate from soil.
TS = % Silt after remove of calcium carbonate from soil.
WDC = % Clay before remove of calcium carbonate from soil.
WDSi = % Silt before remove of calcium carbonate from soil.
WDSa = % Sand before remove of calcium carbonate from soil.

Descriptive statistics of K_{USLE} Value and soil erodibility indices were analyzed using analysis of variance (ANOVA), correlation and regression analysis to estimate the relationship between K_{USLE} value and the other indices, CAI, CFI , CDR , DR, and EIB. The MLR method was also used to determine the levels of significance of the parameters at $P < 0.05$ with the Minitab Statistical package.

RESULTS AND DISCUSSION

The study soils characterized by alkaline (pH > 7) non-saline (EC < 4 dS/ m) with low content of organic matter, Sesquioxides and high content of calcium carbonate (Table 2).

The soil texture was generally uniform for all the studied soil (Loamy) before removal calcium carbonate from the soil samples and changed to loamy - clay loam texture after remove calcium carbonate from it. This changing in soil texture may be due to the relative distribution of calcium carbonate in soil separates. The partial solubility of calcium carbonate in the studied soils (decalcification) in sand-size aggregates, cause to increasing the silt and clay separate in studied soils which makes changing in soil texture (Table 3).

Table (2): Some chemical properties of the studied calcareous soils.

Soils	%			EC dS.m^{-1}	pH
	O.M.	$CaCO_3$	Sesquioxides		
C_{27}	1.03	27.4	0.328	0.45	7.48
C_{29}	0.96	29.5	0.285	0.36	7.51
C_{30}	0.99	30.2	0.356	0.42	7.52
C_{31}	1.09	31.9	0.286	0.44	7.58
C_{32}	1.04	32.4	0.428	0.40	7.60
C_{33}	0.82	33.7	0.372	0.41	7.61
C_{34}	1.40	34.3	0.357	0.48	7.64
C_{36}	1.15	36.2	0.314	0.41	7.67
C_{37}	1.47	37.4	0.287	0.43	7.69
C_{38}	1.45	38.5	0.428	0.29	7.71
C_{40}	1.31	40.9	0.371	0.38	7.73
C_{46}	1.05	46.3	0.342	0.43	7.75

Table (3): Particle size distribution of the studied calcareous soils before and after removal of calcium carbonate.

Soils	%							
	Clay	Silt	Sand	Texture	Clay	Silt	Sand	Texture
	Before Removal				After Removal			
C_{27}	17.7	30.9	51.4	Loam	23.6	36.0	40.4	Loam
C_{29}	18.8	31.2	50.0	Loam	25.9	36.2	37.9	Loam
C_{30}	19.3	31.9	48.8	Loam	26.5	37.6	35.9	Loam
C_{31}	19.9	33.1	47.0	Loam	28.1	38.9	33.0	Clay loam
C_{32}	20.5	33.1	46.4	Loam	30.0	39.8	30.2	Clay loam
C_{33}	21.8	37.0	41.2	Loam	31.0	40.0	29.0	Clay loam
C_{34}	21.9	38.5	39.6	Loam	31.2	40.9	27.9	Clay loam
C_{36}	22.6	39.1	38.3	Loam	32.1	41.5	26.4	Clay loam
C_{37}	22.7	40.3	37.0	Loam	33.7	42.2	24.1	Clay loam
C_{38}	23.8	40.4	35.8	Loam	34.1	42.8	23.1	Clay loam
C_{40}	25.9	42.1	32.0	Loam	35.7	42.9	21.4	Clay loam
C_{46}	26.9	45.4	27.7	Loam	35.9	43.5	20.6	Clay loam

Soil erodibility factor of USLE (K_{USLE}):

Generally, for all the studied soils, it can be seen from Table (4) that the values of soil erodibility factor of (K_{USLE}) varied from (3.687 to 4.610) × 10^{-2} metric unit with coefficient of variance (C.V.) equal to 9.776%. This variation in K_{USLE} values depend on some physical properties especially their texture class (particle size distribution) in relation to soil calcium carbonate content. Therefore, it seems reasonable that K_{USLE} value gave a significant negative correlation with clay and $CaCO_3$ with was agreed following regression equation:

$$K_{USLE} \times 10^{-2} = 6.61 - 0.0278 \ (\%\ CaCO_3) + 0.122 \ (\%\ Clay)$$

$$R^2 = 86.7\%$$

Generally for all the soil studied, K_{USLE} values were seen to be decrease with increasing calcium carbonate and clay content in all studied soils, This may be due to the fact that the soil aggregates increasing with increasing calcium carbonate in soil and reducing their capability to erode by water erosion .

Soil erodibility indices :

Various soil erodibility indices derived from soil particle size distribution before and after removing of calcium carbonate have been listed in Table (4). Among these indices, CAI was observed to be the highest (5.9 - 11) , while the values of CFI ranged from (0.250 to 0.326) , CDR ranged between (0.673 to 0.750) and DR were from (0.767 to 0.910) .

Table (4): Values of K_{USLE} and selected Indices used in this study.

Soils	K_{USLE}	Indices				
		CAI	CFI	CDR	DR	EIB
C_{27}	4.610	5.9	0.250	0.750	0.815	4.649
C_{29}	4.448	7.1	0.274	0.725	0.805	4.319
C_{30}	4.225	7.2	0.271	0.728	0.798	4.181
C_{31}	3.743	8.2	0.291	0.708	0.791	4.025
C_{32}	3.741	9.5	0.316	0.683	0.767	3.878
C_{33}	3.730	9.2	0.296	0.703	0.828	3.587
C_{34}	3.710	9.3	0.298	0.701	0.837	3.566
C_{36}	3.687	9.5	0.295	0.704	0.838	3.424
C_{37}	3.614	11.0	0.326	0.673	0.830	3.405
C_{38}	3.561	10.3	0.302	0.697	0.834	3.201
C_{40}	3.556	9.8	0.274	0.725	0.865	2.861
C_{46}	3.451	9.0	0.250	0.749	0.910	2.717
%C.V.	9.776	16.6	8.275	3.353	4.464	15.962

EIB values showed that were higher (2.717 to 4.649) than other indices, which may be instead of because of the particles size distribution before the removal calcium carbonate to particle size distribution after removal of calcium carbonate.

Statistically, the results (as mentioned in Table 5) showed that there is a highly significant and positive correlation (r=0.891**) between EIB and K_{USLE} in comparison to the other criteria which pointed a weak correlation . The relationship of erodibility indices with K_{USLE} was observed to be negatively. The correlation coefficient (r) was the highest with CAI (-0.890), followed by DR (-0.481), CFI (0.453), accept CDR which show positively correlation (0.458). All these correlation values were significant at 5% level of significance.

Table (5):Correlation analysis between K_{USLE} Value and Erodibility Indices .

Criteria	K_{USLE}
EIB	0.891**
DR	-0.481
CFI	-0.453
CAI	-0.890
CDR	0.458

Also, the result variance analysis using Duncan multiple analysis (as mentioned in Table 6) shows that the mean of EIB values (3.6511) was the closest to the mean of the K_{USLE} values (3.8397). It thus appears that EIB is a better index for prediction the soil erodibility instead of (K_{USLE}).

Table (6): Duncan multiple range analysis for K_{USLE} in relation to erodibility indices.

Criteria	Means	DMRA
CAI	8.8333	A
K_{USLE}	3.8397	B
EIB	3.6511	B
DR	0.8265	C
CDR	0.7122	C
CFI	0.2869	C

In addition, when the EIB values were regressed with the K_{USLE} values, the result pointed that relationship is governed by a quadratic regression equation as in the following mathematical formula:

$$\mathbf{K_{USLE} \times 10^{-2} = 6.571 - 2.125\ EIB + 0.3684\ EIB^{2}}$$

$$\mathbf{R^{2} = 91.2\ \%}$$

The residuals analysis for this model confirmed that the calculated values of the K_{USLE} through the EIB criterion were relatively applicable with predicted values (K_{USLE}) .

Based on the soil erodibility scale of Roslan et al. (2017), which classified the risk of water erosion into five classes depending on the EIB values, we can obtained that all the soil studied classified within the moderate - risk class except soil C_{40} and C_{46} (soils with highest content of $CaCO_3$) which fell within the low risk - class for soil water erosion.

مقارنة بعض دلائل تفكك التربة الكلسية بعامل قابلية الترب للتعرية المائية

خالد فالح حسن كل جيهان عبدالله ابراهيم
قسم علوم التربة والموارد المائية -جامعة الموصل، كلية الزراعة والغابات
Email: Khalid-a222@yahoo.com

الخلاصة

تهدف الدراسة إلى استخدام بعض دلائل تفكك تجمعات التربة بدلاً من عامل قابلية التربة للتعرية المائية KUSLE في المعادلة العامة لفقد التربة لترب كلسية مختارة من محافظة نينوى . حيث جُمعت 12 عينة مركبة ممثلة لـ 12 موقع ولعمق (0-5) سم . تم حساب قيم هذه الدلائل باستخدام التوزيع الحجمي لدقائق التربة قبل وبعد إزالة كاربونات الكالسيوم والتي شملت دليل تجمعات الطين (CAI) , ودليل نسبة تشتت الطين(CDR)، ودليل تخثر الطين (CFI), ودليل انتشار دقائق التربة (DR) , ودليل تعرية بيوكس (EIB). أشارت النتائج إلى أن هناك ارتباط موجب عالي المعنوية (r = **0.891) بين دليل تعرية بيوكس وعامل قابلية التربة للتعرية المائية مقارنة بباقي الدلائل المستخدمة بالدراسة التي أظهرت ارتباطا ضعيفاً. كما أشارت النتائج من خلال تحليل التباين لقيم هذه الدلائل إلى أن متوسط قيم دليل تعرية بيوكس (3.651) مقارب لمتوسط عامل قابلية التربة للتعرية المائية (3.839) حيث يقودنا هذا الاستنتاج إلى أن دليل التعرية بيوكس يمكن اعتباره هو الدليل الافضل مقارنة بالدلائل المستخدمة لتعبير عن عامل قابلية التربة للتعرية المائية.

الكلمات المفتاحية: هدم، التعرية المائية، الترب الكلسية .

تاريخ تسليم البحث 2019/8/5 , وقبوله: 22 / 12 / 2019 .

REFERENCES

Calero, N., V . Barron and J. Torrent (2008). Water dispersible clay in calcareous soil of southwestern spain. *Catena, 74, 22-30.*

Chan, K., D. Heenan and R. Ashley (1994). Seasonal changes in the surface aggregate stability under different tillage and crops. *Soil and Tillage. Res., 28:301-314.*

Igwe, C., F. Akamigbo and J. Mbagwu (1995a). Physical properties of soils of southeastern Nigeria and the role of some aggregating agents in their stability. *Soil Science. 160, 431- 10***.**

Igwe, C., F. Akamigbo and J. Mbagwu (1995b). The use of some soil aggregate indices to assess potential soil loss in soils of southeastern Nigeria. Inter. *Agro –physics:95-100.*

Jackson , M. L. (1958). Soil Chemical Analysis. Prentice Hall, Inc., Englewood Cliffs , New Jersey . U.S.A.

Mbagwu , J. (1986). Erodibility of soils formed on a catenary topo-sequence in southeastern Nigeria as evaluated by different indexes. East African *Agricultural and Forestry Journal., 52: 74-80.*

Renard, K., G. Foster, G. Weesies, D. McCool , and D. Yoder (1997). Predicting soil erosion by water: A guide to Conservation Planning With the Revised Universal Soil Loss Equation (RUSLE). USDA, Agriculture Handbook No.703, Washington DC, 404 pp. Salako .

Richard , L. A. (1954). Diagnosis and Improvement of Saline and Alkaline Soils .USDA Handbook No . 60. U.S.A.

Roslan, Z., S. Mazidah , and N. Yusoff. (2017). Erosion risk assessment: A case study of Langat River bank in Malaysia. *International Soil and Water Research. 5(1): 26-35.*

Wischmeier, W. H. and D. Smith. (1978). Predicting Rainfall Erosion Losses. A-guide to Conservation Planning. U.S. Dep. Agric., Agric. Handbook. No. 537.