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Soil erodibility estimation and its correlation with soil properties in Coimbatore district

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Abstract

Soil erodibility represents soil susceptibility to suffer detachment by hydric erosion processes. Spatial representation of soil erodibility is decisive for allocation of soil conservation practices, site-based land management, and soil erosion modelling. Soil erosion by water is becoming a major environmental concern in the Western-Ghats and many parts of Coimbatore due to deforestation, rapid urbanisation and lack of conservation practices in the region. The application of erosion prediction model (i.e., RUSLE) requires an estimate of the soil erodibility factor for the main soil types of the region. Therefore, the objective of this study was to calculate the soil erodibility from the soil survey database and to correlate the K-factor values with soil texture and organic matter. This study presents soil erodibility values computed for a large variety of soil types and surface conditions (367 points based on physiography) and provide the soil erodibility values for most of the cultivated land areas of the district. The average K-factor value in the study area was estimated to be 0.0174 ± 0.005881 t ha h ha^{-1} MJ^{-1} mm^{-1}. Most of the study area had erodibilities between 0.01 and 0.03 $t\cdot ha\cdot h\cdot ha^{-1}\cdot MJ^{-1}\cdot mm^{-1}$. Soil erodibility increased with silt content (r=0.872), and soil textures that contained predominantly silt as the primary particles were estimated to be the most vulnerable to water erosion. Organic matter content was not correlated to soil erodibility (r=0.056). The results of this study demonstrated the convenience of using silt content instead of clay, organic matter, or sand in preliminary classifications of water erosion vulnerability in Coimbatore or areas with similar soil characteristics.

Keywords: Soil erodibility, RUSLE, silt content, organic matter, coimbatore

1. Introduction

Soil is a valuable gift of nature to all the living beings and at the same time the most neglected commodity on this planet. Shifting cultivation on the hill-slopes, non-adoption of soil conservation techniques, overexploitation of land for crop production and other human induced activities due to population stress lead to enormous soil erosion. It is one of the leading environmental problems of the world which includes detachment or entrainment, transportation of surface soil particles from original location and accumulation of it to new depositional area (Cooke and Doornkamp, 1990; Kandrika and Venkataratnam, 2005) [3, 9]. Soil erosion is being posed as second biggest problem in India next to population explosion (Pimentel, 2006) [17], thus becoming a major social and economic problem.

The current rate of agricultural land degradation world-wide by soil erosion and other factors is leading to an irreparable loss in productivity on about 6 million hectare of fertile land a year. The alarming facts figured out by Narayana *et al.* (1983) that in India about 5334 Mt (16.4 ton/hectare) of soil is detached annually, about 29% is carried away by the rivers into the sea and 10% is deposited in reservoirs resulting in the considerable loss of the storage capacity. Das *et al.* (1981) [5] has reported in India it is estimated that about 38 % out of a total reported geographical area, that is about 127 million hectares are subjected to serious soil erosion. Thus, quantification of soil loss and delineation of degraded areas is necessary for effective conservation planning and sustainability (Yadav and Sidhu, 2010) [28].

The Revised Universal Soil Loss Equation (RUSLE) is an empirical erosion model for predicting long-term average annual soil loss resulting from raindrop splash and runoff from field slopes in specified cropping and management systems and rangeland (Renard *et al.*, 1997) [19]. Similar to its predecessor, the USLE (Wischmeier and Smith, 1978) [27], RUSLE provides a convenient working tool for conservationists. Most of the advantages of RUSLE result from the following conditions: the equation factors can be represented by a single number; soil erosion can be predicted from meteorological, soil, or erosion research data for each location; and the equation is free from any geographically oriented base (Renard *et al.*, 1997) [19].

RUSLE computes the average annual erosion expected on field slopes as the product of six factors representing rainfall and runoff erosivity (R), soil erodibility (K), slope length (L), slope steepness (S), cover and management practices (C), and supporting conservation practices (P).

Soil erodibility is one of the important factor which can be used for assessing the annual soil erosion rate using USLE/RUSLE model integrated with Remote sensing and GIS. Spatial representation of soil erodibility is decisive for allocation of soil conservation practices, site-based land management, and soil erosion modeling (Auerswald *et al.*, 2014; Panagos *et al.*, 2014; Renard *et al.*, 1997) [2, 15, 19]. Soil erodibility can be estimated based on soil attributes (Renard *et al.*, 1997; Wischmeier *et al.*, 1978) [19, 27].

Soil erodibility (K) represents the susceptibility of soil or surface material to erosion, transportability of the sediment, and the amount and rate of runoff given a particular rainfall input, as measured under a standard condition. The standard condition is the unit plot, 72.6 ft long with a 9 percent gradient, maintained in continuous fallow, tilled up and down the hillslope (Renard *et al.*, 1997) [19]. K values reflect the rate of soil loss per rainfall-runoff erosivity (R) index. Soil erodibility factors (K) are best obtained from direct measurements on natural runoff plots. Rainfall simulation studies are less accurate, and predictive relationships are the least accurate (Romkens, 1985) [21]. For satisfactory direct measurement of soil erodibility, erosion from field plots needs to be studied for periods generally well in excess of 5 years (Loch *et al.*, 1998) [12]. Therefore, considerable attention has been paid to estimating soil erodibility from soil attributes such as particle size distribution, organic matter content and density of eroded soil (Wischmeier *et al.*, 1978) [27]. Fig. 1. represents the nomograph used to determine the K factor for a soil, based on its texture; % silt plus very fine sand, % sand, % organic matter, soil structure, and permeability.

Soil erosion by water is becoming a major environmental concern in the western-ghats and many parts of Coimbatore due to deforestation, rapid urbanisation and lack of conservation practices in the region. The application of erosion prediction model (i.e., RUSLE) requires an estimate of the soil erodibility factor for the main soil types of the region. However, the lack of such information may result in severe limitations in adoption of soil and water conservation practices across the district. Therefore direct measurement of soil erodibility requires long-term erosion plot studies, which are time-consuming and costly. Therefore, the objective of this study was to calculate the soil erodibility from the collected soil survey data from the entire district. This study presents soil erodibility values computed for a large variety of soil types and surface conditions (367 points based on physiography) and provides the first soil erodibility map for most of the cultivated land areas of the district.

2. Materials and Methods

2.1 Study area

The study area for soil erodibility estimation is Coimbatore district located in the western part of Tamil Nadu in the Kongu region. It is surrounded by Palakkad district of Kerala on the west and by Idukki district of Kerala in the South. Coimbatore shares its borders with Tirupur in the East and Nilgiris in the North. It is located between latitudes 11°24′23″N to 10°13′12″N and longitudes 76°39′20″E to 77°18′00″E occupying an area of 4721.28 sq. km.

The Western Ghats, Nilgiri biosphere as well as the Anaimalai and the Munnar ranges runs parallel along the entire western and northern borders of the district. The Noyyal River passes through the district and forming the southern boundary. The relief is undulated with gentle slope with many hill ranges and hillocks except for the hilly terrain in the west. The undulating topography with innumerable depressions, are used as tanks for storage of rainwater for agriculture.

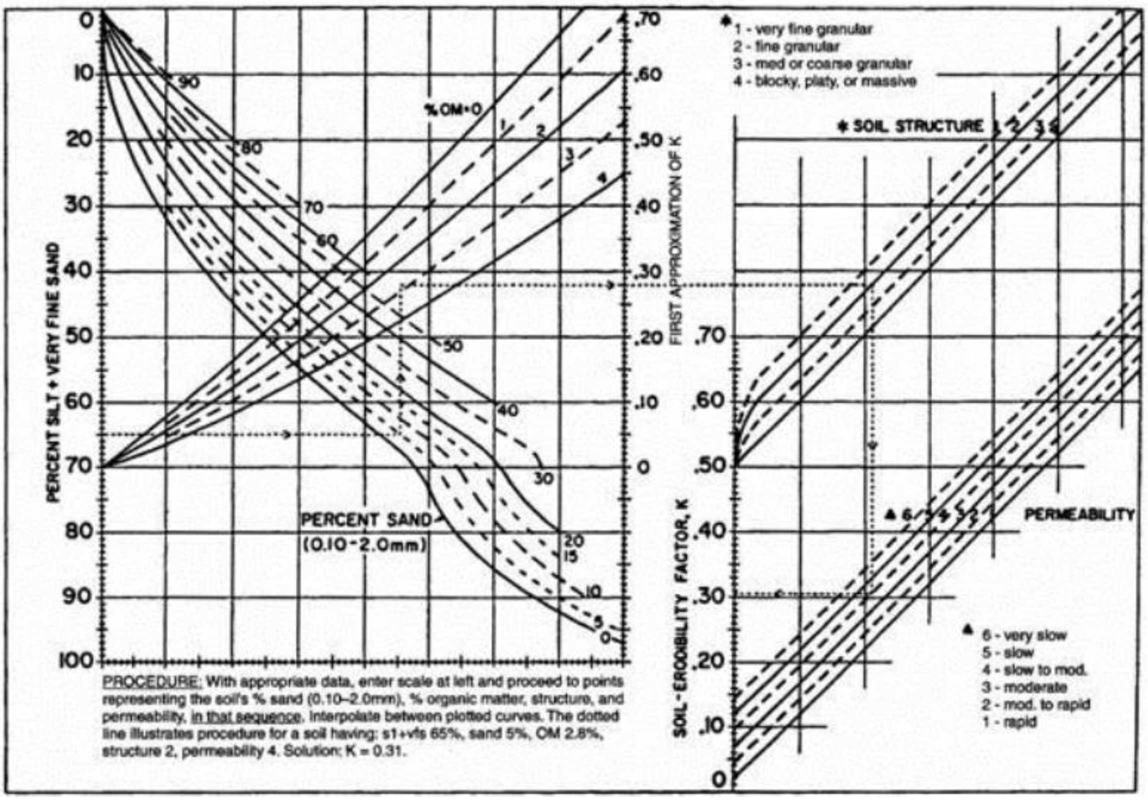
The district receives the rain under the influence of both southwest and northeast monsoons. The northeast monsoon chiefly contributes to the rainfall in the district and summer rains are negligible. The total rainfall varies from 550mm to 900mm which is minimum around Sulur and maximum around the Anamalai hills. The district enjoys a tropical climate. The temperature recorded varies from 11.7°C to 42.6°C.

There are 6 major soils types viz., Red calcareous Soil, Black Soil, Red non-calcareous, Alluvial and Colluvial Soil, Brown Soil, and Forest Soil. About 60 per cent of the district is covered by red soils, of which red calcareous soil is predominant. The highlands in Coimbatore, Palladam and Avinashi taluks are mostly occupied by the black soils, which are dark gray to grayish brown in colour. The texture varies from clay (fine) to sandy loam (coarse), sandy clay loam occupying the largest area. Coimbatore district is underlain by a wide range of high grade metamorphic rocks of the peninsular gneissic complex. These rocks are extensively weathered and overlain by recent valley fills and alluvium at places.

2.2 Field data and point erodibility classification

The soil Erodibility factor measures the susceptibility of soil particles or surface materials to transportation and detachment by the amount of rainfall and runoff input (Renard *et al.*, 1997) [19]. It is known that the most easily eroded soil particles are silt and very fine sand and the less erodible soil particles are aggregated soils because they are accrued together making it more resistible (Kim *et al.*, 2005) [10].

The most widely used and frequently cited relationship to estimate the K factor is the soil-erodibility nomograph (Fig. 1) using measurable properties. The soil erodibility nomograph comprises five soil profile parameters: percent of modified silt (0.002-0.1mm), percent of modified sand (0.1-2mm), percent of organic matter (a), class for soil structure (b) and permeability (c).



PROCEDURE: With appropriate data, enter scale at left and proceed to points representing the soil's % sand (0.10–2.0mm), % organic matter, structure, and permeability, in that sequence. Interpolate between plotted curves. The dotted line illustrates procedure for a soil having: s1+vfs 65%, sand 5%, OM 2.8%, structure 2, permeability 4. Solution: K = 0.31.

Fig 1: Soil erodibility nomograph (After Wischmeier and Smith, 1978) [27].

Soil erodibility calculation involved 367 point samples from surface layer. Point sampling distribution was intended to be done on the basis of physiographic units; however, due to the low accessibility condition of the area, it was not possible to visit some points and opportunistic sampling locations were collected.

Samples were analysed to determine the organic carbon content using Walkley and Black wet dichromate oxidation method (Walkley and Black, 1934) [24] and converted to organic matter by multiplying it by 1.724, textural analysis using International pipette method (Piper, 1966) [18] and spatial maps were generated for these parameters for future purposes. The saturated hydraulic conductivity (inch/h) was determined using Saxon equation (Saxton *et al.,* 1986) [22] and soil permeability classes were assigned to different hydraulic conductivity classes. The very fine sand per cent was determined using RUSLE2 model formula (Corral-Pazos-de-Provens *et al.,* 2018) [4]. Soil structure classes were assigned to each point based on measurements from on field and laboratory observations of the aggregates.

The properties used to calculate the K-factor were the following: the primary particle size fraction as a percent clay, percent silt, percent very fine sand, percent organic matter, and the soil structure code and permeability classes. Permeability class was determined based on the methodology of the Soil Survey Manual (NRCS, 2007) as shown in the Table 1 in which each soil texture is assigned a permeability code.

Table 1: Soil-water data for major USDA soil textural classes

Texture	Permeability code	Saturated hydraulic conductivity (inch hr^{-1})	Hydrologic soil group
Silty clay, clay	6	<0.04	D
Silty clay loam, sand, clay	5	0.04-0.08	C-D
Sandy clay loam, clay loam	4	0.08-0.2	C
Loam, silt loam	3	0.2-0.8	B
Loamy sand, sandy loam	2	0.8-2.4	A
Sand	1	>2.4	A^{+}

2.3 Soil erodibility estimation

The most commonly used and cited relationship is the soil erodibility nomograph (Wischmeier *et al.*, 1971) [27] as shown in Fig. 1. The nomograph comprises five soil and soil profile parameters. A useful algebraic approximation of the nomograph for those cases where the silt fraction does not exceed 70% is given by (Wischmeier and Smith, 1978) [27] which was used for calculation of soil erodibility factors as shown below:

$$K = [2.1 \times 10^{-4} \times (12-a) \times M^{1.14} + 3.25 \times (b-2) + 2.5 \times (c-3)]/759 \qquad \text{Eq. (1)}$$

Where, K is the soil erodibility factor (t·ha·h·ha^{-1}·MJ^{-1}·mm^{-1}), M is the particles percentage [% of very fine sand + % of silt x (100% clay)], a is the organic matter content (% C x 1.724), b is the soil structure code and c is soil permeability class.

3. Results & Discussion

3.1 Soil properties in the study area

The analysis showed that 40.05% of samples had sandy clay loam texture followed by Sandy loam (29.42%), Sandy clay (9.80%), clay (8.70%), loamy sand (6.53%), loam (5.44%) and clay loam (4.90%) texture. Erodibility is low for clay rich soils with a low shrink swell capacity, as clay particles mass together into larger aggregates that resist detachment and transportation. Organic matter content varies from 0.034 % to 3.413%.The permeability of is mostly slow to rather fast, a result that was observed that the presence of clay decreases the level of soil permeability. The result shows that Coimbatore has soil erodibility, ranges from 0.0059 to 0.049, the region has a low to moderate soil erodibility with 62.94% of the area ranges between 0.01 $t{\cdot}ha{\cdot}h{\cdot}ha^{-1}{\cdot}MJ^{-1}{\cdot}mm^{-1}$ and 0.02 $t{\cdot}ha{\cdot}h{\cdot}ha^{-1}{\cdot}MJ^{-1}{\cdot}mm^{-1}$.

Sand contents were generally between 15% and 89%. Most soils contained between 2.5% and 45% silt and from 6% and 65% clay. The analysis showed that all the soil sample contained ≤4% organic matter in the surface horizon. The average standard errors of the clay, silt, sand, and organic matter fractions were 0.581, 0.400, 0.765 and 0.043 respectively. Unlike the silt fractions, there was a wide range in clay contents, from almost gone up to 89%.

3.2 Soil erodibility factors

Using Eq. (2), the average K-factor value was estimated to be 0.0174±0.0058 $t{\cdot}ha{\cdot}h{\cdot}ha^{-1}{\cdot}MJ^{-1}{\cdot}mm^{-1}$, and 62.94% of the soils showed values between 0.01 $t{\cdot}ha{\cdot}h{\cdot}ha^{-1}{\cdot}MJ^{-1}{\cdot}mm^{-1}$ and 0.02 $t{\cdot}ha{\cdot}h{\cdot}ha^{-1}{\cdot}MJ^{-1}{\cdot}mm^{-1}$. K-factor values ranged from 0.0059 $t{\cdot}ha{\cdot}h{\cdot}ha^{-1}{\cdot}MJ^{-1}{\cdot}mm^{-1}$ to 0.0495 $t{\cdot}ha{\cdot}h{\cdot}ha^{-1}{\cdot}MJ^{-1}{\cdot}mm^{-1}$ in the region.

3.3 Relationship between soil erodibility and soil texture

When analyzing the entire soil dataset (n=367), we observed that soil erodibility decreases as the sand content increases (r= -0.672). No trend was found between clay content and the erodibility factor (r=0.283). A different situation was observed in the case of silt: the correlation between erodibility and silt was higher than for the other soil particles (r=0.872) (Table 3.1.). Similarly, Di Stefano and Ferro (2002) noted that detachment decreases as particle size either decreases or increases beyond the range of 20–200 μm. Above this range, it is more difficult to detach and transport particles because of the particle mass, and below this range, cohesive forces counter particle detachment. Consequently, soil particles with diameters in the size fractions of silt, fine and very fine sand are more easily eroded. The same results were reported by Ampontuah *et al.* (2006), who studied soil particle redistribution in two contrasting cultivated hill-slopes in England. Their research addressed high-silt fields containing about 67–80% silt, which were very susceptible to water erosion.

Table 2: Correlation coefficient between K factor and other properties

	CLAY	SILT	SAND	OM (%)	K-Factor
CLAY	1				
SILT	0.186	1			
SAND	-0.857	-0.664	1		
OM (%)	0.103	0.196	-0.181	1	
K-factor	0.283	0.872	-0.672	0.056	1

Other studies have shown that the correlation between K-factors and soil properties increases when those properties are not considered to be isolated. This revealed the existence of a synergistic effect between soil properties (Duiker *et al.*, 2001; Romero *et al.*, 2007) [7, 20], because an increase in a particular particle size fraction reduces the fraction of another particle size. Therefore, it is more reliable to analyse erodibility based on soil texture than on a single particle size. Because soil texture accounts for the relative proportion of sand, silt, and clay present in the soil, a texture-based analysis would be a better alternative.

Soils in the study area had 7 of 12 USDA soil textures. Only sand, silty clay, silty clay loam, silt loam and silt soils were not found. The number of soil samples and the average K-factor values of each texture are shown in Table 3. Soils with high clay content (clay and sandy clay) showed statistically similar erodibility to soils with high sand content (sandy loam, and loamy sand). These textures showed the lowest K-factor values and also contained less than 40% silt. Consequently, as explained by Di Stefano *et al.* (2002), soil erodibility decreases as particle size either decreases or increases beyond the range of 20–200 μm.

Table 3: Soil erodibility values for different soil textures in the study area

Soil texture	N	K-factor ($t{\cdot}ha{\cdot}h{\cdot}ha^{-1}{\cdot}MJ^{-1}{\cdot}mm^{-1}$)	
		Mean	Standard Deviation
Clay	32	0.0203	0.0034
Clay loam	18	0.0266	0.0035
Loam	2	0.0419	0.0108
Loamy sand	24	0.0097	0.0023
Sandy clay	36	0.0179	0.0038
Sandy clay loam	147	0.0172	0.0045
Sandy loam	108	0.0165	0.0059
Total	367		

Wischmeier and Mannering (1969) [26] found a similar condition when examining the organic matter content as an indicator of erodibility. They found that the runoff was inversely related to organic matter content, but not for all the soils studied. Their analysis showed a complex interrelation between organic matter and clay. On silts, silt loams, loams and sandy loams, the inverse relation of erodibility to organic matter level was strong, but it significantly declined as the clay fraction became larger, and it may become insignificant on clay soils. In our study the highest vulnerability to water erosion occurred where soils contained predominantly silt (silty clay loam, silt loam, and loam), which also agreed with the findings of other studies (Duiker *et al.*, 2001; Lal and Elliot, 1994; Pérez-Rodríguez *et al.*, 2007; Romero *et al.*, 2007; Zhang *et al.*, 2004) [7, 20, 16, 29].

The interaction between soil texture and organic matter and the effect on soil erodibility were also explored in this study. Fig. 2 shows that the mean organic matter contents differed among the soil textures in the study area. Fine-textured soils tended to have more organic matter than loam or sandy soils. Soils with sandy textures exhibited the lowest organic matter contents but not the highest K-factor values. These results provide another reason to perform water erosion vulnerability analyses based on soil properties but not organic matter contents alone.

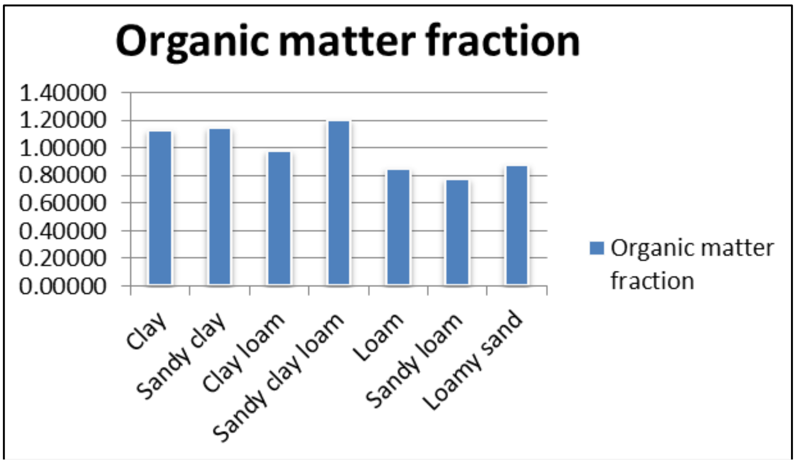


Fig 2: Mean organic matter contents for soil textures. Fine-textured soils tended to have more organic matter than loam or sandy soils.

3.4 Relationship between soil erodibility and organic matter

For the soils in the study area, results showed no correlation between K-factor values and soil organic matter (r=0.056), and no difference in the average erodibility values among the groups when soils were grouped based on organic matter content (Table 4).

Table 4: Soil erodibility values for different soils based on organic matter content.

Organic matter fraction	N	K-factor (t·ha·h·ha^{-1}·MJ^{-1}·mm^{-1})	
		Mean	**Standard deviation**
0-0.5	108	0.0177	0.0067
0.5-1.0	155	0.0172	0.0059
1.0-1.5	91	0.0182	0.0063
1.5-2.0	34	0.0170	0.0076
2.0-2.5	17	0.0182	0.0041
2.5-3.0	7	0.0168	0.0050
>3.0	4	0.0187	0.0061
Total	367		

However, when different soils are pooled together, no trend in erodibility is observed as a result of the organic matter content. This lack of a trend occurred because Eq. (1) uses organic matter values but also other soil properties (e.g., permeability, structure, and particle size distribution), which change at same time as organic matter. This is a concern for soil conservation programs where soils with higher organic matter content are assumed to be less vulnerable to water erosion regardless of the soil texture. Previous research has indicated that organic matter alone does not explain the erodibility of the soils, because organic matter interacts with other factors such as texture and permeability (Jin *et al.*, 2009; Tejada *et al.*, 2006; Wischmeier *et al.*, 1969) [8, 23, 26]. Much of the soil organic carbon in soil was associated with the occurrence of fine particles (0–0.02 mm), such as clay and fine silt, and these particles were most susceptible to water erosion. Therefore, in this study area, it is possible that soils with high organic matter contents also contain large fractions of silt (r= 0.196), which would offset the effect of the former variable in the final K-factor value.

4. Conclusion

The average K-factor value in the study area was estimated to be 0.0174±0.005881 t ha h ha^{-1} MJ^{-1} mm^{-1}. Most of the study area had erodibilities between 0.01 and 0.03 t·ha·h·ha^{-1}·MJ^{-1}·mm^{-1}, and values between 0.01 and 0.02 t·ha·h·ha^{-1}·MJ^{-1}·mm^{-1} were typical.

No correlation was found between K-factor values and organic matter contents. Conversely, when erodibility was analyzed based on the primary soil particles, erodibility decreased as the sand content increased, and the opposite effect was observed for silt. When grouped according to soil texture, all of the soils with less than 40% silt showed the same erodibility and were the least vulnerable to water erosion. Similarly, the textures with the highest K-factor values turned out to be those where silt was the predominant particle size. Fine-textured soils (i.e., soils rich in clay or silt), showed higher levels of organic matter than coarse-textured soils. This relationship between texture and organic matter content explains the absence of a direct correlation between organic matter and the erodibility factor. In addition, as a result of the wide range of soil textures in each soil order, there was considerable variability in K-factor values within each order; this variability explains why it is not possible to estimate the erodibility of a particular soil based solely on its taxonomic order.

The results of this study show that in the absence of field plot measurements in Coimbatore, it is appropriate to calculate K-factors using Eq. (1). In addition, in the absence of local soil property data, the soil erodibility values generated provides an estimate of K-factor values that can be used as guidance for soil conservation practices and modeling of landscape processes.

Although the soil erodibility of the area is low to moderate but the region is turning out to be a potential area for land degradation due to many man-made activities such as deforestation, lack of management and conservation practices and planning to minimise the soil loss. There is an urgency to take into consideration this soil loss by all possible ways so as to reduce the existing amount of soil loss and to raise watershed rehabilitation and productivity.

5. References

1. Ampontuah EO, Robinson J, Nortcliff SJG. Assessment of soil particle redistribution on two contrasting cultivated hillslopes. 2006; 132(3-4):324-343.
2. Auerswald K, Fiener P, Martin W, Elhaus DJC. Use and misuse of the K factor equation in soil erosion modeling: An alternative equation for determining USLE nomograph soil erodibility values. 2014; 118:220-225.
3. Cooke R, Doornkamp JC. Geomorphology in environmental management: a new introduction: Oxford University Press (OUP), 1990.
4. Corral-Pazos-de-Provens E, Domingo-Santos JM, Rapp-Arrarás ÍJLd, development. Estimating the very

fine sand fraction for calculating the soil erodibility K-factor. 2018; 29(10):3595-3606.

5. Das D, Bali Y, Kaul RJIJosc. Soil conservation in multi-purpose river valley catchments, problems, programme approach and effectiveness, 1981.
6. Di Stefano C, Ferro VJBE. SW—Soil and water: linking clay enrichment and sediment delivery processes. 2002; 81(4):465-479.
7. Duiker S, Flanagan D, Lal RJC. Erodibility and infiltration characteristics of five major soils of southwest Spain. 2001; 45(2):103-121.
8. Jin K, Cornelis W, Gabriels D, Baert M, Wu H, Schiettecatte W, Hartmann RJC. Residue cover and rainfall intensity effects on runoff soil organic carbon losses. 2009; 78(1):81-86.
9. Kandrika S, Venkataratnam LJJoSH. A spatially distributed event-based model to predict sediment yield. 2005; 5(1).
10. Kim JB, Saunders P, Finn JTJEM. Rapid assessment of soil erosion in the Rio Lempa Basin, Central America, using the universal soil loss equation and geographic information systems. 2005; 36(6):872-885.
11. Lal R, Elliot WJSerm. Erodibility and erosivity. 1994; 1:181-208.
12. Loch R, Slater B, Devoil CJSR. Soil erodibility (Km) values for some Australian soils. 1998; 36(6):1045-1056.
13. Narayana DV, Babu RJJoI, Engineering D. Estimation of soil erosion in India. 1983; 109(4):419-434.
14. NRCS U. National soil survey handbook, 2007, 430-VI.
15. Panagos P, Meusburger K, Ballabio C, Borrelli P, Alewell CJSotte. Soil erodibility in Europe: A high-resolution dataset based on LUCAS. 2014; 479:189-200.
16. Pérez-Rodríguez R, Marques MJ, Bienes RJSotTE. Spatial variability of the soil erodibility parameters and their relation with the soil map at subgroup level. 2007; 378(1-2):166-173.
17. Pimentel. Soil erosion: a food and environmental threat. 2006; 8(1):119-137.
18. Piper C. Mechanical analysis of soil by International Robinson’s Pipette method, 1966.
19. Renard KG, Foster GR, Weesies G, McCool D, Yoder D. Predicting soil erosion by water: a guide to conservation planning with the Revised Universal Soil Loss Equation (RUSLE) (Vol. 703): United States Department of Agriculture Washington, DC, 1997.
20. Romero CC, Stroosnijder L, Baigorria GAJC. Interrill and rill erodibility in the northern Andean Highlands. 2007; 70(2):105-113.
21. Romkens M. The soil erodibility factor: a perspective, 1985.
22. Saxton K, Rawls WJ, Romberger J, Papendick RJSSSoAJ. Estimating generalized soil-water characteristics from texture. 1986; 50(4):1031-1036.
23. Tejada M, Gonzalez JJS, Research T. The relationships between erodibility and erosion in a soil treated with two organic amendments. 2006; 91(1-2):186-198.
24. Walkley A, Black IAJSs. An examination of the Degtjareff method for determining soil organic matter, and a proposed modification of the chromic acid titration method. 1934; 37(1):29-38.
25. Wischmeier WH, Johnson C, Cross BJJos. Conservation w. Soil erodibility nomograph for farmland and construction sites, 1971.
26. Wischmeier WH, Mannering JJSSSoAJ. Relation of soil properties to its erodibility. 1969; 33(1):131-137.
27. Wischmeier WH, Smith DDJPrel-agtcp. Predicting rainfall erosion losses-a guide to conservation planning, 1978.
28. Yadav R, Sidhu GJJotISoSS. Assessment of soil erosion in Himachal Pradesh. 2010; 58(2):212-220.
29. Zhang K, Li S, Peng W, Yu BJS, Research T. Erodibility of agricultural soils on the Loess Plateau of China. 2004; 76(2):157-165.