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MUSLE Model Approach for Soil Loss Studies in Tonshyal Micro Watershed

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A B S T R A C T

Soil erosion depletes the productive layer of soil which is an ultimate resource for all agricultural activities. Since erosion rate varies with watershed characteristics, a study of soil and water dynamics at a watershed level can facilitate a scientific approach toward their conservation and management. The study involves obtaining peak runoff and input parameters (K,LS,C & P) of Modified Universal Soil Loss Equation (MUSLE) integrating GIS platform to estimate soil loss of Tonshyal micro watershed which lies between 16º 30'- 16º 45' latitudes and 75º 30'- 75º 45' longitudes with area of 269.42 ha, watershed code of 4D7A5E2. The base map and thematic maps were prepared using Survey of India toposheet No. 47 P/10 with scale of 1:50000 in a QGIS environment. The study area contains Very deep (>150 cm), Clay soils occurring on very gently sloping (1-3%), Clay soils occupy in entire micro-watershed. The calculated data and factors that were considered in the present study summarized and applied in MUSLE model for estimating annual soil loss.

Introduction

Soil loss is a process wherein soil features are disturbed influenced by variable parameters like rainfall, runoff. The process threatens natural resources and environment. Soil loss is deeply fallen because of biophysical and socioeconomic factors, e.g., pasturage, agriculture system, and impoverishment (Hoffman and Todd, 2000).

In India, an area of about 175 M ha out of the total land area of 328 M ha, accounted nearly 53 percent of the total land area is prone to soil erosion (Upadhyay *et al.*, 2012). It is estimated that about 5334 Million tons (16.4 t ha^{-1}) of soil is detached annually in India out of which about 29 percent is carried away by river into the sea and 10 percent is deposited in reservoirs resulting in the considerable loss of the storage capacity. Thus quantification of soil loss is a significant issue for soil and water conservation practitioners and policy makers.

According to Martin and Saha (2007) the most effective way of estimating soil loss is to integrated remote sensing and GIS. RS is a technique significantly provides the input parameters necessary in MUSLE model. In GIS platform database for the catchment which is very much useful for carrying out spatial analysis thereby can be created effectively (Shwetha *et al.*, 2016)

Materials and Methods

Study Area

Tonshyal micro-watershed is located in Vijayapur district and geographically lies between 16°30' and 16°45' N latitude and 75° 30' and 75° 45' E longitude with an area of 269.2 ha as delineated from Survey of India (SOI) toposheet No. 47 P/10. Figure 1 shows the location map of the study area.

Data Used

The Survey of India topographic map no 47 P/10 was used for the demarcation of the watershed boundary on 1:50000 scale. The rainfall data of Meteorology Department, RARS Vijayapur. The soil information was collected from the soil map prepared by Karnataka State Remote Sensing Application Centre (KSRSAC).

Morphometric analysis was done to understand the characteristics of watershed and further study was done based on the results obtained (presented in Table 1). The thematic maps were generated keeping the toposheet map as a base.

MUSLE model

$$A = 11.8 \times (Q \times Q_p)^{0.56} \times K \times LS \times C \times P$$

Where

A = Annual soil loss (t km^{-2} yr^{-1})
Q = Runoff volume (mm^3)
Q_p = Peak discharge in cubic metres per second (m^3 s^{-1})
K = Soil erodability factor
L = Slope length factor
S = Slope steepness factor
C = Cover and management factor and
P = Supporting conservation practice factor

The peak discharge (Q_p) was calculated through the equation

$$Q_p = \frac{(0.208 \times A \times Q)}{(0.5 \times D + 0.6\, t_c)}$$

Where

A = Basin size (km^2)
Q = Depth of runoff (mm)
D = Duration of storm in hours, assumed as 24 hours, and
t_c = Concentration time in hours calculated through standard formulae
Kirpich equation:

$$t_c = 0.0195 \times L^{0.77} \times S^{-0.385}$$

Where

A = Basin size (km^2)
S = Average channel slope (m m^{-1})
L = Length of channel from divide to outlet (km)

Peak discharge obtained using kirpich time of concentration, runoff volume along with four potential and actual soil erosion-controlling factors K, LS, C and P were integrated as in MUSLE to obtain soil loss.

Results and Discussion

Thematic layers obtained by the digitization in QGIS platform is presented in Figure 2.

Annual soil loss is estimated from the product of factors (Q, Q_p, K, LS, C and P) which represents geo-environmental scenario of the study area. The values of soil loss obtained through the MUSLE model are presented in Table 2.

Table.1 Linear aspects of drainage network

Parameters	Stream order				Total
	I	II	III	IV	
No. of streams	68	15	5	1	89
Bifurcation ratio (R_b)	4.53	5	5	-	

Table.2 Estimated soil loss using MUSLE model

MUSLE factors						
K	**L.S**	**C**	**P**	**Time of concentration(min)**	**Peak discharge (m^3s^{-1})**	**Soil loss ($t\ ha^{-1}yr^{-1}$)**
0.12	2.2	0.655	0.55	53.15	1.58	1.773

Fig.1 Location map of the study area

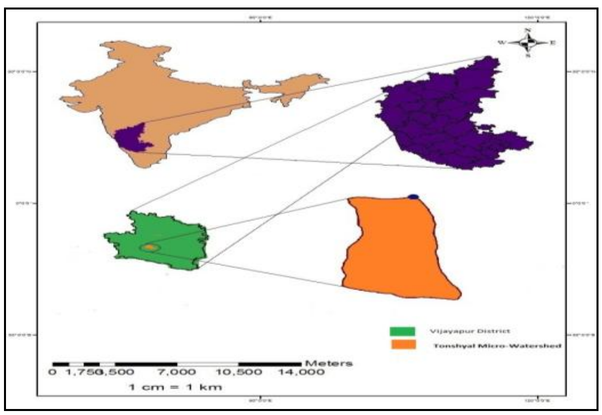

Fig.2 Thematic layers of watershed

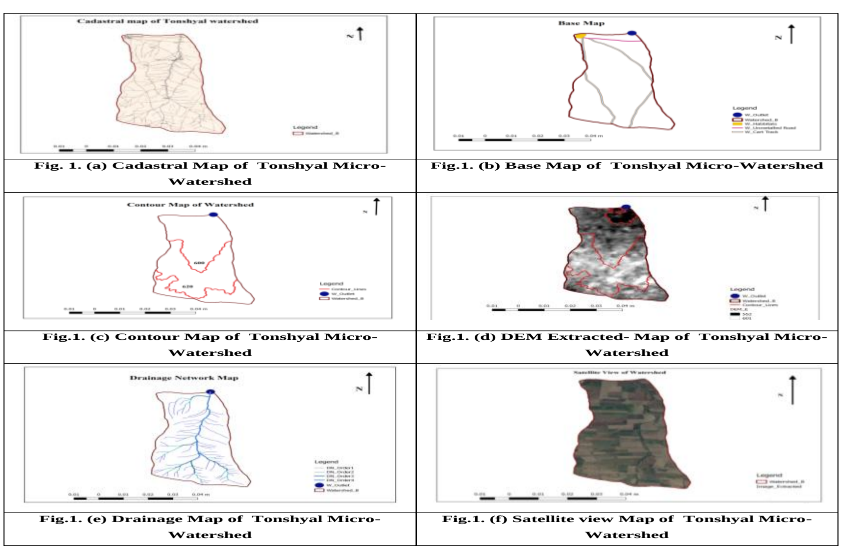

Fig. 1. (a) Cadastral Map of Tonshyal Micro-Watershed

Fig.1. (b) Base Map of Tonshyal Micro-Watershed

Fig.1. (c) Contour Map of Tonshyal Micro-Watershed

Fig.1. (d) DEM Extracted- Map of Tonshyal Micro-Watershed

Fig.1. (e) Drainage Map of Tonshyal Micro-Watershed

Fig.1. (f) Satellite view Map of Tonshyal Micro-Watershed

In conclusion the soil erosion can be controlled effectively if it is predicted accurately with different available management strategies. Thus application of MUSLE is appropriate as it produces reasonable estimate of the soil loss from a watershed. Integrating the model with remote sensing and GIS technology for obtaining the input parameters makes the work more accurate.

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