PAPER SOIL LOSS ASSESSMENT AT STEEP SLOPE: A CASE STUDY AT THE GUTHRIE CORRIDOR EXPRESSWAY, SELANGOR, MALAYSIA

[1]MD. RABIUL ISLAMA, [2]WAN ZURINA WAN JAAFAR, [3]LAI SAI HINA

[1,2,3]Department of Civil Engineering, University of Malaya, Kuala Lumpur, 50603 Malaysia.
E-mail: mriceduet@gmail.com, wanzurina@um.edu.my, laish@um.edu.my

Abstract- The study was in order to assess soil erosion at plot scale Universal Soil Loss Equation (USLE) erosion model and Geographic Information System (GIS) technique have been used for the study 8 plots in Guthrie Corridor Expressway, Selangor, Malaysia. The USLE model estimates an average soil loss soil integrating several factors such as , rainfall erosivity factor(R), Soil erodibility factor (K), slope length and steepness factor (LS), vegetation cover factor as well as conservation practice factor (C &P) and Results shows that the four plots have very low rates of soil loss, i.e. NLDNM, NDNM, PLDM, and NDM having an average soil loss of 0.059, 0.106, 0.386 and 0.372 ton/ha/ year, respectively. The NBNM, PLDNM and NLDM plots had a relatively higher rate of soil loss, with an average of 0.678, 0.757 and 0.493ton/ha/year. Whereas, the NBM is one of the highest rate of soil loss from 0.842 ton/ha/year to maximum 16.466 ton/ha/year. The NBM plot was located at bare the land; hence the magnitude of C factor(C=0.15) was the highest one.

Keywords- Guthrie Corridor Expressway (GCE), GIS, Soil Erosion, USLE Model.

I. INTRODUCTION

SOIL erosion is a worldwide phenomenon and never ending problem in all over the world. Soil erosion is a two phase process, consisting of the detachment of individual particles from the soil mass and transported by erosive agents such as wind and water [1]. It is a natural process, and started before the history of man's existence on the earth. Disturbance from human activities has further aggravated the process of soil erosion especially on steep slopes. Erosion can also be triggered or accelerated by climatic change, tectonic activities, human influence or a combination of them[2]. Soil erosion has become an important environmental problem in recent years especially in areas where there has been intensive use of land for development net urbanization and agricultural activities accentuating the problem. Soil erosion affects not only on soil productivity of upland fields but also the water quality of the streams in the catchment area. The chemical influx from pesticides and fertilizers due to agricultural activities increased the chemical concentration such as nitrogen, phosphorus and heavy metals contents in the lacustrine water and sediment. The encroachment of development into the environmental sensitive areas has resulted in accelerated soil erosion, water pollution, sedimentation and consequently the flooding in the downstream areas.

II. METHODOLOGY

The study was conducted at berm Latitude 3°13'12.40"N to 3°13'27.30"N and Longitude 101°30'29.30"E to 101°30'50.21"E of Guthrie Corridor Expressway (GCE) in Kuala Selangor, Malaysia shown in figure 1. The overall study area is divide two locations (1 & 2).

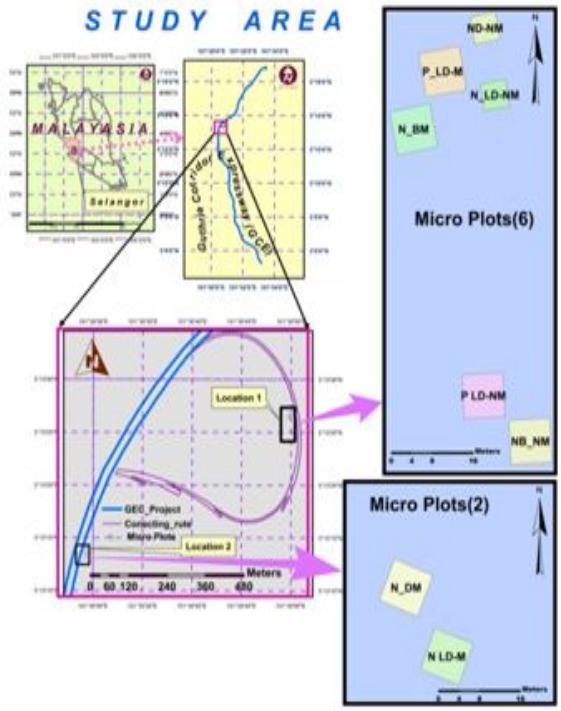


Fig.1 Study area showing all plots along the Guthrie Corridor Expressway, Selangor, Malaysia.

The universal soil loss Eq. (1) is an empirical model developed by [1] to estimate soil erosion from fields.

$$A(\text{ton/hac/year}) = R.K.LS.C.P \quad (1)$$

The R value calculation in the study area is shown in Table 1. P is the annual rainfall mean equivalent of the study area (2000-2013) which is 2663.34 mm for Selangor. The best estimates of the R factor value calculated for the study area were either 2323.254[2] or 1851.7333MJ mm ha-1 yr-1.

TABLE II
Rainfall Erosivity Factor (R)

Authors	Equations	R value(MJ mm ha-1 h-1 yr-1)	Best Estimation of R value according to [2]. (MJ mm ha-1 h-1 yr-1)
[3]	$[(9.28P - 8838.15) * 75]$ in metric unit	1190.824	2323.254
[4]	$R = P * 0.75 * 1.73$ in metric unit	3455.684	
[5, 6]	$R = \frac{2.5 * P^2}{100(0.073P + 0.73)}$	908.691	

Where, the K factor is 0.005 (Mg h MJ^{-1} mm^{-1}) used for this research, that on obtained from [7].

The slope length and slope steepness can be used in a single index, which expresses the ratio of soil loss as defined by [1] in Eq. 2.

$$LS = (X/22.1)^m(0.065 + 0.045\,S + 0.0065\,S^2) \quad (2)$$

Where, X = slope length (m) and S = slope gradient (%)

Slope percentage layer was derived from digital elevation model (DEM) of the study area and slope length was assumed to be fixed as 20 m for each pixel. The values of X and S were derived from DEM.

The X value is calculated using Eq. (3), Flow Accumulation was derived from the DEM after conducting FILL and Flow Direction processes in ArcGIS10.1.

$$X = (\text{Flow accumulation} * \text{Cell value}) \quad (3)$$

By substituting X value, LS equation will be:

$$LS = (\text{Flow accumulation} * \text{Cell value}/22.1)^m(0.065 + 0.045\,S + 0.0065\,S^2) \quad (4)$$

Moreover slope (%) also directly derived from the DEM using ArcGIS. The value of m varies from 0.2 –0.5 depending of the slope as shown in table 2[1].

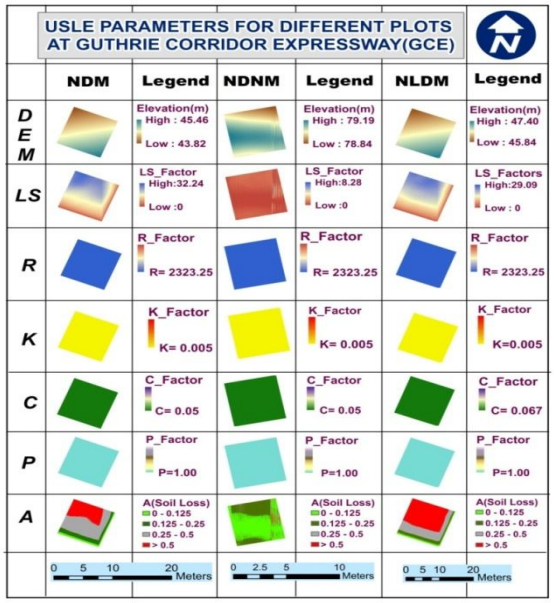
TABLE III
M Value

Slope (%)	<1	1-3	3-5	>5
m -value	0.2	0.3	0.4	0.5

The value of C factor determine for various vegetation condition [8]. Also the P-factor was not taken into account, Assuming no support practice in the study area, it was not used in calculations (P factor = 1).

III. RESULTS AND DISCUSSION

After completing data input procedure and preparation of R, K, LS and C maps as data layers, they were multiplied in the GIS to provide erosion risk map which shown in figure 3 spatial distribution of soil loss of plots NLDNM, PLDM, PLDNM and NDM, NDNM, NLDM plot shown in figure 2. The result found of the soil erosion based on the USLE model of NLDNM, NDNM, PLDM, and NDM plots had very low rates, an average of 0.059, 0.106, 0.386 and 0.372ton/ha/ year respectively. The plots with the steepest slopes were in the location 2 of the study area. The location 1 was in relatively lower steeped area. However, the micro plots NDN, NDNM and NLDNM have contained in the dense vegetation cover thereby, showing the lower values of C factor (0.0125-0.05) as well as low erosion yields. The NBNM, PLDNM and NLDM plots had a relatively higher rate of soil loss, with an average 0.678, 0.757 and 0.493ton/ha/year. These plots were located in the area with surface cover bare to less dense vegetation; hence the value of erosion yield was moderately higher. Among all of the micro plots in both locations, the NBM is one which had the highest rate of soil loss, with an average of 0.842 ton/ha/year to maximum 16.466 ton/ha/year. The NBM plot was located under bare the land; hence the magnitude of C factor(C=0.15) was the highest one.



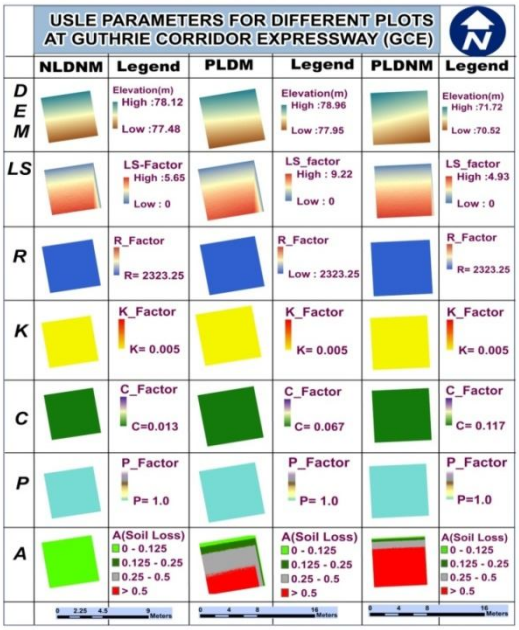


Fig. 3 Amount of soil loss of NLDNM, PLDM, PLDNM plots with USLE parameters

ACKNOWLEDGEMENTS

The authors would like to acknowledge the University of Malaya. This research is supported by University of Malaya Research Grant (UMRG) under the project "Integrate soil hydrological aspect and vegetation cover for slope erosion" Project no. RP005B-13SUS.

REFERENCES

[1]. Wischmeier, W. and D. Smith, Predicting rainfall erosion losses. USDA Agricultural Research Services Handbook 537. USDA, Washington, DC, 1978: p. 57.

[2]. Mir, S.I., et al., Soil loss assessment in the Tasik Chini catchment, Pahang, Malaysia. Bulletin of the Geological Society of Malaysia, 2010(56).

[3]. Morgan, R.P.C., Soil erosion and conservation. 2005: UK: Blackwell.

[4]. Roose, E. Application of the universal soil loss equation of Wischmeier and Smith in West Africa. in Soil Conservation and Management in the Humid Tropics; Proceedings of the International Conference. 1977.

★★★