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Developing Point Spectro Transfer Functions in Soil Erodibility Prediction in VIS-NIR-SWIR Rang

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Introduction: Soil erodibility (K factor) is generally considered as soil sensitivity to erosion and is highly affected by different climatic, physical, hydrological, chemical, mineralogical and biological properties. This factor can be directly determined as the mean rate of soil loss from standard plots divided by erosivity factor. Since measuring the erodibility factor in the field especially watershed scale is time-consuming and costly, this factor is commonly estimated by pedotransfer functions (PTFs) using readily available soil properties. Wischmeier and Smith (1978) developed an equation using multiple linear regressions (MLR) to estimate erodibility factor of the USA using some readily available soil properties. This equation has been used to estimate K based on soil properties in many studies. As using PTFs in large sales is limited due to cost and time of collecting samples, recently soil spectroscopy technique has been widely used to predict certain soil properties using Point SpectroTransfer Functions (PSTFs). PSTFs use the correlation between soil spectra in Vis-NIR (350-2500 nm) and certain soil properties. The objective of this study was to develop PSTFs and PTFs for soil erodibility factor prediction in the Simakan watershed Fars, Iran.
Materials and Methods: The Semikan watershed, which mainly has calcareous soil with more than 40% lime (total carbonates), is located in the central of Fars province, between 30°06'-30°18'N and 53°05'-53°18'E (WGS′ 1984, zone 39°N) with an area of about 350 km^2. For this study, 40 standard plots, which are 22.1×1.83 m with a uniform ploughed slope of 9% in the upslope/downslope direction, were installed in the slopes of 8-10% and the deposit of each plot was collected after rainfall. From each plot three samples were sampled and some physicochemical properties including soil texture, organic matter, water aggregate stability, soil permeability, pH, EC were analyzed Spectra of the air-dried and sieved soil samples were recorded in the Vis-NIR-SWIR (350 to 2500 nm) range at 1.4- to 2-nm sampling intervals in a standard and controlled dark laboratory environment using a portable spectroradiometer apparatus (FieldSpec 3, Analytical Spectral Device, ASD Inc.). Some bands which had the highest correlation with K factor were chosen as input parameter for developing PSTFs. A stepwise multiple linear regression method was used for developing PTFs and SPTFs. R2, RMSE and ME were used for comparing PTFs and SPTFs.
Results and Discussion: The K values varied from 0.005 to 0.023 t h MJ^{-1} mm^{-1} with an average standard deviation of 0.014 and of 0.003 t h MJ^{-1} mm^{-1}, respectively. The K estimated by Wischmeier and Smith (1978) equation varied from 0.015 to 0.045 t h MJ^{-1} mm^{-1} with an average of 0.030 t h MJ^{-1} mm^{-1}. There was a significant difference ($p<0.001$) between measured soil erodibility factor and those estimated based on Wischmeier and Smith (1978) in the studied area. A comparison between measured and estimated K values revealed that the measured soil erodibility factor values were from 1.08 to 3.57 with average 2.18 times smaller than the estimated values. The K had positive significant correlation with silt content (r= 0.47, $p<0.01$) and very fine sand content (r=0.43, $p<0.01$). The results indicated that $CaCO_3$ had negative effect on the K factor because Ca^{2+} affects flocculation and aggregate stability, and hence decreases erodibility factor. This parameter had, therefore, a significant coefficient in developed PTFs, while it was not considered as input parameter in Wischmeier and Smith (1978) equation. Based on correlation between band reflectance and K factor some band including B_{532}, B_{622}, B_{1442}, B_{2227}, B_{2327} and B_{2343} were selected for developing PSTFs. PTFs with R^2= 0.84, RMSE= 0.0014 t h MJ^{-1} mm^{-1} and ME= 0.000 t h MJ^{-1} mm^{-1} were the best method to predict K. After PTFs,

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SPTFs with R^2= 0.53, RMSE= 0.0028 t h MJ^{-1} mm^{-1} and ME= 0.0011 t h MJ^{-1} mm^{-1} were the second best method to estimate K.

Conclusions: The results showed that the annual average of soil loss was 7.90 t h^{-1} ya^{-1} and measured K factor was 0.014 t h MJ^{-1} mm^{-1}. Organic matter (r=-0.60) and permeability (r= -0.77) had high significant correlation with the K factor. Although the content of lime was not considered in Wischmeier-Smith and RUSLE model, we found that this soil property decreased K significantly due to its strong effects on aggregate stability and soil permeability. Overall, PTFs and SPTFs had better accuracy than Wischmeier-Smith function to predict K factor. Wischmeier-Smith function showed an overestimation to predict K factor particularly for higher values of K.

Keywords: Spectral Reflection, Simakan Dam, Radiospectrometer, Rainfall Erosivity, USLE