AN APPROACH TO ESTIMATION OF SOIL ERODIBILITY FOR IALPUG RIVER BASIN (REPUBLIC OF MOLDOVA)

O ABORDARE A ESTIMĂRII ERODIBILITĂȚII SOLULUI PENTRU BAZINUL RÂULUI IALPUG (REPUBLICA MOLDOVA)

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Summary. *Erodibility (k-factor) as a part of the Revised Universal Soil Equation Model (RUSLE) was estimated for a case-study area (Ialpug River Basin), quantifying the capacity of various soil types to withstand the detachment of its particles and their consequent transport. World Reference Database of Soil Resources classification was used. GIS tools of soil's erodibility were used, and the distribution of soil taxa and various erosion degrees for it was analyzed. K-factor varies from 0.135888 (Antrosols) till 0.496222 ton·ha·h/ha·MJ·mm (Calcic Chernozems). Both pedological and geological approaches were applied (for active landscapes). The choropleth method of cartography was used to present the classes of resulting erodibility k.*

Keywords: RUSLE, *soil erodibility, erosion degree levels, soil granulometric properties, river basin.*

INTRODUCTION

Water erosion, leading to the loss of the topsoil on slopes, and terrian deformation, is a well-known and urgent problem for many European countries, as well as for Republic of Moldova.

There were several approaches to estimating the quantifiable measure of soil erosion based on their physical properties, e.g. soil erodability. For example, several authors are calculating the classes of soil's capacity to erode using only its clay and humus content and porosity (bulk density, g*cm^{-3}) [1-4].

Moțoc [5], on the contrary, did not consider soil properties to be a decisive factor in case of erosion, placing the priority in the erosion's driving forces on climate and relief.

When assessing erodibility he grouped soils in three major categories according to the by how much resistance to erosion changes with horizon depth, and then grouped them further by their resistance to erosion in general. There are numerous authors that use his take on the RUSLE formula as whole and erodibility as part of his modified formula [6-7]. This methodology, however, is not transferrable to RUSLE model directly as it is neither based on WRB-classification nor uses the k-factor formula, but most importantly, it uses the erosivity classes (R-factor), that were calculated for Romania in the 1970s and are not applicable during the present period of climatic changes.

There were also numerous authors that had calculated erodibility as a part of RUSLE equation for study areas in Republic of Moldova [8, 9], or whole territory of Europe [10]. There seems to be a consensus among the above-mentioned authors, that soils properties, such as structure and permeability, is one of the five equally influential factors that determine the amount of the soil losses for a certain area.

The present article will aim to assess the erodibility of soils in the study area (Ialpug River Basin), or the so-called k-factor of the RUSLE equation [11]. This factor has been and is still used as a characteristic of the soil and measures the susceptibility of the soil to be detached and transported by erosion agents, mainly by sampling an area and using kriging interpolation for obtaining the spatial distribution of the k-factor [12, 13]. Some authors [12] used k-factor in order to measure the actual results of Sustainable Land Management (SLM) practices, used data from 240 samples, and compared SLM plots erodibility with control group.

MATERIALS AND METHODS

The data on the soil types and texture classes from [14] was used for the study area, the taxa were correlated with the WRB (World Reference Database of Soil Resources) classification based on the works of [15]. The k-factor as a part of the RUSLE model was calculated according to the classic formula of [16]:

(1)

where K – soil erodibility factor, ton·ha·h/ha·MJ·mm; M – is calculated according to (2); S – soil structure code; and P – soil permeability rating.

(2)

where MO – organic matter content in soil.

As we didn't use the correctional coefficient of 0.1318 that some of the authors [17] use for the formula, our results differ by a factor of approximately 0.1.

The data on soil particles distribution was taken from ISRIC-WISE database [18] using only the entries for Republic of Moldova for the necessary soil types, and, in one case, using the entry RO0018 for granulometric data on solonchaks, as there were no entries for this soil type for Moldova. We also used the data on erosion degrees from The State Planning Institute for Land Management (in Rom. – IPOT). If a certain polygon representing a soil type also had an erosion degree, we had calculated the M-parameter according to the granulometric properties of a corresponding lower part of the horizon, based on the fractional classification of eroded soils by degree of erosion [19, p. 50].

Although the classic method suggests using the soil erodibility nomograph, due to the sparse nature of data we had to derive structure code and permeability rating from the granulometric properties, using the soil texture triangle and according to the *Methodology of Elaboration of Pedological and Agrochemical Studies* [20], which is used as a basis for INSPIRE maps of Soil Permeability in Romania [21].

The IPOT attribute table for the Ialpug Basin area also contained a class of active landslides. In this case we used the already known texture classes and typological groups of sandy-clayey rocks of landslide slopes of Moldova according to the combination of granulometric elements in them [22, p. 282]. As [14] lacked the texture code for this category, we used the lithology map [23], splitting the active landslides polygons between the two maternal rocks' texture codes: „silty clay loam” (in Rom. – lut argilos prafos, TP) and „coarse sand” (in Rom. – nisip grosier, NG). This geological approach to calculating erodibility is also been used by [24, 25].

The choropleth method of cartography was used to present the classes of resulting erodibility k, and Merge and Dissolve tools in ArcGIS 10.3 were used to generalize the polygons according to their WRB classification, erosion levels and texture class only.

RESULTS AND DISCUSSIONS

The elaborated GIS of erodibility in Ialpug River Basin (Figure 1) makes it possible to either assess the levels of erodibility in the study area according to the equal interval classification or, accordingly, to identify exact erodibility values pertaining to the WRB soil types and erosion degrees.

65% of the basin area is covered by soils with a k-factor above the average level (0.3-0.4) namely, Haplic Chernozems (CHh) of all degrees of erosion; non-eroded Calcic Chernozems (CHk) as well as those with an erosion level not higher than medium; Fluvisols (FL); slightly eroded Gleysols (GL); Cambisols (CM); and heavily eroded Vertisols (VR) (Table 1, histogram on Figure 1a). A high k-factor (0.4-0.5) is characteristic for Solonetz (SN), heavily eroded Calcic Chernozems (CHk), and for active landslides located on sometimes sandy carbonate clays, with a thin layer of marl, limestone and sand and on coarse clays with sparse layers of silt, sand and limestone (both of these lithology categories were coded as TP texture). The smallest area (12.1 km^2) and the lowest values of erodibility factor k is characteristic for Antrosols (AT), Solonchaks (SC) and active landslides that developed on sands, which either unevenly alternate with siltstones, clays, and in places with limestones, or are combined with gravel and with lenses of pebbles and conglomerates, silts and clays (both bedrock categories were postulated as texture code NG) (Table 1). The second largest areas (22.7%) pertain to the medium erodibility class (0.2-0.3).

It should also be noted that the average value of the k-factor for the Ialpug River Basin area is 0.301672, which approximates to the erodibility values for slightly

(0.29067) and heavily eroded Vertisols (0.303856), as well as in Fluvisols and Cambisols (0.302527) (Figure 1b).

Table 1. Quantifiable attributes of k-factor (ton·ha·h/ha·MJ·mm) classes

k-factor class	Area, %	Area, km^2	WRB (erosion level)
0.14-0.2	0.5%	12.1	AT(0), landslide_NG(0), SC(0)
0.2-0.3	22.7%	549.3	CHh(0), CM(2), GL(0), PH(0-2), VR(0-2)
0.3-0.4	65.8%	1593.0	CHh(1-3), CHk(0-2), FL GL(1), CM(0), VR(3)
0.4-0.5	11.0%	267.6	CHk(3), landslide_TP(0), SN(0)

Note: 0 –no erosion, 1 – slight erosion; 2 – medium erosion; 3 – heavy erosion recalculated according to data from IPOT. If the polygon had an attribute of mixt erosion, the highest level was prioritized, e.g., slight+medium erosion was coded 2; and medium+heavy – 3.

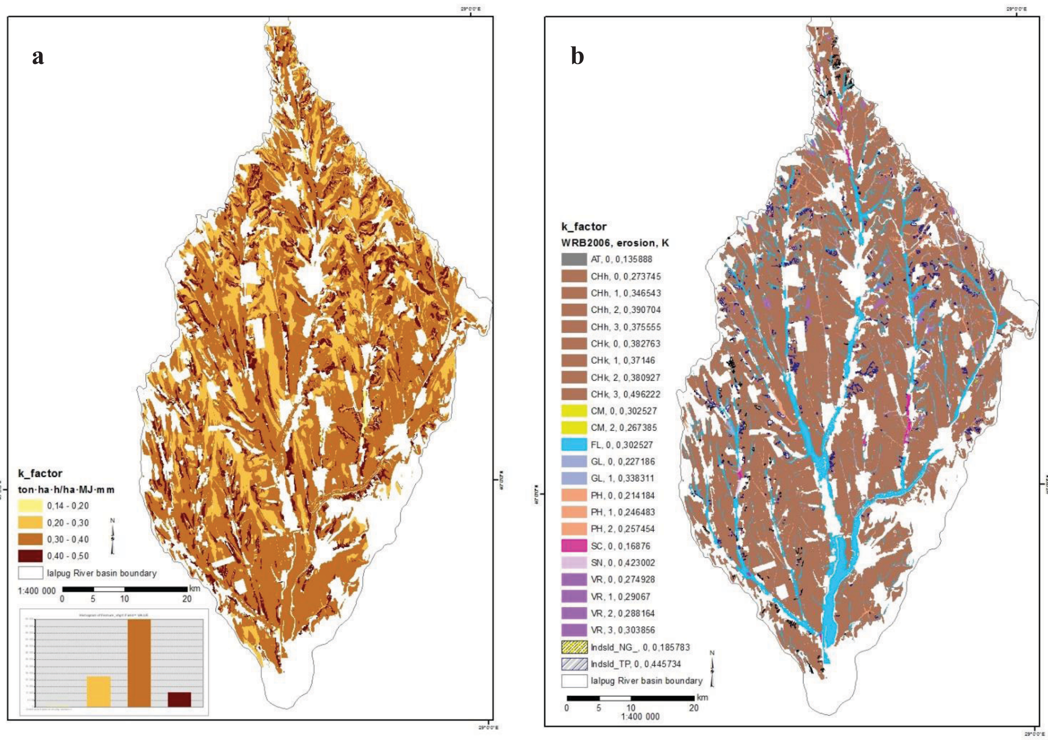

Figure 1. (a) Soil erodibility according to classes, (b) Spatial distribution of erodibility values for upper-level WRB soil taxa of various degrees of erosion

While Vertisols vary little with increase of intensity of erosion (Figure 2), some soil types (CHk, GL, VR, PH) display an increase in k-factor values with the increase of erosion levels, most steep rise is characteristic to Calcic Chernozems (0.124762). There are however two soil types that demonstrate a decrease in erodibility with the intensity of the soils' wash-off, namely Haplic Chernozems and Cambisols.

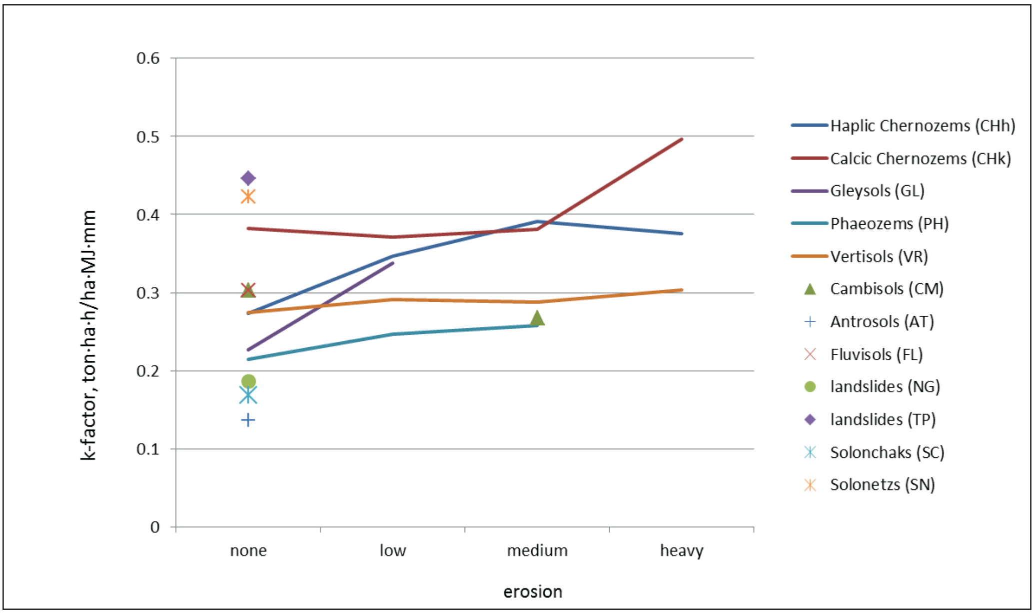

Figure 2. Dynamics of k-factor according to the erosion levels

CONCLUSIONS

Since the Ialpug River Basin has a low elevation difference, one of the main exogenic processes in this region is soil erosion. Its study and analysis are crucial, since this process causes the loss of soil material from the upper, humus-rich horizon A. In turn, this leads to a decrease in the overall land fertility, namely in the quality and quantity of crop products.

Spatially distributed soil erodibility for the case-study area within the Ialpug River Basin had demonstrated several tendencies – 76.8% of the study area can be classified highly susceptible to erosion, with Calcic and Haplic Chernozems classified as soil with high erodibility (except non-eroded Haplic Chernozems that has k-factor values below the average for the basin). Fluvisols, Cambisols and Vertisols (except for heavily eroded Vertisols) are classified as moderately erodible. Antrosols, Solonchaks, Gleysols, Phaeozems and other have erodibility values below the average.

Anti-erosive practices, such as mandatory crop rotation, plowing horizontally along the contours of the land, and the use of appropriate agricultural techniques (no- or mini-tillage) are recommended.

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