

THE MOTRU MINING BASIN – GIS APPLICATION ON SHEET EROSION

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ABSTRACT.- *The Motru Mining Basin – GIS Application on Sheet Erosion. The activation of the sheet erosion has important negative effects upon the soil profile. The anticipation of this geomorphologic process is important for taking some measures for protecting the susceptible areas. Within our study, we will carry out a quantitative estimation of the soil losses in the Motru Mining Basin, caused by the activation of the sheet erosion mechanism. We will apply the classic methodology proposed by the ROMSEM model of the USLE type by using the GIS technology*

1. Introduction

Soil erosion is a complex geomorphologic process, slightly visible, but with a great spatial spreading. The mechanism of the erosional process is active especially during the rains with torrential character. The negative effects induced by the activation of this geomorphologic process (the removal of the superior segment present in the soil profile) are immediately perceived and they manifest themselves through the rarefaction of the vegetal cover, the appearance of some spontaneous species of plants characteristic for the degraded soils, the generation of a specific erosion micromorphology (fine accumulations of eroded material, small sheets of mobilized soil, small rills and ditches that can culminate with the creation of a bad-land-type landscape etc.) etc.

The processes taking place within the erosion mechanism define its typology, thus, two types of erosion can be distinguished: sheet erosion (the mobilization of the particles from the surface) and gully erosion (erosion in depth). Depending on the type of erosion, there are indicators for estimating

the effects of the sheet erosion (the multi-annual specific soil loss per homogenous land unit, the weighted average soil loss, the thickness of the washed soil layer, the admissible erosion, the effluent erosion, etc.) and indicators for estimating the effects of the gully erosion (Dârja, 2000).

Within our study, we will carry out a quantitative estimation of the soil losses caused by the activation of the sheet erosion mechanism. Among the favouring factors, declivity (slope and the length of the slope), the meteorological and climatic conditions from the respective area, the physical characteristics of the substratum, the characteristics of the vegetal cover, the activity of the anthropic factor etc.

The geographical methodology of quantitative estimation of the risk related to the destruction of the edaphic cover through erosional processes is borrowed from the soil science domain. The calculation of the eroded soil is done by applying the empirical mathematical models based on computerized processing of the database (geodatabase). The practical utility of the computerized applications within the deterministic models for assessing the risk of sheet erosion activation is motivated by the rapidity of the operations, the precision of the results, and their spatial distribution.

In the last seven decades, several empirical mathematical relations, destined to approach the problematic of sheet erosion, have been elaborated. **Universal Soil Loss Equation (U.S.L.E.)**, as it was called in the USA, has the most frequently used contemporary calculus methodology. This mathematical equation appeared as an answer to the necessities from agriculture related to the assessment of the average soil losses due to cultivation. Afterwards, the utility of this model was extended over the erosion of the lands with other practical uses. We mention that in the areas where concentrated flows of the surface water take place, the greatest quantitative soil losses appear, these being always greater than the ones estimated through the U.S.L.E. The utility of this calculus model is argued by the fact that it reflects the actual increases in erosion and indicates, with a good precision, the areas with ravination potential.

2. History of soil loss equations.

Although it does not represent the main approach of this study, the contradictory information from the Romanian literature as regards the history of the U.S.L.E. made us pay a supplementary attention to this problem.

Since the fourth decade of the 20th century (the beginning of the 30's), several research programmes have been developed in the USA that

tackled the problem of soil erosion by using the experimental runoff plots. The first applications were developed in the Corn Belt region. Later on, between 1940 and 1960, the methodology regarding the estimation of the soil losses centred especially on the concept of “the slope-practice method”. Thus, in 1940, R.W. Zingg, established an operable mathematical relation, using the length and the slope steepness as the main calculus factors (Zingg, 1940). A year later, Dwight Smith improved this equation by adding factors such as the type of the agricultural crops (land use) and the antierosional methods carried out in the area. The American scientist, Dwight Smith, also introduced the notion of „*specific soil loss limit*”, having in view the development of a graphical methodology for determining the preservation stage of the edaphic cover (Smith, 1941, Smith, Whitt, 1947, Wischemeier, Smith, 1978). In 1947, G. H. Browning and contributors published a mathematical relation in which the soil losses were calculated depending on several physical factors that influence the erosion: the type of soil, the quantity of organic matter of the soil, the state of the vegetal cover, the manner of working the soil, the slope steepness and length. These factors were ordered in tables for simplifying the manner in which the equation is applied (Browning et. al. 1947, Wischemeier, Smith, 1978, Dârja., 2000.). A solution with graphic character, regarding the soil losses resulted from the activation of the sheet erosion, was published in 1952 and was used especially in the north eastern part of the USA (Lloyd, Eley, 1952, Wischemeier, Smith, 1978).

Beginning with 1954, the scientific co-operation of the American federal states within the pedological research projects developed in 49 locations (with experiments since 1930) determined the formation of a significant experimental database. These data proceeded from over 10.000 “plot-years” found under the impact of natural rainfalls, about 2.000 plot-years of data from rainfall simulators and more than 10,000 special cases of soil losses. Thus, all the conditions necessary for the centralization of the accumulated experience and implicitly of the statistical operations necessary for the improvement of the new calculus formulae for sheet erosion were available. The development of these research centres allowed the generalization process, which, in spite of the geographical and climatic restrictions, led to a generalization of the sheet erosion model that received the name of Universal Soil Loss Equation (U.S.L.E.). Wischemeier and Smith’s study, known under the name of Agriculture Handbook No.282 and published in 1965, certifies the name of U.S.L.E. In the USA, the U.S.L.E. model was implemented at the beginning of the 60’s by U.S.D.A. - Soil Conservation Service, an institution that nowadays is called Natural

Resources Conservation Service. The model has evolved in time and its applications have been improved. Thus, the study Agriculture Handbook No.537, published in 1978 by the same researchers, certifies the fact that the U.S.L.E. model represented the first methodological solution used at the end of the 70's and the beginning of the 80's in the USA.

The revision of the U.S.L.E. model was made on the basis of the previously-gained experience and a new model called R.U.S.L.E. (Revised Universal Soil Loss Equation) asserted itself. This model uses the same empirical principles as the U.S.L.E. model, but includes improvements such as the one regarding the integration of the influence of the slope concavity or convexity profile by using the segmentation of the irregular slopes. K.G. Renard's research, published in 1985, brought an important contribution in the creation of the R.U.S.L.E model. In 1995, R. Loch and K.G. Evans also introduced modifications in the U.S.L.E. model (Mitasova, Mitas, 1999). As a result of the studies made by the two researchers, the erodibility factor was corrected depending on the density of the sediments. R. Loch (1996) interfered again in the R.U.S.L.E. equation by modifying the vegetation factor and the applied agrotechnical method. The resulted model of calculus has a greater precision, being one of the models with concentrated parameters.

By using the revised model called R.U.S.L.E., the influence of each erosion factor is analysed. Its calibration was made by using the Anglo-Saxon measure units, thus, becoming unusable in Europe. The EUROSEM Model (European Soil Erosion Model) was elaborated in 1992 by the European researchers co-ordinated by R.P.C. Morgan (Cranfield University, United Kindom) and appeared as a response to the necessity of adapting the American models to the European conditions.

The recent RUSLE and USLE methodology requires the use of the GIS techniques (Mitasova, Mitas, 1999; Mitasova et al., 2001, Barton, Sarjoughian, 2005).

3. Romanian models of assessing the sheet erosion.

In Romania, the researches regarding the soil erosion started from the elements of the erosion universal equation. Being the best-known and often-used model of assessing the sheet erosion, U.S.L.E. was adapted to the conditions from Romania by a team of researchers working at the Institute of Pedology and Agrochemical Studies from Bucharest.

The first quantitative model of assessing the soil erosion on agricultural lands was proposed by Mircea Moțoc, in 1963. The model

assessed the effect of the erosion factors, excepting the pluvial aggressiveness, the calibration being made on the basis of the data regarding the erosion rate obtained with the help of the runoff plots from the Câmpia Turzii Research Station. A second variant of the model was published in 1973 and kept the structure of the Wischemeier-Smith model from 1965. In the formula of this equation, the pluvial aggressiveness factor was also introduced, the calibration being made on the basis of the data obtained from several pedological research stations. In 1979, Moțoc and contributors proposed an improved variant of the equation, a variant that was called ROMSEM Model (Romanian Soil Erosion Model). The values of the factors within the mathematical relation were established within the soil preservation laboratory of I.S.C.I.F., having a specific application in the pedo-climatic conditions from Romania. In 1982, Moțoc elaborated a study for zoning the total specific erosion on agricultural lands. Another model proposed by Moțoc was published as a manuscript in 1987, within the Institute of Pedology and Agrochemical Studies from Bucharest. This model assesses the effluent erosion in small basins characterized by sheet and gully erosion (numerical and graphical methods are used).

In 1999 and 2002, Mircea Moțoc proposed the continuation in using the 1979 form of the ROMSEM model (Moțoc, Sevastel, 2002).

4. The characteristics of the Motru Mining Basin

The Motru Mining Basin is situated in the northwestern part of the Getic Plateau, within the framework of the Motru Piedmont, being “housed” by the Jițului Hills (Fig. 1). The studied area is fragmented in an ensemble of long hilly ridges sculptured into monoclinial formations disposed on the northwest-southeast direction, whose altitude does not exceed 450 m. Lithology is specific to the Carpathian foreland. The petrographical formations were deposited in the geological interval Miocene – Holocene, in mainly lacustrine facies, under the form of some successions of clay, marl clay, sand clay, and sand, partially covered by Pleistocene gravel and loess-like deposits. The piedmont area was sectioned in the north-south direction by the Motru river, the primary morphology of the piedmont plateau being subsequently modified under the activity of the temporary rivers (Ploștina, Lupoiaia, etc.).

The analysis of the temperature values between 1961 and 2000 indicates a multi-annual mean temperature ranging between 9.2°C (at Polovragi meteorological station, in the northern part of the area) and 11.6°C (at Drobeta Turnu Severin meteorological station, in the

southwestern part). The influence of the sub-Mediterranean climate determines heavier precipitations than usually, the highest registered values appearing in the northern part, in the vicinity of the Sub-Carpathian sector. The multi-annual average precipitation between 1961 and 2000 ranges between 602.2 mm at the Bâcleșu meteorological station (in the eastern part) and 882.5 mm at the Apa Neagră meteorological station (in the north western part).



Fig.1. The geographical position of the Motru Mining Basin

The lignite deposits from the Pliocene sedimentary deposits (lower Dacian and Romanian) are present as a productive complex composed of 17 strata (I-XVII) exploited after 1960 by underground pit mining and then, in the 70's, by open-pit mining.

5. Methodology and research methods – Application: ROMSEM Model of U.S.L.E. type

The mathematical models of assessing the sheet erosion risk propose easy solutions for calculating the active factors in the erosional process. The produce of the factors that take part in the equation determines the estimation of the eroded soil quantity (mobilized) per hectare, throughout a year, in normal climatic conditions. The calculus structure of the sheet erosion was elaborated by applying the statistical methods of data processing obtained through direct measurements.

In the USA, the most commonly used calculus formula is the one suggested in the U.S.L.E. guide book, Agriculture Handbook No. 537 - „*Predicting rain fall erosion losses - a guide to conservation planning*” (Wischmeier, Smith, 1978). The formula appears as in the following: $A = R \cdot K \cdot L \cdot S \cdot C \cdot P$; where: **A**= the average soil loss quantity per land unit (tons/acre/year), **R**= the rainfall and runoff factor, **K**= the soil erodibility, **L**= the slope-length factor, **S**= the slope steepness factor, **C**= the cover and management factor, **P**= the support practice factor. This formula was brought up-to-date by Renard and contributors, being called R.U.S.L.E. (Renard et. al, 1991, Mitasova și Mitas, 1999).

In Romania, experimental data were accumulated with the help of the runoff plots taken into observation for periods that exceed 20 years of measurements (about 30 years at Perieni and Aldeni, 20 years at Bilcești, etc.). This database allowed the creation of a valid chronological series, giving the possibility for proposing an improved form of the sheet erosion prediction model, generically entitled ROMSEM (Romanian Soil Erosion Model). This model, adapted to the conditions of Romania, is based on the analysis of the action of the factors that determine the susceptibility to the erosion risk, being preferred to the R.U.S.L.E. or U.S.L.E. models. Therefore, the most indicated calculus structure for the Romanian territory is the one proposed by M. Moțoc and contributors in 1979, the formula being reconfirmed in 2002. The final form of this mathematical relation has the following structure:

$$E_s = K \cdot L^m \cdot i^n \cdot S \cdot C \cdot C_s$$

where: E_s - the quantity of sediments generated by the sheet erosion as multi-annual average (tons/ha/year), K - the rainfall-runoff erosivity factor, L^m - the slope length factor, i - the slope steepness factor, S - the soil erodibility factor, C - the cover-management factor, C_s - the supporting practices factor.

The calculus formula of the ROMSEM model can be also written in a simplified manner as in the following: $E_s = A \cdot Li$, in which $Li = L^m \cdot i^n$; where: A = the coefficient which comprises the influence of the other factors excepting the relief, Li = the relief factor. Following the researches, and as a result of the fact that it has a greater applicability, M. Dârja (2000) proposes the following formula: $E = A \cdot L^{0.3} \cdot i^{1.5}$.

The assessment of the sheet erosion is classically applied to homogenous land surfaces. Thus, some land units of constant value are required for the slope of the terrain, the length of the runoff slope, the same slope exposition, the form of the homogenous surfaces having to be as regular as possible, etc. The potential of the sheet erosion for the entire perimeter is established by using the weighted average of the sheet erosion size, determined for each homogenous land unit.

Having an important spatial component, the quantitative estimation of the soil losses requires the application of software with spatial attributes, a series of computerized models being, thus, elaborated. When using the GIS techniques, the main principle consists in superposing the strata with information of the same type, all the procedures previously enumerated being performed instantaneously through the application within this software of the traditionally-used calculus formulae. The use of the GIS methodology in the calculation of the U.S.L.E. - R.U.S.L.E or ROMSEM equations, requires a complex and complete database, which has to contain Digital Elevation Models, having a 10-metre resolution at the most; complex data regarding the soil characteristics (territorial repartition, soil type and its physical properties: texture, structure, erodibility, etc.); concrete information regarding the type of the land use (the vegetation covering, the characteristics of the vegetal ecosystems, their spatial repartition, using a resolution as good as possible); the correct repartition of the precipitations indices (indices regarding the climatic aggressiveness and their spatial repartition); complete data regarding the soil protection arrangements; information regarding the types of the anthropic arrangements of the studied areas, etc. The result depends very much on the quality of the introduced data. The use of the GIS techniques is motivated by the working speed, the

facility of its use and the spatial repartition of the result.

In the following, each of the factors of the ROMSEM model ($E_s = K \cdot L^m \cdot i^n \cdot S \cdot C \cdot C_s$) will be presented individually, taking as example the corresponding area of the Motru Mining Basin. The data sources for the calibration of this model were the determinations with the help of the runoff plots from the following research stations: Perieni – Vaslui county, with data collected for 30 years, Aldeni – Buzău county, Bilcești – Argeș county, Câmpia Turzii – Cluj county and Valea Călugărească – Prahova county); the pedological and erosion studies made by I.C.P.A. Bucharest; U.S.L.E. and R.U.S.L.E. models created in the USA, as well as the pluviograms made by the National Institute of Meteorology and Hydrology (I.N.M.H.), regarding torrential rainfalls.

5. 1. The rainfall - runoff erosivity factor - K

The rainfall-runoff erosivity factor represents the soil loss in rapport with the pluvial aggressiveness (the erosion capacity exerted by the occurrence of torrential rainfalls or snowmelt). Erosivity is defined as the rapport between the quantity of eroded soil in a standard plot and the pluvial aggressiveness.

The rainfall-runoff erosivity factor K represents the Romanian adaptation of the R factor proposed by Wischmeier and Smith in 1978. According to Nearing (1999), the relation between R factor and sheet erosion is expressed by a logistic function of the $R = E \cdot I_{30}$ type; E represents the intensity of precipitations and is expressed in mm/hour (is established by deciphering the pluviographs), while I_{30} represents the intensity of the torrential nucleus developed for 30 minutes. In the USA, the R coefficient is also calculated as the average of the annual erosivity, a value divide by 100: $R = E \cdot I_{30} / 100$. By definition, the value of EI for a given rainfall is equal to the result of the equation: total storm energy (E) for an intensity of maximum 30 minutes (I_{30}) (Moțoc, Sevastel, 2002).

In Romania, the researches performed with the help of the runoff plots have established the quantity of 20 mm, according to M. Moțoc (1956), as the critical rainfall value at the national level, or smaller quantities, according to other authors, but not less than 10 mm (the quantities differ because they depend on the intensity of the respective rainfall and the soil humidity conditions, taking into consideration the role of the rainfall intensity). The researches carried out by P. Stănescu, and published in 1969, brought their contribution to the establishing of the

rainfall-runoff erosivity factor as being the produce between the quantity of rainfall and the intensity of the 15-minute-torrential nucleus: $K=H I_{15}$, where: H represents the quantity of precipitation during the entire rainfall, and I_{15} represents the 15-minute-torrential nucleus. The duration of 15 minutes represents the time for the concentration of water within the runoff plots in order to form the rills. In the case of the runoff plots, the erosion starts if the produce $H I_{15}$ exceeds the value of 10 for the entire territory of Romania (Moțoc, Sevastel, 2002).

The rainfall-runoff erosivity factor has different specific values on the territory of Romania, the regionalization of this coefficient being the result of the physical-geographical disparities. Thus, several zones of climatic aggressiveness have been individualized, the values of this correction coefficient having been taken from the hydrological regionalization used by the National Institute of Meteorology and Hydrology. The exact establishment (regionalization) of the rainfall-runoff erosivity value is done in conformity with the map elaborated by P. Stănescu and contributors and published in 1969. For the Motru Piedmont, the climatic aggressiveness index is the one specific to zone 3, presented in the above-mentioned map: $K_{MOTRU} = 0.140$.

5. 2. The slope length factor - L^m

Microrelief is one of the favouring factors, both for the activation and the maintenance of the erosional process. The morphological components with an important participation in the erosional process are the declivity of the terrain (slope steepness), the length of the inclined surfaces (slope length) and the slope form. The relation between erosion, slope steepness and slope length was established for the slopes with straight, uniform profile, erosion actually increasing in proportion to the convexity degree and decreasing in rapport with the concavity degree. The spatial variability of the relief factor is very great in comparison with the climatic aggressiveness or the pedo-lithological erodibility. In a traditional manner, the value of the slope length factor is calculated on homogenous land units (on the topographical map) and is expressed in meters. The slope length factor is a topographical coefficient (the presence of the relief in the equation), being a function of the slope and of the terrain length; the increase of the slope length determines the amplification of the total precipitations drained on the respective surface.

For the original U.S.L.E. model, the initial equation for calculating

the **LS** (the slope length factor) is an empirical one, being taken over from the USDA Agriculture Handbook No. 537 (Wischmeier, 1978). In Romania, the influence of the slope steepness and the slope length upon the sheet erosion was established with the help of the runoff plots, which had lengths ranging between 20 and 40 m and values of the slope steepness ranging between 6 and 32%. Other methods were also used: the reference point method for slope lengths of about 200 m (Stănescu, 1960) and soil profile method, reconstituted for the arable lands (Luca, 1971). The critical slope length, for which sheet erosion is significant in the conditions from Romania, is 10 m, while the slope steepness is 3% (the rain wash process changes into rill wash, erosion becoming sheet erosion) (Moțoc, Sevastel, 2002). The effect of slope length is estimated with the aid of a function of the L^m type, in which $m=0.3$ or $m=0.4$. The m exponent, present in the formula, is estimated to have the value of 0.4 for slope lengths of more than 100 m, while the value of 0.3 is attributed to a slope length less than 100 m. The variability of the slope length factor is presented in a table on page 45 in Moțoc and Sevastel's study (Moțoc, Sevastel, 2002).

When using GIS, the slope length factor is calculated with the aid of the Digital Elevation Model, with a 10-metre resolution, by applying the above-mentioned values for the m exponent. The corresponding value is introduced in the calculus formula proposed by Desmet and Govers, for calculating the L factor (Desmet, Govers, 1996): $\{[(\text{flow accumulation}) \cdot \text{resolution}] / (22.1)^{0.3}\}$; where $(22.1)^{0.3}$ represents a GIS calculus parameter. For the area corresponding to the Motru Mining Basin, the spatial distribution of the slope length factor is presented in Figure 2.

5. 3. The slope steepness factor - i^n

The slope steepness substantially contributes to the transport of the sediments. The steeper the slope, the higher the speed of the pluvial water runoff, resulting thus, a higher erosion. The slope steepness factor is traditionally calculated on homogenous land units, its value being expressed in percents. In the Romanian literature of specialty, the slope steepness factor is calculated in conformity with the formula: $i^n = 1,36 + 0,97i + 0,138i^2$; where: i is the tangent of α (alpha), expressed in% (Moțoc, Sevastel, 2002).

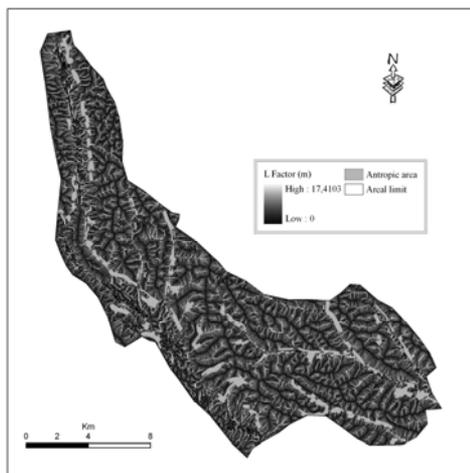


Fig.2. The map of the slope length factor (L^m) spatial distribution



Fig.3. The map of the slope steepness factor (i^n) spatial distribution

This equation is subsequently introduced in GIS, the result being represented in Figure 3.

5. 4. The soil erodibility factor - S

The layer of the topsoil generally consists of slightly cohesive materials (soils and surface deposits), a fact which determines a high susceptibility to erosion. The soil erodibility factor represents the resistance of the soil layer or of the rock to the impact of the raindrops or of the microcurrents generated during the meteoric water runoff. For the quantitative estimation of the soil erodibility factor, the intrinsic properties of the soil were taken into consideration (texture, humus contents, permeability, and hydric stability of the structure).

The researches made by Eppink L.J. (1985); Nearing M. A. (1988); Moțoc M. (2000), etc. demonstrate that erodibility has a seasonal variability, depending on the climatic conditions, soil works, vegetation structure, etc.

Unlike the U.S.L.E. model, in the Romanian model, ROMSEM, erodability is a non-dimensional parameter, established on the basis of the determinations carried out on the runoff plots. Sandy loam soils were used, characterized by a very strong erosion, whose maximum value was considered 1 (at Perieni station) and loamy clay soils, slightly erodible, rich in humus, with a stable structure and a maximum erodibility of 0.6 (at Câmpia Turzii station). The interpolation between these values for other soils was made on the basis of the determinations carried out with the aid of

the sprinkler infiltrometer (Luca, 1971). As soils with a greater erodibility than the sandy loam ones were also identified, the maximum value of the pedo-lithological erodability index was identified as being 1.2. Usually, the method for estimating the soil erodibility factor is based on the **Indicator 186**, used in the study entitled “*The Methodology of Elaborating Pedological Studies*” published by I.C.P.A. Bucharest in 1987. Indicator 186 establishes the classes of erodibility by taking into consideration the genetic type of the land cover, its degree of erosion, and its texture. This coefficient is found in the Romanian literature in the form of some tables and appears in the studies of the following authors: Moțoc et.al (1975) (Table no.2.5), Dârja et al. (2002) (Table no. 13.), Moțoc, Sevastel M. (2002) (Table no.3), etc. As far as the problem of soil erodibility is concerned, and implicitly that of the manner of calculating the S factor, M. Moțoc and V. Morărescu, in their study published in 2000, tackled the main deficiencies of this methodology of estimation.

The value of the soil erodibility factor is determined by introducing the value parameters into GIS. This operation implies the transformation of the soil distribution from analogous format into digital format (Fig. 4.), a process followed by the attribution of the coefficients estimated by I.C.P.A.. The result consists in the spatial representation of the soil erodibility factor, depending on the edaphic typology of the Motru Mining Basin (Fig. 5.).

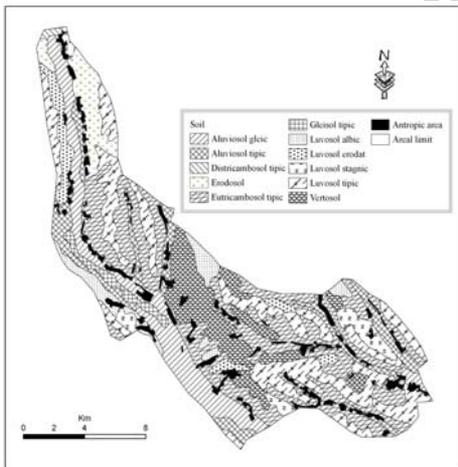


Fig. 4. The soil map of the Motru Mining Basin. (Source: Târgu Jiu Sheet 1979 and Orșova Sheet 1988)



Fig. 5. The map of the soil erodibility factor (S) spatial distribution

5. 5. The cover-management factor - C

Vegetal cover represents the main erosion control factor. Thus, the crown influences erosion by intercepting the raindrops before their contact with the land surface, and thus, by dissipating their kinetic energy; trunks contribute to the increase of land rugosity, by reducing the runoff speed and by stopping the formation of the concentrated currents; and the roots fix the soil, favour the accumulation of the organic substances and enhance the hydric stability of the soil structure. The replacement of the natural ecosystems with agroecosystems determines the modification of the soil protection capacity accomplished by the plants. The natural ecosystems (forests and grasslands) have a small spatial variability; they differentiate zonally, depending on the climate, or regionally, depending on the edaphic conditions. The temporal variability of the cultivated plants depends on the vegetation phases and the applied agricultural techniques.

The cover-management factor expresses the influence of the vegetation over the erosional process. The indicators that assess the soil protection capacity offered by the plants are the dimension of the plants, their height, the volume of the vegetal mass, etc. The concordance between the aggressiveness of the precipitations and the protection degree offered by the plants has also a great importance. In Romania, the critical season of erosion is between May 1st and August 31st (Moțoc, Sevastel 2002).

The delimitation of the plots on categories of land use, and implicitly the identification of the different vegetal associations within the Motru Mining Basin, were carried out in conformity with the Corine – Land Cover 2000 and Corine – Land Cover 1992 database, with several corrections made in conformity with the 2003-2005 orthophotoplans and with the Landsat ETM satellite images dating from 2001 (Fig.6).

In Romania, the assessment of the indices regarding the value of the protection capacity offered by the vegetal cover was accomplished with the aid of the runoff plots by dividing the quantity of the eroded soil on the land covered with different vegetal species or associations by the quantity of eroded soil on the land uncovered with vegetation or covered with slightly protective cultures. Therefore, the cover-management factors are coefficients recommended in conformity with the cartogram of the use and of the stipulations regarding the crop structure: Dârja. et al., 2002 (Table no. 14), Moțoc, Sevastel, 2002 (Table no.6), etc.



Fig. 6. The map of the vegetation spatial distribution in the Motru Mining Basin. (Source: CORINE - Land Cover -1992 and 2000; orthophotoplans; Landsat ETM satellite images 2001)



Fig. 7. The map of the cover-management factor spatial distribution

The spatial representation of the cover-management factor was made after introducing into GIS the values present in the cartogram of the use and of the stipulations regarding the productive land structure (Fig.7).

As can be seen from the map, the lowest values appear in the urbanized and forested zones, while the agricultural lands, the degraded lands, or the perimeters with mining exploitations record the highest values.

5. 6. The supporting practices factor - C_s

The result of the field research carried out in Romania with regard to the antierosional efficiency and the frequently used methods for soil preservation underlies the determination of the supporting practices factor. For the zones in which there is soil erosion land management or for those in which land reclamation is to be projected (vegetation land management and hydrological land management), the antierosional influence has been determined (Dârja et al. 2002, Table no.15). In case the protection works of the layer of topsoil lack, such as in the Motru Mining Basin, C_s factor has the recommended value of 1.

6. Results and discussions

In order to assess the opportunity of carrying out some works for preserving the soil, the guiding values of the erosion from the studied area

must be known. Our study has in view both the quantitative estimation of the soil loss and the spatial distribution of the pluviometrically- induced sheet erosion.

The calculation of the estimative quantities of the soil losses determined by sheet erosion implies the insertion of the value of the previously mentioned factors in the relation proposed by the ROMSEM model. The final result of the GIS application consists in the creation of a thematic map that represents the territorial repartition of the quantity of dislocated material due to the sheet erosion, as a weighted average for each homogenous land unit from the Motru Mining Basin (Fig. 8).

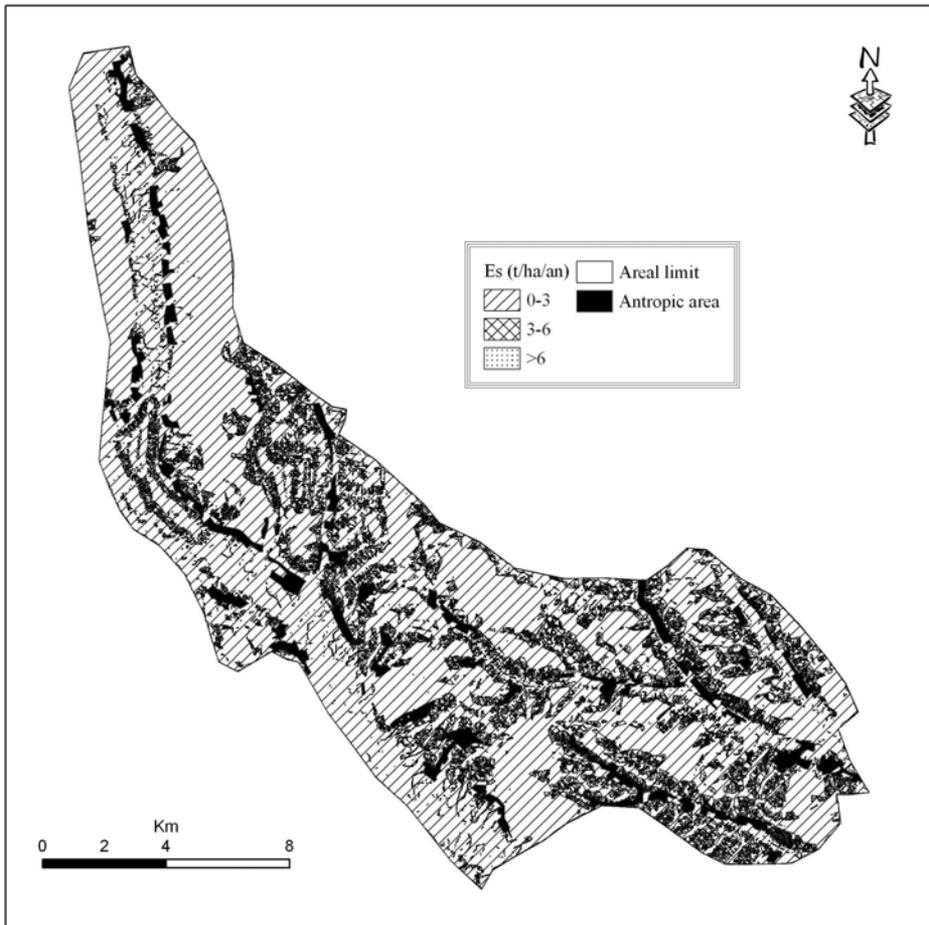


Fig. 8. The map of the average soil loss (Es) from the Motru Mining Basin.

The general accepted limit value of the tolerable sheet erosion is 3 tones per hectare, as an average established for a calendar year. The estimative quantities of the annual average critical erosion expressed in tones/ha/year can be found in the table created by Moțoc M. et al (1973).

Within the Motru Mining Basin, we individualized three classes of values for the sheet erosion: 0-3 t/ha/year, 3.1-6 t/ha/year and more than 6 t/ha/year. The analysis of the sheet erosion thematic map indicates that more than 70% of the studied area presents tolerable values of erosion ($E_s < 3$ t/ha/year), the respective zones being characterized by a low degree of anthropization, a good vegetation coverage (especially trees and shrubs), and slopes that rarely exceed 30% (Iormănești Hill, Băzăvani Hill, the natural meadow of the Motru river, Slivilești Hill, etc.).

The areas with high sheet erosion values are represented by open pit mines or micro-open pit mines (Lupoia, Roșiuta, Steic, Știucani, etc.), characterized by a slope steepness which can get up to 90%, by the lack of the protective vegetal cover and by a friable lithology; mine damp, with a high degree of looseness, lack of a firm vegetation cover and the presence of some steep slopes and protosoils susceptible to erosion; high values also appear in the immediate proximity of localities, where the arable land predominates and the agricultural techniques are not adapted to the morphological and soil conditions.

7. Conclusions

The field researches carried out in the area corresponding to the Motru Mining Basin have confirmed the sectors with high values of soil erosion. The experimental data of ICPA Gorj generally confirm the values obtained through the application of the ROMSEM model. Thus, it can be confirmed that this sheet erosion calculus model has a special geographical importance. Due to its support, quantitative estimations, spatial representations, as well as a generalized outline of the ravination-prone areas, can be made. Other advantages of the method consist in the relatively easy-to-use methodology, its predictive character- as far as the areas with a high susceptibility to erosion are concerned, offering the possibility of intervention by using the antierosional measures. The model can be applied on any kind of natural or anthropized areas.

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