Turkish Journal of Agricultural and Natural Sciences
Special Issue: 1, 2014

TÜRK
TARIM ve DOĞA BİLİMLERİ
DERGİSİ

TURKISH
JOURNAL of AGRICULTURAL
and NATURAL SCIENCES

www.turkjans.com

Application Of The Intero Model For The Assesment Of The Soil Erosion Intensity And Runoff Of The River Basin Dragovo Vrelo, Montenegro

[a]Velibor SPALEVIC*, [a]Milic CUROVIC, [b]Vjekoslav TANASKOVİC,
[c]Nevenka DJUROVİC, [d]Tom LENAERTS and [d]Jan NYSSEN

[a]Institute of Forestry & Biotechnical faculty, University of Montenegro, Podgorica, Montenegro
[b]Faculty of Agricultural Sciences and Food, University St. Cyril and Methodius, Skopje, Macedonia
[c] Faculty of Agriculture, University of Belgrade, Belgrade, Serbia
[d] Department of Geography, Gent University, Gent, Belgium
*Corresponding author: velibor.spalevic@ac.me

Abstract

This paper presents the use of IntErO model for prediction of runoff and soil loss in the river basin Dragovo Vrelo of Polimlje, Montenegro. Physical-geographical inputs, which are the basis for calculation of soil erosion intensity, we included in the IntErO model. This allowed the quantification of the environmental effects of soil erosion. Data concerning runoff and sediment yield from the Dragovo Vrelo watershed located in the North-East of Montenegro are reported. The value of the Z coefficient was calculated on 0.393, what categorises the studied river basin in the fourth destruction category out of five. Our results suggest that the calculated maximal outflow from the river basin was 174 m^3s^{-1} for the incidence of 100 years and the net soil loss was 3857 m^3 per year, specific 335 m^3km^{-2} per year. The strength of the erosion process is low. Because of simple and reliable identification of critical areas of soil erosion the IntErO model may be applied for sediment modelling in other river basins of the Balkan Peninsula.

Keywords: IntErO model, soil erosion, sediment yield, runoff, Montenegro

Introduction

A large number of environmental problems involve the destruction of the natural balance as a result of the misuse or abuse of nature. Since soil is one of the basic elements of nature, soil problems are important environmental problems (Dengiz and Akgül, 2005). Soil degradation caused by erosion, together with rapid population increase, are ranked as the most important environmental problems in the world (Pimentel, 2006; Pradhan et al., 2011; Nikkami, 2012, Stoffel and Huggel, 2012) and primary drivers of land degradation (Verheijen et al. 2009); the biggest threat to the conservation of soil and water resources (Bayramin et al, 2003).

This natural process is occurring over geological time. The most concerns about erosion are related to accelerated erosion, where the natural rate has been significantly increased by human activity. As such soil erosion poses severe limitations to sustainable agricultural land use, as it reduces on-farm soil productivity and causes the accumulation of sediments and agrochemicals in waterways (Kirkby et al. 2004).

In Europe, soil erosion is caused mainly by water. Soil losses due to water erosion are high in southern Europe (Van Lynden, 1995). According to Poesen et al. (2003) in this part of Europe, erosion has led to the formation of extensive degraded areas called badlands, in which high rates of soil loss is observed. According to the expert-based GLASOD map (Oldeman et al. 1991), the area of human-induced soil erosion by water in Europe, excluding Russia, is roughly estimated to be 114 million hectares (17% of total land area), of which 80% is topsoil loss and 20% terrain deformation (Gobin et al. 2004).

According to Kostadinov et al. (2006), water erosion has affected 13,135 km^2 or 95% of the total territory of Montenegro (13,812 km^2).

Many authors have studied the erosion processes using different methods for calculation of the soil erosion intensity and runoff. The aims of this study are 1) to quantify the climate, relief, geological, pedological and land use parameters needed for calculation of the soil erosion intensity and runoff by the IntErO model (Spalevic, 2011); 2) analysis of the IntErO model performance; and 3) testing applicability of this program package for soil loss modelling in the Region.

The important results of this study are the first particular information on soil erosion of the Dragovo Vrelo watershed, contributing to the overall knowledge on soil erosion process of the Polimlje Region and Montenegro, all in formats that may further facilitate its efficient management and protection.

Materials and Methods

Study area. The study was conducted in the area of the river basin of Dragovo Vrelo, a right-hand tributary of the river Lim, which lies on the slopes of the mountain Prijedolska Glava (2003m) on the North, going downstream to the South at the area of the village Gornja Rzanica. The river basin of Dragovo Vrelo encompasses an area of 11.5 km^2. The studied river basin is categorized in the group of the smallest watersheds of the natural entity of the Polimlje region (Spalevic, 2011). The natural length of the main watercourse, Lv, is 3.8 km. The shortest distance between the fountainhead and the mouth, Lm, is 3.2 km. The total length of the main watercourse, with tributaries of I and II class, ΣL, is 3.8 km.

Fieldwork & laboratory analysis. Fieldwork was undertaken to collect detailed information on the intensity and the forms of soil erosion, the status of plant cover, the type of land use, and the measures in place to reduce or alleviate the erosion processes. Morphometric methods were used to determine the slope, the specific lengths, the exposition and form of the slopes, the depth of the erosion base and the density of erosion rills.

Some pedological profiles had been opened, and soil samples were taken for physical and chemical analysis. The granulometric composition of the soil was determined by the pipette method (Gee and Bauder, 1986; Karkanis et al. 1991); the soil samples were air-dried at 105 °C and dispersed using sodium pyrophosphate. The soil reaction (pH in H_2O and nKCl) was determined with a potentiometer. Total carbonates were determined by the volumetric Scheibler method (Thun and Herrmann, 1949); the content of the total organic matter was determined by the Kotzman method (Jakovljevic et al. 1995); easily accessible phosphorous and potassium were determined by the Al-method (Egner et al. 1960), and the adsorptive complex (y1, S, T, V) was determined by the Kappen method (Kappen, 1929).

Soil loss model application. We used the Intensity of Erosion and Outflow (IntErO) program package (Spalevic, 2011) to obtain data on forecasts of maximum runoff from the basin and soil erosion intensity, with the Erosion potential method – EPM (Gavrilovic, 1972) embedded in the algorithm of this computer-graphic method.

The analytical equation for the calculation of the annual volume of detached soil due to surface erosion is as follows:

$$W_{year} = T \cdot H_{year} \cdot \pi \cdot \sqrt{Z^3} \cdot F$$

where W_{year} is the total annual erosion in m^3year^{-1}; T is the temperature coefficient; H_{year} is the average yearly precipitation in mm; Z is the erosion coefficient.

The erosion coefficient, Z, was calculated as follows

$$Z = Y \cdot X \cdot (\phi + \sqrt{I})$$

where, Y is Soil erodibility coefficient; X is Soil protection coefficient; ϕ is Erosion development coefficient (tables for Y, X and ϕ coficients available at Gavrilovic, 1972). F is the watershed area in km^2.

The actual sediment yield was calculated as follows:

$$G_{year} = W_{year} \cdot R_u$$

where, G_{year} is the sediment yield in m^3year^{-1}; W_{year} is the total annual erosion in m^3year^{-1}; R_u is sediment delivery ratio.

The actual sediment yield was calculated as follows:

$$R_u = \frac{\left(\sqrt{O \cdot D}\right)}{0.2 \cdot (L+10)}$$

where, O is perimeter of the watershed in km; D is the average difference of elevation of the watershed in km; L is length of the catchment in km.

This methodology is in use (by alphabetical order) in: Bosnia & Herzegovina, Bulgaria, Croatia, Czech Republic, Italy, Iran, Montenegro, Macedonia, Serbia and Slovenia (Spalevic et al, 2014b; Kostadinov et al., 2014). In Montenegro have been successfully used in the Region of Polimlje (Spalevic et al. 2014a, 2014b, 2014c, 2013a, 2013b, 2013c, 2013d, 2013e, 2013f, 2012a, 2012b, 2003).

It is distinguished by its high degree of reliability in calculating sediment yields as well as transport and reservoir sedimentation (Ristic et al., 2011).

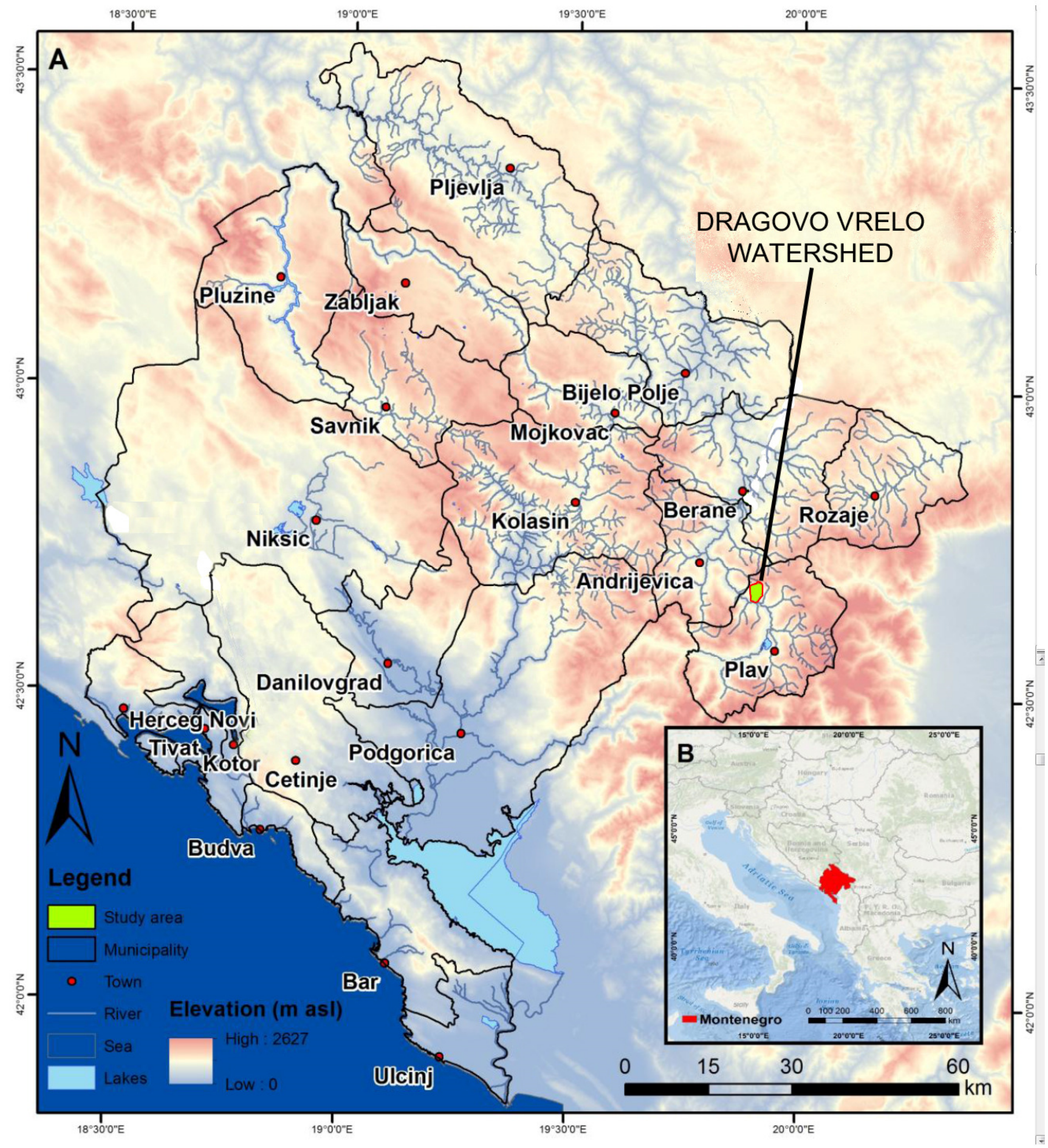

Figure 1. A. Montenegro and the Study area; B. Situation of Montenegro in Balkan Peninsula

Results and Discussion

Physical-geographical characteristics and erosion factors. Many authors have studied the physical-geographical characteristics of this area. Cvijic (1921) called attention to the geographical individuality of the Region, with special emphasis on the Prokletije mountain group, where the river basin of Dragovo Vrelo is located. Knezevic and Kicovic (2004) described the natural characteristics; Pavicevic (1956) and Spalevic (2011) characterized erosion processes of the upper part of the Polimlje Region.

The river basin of Dragovo Vrelo stretches from its inflow to Lim (H_{min}, is 849m) to the tops of the Prijedolska Glava, where the H_{max} is 2003m. There is a flat area on the lower alluvial terraces, close to the inflow of Dragovo Vrelo to the river Lim, in the village of Gornja Rzenica, and steep slopes in the upper part of the river basin on the slopes of the Prijedolska Glava. The average slope gradient in the river basin, Isr, is 39% and indicates that in the river basin prevail very steep slopes. The average river basin altitude, Hsr, is 1341 m; the average elevation difference of the river basin, D, is 492 m.

Climatic characteristics. The studied area is characterised by dry summers; rainy autumns and springs; and cold winters. The absolute maximum air temperature is 35°C. Winters are severe, so much so that negative temperatures can fall to a minimum of -29.8°C (Source: Institute of Hydrometeorology of Montenegro). In terms of rainfall, there are two characteristically rainy periods of the year: the first-cold period (October-March) and the second-warm period (April-September). For the specific methodology of calculation of soil erosion intensity and runoff it is important to highlight that the amount of torrential rain, hb, is 89.4 mm. The average annual air temperature, t0, is 8 °C. The average annual precipitation, Hyear, is 1182.3 mm.

The geological structure and Soil characteristics of the area. In the structural-tectonic sense, the studied area belongs to the Durmitor geotectonic unit of the inner Dinarides of Northern and North-eastern Montenegro (Zivaljevic, 1989).

The geological structure of that part of Montenegro consists mainly of Paleozoic clastic, carbonate and silicate volcanic rocks and sediments of the Triassic, Jurassic, Cretaceous-Paleogene and Neogene sediments and Quaternary.

According to our analysis, the structure of the river basin, according to bedrock permeability, is: f0, poor water permeability rocks, 76%; fpp, medium permeable rocks, 11%; fp, very permeable products from rocks: 13%. The coefficient of the region's permeability, S1, is calculated on 0.89.

The most common soil type in the studied area are Dystric cambisol (80%); Calcomelanosol (17%); and Fluvisol (3%) on the lower alluvial terraces close to the inflow of Dragovo vrelo to Lim (Fustic, Djuretic, 2000; Spalevic, 2011). In some smaller areas in the river basin there are also soils such as rankers, resting on bedrock within 30 cm depth; and rendzina, shallow soils with solid or fragmented calcareous rock at depth, in certain topographic positions with brightly coloured subsoil or mixed AB horizon, distinctive vegetation cover.

Vegetation and land use. The studied area is located in Dinarid Province of the Middle-Southern-East European mountainous bio-geographical region.

The dominant types of vegetation are meadows and orchards covering 51% of the studied area. Ploughed lands are participating with 4%. The forests accounting for 45% of the total land cover. The coefficient of the vegetation cover, S2, is calculated on 0.72. The land use structure of the studied river basin is presented in Figure 2.

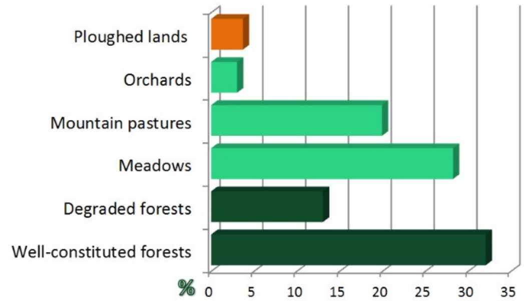

Figure 2. Land use structure of the Dragovo Vrelo watershed, % (Source: original)

Plant communities of the subject area belong to the following vegetation classes: Erico-pinetea Horvat 59., Vaccinio-picetea Br.-Bl. 39., Betulo-adenostiletea Br.-Bl. 48., Epilobietea angustifolii Tx. Et Prsc. 50., Salicetalia purpureae Moor 58., Alnetea glutinosae Br.-Bl. et Tx. 43., Arhenanteretea Br.-Bl. 47., Festuco brometea Br.-Bl. et Tx. 43. Plantaginetea majoris Tx. et Prsg. 50., Salicetea herbacea Br.-Bl. 47., Montio-cardaminetea Br.-Bl. et Tx. 43.

On the vertical profile, the subject basin includes the following forest communities:

1. Fagetum montanum. Differentiated into several associations of which the most characteristic is Luzulo – Fagion moesiacae.
2. Abieti - Fagetum moesiacae, Blec and Lak.
3. Picetum excelsae montanum.
4. Fagetum subalpinum, above 1500 m including all exposures and various geological substrates.
5. Picetum excelsae subalpinum, above 1600m.

Most of the river basin is covered with conifer forests with or without beach (*Abieti - Fagetum moesiacae*, Blec and Lak. and *Picetum excelsae montanum*). Lower part of studied area are covered by low beech forests (*Fagetum montanum*) with a narrow belt near the river which is covered with hygrophilic forest (*Alnetea glutinosae, Salicetea herbacea*). The upper part of the basin includes mixed forests of broadleaves and deciduous tree species (*Abieti - Fagetum moesiacae*) and conifer forests of fir and spruce (*Picetum excelsae montanum*). At the highest altitudes of the basin there are subalpine forests of beech (Curovic et al. 2011), as well as those of subalpine forests of spruce with junipers.

Soil erosion and runoff characteristics. The dominant erosion form in this area is sheet erosion, but more severe forms of erosion, such as rills, gullies and ravines, occur also. The erosion causes some places to lose fertile land, and results in coarse alluvial deposits on the fertile soils in the alluvial plain downstream, close to the main watercourse. Surface erosion has taken place in all the soils on the slopes, with the effect that this erosion is most pronounced on the steep slopes with scarce vegetation cover.

We used the software IntErO for calculation of the soil erosion intensity and the maximum outflow.

Coefficient of the river basin form, A, is calculated on 0.74. Coefficient of the watershed development, m, is 0.31 and average river basin width, B, is 2,06 km. (A)symmetry of the river basin, a, is calculated on 0.11 and indicates that there is a possibility for large flood waves to appear in the river basin (Source: original).

Drainage density, G, is calculated as 0.32 km km^{-2} which corresponds to low density of the hydrographic network. The height of the local erosion base of the river basin, Hleb, is 1154 m. Coefficient of the erosion energy of the river basin's relief, Er, is 199.49 (Source: original).

Coefficient of the river basin erosion, Z, is 0.393 what categorises the studied river basin in the fourth destruction category out of five. The strength of the erosion process is low, particularly sheet erosion occurs, although forests are covering 45% of the studied area.

For the current state of land use, calculated peak flow is 174 m^3s^{-1} for a return period of 100 years.

The production of sediment in the basin, W_{year}, is calculated as 10039 m^3 $year^{-1}$; and Coefficient of the intra-basin deposition, Ru, at 0.384.

Sediment yield at catchment outlet (G_{year}) was calculated as 3857 m^3year^{-1}; and specific sediment yield at 335 $m^3km^{-2}year^{-1}$.

Suitability of the IntErO model for modelling.

Sediment yields were calculated with the IntErO model on for the 57 basins of Polimlje in Montenegro including soil losses of 335 $m^3km^{-2}year^{-1}$ for the subject river basin (Spalevic, 2011). According to Babic Mladenovic et al. (2003), real soil losses are 350 $m^3km^{-2}year^{-1}$ for the Lim river basin (Polimlje).

The calculations the IntErO model for the Polimlje region (347,273 m^3year^{-1}) obtained by

Table 1. IntErO report

Spalevic (2011) corresponded to the results Begic and Vranic (2013) for the Potpec accumulation (360,000 m^3year^{-1}), which comprises the study area. This correspondence suggests that the assessment results of actual losses of soil erosion potential obtained by IntErO model are eligible for the study area.

Conclusion

According to our findings, it can be concluded that there is a possibility for large flood waves to appear in the studied river basin of Dragovo Vrelo.

Coefficient of the river basin erosion, Z, is 0.393 what categorises the studied river basin in the fourth destruction category out of five. The strength of the erosion process is low, particularly sheet erosion occurs, although forests are covering 45% of the studied area.

For the current state of land use, calculated peak flow is 174 m^3s^{-1} for the incidence of 100 years. The production of sediment in the basin, W_{year}, is calculated as 10039 m^3 $year^{-1}$; and Coefficient of the intra-basin deposition, Ru, at 0.384. Sediment yield at catchment outlet (G_{year}) was calculated as 3857 m^3year^{-1}; and specific sediment yield at 335 $m^3km^{-2}year^{-1}$.

The soil loss rates in the catchment (335 $m^3km^{-2}year^{-1}$) and in the wider Polimlje region (350 $m^3km^{-2}year^{-1}$) are very low in comparison to adjacent watersheds of the Coastal zone of Montenegro: 1900 $m^3km^{-2}year^{-1}$ in some watersheds (Spalevic, 2012a; Spalevic, 2014b).

This shows that vegetation cover and land management in northern Montenegro are effective in protecting the land from erosion as was also observed by Nyssen et al. (2014).

This study further confirmed the findings of Kostadinov (2014), Tazioli (2009), as well as Spalevic (2011), what leads to the conclusion that the Gavrilovic method as well as the IntErO model is a useful tool for researchers in calculation of runoff and sediment yield at the level of the river basins of Balkan Penisula, similar to the Polimlje basin of Montenegro.

Input data		
River basin area	F	11.5 km^2
The watershed perimeter	O	14.13 km
Natural length of the main watercourse	Lv	3.73 km
The shortest distance between the fountainhead and mouth	Lm	3.2 km
The total length of the main watercourse with tributaries of I and II class	ΣL	3.73 km
River basin length measured by a series of parallel lines	Lb	5.58 km
The area of the bigger river basin part	Fv	6.06 km^2
The area of the smaller river basin part	Fm	5.44 km^2
Altitude of the first contour line	h0	900 m
The lowest river basin elevation	Hmin	849 m
The highest river basin elevation	Hmax	2003 m
A part of the river basin consisted of a very permeable products from rocks	fp	0.13
A part of the river basin area consisted of medium permeable rocks	fpp	0.11
A part of the river basin consisted of poor water permeability rocks	fo	0.76
A part of the river basin under forests	fš	0.45
A part of the river basin under grass, meadows, pastures and orchards	ft	0.51
A part under bare land, plough-land and without grass vegetation	fg	0.04
The volume of the torrent rain	hb	89.4 mm
Incidence	Up	100 years
Average annual air temperature	t0	8 °C
Average annual precipitation	Hgod	1182.3 mm
Types of soil products and related types	Y	1.1
River basin planning, coefficient of the river basin planning	Xa	0.34
Numeral equivalents of visible and clearly exposed erosion process	ϕ	0.38
Results:		
Coefficient of the river basin form	A	0.74
Coefficient of the watershed development	m	0.31
Average river basin width	B	2.06 km
(A)symmetry of the river basin	a	0.11
Density of the river network of the basin	G	0.32
Average river basin altitude	Hsr	1341.05 m
Average elevation difference of the river basin	D	492.05 m
Average river basin decline	Isr	39.8 %
The height of the local erosion base of the river basin	Hleb	1154 m
Coefficient of the erosion energy of the river basin's relief	Er	199.49
Coefficient of the region's permeability	S1	0.89
Coefficient of the vegetation cover	S2	0.72
Analytical presentation of the water retention in inflow	W	1.1134 m
Energetic potential of water flow during torrent rains	2gDF^½	333.14 m km s
Maximal outflow from the river basin	Qmax	174.65 m^3/s
Temperature coefficient of the region	T	0.95
Coefficient of the river basin erosion	Z	0.393
Production of erosion material in the river basin	Wgod	10039.6034 m^3/god
Coefficient of the deposit retention	Ru	0.384
Real soil losses	Ggod	3857.68 m^3/god
Real soil losses per km2	Ggod/km^2	335.57 m^3/km^2 god

Acknowledgement

This research was funded by the Ministry of Science of Montenegro.

References

Babic Mladenovic, M., Obuskovic, Z. and Knezevic, Z., 2003. Zasipanje akumulacija u Srbiji – Problemi i pravci resavanja. Vodoprivreda 35: 387-393; 0350-0519.

Bayramin, İ., Dengiz, O., Başkan, O., Parlak, M. 2003, Soil Erosion Risk Assessment with ICONA Model; Case Study: Beypazarı Area. Turkish Journal of Agriculture and Forestry. 27, p 105-116.

Begić, M., Vranić M., 2013. Report on sedimentation of the Potpec hydropower plant. Drina-Lim hydropower plants report 2013, p 1-7.

Cvijic, J. 1921. Ledeno doba u Prokletijama i okolnim planinama. Glasnik Srpske Kraljevske Akademije, knj. XCI, Beograd, 1913, knj. XCIII, Beograd.

Čurović, M., Stešević, D., Medarević, M., Cvjetićanin, R., Pantić, D. and Spalevic, V., 2011. Ecological and structural characteristics of monodominant montane beech forests in the National park Biogradska Gora, Montenegro. Archives of Biological Sciences 63 (2), 429-440.'

Dengiz, O., Akgül, S., 2005. Soil Erosion Risk Assessment of the Gölbaşı Environmental Protection Area and Its Vicinity Using the CORINE Model. Turkish Journal of Agriculture and Forestry. 29, p 439-448.

Egner, H., Riehm, H., and Domingo, W.R., 1960. Untersuchungen über die chemische Bodenanalyse als Grundlage für die Beurteilung des Nährstoffzustandes der Böden. II. Chemische Extraktionsmethoden zur Phosphor- und Kaliumbestimmung. K. Lantbrukshoegsk. Ann 26:199-215.

Fustic, B. and Djuretic, G., 2000. Soils of Montenegro. Biotechnical institute, University of Montenegro.

Gee, G.W. and Bauder, J.W., 1986. Particle size analysis. In: Methods of Soil Analysis: Part I, pp. 383–411 (2nd ed.). Madison: American Society of Agronomy (Agronomy 9).

Gobin, A., Jones, R., Kirkby, M., Campling, P., Govers, G., Kosmas, C., Gentile, A.R., 2004. Indicators for pan-European assessment and monitoring of soil erosion by water. Environ. Science & Policy 7, 25–38.

Jakovljevic, M., Pantovic, M. and Blagojevic, S., 1995. Laboratory Manual of Soil and Water Chemistry (in Serbian). Belgrade: Faculty of Agriculture.

Kappen, H., 1929. Die Bodenazidität. 363p. Berlin: Springer Verlag.

Kirkby, M.J., Jones, R.J.A., Irvine, B., Gobin, A., Govers, G., Cerdan, O., Van Rompaey, A., Le Bissonnais, Y., Daroussin, J. King, D., Montanarella, L., Grimm, M., Vieillefont, V., Puigdefabregas, J., Boer, M., Kosmas, C., Yassoglou, N., Tsara, M., Mantel, S., Van Lynden, G.J. and Huting, J., 2004. Pan-European soil erosion risk assessment. European Soil Bureau Research Report: 16, EUR21176. p 18.

Karkanis, P.G., Au, K., and Schaalje, G.B., 1991. Comparison of 4 measurement schedules for determination of soil particle-size distribution by the hydrometer method. Can. Agr. Eng. 33(2): 211–215.

Knezevic, M. and Kicovic, D., 2004. Prirodne specificnosti polimskih Prokletija u svetlu aktivne zastite. Glasnik srpskog geografskog drustva. Sveska LXXXIV – Br.1. Beograd.

Kostadinov S., Zlatić M., Dragićević S., Novković I., Košanin O., Borisavljević A., Lakićević M., Mlađan D., 2014. Anthropogenic influence on erosion intensity changes in the Rasina river watershed - Central Serbia.

Kostadinov, S., Zlatic, M., Dragovic, N., Gavrilovic, Z., 2006. Soil Erosion in Serbia and Montenegro. In Boardman, J., Poesen, J. (eds), Soil Erosion in Europe. John Wiley & Sons, Ltd; London: 271-277.

Nikkami, D.,(2012. Investigating sampling accuracy to estimate sediment concentrations in erosion plot tanks. Turk J Agric For 36: 583–590.

Nyssen, J., Van den Branden, J., Spalevic, V., Frankl, A., Van de Velde, L., Curovic, M. and Billi, P., 2014. Twentieth century land resilience in Montenegro and consequent hydrological response. Land Degradation & Development. 25: 336-349.

Oldeman, L.R., Hakkeling, R.T.A., Sombroek, W.G., 1991. GLASOD World Map of the Status of Human-induced Soil Degradation. ISRIC, Wageningen UNEP, Nairobi (second revised ed.).

Pavicevic, N., 1956. Soil erosion in the upper part of the Lim river basin. Agriculture and Forestry 2(2): 1-18.

Pimentel, D., 2006. Food and environmental threat of soil erosion. J Env Dev and Sustain 8: 119–137.

Poesen, J., Nachtergaele, J., Verstraeten, G., Valentin, C., 2003. Gully erosion and environmental change: Importance and research needs. Catena, 50: 91-133.

Spalevic, V., Railic, B., Djekovic, V., Andjelkovic, A., and Curovic, M., 2014, Calculation of the Soil Erosion Intensity and Runoff of the Lapnjak watershed, Polimlje, Montenegro. Agriculture and Forestry, Vol. 60. Issue 2: 261- 271.

Spalevic, V., Radanovic, D., Behzadfar, M, Djekovic, V., Andjelkovic, A., Milosevic, N., 2014. Calculation of the sediment yield of the Trebacka Rijeka, Polimlje, Montenegro. Agriculture and Forestry, Vol. 60. Issue 1: 259-272.

Spalevic, V., Curovic, M., Simunic, I., Behzadfar, M, Tanaskovic, V., 2014. Land degradation, land use and soil erosion: the case of Montenegro. CIHEAM, The Watch Letter: Land Issues in the Mediterranean Countries Vol. 28, Issue 1: 58-62.

Spalevic, V., Djurovic, N., Mijovic, S., Vukelic-Sutoska, M., Curovic, M., 2013. Soil Erosion Intensity and Runoff on the Djuricka River Basin (North of Montenegro). Malaysian Journal of Soil Science, Vol. 17: p.49-68. ISSN: 1394-7990.

Spalevic, V., Grbovic, K., Gligorevic, K., Curovic, M., and Billi, P., 2013. Calculation of runoff and soil erosion on the Tifran watershed, Polimlje, North-East of Montenegro. Agriculture and Forestry, Vol. 59, Issue 4: p.5-17.

Spalevic, V., Simunic, I., Vukelic-Sutoska, M., Uzen, N., Curovic, M., 2013. Prediction of the soil erosion intensity from the river basin Navotinski, Polimlje (Northeast Montenegro). Agriculture and Forestry, Vol. 59, Issue 2: p.9-20.

Spalevic, V., Curovic, M. Tanaskovik, V., Oljaca, M., Djurovic, N., 2013. The impact of land use on soil erosion and run-off in the Krivaja river basin in Montenegro. The First International Symposium on Agricultural Engineering, 4th - 6th October 2013, Belgrade–Zemun, Serbia, VI: 1-14.

Spalevic, V., Nyssen, J., Curovic, M., Lenaerts, T., Kerckhof, A., Annys, K. Van Den Branden, J., Frankl, A., 2013. The impact of land use on soil erosion in the river basin Boljanska rijeka in Montenegro. Proceeding “Agrosym 2013”. Key note papers, p. 54-63.

Spalevic, V., Curovic, M., Uzen, N., Simunic, I., Vukelic-Shutoska, M., 2013. Calculation of soil erosion intensity and runoff in the river basin of Ljesnica, Northeast of Montenegro. In proceeding of the 24th International Scientific-Expert Conference on Agriculture and Food Industry, Sarajevo.

Spalevic, V., Čurović, M., Borota, D. and Fuštić, B., 2012. Soil erosion in the river basin Zeljeznica, area of Bar, Montenegro. Agriculture and Forestry, Vol. 54. (08) (1-4): p.5-24, Podgorica.

Spalevic, V., Mahoney, W., Djurovic, N., Üzen, N. and Curovic, M. 2012. Calculation of soil erosion intensity and maximum outflow from the Rovacki river basin, Montenegro. Agriculture and Forestry, Vol. 58. Issue 3: p.7-21.

Spalevic, V., 2011. Impact of land use on runoff and soil erosion in Polimlje. Doctoral thesis; p 1-260. Faculty of Agriculture of the University of Belgrade, Serbia.

Spalevic, V., Seker, G., Fustic, B., Ristic, R., Sekularac, G., 2003. Conditions of erosion of soil in the drainage basin of the Crepulja - Lucka River. Natural and Socioeconomic effects of Erosion Control in Mountainous Regions, pp. 287-292, Banja Vrujci, Srbija.

Stoffel, M., Huggel, C., 2012. Effects of climate change on mass movements in mountain environments. Progress in Physical Geography 36, 421–439.

Tazioli, A., 2009. Evaluation of erosion in equipped basins: preliminary results of a comparison between the Gavrilovic model and direct measurements of sediment transport. Envir. Geology 56, no. 5: 825-831.

Thun, R. and Herrmann, R., 1949. Die Untersuchung von Boden. Neumann Velag, Radebeul und Berlin, pp 15-28.

Van Lynden, G.W.J., 1995. European Soil Resources. Nature and Env. No. 71. Council of Europe, Strasbourg.

Verheijen, F.G.A., Jones, R.J.A., Rickson, R.J., Smith, C.J., 2009. Tolerable versus actual soil erosion rates in Europe. Earth-Science Reviews 94, 23–38.

Zivaljevic, M., 1989. Tumac Geoloske karte SR Crne Gore, 1:200 000; Posebna izdanja Geoloskog glasnika, Knjiga VIII, Titograd.