SOIL LOSS ESTIMATION USING THE INTERO MODEL IN THE S1-2 WATERSHED OF THE SHIRINDAREH RIVER BASIN, IRAN

Jovana DRAGANIĆ[1], Morteza BEHZADFAR[2*], Marx Leandro Naves SILVA[3], Junior Cesar AVANZI[4], Ivica KISIĆ[5], Goran BAROVIĆ[6],Velibor SPALEVIĆ[6]

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ABSTRACT

Soil erosion is one of the main problems of land degradation of agricultural land, especially in the mountainous areas. This negative process is one of the key problems to the environment and water resources in Iran. Using the computer-graphic modelling, we calculated sediment yield and peak discharge of the S1-2 catchment, of the Shirin-Dareh Basin of the Caspian Sea watershed. The area characterized cold winters (the minimum of 24.4°C) and warm, dry summers (the absolute maximum air temperature of 34.6°C; the average annual precipitation of 328 mm). The coefficient of the region's permeability, S1, is calculated on 0.84. The structure of the river basin, according to water permeability, is the following: f0, poor water permeability rocks, 53%; fpp, medium permeable rocks, 41%; fp, very permeable products from rocks: 6%. The most common soil type in the studied area is Inceptisols with Calcic horizon. The river basin is under the mountain pastures (51%) and the rest (49%) is the ground without grass vegetation and plough-lands. The coefficient of the river basin planning is calculated on 0.75. The coefficient of the vegetation cover is calculated on 0.9. We calculated the soil losses from the S1-2 catchment on 20404 m^3 yr^{-1} and the peak discharge on 209 m^3s^{-1} (for the incidence of 100 years). The value of the Z coefficient of 0.917 indicates that the river basin belongs to the second destruction category, where the strength of the erosion process is high. With this study we provided new information about the recent state of the sediment yield of the S1-2 catchment, of the Shirin-Dareh Basin in the North Khorasan province of Iran in formats that can simplify the management in the watersheds, demonstrating the possibility of Soil Loss Estimation using the IntErO Model.

Keywords: *soil erosion, IntErO Model, sediment yield, ShirinDareh watershed*

[1] University of Montenegro, Biotechnical Faculty, Mihaila Lalića 1, 81000 Podgorica, Montenegro
[2] North Khorasan Provincial FRWO, Iran
[3] Federal University of Lavras, Department of Soil Science, Lavras, Brazil
[4] University of São Paulo, College of Animal Science and Food Engineering, Pirassununga, Brazil
[5] Faculty of Agriculture, University of Zagreb, Croatia
[6] Department of Geography, Faculty of Philosophy Niksic, University of Montenegro
*Corresponding author: mbehzadfar@gmail.com

INTRODUCTION

Various environmental problems are involving the destruction of the natural balance as a result of the misuse or abuse of nature. Soil is one of the basic elements of nature and its problems are essential 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; Nikkami, 2012, Stoffel and Huggel, 2012, Ristic *et al.*, 2001) where the erosion is a key driver of land degradation heavily affecting sustainable land management in various environments worldwide (Stoffel *et al.*, 2013; Verheijen *et al.*, 2009); the biggest threat to the conservation of soil and water resources (Bayramin *et al.*, 2003).

Soil erosion is a growing problem globally and is serious problem in Iran. The off-site impact of loss of reservoir capacity is increasing in this Region. Quantitative information on soil loss is needed for erosion risk assessment. The modelling of the erosion process has progressed rapidly, and a variety of models have been developed to predict both runoff and soil loss. The authors of this study used the computer - graphic models (Spalevic, 2011; Spalevic, 1999a) for prediction of soil erosion intensity from the catchment area – IntErO model (Spalevic, 2011).

The objective of this research was characterization of the erosion processes in relation to the recent state of the sediment yield in the S1-2 Watershed of the Shirindareh River Basin. The results, consistent with previous researches on the neighbouring river basins, presented in formats that may be further used for the efficient management and protection, illustrating the possibility of modelling sediment yield by the IntErO model.

MATERIAL AND METHODS

The study was conducted in the area of the S1-2 watershed of the Shirindareh River Basin of the Caspian Sea Watershed (Figure 1).

Figure 1. Study area of the S1-2 watershed, the Shirindareh River Basin, Iran

The studied river basin is placed in the mountainous area of the north-eastern part of Iran. The river dam has been constructed on the main river of the basin; surface runoff is used for supply of water for drinking and agriculture and it is important to keep the reservoir in good condition, decreasing sedimentation and controlling the runoff at the upstream watersheds (Behzadfar *et al.*, 2015).

The S1-2 watershed is covering an area of 56 km^2. It is one of the medium to big sized watersheds of the natural entity of the Shirindareh region. During the field work, using a morphometric methods, various data on intensity and forms of soil erosion, land use, and the measures taken to reduce or mitigate erosion were recorded.

Figure 2. Details from the filed visit on the Shirindareh River Basin, Iran V. Spalevic & M. Behzadfar (Feb. 2015): Problems with overgrazing and livestock traces

According to our calculations, the shortest distance between the fountainhead and the mouth, lv, is 7.5 km; and the total length of the main watercourse with tributaries is 129 km. The relief has very pronounced dynamics; the average slope gradient in the river basin, Isr, is calculated on 26% what indicates that in the river basin prevailing steep slopes. The average river basin altitude Hsr, is calculated on 1700 m; the average elevation difference of the river basin, D, on 274 m.

The analysis of the geological structure and soil characteristics of the area was based on the research of the National Geological Survey Organization (NGS) led by Bolourchi (1987), who analysed the physical and chemical properties of all geological formations of North Khorasan province, including those in the study area of the S1-2

Basin. Climatological data were received from the North Khorasan Meteorological stations of Iran.

For obtaining data on forecasts of sediment yield and peak discharge from the basin we used the IntErO model (Intensity of Erosion and Outflow - program package; Spalevic, 2011), with the Erosion Potential Method – EPM (Gavrilovic, 1972) embedded in the algorithm of this computer-graphic method.

The basic analytical equation for the calculation of erosion-induced soil losses, as developed by Gavrilovic (1972), is as follows:

$$G_{yr \times sp^{/1}} = T \times H_{yr} \times \pi \sqrt{Z^3} \times R_u$$

where: $G_{yr\ sp}{}^{-1}$– specific annual total erosion-induced sediment yield reaching the confluence, m^3 yr^{-1} km^{-2}; T – temperature coefficient of the catchment; H_{yr} – amount of rainfall, mm; π – 3.14; Z– coefficient of erosion; R_u– coefficient of retention of soil in the catchment.

This methodology is currently in use in: Bosnia & Herzegovina, Brazil, Bulgaria, Croatia, Czech Republic, Italy, Macedonia, Montenegro, Morocco, Serbia, South Africa and Slovenia (Gazdic *et al.*, 2015; Spalevic *et al.*, 2015a, 2015b, 2015c, 2015d, 2015e, 2015f, 2015g, 2015h, 2015i, 2015k; Kostadinov *et al.*, 2014, Curovic *et al.*, 1999). In Iran have been successfully used in the regions of Chamgardalan, Kasilian, Kermanshah, Razavi Khorasan (Barovic *et al.*, 2015; Behzadfar *et al.*, 2015; Behzadfar *et al.*, 2014a; Behzadfar *et al.*, 2014b; Sadeghi, 2005, Sadeghi, 1993; Yousefi *et al.*; 2014; Zia Abadi & Ahmadi, 2011; Amiri, 2010) and other regions.

RESULTS AND DISCUSSION

The climate in the studied area is continental, with the absolute maximum air temperature of 34.6°C and the negative -24.4°C. The average annual air temperature, t0, is 10.2°C. The average annual precipitation, H_{yr}, is 328.4 mm (Source: Data from the North Khorasan Meteorological stations of Iran).

The temperature coefficient of the region, T, is calculated on 1.06; the amount of torrential rain, hb, on 35.61 mm.

Vegetation and land use. The studied area is located in Middle- East of the Kope-Dagh geographical region. According to the available literature and the analysis using the Google maps and Google Earth, including the records from the field visits, the pastures and meadows are covering the area of 51% and non-arable land of 49%. The coefficient of the river basin planning, Xa, is calculated on 0.75. The coefficient of the vegetation cover, S2, is calculated on 0.9.

Soil erosion and runoff characteristics. The dominant erosion form in this area is surface erosion and is the most pronounced on the steep slopes without vegetation cover. Problems with overgrazing and livestock traces are recorded also all over the studied area.

Processing the input data by the IntErO model we received the results in relation to the sediment yield of the S1-2 Watershed of the Shirindareh River Basin of Iran. The results are presented at the Table 1.

Table 1. The IntErO report for the S1-2 watershed river basin

River basin area	F	56.06	km²
The length of the watershed	O	40.28	km
Natural length of the main watercourse	Lv	7.54	km
The shortest distance between the fountainhead and mouth	Lm	6.59	km
The total length of the main watercourse with tributaries of I and II class	ΣL	128.97	km
River basin length measured by a series of parallel lines	Lb	11.81	km
The area of the bigger river basin part	Fv	31.64	km²
The area of the smaller river basin part	Fm	24.42	km²
Altitude of the first contour line	h0	1500	m
The lowest river basin elevation	Hmin	1426	m
The highest river basin elevation	Hmax	2189	m
A part of the river basin consisted of a very permeable products from rocks	fp	0.06	
A part of the river basin area consisted of medium permeable rocks	fpp	0.41	
A part of the river basin consisted of poor water permeability rocks	fo	0.53	
A part of the river basin under grass, meadows, pastures and orchards	ft	0.51	
A part of the river basin under plough-land and without vegetation	fg	0.49	
The volume of the torrent rain	hb	36.16	mm
Average annual air temperature	t0	9.8	°C
Average annual precipitation	Hyr	335	mm
Types of soil products and related types	Y	1.1	
River basin planning, coefficient of the river basin planning	Xa	0.75	
Numeral equivalents of visible and clearly exposed erosion process	φ	0.59	
Coefficient of the river basin form	A	1.04	
Coefficient of the watershed development	m	0.28	
Average river basin width	B	4.75	km
(A)symmetry of the river basin	a	0.26	
Density of the river network of the basin	G	2.3	
Coefficient of the river basin tortuousness	K	1.14	

Average river basin altitude	Hsr	1700.45	m
Average elevation difference of the river basin	D	274.45	m
Average river basin decline	Isr	26.01	%
The height of the local erosion base of the river basin	Hleb	763	m
Coefficient of the erosion energy of the river basin's relief	Er	88.76	
Coefficient of the region's permeability	S1	0.84	
Coefficient of the vegetation cover	S2	0.9	
Analytical presentation of the water retention in inflow	W	0.4838	m
Energetic potential of water flow during torrent rains	2gDF^½	549.42	m km s
Maximal outflow from the river basin	Qmax	209.29	m^3/s
Temperature coefficient of the region	T	1.04	
Coefficient of the river basin erosion	Z	0.917	
Production of erosion material in the river basin	Wyr	53820.52	m^3/yr
Coefficient of the deposit retention	Ru	0.379	
Real soil losses	Gyr	20404.44	m^3/yr
Real soil losses per km^2	Gyr/km^2	363.98	m^3/km^2yr

The coefficient of the river basin form, A, is calculated on 1.04. Coefficient of the watershed development, m, is 0.28 and average river basin width, B, is 4.75 km. (A)symmetry of the river basin, a, is calculated on 0.26 and that indicates that there is a possibility for large flood waves to appear in the studied river basin. The value of G coefficient of 2.3 indicates there is very high density of the hydrographic network.

The height of the local erosion base of the river basin, Hleb, is 763 m. Coefficient of the erosion energy of the river basin's relief, Er, is calculated on 88.76. According to the erosion type, the dominant process is surface erosion.

The value of Z coefficient of 0.917 indicates that the river basin belongs to II destruction category. The strength of the erosion process is high, and according to the erosion type, it is intrusive erosion. We calculated the soil losses from the S1-2 catchment on 20404 $m^3\ yr^{-1}$ and the peak discharge on 209 m^3s^{-1} (for the incidence of 100 years).

CONCLUSIONS

Sediment yield and peak discharge of the S1-2 catchment of the Shirin-Dareh Basin of the Caspian Sea watershed were calculated using the computer-graphic modelling. The results of the processing of the inputs, using the IntErO model, are the following:

- The structure of the river basin, according to water permeability, is the following: f0, poor water permeability rocks, 53%; fpp, medium permeable rocks, 41%; fp, very permeable products from rocks: 6%. The coefficient of the region's permeability, S1, is calculated on 0.84.

- The most common soil type in the studied area is Inceptisols with Calcic horizon.
- The river basin is under the mountain pastures (51%) and the rest (49%) is the ground without grass vegetation and plough-lands.
- The coefficient of the river basin planning is calculated on 0.75.
- The coefficient of the vegetation cover is calculated on 0.9.
- Calculated soil losses from the S1-2 catchment are 20404 m^3yr^{-1} and the peak discharge is 209 m^3s^{-1} (for the incidence of 100 years).
- The value of the Z coefficient of 0.917 indicates that the river basin belongs to the second destruction category, where the strength of the erosion process is high.

With this study we provided new information about the recent state of the sediment yield of the S1-2 catchment, of the Shirin-Dareh Basin in the North Khorasan province of Iran in formats that can simplify the management in the watersheds, demonstrating the possibility of Soil Loss Estimation using the IntErO Model. For more reliable conclusions measurements are needed for the model verification, including additional analysis in relation to the land use changes.

This study further confirmed the findings of Barovic *et al.*, 2015; Behzadfar *et al.*, 2015, 2014a, 2014b; Amini *et al.*, 2014; Yousefi *et al.*, 2014; Moradi *et al.*, 2015; Zia Abadi & Ahmadi, 2011; as well as Amiri, 2010; Khaleghi, 2005; Maleki, 2003; Nadjafi, 2003; Sadeghi 1993 in possibility of implementing the Erosion Potential Method in Iran, what leads to the conclusion that the IntErO model may be a useful tool for researchers in calculation of runoff and sediment yield for the river basins of the Caspian Sea Watershed with the similar physical-geographical characteristics like the Shirindareh river basins. We would like to highlight that the team of authors have the same good experience about the simplicity in operation and practicality in use of the IntErO also in the Saudi Arabia (Al-Turki *et al.*, 2015) and in the Western Balkans (Barovic & Spalevic, 2015; Vujacic & Spalevic, 2015; Spalevic *et al.*, 2014a, 2014b, 2014c, 2014d, 2013a, 2013b, 2013c, 2013d, 2013e, 2003a, 2003b, 1999b, 1999c).

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