



DETERMINATION OF THE LEVEL OF EROSION IN THE BREGALNICA RIVER BASIN

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Abstract: Geomorphology as a special branch of geology describes and classifies the form of the relief. It defines the mechanisms of processes in which relief forms develop, the evolution, their properties and relation of the form to the properties and the form of the rock masses in which relief forms and formations have developed. The paper deals with the geomorphology and the mathematical-physical calculation of the erosion of the Bregalnica river basin, which is one of the longest rivers in the eastern part of the Republic of Macedonia. The paper aims at unraveling the state of erosion in the region along the river course and the material deposited starting from the spring as far as the estuary of the Bregalnica and Vardar. It will give a brief account of the changes of the present day relief.

Key words: geomorphology; relief; erosion; deposition of material

INTRODUCTION

It is well known that some parts of the relief erode more intensely than others. This depends on various natural geomorphological factors such as climate, geological composition, pedology, vegetation, and anthropological activities. In geomorphology and other disciplines such as agriculture, forestry and civil engineering it is not sufficient to

decide whether erosion is more or less intense, but there is the need of quantitative calculation of annual and multi-annual intensity of erosion in certain regions. Based on field and laboratory investigations mathematical-physical equations were worked out for the calculation and production of detritus from river basins that can be used easily.

MATHEMATICAL-PHYSICAL MODEL FOR THE DETERMINATION OF EROSION OF THE BREGALNICA RIVER BASIN

The following equation is used for the calculation of the total erosion layers in a river basin (S. Gavrilović, 1973):

$$W_{\text{year}} = T \cdot H_{\text{year}} \cdot \pi \cdot \sqrt{Z^3} \cdot F \quad (\text{m}^3/\text{year}) \quad (1)$$

where:

W_{year} – is the total production of annual erosion layers, m^3 ,

T – is the temperature coefficient in the river basin,

H_{year} – annual precipitation in mm/year,

π – is the Ludolph's number,

Z – is the erosion coefficient,

F – is area of the entire river basin for which erosion layers are determined, km^2 .

Temperature coefficient of the river basin T (S. Gavrilović, 1973) is calculated by the equation:

$$T = \sqrt{\frac{t^0}{10}} + 0.1 \quad (^\circ\text{C}) \quad (2)$$

Where t is the terrestrially measured temperature in the regions of the field under investigation.

Based on the results from a number of field investigation Fig. 1, a table was written for the

mean values of the erosion coefficient Z (Table 1).

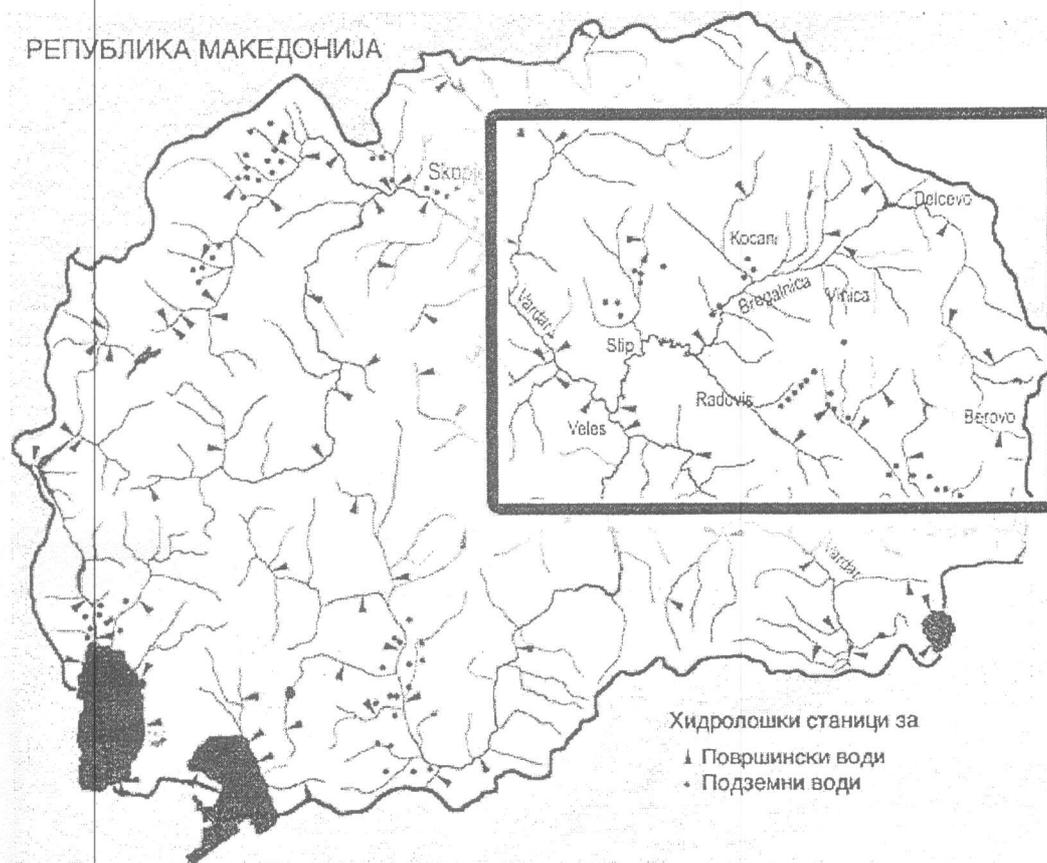


Fig. 1. The Bregalnica River basin

Table 1

Values for erosion coefficient Z (M. Marković, 2001)

Type of erosion processes	Category of destruction	Subgroup	Type of erosion	Coefficient of erosion level Z
Excessive erosion	I	a	deep seated	1.31–1.50
		b	mixed	1.21–1.30
		c	surface	1.01–1.20
Strong erosion	II	a	deep seated	0.91–1.00
		b	mixed	0.81–0.90
		c	surface	0.71–0.80
Medium erosion	III	a	deep seated	0.61–0.70
		b	mixed	0.51–0.60
		c	surface	0.41–0.50
Poor erosion	IV	a	deep seated	0.31–0.40
		b	mixed	0.25–0.30
		c	surface	0.20–0.24
Very poor erosion	V	–	traces of erosion	00.1–0.19

Part of the detritus remains in the river basin passing a short or a long way to or through the riverbed and does not arrive at the estuary. However, the amount of deposition material that is taken or washed away from the river basin every year and is mixed with material speaks for the evolution of the relief of the region. The material that remains in the river basin is called coefficient of retention R_u , (M. Klimasevski, 1979) is given by the equation:

$$R_u = \frac{(O \cdot D)^{0.5}}{0.25 \cdot (L+10)} \text{ (m}^3\text{/year)} \quad (3)$$

where:

R_u – is the coefficient of retention,

O – is the length of watershed (partial), km,

D – is the mean height difference of the river basin, km,

L – the length of the river basin, km.

The annual amount of detritus W_{year} and the coefficient of retention R_u yield the annual amount of erosion detritus that passes through hydrometric profile and deposit as far as the estuary of the river:

$$G_{\text{year}} = W_{\text{year}} \cdot R_u \text{ (m}^3\text{/year)} \quad (4)$$

where:

G_{year} – is the annual amount of erosion detritus that is deposited as far as the river mouth,

W_{year} – is total production of annual erosion material in the river basin,

R_u – is the coefficient of retention.

Above-mentioned calculations yield the annual production of detritus for the entire river basin or, more precisely, the amount of detritus that comes to the estuary of the river. This yields data on the annual denivellation of the terrain or the average lowering of part of the topographic surface. This means that a clear picture is obtained for the further evolution of the relief. Several river basins that join the area under investigation were involved in the calculation of the mathematical model of the erosion of the Bregalnica River catchment. They are the Berovo–Delčevo, Delčevo–Kočani, Kočani–Štip, the Kratovo–Zletovo and Štip–Veles river basins where the Bregalnica empties into the Vardar. Calculations were not carried out on the Radoviš river basin, which joins the “Mantovo” water reservoir and does not join the Bregalnica River. The entire river basin occupies an area of 4324 km². The length of the Bregalnica

is 370 km. The values of coefficient of erosion Z were taken from a precise geomorphological study.

Strong surface erosion prevails in the Berovo–Delčevo area with coefficient $Z = 0.80$. The area is mountainous with sporadic poor vegetation. The average annual temperature is 9.3 °C, annual precipitation amounts to 870 mm/year (data from the Hydrometeorological Institute of Macedonia). The area of the watershed occupies 120 km², the length being 120 km, with mean height variation between Berovo and Delčevo of about 355 m (Table 2).

Table 2 shows that the total production of erosion of river drift in the river basin amounts to 5 353 700 m³/year, and erosion of the relief of 4.7 mm/year.

Table 2

The Berovo–Delčevo river basin

T	°C	1.06
H_{year}	mm/year	870
π		3.14
$\sqrt{Z^3}$		0.71
F	km ²	120
W_{year}	m ³ /year	2 467 143
G_{year}	m ³ /year	5 353 700
$G_{\text{morf.}}$	mm/year	4.7
O	km	120
D	m	355
L	km	370
R_u	m ³ /year	2.17

In the Delčevo–Kočani river basin there is medium mixed erosion with coefficient $Z = 0.60$. The terrain is mountainous, grading to flatland towards Kočani. In some places it is forested and in some places does not abound in vegetation. The lower parts abound in vegetation. The average annual temperature is 11.6 °C, the annual precipitation amounts to 820 mm/year, according to data obtained from the Hydrometeorological Institute of Macedonia. The river basin occupies an area of 90 km, with mean height variation between Delčevo and Kočani of some 273 m (Table 3).

Table 3 shows that the total production of river drift in the river basin amounts to 2 259 920 m³/year, and erosion of the relief of 2.3 mm/year.

Table 3

Delčevo–Kočani river basin

T	°C	1.18
H_{year}	mm/year	820
π		3.14
$\sqrt{Z^3}$		0.46
F	km ²	980
W_{year}	m ³ /year	1 369 649
G_{year}	m ³ /year	2 259 920
$G_{\text{morf.}}$	mm/year	2.3
O	km	90
D	m	273
L	km	370
R_{μ}	m ³ /year	1.65

In the Kočani–Štip river basin there is medium mixed erosion with coefficient $Z = 0.60$. The terrain is flatland with abundant vegetation. The average annual temperature is 13.0 °C, the annual precipitation amounting to 620 mm/year, according to data obtained from the Hydrometeorological Institute of Macedonia. The river basin occupies an area of 890 km² and the length of the watershed is 60 km, with mean height variation between Kočani and Štip of some 44 m (Table 4).

Table 4 shows that the total production of river drift in the river basin amounts to 5 333 684 m³/year, and erosion of the relief of 0.59 mm/year.

Table 4

The Kočani–Štip river basin

T	°C	1.24
H_{year}	mm/year	620
π		3.14
$\sqrt{Z^3}$		0.46
F	km ²	890
W_{year}	m ³ /year	988 305
G_{year}	m ³ /year	5 333 684
$G_{\text{morf.}}$	mm/year	0.59
O	km	60
D	m	44
L	km	370
R_{μ}	m ³ /year	0.54

The Kratovo–Zletovo area has a strong surface erosion with coefficient $Z = 0.80$. The terrain is mountainous and does not abound in vegetation. The average annual temperature is 11.5 °C, the annual precipitation amounting to 590 mm/year, according to data obtained from the Hydrometeorological Institute of Macedonia. The watershed occupies an area of 880 km². The river basin is 40 km long with mean height variation between the Kratovo–Zletovo area (and the Kočani depression where the basin joins the Bregalnica River) amounts of some 631 m (Table 5).

Table 5

The Kratovo – Zletovo River Basin

T	°C	1.17
H_{year}	mm/year	590
π		3.14
$\sqrt{Z^3}$		0.71
F	km ²	880
W_{year}	m ³ /year	1 354 280
G_{year}	m ³ /year	2 261 648
$G_{\text{morf.}}$	mm/year	2.60
O	km	40
D	m	631
L	km	370
R_{μ}	m ³ /year	1.67

The Štip–Veles river basin is characterized by poor surface erosion, the coefficient being $Z = 0.24$. The terrain is flatland with poor vegetation in which the Bregalnica winds intensively. The average annual temperature is 12.9 °C and average annual precipitation about 570 mm/year according to the Hydrometeorological Institute of Macedonia. The river basin occupies an area of 380 km², the length of watershed being 60 km, with mean height variation between Štip and Veles of some 140 m (Table 6).

Table 6 shows that the total production of river drift in the river basin amounts to 88 339 m³/year, and erosion of the relief of 0.23 mm/year.

Table 6

The Štip-Veles river basin

T	°C	1.23
H_{year}	mm/year	570
π		3.14
$\sqrt{Z^3}$		0.11
F	km ²	380
W_{year}	m ³ /year	92 020
G_{year}	m ³ /year	88 339
$G_{\text{morf.}}$	mm/year	0.23
O	km	60
D	m	140
L	km	370
R_u	m ³ /year	0.96

efficient $Z = 0.60$. The terrain is mountainous with poor vegetation grading in some places to flatland of abundant vegetation. In the Štip-Veles basin the Bregalnica possesses a specific geomorphologic formation with poor vegetation intense winding. The watershed is 370 km long. Total annual river drift ΣG_{year} that is deposited from the Bregalnica into the Vardar and annual erosion $G_{\text{morf.}}$ of the terrain have an effect on the largest river in the country. The amount is given in Table 7.

Table 7 shows that the total production of erosion detritus for the Bregalnica river basin is 10 497 291 m³/year, and erosion of the relief of 2.40 mm/year.

Table 7

The Bregalnica river basin

F km ²	ΣW_{year} m ³ /year	ΣG_{year} m ³ /year	$G_{\text{morf.}}$ mm/year
4 324	6 271 397	10 497 291	2.40

The Bregalnica river basin occupies an area of 4 324 km². It is medium mixed erosion with co-

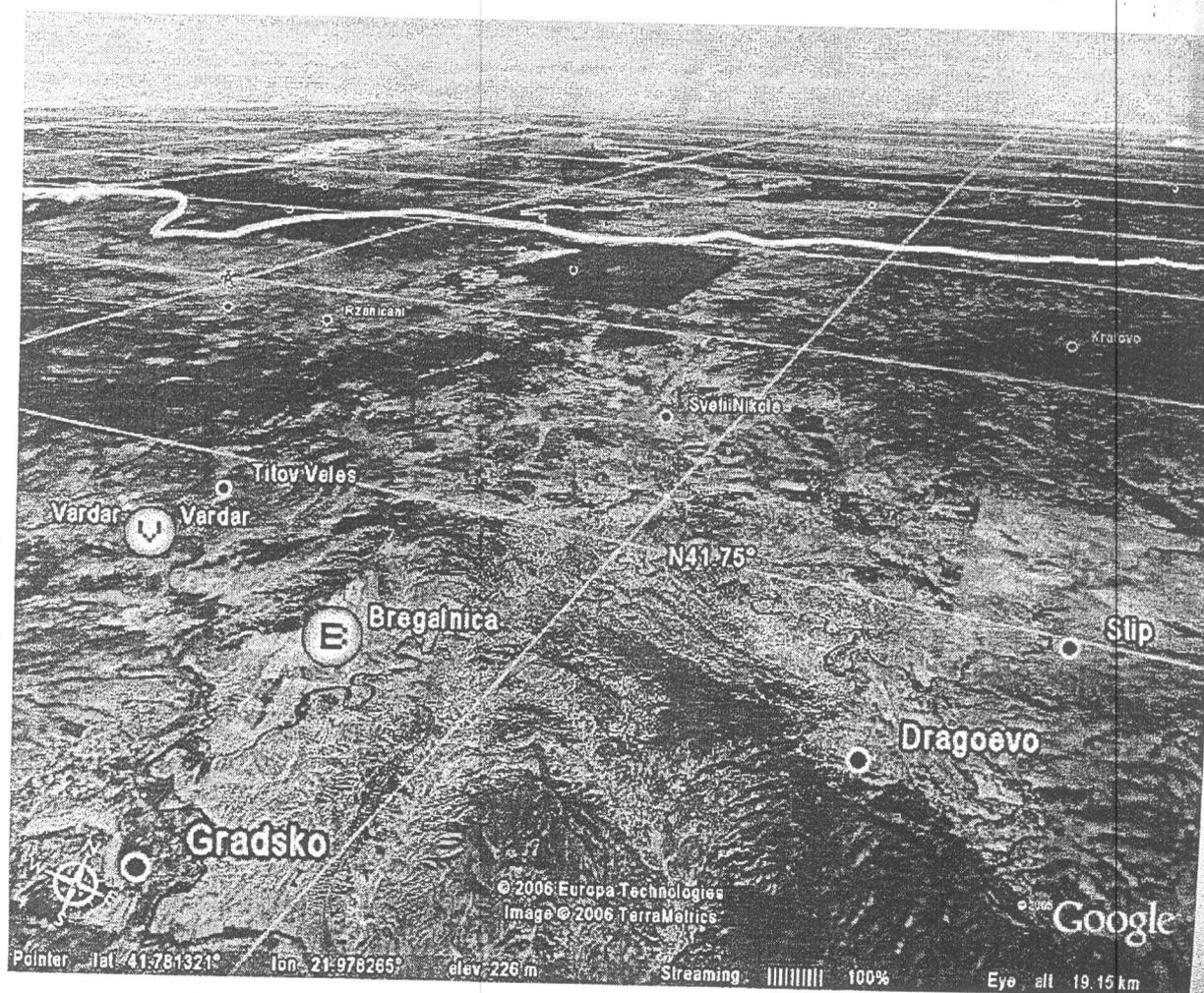


Fig. 2. The Bregalnica River – B, and Vardar River – V.

CONCLUSION

The Bregalnica River is one of the longest in the country flowing through a third of the territory. In some geologic time it may perform a significant role on the formation and denivelation of the area

it flows. The facts presented in the paper attest that the river basin has a present day and future geomorphologic role.

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Резиме

ОПРЕДЕЛУВАЊЕ НА ИЗНОСОТ НА ЕРОЗИЈА ВО СЛИВОТ НА РЕКАТА БРЕГАЛНИЦА

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Клучни зборови: геоморфологија; релјефни форми; ерозија; депонирање на материјал

Геоморфологијата како посебна дисциплина од географијата има задача да даде јасен опис и класификација на формата на одреден релјеф. Тоа значи да врши утврдување на механизмот на процесите во настануваат релјефните форми, да ги одреди нивна еволуција, нивните својства и односот на формата со својствата и формата на карпестите маси во се формирани таквите релјефни форми или форми. Овој труд го опфаќа делот од геоморфологија која го дава математичко-физичкото пресметување на ерозијата на сливот на реката Брегалница, која е една од поголемите реки во источниот дел на Македонија, за да се добие појасна слика на ерозијата во адениот регион по текот на оваа река, како и за депонираниот материјал од изворот па сè до вливот на

реката Брегалница во реката Вардар. Со ова се дава јасна слика на промена на релјефот во денешно време.

Фактот, што сам по себе зборува, дека реката Брегалница е една од поголемите реки во источниот дел на Македонија како по должина така и по своето сливно подрачје, кое зафаќа речиси една третина од територијата на Република Македонија, придонесува во догледното геолошко време оваа река да врши голема улога врз формирањето и денивелацијата на теренот низ кој минува. Самите бројки од овој труд зборуваат за тоа дека оваа река со своето сливно подрачје врши генерална геоморфолошка еволуција во регионот како во најново време така и во понатамошната еволуција на теренот.

