Theoretical background

River basin areas (F), watershed line length (O) and natural length of the main watercourse (Lv) are measures from topographic maps using the "IntErO" program, subroutine part "Areas and distances".

Basin shape coefficient, **A**, is calculated from the following formula:

$$A = 0.195 \cdot \frac{O}{Lv}$$

where:

O - length of the watershed line (circumference of the basin), in km,
Lv - natural length of the main course of the main watercourse, in km.

Watershed development coefficient, **m**, by Biolchev, is obtained using the formula:

$$m = \frac{O}{2\sqrt{\pi F}}$$

where:

O - watershed length, in km,
basin area, in km^2.

Mean basin width, **B**, by Biolchev, is calculated with the following formula:

$$B = \frac{F}{L_b}$$

where:

F - river basin area, in km^2,
Lb - basin length measured with a series of parallel lines, in km.

(A)symmetry of the basin, **a**, is calculated with the following formula:

$$a = \frac{F_v - F_m}{0{,}5 \cdot (F_v + F_m)}$$

where:

Fv - area of the larger part of the river basin, in km^2,
Fm - area of the smaller part of the river basin, in km^2.

River basin network density, **G**, is calculated with the following formula:

$$G = \frac{\sum L}{F}$$

where:

Sum (Σ) L - total length of the main watercourse with tributaries of the I and II order, in km,
F - basin area, in km^2.

Coefficient of the flow sinuosity, **K**, is calculated with the following formula:

$$K = \frac{L_v}{L_m}$$

where:

Lv - natural length of the main watercourse, in km,
Lm - the shortest distance between the source and the mouth, in km.

Mean altitude above sea level of the basin, **Hsr**, is calculated with the following formula:

$$H_{sr} = \frac{\sum (h \cdot f)}{F}$$

where:

h - mean altitude above sea level of the two adjacent isohypses, in km
f - area between two adjacent isohypses, in km^2,
F - river basin area, in km^2.

Mean height (elevation) difference, **D**, is calculated with the following formula:

$$D = Hsr - Hmin$$

where:

Hsr - mean elevation, in m,
Hmin - the lowest elevation spot in the basin, in m.

Mean basin slope, **Isr**, is calculated with the following formula:

$$Isr = \frac{\Sigma(Lsr \cdot \Delta h)}{F}$$

where:

Isr - mean length of the two adjacent isohypses, in km,
h - equidistance, in km,
F - basin area, in km^2.

Height of local erosion basis of the basin, **Hleb**, is calculated with the following formula:

$$Hleb = Hmax - Hmin$$

where:

Hmax - the highest elevation spot of the basin, in m,
Hmin - the lowest elevation spot of the basin, in m.

Coefficient of the basin relief erosion energy, **Er**, is calculated with the following formula:

$$Er = \frac{Hleb}{\pi \cdot \sqrt[4]{F}}$$

where:

Hleb - height of local erosion base, in m,
F - river basin area, in km^2.

The total production of erosion sediments in basins, **Wgod**, is calculated analytically using Prof. Gavrilovic's method:

$$Wgod = T \cdot Hgod \cdot \pi \cdot \sqrt{Z^3} \cdot F$$

where:

T - temperature coefficient of the area:

$$T = \sqrt{\frac{t_0}{10} + 0{,}1}$$

whereby:

to - mean annual air temperature, in °C,

H god - mean annual precipitation, in mm,

Z - river basin erosion coefficient:

$$Z = Y \cdot X \cdot a \cdot (\varphi + \sqrt{I_{sr}})$$

whereby:

Y - reciprocal value of the soil resistance to erosion and it is in the function of soil type

Table 1: Mean values of the coefficient "Y"

Types of soil products and related types	Mean value coefficient Y
Sands, gravel and loose soils	2.0
Loess, tuffs, saline, steppe soils...	1.6
Disintegrated limestone and marl	1.2
Serpentine soil, red sandstones, flysch deposits	1.1
Podzols and parapodzols, disintegrated shales	1.0
Compact and shaley limestone, red soils and humus silicate soils	0.9
Eutric cambisols and mountain soils	0.8
Vertisols, boggy ploughand and marsh soils	0.6
Chernozem and alluvial sediments of good structure	0.5
Bare, compact eruptives	0.25

X a - basin regulation coefficient, values tabulated,

Table 2: Mean values of the coefficients "X a"

	X	a	X a
Bare land	1.0	1.0	1.0
Ploughland	0.9	1.0	0.9
Orchards and vineyards	0.7	1.0	0.7
Mountain pastures	0.6	1.0	0.6
Meadows	0.4	1.0	0.4
Degraded forests	0.6	1.0	0.6
Forests of good spacing	0.05	1.0	0.05

φ - numerical equivalent of visible and clearly pronounced soil erosion processes,

Table 3: Mean values of coefficients "φ"

Deep erosion	1.0
80% of basin under rill and gully erosion	0.9
50% of basin under rill and gully erosion	0.8
100% of basin under surface erosion	0.7
100% of basin under surface erosion without visible rills, gullies and landslides	0.6
50% of basin under surface erosion	0.5
20% of basin under surface erosion	0.3
Minor slides in watercourses beds	0.2
Basin mostly under ploughland	0.15
Basin under forests and perennial vegetation	0.1

Isr - mean basin slope

Based on erosion coefficient values, **Z**, Prof. Gavrilović divided the erosion processes into five (5) groups, i.e. five categories by power of destruction.

Table 4: categories by power of destruction and value of the coefficient "Z"

Power of destruction	Erosion process intensity	Prevailing erosion type	Z	Mean value Z
I	Excessive	deep mixed surface	1.51 1.21-1.50 1.01-1.20	1.25
II	Strong	deep mixed surface	0.91-1.00 0.81-0.90 0.71-0.80	0.85
III	Medium	deep mixed surface	0.61-0.70 0.51-0.60 0.41-0.50	0.55
IV	Low	deep mixed surface	0.31-0.40 0.25-0.30 0.20-0.24	0.30
V	Very low	erosion marks	0.01- 0.19	0.10

This method gives the total sum of erosion sediment produced in a river basin or the gravitation area. However, the total quantity of the sediment produced in erosion process in a basin does not reach the lowest point in the basin. Significant portion of the sediment is retained in coves and depressions. The "production" of the erosion sediment is divided by the annual sediment volume that reaches a specific hydrometric profile by introduction of the erosion sediment retention coefficient.

$$Ru = \frac{(O \cdot D)^{0.5}}{0.25(L + 10.0)}$$

where:

O - watershed line length (circumference length), in km,
D - mean height difference of the basin, in km,
Lv - basin length measured by the main watercourse, in km.

The erosion sediment retention coefficient is a factor reducing the general quantities of average deposits produced annually. The reduction of the quantity of erosion sediments from the source to the mouth of the basis is a natural process.

With introduction of the erosion coefficient, Prof. Gavrilovic's model is as follows:

$$Ggod = Wgod \cdot Ru$$
$$Ggod = T \cdot Hgod \cdot \pi \cdot \sqrt{Z^3} \cdot F \cdot Ru$$

where **G god** is the actual loss of soil.

Maximum outflow from the basin, **Qmax**, is calculated analytically

$$Q_{max} = A \cdot S_1 \cdot S_2 \cdot W \cdot \sqrt{2 \cdot g \cdot D \cdot F}$$

where:

A - river basin shape coefficient.
S1 - coefficient of water permeability of the area, calculated with the following formula:

$$S_1 = 0.4f_p + 0.7f_{pp} + 1.0f_0$$

whereby:

fp - part of the basin area that consists of very permeable rock products (limestone, sand, gravel), in %,
fpp - part of the basin area that consists of rocks of medium permeability (slates, marls, sandstones) , in %,
fo - part of the basin area that consists of the rocks of poor permeability (heavy clay, compact eruptives) , in %.

S2 - vegetation cover coefficient, calculated with the following formula:

$$S_2 = 0.6f_š + 0.8f_t + 1.0f_g$$

whereby:

fš - part of the basin area under forest, in %,
ft - part of the basin area under grass, meadows, pastureland and orchards, in %,
fg - part of the basin area under bare land, ploughland and soils without grass vegetation, in %.

W - analytical expression of inflowing water retention

$$W = h_b (15{,}0 - 22{,}0 \cdot h_b - 0{,}3\sqrt{L})$$

whereby:

hb - torrential rain height, in m,
Lv - basin length by main course of the main watercourse, in km.
$2gDF^{1/2}$ - energetic potential of water flow during torrential rain,

where:

g - gravitational acceleration, ($9{,}81 m\ s^{-2}$)
D - mean height difference of the basin, in m,
F - basin area, in km^2.