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Ten-years of sediment discharge measurement in the Jasenica research drainage basin, Yugoslavia

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Abstract The Jasenica drainage basin is a representative basin for the hilly mountain region in the central part of the Serbian Republic in Yugoslavia. It was selected as a research basin for a variety of research in forestry, hydrology, erosion and sediment transport. Since the 1980s, water discharge and suspended sediment concentration have been measured at the D. Satornja gauging station in the basin. The results of 10 years of data collection for water and sediment discharge make it possible to test the methods most widely applied in Yugoslavia for estimating annual water discharge and sediment yield. The estimates produced by these methods, namely the Poljakov method, the Keller method and the Herheulidze method, are compared with the measured values of water discharge and suspended sediment yields for the period 1980-1989 on the basis of an average year. The results show that these methods have serious limitations for practical use, at least in the central part of the Serbian Republic.

INTRODUCTION

The prediction of total annual sediment yield from river basins in hilly mountain regions is very important for land use planning, for developing erosion control measures on agricultural land, and for the design of reservoirs. It is well known that this information can be obtained by the use of various equations, formulae or models calibrated against long-term measurements. Such measurements are rare in the hilly mountain regions of Yugoslavia and there is therefore always uncertainty as to the applicability of methods or models developed elsewhere. The Jasenica basin has been selected as a representative hilly mountain river basin for the central part of the Serbian Republic, and it has been used as a research basin since the 1980s. Various research projects in forestry, erosion and sediment transport and hydrology have been undertaken. Some of the results of 10-years of suspended sediment yield measurements between 1980 and 1990 are presented in this paper.

METHOD

Water and sediment discharges from the Jasenica basin were measured at the

D. Satornja gauging station. Water discharge was measured using standard equipment comprising a water level recorder with 24-h rotation installed above a broad crested weir. Suspended sediment concentration was measured by manual sampling. One 5 litre sample was collected each day and assumed to be representative of that day. During flood flows, additional manual sampling was undertaken every 2-3 h on the rising stage of the flood. This manual sampling strategy has its limitations, but it is acceptable for stable flows with stable concentration. Sediment concentrations were measured by routine laboratory methods involving filtering, drying and weighing.

RESULTS

The Jasenica River basin is typical of hilly mountain rivers in the Serbian Republic. Its physical characteristics are:

Area = 95.56 km^2
Length = 12.00 km
Circumference = 47.20 km
Mean elevation = 507.84 m
Valley slope = 22.4%
River slope = 3.20%
Mean rainfall = 760 mm

The soils and land use are given in Table 1. A summary of the annual water and sediment discharge data for the whole period of investigation is presented in Table 2.

Table 1 Soils and land use in the Jasenica basin.

Soil type	Area (%)	Land use	Area (%)
Brown acid soils	83.0	Good forest (hardwoods)	42.26
Brown forest soils	13.3	Cultivated land	33.24
Smonitzas	2.5	Pasture	22.72
Alluvial soils	1.2	Orchards	1.78

The procedure commonly employed for estimating sediment yields (V, m^3 year^{-1}) in Yugoslavia is the Polakov method (Jeftic, 1978):

$$V = Q_c\ (M_o\ A/10^3\ g_v)\ 31.5 \times 10^6\ (\text{m}^3\ \text{year}^{-1})$$

where:

Q_c = mean sediment concentration (g m^{-3}) = $a\sqrt{(i \times 10^8)}$ with a= erosion index (= 1.4 for Jasenica), i = average river slope (= 3.2% for Jasenica);
M_o = mean water discharge (m^3 s^{-1} km^{-2});
A = area (km^2);
g_v = sediment density (kg m^{-3}).

The mean water discharge is calculated either by the Keller method (M_{o1})

or by the Herheulidze method (M_{o2}). viz.:

$$M_{o1} = (0.942P - 430) \times 10^3/31.5 \times 10^6 \text{ (m}^3 \text{ s}^{-1} \text{ km}^{-2})$$

where P = annual rainfall in mm;

$$M_{o2} = fA^{0.86}/A \text{ (m}^3 \text{ s}^{-1} \text{ km}^{-2})$$

where f = aridity index (for Jasenica $f = 0.13$).

Table 2 Annual water (Q) and sediment (Q_s) discharges during the period 1980-1990 at the D. Satornja gauging station on the Jasenica River.

Year	Q (m^3 $year^{-1}$ × 10^6)	Q_s (t $year^{-1}$)	Year	Q (m^3 $year^{-1}$ × 10^6)	Q_s (t $year^{-1}$)
1980	13.91	1304.0	1985	12.28	2839.19
1981	29.43	3183.2	1986	18.49	3991.00
1982	18.29	1940.2	1987	18.03	6123.70
1983	11.67	1228.8	1988	16.04	2883.30
1984	32.75	3814.3	1989	19.05	3128.30

Mean annual water yield = 18.99 × 10^6 m^3 $year^{-1}$
Mean annual sediment yield = 3043.6 t $year^{-1}$
Mean water discharge (M_o) = 0.006 24 m^3 s^{-1} km^{-2}
Mean sediment concentration (Q_c) = 160.3 g m^{-3}

Table 3 A comparison of measured and estimated values of water discharge.

	Mean water discharge (M_o) (m^3 s^{-1} km^{-2})	Mean sediment concentration (Q_c) (g m^{-3})
Measured	0.006 24	160.3
Keller estimate	0.009	
Herheulidze estimate	0.068	
Poljakov estimate		2504.0

Table 4 A comparison of measured and estimated values of sediment yield for the Jasenica research basin during the period 1980-1989.

	t $year^{-1}$	t km^{-2} $year^{-1}$
Measured sediment yield	3 043.60	31.52
Sediment yield estimates by Poljakov + Keller	68 546.40	709.00
Sediment yield estimates by Poljakov + Herheulidze	517 906.00	5363.60

A comparison of measured and estimated values of sediment and water yield for the Jasenica River basin is provided in Tables 3 and 4.

CONCLUSIONS

Water and sediment yield measurements in the Jasenica basin during the period 1980-1990 offered the possibility of testing the accuracy of the Poljakov, Keller and Herheulidze equations under Yugoslavian conditions, where they are in common use. The main conclusions are summarized as follows:

(a) The Herheulidze method overestimates the mean water discharge ($m^3\ s^{-1}\ km^{-2}$) eleven-fold when compared with the measured value, and therefore cannot be recommended for practical use. For the same calculation, the Keller method is much more appropriate and can be applied with a reasonable degree of confidence (Table 3).

(b) If we accept that the method used for measuring sediment concentrations in the Jasenica basin was adequate and reasonably accurate, the Poljakov method for estimating sediment concentrations ($g\ m^{-3}$) can be seen to be problematic, since it leads to incorrect estimates of sediment yield, especially when combined with the Herheulidze formula (Table 4).

(c) All the methods tested need further refinement of their parameter values. This can only be achieved by experimental studies under various natural conditions. Until such refinement is achieved, the use of the methods in Yugoslavia, and especially in the Serbian Republic, cannot be recommended.

REFERENCE

Jeftic, L. J. (1978) *Inzenjerijski prirucnik za resavanje problema iz oblasti bujicnih tokova* (Manual for torrent erosion control). Posebno izdanje ICS, Beograd.