Concentrations and Transport of Suspended Sediment in Slovene Rivers

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Abstract: The purpose of suspended sediment load monitoring is to determine the concentration and total amount of suspended sediment at specific place along the river. Thus are obtained data for specific years and in multiannual periods. In monitoring network are included stations on 11 rivers. Multiannual mean values of transported suspended material of the Mura River are 360 thousand tons, of the Savinja River is about 320 thousand tons and of the Vipava River is about 27 thousand tons.

Key words: suspended sediment concentration, transport of suspended sediment, watershed area, gauging station, extreme hydrological situations.

Introduction

Hydrology service of Environmental Agency of the Republic of Slovenia is also carrying out systematic measurements of concentration and transport of suspended sediment. The sediment load is caused by river erosion on upstream section, by washing out of soil within catchment area or is a result of men interference in river bed. The purpose of suspended sediment measurements is to determine the total amount of suspended load sediment concentration at specific place along the river in one year and in long period.

In monitoring network are included stations on 11 rivers. On five rivers concentration of suspended sediment is measured every day and on six rivers only in time of extreme hydrological situations. Few times a year suspended sediment samples are taken in the cross sections of gauging stations, together with measurements of discharge. The result is determination of transport of suspended sediment in river, which is product of measured concentration and discharge. Sampling is performed by milk bottle, ´water trap´ and portable water sampler. In laboratory is done sample filtering and drying for evaluation of suspended material content.

Suspended material monitoring network

The frequency of sampling depends on the characteristics of the area in question and on the discharge regime. The analyses of the suspended material made so far showed that approximately 70% of the entire material is transported by high water. Thus, frequent sampling during high water waves is necessary. The network of stations for monitoring

Short scientific paper

the concentration of suspended material has been changing in Slovenia. The beginnings date back to 1955, when sampling started in the catchment area of the Savinja River. A regular monitoring of suspended material concentration on the rivers Mura and Vipava has been taking place since 1985. The number of sampling points on the Sava River is subject to change. Some stations were included in monitoring network only for short periods.

In year 2005 regular measurements of suspended material are carried out on six gauging stations: on the Mura River in Gornja Radgona, on the Sava River in Radovljica and Hrastnik, on the Sora River in Suha, on the Savinja River in Veliko Širje and on the Vipava River in Miren. Once a day a 1 liter sample is taken, it is then analyzed in a laboratory according to a classical filtration method. The results are the measured concentrations of suspended material (**c**) in g/m^3 of water. Along with regular taking and analyzing of samples, a sample taking in exceptional hydrological situations on six gauging stations takes place. With the help of sample analysis of the supplementary network, the data of regular measurements are easier and more accurately evaluated and at the same time the results present an overview of the high-water conditions all over Slovenia. Non regular sampling took place in 2005 on the Dravinja River in Videm, on the Sotla River in Rakovec, on the Soča River in Kobarid, on the Idrijca River in Hotešk, on the Bača River in Bača near Modrej and on the Reka River in the Cerkvenikov mlin.

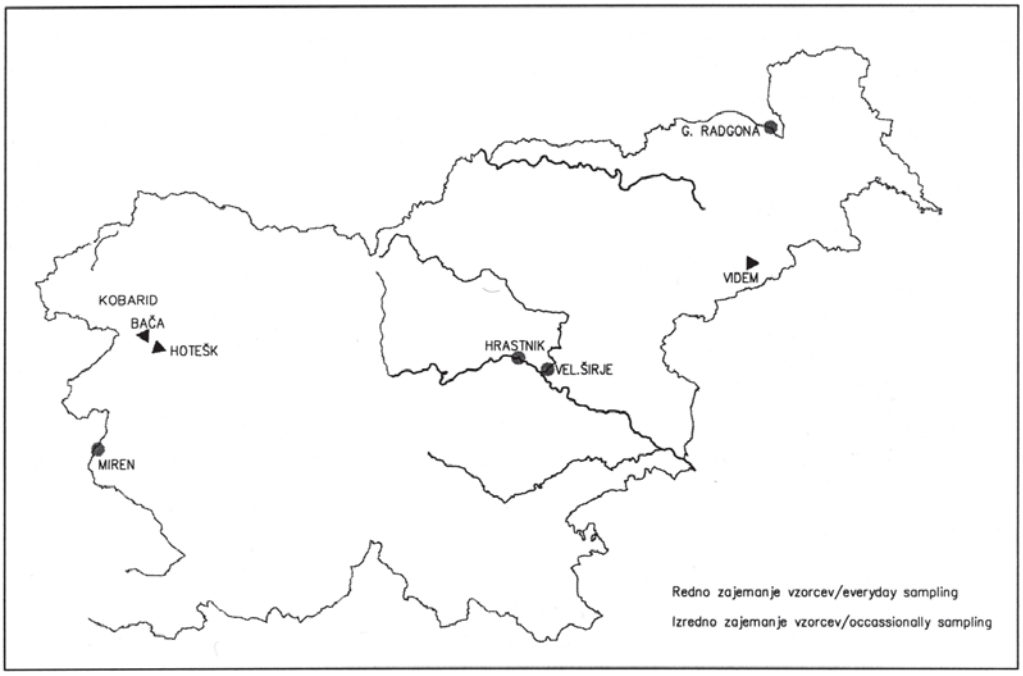

Figure 1. Stations with daily and occasional suspended sediment sampling in 2005

The highest concentration of suspended material in samples

On examination of the measured concentrations of suspended material on stations where samples are taken daily, it was found out that time of the increased concentration is in accordance with discharge regime. A discharge surplus, characteristic of the snow discharge regime (the Mura River), occurs in the transition from spring to summer. The highest concentration of suspended material was measured in May 1996, and it exceeded the mean concentration of the multiannual period by 43 times. The highest yearly concentrations in the Savinja River and in the Vipava River were measured in November, as was expected judging from the rain-snow

Table 1. The highest concentration of suspended material in samples taken in the period 1985-2004.

Station	*River*	*max c (g/m^3)*	*Date of max c*	*Multiannual mean c*
Gornja Radgona	Mura	2364	16.05.1996	50
Medno	Sava	3843	24.04.2000	24
Veliko Širje	Savinja	6026	07.11.2000	53
Miren	Vipava	1066	21.11.2000	17
Domžale	Kamniška Bistrica	2604	26.03.1986	
Pristava	Ščavnica	2623	29.11.1990	
Zamušani	Pesnica	4780	25.06.1997	
Otiški vrh	Meža	1606	08.11.1997	
Videm	Dravinja	4832	22.05.1999	
Kobarid	Soča	**8112**	17.11.2000	
Hotešk	Idrijca	3743	09.10.1993	
Rakovec	Sotla	1817	14.04.2002	
Bača pri Modreju	Bača	3085	10.10.2004	

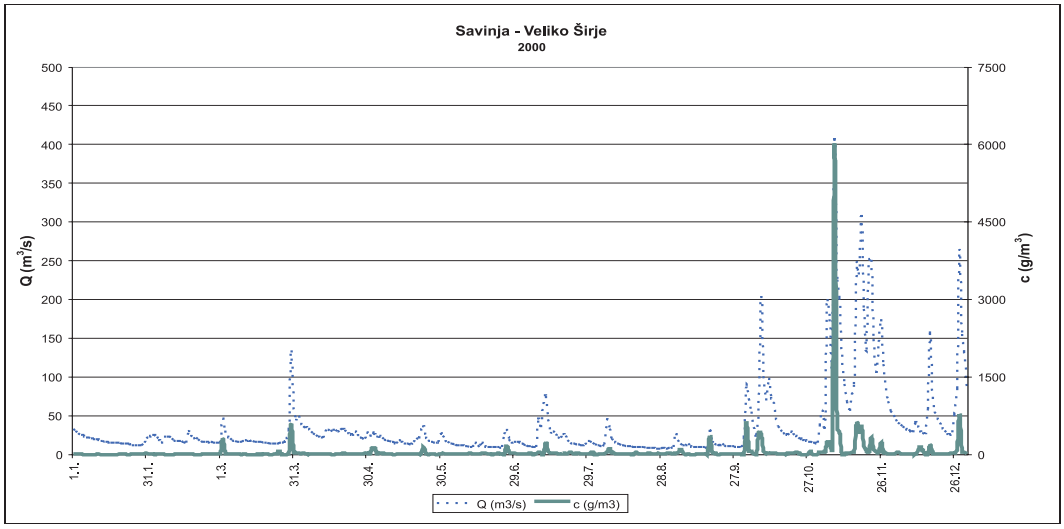

Figure 2. Mean daily discharges and concentrations of suspended material of the Savinja River in year 2000

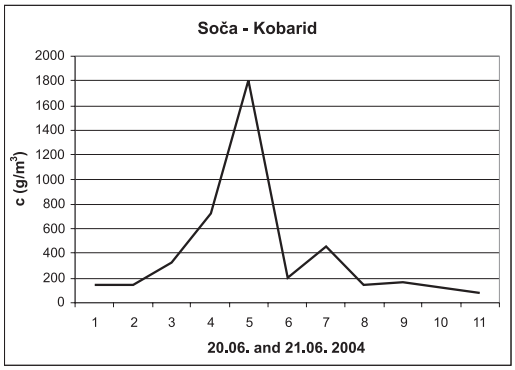

Figure 3. An example of suspended sediment concentration in extreme hydrological situation

Figure 4. Sample taking with water sampler

discharge regime, a characteristic of which is a discharge peak in spring and autumn. The highest concentration of suspended material in the Sava River was also measured in spring. On stations with samples taken in exceptional hydrological situations it was found out that concentrations of suspended material have been extremely high in last eight years. It is assumed to be the result of climatic change and strong storms in last years causing torrential flows.

SUSPENDED MATERIAL TRANSPORT

The relationship between the discharge change and the concentration of suspended material in a specific time is not entirely linear. The highest concentration of the sediment frequently occurs just before the peak of the high-water wave. Hence, it is difficult to foresee the quantity of the sediment. Into consideration have to be taken the part of the catchment where precipitation event took place, the geological structure of the area, antecedent soil moisture and the time elapsed since the last high-water wave.

The product of the concentrations of suspended material and water discharge through cross section equals to the transport of suspended material S (kg/s). In Table 2 are shown the yearly values of suspended sediment transport as well as the total sum for the period. On the basis of the catchment area knowledge, the decrease of earth surface in

Table 2. Yearly values of suspended material transport (thousand tons).

Station \ Year	*1990*	*1991*	*1992*	*1993*	*1994*	*1995*	*1996*	*1997*	*1998*	*1999*	*2000*	*2001*	*2002*	*2003*	*2004*	*Total*
MURA: G. Radgona	268	831	561	428	154	116	661	255	211	670	275	96	508	31	412	**5477**
SAVINJA: V. Širje					525	136	283	1322	381	244	269	109	57	49	191	**3566**
VIPAVA: Miren	15	8	54	49	29	16	25	37	20	9	32	24	43	5	44	**410**

the hinterland of individual stations can be estimated. In this way, the following estimate is possible: in similar hydrological and erosion conditions as registered in the 15-year period, the surface of the Mura River catchment area would decrease on average for 12 mm, the catchment area of the Vipava River for 16 mm and of the Savinja River for 86mm in thousand years. When interpreting these values it is necessary to take into account the geological variety of the hinterland, the selectivity of erosion, the corrosion in karstic areas, the short set of data and the long period necessary for most of the geomorphological changes. This factors are source of erosion variability within the catchments as well as source of differences among the catchments shown.