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GRAIN SIZE DISTRIBUTION OF SUSPENDED SEDIMENT DURING RAINFALL AND SNOWMELT FLOODS IN SMALL LOWLAND RIVER

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ABSTRACT

This paper present information on particle size variation during rainfall and snowmelt flood from the small agricultural catchment. The grain size distribution during two rainfall, three snowmelt and one rainfall-snowmelt flood was compared. The average percentage of clays size material (<4 μm) for all samples was 2.7%, silt size material (> 4 μm and <62 μm) was 42.8% and sand (>62 μm) was 54.5%. The average median (d_{50}) for floods ranged between 49.8 microns and 98.3 microns depend on the flood.

Key words: suspended sediment, particle size, rainfall and snowmelt floods.

INTRODUCTION

The suspended sediment is usually a major part of the sediment transported in the particular river cross-section. It is know that excessive quantity of the suspended sediment has negative impact on the environment. One of the basic parameter of suspended sediment is a grain size which has an important role in water quality, contaminant adsorption, river bed stability and siltation of the reservoirs. During large floods the particle size classes can depend of discharge. In a mountain stream [5] it is reported the increasing of coarser suspended material near the peak flow. Similarly, the pulse of the coarser particle on the rising limb of the hydrograph was also reported during large floods in British rivers [6]. But there is no much investigation in a small watershed when the floods are not big. In our case we use laser diffraction method for estimation of suspended sediment grain size during floods for small lowland watershed.

STUDY CATCHMENT

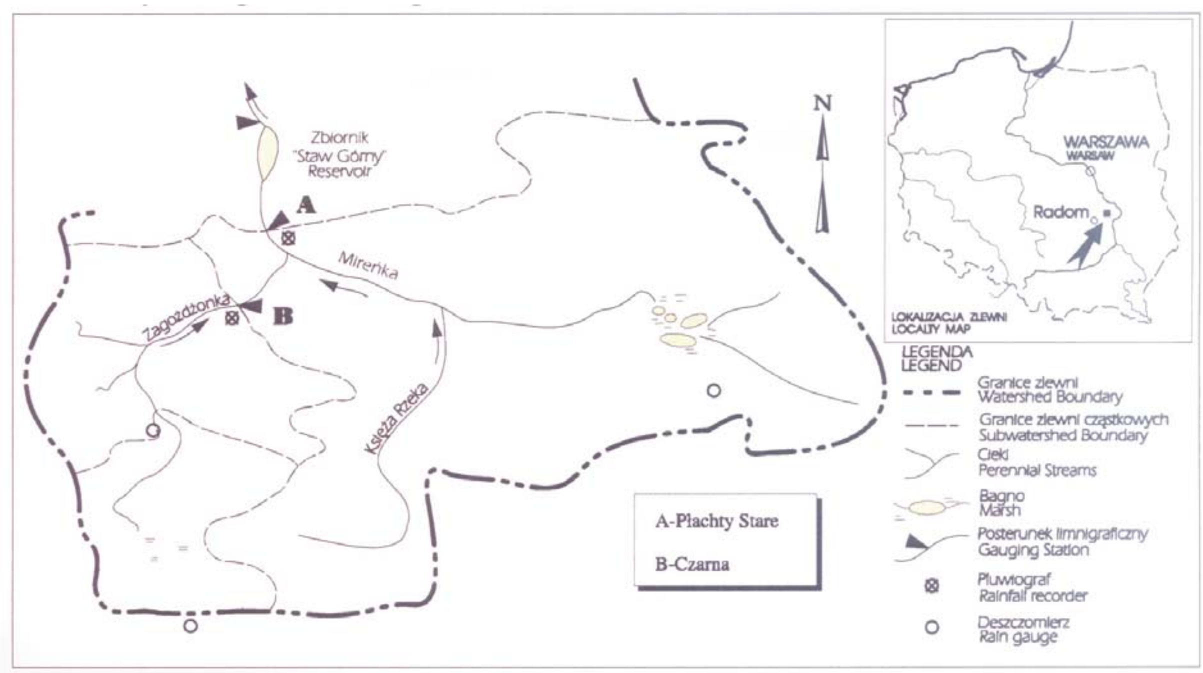
The Zagożdżonka watershed is located in central Poland, about 100 km south of Warsaw. Total area of the watershed with the considered in this study outlet point at Czarna gauging station (Figure 1) is 23.4 km^2.

The dominant soil type are sandy soil, ranging from almost pure to loamy sands. In depressions areas like river beds, peaty soils can be found. Generally sandy soil cover over 90% of watershed to Czarna gauging station. The Zagożdżonka watershed is located about 170 m above sea level, and absolute relief of the sub-catchments is 26.5 m, so it can be considered of lowland type and is typical for central Poland. The area is for 64% under cultivation, almost one forth (24.1%) is covered by forest and 10.7% is pasture land. The remaining 1.2% is occupied by other forms of land use [1]. The mean annual suspended sediment concentration (SSC) is low and estimated for 14 mg/l, however during floods the concentration increase and the highest recorded reach 219 mg/l [3].

METHODS OF INVESTIGATIONS

The Czarna gauge station is equipped with electronic monitoring system consist of data logger, tipping bucket rainfall gauge, water level sensor, infra red Partech IR100C concentration sensor, water and air temperature, and humidity sensors [2]. To receive the suspended sediment grain size distribution during floods, the samples with 2 hour time step were collected by refrigerated sampler.

Fig. 1. Locality of Zagożdżonka catchment



The laser diffraction method was applied for estimation of grain size distribution [4]. The laser diffraction method allows to estimate the small particle sizes. In this investigations the Malvern Mastersizer Micro Plus was applied. The range of measurement is from 0.05 to 550 micrometers. The method determined the equivalent diameters as sphere of the same volume.

RESULTS AND DISCUSSION

The Lane's sediment grade scale [7] has been used for determination of sediment classes during floods. The size of 4 micrometers is the value which distinguish between clay and silt and diameter of 62 micrometer distinguish silt and sand.

During the investigation period the six flood events were taken into consideration. The table 1 present major parameters of the floods. Three of considered events were snowmelt, when the floods were caused by melting of snow cover. The flow peaks as well as peak of SSC were smaller comparing with rainfall floods. Two floods were typical rainfall and one begins with melting of the snow cover and next was supply by rainfall.

Table 1. Basic characteristic of floods

Number	Data	Type of the flood	Peak flow (m^3/s)	Peak of SSC (mg/l)
1	2-3.02.2004	snowmelt	0.18	17.0
2	13-14.03.2004	snowmelt	0.21	22.0
3	21-22.03.2004	rainfall	0.60	29.4
4	24-25.02.2005	snowmelt	0.20	23.6
5	16-18.03.2005	snowmelt-rainfall	3.35	69.9
6	4-5.05.2005	rainfall	0.90	41.4

When we compare the hydrograph and sedimentgraph of each flood, the different pattern can be noticed. Snowmelt floods (nr 1 and 4) are a kind of two peak floods. The highest SSC occurs during first small peaks in this cases. Snowmelt flood nr 2 is more similar to rainfall flood nr 3 where the peak of SSC and flow peak are almost in the same time. During floods nr 5 and 6 the SSC priori the flow peak.

Sampling of suspended sediment during floods made possible to analyzed the variation of grain size distribution during particular floods. The hydrographs, sedimentgraphs and percentage of suspended sediment classes are shown on figures 2 to 7.

Fig. 2. Hydrograph, SSC and suspended sediment size classes of flood nr 1

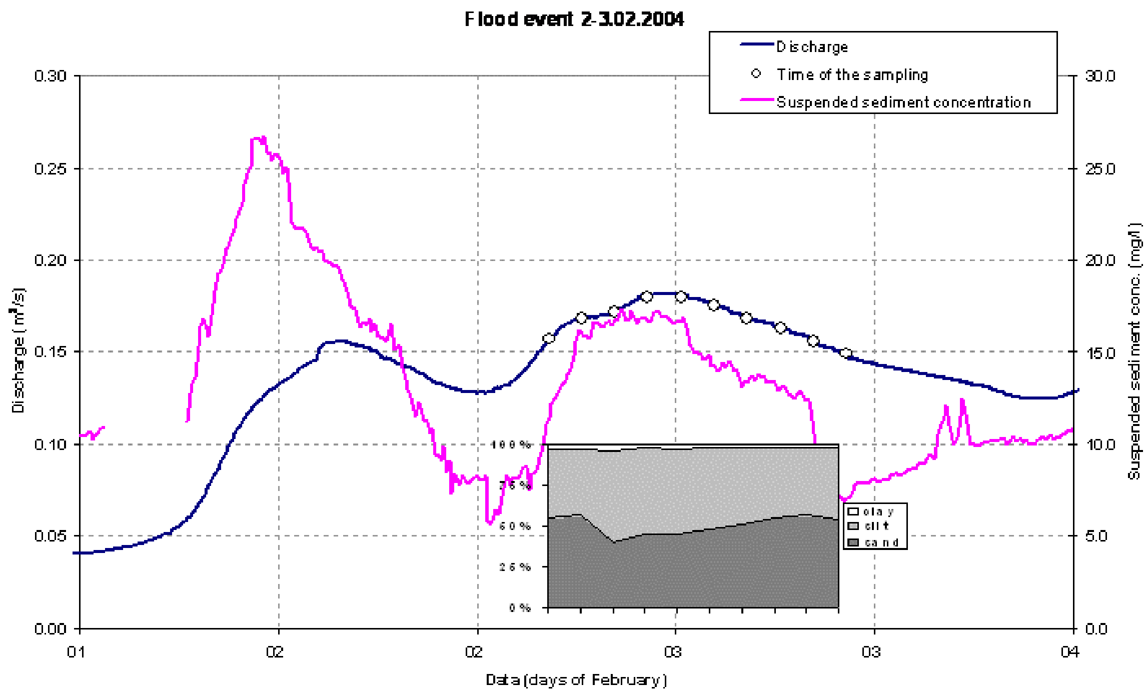


Fig. 3. Hydrograph, SSC and suspended sediment size classes of flood nr 2

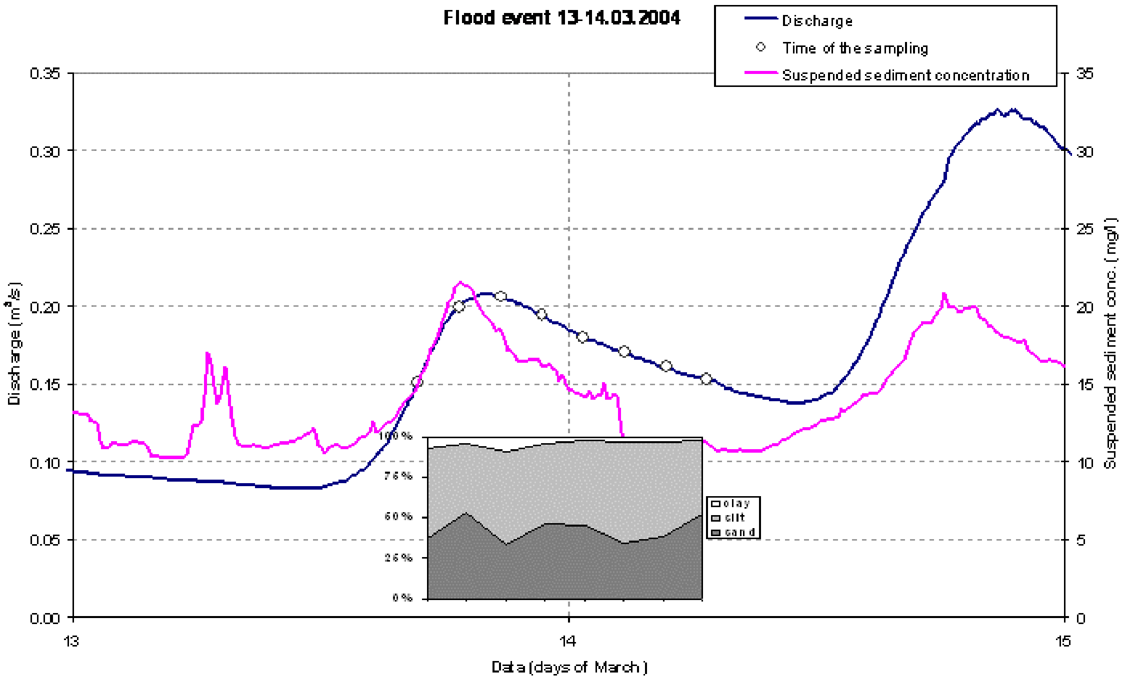


Fig. 4. Hydrograph, SSC and suspended sediment size classes of flood nr 3

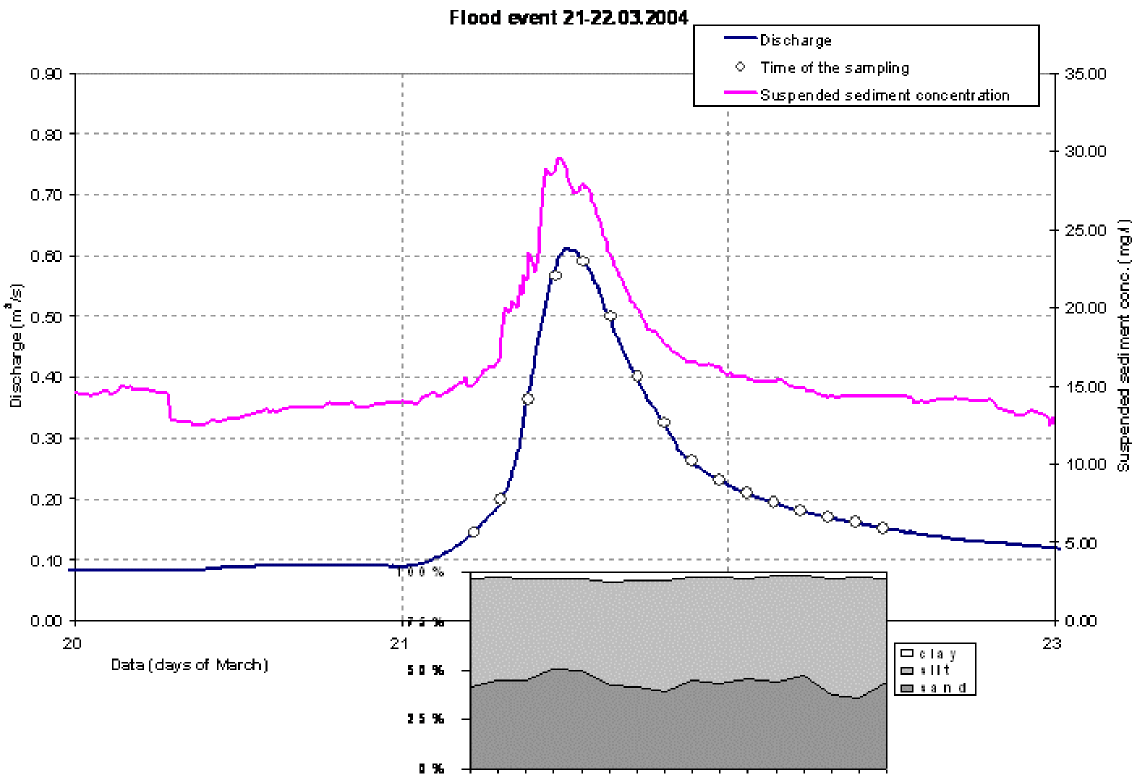


Fig. 5. Hydrograph, SSC and suspended sediment size classes of flood nr 4

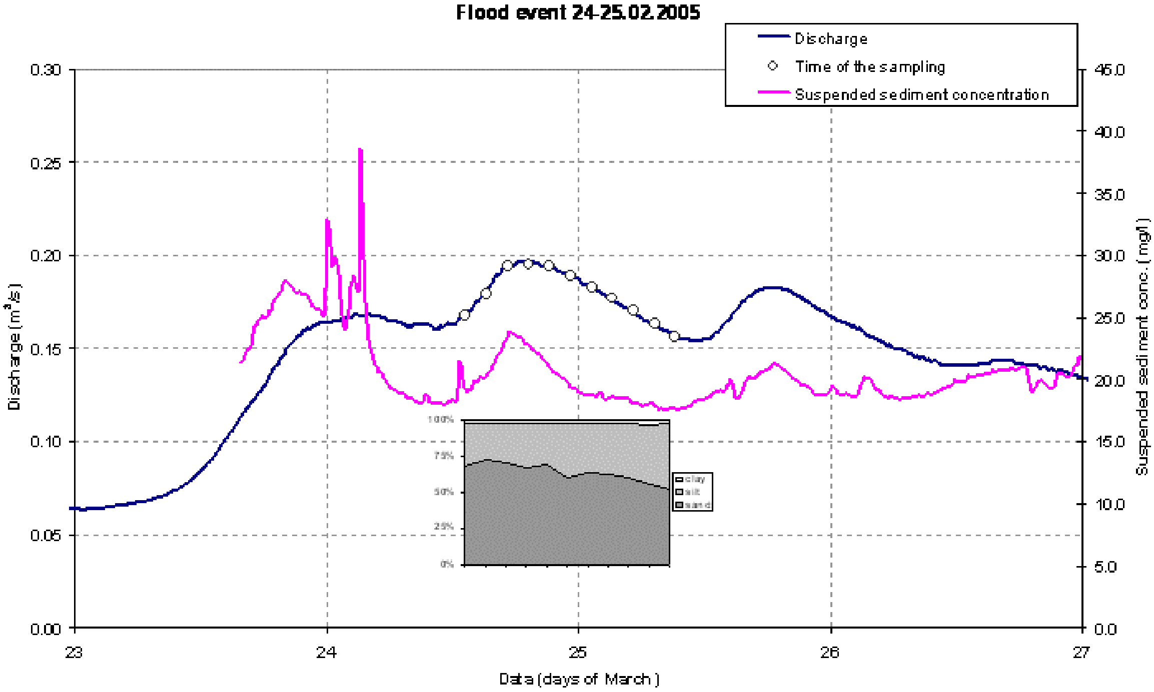


Fig. 6. Hydrograph, SSC and suspended sediment size classes of flood nr 5

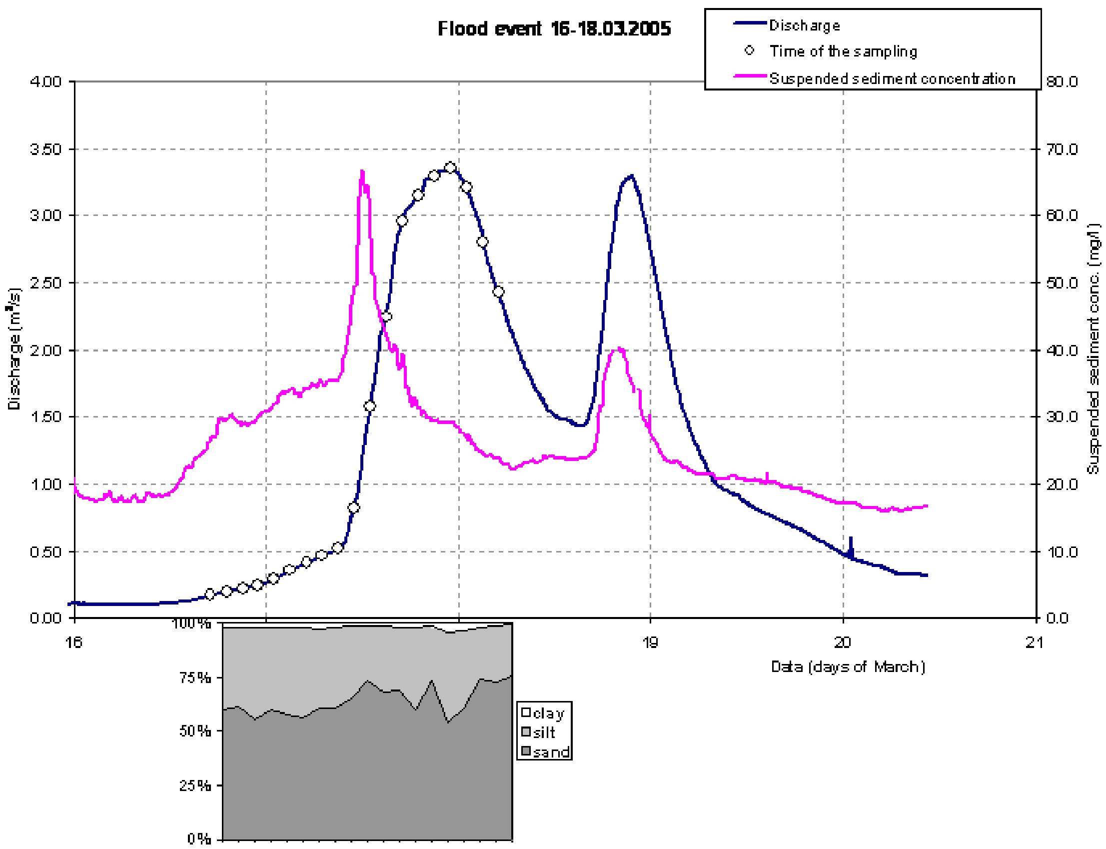
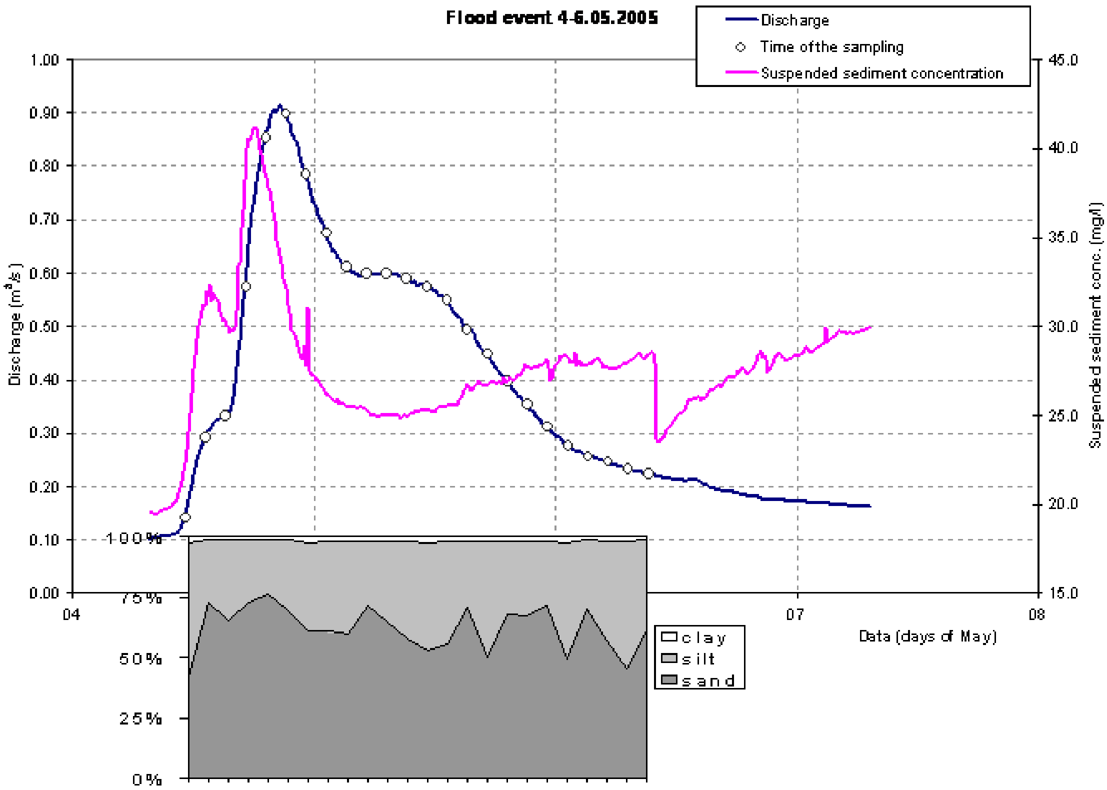


Fig. 7. Hydrograph, SSC and suspended sediment size classes of flood nr 6



Generally there was no significant relation between increasing of discharge and particle sizes. The percentage of clay, silt and sand is quite similar during particular floods. Average percentage of classes is shown in table 2. Even during the biggest flood (nr 5) there is no evidence of increasing of percentage of coarser material. The flow velocity seems to be to small to mobilize the coarser particle and transported as suspended sediment for all considered floods. There was no significant differences between particle size during snowmelt and rainfall floods.

Table 2. Average percentage of suspended sediment classes

Number	Clay (%)	Silt (%)	Sand (%)
1	2.3	47.0	50.7
2	4.5	53.0	42.5
3	3.2	53.2	43.6
4	2.2	33.9	63.9
5	2.2	33.7	64.1
6	1.7	36.0	62.3
Avarage	2.7	42.8	54.5

The good characterization of grain size distribution are the characteristic diameters (Table 3). The data represent average of all samples taken during particular flood. The standard deviation (SD) characterize the variations of particular characteristic diameter during certain flood. The low values of SD in case of d_{10} suggest that the was no significant variation of small particles. The highest variation can be seen in values of d_{90}. It can suggest that the biggest particles vary the most during flood.

Table 3. The average characteristic diameters d_{10},d_{50},d_{90} and SD

Number	d_{10}	SD	d_{50}	SD	d_{90}	SD
1	12.4	1.06	62.5	7.02	218.7	92.63
2	9.9	4.10	49.8	12.80	165.1	55.26
3	10.2	2.01	53.5	6.24	197.1	29.50
4	19.1	3.90	98.3	26.04	297.9	66.34
5	20.9	5.32	95.5	22.76	294.5	50.01
6	21.1	5.57	88.7	21.05	297.7	43.47

SUMMARY

The pattern of grain size classes show variation during particular floods. There was no significant increasing of suspended sediment sizes near the peak flow, what can be explained by quite low flows. Even during the biggest flood (peak flow 3.35 m^3/s), the velocity was probably to low to mobilize the coarser material to be transported as suspended sediment. The percentage of clays size material (<4 µm) varied from 1.7 to 4.5%, silt size material (> 4 µm and <63 µm) was between 33.7 to 53.2% and sand material (>63 µm) ranged between 42.5% to 62.1%. The average median (d_{50}) for floods ranged between 49.8µm and 98.3 µm.

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