II－49

THE TRANSPORT OF FINE PARTICULATE MATTER DUE TO RAPID CHANGE OF FLOW

Tohoku University Member Sitang PILAILAR
Tohoku University Member Yuko HARA
Tohoku University Member Norihiro IZUMI
Tohoku University Member Hitoshi TANAKA

1. INTRODUCTION

While the majority of organic matter inputs to streams are as coarse particulate matter (CPOM: > 1mm), the smaller size fractions, that are fine particulate organic matter (FPM: 1 mm to 0.45 μm) and dissolved organic matter (DOM: < 0.45 μm), dominate in the export of organic matter in streams. The concentrations and fluxes of these three fractions have been extensively studied. The concentration of DOM varies little with changes in discharge, but CPOM and FPOM concentrations increase greatly as discharge increases.

In order to clarify the movement of fine particulate mater (FPM) due to the fluctuation of flow, comparisons of the FPM concentrations in the flowing water during a small flood period and the operation of weir have been done. The entrainment and deposition fluxes of FPOM due to hydrologic fluctuations have been assessed based on the amount of FOM in the riverbed before and after rapid change of flow.

2. STUDY AREA

This study focuses on the lower reach of the Nanakita River, 4 to 17 km upstream of the river mouth, as shown in Figure 1. The riverbed gradient is about 0.0016 in the relatively upstream reach in the study area and about 0.0003 in the lower reach.

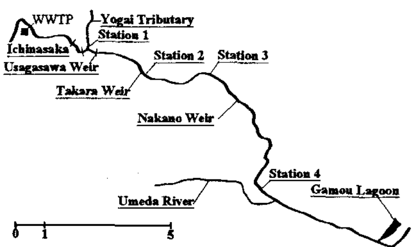

Fig.1 The Nanakita River, 17-km reach from river mouth

3. METHODOLOGY

3.1 Experiments and Analysis of Sediment and Resuspendable FPM

In order to obtain the information on the availability of resuspendable solid in the riverbed, bed sediment were collected at four stations, as depicted in Figure 1 before and after the field experiments of rapid change of discharge. A full description of sampling methods and analysis were mentioned in Pilailar et al., 2004. The samples were analyzed to determine the amount of suspended solids (SS) which represents the availability of resuspendable solids.

3.2 Experiments and Analysis of Suspended Solids in Flowing Water during Periods of a Small Flood

During a small flood caused by Typhoon No.10 on 9 Aug. and 10 Aug., 03, the flowing water samples were collected by portable auto samples S-4800 at three stations: Stations 1, 3 and 4 (Figure 1). The samples were analyzed to determine SS by the same methods mentioned in 3.1.

3.3 Experiments and Analysis of Suspended Solids in Flowing Water during Weir Operation Period

On 16 Sept., Usugasawa weir was operated, in which the stored water was released. It caused the rapid change of flow downstream. The flowing water samples were collected at Stations 3 and 4. Water of 1000-ml was taken every 20 minutes. The samples were analyzed to determine SS.

4. RESULTS AND DISCUSSION

4.1 Transport of FPM during the Flood

The temporal change of SS in flowing water at Station 1 during flood is presented in Figure 2. The figure also shows the discharge that is estimated based on water level recorded near the station.

There are two distinct peaks of the discharge. Both of the peaks were accompanied by the peaks of SS. The first peak of the concentration of SS was observed at almost the same time as the first peak of discharge. Before the second peak of discharge appeared, SS increased sharply at the beginning of the increase in discharge, and then gradually increased in the next several hours. The second peak of SS was achieved a moment after the peak of discharge appeared. It is suggested that the first peak of SS concentration was caused by the entrainment in the proximity of the stations. Similarly, the sudden rise of SS at the beginning if the second peak of the discharge was also due to the entrainment near the stations. Meanwhile, the second peak of SS was transported from further upstream. This is because the peak of discharge travels downstream faster than the velocity of flow (Kleitz-Seddone's theory) while substances are usually transported with flowing water.

4.2 Spatial Variations of FPM before and after the Flood

The amount of resuspendable fine particles on 7 Aug., before the flood, and 11 Aug., after the flood, at four stations is shown in Table 1. From the differences in the amount of SS before and after the flood around four stations, the total entrainment and deposition during this period can be estimated. The availability of FPM in mixed bed at Station 1 increased about 22%. The total deposition rate is then estimated to be 25 g/m^2. At Station 2, the total entrainment rate was approximately 1.2 g/m^2. The availability of FPM in the riverbed was remarkably decreased at Station 3 by 59 %, in which the entrainment rate was 41.8 g/m^2. At Station 4, there was 12% of the increase of fine particles, the total deposition rate of which is 66.4 g/m^2.

4.3 Transport of FPM during the Operation of Usugasawa Weir

On 16 Sept., 03, from 17:00 to 18:00, all of the stored water by Usugasawa weir was released to the downstream. It caused the abrupt change of discharge along the reach. FPM in the riverbed was suspended and transported downstream as presented in the spatial and temporal changes of SS concentration at Stations 3 and 4 (Figure 3). The discharges, which are estimated based on water surface level at Takara weir and Nakano weir, are also shown.

Peaks concentrations of SS are achieved on the rising limb of the hydrograph and decline sharply before maximum discharge are reached. Export of FPM by flowing water due to the weir operation behaves in the different manner from the behavior found during small flood (Figure 2.).

This phenomenon is probably due to a rapid suspension of very light particles early at the beginning of flow increase. The availability of FPM in the riverbed is then depleted rapidly before peak of discharge is reached, accounting for the decrease in concentration during later stage of flow.

4.4 Spatial Variations of FPM before and after the Rapid Change of Flow

The availabilities of resuspendable FPM in the riverbed at four stations before and after the period of the rapid change of discharge are presented in Table 1. The amount of FPM in the mixed bed at Station 1, which is located at the upstream of Usugasawa weir, increased as time progressed. The total deposition rate within 2 days is then estimated to be 3 g/m^2. At Stations 2 and 3, the total entrainment rate of fine solids was approximately 20 g/m^2 and 48 g/m^2, respectively. At Station 4, the abundant FPM was observed on 17 Sept., in which the total deposition rate is 245 g/m^2.

5. SUMMARY

The transport processes of fine particulate matter due to the rapid change of discharge were investigated twice, during the small flood caused by a typhoon and during the weir operation.

The flood caused hydrologic fluctuation along the river, in which two typical patterns of the time variation of FPM concentration were observed. It is suggested that the first peak of SS which appeared simultaneously with the peak of discharge was caused by the entrainment in the proximity of the sampling points. In the other pattern, in which the peak of SS appeared several hours after the peak of discharge, fine particles were transported from further upstream.

The rapid change of flow due to the weir operation caused the entrainment of light material at the beginning of the change of discharge. Since the availability of FPM in the riverbed is then depleted rapidly, FPM concentration decreased sharply before peak of discharge is reached.

Table 1 The availability of FPM (mg/cm^2) in the sediment before and after the rapid change of flow

Sampling Point	During Flood			During Weir Operation		
	7 Aug.	11Aug.	Dif (%)	16Sep.	17Sep.	Dif (%)
St1	11.16	13.65	22.3	17.68	17.97	1.6
St2	5.28	5.16	-2.3	7.54	5.55	-26.4
St3	7.06	2.88	-59.2	7.76	2.98	-61.6
St4	52.24	58.88	12.7	72.51	96.97	33.7

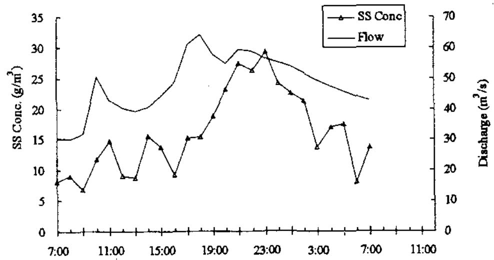

Fig.2 The time variation of SS concentration during the flood at Station 1.

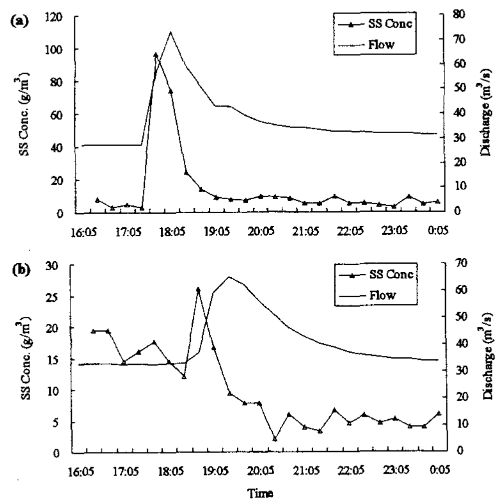

Fig.3 The time variation of SS concentration caused by Usugasawa weir operation, at (a) Station 3, (b) Station 4.

REFERENCES

1) Pilailar S. et al. "Effects of Hydrologic Fluctuations on the Transport of Fine Particulate Organic Matter in the Nanakita river", *Annual J. of Hyd. Eng., JSCE.* 48, 2004(in Published).