Monitoring method on pick-up rate of sediments in rivers

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INTRODUCTION

To manage and control water quality environments in an urban river, it is quite important to quantitatively evaluate the yields and transport processes of pollutants from point and non-point sources. Sediments in an urban river, one of non-point sources, are transported due to hydrologic events. The water quality environments in rivers under rainy conditions are directly dependent upon a pick-up rate of sediments. However we have poorly understood a pick-up rate of sediments in an urban river under various flow conditions. One of the reasons is that there is not an appropriate device to measure an in situ pick-up rate of sediments. In the present study, we present a new device which may easily measure an in situ pick-up rate of sediments under various flow conditions. With the new device, we conducted field observations for the erosional properties of sediments in an urban river.

MEASUREMENTS FOR A PICK-UP RATE OF SEDIMENTS WITH A NEW DEVICE

To monitor a dependence of the pick-up rates of sediments P_k on flow conditions, we attempt to make a new device which can directly observe in situ pick-up rates of sediments. Figure 1 shows the schematic view of the new device which has two cylinders arranged in a concentric configuration. We stir a rod in the gap between two cylinders with width of 7 cm. Since the width of the gap is narrow, the velocity distribution in the gap is expected to be almost uniform in the radial direction. We may vary the current speeds in the gap of the device, and hence the pick-up rates P_k can be evaluated under various flow conditions with the device.

The procedure of the filed measurement with the new device is described as follows:

1. We set the device at prescribed positions on river bed.
2. We stir a rod in the gap between two cylinders during 30s.
3. The surface turbidity is measured during 30s after the step 2.

In measuring the turbidity, we adopted a turbidity sensor (W-22P, HORIBA Co., Ltd.). The current speeds in the gap, U, were set to be 0.32, 0.43, 0.64, 0.85 and 1.28m/s. The pick-up rate P_k is evaluated with the measured turbidity and a well-known formula of sediment transport.

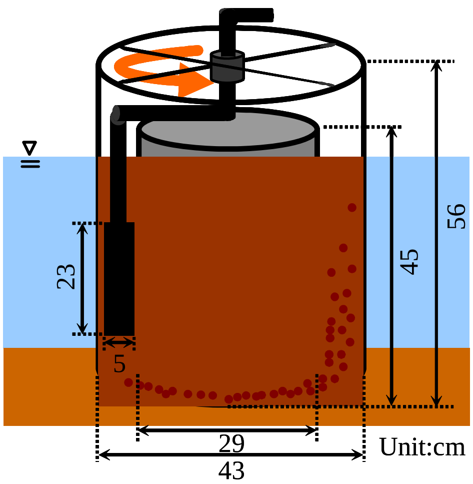


Fig. 1 Schematic view of a new device

As shown in Fig.2, the field measurement was done at three stations in the Oohori River which flows into Lake Taganuma, one of well-known eutrophied lakes in Japan. At the upstream region of Stn.1, the flooding from the north-Chiba water conveyance channel has been done to improve the water quality environments in the Oohori River. The observational period was from July 1 to 26, 2002. The water depth at the measuring stations was from 0.2 to 0.4m under normal atmospheric conditions. We also monitored continuously the water elevation and turbidity at Stns.1 and 3 with memory-type sensors.

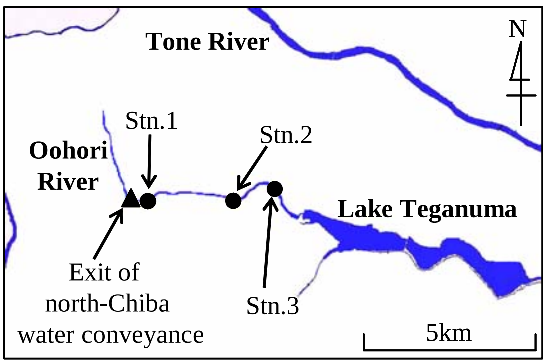


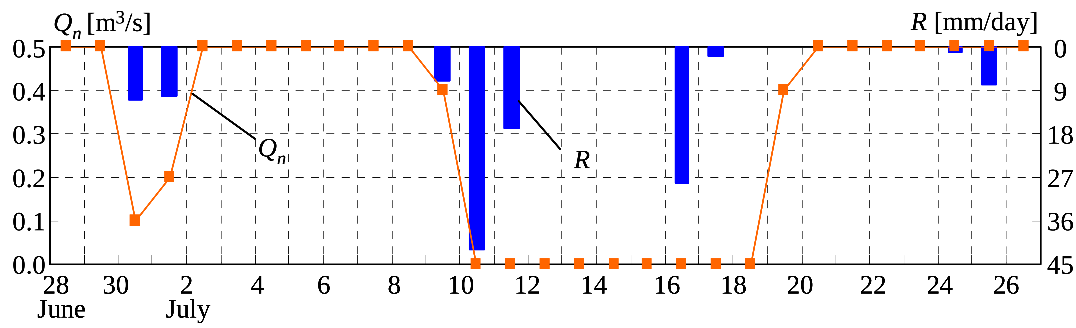
Fig. 2 Locations of measuring points in the Oohori River

RESULTS AND DISCUSSION

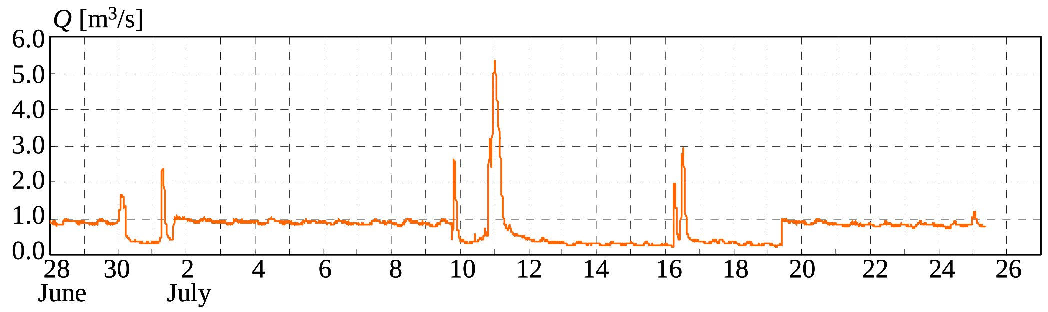
To understand the characteristics on the temporal and spatial variations of P_k, Fig.3 displays the time series of P_k

and hydrodynamic environments in the river which are daily precipitation R, the flooding discharge from the north-Chiba water conveyance channel Q_n and the river discharge Q at Stn.1. The averaged value of P_k under the velocities of 0.64m/s and 0.85m/s is depicted in the figure. During this period, there were two hydrologic events: one occurred from July 9 to 11 and the other appeared on July 16. The comparison of P_k among three stations illustrates that the pick-up rate at Stn.1 was wholly larger than those at Stns. 2 and 3. To clarify these spatial differences of P_k, the grain-size distributions of sediments at Stns. 1, 2 and 3 are compared. The result of the grain-size distribution exhibits that the grain size at Stn.1 was finer than those at Stns. 2 and 3. Since the erosion rate of fine sediments may be generally greater than that of coarse sediments under same flow conditions, the spatial difference of the erosion rates among three stations may be caused by that of the grain size.

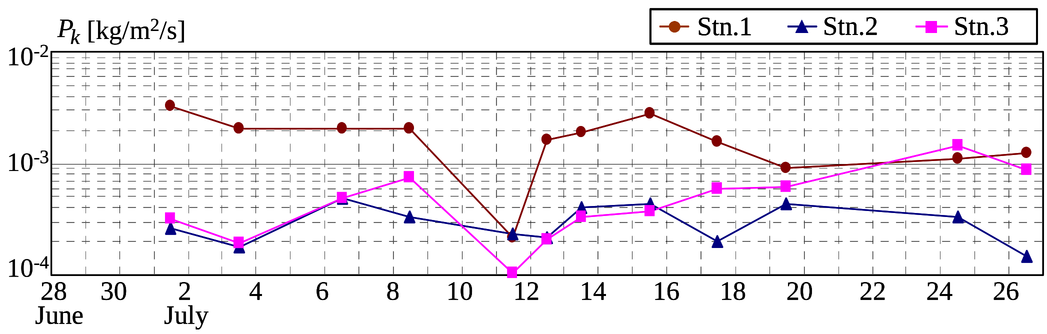
To reveal the influences of hydrodynamic envirnments on the temporal variations of the pick-up rates, we examine the relationship between the pick-up rate P_k and the hydrodynamic environments. The comparison between the daily precipitation R and the pick-up rate P_k indicates that in the hydrologic event from July 9 to 11, the erosion rates at three stations decreased. On the other hand, in the hydrologic event on July 16, P_k at Stns. 1 and 2 decreased and at Stn.3 increased, respectively. The precipitation in the latter event was less than that in the former event. Since the deposition process in the estuary of the Oohori River is dominant under relatively less precipitation and river discharge, the temporal fluctuations of P_k differed in two hydrologic events. Noteworthy in Fig. 3 is that, after the former hydrologic events, the pick-up rate increased rapidly at all stations. It took a few days until P_k after the event reached that before the event. The rapid increase of the pick-up rate of sediments may be strongly influenced by high pollutant loads from the urban basin, which directly causes the eutrophication of Lake Teganuma.



(a) Daily precipitation R and discharge from north-Chiba conveyance channel Q_n



(b) River discharge Q at Stn.1



(c) P_k at Stns.1, 2 and 3

Fig.3 Time series of P_k and the hydrodynamic environments