Sediment outflow on the steep slope fields which have been contributing to the Mrica reservoir sedimentation in Central Java, Indonesia

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1. Introduction

Mrica reservoir is located in Banjarnegara Regency, Central Java Province, Indonesia. The reservoir that was built for irrigation water supply and hydroelectric power has inundation area $8.2\text{x}10^{6}$ km^2. Recently, turbidity and reservoir sedimentation due to sediment discharge from upper area has becomes severe problem. About $4.27\text{x}10^{6}$ m^3 of sediment discharged from watershed into reservoir annually. Since last 2 decades land use changes from forest to cultivation lands has started in upper Mrica watershed intensively. Purpose of this study is to reveal actual sediment discharge situation from steep slope field by conducting hydrological observation as sediment supply to reservoir sedimentation.

2. Study area

Mrica watershed (A = 905 km^2) contains 3 main basins that are Serayu (A = 678 km^2), Lumajang (A = 8 km^2) and Merawu (A = 219 km^2) river basin (Figure 1). Altitudes are varies range from 250-2,300 meter above sea level. Wet season more dominate than dry season with average annual rainfall is 2,800 mm. Main prevailing soil type is *laterite* or *solum* (66%). Land use is paddy field and dry field in the lower, bushes, and forest in the middle and mostly cultivated land in the upper area. Approximately 30% of the watershed is cultivated area, especially in Merawu river basin (satellite image LS7 / 2003-5-20).

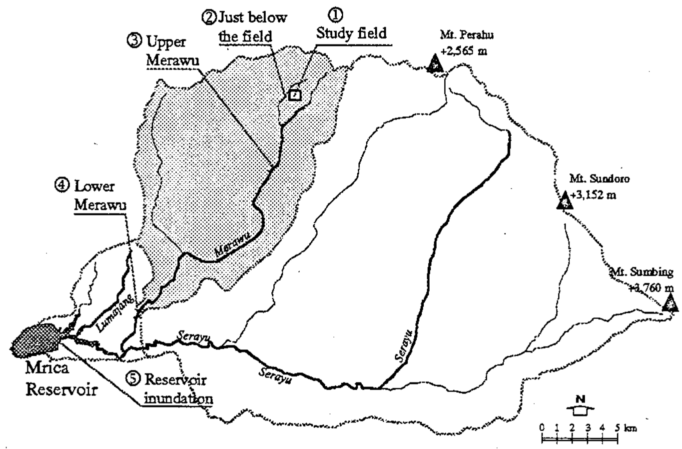

Fig.1 Catchment area of Mrica reservoir and Merawu river basin [①~⑤ observation point]

Numerous fields as terrace-bench were established in large scale up to steep slope (>10°), with high frequent of 3 times plowing per year. Main crop are potatoes, cabbage, corn and tobacco. Based on UBP Mrica office 1989-2002 measurement data, Merawu river basin contributes major sediment discharge into reservoir with average annual erosion rate is approximately 10 mm.

3. Hydrological observations

Sediment discharge observation at field, and hydrological measurements (surface water sampling, flow velocity and discharge) has been conducted during February 14-22, 2004. Monitoring of rainfall-runoff response (soil moisture, sediment discharge, concentration, and grain size) was conducted in two different plots condition. First, *plot A* in planted area (vegetation cover ratio about 30%) of 16x25 m^2 with 20° slope gradient at upper part of field and second is *plot B* on the same gradient of new cultivated area 4x4 m^2 below the first plot, for monitoring the soil pile formation due to erosion. Hydrological measurement and surface water sampling was conducted simultaneously at upper, middle and lower river course.

4. Results

① Rainfall intensity of 42-58 mm/hour produces surface erosion with average erosion depth 1 cm (indicated by soil piles, the height varies from 0.5-2.0 cm). Approximate of erosion velocity for 70 minutes rainfall is varies from 0.01-0.03 cm/min and average surface flow velocity is about 25 cm/s.

② Hourly rainfall intensity of 18 mm cannot cause sediment outflow from field, but 58-mm/hr of rainfall intensity can produce sediment outflow from field.

③ Ratio of gully sediment discharge volume is about 2% of surface erosion. It might be due to terrace bench step restricted gully length development. Slope gradient near the gully varies 15°-20° with gully slope length ranging from 5-12 m. Most of the gully was developed by spill of flow from drainage in the field.

④ Response of sediment discharge hydrograph of each plot A and B rise sharply near peak of rainfall and decline sharply as well (Figure 2). Maximum sediment discharge at near peak is about 675 ml/s.

⑤ Sediment concentration of both plots A and B is approximately alike ($C_A \approx C_B$) in range 18-30% although sediment discharge is totally different ($Q_A >> Q_B$). Judging from this high concentration, the sediment movement type is categorized as sediment flow.

⑥ Grain size of discharged sediment from plot A and plot B are fine material as silt 40 -60% and the remaining (60-40%) are sand. Original condition of soil in the field was 70% as silt and clay.

⑦ After 3 hours peak rainfall, turbidity at lower Merawu raise sharply to 780 mg/L (Figure 3). Judging from this time lag of increasing turbidity at lower Merawu and flow velocity, as well as middle reach land use, it can be assumed that fields in the upper Merawu is the main sediment sources.

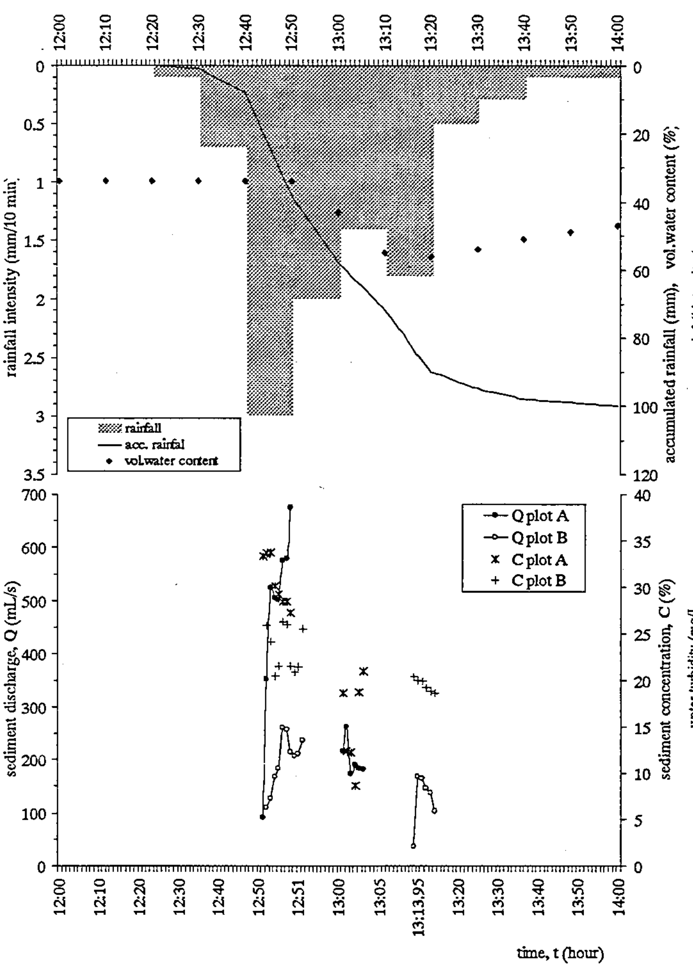

Fig. 2 Sediment discharge and concentration response to rainfall event on Feb 21, 2004

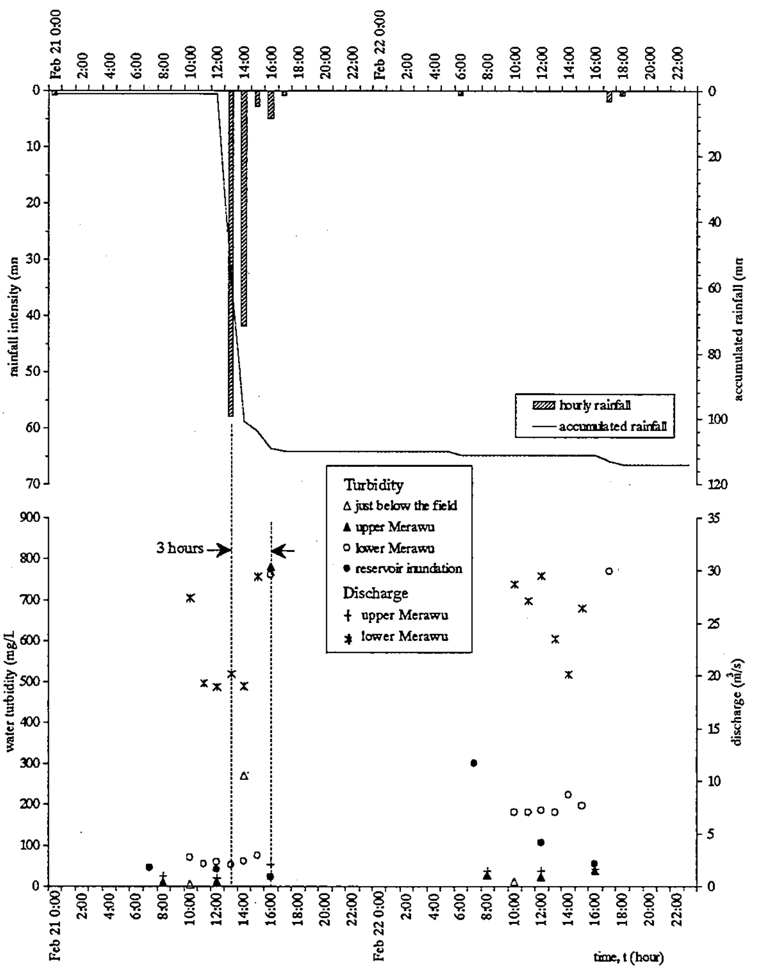

Fig. 3 Hyetograph of hourly rainfall and turbidity relationship at several sampling point on Feb 21-22, 2004

5. Acknowledgement

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6. Reference

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