

## RESERVOIR SEDIMENTATION DUE TO DEBRIS FLOW AND ITS MEASURES IN WLINGI, EAST JAVA AND BILI-BILI, SOUTH SULAWESI

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**Abstract:** This paper reports the sedimentation of Wlingi reservoir and Bili-Bili reservoirs that have similar mode of sedimentation in the volcanic region. Measures to sedimentation for both reservoirs are construction of sabo dam facilities and land conservation. Specific measures to sedimentation for Wlingi reservoir are dredging works, flushing and bypassing whereas for Bili-Bili reservoir is sediment removal from rivers.

**Keywords:** Reservoir, measures to sedimentation, debris flow, volcanic region

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### INTRODUCTION

Wlingi reservoir is located in the Regency of Blitar, Province of East Java (Fig. 1a). The reservoir collected water from the catchment area of 2.890 km<sup>2</sup> in the south of Mt. Kelud, collecting water for the design capacity 24 millions m<sup>3</sup>. The annual rainfall in the basin ranges from 1,721 mm to 2,487 mm and the maximum and minimum monthly rainfall are 448 mm and 12 mm respectively. This reservoir construction was completed in 1977. Mt. Kelud erupted on a large scale every 15 years and the last biggest eruption occurred in February 1990 [5]. The erupted material contributed rapid sedimentation in the reservoir and other cultivated lands.

Bili-Bili reservoir is located in the Regency of Gowa, Province of South Sulawesi (Fig. 1b). The reservoir stands at 25 downstream of Mt. Bawakaraeng, draining an area of 384.4 km<sup>2</sup>, collecting water for the design capacity of 346 millions m<sup>3</sup>[1]. It is a multi-purpose reservoir which has function of irrigation as the main function, flood control, municipal and industrial water supply of Makassar city and power plant with the total installed capacity of 20.1 MW [4]. A gigantic collapse of caldera-wall of Mt. Bawakaraeng occurred on March 26, 2004 caused debris flow and affected rapid sedimentation in Bili-Bili reservoir, disturbance of water supply and other services provided by Bili-Bili Dam [1,6].

This paper describes the sedimentation measures. Volcanic activity and products contributed sedimentation of Wlingi and Bili-Bili reservoirs. However, measures to sedimentation were site-specific.

## MATERIALS AND METHODS

The research was conducted in Wlingi reservoir (2005) and Bili-Bili reservoir (2007). The former is in the regency of Blitar, the Province of East Java and the later is in the regency of Gowa, Province of South Sulawesi (Fig. 1). Data were collected from water resources management in each basin and field observations. The following data were collected: the time series of reservoir sounding, sedimentation rate, inflow-outflow of reservoirs, rainfall, water level, turbidity and other hydrological data, and digital map published by the Agency National Survey and Mapping (BAKOSURTANAL) at the scale of 1:50.000. The field observation consists of debris flow discharge, existing sabo technology for sedimentation control. The sedimentation rate of reservoir was estimated by comparing the series of reservoir sounding.

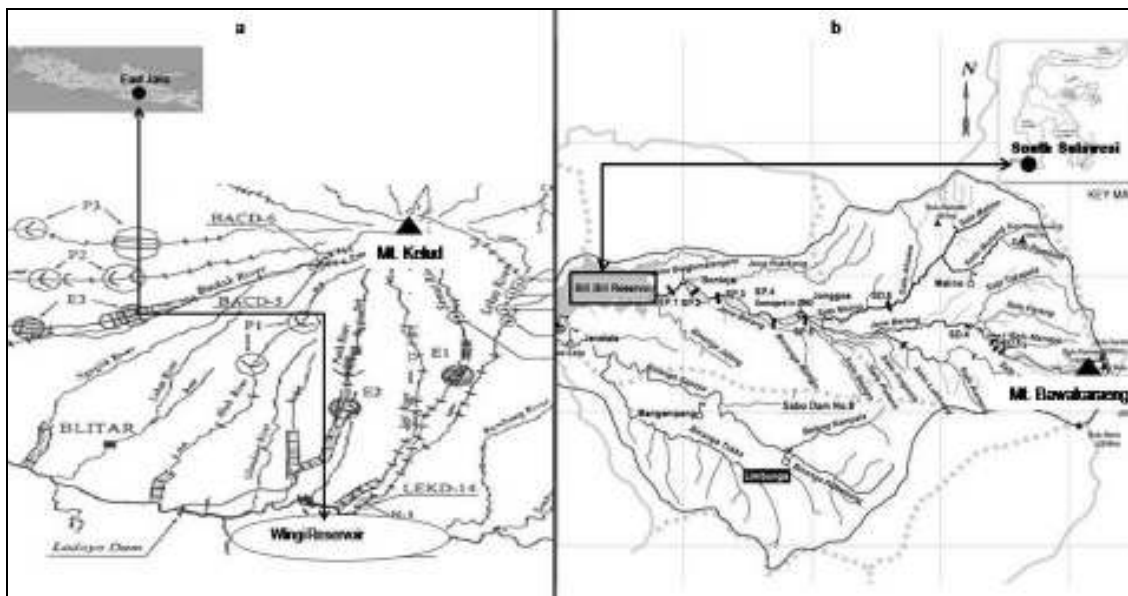


Fig. 1: Map of Wlingi reservoir basin (a) and Bili-Bili reservoir basin (b).

## RESULTS AND DISCUSSION

Debris flow occurred frequently in rainy season, causing burial of thousands hectares of paddy field along the rivers. In some cases, debris flow may occur in the dry season. Small slope failures may create small ponds or temporary dam and then accumulated water may initiate debris flow when the temporary dam breaches. Examples of morphology change are widening of river and rising of river bed.

### Wlingi reservoir

Volcanic materials of Mt. Kelud contributed large sedimentation in catchments area of Wlingi reservoir. The catchments area is covered with younger volcanic products which distributed over the area above 600 m and secondary volcanic products which deposited and distributed over the area from elevation 600 m to 100 m. The storage capacity of Wlingi Reservoir decreased sharply

from 24 million m<sup>3</sup> to 4.6 million m<sup>3</sup> (81%) between 1977 to January 1990 (Fig. 2). It was recorded that Mt. Kelud erupted on a large scale every 15 years, i.e. 1901, 1919, 1951, 1966 and the last biggest eruption occurred in February 1990 [5]. The erupted material spread over almost all direction of the slope, buried an extensive area of paddy field, plantation, forest and other cultivated lands, filled up the river courses and transported by rain water forming debris flow. The grain size distribution is 6 – 15% sand, 57 - 81% silt and 10 – 28% clay.

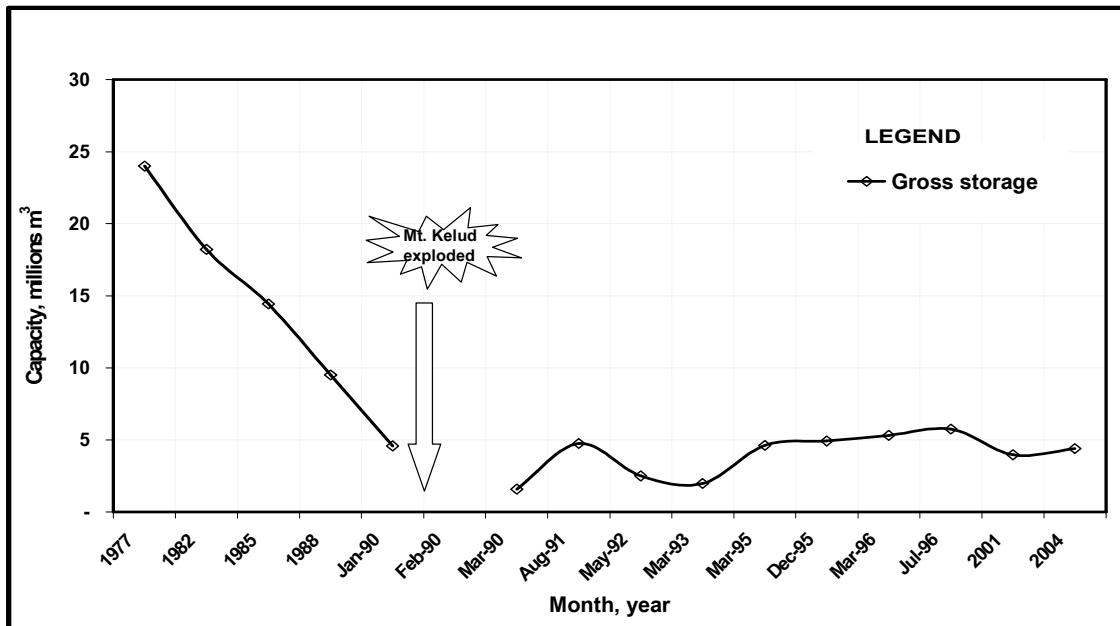


Fig. 2: Transition of storage capacity in Wlingi Reservoir

Dredging was conducted due to the eruption of Mt. Kelud in January 1990, however, the recovered storage was only 4.4 million m<sup>3</sup>. It was recorded that sedimentation rate of the reservoir was very high in the rate of 1.3 million m<sup>3</sup> month<sup>-1</sup> during 1999-2004 [5]. Dredging was not effective measure against regular sedimentation and therefore, some measures were carried out as follows. Eleven sabo dams have been constructed in the upstream of the reservoir, consisting of check dam, consolidation dam and bottom controller. The dams could control sedimentation volume as much as 3.87 millions m<sup>3</sup> year<sup>-1</sup>. Flushing of the reservoir was conducted in the rainy season by operating 2 flushing gates. Sediment with an amount of 0.40 m<sup>3</sup>/ year could be flushed away. Bypass channel to prevent sediment flow to Wlingi reservoir started in 1991 and, so far, it has not finished yet due to problems on the land acquisition. Land conservation was ineffective in addition to ineffective measure on bypass channel, because the change of function from forest to dry field did not follow the conservative principles [2]. It is hard to recover design storage capacity, however, all mentioned measures have to be maintained and improved to prevent emptied reservoir.

### Billi-Billi reservoir

Bawakaraeng caldera collapsed on March 26, 2004 (Fig. 3). During rainy season, debris flow occurred frequently through Jeneberang river and brought about rapid sedimentation in Bili-Bili reservoir. The sediment also decreased the quality of water supply. Result of reservoir sounding showed that the mean monthly sedimentation rate was 0.572 million m<sup>3</sup>. In April 2008, the

accumulated sedimentation in the reservoir was 63.96 million m<sup>3</sup> which was equivalent to 18.5% of the total storage capacity. The sediment occupies 4% of the flood control capacity, 12% of water utilization capacity and 47% of sediment storage capacity [3]. The remaining storage capacity was 285 million m<sup>3</sup> in April 2008 the remaining service life of the reservoir will be 43 years.

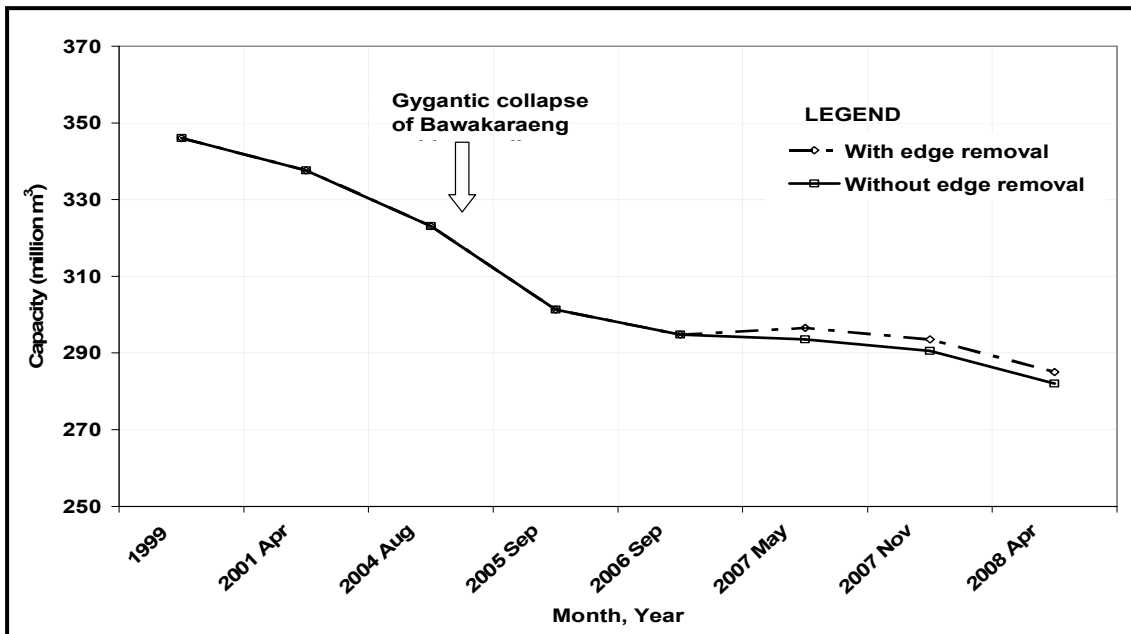


Fig. 3: Transition of storage capacity in Bili-Bili Reservoir

Measures to sedimentation were planned along the Jeneberang river by provision of 9 sabo dams, 2 consolidation dams in combination with bridge, rehabilitation of 5 existing sand pockets on the river downstream, sediment removal works on the edge of the reservoir instead of dredging and trees plantation of 45 Ha on the upstream area. The measures aimed to control sediment volume of 79.5 million m<sup>3</sup>. Bypassing method was not applied due to topographical constraint.

## CONCLUSION

The rapid sedimentation rate of 4.48 m<sup>3</sup>/year in Wlingi reservoir and 9.24 millions m<sup>3</sup>/year in Bili-Bili reservoir were as a result of debris flow originated from volcanic product. Sediment having diameter of less than 1 mm was the major component of the debris flow. Storage capacity recovery for the design capacity was not possible and therefore, measures to sedimentation were approached to maintain the present capacity.

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