Sabodam and the Impact Sand Mining of Merapi

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ABSTRACT
The 2010 eruptions of Mount Merapi resulted in 140 million m^3 of pyroclastic materials. The eruptions carried associated eruption hazards and lava floods that transported sand, gravel and stone materials. However, apart from hazards, the eruptions present deposit of mineral sand and stone, which are the most populer materials on the market. In anticipating lava flood disaster, the government built a number of s*abodam*. It is a construction to control the flow of debris or lava, built across the river. The working principle is to control sediment by containing, partially accommodating and draining the material/sand carried by the flow. The sand accommodated by the sabodam has high volume and excellent quality for materials, making it highly desirable to mine. However, over-excavation of sand in the rivers of Mount Merapi, exceeding the natural supply from upstream, will degrade the riverbed. Therefore, a sandstone mining mechanism needs to be established. It should regulate permitted locations and volumes so that sandstone material can be mined without disrupting the sabodam. Without a proper mining regulation in place, sand reserves will be depleted and the existence of sabodam is threatened.

Keywords: *sabodam, lava floods, sand mining*

1. INTRODUCTION

In October 2010, Mount Merapi erupted large volume of pyroclastic material towards the Gendol watershed. Millions of cubic meters of unstable pyroclastic material settle on tops, mountain slopes and riverbeds. If it rains with a high intensity, they can easily turn into lava flows [1] [2]. The sabodam system is an effort to anticipate and control lava flow. The sabodam is one of the most dominant structures in controlling sediment flow. The sabodam upstream contains pyroclastic material, so that sandstone mining is possible. However, uncontrolled sandstone mining may damage the environment as well as the sabodam. Sandstone mining activity has been going on for a long time along the river stream at Merapi. This activity is a direct result of volcanic activity of Mount Merapi which discharges pyroclastic material, source of sandstone material along the river stream. This mining activity is still carried out traditionally and does not meet safe mining standards. It involves heavy vehicles and equipment (Figure 1).

In general, sediment potential comes from pyroclastic material deposits resulting from eruptions, slope erosion, cliff erosion, cliff collapse and sediment at the bottom along the river. Sabodam capacity refers to the ability of the to contain and control sediment without causing damage to the river body. It consists of dead storage volume (Vds) or the amount of sediment transported downstream and accommodated by the sabodam. Control volume (VC) is the amount of sediment temporarily deposited in the upstream part of the sabodam dam due to the presence of the sabodam, and the retained volume (VH) is the amount of sediment retained by the sabodam both at the bottom and on the river bank which is expected to be transported downstream in the absence of a [3].

Figure 1. Mining conditions on the river of the Merapi slope (Source: wartahijau.com)

Martini (1997) in Mulyaningsih [4]defines lava as a flow of concentrated mud which is a mixture of water, particles, and pyroclastic mud that has existed before or is generated directly from an eruption. The composition of lava particles varies ranging from ash to bomb and lytic granules to boulders (Ø >1 m). the density and viscosity of lava are high with a particle concentration of 20-60% or 60-90% of the total weight. The Disaster-Prone Area Map (*KRB*) states that large-scale lava can occur if the rainfall reaches more than 40 mm within 2 hours [5]. The amount of material in Kali Putih is 34 million cubic meters [6]. The volume of sand mining on the slopes of Merapi is highly dependent on the sand potential and market needs. The growing market needs and uncertain availability depending on the volume of the eruption result in fluctuations in the volume of sand and stone mining [7]. During the eruption process of Mount Merapi in 2010, the total volume of material discharged reached 140 million m^3 spread over the main rivers of Mount Merapi. In addition to primary dangers, it can also be a source of sandstone [8].
This study aimed to determine the extent to which sabodam benefit sand mining activities along the Gendol River stream, as well as to provide pointers for mining management along the Kali River stream in the future.

2. METHOD

This study began with the examination of literatures on sandstone mining and the existence and function of sabodam. Then we analysed potential sources of sediment in Gendol River and the production of sediment or sediment that sabodam can contain. Furthermore, we analysed the ongoing mining and the impact of such activity. A field survey was carried out on the sabodam to determine the effect of mining activities on the condition of the existing sabodam and to identify if damage occurs. Investigation was not only carried out on the sabodam but also on changes in the morphological conditions of the lava/sediment. We also analysed conditions of sediment or lava deposited at some of these locations.

3. RESULTS AND DISCUSSION

The capacity of a sabodam is calculated by taking into account parameters such as the width of the river, the design height of the sabodam, the slope of the river bed, the slope of the design river bed (Id), the length of sediment deposits and the distance between s. The working principle of sabodam is to control the flow of lava. With the sabodam, the lava flow is mitigated because it can reduce the energy of the lava flow and contain the lava material. If the sabodam has been completely filled with lava material, it must be emptied immediately so that if another lava flood occurs the sabodam can function again. In general, a lava control consists of a check dam and lava pocket (Figure 2).

Check dams serve to accommodate as much sedimentary material of various sizes as possible, especially upstream of weirs and dams. Accommodating a portion of sedimentary material of various sizes takes into account the capacity of the river in the section to drain sediment flow. Check dams may function to prevent cliff erosion and riverbed caused by water flow, as well as reduce the speed of lava flood because the riverbed becomes gentler.

Figure 2. A check dam (left), and lava pocket (right) in Batang River, Magelang

A lava pocket is constructed to contain the material. This is built further downstream from the check dam in a slightly flat location where lava once spread because the river bank was no longer high. The area where lava spreads is called the Alluvial Fan. The construction of the lava pocket consists of embankments on the right and left of the river. When this sand pocket is full, it needs to be emptied by excavating and hauling out the sandstone minerals. These minerals can be used as materials for various purposes.

Sediment-retaining structures in lava rivers are constructed to permanently retain sediment. In general, sediment retaining infrastructure, such as check dams, consolidation dams, groundsills, girdles, lava pockets, and embankments are built in upstream areas far from residential areas [3]. Sediment retaining infrastructure is built in a series system because the foundation is floating because it is located in a very thick and easily eroded layer of sedimentary eruption material. Sediment-retaining s require special attention in operation and maintenance because it must be emptied immediately once full so that it keeps functioning optimally (Figure 3).

In general, there is a prohibition on mining around sediment retaining s because if sediment deposits are mined, the foundations are easily subject to local abrasion. When local abrasion reaches a certain depth, the will crumble easily. Any mining activity must obtain a permit from the relevant agency on the technical considerations of the Operation and Maintenance Unit/Task Force of the River Main Station/Regional Station. Prior to the commencement of mining activities, a joint survey is conducted to issue a technical consideration document that will be used as a mining reference, especially to determine the mining method and boundaries of the mineable area so as not to damage and disrupt the main functions of the infrastructure.

Figure3. Check dam excavation activity

Lava materials such as sand and stones are among natural resources commonly observed in the area of Mount Merapi. These minerals are very much needed by the community for materials for physical facilities such as s, bridges, and roads. Every physical development requires sand and stone materials. The quality of sand and stone from the Mount Merapi area has been known to be of high quality.

Lithologically, the sediment at the bottom of the river originating from Merapi from upstream to downstream is relatively the same, namely pyroclastic deposits from Mount Merapi. The riverbed deposits in this area are generally the same, namely lahar deposits in the form of sand-stone-sized volcanic material with varying abundances.

Mining activities along the river stream are sporadic. Such condition from a geological point of view tends to be dangerous because from a geological point of view, the cliff lithology is not of compact lithology, so it is prone to cliff landslides. The river where mining takes place is also Merapi lahar flow path, which pose a danger to the mining activities since lava flood may occur at any time. Mining activities caused some damage to the physical environment including damage to roads around the entrance to the mining site as well as damage to the reinforcement walls of the cliffs due to mining activities that took place close to the walls of the reinforcement walls.

Factors driving sand mining is the high price of Merapi sand, tempting capital owners to take advantage without controlling for environmental damage. Some of the land owners who live in disaster-prone areas move to neighboring villages causing the abandoned land to be neglected. They then lease or sell the land for sand mining.

The Danger of Landslides And Lava Floods

Mining activities often lead to landslides and lava floods (Figure 4). On Tuesday, 12 March 2019, a sand miner becomes a victim of a landslide on the cliffs of Kali Woro, the slopes of Mount Merapi. The victim, a resident of Glagahsari, Kendalsari Village, Kemalang District, Klaten, was buried under landslide material at the mining site not far from his house. Mining was done manually, so the risk of being buried by landsides was high. The volcanic activity of Merapi poses a threat to the people who live in the valley area and even more so when the community settlements are generally located less than 10 km from the center of the eruption. The effect of climate on the weathering of rocks from past eruptions of volcanic material brings about landslide risks [9].

Lahar flood is a hazard in its own right on the slopes of Merapi. Some of the factors contributing to the intensity of the lava flood in the Merapi area include the characteristics of Merapi volcanic material deposits and the intensity of rainfall in the Merapi area. The Merapi area stores a lot of volcanic material. The abundance of this volcanic material makes the Merapi area amasses a lot of vertically oriented eruption materials such as ash, sand and gravel. Small-scale eruptions that occurred in early 2019 also have the potential to cause lava floods, such as the incident on February 19 in Gendol River. Heavy rain that falls on the peak of Mount Merapi has the potential to cause lahar floods around Gendol River. People around Gendol River are alert and ready to evacuate. Heavy rain will cause the magma that comes out of the eruption to be carried away from the Upper Gendol River. The volume of Merapi lava material flowing in the Gendol River will increase and be heavy because it mixes with rainwater.

http://jateng.metrotvnews.com/peristiwa/zNPWz0VK-banjir-lahar-berpotensi-menerjang-kali-gendol-lereng-merapi

Figure 4. Landslides and lava floods in Gendol River

Sandstone mining must take into account the impacts of its activities. Impacts can be in the form of environmental impacts or damage to sabodam. The sabodam is used to control lava floods. It is expected to mitigate the impact of the lava flood. The construction of sabodam costs hundreds of billions, so it would be a waste if it had to be damaged by mining activities. Mining activities must ensure the existence of sabodam. Figure 5 shows the sabodam that has been eroded by mining and the mineable areas so as to maintain the existence of the sabodam.

The concept of EIA studies the impact of development on the environment based on ecological concepts. It is part of ecological science that studies the interrelationships or interactions between development and the environment [10].

EIA is part of business aspects. To carry out business activity or project, EIA becomes one of the business eligibility requirements. This is necessary considering that investment activities in general will change the environment. Environmental components whose functions must be maintained and preserved include forests, human resources, biodiversity, air quality, cultural heritage, and environmental comfort.

ISBN 978-602-6258-30-4

Figure 5. Eroded Sabodam (left) and Mining Limits (right) (Sumber: Jcpoweryogyakarta. Blogspot.Com)

Sand mining activities at Mount Merapi rivers have brought environmental impacts, namely physical and socioeconomic impacts [11]. Environmental physical impacts include damaged sediment-retaining s, the emergence of landslide-prone cliffs, damaged roads, and air pollution. Socioeconomic impacts include absorption of labour because some people work as workers in sand mining or influx of outsiders to participate in mining, causing conflict. Sand mining also worries people due to landslide may occur at any time, especially during heavy rainfall.

To determine the prospective location for sand mining, it is necessary to identify and stocktake sand reserves. It is important to determine the degree of benefit of sand mining if it is cultivated. With clear, assertive and transparent policy for sang mining as well as community participation, both miners and general people, favorable climate can be achieved. In taking advantage of sand mining area, we need to take land conservation into account, so that sandstone mining activities around Mount Merapi can be carried out in a sustainable fashion.

Weakened sabodam stability is also exacerbated by sand-stone mining activity that exceeds the availability volume threshold, exceeds the sediment supply from upstream. Oftentimes, mining is also carried out in prohibited location that endanger sabodam. Mining activities of sand-stone material on sabodam are actually needed to provide storage space, so that the sabodam can accommodate sediment in subsequent floods. Mining must be carried only in permitted areas. The mining location is upstream of the sabodam in the dead storage area, not too close to the sabodam so as not to endanger it. Mining cannot exceed the supply volume. Excessive mining will affect the morphology of the river and endanger the sabodam.

4. CONCLUSIONS

The eruption of Mount Merapi produces large amounts of pyroclastic material. The eruption also poses a danger of eruption and lahar flooding that transports sand, gravel and stone materials. In anticipation of the lahar flood disaster, the government has built a number of sabodam. The working principle of controlling sediment is to hold, partially accommodate and drain the material / sand carried by the flow.

The sand accommodated by the Sabo building has high volume and good quality for building materials, making it interested for mining areas. Excavation of sand in the rivers of Merapi, if carried out excessively, exceeds the supply from upstream, it will cause degradation of the riverbed. As a result it will damaged the condition of the sabo building. Therefore, it is necessary to regulate the mechanism of rock sand mining. Which locations are allowed, and what volumes are allowed. So that the sandstone material can be mined and the existence of the sabo building is not disturbed. Without a good mining arrangement, the sand reserves will be depleted and pose a danger to the sabo building.

ACKNOWLEDGMENT

The author would like to thank the Head of Balai Sabo for his support as well as colleagues at Balai Sabo who have given a lot of support and input and all those who have supported so that this paper can be compiled

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