Determination risk of liquifaction disaster based on spatial distribution unconfined aquifer at the Tindaki Groundwater Basin, Parigi Moutong District

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Abstract. Natural disasters such as earthquake, tsunami and liquefaction in Central Sulawesi Province in 2018 had a significant impact on economic growth. This demands disaster risk reduction, especially liquefaction disasters. This research was conducted in Tindaki Groundwater Basin, Parigi Moutong Regency, especially in Parigi sub-district, which includes: Lebo, Bambalemo, Kampal, Maesa, Bantaya, and Olaya. The purpose of this study was to determine the level of risk of liquefaction based on the spatial distribution of the unconfined aquifer in Tindaki Groundwater Basin. The number of samples is 100 points taken randomly, consisting of community dug wells to obtain phreatic depth. The technique of collecting data is random and proportional sampling. The method used in this study is geological and hydrogeological approaches with rock formation as a determining parameter for groundwater density. The results showed that the average depth of the phreatic level was <10 meters from the ground and was in the alluvium formation. Based on the results of the study, it can be concluded that the potential for liquefaction in the research area is in the medium to high potency.

1. Introduction

Disasters and losses due to disasters are strategic issues because of the impact on the economic growth target of 5.4% in 2018 [1]. The increase in disaster incidence in 2018 requires efforts to reduce disaster risk, including liquefaction [2]. Liquefaction is a phenomenon where the strength and stiffness of the soil is reduced due to an earthquake or other ground motion. Basically, liquefaction can occur in areas prone to earthquakes, shallow phreatic and poorly consolidated soils. Factors that influence liquefaction: vibration characteristics, soil type, groundwater level or phreatic, grain diameter distribution, initial density, drainage and deposit dimensions and drainage capability [2, 3]. This study aims to determine the risk of liquefaction based on the unconfined aquifer in the Tindaki Groundwater Basin, Parigi Moutong Regency. On the one hand, the existence of Tindaki Groundwater Basin provides a very positive value in meeting the clean water needs of the population. But on the other hand, when the aquifer is saturated with water and not followed by proper spatial planning, it can result in a liquefaction disaster.

2. Materials and methods

This research was conducted in Parigi Moutong Regency, especially in Parigi sub-district, which includes: Lebo, Bambalemo, Kampal, Maesa, Bantaya, and Olaya, which are included in Tindaki Groundwater Basin. The number of samples is 100 points taken randomly, consisting of community dug wells to obtain phreatic depth. The technique of collecting data is random and proportional sampling.
Data obtained through primary data surveys which are supported or complemented by secondary data surveys. The analysis method used is geospatial analysis. This analysis is intended to determine the groundwater divide with the landform as the evaluation unit [4-6]. For more details, the research location can be seen in Figure 1.

This analysis process is carried out by means of satellite image interpretation followed by field checks to compile a map of the landforms [7-8]. The classification of land forms is based on genetics, refers to Verstappen and Van Zuidam (1968) and the scale refers to the classification of landforms on a 1: 250,000 scale mapping based on the land unit map, field observations were made on the physical environmental factors related to the presence and characteristics of groundwater [9]. [10, 15, 16]. Physical environmental factors include: lithology, stratigraphy, geological structure and land use [11, 12]. The mapping process uses the Arc / Info PC Geographic Information System, which is presented using Arc View GIS version 3.3. Based on the results of calculations and analysis of phreatic potential, several spatial direction patterns can be formulated, as follows [13, 14]. Furthermore, to determine the level of vulnerability to liquefaction, it is divided by zone, as follows:

2.1. **Zone I**
This zone is a liquefaction zone with high to moderate potential. The groundwater group in the hydromorphology and hydrogeology units can be utilized without inhibiting factors. In this zone groundwater with high productivity.

2.2. **Zone II**
This zone is a liquefaction zone with medium groundwater potential. The potential of groundwater in this zone can be utilized in limited quantities, due to local inhibiting factors. The inhibiting factors, such as: phreatic face and deep piezometric face, depth and thickness of the aquifer, permeability value and aquifer productivity (Qs and Qopt) are medium - low.

2.3. **Zone III**
This zone is a potential liquefaction zone with very limited potential. The groundwater potential in this zone can be utilized in a very limited amount, due to inhibiting factors such as productivity and quality of groundwater. This zone is preferred as a groundwater recharge area.

3. **Results and discussion**
The research on liquefaction potential was carried out in Parigi District, Parigi Moutong Regency, which includes: Lebo, Bambalemo, Bantaya, Olaya and Maesa Villages which are positioned along the coast with a radius of 2 km to the west Parigi Moutong Regency. The data available for the investigation area is the geological data of the Poso sheet and the position of the unconfined aquifer in the Tindaki Groundwater Basin so that the choice of method in this case uses sources from Keith, drr., 1999 in Piya, BK, 2004. According to Keith, the liquefaction potential is qualitatively influenced by three factors, among others: 1). Sand thickness <12 m below ground level, 2). Phreatic depth <10 m and 3). Estimation of the critical limit of surface earthquake acceleration that triggers liquefaction if there is drill data using the Seed and Idriss method, 1971 [16, 17, 18]. Regional geomorphology of Parigi Moutong Regency can be broadly divided into three forms, as follows: Lowland geomorphological unit, hill geomorphological unit, and mountainous geomorphological unit.

The results showed that the average depth of the phreatic in the study area was <10 meters from the ground and was in the alluvium formation. The phreatic depth is spread over 6 villages, which is Lebo, Bambalemo, Kampal, Maesa, Bantaya, and Olaya, with varying distribution following the contours of the land. The depth of the phreatic face shows the lowest number of ground levels in the alluvium formation or those that are close to the shoreline. In Figure 2, it can be seen that the distribution of the phreatic in the study area ranges from low to high, with the distribution, namely: 7.5 meters from the ground level and the lower towards the coast, which is <2.5 meters from the ground level.
Furthermore, in Figure 3, based on the phreatic distribution data, it can be seen the zone of the potential level of unconfined aquifer. Based on the results of calculations and analysis of the level of
unconfined aquifer potential in the study area, all areas in the Parigi sub-district, in particular: Lebo, Bambalemo, Bantaya, Olaya and Maesa villages, are in the zone 1 to zone 3. The level of vulnerability to liquefaction varies based on contours ground surface and phreatic with a radius of 2 km from the coastline.

![Figure 3. Map of unconfined aquifer level at CAT Tindaki](image)

Based on the phreatic distribution at the research location, in Figure 4 it can be seen the level of susceptibility of the research area to liquefaction based on phreatic parameters. From the map, it can be seen that the 6 villages: Lebo, Bambalemo, Bantaya, Olaya and Maesa villages have high potential for liquefaction at a distance of <0.5 kilometers from the coastline. This is because the form of the land is on an alluvial plain with a swamp area locally.

![Figure 4. Map of Zone of Liquefaction Vulnerability at Tindaki Groundwater Basin Parigi Moutong Regency](image)
4. Conclusion
Based on the results of the study, it can be concluded that the potential for liquefaction in the study area is medium to high (Zone I: Prone Zone) because the average phreatic in the study area is in the range of <10 meters in the alluvium formation.

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