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Delineation of Recharge and Discharge Area for Geothermal Energy in Natar

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Abstract. Geothermal is one of the renewable energies which is abundant in Indonesia (~29 GW). Lampung has several potential areas of the geothermal energy, such as Way Panas, Rajabasa, Sekincau, Way Ratai, Natar, etc, 110 MW potential in total. Natar hot spring is one of the geothermal manifestations located in Natar, South Lampung and included in Metro-Kotabumi Groundwater Basin. This indicates that Natar has potential in geothermal energy. Geothermal energy is known as renewable energy, if only the system can be maintained. One component that can be maintained is presence of water in the reservoir. To maintain this component, recharge area must be known. This paper, provide analysis recharge area delineation based on topographic and geological map. Based on topographic map, recharge area is located at western and at southern part of Metro-Kotabumi Groundwater Basin. The recharge area is located in high terrain topography and covered by volcanic product (intercalation between tuff, lava, and volcanic breccia). Ratio value between recharge and discharge area is 0.17. Due to the recharge area is very small compared to discharge area, it is need to conserve recharge area seriously hence Natar hot spring can be sustainable.

1. Introduction

Geothermal energy is one of the abundant energy resources which lies in Indonesia. It uses heat from inside the earth and the electricity can be extracted by energy conversion. The main recognized feature of the existence of geothermal in certain area are geothermal manifestations such as hot spring, mud pool, fumarole, warm ground, and etc. Natar hot spring is one of geothermal manifestation located in Natar district, South Lampung. The government, in this circumstances, Centre for Mineral, Coal and Geothermal Resources (*PSDMBP*) already calculate Lampung geothermal potential in total [1] based on geology, geochemistry, and geophysical data. There is no specific research has been conducted for Natar hot spring. At present, the Natar hot spring is only used as a tourist attraction in the form of a hot spring. Therefore, the research to determine the geothermal potential becomes necessary in order to fully exploit the geothermal area for power generator (e.g. PLTP). In terms of geology, Natar hot spring appears in the area which relatively flat and far from volcanoes as the heat source.

However, the geothermal energy can be renewable if only one of its components is maintained properly. Natar hot spring is one of the geothermal manifestations which the existence can be continued if the presence of water in the reservoir can be maintained. This research provides preliminary study to determine recharge and discharge area in Natar and its surrounding. The purpose of this research is to delineate groundwater recharge area as a source of water for Natar hot spring. By conserving the recharge area, it is expected that the existence of groundwater in the Natar geothermal system can be sustained.

2. Study Area



Study area is bounded by groundwater basin/GWB (*cekungan airtanah/CAT*) of Metro-Kotabumi, the data of groundwater basin is obtained from Minister of Energy and Mineral Resources regulation No. 2 2017. Natar hot spring is located in the southern part of Metro-Kotabumi GWB (**Figure 1**). Metro-Kotabumi groundwater basin covered area around 21.934 km² and included into two provinces, i.e. Lampung and South Sumatera. This GWB bounded by Mount Betung and Mount Pesawaran at southern part, Java Sea at eastern part, Bukit Barisan mountain range at western part. Most of the morphology of the study area shows a flat terrain topography except at the western part which covers Bukit Barisan area and at the southern part which covers the foot of Mount Pesawaran and Betung.

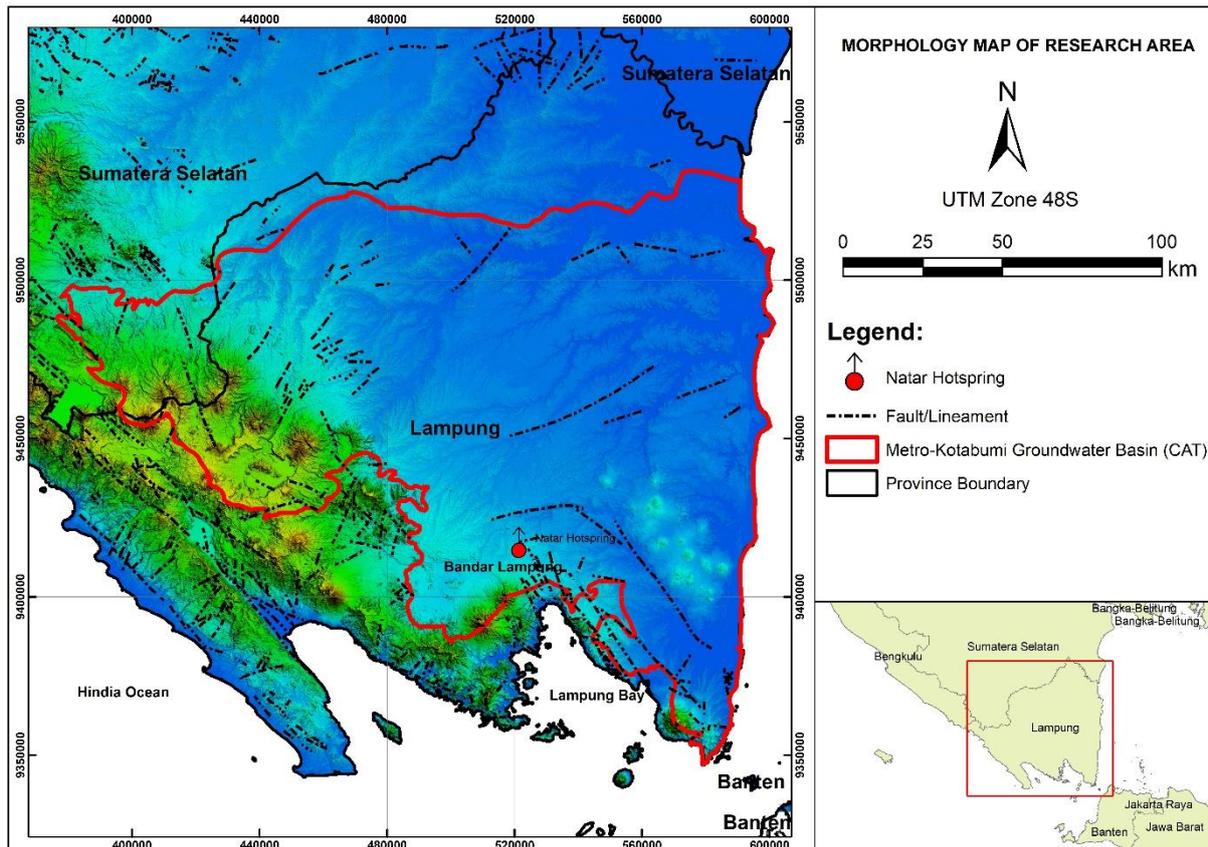


Figure 1. Morphology map of research area based on digital elevation model (DEM).

The geological setting in the research area is obtained from four quadrangles geological map (**Figure 2**), i.e. Menggala Quadrangle [2], Baturaja Quadrangle [3], Kota Agung Quadrangle [4], and Tanjung Karang Quadrangle [5]. Rock formation in Metro-Kotabumi GWB is simplified into four groups, that is volcanic rocks group, sedimentary rocks group, metamorphic rocks group, and intrusive rocks group. Volcanic rocks group consists of Lampung Formation (pumiceous tuff, tuffaceous sandstone locally with tuffite intercalations), Hulusimpang Formation (andesite basalt lava, tuff and volcanic breccia with lenses of limestone), Tarahan Formation (welded tuff, breccia with intercalations of chert), Ranau Formation (rhyolitic tuff, pumiceous tuff, welded tuff with carbonaceous claystone intercalations), Lakitan Formation (basaltic-andesitic volcanic breccia with volcanic sandstone and claystone intercalations), Bal Formation (dacitic volcanic breccia with volcanic sandstone intercalations), Kikim Formation (volcanic breccia, welded tuff, tuff, lava, sandstone and claystone), Pesawaran-Rajabasa-Sekincau Volcanic Product (andesitic to basaltic breccias, lavas and tuff). Sedimentary rocks group consist of Muaraenim Formation (Alternating claystone, sandy claystone and tuffaceous siltstone with tuffaceous sandstone and black claystone intercalations), Kasai Formation (Conglomerate and quartz sandstone, tuffaceous claystone containing silicified wood with pumiceous tuff, tuffaceous sandstone, sandstone with siltstone and claystone intercalations), Situlanglang Member

(chert, yellow, red brown, massive, hard and weathered, contains radiolarian), Cawang Member (Quartz conglomerate and quartz sandstone), Gumai Formation (Calcareous shale, marl, claystone with tuffaceous sandstone and calcareous sandstone intercalations), Terbanggi Formation (Sandstone with claystone intercalations), Air Benakat Formation (Claystone with intercalation of tuffaceous claystone, marl, sandstone and shale), Baturaja Formation (Reef limestone, calcarenite, with calcareous shale and marl intercalations), Talang Akar Formation (Quartz sandstone containing silicified wood, conglomeratic sandstone, and siltstone containing molluscs), Menanga Formation (Alternating shale, and claystone with basalt, intercalations of chert and lenses of limestone), Gading Formation (sandstone, siltstone and claystone with intercalation of limestone and lignite).

Metamorphic rocks group consist of Trimulyo slate (Marble and schists), Gunung Kasih Complex (Mainly pelitic schist and minor gneiss), Sidodadi Quartzite (Quartzite with intercalations of schists quartz sericite), Way Galih Schist (Green amphibole-schist, dioritic orthogneiss amphibolites).

Intrusive rocks group consist of Dasite Piabung, Kalimangan Granite, Jatibaru Granite, Basalt plug, Seputih Granodiorite, Branti Granodiorite, Sekampung Foliated Diorite, Kalimangan Granite, Sulan Granodiorite, Garba Granite, Sukadana Basalt, Kapur Granite, Seblat Granite, Padean Monzo-granite.

The geological structure here is dominated by lineament trending northwest-southeast, particularly in Bandar Lampung area. This lineament has the same trend with the Great Sumatra Fault and interpreted is still related to the Great Sumatra Fault. At the northern area, there are some lineament trending northeast-southwest. Lineament in the research area is interpreted as a secondary geological structure such as fault and joint

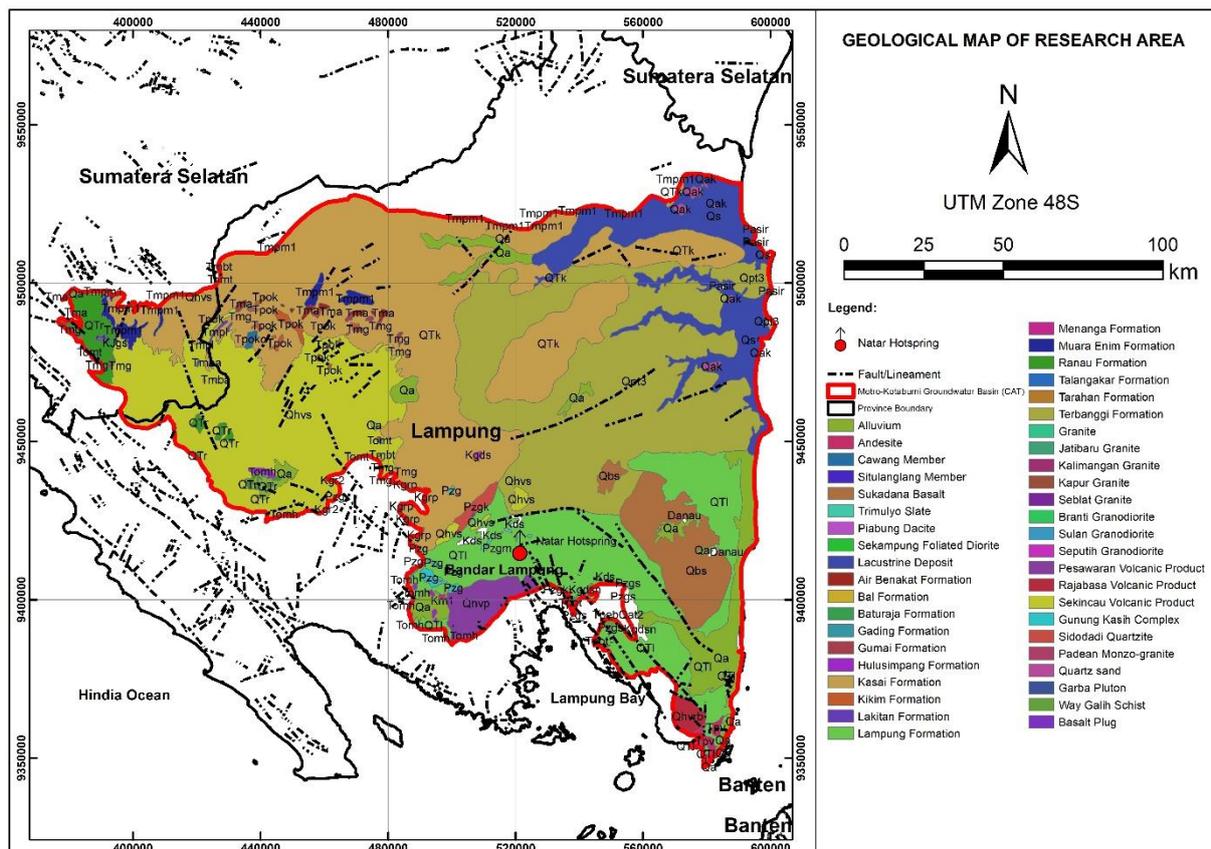


Figure 2. Geological Map of Research Area [2–5].

3. Methods

This research is conducted using a qualitative method such as analyzing morphology and geology in GWB Metro-Kotabumi. This analysis is done as a determination for recharge and discharge area in the research area and its vicinity. In the recharge area, the flow of water is moving to downward and in the

discharge area the flow of water flow upward (**Figure 3**Figure 3. Groundwater flow illustration due to gravity-driven [6].) [6]. Regional groundwater flow is controlled by two factors, i.e. topography and geology condition [7]. Therefore, the morphological and geological analysis needs to be done to delineate the recharge and discharge areas especially for Natar geothermal area.

Morphology analysis is conducted based on digital elevation model (DEM). Areas with higher elevations can be indicated as recharge areas because it has relatively higher hydraulic head values compared to areas with lower topography.

Aquifer is defined as a saturated permeable geologic unit that can transmit significant quantities of water under ordinary hydraulic gradients. An aquiclude is defined as a saturated geologic unit that is incapable of transmitting significant quantities of water under ordinary hydraulic gradients [7]. Generally, rocks that can act as aquifers are loose sand and gravel, sandstones, fractured igneous rocks [7,8]. Based on the definition of aquifer and aquitard, another factor used to delineate the recharge area is lithology.

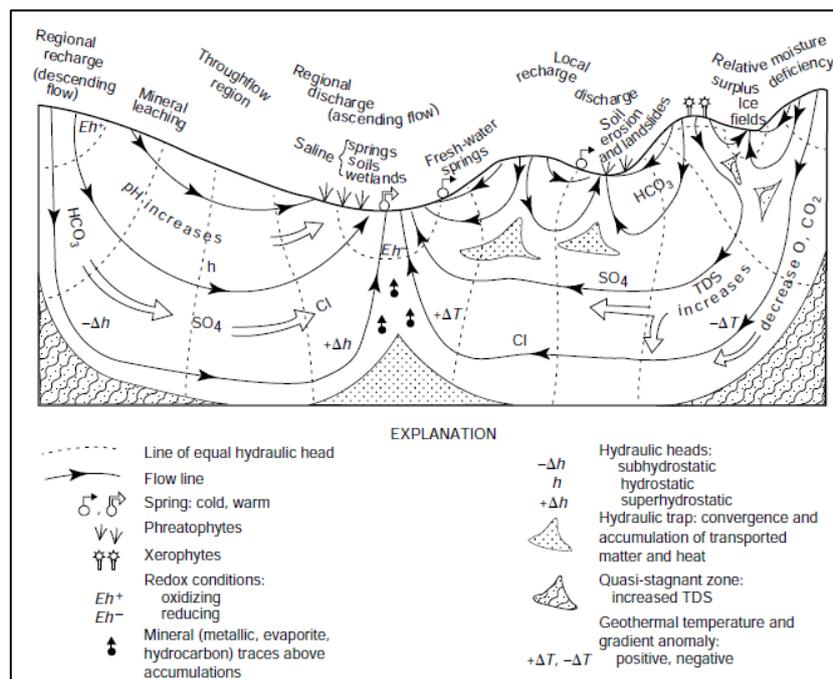


Figure 3. Groundwater flow illustration due to gravity-driven [6].

4. Result and Analysis

Based on the morphology in study area, the western and southern part of Metro-Kotabumi Groundwater Basin have a high terrain topography. The high terrain topography in western area is covered by Sekincau Volcanic Product (Qhvs) and Ranau Formation (QTr). And in the southern part area is covered by Pesawaran Volcanic Product (Qhvp) and Lampung Formation (QT1).

The Sekincau-Pesawaran volcanic product, Ranau Formation, and Lampung Formation can be act as aquifer due to permeability of tuff or tuffaceous sandstone that can be transmit water. Beside the characteristic of the rock that can be transmit water, the tight lineament in the southern part area near Natar hot spring can be act as high permeability zone.

Recharge area can be delineating in area that have a high terrain topography and permeable rock. Therefore, the recharge area in this groundwater basin is located in the western and southern part of research location (**Figure 4**). Based on its location, the catchment area for the Natar hot springs is in the south which is formed from tight lineament and Lampung Formation.

The recharge area in western part is 2,919 km² and in southern part is 329 km². The discharge area is 18,686 km². Ratio value between recharge and discharge area is 0.17. This ratio less than one shows the

recharge area is much smaller than the discharge area. Therefore, it is necessary to conserve the recharge area to maintain the sustainable of water in this groundwater basin, especially for Natar hot spring.

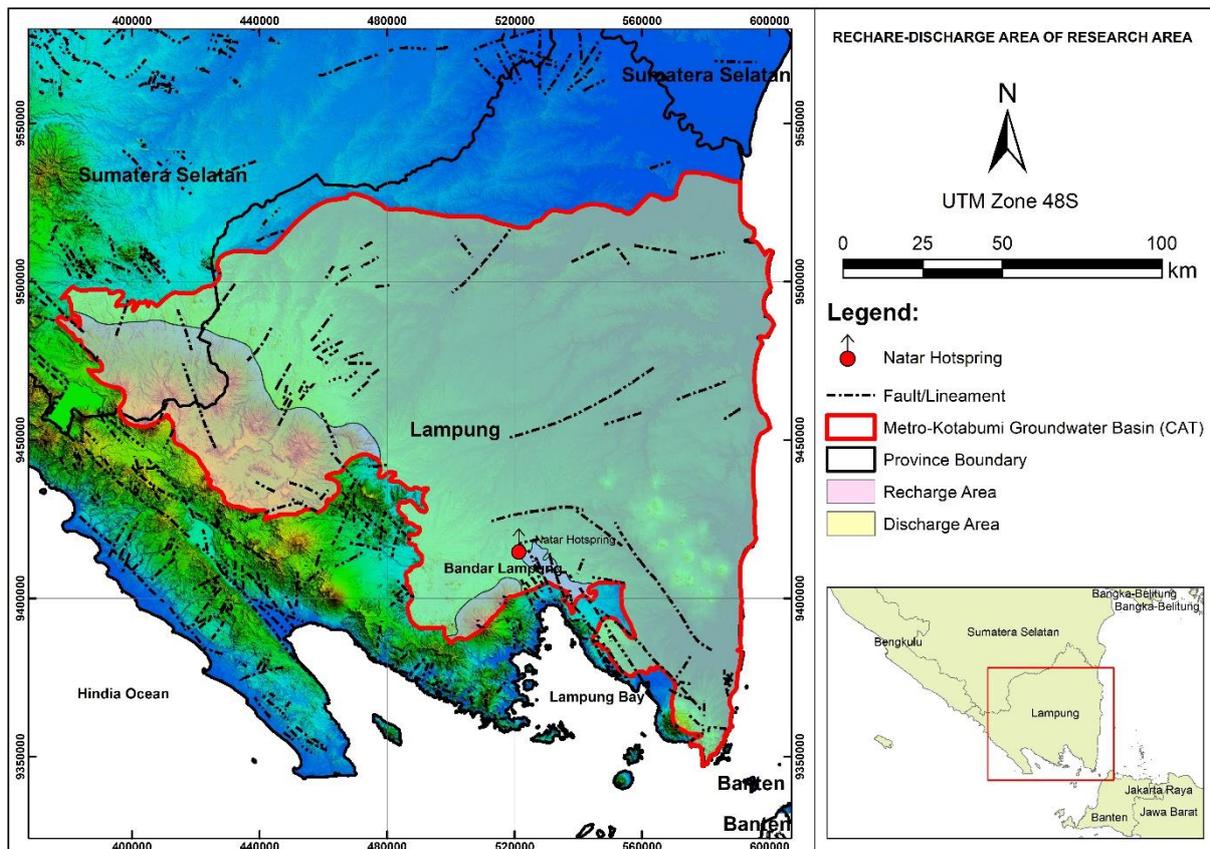


Figure 4. Map of recharge and discharge area of research area.

5. Conclusion

The research area is bounded by Groundwater Basin of Metro-Kotabumi within area of 21.934 km². The recharge area are located at the western and southern part that have high terrain topography and covered by volcanic product (intercalation between tuff, lava, and volcanic breccia). The recharge area of Natar Hot Spring is located at the south of the Metro-Kotabumi Groundwater Basin. The recharge area covers 3,248 km² in total and located at west and south of the Metro-Kotabumi Groundwater Basin. Ratio value of recharge and discharge area is 0.17 which means the discharge area is vast enough compared to the recharge area.

6. Acknowledgement

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