Geoelectric imaging for saline water intrusion in Geopark zone of Ciletuh Bay, Indonesia

N D Ardi*, M Iryanti, C P Asmoro, A Yusuf, A N A Sundana, H Y Safura, M Fitri, M Anggraeni, R Kurniawan, R Afrianti, Sumarni
Physics Program, Universitas Pendidikan Indonesia, Bandung, Indonesia

*Corresponding author’s e-mail: nanang_dwiardi@upi.edu

Abstract. Saline water intrusion in estuary is an urgent ecological encounter across the world. The Ciletuh Bay, located in the southern Sukabumi district, is an area with high cultivated potential becoming one of the most important geology tourism zones in Indonesia. However, salt water intrusion along the creek is a natural spectacle that disturbs the economic growth of the whole region. This research was intended at plotting the subsurface level of saltwater interventions into aquifers at the northern part of Ciletuh creek, Indonesia. The study implemented geoelectric imaging methods. 37 imaging datum were acquired using Wenner array configuration. The saline water were identified across the study area. The result of two dimensional cross-sectional resistivity shows that there is an indication of sea content in our measured soil, i.e. the smallest resistivity value is 0.579 Ωm found at a depth of 12.4 m to 19.8 m at a track length of 35 m to 60 m is categorized in the clayey which shows low groundwater quality. However, when compared with the results of direct observation of groundwater from the wells of residents, the water obtained is brackish water. A water chemistry test is conducted to ascertain the initial results of this method so that a potential sea intrusion potential map can be interpreted more clearly. This can consequently help as an extrapolative model to define depth to saline water at any site within the saline water zone in the study area.

1. Introduction
Ciletuh Bay, known as a unique geological area, resulted from the collision of Eurasian Plate (continental plate) with granite composition (acid), and Indo-Australian plate (basaltic plate) which composed basalt (base), produce marine sedimentary rocks (pelagic sediment), metamorphic rocks (altered rocks), and alkaline to alkaline ultra-basic rocks. Inside this trough there are rocks known as mélangé is the oldest rock group (Pre Tertiary) exposed on the surface of the mainland of Java Island, with ages ranging from 120 to 65 million years. The Pre-Tertiary rocks in the Ciletuh area throughout its outcrops are inside a large valley resembling an amphitheater with a horseshoe shape that opens toward the Indian Ocean. Communities around Ciletuh to meet the needs of clean water, people rely on ground water either taken from shallow and deep soil aquifers. The ongoing exploitation of groundwater increasing from time to time is expected to result in the occurrence of seawater intrusion into the aquifer in the Ciletuh Bay area. In addition to water quality degradation drinking water, groundwater exposed to seawater intrusion can cause corrosion on the foundation buildings when under construction using groundwater that is intruded by sea water [1]. Intrusion of sea water has a very wide impact on various aspects life so it is necessary to study about the intrusion of sea water at
Ujung Genteng Beach. To identify the intrusion of sea water that occurred at Ujung Genteng Beach, it is used wrongly one method in the field of geophysics, i.e. resistivity method of type resistance [2]. Resistivity Method is one method of geophysical measurement that focuses on electrical potential from various rock type resistances beneath the earth's surface [3].

To know the spread of seawater intrusion that is based on price change of type resistivity parameter. This method is used in the measurement of the type of underground rock layer resistance by the arrangement of the Wenner electrode, in particular for the initial exploration of groundwater by studying subsurface geology and to estimate groundwater quality based on the value of resistance types and electrical conductivity values in rocks that are heavily influenced by the content water on the medium so that a boundary between freshwater and salt water can be determined [4]. Distribution of ground water salinity occurred in the Gulf region Ciletuh due to the influence of sea water intrusion. Run off water entering the plains directly or through coastal drainage has a direct effect on increasing the intrusion of sea water into free aquifers [5]. So, we conducted the research to identify the depth of sea water, which can be identified with the type of rock layers in the field and the salinity of ground water. The rock layers presented by variations of ground and ground salinity resistance values can be determined using the conductivity value or DHL. Based on the value of DHL, conductivity contour maps were made to map the spreading of the groundwater salinity.

2. Methods
The research location is located in Geopark Ciletuh Area, Ciemas Sub-district, Sukabumi Regency, at the southwestern of West Java about 30 km south of southwest of Pelabuhan Ratu, at the coordinates of UTM 0652609E, 9199654S. Acquisition was carried out by using Wenner configuration with spacing value between electrode multiples of 5 that is 5 meter, 10 meter, 15 meter, 20 meter, 25 meter, 30 meter, and 35 meter, and then processed by Res2dinv software figure 1 [6] [7].

Figure 1. Research location and acquisition near Ciletuh Bay, Sukabumi

3. Result and Discussion
From the 2D cross-section (figure 2), there is no resistivity value which can indicate the presence of sea water content in the soil which is used as the measurement path. Explicitly the seawater itself has a resistivity of 0.2 Ωm, while the smallest resistivity value measured alone is 0.579 Ωm. However, it can be indicated in the presence of water that has been contaminated by sea water, where the resistivity value is less than 15 Ωm. The depth of sea water on the measurement results has not been found due to the lack of measurement data that causes the depth of sea water has not been detected. However, the contaminated water content of sea water can be detected at a depth of 12.4 m with a resistivity value of 9.70 Ωm. This shows when there is already contamination of sea water to the water in the measurement area. In the processing results there is also the smallest resistivity value of 0.579 Ωm which indicates that the water has also been contaminated by sea water but not too large. It also shows if the water quality in the area is good, because the water in the lodging area that we occupy is also not a fresh or brackish water. But for the measurement area, we presumably sanction will the quality of water that is under the surface of the ground due to the nearby measuring areas there are estuaries
where the water is brackish water. At one end of the estuary there is also an area that is the entry of seawater from the coast to the estuary; it cannot be identified because we did not examine the mineral content. Interpretation from the inversion data of geological cross-section and resistivity value, the possibility of sea water penetrating soil and ground water contaminated by sea water is at a depth of 12.4 m and on the track about 70 m when taken more tightly data. It can be estimated by the resistivity value shown at a depth of 12.4 m which indicates that the water in the area of measurement has been contaminated by sea water.

**Figure 2.** Resistivity distribution from 2D inversion model

4. **Conclusion**

Based on the results of geological research in Ciletuh Bay, we can conclude that Ciletuh Formation rocks found are conglomerate and sandstone. When viewed from the results of resistivity distribution performed, the value of sea water in this area is $0.579 \Omega m < \rho < 9.70 \Omega m$ and identified at a depth of 12.4 m to 19.8 m at length of trajectory 35 m to 60 m so that the sub surface lithology of clay and boundary between ground water and sea water at a depth of 12.4 m with a resistivity value of 9.70 $\Omega m$.

5. **References**

[1] Ambarsari E S 2013 *Aplikasi Metode Geolistrik untuk Identifikasi Intrusi Air Laut Studi Kasus Semarang Utara* (Semarang: Universitas Negeri Semarang)

[2] Nisa K, Yulianto T and Widada S 2012. *Aplikasi Metode Geolistrik Tahanan Jenis untuk Menentukan Zona Intrusi Air Laut di Kecamatan Genuk Semarang* *Berkala Fisika* **15** 1 7-14

[3] Ardi N D and Iryanti M 2016 Sliding zone identification of landslide area using resistivity method in Cijambe, Subang West Java *AIP Conference Proceedings* **1708** 1 070001

[4] Oladapo M I, Ilori O B, Adeoye-Oladapo O O 2014 Geophysical study of saline water intrusion in Lagos municipality *African Journal of Environmental Science and Technology* **8** 1 16-30

[5] Wijaya S 2004 Analisis Sebaran dan Penelusuran Sumber Keasinan Air Tanah Akuifer Bebas di Wilayah Semarang Bawah
[6] Loke M 2000 Electrical imaging surveys for environmental and engineering studies: A Practical Guide to 2D & 3D Electrical Imaging Surveys. *Technical Reports*

[7] Ardi N D and Iryanti M 2015 Resistivity mapping and geochemical data for groundwater contamination at Sarimukti municipal landfill, West Bandung *AIP Conference Proceedings* **1677** 1 060019