IJISET - International Journal of Innovative Science, Engineering & Technology, Vol. 7 Issue 6, June 2020
ISSN (Online) 2348 – 7968 | Impact Factor (2020) – 6.72
www.ijiset.com

Groundwater Table and Salinity Zone Mapping In the Coastal Areas of Padang

***Mulya Gusman[1,2], Adree Octova[2], Yoszi Mingsi Anaperta[2], Bustari Muchtar[3], Nurhasan Syah[4], Dedi Hermon[5]**

[1]Doctoral Study Program of Environmental Sciences, Universitas Negeri Padang, Indonesia

[2]Mining Engineering Department, Universitas Negeri Padang, Indonesia

[3]Economics Faculty, Universitas Negeri Padang, Indonesia

[4]Civil Engineering Department, Universitas Negeri Padang, Indonesia

[5]Geography Department, Universitas Negeri Padang, Indonesia

Abstract

Water is one of the most important components in the life of living things. The availability of clean water is still a problem at this time. One of the solutions for clean water needs at this time is groundwater. However, groundwater also has its problems, especially in coastal areas. Some residents complained that the quality of their groundwater changed when the seasons changed. In the dry season, groundwater levels tend to decrease. One of the parameters of groundwater that can be affected by intrusion is salinity. Salinity is the level of salt dissolved in water. This study aims to find out the effect of seasonal changes on the groundwater table and the value of groundwater salinity in the coastal areas of Padang and to detect whether there is seawater intrusion on groundwater. Researchers measured groundwater quality in resident wells along with the coastal areas of Padang. Then the researchers mapped the value of groundwater salinity in both seasons. The method used for mapping salinity is the kriging interpolation method. The results showed that the groundwater table in the rainy season increases than during the dry season. From the results of data processing it was found that the salinity value in the rainy season ranged from 0.1 - 30 ppt, whereas in the dry season it ranged from 0.1 - 33 ppt, with the highest salinity in North Padang sub-district.

Keywords: *Salinity, Groundwater, Rainy Season, Dry Season, Kriging.*

1. Introduction

Water is one of the most important components in the life of living things. The availability of clean water is still a problem at this time. One of the solutions for clean water needs at this time is groundwater. However, groundwater also has its problems, especially in coastal areas. Some residents complained that the quality of their groundwater changed during the change of seasons.

In the dry season, groundwater levels tend to decrease. This will provide an opportunity for seawater intrusion. Seawater intrusion is the process of entering seawater into groundwater. Coastal areas have the potential for intrusion symptoms. Seawater intrusion can cause changes in groundwater quality. One of the parameters of groundwater that can be affected by intrusion is salinity. Salinity is the total concentration of ions found in waters [1]. This study aims to determine the effect of seasonal changes on the value of groundwater salinity in the coastal areas of Padang and to detect whether there is seawater intrusion on groundwater. Groundwater is part of the hydrological cycle that takes place in nature and is present in rocks that are below the surface of the ground including the density, distribution and movement of groundwater with an emphasis on its relationship to the geological conditions of an area [2]. Groundwater is the amount of water below the surface of the earth that can be collected through wells, tunnels or drainage systems or can also be called a flow that naturally flows to the surface of the ground through jets or seepage [3].

Seawater has a specific gravity greater than freshwater, consequently, seawater will easily push groundwater. **N**aturally, seawater cannot go far inland because groundwater has piezometric pressure more strongly than seawater, so an interface is formed as the boundary between groundwater and seawater. This situation is a state of equilibrium between seawater and

groundwater. **S**eep seawater or saltwater into groundwater is called seawater intrusion [4]. Seawater intrusion is the process of entering seawater into groundwater because seawater can force groundwater into groundwater.

Excessive extraction of groundwater will cause a space under the ground which allows the compacting process to occur due to the pressure of the soil load of overlying rock, which is reflected on the surface as subsidence which can come slowly or suddenly. Calculation of the probability of this collapse is difficult to predict, just like calculating the probability of an earthquake, because it must be monitored continuously so that the critical point is not exceeded. In aquifers that are close to shore, vacancy due to excessive groundwater uptake can result in changes in hydraulic equilibrium between freshwater and seawater pressure water, which results in the entry of seawater in the direction of land or what is known as seawater intrusion [5].

Salinity is the level of salt dissolved in water. Salinity is the total concentration of ions found in waters. Salinity represents total solids in water after all carbonates are converted to oxides, all bromides and iodides are replaced by chlorides, and all organic matter has been oxidized. Salinity is expressed in units of g/kg or permit ($^0/_{00}$). The following criteria for assessing well water salinity can be seen in Table 1 below:

Table 1: Criteria for Well Water Salinity

No.	Salinity ($^0/_{00}$)	Salinity Level
1	< 0,5	Fresh Water
2	0,5 – 30	Moderately Saline
3	30 – 50	Saline
4	> 50	Brine

Source: [6]

2. Methodology

Interpolation is usually necessary for mapping, and nowadays kriging is used for the purpose [7]. Kriging interpolation is a well-known geostatistical technique for spatial interpolation in geology and mining [8]. The term kriging is taken from the name of an expert, i.e D.G. Krige, who first used spatial correlation and unbiased estimators [9]. Kriging is a generic name for a family of generalized least-squares regression algorithms, used in recognition of the pioneering work of D. G. Krige [10]. The generalization of this method was developed by Matheron [11]. Kriging is a method of estimating the value of a variable at a point or block for which there is no sample value by using a linear combination of known variables [12]. Kriging estimate is known as the Best Linear Unbiased Estimate (BLUE), because it is a linear combination of weighted sample values, the whose expected value for error equals zero and whose variance is a minimum.

In variogram, analysis modelling is done by kriging interpolation technique. Variograms are statistical tools to describe, model and explain spatial correlations between observations [13]. Variograms can be used to analyze the level of similarity or variability between each data level [14].

A variogram is a vector function that can be used to quantify the degree of similarity or variability between two samples that are separated by a certain distance. Variogram analysis begins with making an experimental variogram. After that, it is continued with fitting variogram, which is matching experimental variogram with theoretical variogram. From the fitting variogram, the variogram model will be selected. There are three variogram models used [15, 16]:

1. Spherical model
2. Exponential model
3. Gaussian model .

IJISET - International Journal of Innovative Science, Engineering & Technology, Vol. 7 Issue 6, June 2020
ISSN (Online) 2348 – 7968 | Impact Factor (2020) – 6.72
www.ijiset.com

2. Result

3.1 Groundwater Table Mapping

From the results of data processing, groundwater table map during the rainy and dry season is obtained. The map can be seen in Fig. 1 and Fig. 2 below.

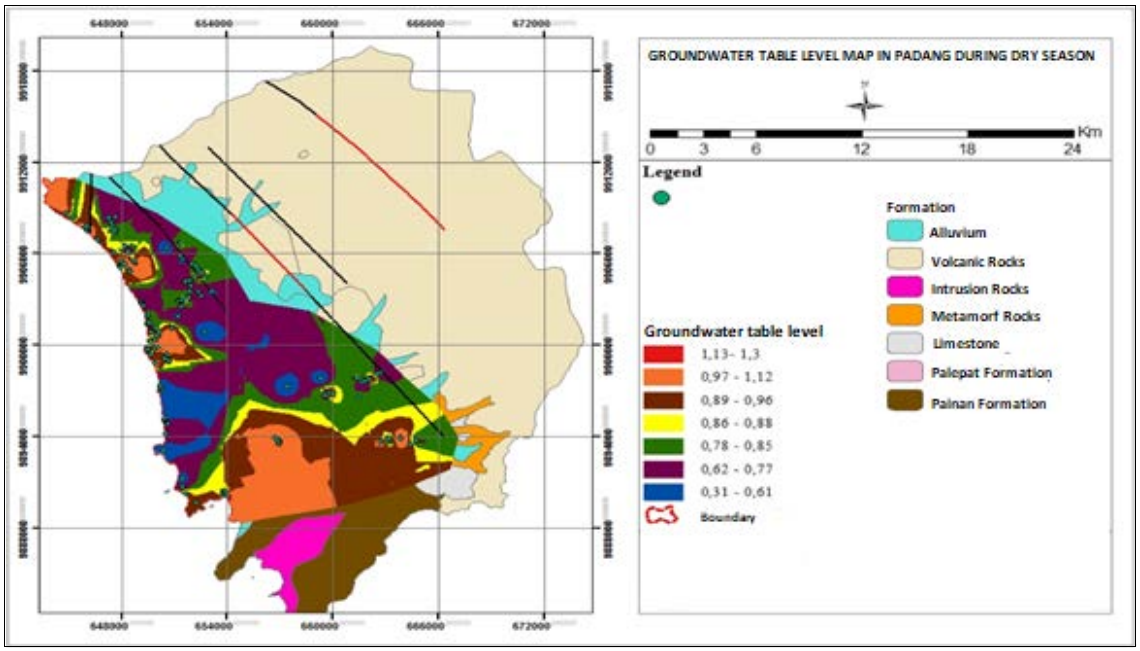

Fig.1 Zoning Map of Groundwater Table During Dry Season

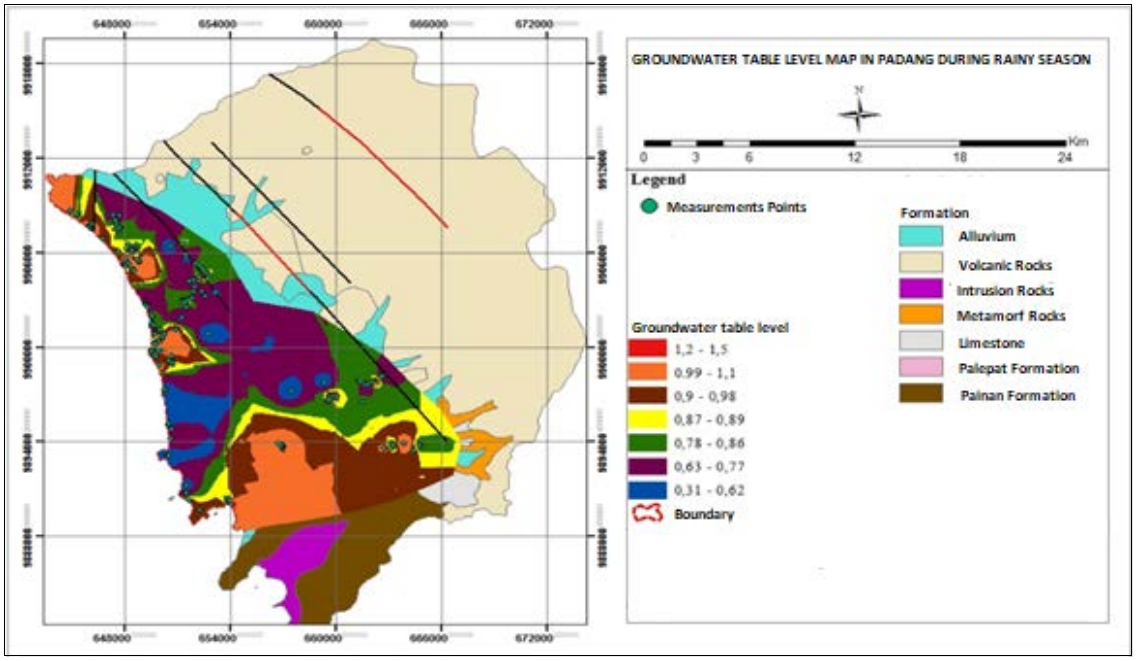

Fig.2 Zoning Map of Groundwater Table During Rainy Season

From the map, we can see the groundwater table level in rainy and dry season is different. In the dry season, the groundwater table ranges between 0,31–1,3 meters, while in the rainy season, the ground water table ranges between 0,31–1,5 meters. From these results, we know that groundwater level increased during rainy season.

3.2 Salinity Zone Mapping

Based on the data processing of salinity value, a histogram of salinity in both seasons is obtained. The histogram of salinity can be seen in Fig. 3 below.

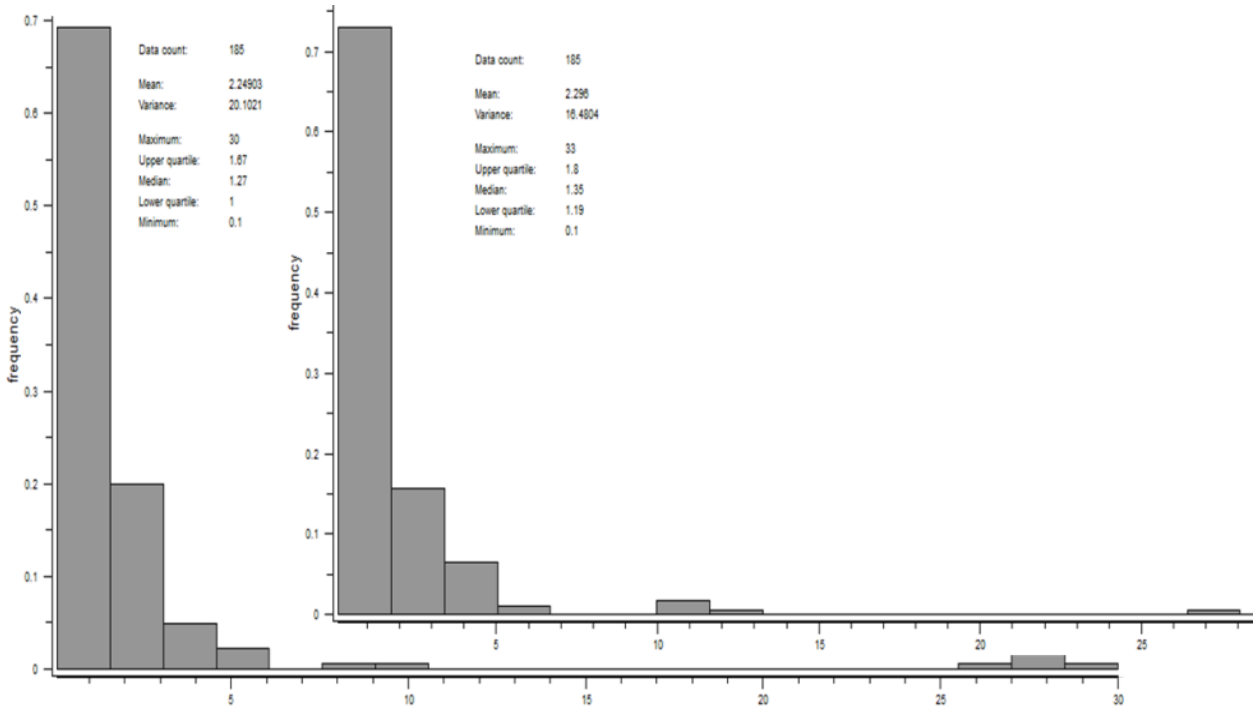

Fig. 3 Histogram of Salinity Data During Dry Rainy and Dry Season

From the histogram can be seen that the average of salinity value in the rainy season is 2,2493 ppt and in the dry season is 2,296 ppt. From these results, the average salinity value in dry season is higher than rainy season. After analyzing the histogram, then an analysis of the variogram is performed. Based on fitting variogram, variogram model of salinity during both seasons is obtained. Variogram model used is spherical model. Variogram model can bee is seen in Fig. 4. Based on the variogram model, several variogram parameters are obtained. The parameters can be seen in Table 2 and Table 3 below.

Table 2: Parameter Variogram of Salinity During Rainy Season

Parameter	Value
Nugget	0
Sill	20,1021
Range	2700

Table 3: Parameter Variogram of Salinity During Dry Season

Parameter	Value
Nugget	0
Sill	16,48
Range	2600

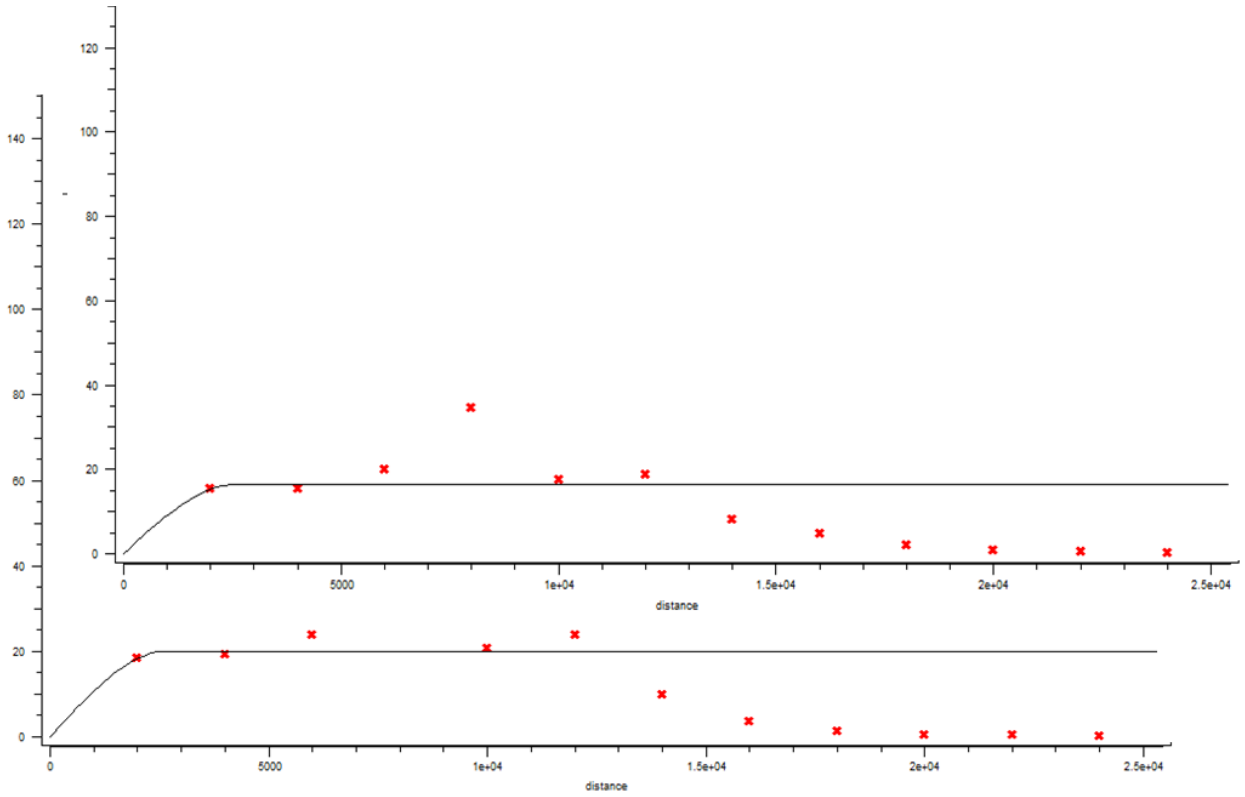

Fig. 4 Variogram Model of Salinity During Rainy Season and Dry Season

From the results of the data processing, the salinity zoning map during the rainy season and dry season is obtained. The map can be seen in Fig. 4 and Fig. 5 below.

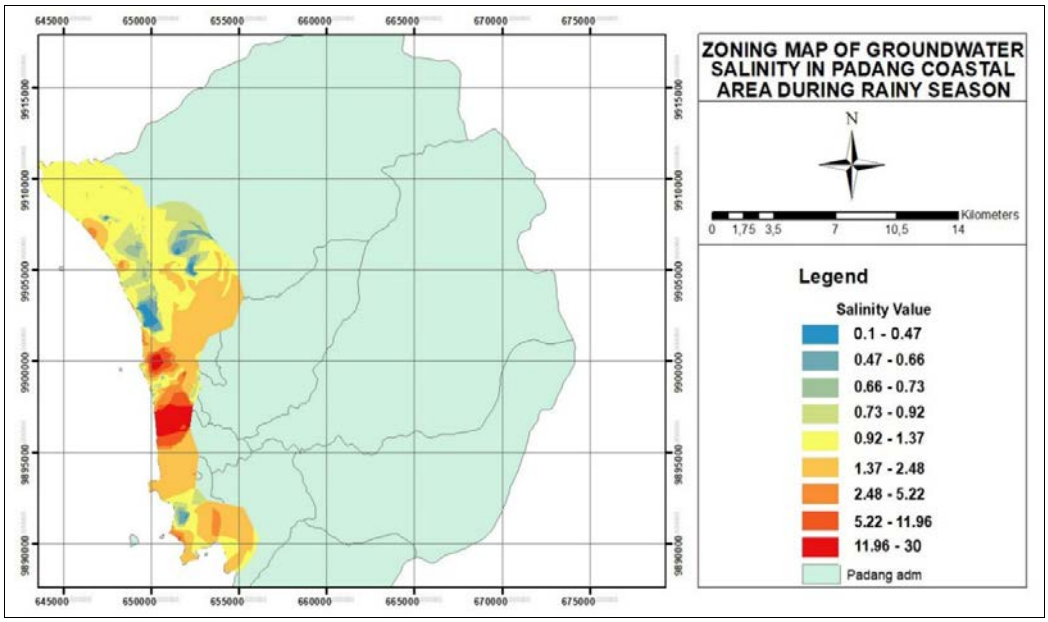

Fig.4 Zoning Map of Salinity During Rainy Season Using Kriging Interpolation Method

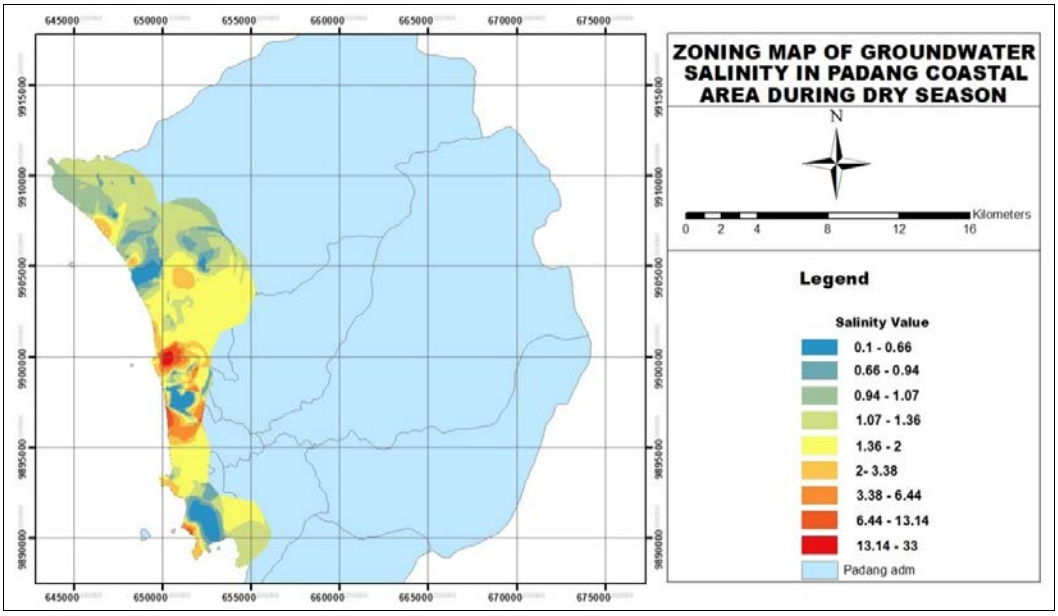

Fig.5 Zoning Map of Salinity During Dry Season Using Kriging Interpolation Method

From the map (Fig. 4 and Fig. 6), can see the different of salinity value in the rainy and dry season. In the rainy season, the salinity value ranged from 0.1-30 ppt, while in the dry season it ranged from 0.1-33 ppt, with the highest salinity in North Padang sub-district and West Padang sub-district. From the map, can be seen that in some locations there was a decrease in the value of groundwater salinity during the dry season. This could have happened because of the influence of the geological conditions in the surrounding area, so that requires further research.

4. Conclusion

From the research, it is known that the groundwater level increases during the rainy season, while the value of groundwater salinity tends to rise during the dry season. This proves that seasonal changes affect the value of groundwater salinity. Two sub-districts are indicated to have occurred in seawater intrusion, the North Padang sub-district and West Padang sub-district.

Acknowledgements

This paper is a part of a research project supported by Universitas Negeri Padang. The authors thank the people who get involved in this research.

References

[1] A. Nurrohim, T.B. Sanjoto, and W. Setyaningsih, Kajian Intrusi Air Laut Di Kawasan Pesisir Kecamatan Rembang Kabupaten Rembang. Geo-Image, Vol.1, Issue 1, 2012, pp.21-27.
[2] H. Danaryanto, Djaendi, and S. Hadipurwo, Air Tanah di Indonesia dan Pengelolaannya. Departemen Energi dan Sumberdaya Mineral, Ditjen Geologi dan Sumberdaya Mineral, 2005.
[3] R.J. Kodoatie, Tata Ruang Air Tanah. Penerbit Andi, 2012.
[4] H. Amri, and A. Putra, Estimasi Pencemaran Air Sumur yang Disebabkan Oleh Intrusi Air Laut di Daerah Pantai Tiram, Kecamatan Ulakan Tapakis. Jurnal Fisika Unand, Vol. 3, Issue 4, 2018, pp.235-241.
[5] A. Herlambang, and R.H. Indriatmoko, Pengelolaan Air tanah dan Intrusi Air Laut. Jurnal Air Indonesia, Vol. 1, Issue 2, 2018.
[6] M. Fatoni, C. Muryani, and S. Nugraha, Studi Agihan Salinitas Airtanah Dangkal Di Kecamatan Puring Kabupaten Kebumen Tahun 2016. GeoEco, Vol. 4, Issue 1, 2018.
[7] H.Y. Li, R. Webster, and Z. Shi, Mapping soil salinity in the Yangtze delta: REML and universal kriging (E-BLUP) revisited. Geoderma, Vol. 237, 2015, pp.71-77.
[8] T.Q. Bui, T.N. Nguyen, and H. Nguyen-Dang, A moving Kriging interpolation-based meshless method for numerical simulation of Kirchhoff plate problems. International Journal for Numerical Methods in Engineering, Vol. 77, Issue 10, 2009, pp.1371-1395.

[9] A. Octava, M. Gusman, P. Razi, and A.E. Putra A E, Modeling of aquifer using vertical electrical sounding data with kriging interpolation in Padang City. Journal of Physics: Conference Series, Vol. 1481, Issue. 012008, 2020, pp.1-12.
[10] J. Li, and A.D. Heap, A review of spatial interpolation methods environmental scientists. Geo. Australia, 2008, pp.1-137.
[11] C. Caruso, and F. Quarta, Interpolation methods comparison. Computers & Mathematics with Applications, Vol. 35, Issue.12, 1998, pp.109-126.
[12] S.A. Pramuditya, and M.A. Azizi, Geostatistik Mineral Matter Batubara Pada Tambang Air Laya. FKIP Unswagati, 2017.
[13] F. Faisal, and J. Rizal, Kajian Pemilihan Model Semivariogram Terbaik pada Data Spatial. GRADIEN: Jurnal Ilmiah MIPA, Vol. 8, Issue 1, 2012, pp.756-762.
[14] M. Gusman, B. Muchtar, N. Syah, M.D. Akbar, and A.V. Deni, Estimation of Limestones Resources Using Three Dimension Block Kriging Method, a Case Study: Limestone Sediment at PT Semen Padang. IOP Conf. Series: Earth and Environmental Science, Vol. 314, Issue. 012069, 2019, pp.1-10.
[15] F. Ersyad, D. Yulhendra, and H. Prabowo, Kajian Teknis dan Ekonomis Perancangan Design Kemajuan Penambangan Quarry Batukapur pada Bulan April–Agustus 2017 di Front III B–IV B Bukit Karang Putih PT. Semen Padang. Bina Tambang, Vol.3, Issue3, 2018, pp.1185-1201
[16] M. Gusman, A. Nazki, and R.R. Putra. The modelling influence of water content to mechanical parameter of soil in analysis of slope stability. Journal of Physics: Conference Series, Vol. 1008, Issue. 012022, 2018, pp.1-8

Mulya Gusman, ST, MT is a Doctoral candidate in Universitas Negeri Padang, Indonesia. His research interests are the field of mining and environmental science. contact E-mail is mgusman1974@gmail.com

Adree Octova, S.Si., MT is a researcher staff in Mining Engineering department of Universitas Negeri Padang. His research interests are geophysics, mining exploration and geological modeling. contact E-mail is adree@ft.unp.ac.id

Yoszi MIngsi Anaperta, ST, MT is a researcher staff in Mining Engineering department of Universitas Negeri Padang. Her research interests are geomechanics, mining exploration, and geological modeling. contact E-mail is yosziperta@ft.unp.ac.id

Prof. Dr. Bustari Muchtar is a Professor in Department of Economic Universitas Negeri Padang. His researcher interest are Population and Environmental Education. Contact E-mail is bustarimuchtar@yahoo.com

Dr. Nurhasan Syah, M.Pd is a Assosiate professor in Civil Engineering Department Universitas Negeri Padang. His research interests is environmental sience. Contact E-mail is nurhasansyah@gmail.com

Prof. Dr. Dedi Hermon is a Professor in the Department of Geography, Graduate School of Natural Resources and Environment - Bogor Agriculture University, Indonesia. His research interests include Environment Geography and Disaster. contact E-mail is dihermon006@gmail.com