

Characterization of Soil Physical Properties in Rice Fields Affected by Seawater Intrusion in Pemalang Regency

Ismi Izzatun Naeli*, Indriyana Atmaja, Roudhotul Muna Zen

Master of Physics Education Study Program, Universitas Negeri Semarang, Semarang, Indonesia

Abstract

Seawater intrusion in coastal agricultural areas has become a significant problem affecting soil quality and crop productivity. Therefore, this study aims to analyze the physical properties of rice field soil affected by seawater intrusion in Ulujami Subdistrict, Pemalang Regency. Soil samples were collected from Limbangan Village and analyzed in the laboratory in November 2024, focusing on electrical conductivity (EC), salinity, and soil pH. The average EC value reached 7.43 mmhos/cm, which exceeded the plant tolerance threshold of 4 mmhos/cm. These results indicate a high dissolved salt content, classifying the area as saline soil with salinity class 2, where only salt-tolerant plants can grow and productivity may decline. The soil also showed alkaline characteristics, with an average pH value of 8.47. The elevated pH is associated with sodium chloride ions displacing essential soil cations such as calcium and magnesium, thereby reducing microbial water absorption and potentially disrupting nutrient balance. Overall, the EC, salinity, and pH measurements indicate that the soil fertility in this area is low, making the land less suitable for optimal rice cultivation.

Keywords: electrical conductivity, soil salinity, seawater intrusion, pH level.

Article Info

Article History: Received: 07 December 2025 | Accepted: 21 August 2026 | Published: 10 October 2026

© 2026 Universitas Negeri Semarang

✉ Correspondence address:
Master of Physics Education Study Program, Universitas Negeri Semarang
E-mail: ismiizzatunnaeli@students.unnes.ac.id

p-ISSN 2088-1509

INTRODUCTION

Indonesia is a region rich in natural resources, including water, forests, land, seas, and biodiversity (Setiawan, 2023). The majority of Indonesia's population works in agriculture, making it known as an agrarian country. The vast and fertile agricultural areas and tropical climate support the cultivation of rice, corn, and various types of vegetables. The largest agricultural area is located on the island of Java. This is because the soil in Java is more fertile than other islands in Indonesia. Rice crops dominate agricultural land, with nearly 80-90% of farmland used for rice (Timikasari et al., 2022).

Based on data from the Central Statistics Agency (BPS, 2024), East Java province has the most farming businesses in Indonesia, reaching 5,676,675 businesses. This figure shows the importance of the agricultural sector for this province. The second position is occupied by Central Java province with 4,363,201 agricultural businesses. Central Java province has 7,810 villages and 753 sub-districts (BPS, 2024). The large number of villages shows that the agricultural sector plays an important role in supporting the community's livelihood (Syahrindra et al., 2023). On the other hand, the third position is held by West Java province with 3.292.107 businesses. These three provinces on the island of Java are rice producers as well as the main suppliers of agricultural activities in Indonesia.

The demand for rice continues to increase every year as the population grows. Rice production continues despite various challenges in agriculture (Swardana et al., 2023). Climate change, drought, and sea level rise are major challenges in agriculture. Previous studies have shown that 1 billion hectares of land are affected by salinity (Negacz et al., 2022), and 62 million hectares or 20% of irrigated land are also affected by salinity (Egamberdieva et al., 2019). These conditions are in line with the research by Kamran et al. (2020) & Liu et al. (2022), which states that 20% of land is affected by salinity out of a total of 230 million hectares of agricultural land worldwide each year. This is due to inappropriate agricultural practices and natural conditions causing sea level rise. Thus, soil salinity can affect productivity, reducing agricultural yields by between a quarter and a third.

Soil salinity is a phenomenon in soil that has high sodium content and easily soluble salts, thereby limiting rice productivity (Masganti et al., 2022). Increased salinity concentrations generally occur in rice fields near the coast, especially in rice fields in the northern coastal area of Java (Hasrianda et al., 2024). Data from the National Research and Innovation Agency (BRIN) shows that one million hectares of agricultural land are affected by salinity, thereby reducing national agricultural productivity. The areas in Central Java that have saline land affected by seawater intrusion are Demak Regency, Pati Regency, Cilacap Regency, Brebes Regency, Rembang Regency, and the coastal area of Semarang City (Nurrohim et al., 2012; Darmanto and Cahyadi, 2013; Suhartono et al., 2013; & Putra et al., 2023). The areas most affected by seawater intrusion are the northern coastal areas of Central Java, namely Kendal and Pemalang Regencies. Both areas have soil salt content exceeding the threshold for crops. Rice fields in Brangsong District, Kendal Regency, with 10 to 60 percent affected by saline soil, and in Ulujami District, Pemalang Regency, up to 90 percent of rice fields cannot be planted with rice or vegetables.

The Pemalang Regency area has a population of more than 100,000, most of whom work in agriculture (Sundarti and Robertus, 2022). This area is also one of the top 10 largest rice producers in Central Java, making it a rice granary that functions as a food buffer zone (Dinas Pertanian Kabupaten Pemalang, 2023). Pemalang Regency has a total land area of 38,617 hectares and 23,813 hectares of dry rice fields, which produce rice, cassava, corn, and vegetables (Daniswari, 2022). Ironically, the Pemalang region is located in a flood-prone area, which causes rice fields to be affected by flooding (Aldian and Pigawati, 2024). The condition of the drainage system in residential areas, which is not well managed, is a factor that triggers flooding (DLH Kabupaten Pemalang, 2019). This increases the possibility of an area being inundated by seawater due to flooding. The inundation of seawater in rice fields will cause changes in the nature of the rice field soil.

Conditions in the field show that soil quality can change over time. The physical properties of soil are related to the shape or condition of the soil, texture, porosity, color, temperature, pH, and others (Bakri et al., 2022). Although the impact is not felt directly, a decline in soil quality results in the deterioration and damage of soil structure (Mujiati et al., 2017). The influx of seawater reduces soil quality over time. The coastal rice fields in Ulujami District, Pemalang Regency, are considered to have saline soil affected by seawater intrusion. Nearly 90% of agricultural land cannot be cultivated due to the high salt content in the soil structure. The electrical conductivity of saline soil is more than 4.0 dSm-1 and the pH value is around 8.5 (Hendri and Saidi, 2020).

Furthermore, the physical properties of the soil greatly affect the availability of water, air, and plant nutrients (Bakri et al., 2022). This also affects the potential for soil quality to develop optimally. Rice fields with high salinity are located near the coast or channels close to seawater (Rachman et al., 2018). In addition, sea levels are also rising as a result of climate change in coastal areas where rice is grown. An area that meets these criteria is Limbangan Village, Ulujami District, Pemalang Regency. Therefore, research was conducted to analyze the properties of rice field soil affected by seawater intrusion in Ulujami District, Pemalang Regency. This study analyzes the quality of rice field soil based on physical soil parameters, with the aim of restoring rice productivity.

METHOD

Topographical and Geographical Conditions of the Research Location

The research was conducted in Limbangan Village, Ulujami Subdistrict, Pemalang Regency. Astronomically, Pemalang Regency is located on the north coast of Java Island with a latitude of $80^{\circ}52'30'' - 70^{\circ}20'11''$ south and an east longitude of $1090^{\circ}17'30'' - 1090^{\circ}40'30''$ east. Pemalang Regency, with an area of 1.115,30 km², is bordered by the Java Sea to the north, Purbalingga Regency to the south, Pekalongan Regency to the east, and Tegal Regency to the west. The northern part of Pemalang Regency is a coastal area with an elevation of about 1 to 5 meters above sea level. Additionally, this area also has two major rivers, namely the Waluh and Comal Rivers, which are part of a fertile river basin. The research or sampling location is in Limbangan Village, Ulujami Subdistrict, Pemalang Regency, with astronomical coordinates of latitude $6^{\circ}52' - 7^{\circ}20' S$ and longitude $109^{\circ}17'30'' - 109^{\circ}40' E$. Figure 1 shows the location of the survey of rice fields affected by seawater intrusion in Limbangan Village, Ulujami Subdistrict, Pemalang Regency.



Figure 1. Location of the study area in Ulujami Subdistrict, Pemalang Regency

Sample Collection Location

This type of research is field research. The sample location consists of three points, namely the center, right side, and left side of the rice fields affected by seawater intrusion. The samples were taken from rice fields in the coastal area of Limbangan Village, Ulujami Subdistrict, Pemalang Regency, Central Java Province (Figure 1). This was based on a literature review which showed that the closer the land is to the coast, the greater the potential for seawater intrusion into the land.

Research Implementation

This study began with a field survey based on rice field maps. The next step was to prepare the tools and materials at the specified coordinates. At each point, 500 grams of soil was collected at a depth of 60 cm. The tools used for sampling included a hoe, transparent containers, buckets, a measuring stick, label paper, and writing instruments. Figure 2 shows a sample of the soil used in this study.



Figure 2. Soil sampling in the study area: (left) process of collecting soil samples at a depth of 60 cm; (right) collected soil samples stored in labeled containers

Laboratory Analysis

The methods applied in this study included laboratory analysis of soil pH, salinity, and electrical conductivity (EC).

a. Electrical Conductivity (EC)

Electrical conductivity is used to measure the total amount of dissolved salts. The DHL value can be determined by mixing soil and water in a ratio of 1 part soil to 5 parts water. The solution is then stirred until evenly mixed and left to settle for 30 minutes. The next step is to insert the Portable EC Meter measuring device into the solution above the sediment. An increase in salt concentration causes electrical conductivity to also increase. The EC value indicates the concentration of dissolved salts, which can be influenced by the water absorption capacity of plant roots. Although this measurement cannot determine the type of salt, it is used to determine electrical conductivity, which indicates the salt content in the solution. Table 1 shows the effect of DHL on plant productivity.

Table 1. Electrical Conductivity Values in Relation to Plant Productivity

DHL Value (mmhos/cm)	Salinity	Effect on Plant Productivity
0,0 - 2,0	Normal	Does not affect crop productivity
> 2,0 - 4,0	Low	Potentially reduces plant productivity
> 4,0 - 8,0	Moderate	Reduces crop productivity
> 8,0 - 16,0	High	Potentially affects the productivity of tolerant plants
> 16,0	Very high	Tolerant plants produce little

Source: Abrol *et al.* (1988)**b. Soil pH value**

The indicator of soil fertility is soil pH level. Agricultural land has varying degrees of pH. Neutral soil has a pH value of 7, while soil with a pH below 7 is considered acidic and soil with a pH above 7 is considered alkaline. Soil pH is measured using a pH meter to determine the condition of agricultural land. pH measurements can be taken using a pH meter that is inserted into the soil. This measuring device provides quick and accurate readings.

c. Soil Salinity Level

Salinity can reduce water availability for plants. Excessive salt content can inhibit water absorption and cause plants to become physiologically dry. Plants have sufficient moisture in the soil, but their roots cannot absorb water. Plants are usually most vulnerable to salt when they begin to germinate and are in the first stage of growth. In addition, salinity is indicated when excessive amounts of salt enter the plant through transpiration and damage the leaf cells.

Salinity values can be categorized by comparing the DHL values of soil samples. The DHL value approach is related to salinity values caused by dissolved salt ions (Youger, 2007; Aris *et al.*, 2013; & Hounsinnou, 2020). The distribution of DHL values can be used as a distribution of the effects of seawater intrusion. High soil salinity is indicated by high levels of Na⁺ and Cl⁻ ions, resulting in a lack of available nutrients. Symptoms include limited root growth, burnt or browned leaf tips or edges, stunted flowering, and reduced yields. Table 2 shows the salinity value categories, while Table 3 shows the effects of salinity on rice plants.

Table 2. Salinity Categories

Salinity Level	Conductivity (mS/cm)	Salinity Class
Non Salinity	0,0 - 2,0	0
Low	> 2,0 - 4,0	1
Modeate	> 4,0 - 8,0	2
High	> 8,0 - 16,0	3
Very high	> 16,0	4

Source: Abrol *et al.* (1988)

Table 3. Effect of Salinity on Rice Plants

No	DHL Value (mmhos/cm)	Decrease in Productivity
1	< 4,0	< 10,0
2	4,0 - 6,0	10,0 - 20,0
3	> 6,0 - 10,0	> 20,0 - 50,0
4	> 10,0	> 50,0

Source: FAO (2005)

d. Data Presentation

Data analysis uses descriptive methods to describe each variable of soil physical properties based on the results of soil analysis in the laboratory. The data obtained from the analysis will be interpreted by examining the values of the data produced.

RESULTS AND DISCUSSION

Electrical Conductivity and Soil Salinity Results

Electrical conductivity (EC) is a phenomenon in which charges in the soil are generated by ions, creating an electric field (Swardana, 2023). Electrical conductivity is an indicator of the electrical measurement of dissolved salts. In addition, EC values can also be influenced by mineral content, salt content, and rainfall. Human activities through irrigation and pollution can also affect soil EC values. High EC results indicate high dissolved salt content in saline soils.

Soil salinity can affect plant growth, inhibiting cell division and biomass production in plants (Anugrah et al., 2022). Seedlings are very sensitive to salinity. This shows that high salinity can reduce the number of seedlings and increase plant height. The results measured with an EC meter are classified into salinity classes, which can be seen in Table 4.

Table 4. DHL and Soil Salinity Measurement Data

Location	Soil DHL (mmhos/cm)	Salinity Category	Salinity Class	Impact on Plants
Location A (in the middle)	7,8	Moderate	2	Salt-tolerant plants can grow, but productivity is reduced
Location B (on the right side)	7,4	Moderate	2	Salt-tolerant plants can grow, but productivity is reduced
Location C (on the left side)	7,1	Moderate	2	Salt-tolerant plants can grow, but productivity is reduced

Saline soils are generally affected by seawater intrusion in some areas for more than four months a year, with sodium content ranging from 8 to 15% (Sukarman et al., 2020). In addition, the electrical conductivity of saline soil is greater than 4 mmhos/cm. NaCl content is one of the main salts in saline soil with a composition of approximately 2 to 6% (Karolinoerita and Annisa, 2020). Several

factors influence the increase in salinity, including the influx of large amounts of salt water onto land. This allows seawater to enter the subsoil. A study by Rachman et al. (2018) states that seawater intrusion can also occur on land far from the coast, such as dry land with low rainfall or land contaminated with high-salt waste. Land affected by seawater intrusion experiences gradual damage and changes.

Electrical conductivity values are a qualitative method for evaluating ionic content in soil. The higher the ion concentration in the solution, the higher the DHL value, and vice versa. The ion concentration in the soil is related to the DHL value in the soil. If the DHL value exceeds 4 mmhos/cm, root decay due to plasmolysis can occur. The results of this study show that the soil at all sampling locations is classified as hazardous because the measured values are above the threshold, as shown in Figure 3.

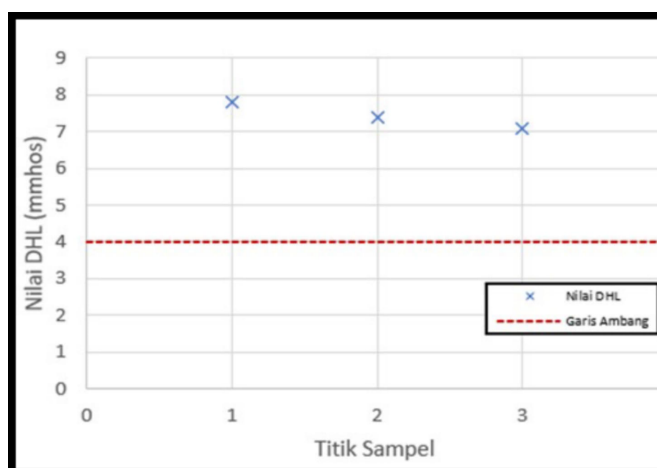


Figure 3. DHL values

The rice fields in this study are typically used to grow rice and vegetables, but the phenomenon of seawater intrusion has rendered the land infertile. Rice plants can generally grow in land covered with 18-22 cm of mud and a pH of 7 or neutral. As seawater intrusion spreads, the productivity of rice and vegetables decreases. The spread of seawater intrusion reduces the yield of rice and other vegetables.

The large amount of empty grains and reduced crop productivity found on this land is also consistent with the results of several similar studies. Hasrianda's (2024) study shows that the age of the plant is important when rice is exposed to salinity. Rice that is less than 12 days old will wither quickly when exposed to salinity, while rice that is 30 days old will survive for quite a long time but eventually die. Rice that is 55 days old will experience delayed grain filling and reddening of the leaves, and rice that is 65 days old will experience grain filling disorders, resulting in a large number of empty grains. Therefore, salt-tolerant rice is urgently needed to address the decline in productivity caused by salinity and seawater intrusion.

Soil pH Measurement

The soil pH values in this study were obtained from rice fields affected by seawater intrusion. Seawater intrusion is a phenomenon in which seawater seeps into aquifers in coastal areas. This phenomenon can affect soil quality, making pH an important indicator in determining soil quality. The results of pH measurements in this study are shown in Table 5.

Table 5. pH Measurement Results

Location	pH value	Description
Location A (in the middle)	8,7	Alkaline
Location B (on the right side)	8,5	Alkaline
Location C (on the left side)	8,2	Alkaline

Soil pH measurements were taken using a pH meter at three locations selected as research samples. The measurement results showed an average soil pH scale value of 8.5, which is classified as alkaline. The pH increased along with the increase in organic matter in the soil. This increase was caused by the decomposition of organic matter, especially sodium (Na) compounds, which produced base cations. The release of base cations saturated the soil with these cations and increased the soil pH (Supriadi et al., 2016).

Initial conditions prior to seawater intrusion, soil in coastal areas had varying pH levels depending on mineral content (Hendri and Saidi, 2020). Soil affected by seawater intrusion tended to experience an increase in sodium and chloride ions, causing the soil pH to become alkaline. This study produced an average pH value of 8.5 at three sampling points. This is in line with the research by Hendri and Saidi (2020), which states that soil affected by seawater intrusion has a pH value of around 8.5, indicating alkaline properties.

The soil pH value refers to the acidity of the soil and is indicated by the amount of H^+ in the soil. According to Government Regulation No. 150 of 2000, soil pH is considered problematic if the pH value is below 4.5 or above 8.0 in dry soil. The red line represents the minimum limit (4.5) and the green line represents the maximum limit (8.0). Sample 1 is above the maximum threshold, while Samples 2 and 3 are within the threshold range. The results of this study indicate that the soil samples are classified as critical because the measured pH values exceed the thresholds shown in Figure 4. The red line indicates the minimum threshold (4.5) and the green line indicates the maximum threshold (8.0). Sample 1 is above the maximum threshold, while samples 2 and 3 are within the threshold range.

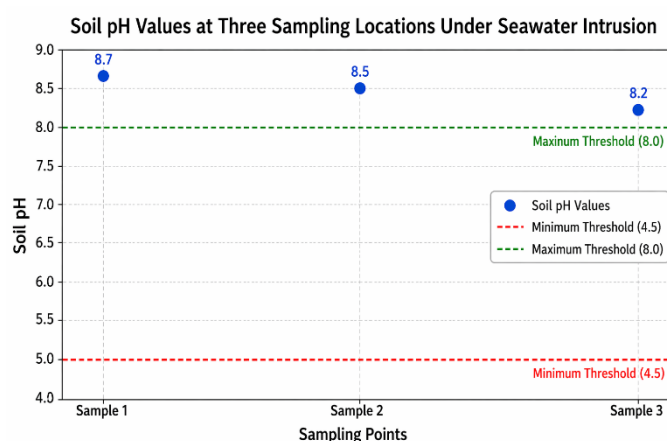


Figure 4. Soil pH values at three sampling locations in the study area

Seawater with high salt content can also change the chemical properties of soil. Salt ions such as sodium chloride replace cations in the soil, such as calcium (Ca) and magnesium (Mg). This condition is a factor in the alkaline properties of soil (Sahwilaksa, 2014). In line with the research by Prayitno et al. (2016), high soil pH values will cause low levels of microorganisms in the soil. In addition, high salt levels such as Na will make it difficult for microorganisms to absorb water in the

soil. Soil with high pH or alkaline levels can cause plant poisoning and inhibit plant growth due to an imbalance of nutrients.

The results of the study indicate that soil pH is affected by seawater intrusion. The distance between land and sea water shows how close the land is to the coast, so it is likely that seawater intrusion will occur, affecting pH values. Research by Sahwilaksa (2014) states that land less than 2 km from the coast will experience changes in soil quality. In addition, this study used a soil depth of 60 cm, which could affect the pH value. According to research by Basuki et al. (2018), the subsoil has a higher pH value than the topsoil because of the amount of salt absorbed from seawater intrusion. Therefore, if seawater intrusion worsens, proper management strategies should be implemented, including the application of gypsum to reduce soil sodicity, improved drainage to facilitate salt leaching, and the use of salt-tolerant rice varieties, considering the high pH and salinity levels observed in this study.

CONCLUSION

Soil fertility is influenced by several factors, such as soil physical properties. The purpose of this study was to measure soil physical properties, including soil pH, DHL, and salinity due to seawater intrusion. This study was conducted in Limbangan Village, Ulujami Subdistrict, Pemalang Regency. Each measurement was taken at three different locations. The results showed that DHL was very high in saline soil due to seawater intrusion, thereby increasing the ion content in the soil. The higher the DHL value, the higher the salt content. The NaCl content in saline land tended to be high. Soil pH measurements showed that the pH of saline soil due to seawater intrusion tended to be alkaline (high). This indicates that the higher the organic content in the soil, the higher the pH value in the soil solution. High salinity can affect rice growth, inhibit water and nutrient absorption, and damage soil structure. Further research can be conducted to determine changes in soil characteristics in areas affected by seawater intrusion, as well as to identify effective techniques for managing and utilizing land affected by seawater intrusion.

DECLARATION OF GENERATIVE AI

The authors declare that no generative AI or AI-assisted technologies were used in the writing process of this manuscript.

CONFLICTING INTEREST STATEMENT

The authors states that there is no conflict of interest in the publication of this article.

FUNDING INFORMATION STATEMENT

This research did not receive any specific grant from funding agencies in the public, commercial, or not-for-profit sectors.

ACKNOWLEDGEMENT

The researchers would like to thank the Pemalang Regency Environment Agency for its support throughout the research process.

REFERENCES

- Aldian, S. K. & Pigawati, B. (2024). Kajian Perkembangan Lahan Permukiman Berdasarkan Kemampuan Lahan pada Kawasan Rawan Banjir di Perkotaan Pemalang. *Teknik PWK (Perencanaan Wilayah Kota)*, 13(3), 234-247. <https://doi.org/10.14710/tpwk.2024.40561>
- Badan Pusat Statistik Provinsi Jawa Tengah, 2024. Jumlah Kecamatan dan Desa/Kelurahan Menurut Kabupaten/Kota di Provinsi Jawa Tengah, 2023. Semarang: Badan Pusat Statistik.
- Bakri, A., Pagi, S., & Rahman, A. (2022). Analisis Sifat Fisika Tanah pada Beberapa Penggunaan Lahan di Desa Maku Kecamatan Dolo Kabupaten Sigi. *AGROTEKBIS: Jurnal Ilmu Pertanian (e-Journal)*, 10(1). Retrieved from <http://jurnal.faperta.untad.ac.id/index.php/agrotekbis/article/view/1175>
- Daniswari, D. (2022, Februari 20). 6 Fakta Pemalang, Daerah Berjuluk Grombyang yang Kaya Kuliner Lokal. Diakses pada November 21, 2024 dari artikel ilmiah: https://regional.kompas.com/read/2022/02/20/060000478/6-fakta-pemalang-daerah-berjuluk-grombyang-yang-kaya-kuliner-lokal?page=all#google_vignette
- Darmanto, D. & Cahyadi, A. (2013). Kajian Intrusi Air Laut melalui Sungai di Pesisir Kabupaten Demak Jawa Tengah. *Majalah Geografi Indonesia*, 27(1). 1-10.
- Dinas Lingkungan Hidup. (2019). Laporan Utama Informasi Kinerja Pengelolaan Lingkungan Hidup Daerah (IKPLHD). Kabupaten Pemalang: Dinas Lingkungan Hidup Kabupaten Pemalang.
- Egamberdieva, D., Wirth, S., Bellingrath-Kimura, S.D., Mishra, J., & Arora, N. K. (2019). Salt-Tolerant Plant Growth Promoting Rhizobacteria for Enhancing Crop Productivity of Saline Soils. *Frontiers in Microbiology*, 10.
- Hasil Sensus Pertanian. (2023, Desember 21). Diakses pada November 21, 2024 dari artikel ilmiah: <https://ro-ekonomi.jatimprov.go.id/berita/1703167203-berdasarkan-hasil-sensus-pertanian-2023-tps-pusat-petani-milenial-di-jatim-menjadi-yang-terbanyak-dan-menduduki-peringkat-pertama-nasional>
- Hasrianda, E. F., Fefirenta, A. D., Gunawan, I., & Davis, L. O. M. M. (2024). Penanganan Stres Salin dalam Pertanian Padi Sawah: Hasil Kajian dari Wilayah Tirtayasa, Kabupaten Serang, Provinsi Banten, Indonesia. *PANGAN*, 33(1), 31-46
- Hendri, J. & Saidi, B. B. (2020). Pengaruh Ameliorasi Lahan yang Terkena Intrusi Air Laut terhadap Pertumbuhan dan Produksi Padi. *Prosiding Seminar Nasional Lahan Suboptimal ke-8 Tahun 2020*, Palembang, 605-615.
- Kamran, M., Parveen, A., Ahmar, S., Malik, Z., Hussain, S., Chattha, M. S., Saleem, M. H., Adil, M. F., Heidari, P., & Chen, J. T. (2019). An Overview of Hazardous Impacts of Soil Salinity in Crops, Tolerance Mechanisms, and Amelioration through Selenium Supplementation. *International Journal of Molecular Sciences*, 21.
- Liu, C., Mao, B., Yuan, D., Chu, C., & Duan, M. (2022). Salt Tolerance in Rice: Physiological Responses and Molecular Mechanisms. *Crop Journal*, 10(1), 13-25. <https://doi.org/10.1016/j.cj.2021.02.010>
- Masganti, Abduh, A. M., Agustina, R., Alwi, M., Noor, M., & Rina, Y. (2022). Pengelolaan Lahan dan Tanaman Padi di Lahan Salin. *Jurnal Sumberdaya Lahan*, 16(2), 83-95. <http://dx.doi.org/10.21082/jsdl.v16n2.2022.83-95>

- Mujiati, M. S., et al. (2017). A Study on The Land Use Change and its Effect Toward The Water Quality in Kampwolker River. *International Journal of Civil Engineering & Technology (IJCIET)*, 8(7). 893-901.
- Negacz, K., Malek, Ž., de Vos, A., & Vellinga, P. (2022). Saline Soils Worldwide: Identifying The Most Promising Areas for Saline Agriculture. *Journal of Arid Environments*.
- Nurrohim, A., Sanjoto, T. B., & Setyaningsih, W. (2012). Kajian Intrusi Air Laut di Kawasan Pesisir Kecamatan Rembang Kabupaten Rembang. *Geo Image*, 1(1). 21-27.
- Setiawan, H. N. (2023). Indonesia dengan Konsep Tradisional Agraris. *Court Review: Jurnal Penelitian Hukum* (e-ISSN: 2776-1916), 3(02), 17–20. <https://doi.org/10.69957/cr.v3i02.686>
- Panen Padi Nusantara 1 (Satu) Juta Hektar. (2023, Maret 13). Diakses pada November 21, 2024 dari artikel ilmiah: <https://dispertan.pemalangkab.go.id/index.php/2023/03/13/panen-padi-nusantara-1-satu-juta-hektar/>
- Putra, D. P. E., Nisaa, F. A., Susatio, R., & Atmaja, R. R. S. (2023). Identifikasi Intrusi Air Laut pada Akuifer Pantai Menganti, Kecamatan Kesugihan, Cilacap, Jawa Tengah. *Jurnal Ilmu Lingkungan*, 21(3). 545- 552.
- Rachman, A., Dariah, A., & Sutono, S. (2018). Pengelolaan Sawah Salin Berkadar Garam Tinggi. Dalam Supriyadi Widiarta IN (Eds.). IAARD PRESS. Jakarta. 60 Hlm.
- Suhartono, E., Purwanto, & Suripin. (2013). Kondisi Intrusi Air Laut terhadap Air Tanah pada Akuifer di Kota Semarang. *Prosiding Seminar Nasional Pengelolaan Sumberdaya Alam dan Lingkungan*. ISBN 978-602-17001-1-2.
- Sundarti, S., & Robertus, M. H. (2024). Pengaruh Penggunaan Dana Desa dalam Bidang Pembangunan Desa dan Bidang Pemberdayaan Masyarakat Desa terhadap Kemiskinan Desa di Kabupaten Pemalang Tahun 2019-2020. *Diponegoro Journal of Economics*, 11(2), 107-114. Retrieved from <https://ejournal3.undip.ac.id/index.php/jme/article/view/34850>
- Supriadi, H., et al. (2016). Korelasi antara Ketinggian Tempat, Sifat Kimia Tanah dan Mutu Fisik Biji Kopi Arabika di Dataran Tinggi Garut. *Sukabumi: J. TIDP* 3(1), 45-52.
- Swardana. A., et al. (2023). Pengukuran Nilai Daya Hantar Listrik pada Berbagai Tanah Sawah di Kecamatan Tarogong Kaler, Kabupaten Garut. *Jurnal Agroteknologi dan sains (JAGROS)*. 7(2). 93-98. <http://dx.doi.org/10.52434/jagros.v7i2.2472>
- Syahrindra, A., Ekowati, T., & Prastiwi, W. D. (2023). Analisis Tren dan Peramalan Produk Domestik Regional Bruto Sektor Pertanian Provinsi Jawa Tengah. *Jurnal Litbang Provinsi Jawa Tengah*, 21(1), 21-34. <https://doi.org/10.36762/jurnaljateng.v21i1.988>
- Timikasari, A. D., Shodiq, D. E., & Setiawan, I. (2022). Literature Review: Sumber Daya Alam Pangan pada Sektor Pertanian di Indonesia. *JSEI: Jurnal Sains Edukatika Indonesia*, 4(2). 44-48. e-ISSN: 2656-4890.