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ANALYSIS CHLORIDE OF GROUND WATER WITH MULTIPLE REGRESSION IN AREAS BELAWAN CITY

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Abstract

Water indispensable for all life forms and crucial for enhancing human well-being, faces threats from unsustainable groundwater abstraction practices. Ignoring soil water chemistry's characteristics and physical properties during groundwater extraction can lead to contamination, jeopardizing both the quality and quantity of groundwater resources. This contamination, resulting from natural processes like sedimentation and human activities such as sewage discharge, poses significant pollution risks. Through the analysis of chloride levels in groundwater, this study examines the intricate relationships between hydrochemical parameters and seawater intrusion. Utilizing multiple regression analysis, it establishes strong correlations between chloride concentration and key variables including water usage, well depth, permeability, and distance from the shoreline. Predictive curve graphs elucidate how these variables influence chloride concentrations, emphasizing the importance of managing groundwater resources sustainably. The research underscores the imperative of addressing the increasing demand for water while mitigating environmental risks, ensuring the availability of clean water resources for future generations.

Keywords: chloride, seawater intrusion, multiple regression.

Abstrak

Air yang sangat diperlukan oleh semua bentuk kehidupan dan sangat penting untuk meningkatkan kesejahteraan manusia, menghadapi ancaman dari praktik pengambilan air tanah yang tidak berkelanjutan. Mengabaikan karakteristik kimiawi dan sifat fisik air tanah selama pengambilan air tanah dapat menyebabkan kontaminasi, yang membahayakan kualitas dan kuantitas sumber daya air tanah. Kontaminasi ini, yang dihasilkan dari proses alami seperti sedimentasi dan aktivitas manusia seperti pembuangan limbah, menimbulkan risiko pencemaran yang signifikan. Melalui analisis kadar klorida dalam air tanah, penelitian ini mengkaji hubungan yang rumit antara parameter hidrokimia dan intrusi air laut. Dengan menggunakan analisis regresi berganda, penelitian ini menunjukkan korelasi yang kuat antara konsentrasi klorida dan variabel-variabel utama termasuk penggunaan air, kedalaman sumur, permeabilitas, dan jarak dari garis pantai. Grafik kurva prediksi menjelaskan bagaimana variabel-variabel ini mempengaruhi konsentrasi klorida, menekankan pentingnya mengelola sumber daya air tanah secara berkelanjutan. Penelitian ini menggarisbawahi pentingnya mengatasi permintaan air yang terus meningkat sambil mengurangi risiko lingkungan, memastikan ketersediaan sumber daya air bersih untuk generasi mendatang.

Kata kunci: klorida, intrusi air laut, regresi berganda.

1. INTRODUCTION

(Castilla-Rho et al., 2019) is one of the many alternative sources of water that have good quantity and quality available throughout the world in the form of groundwater. In particular, groundwater is ubiquitous and easy to exploit at a relatively low cost. Less affected by dry seasons when compared to surface water and will basically maintain an even quality and temperature. These characteristics of groundwater are more accessible, highly usable and more reliable than other water sources and they tend to depend on a variety of available uses.

(Halder et al., 2021)Groundwater has been used in various aspects of human activities and has played a role in its development, especially in some big cities, the abstraction of groundwater has been intensified to meet the increasing demand for water, which can result in negative consequences such as a decrease in groundwater level, a decrease in the quantity of groundwater. wells, groundwater quality degradation, groundwater subsidence and seawater intrusion into the groundwater supply.

(Weaver et al., 2019)Water shortages are becoming increasingly felt as a result of continuous extraction for development activities and the lack of supplies, so that ensuring the availability of clean water resources can become a global problem due to the increasing use of limited water sources, both by a population that continues to grow in number. In addition, the reduced availability of water sources due to poor management, deforestation and worsening pollution are also the causes. To ensure the availability of sustainable water in the future, then The efficiecy of the supply and use of existing water needs to be improved (Lantang et al., 2023) (Casy Brown, 2006).

(Hounsinou, 2020)Belawan is one of the rapidly growing residential, residential and industrial areas, which is reflected in the pace of development. As a consequence, it is necessary to improve facilities and infrastructure, such as the provision of clean water as an economic commodity that has an important role.

(Panjaitan et al., 2018)The northern area of Medan City, precisely in the Belawan area, partly consists of coastal areas, the possibility of sea water intrusion is very large if the surrounding community cannot control the use of underground water effectively and efficiently. According to (Morris & McGuinness, 2019) Sea water intrusion in coastal aquifers results in changes in the chemical composition of underground water, these changes can occur by: The reaction between sea water and the minerals contained in the aquifer; Reaction of sulfate and addition of carbon or other weak acid; Dissolution and precipitation occur.

(Flores & Lacang, 2022)The main parameters that can be used to monitor the occurrence of interfacial zone shifts are chloride (CL) and electrical conductivity (DHL). Chloride is a chemical parameter that exists in water and forms the main difference in ecological systems (fresh water, brackish water, and sea water).(Tarigan & Nurzanah, 2016) Major changes in the environment can occur when fresh water changes to brackish or salt water or the other way around. For this reason, chloride parameters are needed in assessing water quality. And Electrical Conductivity is a parameter that shows the content of ions in water so that a solution is easy or difficult to conduct electricity. Electrical conductivity is not a relevant parameter to measure pollution, but it can be used as a parameter to determine the level of salt in water. Based on the geological observations and information above, the author feels the need to conduct research. Groundwater.

The purpose of this study was to determine the development of deep groundwater, related to seawater intrusion based on hydrochemical parameters. The research objectives are as follows: Analyzing the properties of water as a hydrochemical parameter for seawater intrusion; Calculating and analyzing the relationship of chloride content as the dependent variable with depth, permeability, the amount of groundwater uptake as independent variables affecting seawater intrusion.

2. METHODS

This research was conducted by taking a sample of deep groundwater (direct method) in a confined aquifer (indirect method) which was then analyzed for chloride and dhl concentrations in the groundwater sample.

Determination of the position of the location for deep groundwater sampling assisted by GPS, where the values of the sampling locations are plotted on a topographic map for

further preparation of dhl and cl distribution zone maps, while to obtain the relationship between chloride concentrations and aquifer properties, they are analyzed using multiple regression mathematical methods using SPSS software. .

The data needed in the research method are primary data and secondary data. Implementation of the research, the authors do it in stages. These stages include, among others: Stages of preparatory studies; Stages of data collection in the field; Stages of laboratory analysis; Stages of analysis and interpretation; Stages of preparing the report.

The research area is administratively located in Belawan Deli District, Deli Serdang Regency, North Sumatra Province. The research location is located at coordinates 030 43' 57.6" - 030 49' 35.5" North Latitude and 980 36' 43.7" - 980 47' 28.1" East Longitude. The reach to the Medan - Belawan research area can be reached by land using a motorbike with a travel time of 1 hour.

3. RESULTS AND DISCUSSION

3.1 Deep Ground Water Well Multiple Regression Analysis

Multiple regression analysis was conducted to examine the relationship between the dependent variable, namely chloride concentration and the independent variable, namely the amount of water usage, the distance of the well to the shoreline, the permeability and the depth of the well.

From the results of the statistical analysis of multiple regression for deep groundwater wells, Multiple R 0.96 is obtained, it can be said that the regression model is quite good and this figure shows that the correlation between the dependent variable and the independent variable has a very close relationship, while the coefficient of determination (R Square) is 92.74 %, this means that 92.74% of the dependent variable, namely chloride, can be explained by the independent variable, namely the distance of the well to the shoreline, permeability, the amount of water usage and the depth of the well, while 7.26% is explained by other factors or variables (other independent variables outside the model). As for the results of the multiple regression analysis, the following function formula is obtained:

$$\mathbf{Y = -37.969 + 0.192\ X1 + 0.156\ X2 + 0.052\ X3 - 0.002\ X4}$$

Information :
Y= Chloride level (mg/l)
X1= Total water consumption (m3/h)
X2= Soil permeability (m/day)
X3= Pumping Well Depth (m)
X4= Distance of the well from the shoreline (m)

Furthermore, by looking at the f test (f test) which aims to determine the joint effect of independent variables on the dependent variable, from statistical analysis it can be obtained f test > f table (significant value 0.05), where f test has a value of 15.97 while f f table has a value of 5.19, this means that Ha is accepted and Ho is rejected, so that independent variables such as the distance of the well from the shoreline, the amount of water usage, the depth of the well and the permeability of the soil affect the amount of chloride concentration.

Then to see the partial effect between each independent variable on the dependent variable, a t test was carried out. And from the results of the t-test can be:

By looking at the results of the t test above, that t count > t table (significant value 0.05) so that Ha can be accepted and Ho is rejected and this means that significantly each independent variable (amount of water usage, distance, permeability and well depth) can affect the concentration level. chloride.

Table 1. t test results on deep bore wells

No	Influence	T count	T table
1.	Discharge to chloride levels	6.32	1.81
2.	Permeability to chloride levels	2.19	1.81
3.	Distance to chloride content	6.70	1.81
4.	Depth to chloride content	8.72	1.81

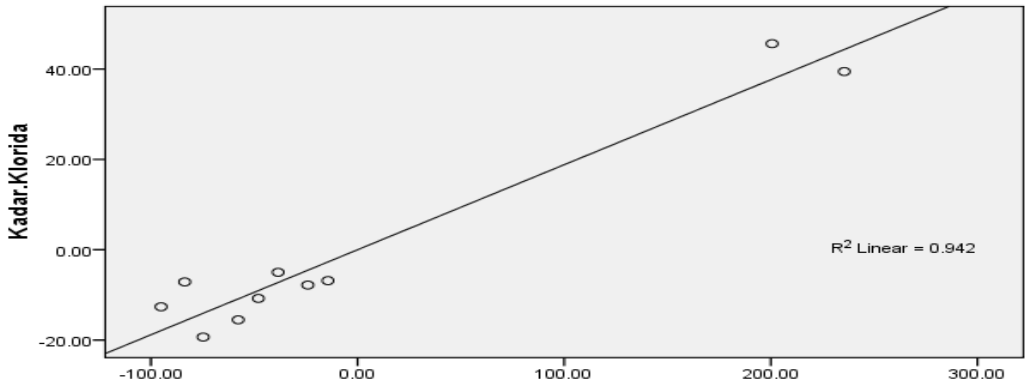

Figure 1. Graph of Prediction of Chloride Concentration on Total Total Use of Deep Well Water

From the graphic above which shows the prediction curve line, it can be concluded that the greater the amount of water usage, it will be predicted to increase the chloride concentration in groundwater, this is evidenced in the marine area (S BB2) which has a chloride concentration of 67.45. mg/L with a total consumption of 560 m3/day, while the chloride concentration is relatively lower in the Marine area I (S BB1) with a total water use of 253 m3/day. This shows that seawater intrusion events can occur due to excessive use of water, because due to excessive use of water it will create a void in the aquifer or the balance of the aquifer is disturbed and this causes the balance of the border between sea water and fresh water cannot be maintained, which in the end water the sea can fill the void in the aquifer.

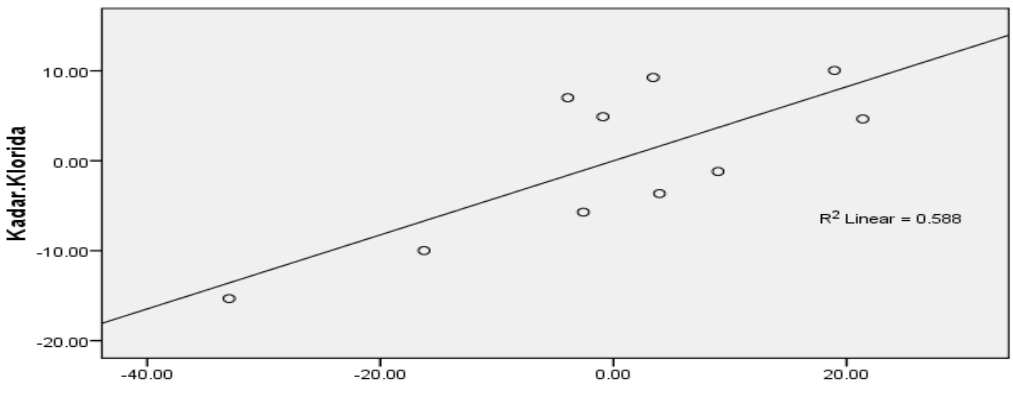

Figure 2. Graph of Prediction of Chloride Concentration on Soil Permeability

The prediction graph above shows that the greater the value of soil permeability can increase seawater intrusion in deep well water, then from the partial test results through the t test above, it can be concluded that soil permeability in deep wells can have an effect on increasing chloride levels in groundwater. , it can be assumed that if the rock has a high permeability, it can pass large amounts of water, so that seawater intrusion is likely to occur due to the void of an aquifer.

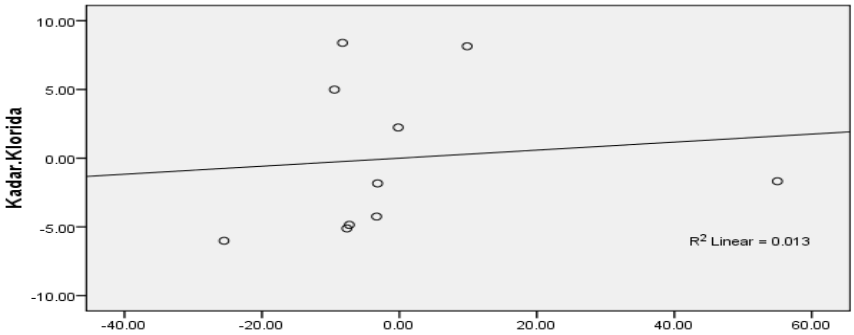

Figure 3. Prediction Graph of Chloride Concentration to Well Depth

The graph above shows a predictive curve that can conclude that the effect of the depth of the well can affect the increase in the concentration of chloride levels in ground water, as previously stated by Hendrayana in 2002 that if there is a vacancy in the aquifer, seawater will penetrate or intrude which then fills the empty space. lower or deeper than an aquifer.

The graph above shows a predictive curve line which explains that the farther the well is from the shoreline, the smaller the chloride concentration will be, this is also evidenced in the Pekan Labuhan (S PLB) area with a chloride concentration of 13.49 mg/L at a distance of 5539 m from the coast, while the marine area (S BB2) has a chloride concentration of 67.45 mg/L with a well distance of 4520.29 m from the shoreline, as previously stated by Hendrayana in 2002, sometimes the position of the well is closer to the beach, seawater has not been intruded, considering that there are still barriers to the infiltration of seawater, such as the growth of mangrove trees, differences in rock lithology that affect the level of rock permeability which can inhibit the rate of seawater intrusion. However, seawater intrusion in general will first affect the water quality in wells that are closer to the coast, considering that the infiltration rate is highly dependent on the distance factor.

4. CONCLUSION

The multiple regression analysis conducted on deep groundwater wells reveals significant insights into the relationship between chloride concentration (dependent variable) and various independent variables including water usage, distance from the shoreline, soil permeability, and well depth. With a high Multiple R value of 0.96 and a coefficient of determination (R Square) of 92.74%, it is evident that these independent variables collectively explain a large portion of the variability in chloride concentration. The results of the F-test confirm that the independent variables have a joint effect on chloride concentration, with significant impacts observed for each variable individually according to the results of the t-test.

Furthermore, predictive curve graphs provide valuable visual representations of these relationships. They highlight the potential for seawater intrusion resulting from excessive water usage and high soil permeability, emphasizing the importance of sustainable groundwater management practices. Additionally, the predictive curves demonstrate how well depth and distance from the shoreline influence chloride concentration, with wells farther from the coast exhibiting lower chloride levels due to natural barriers like mangrove growth and variations in rock permeability.

Managerial implications arising from this research emphasize the importance of optimizing water usage, monitoring soil permeability, strategically placing wells, integrating coastal zone management strategies, engaging communities, and developing policies to safeguard against seawater intrusion in groundwater systems. By focusing on water conservation, assessing soil permeability, and carefully planning well placement and depth, managers can mitigate the risk of seawater intrusion while ensuring sustainable groundwater usage. Integrating coastal zone management practices, community engagement initiatives, and policy development efforts further strengthens groundwater management strategies, fostering resilience and sustainability in the face of increasing water demands and environmental challenges.

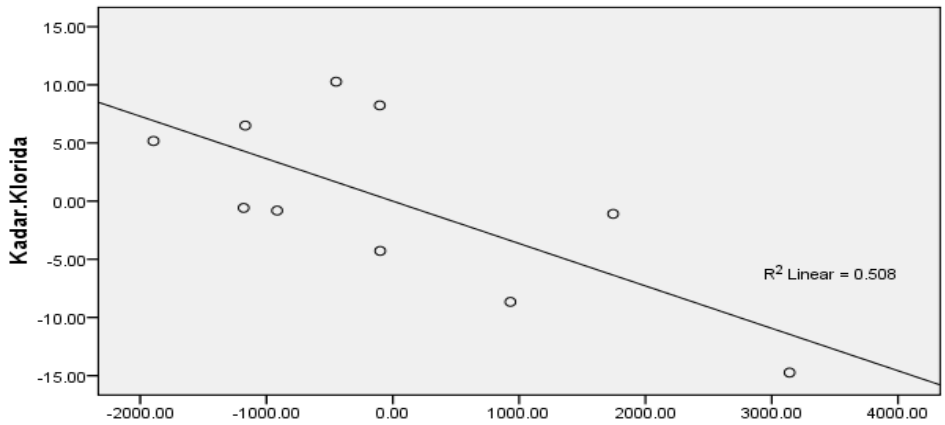

Figure 4. Graph of Prediction of Chloride Concentration on the Distance of the Well from the Coastline

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