Research Paper

Groundwater Surface Contour Modeling Using Kriging Method Around JJLS, Purwosari District, Gunung Kidul

Peter Eka Rosadi[1], Ilham Firmansyah[1], Tedy Agung Cahyadi[1], Faizal Agung Riyadi[1], Muhammad Iqbal Ansori[1], Anky Andra Widha Rezzatama[1], Dila Nur Naningsih[1], Tegar Arya Vandanu[1]

[1] Universitas Pembangunan Nasional "Veteran" Yogyakarta, Indonesia

Received : Sept 1, 2025	Revised : Sept 25, 2025	Accepted : Sept 25, 2025	Online : October 14, 2025

Abstract

Kapanewon Purwosari, Gunungkidul Regency, Special Region of Yogyakarta is one of the areas that still uses groundwater to meet water needs such as household and agricultural needs. Over time, the expansion of development areas such as JJLS has resulted in changes in spatial patterns, including the groundwater conditions within them. Direct data collection in the field, such as data on rivers and residents' wells, can be used as parameters in modeling groundwater conditions in the area. Limited data can be supplemented by using the krigging method with software such as ArcGis to help in groundwater modeling. Based on 36 observation points, including 24 community wells and 12 rivers, interpolation was performed using the krigging method to produce groundwater contour lines in the area around the observation points

Keywords: *Groundwater Level, Krigging*

INTRODUCTION

Groundwater level is one of the parameters often used in geographical studies, especially in the sub-study of the hydrosphere (Tiyawarman et al., 2024). In its preparation, the height of the water table can be obtained from several methods, namely through simple measurements such as monitoring residents' wells or through drilling using drilling equipment or through geophysical methods (Wambena et al., 2024). The high cost of obtaining accurate elevation correlation levels necessitates interpolation of the data that has already been obtained (Rizani, 2024).

Kapanewon Purwosari is one of the subdistricts in Gunung Kidul Regency, Yogyakarta Province, where residents still rely on groundwater to meet their water needs, such as for household and agricultural purposes. To meet their daily water needs, the community utilizes groundwater potential, in this case through dug wells and nearby springs. However, according to information provided by several residents, there are many residents who have dug wells to obtain water but ended up with nothing.

Therefore, knowledge of the current groundwater profile in the Purwosari area is required. The groundwater profile is a contour map of the groundwater surface based on the elevation of the groundwater surface using residents' wells, springs, and nearby rivers as parameters. Modeling related to groundwater contours can be done by interpolating the data obtained, one of which is using the krigging method with the help of software such as ArcGis to facilitate the implementation of groundwater contour modeling. So far, there have not been many studies that examine groundwater contours in the JJLS area of Kapanewon Purwosari. This study was conducted with the aim of identifying groundwater contours in the JJLS area located in the Purwosari Kapanewon region.

Corresponding author's email: peterekarosadi@upnyk.ac.id

LITERATURE REVIEW

The research location was in Kapanewon Purwosari, Gunungkidul Regency, Special Region of Yogyakarta. Observations were made at 25 locations of wells owned by residents and 10 springs located around the JJLS area. Observations were made in two villages, namely Girijati Village and Giriasih Village Error! Reference source not found..

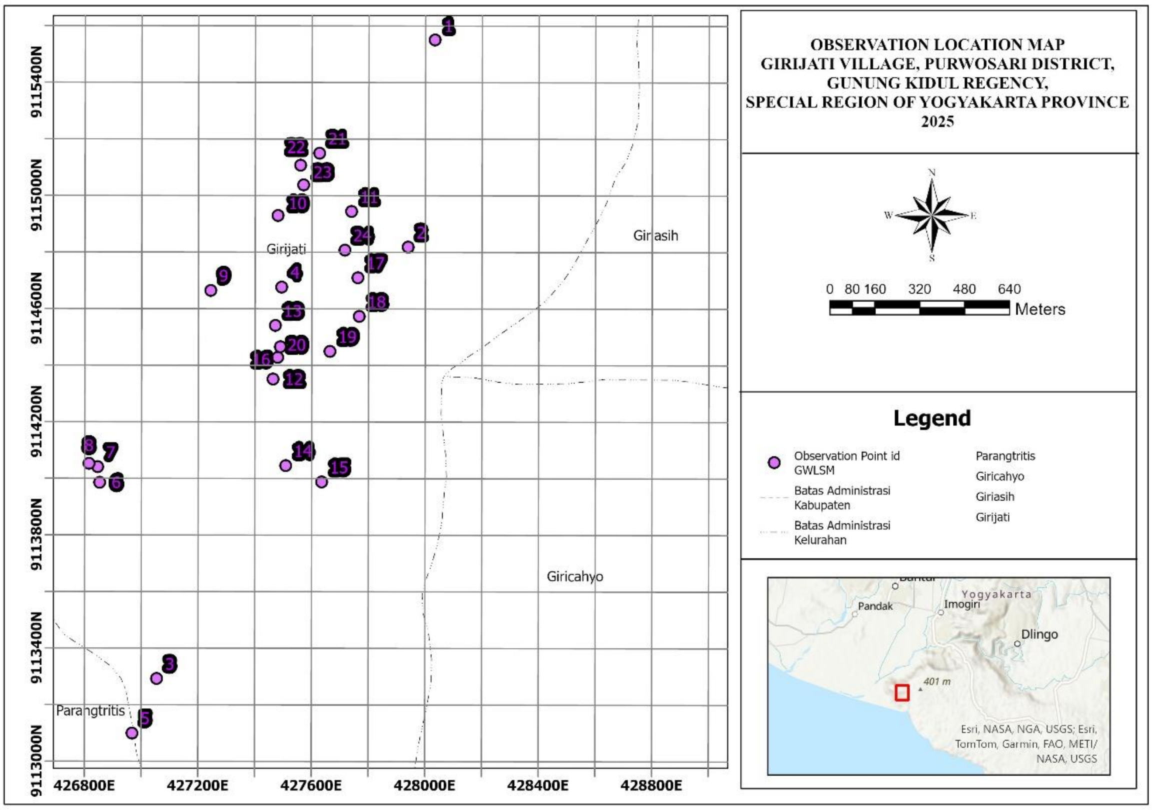

Figure 1. Administrative Map of Observation Areas

RESEARCH METHOD

The water table is the surface of the groundwater body where the water pressure is equal to atmospheric pressure. The height of the water table is the height of the water below the ground surface around a borehole or well, which indicates a height or depth below the ground surface (Badan Standar Nasional, 2012). Groundwater depth is measured using a Water Level Meter that utilizes water conductivity connected to a meter roll and a buzzer to detect the water surface with *high* and *low* conductivity conditions as markers for the water surface limit, which is done manually.

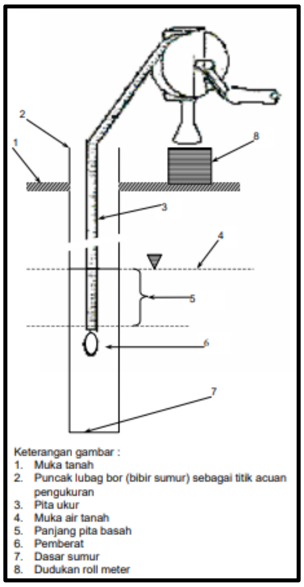

Figure 2. Water level gauge with counterweight
source: SNI 7749:2012

At each point, the well rim is measured with a meter, and the ground surface elevation is determined using a Garmin GPS. Groundwater level measurements are taken by ensuring that the Solinst Water Level Meter is in good working order, checking and cleaning the electrode, then lowering the electrode and meter cable through the well hole until it touches the groundwater surface. When the electrode reaches the groundwater surface, a sound will be heard and a red light will turn on. After the sound is heard, the cable on the Solinst Water Level Meter is read to determine the depth of the groundwater level, and then it is lifted. The cable and electrode are then rinsed with water and cleaned until dry.

The equipment used to measure the water level in dug wells is as follows:

1. Solinst Water Level Meter.
2. Notebook and measurement forms.

Groundwater elevation measurements are taken by calculating the difference between the ground surface elevation and the groundwater depth using the following equation (Amah & Agbebia, 2015):

$$\boxed{El.MAT = El.MT + h - SWL}$$

Explanation:

El. MAT = Groundwater Level Elevation;

El. MT = Ground Elevation;

h = Well Lip Height (m).

SWL = Water Depth in Wells(m).

The observation area must have groundwater elevation data that will represent the observation area. Each observation point data in the form of groundwater elevation will be interpolated and will produce the direction of groundwater flow, so that the direction of groundwater flow and its height relative to the ground surface can be determined.

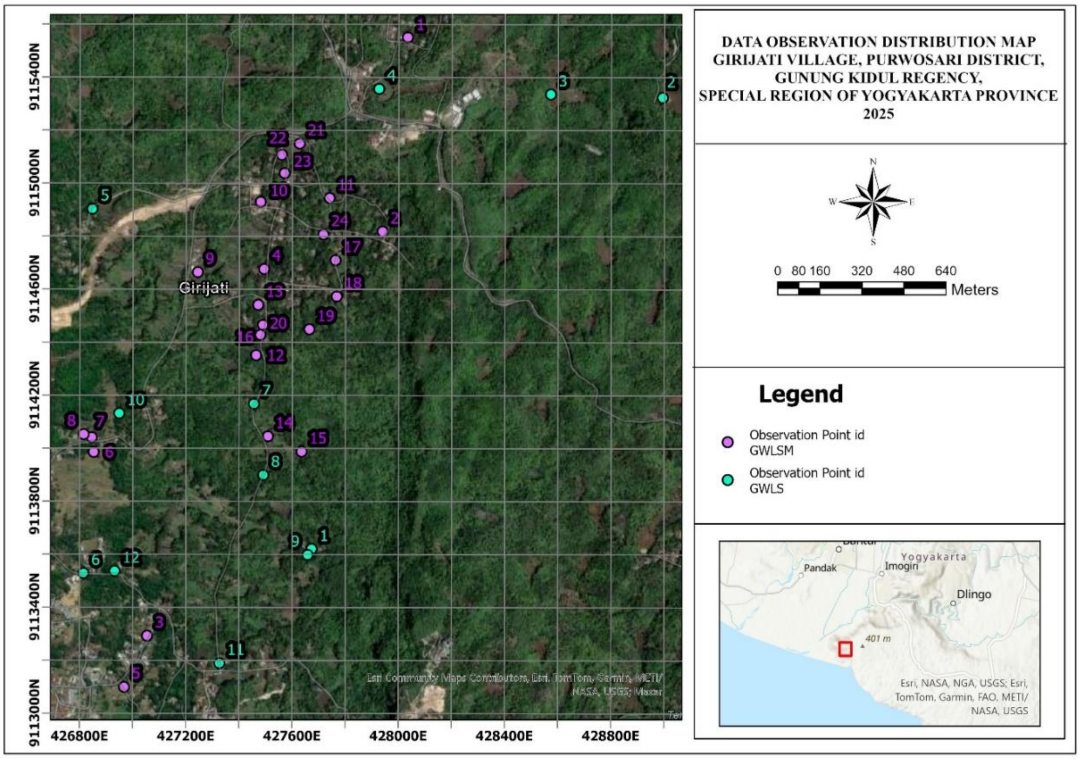

Figure 3. Map of Observation Data Distribution Metode Interpolasi Krigging

Kriging is a statistical method for measuring the correlation between measurement points through variograms. This method predicts values from unmeasured areas based on measured values in surrounding areas using a variogram model (McCoy et al., 2001). The Kriging interpolation technique can be classified as stochastic interpolation, which offers predictive assessment, as it assumes random error values. This technique is used to estimate the z value at unsampled points based on information from the characteristics of the sampled z values in the surrounding area. In addition, this technique also considers the spatial correlation between data using semivariograms (Sun et al., 2009,Hadi, 2013).

FINDINGS AND DISCUSSION

Topographic modeling of the groundwater table was carried out using 24 sample points from community wells with the sample code GWLSM, as well as 12 sample points from rivers with the sample code GWLS. The coordinates and depths of each point can be seen in Table 1. The results of the measurements taken in the field show that the wells have varying heights at each location. The well with the shallowest depth or the depth closest to the surface is located at sample point GWLSM-15, which is 0.1 m deep. Meanwhile, the deepest point is located at GWLSM-22, which is 12.25 m deep.

Similar to the observation locations at residents' wells, measurements taken at river locations also varied in elevation. The river with the highest coordinates was located at GWLS-3 at an elevation of 356.16 m. The river with the lowest elevation was located at GWLS-11 at an elevation of 83.13 m.

Table 1. Observation location and groundwater depth

No	id Sampel	X	Y	Z (m)	GWL (masl)	MAT depth
1	GWLSM-1	428033	9115551	344.51	332.92	11.59

No	id Sampel	X	Y	Z (m)	GWL (masl)	MAT depth
2	GWLSM-2	427939	9114819	271	267.69	3.31
3	GWLSM-3	427055	9113293	45.65	43.07	2.58
4	GWLSM-4	427494	9114677	233.9	230.39	3.51
5	GWLSM-5	426968	9113100	15.34	10.74	4.6
6	GWLSM-6	426853	9113986	141.38	139.44	1.94
7	GWLSM-7	426845	9114041	145.65	141.95	3.7
8	GWLSM-8	426815	9114053	146.71	142.87	3.84
9	GWLSM-9	427243	9114665	225.15	218.08	7.07
10	GWLSM-10	427480	9114930	256.13	250.96	5.17
11	GWLSM-11	427740	9114944	271.5	260.48	11.02
12	GWLSM-12	427463	9114352	204.68	201.38	3.3
13	GWLSM-13	427471	9114541	219.48	215.41	4.07
14	GWLSM-14	427508	9114046	166.1	164.57	1.53
15	GWLSM-15	427635	9113988	164.51	164.41	0.1
16	GWLSM-16	427489	9114466	214.7	208.39	6.31
17	GWLSM-17	427762	9114710	255.8	244.45	11.35
18	GWLSM-18	427767	9114573	242	232.64	9.36
19	GWLSM-19	427664	9114450	226.45	220.17	6.28
20	GWLSM-20	427480	9114428	210.44	207.68	2.76
21	GWLSM-21	427627	9115150	287.9	282.2	5.7
22	GWLSM-22	427560	9115108	285.4	273.15	12.25
23	GWLSM-23	427570	9115038	277.4	268.78	8.62
24	GWLSM-24	427716	9114808	259.9	255.4	4.5
25	GWLS-1	427674	9113621	128.5	128.5	0
26	GWLS-2	428993	9115324	351	351	0
27	GWLS-3	428572	9115336	356.16	356.16	0
28	GWLS-4	427925	9115356	326.77	326.77	0
29	GWLS-5	426847	9114903	272.6	272.6	0
30	GWLS-6	426815	9113529	92.73	92.73	0
31	GWLS-7	427456	9114168	181.78	181.78	0
32	GWLS-8	427491	9113900	158.01	158.01	0
33	GWLS-9	427658	9113599	132	132	0
34	GWLS-10	426949	9114132	163.13	163.13	0
35	GWLS-11	427327	9113190	83.13	83.13	0
36	GWLS-12	426932	9113537	87.61	87.61	0

The data was then used to model the groundwater surface topography using the kriging method with ArcGis software. From the modeling results using the software with the kriging method, a groundwater surface topography map was obtained, as shown in **Error! Reference source not found.**.

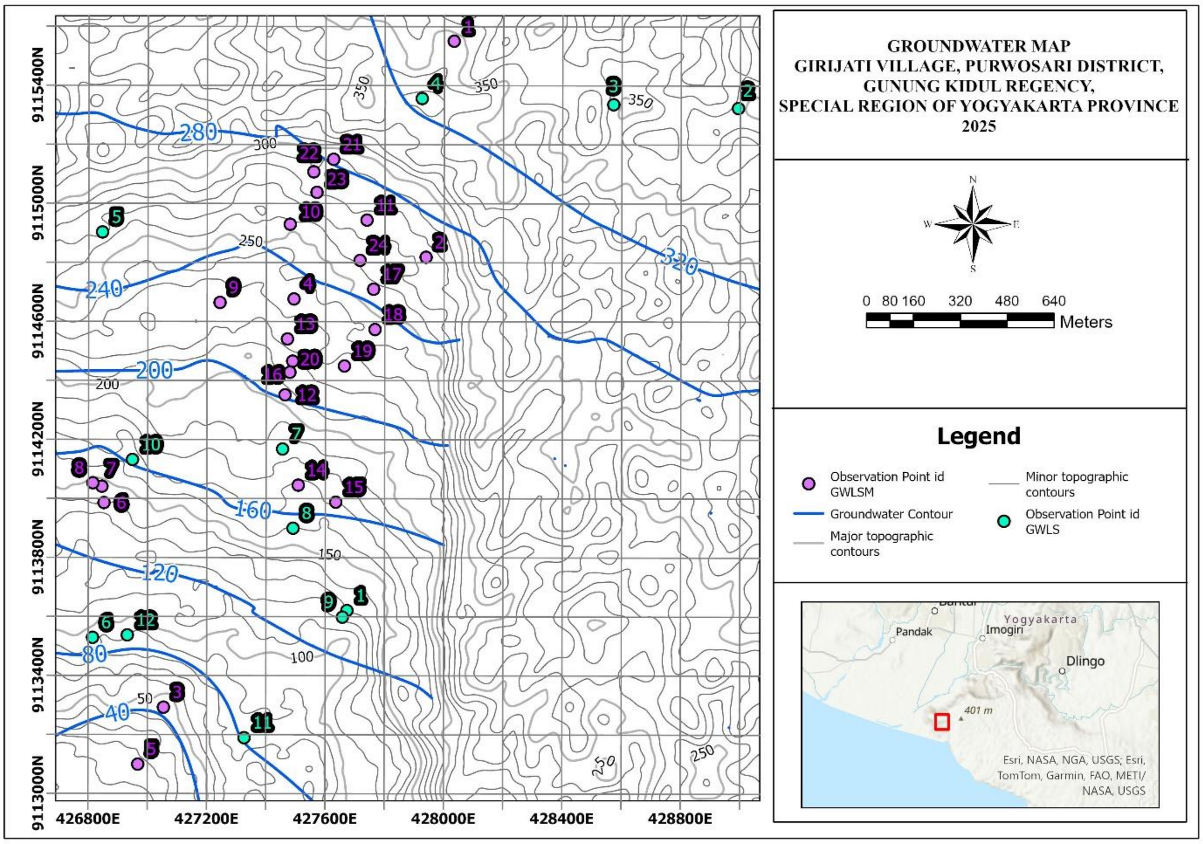

Figure 4. Groundwater contour map

The distribution map of groundwater observation points in Girijati Village, Purwosari District, Gunung Kidul Regency shows a fairly complex hydrogeological condition with a close relationship between topography, groundwater contours, and the existence of geological structure zones. Based on the data presented, there is a pattern of observation points (GWLSM and GWLS) that indicates a structural zone in the center of the map, marked by dense topography lines and significant differences in groundwater contours around it. This structural zone functions as a natural boundary that affects the groundwater flow pattern in the area, so that the flow distribution cannot be assumed to be uniform throughout the observation area.

The existence of the structural zone causes groundwater to tend to split along the direction of the formed fractures or faults, resulting in differences in hydraulic potential between the western and eastern parts. This is clearly seen from the groundwater contour pattern, which shows changes in flow direction and contour line density around the structure. These conditions indicate that the structural zone acts as the main controller of groundwater movement, either as a conduit or a barrier, depending on the lithological properties and the fractures that have formed. Therefore, analysis of groundwater flow in this area cannot be separated from the influence of the structural zone and must take into account the hydrogeological boundaries created by the existence of these structures.

On the other hand, although the observation data at points around the structural zone is relatively sufficient to show the flow pattern trend, the area outside the zone, especially in the eastern part of the map, does not have sufficient observation data. This data gap has implications for the limitations of interpretation, because groundwater level interpolation can only be done if the distribution of observation points is fairly even. Without additional data in these areas, the interpretation results have the potential to be biased and not reflect the actual conditions. In other words, groundwater contour interpolation cannot be extended to areas without data, as it would ignore the possibility of local geological variations and potential hydrogeological anomalies that could occur outside the structure zone.

Limited data in areas adjacent to the structural zone also affects the accuracy of groundwater potential mapping. For example, the direction of flow and hydraulic gradient cannot be accurately determined if we only rely on observation points concentrated on one side. In fact, this information is very important in determining potential reserves, flow direction, and the sustainable use of groundwater resources. Therefore, additional data collection outside the structural zone is absolutely necessary, either through additional monitoring well drilling or geophysical surveys that can indirectly estimate the depth of the water table.

The results of the groundwater surface topography modeling show that the location in the northern part of the map has a much higher elevation than the location in the southern part, especially in the western area. The groundwater contour modeling results shown on the map indicate inconsistencies with actual conditions in the field. This is evident from several measurement points that show higher groundwater elevation values than the ground surface elevation at the same location. Conceptually, this condition is illogical, because the groundwater table cannot be above the ground surface without causing manifestations such as puddles or runoff. This discrepancy indicates limitations in the modeling, both in terms of input data quality, interpolation methods, and local hydrogeological factors that have not been fully accommodated. Therefore, the interpretation of the modeling results needs to be done carefully.

CONCLUSIONS

This observation point distribution map shows the existence of a structural zone that clearly limits the groundwater flow pattern, so the interpretation must take into account the existence of this boundary. However, outside the structural zone, data limitations make it impossible to perform accurate interpolation. Therefore, in order for the groundwater mapping in Girijati Village to provide a more comprehensive picture, additional observation data is needed in areas that are still blank. In this way, the hydrogeological analysis will be more representative and can serve as a basis for better groundwater utilization and management planning in the Gunung Kidul region.

In groundwater level data processing, it is very important to understand that the analysis results cannot rely solely on observation point sampling data. Although this data provides an initial picture of groundwater level conditions, in order to obtain a more accurate and representative interpretation, various other parameters must be taken into consideration. For example, factors such as the lithology of the constituent rocks, geological structures (fractures, faults, and folds), morphology or surface shape, rainfall conditions, and land use patterns that affect groundwater recharge and discharge. In addition, additional hydrogeological data such as hydraulic conductivity, porosity, and rock permeability also need to be analyzed to determine the aquifer's ability to store and drain water.

Furthermore, anthropogenic conditions such as the presence of dug wells, bore wells, and groundwater pumping rates in an area must also be taken into account as they can significantly affect groundwater level fluctuations. The use of supporting methods such as geophysical surveys (e.g., electrical resistivity) and numerical modeling can also help enrich the analysis and reduce uncertainty due to the limited number of observation points. By integrating these various parameters, the interpretation of the groundwater table will be more comprehensive, thus providing a stronger basis for planning the sustainable use and management of groundwater resources.

In groundwater contour modeling, krigging is one of the geostatistical techniques often used to estimate undefined values. The contours created from 36 measurement points with 24 residents well data and 12 river data with varying elevations produce contour lines with the highest elevation in the northern part of the map and the lowest elevation in the southern part of the map, especially in the western region. This modeling is not necessarily valid and must include various other parameters, such as the structural or geological conditions in the area, water flow patterns, and other groundwater modeling parameters.

LIMITATIONS & FURTHER RESEARCH

REFERENCES