IDENTIFICATION OF AQUIFER VULNERABILITY TO POLLUTION BASED ON GIS IN JEKAN RAYA AND SABANGAU DISTRICTS PALANGKA RAYA CITY, CENTRAL KALIMANTAN PROVINCE

Prayetno[1*], Hendrik Segah[2], Deddy NSP Tanggara[3]
[1,2,3]Universitas Palangka Raya
[*] prayetno024@gmail.com

ABSTRACT

Groundwater is the main source of needs for living things. Groundwater is stored in aquifer systems contained in the soil. Under certain conditions, aquifers will be very vulnerable to pollution that can be caused by various sources of pollution depending on existing geological conditions. Therefore, it is necessary to identify the vulnerability of aquifers to polluting sources so that they can assist the government in planning and formulating policies related to regional spatial planning. Identification of aquifer vulnerability can be done using the DRASTIC method which is a weighting method of various parameters such as groundwater table depth (D), Rainfall (R), aquifer media (A), soil media (S), Topography (T), Unsaturated zone (I), and hydraulics conductivity (C) and combined with HAI (Human Activity Impact). The weighting results will produce a Static and Dynamic Aquifer Vulnerability Map. The two maps will be stacked with the Spatial Plans of Palangka Raya City so that it is expected to be a consideration for the Palangka Raya City government in the preparation of the next Regional Spatial Planning policy. The results of weighting with the DRASTIC Index and HAI whole Jekan Raya District and Sabangau District, Palangka Raya City are included in a high level of vulnerability which at this level is an area that is very easy to be polluted by all pollutants, so proper handling is needed so that the impact that will be caused is not too high risk for the condition of aquifers in the area.

Keywords: groundwater, aquifer, Spatial Plans, DRASTIC & HAI

INTRODUCTION

The increase in population has a big impact on the availability of water itself. The average water requirement for each person in developed countries is 60-120 liters per day, while each person in developing countries requires 30-60 liters per day, including in Indonesia (Yustani Leluno et al., 2020). The average population growth rate in Palangka Raya City is around 3.1% per year. With such a growth rate, in the next 10 - 20 years it can be estimated that the population of Palangka Raya City in 2027 will be 375,851 people and in 2037 it will be 512,445 people (Endah Kartika Susanti et al., 2020). Identification activities are carried out to identify areas that have the potential for pollution from low levels to high potential pollution using the DRASTIC method because it prioritizes hydrogeological factors that influence groundwater movement. Such as household activities, the hotel industry, hospitals, workshops, mining, and agricultural activities. All of these activities will produce waste or rubbish which, if not managed properly, can hurt the environment one of which is groundwater pollution (Rahman, 2008; SEJATI & SAPUTRA, 2022).

Geologically, the city of Palangka Raya is included in the Palangka Raya Regional Geological Map Sheet (Carter et al., 1991) and does not have geological structures that can cause geological disasters. The existing geological formations are dominated by the Dahor Formation which is a relatively young deposit that is estimated to be Middle Miocene to Pleistocene (Endah Kartika Susanti et al., 2020). Aquifers are formed in nature according to

existing geological conditions such as petrology, stratigraphy, geological structure, tectonic setting, and geological history. To regulate and protect groundwater sources, it is necessary to understand the geohydrological and hydrogeological processes that take place within them (Adji, 2006).

Groundwater resistance to pollutants originating from the surface or underground is called groundwater vulnerability (Hastuti et al., 2016). According to Harter & Walker (2001), groundwater vulnerability is a measure of the possibility that pollutants will pollute local groundwater. Mapping groundwater vulnerability to pollution based on Geographic Information Systems (GIS) with the DRASTIC model (Saatsaz et al., 2011), emphasizes hydrogeological conditions that influence groundwater movement, and this method is used to determine groundwater vulnerability over a fairly wide area coverage. The DRASTIC method is based on hydrogeological conditions and a combination of parameters that influence groundwater pollution (Bin, 2017; Devianto et al., 2019).

HAI (Human Activity Impact) is a development based on the DRASTIC method, where HAI also considers aspects of land use as the impact of human activities with 4 (four) weights as described in Table 1. below.

Table 2 Land Use Values and Weights

Class	Value
Settlement	8
Agriculture	8
Natural Vegetation Cover	2
Body of Water	3
Evaporation Pond	7
Vacant/Open Land	1
Livestock Area	8
Weight 4	

Source: (Wicaksono & Nurjani, 2013)

Human activities, industrial activities, traffic, septic tanks, drainage systems (gullies), and the use of fertilizers used in agricultural activities are potential hazards that can affect the quality of groundwater and increase the potential for pollution (Al-Hanbali & Kondoh, 2008).

METHOD

The research location is geographically located at 113º 47′ 17″ - 114º 6′ 43″ East Longitude and 2º 4′ 55″ - 2º 24′ 12″ South Latitude and administratively is in Jekan Raya District and Sabangau District, Palangka Raya City. The data used for this research is primary data in the form of groundwater level data, soil type, and other primary data required, and secondary data consists of the Indonesian Geological Map, Earth Map, Hydrogeological Map, and several other thematic maps. Groundwater sampling will be carried out to verify the groundwater vulnerability zone map for pollution that has been created (Afshar et al., 2007; Fiori et al., 2023). Initial information for this research includes searching and collecting references related to potential groundwater pollution using the DRASTIC and HAI methods. The required data

can be obtained through direct observation and data processing at research-related agencies (Berhe Zenebe et al., 2020).

RESULTS AND DISCUSSION

From the results of the analysis of each DRASTIC parameter which is realized in the form of a map. Each map has a score from the product of weight and class. The higher the weight and class value, the higher the DRASTIC value, which indicates that the level of groundwater vulnerability to contaminants is also higher.

Table 2 Calculation of Groundwater Level Depth

Depth of Ground Water Level (m)	Value	Weight	Quantity
0 - 3	10	5	50
3 - 4,5	9	5	45
4,5 - 9	7	5	35
Total			130

Table 4 Calculation of Annual Rainfall Data

Amount of Rainfall (mm/year)	Value	Weight	Quantity
2.000 – 3.000	9	4	36
> 3.000	10	4	40
Total			96

Table 5. Aquifer Media Calculations

Aquifer Media	Value	Weight	Quantity
Sand	8	3	24
Total			24

Table 6. Calculation of soil texture

Soil Texture	Value	Weight	Quantity
Sand	9	2	18
Peat	8	2	16
Total			34

Table 7 Calculation of Land Slope

Land Slope (%)	Value	Weight	Quantity
0-2	10	1	10
2-6	9	1	9
6-12	5	1	5
Total			24

Table 8 Calculation of water unsaturated zone

Water unsaturated zone	Value	Weight	Quantity
Sand and Gravel	9	5	45
Total			45

Table 9 Hydraulic Conductivity

Hydraulic Conductivity (m/day)	Value	Weight	Quantity
18,523	4	3	12
Total			12

Static Vulnerability Map

From the data that has been overlaid, for Jekan Raya District and Sabangau District, overall the resulting DRASTIC index has a very high level of vulnerability, namely with a score of more than 153. In this condition, areas that have a very high level of vulnerability are likely to be polluted by all pollutants.

Table 10 Static Vulnerability Levels of Jekan Raya District and Sebangau District

Vulnerability Level	Index
Very High	>153

Figure 1 Static Groundwater Vulnerability Map in Jekan Raya District and Sebangau District

Dynamic Vulnerability Map

All human activities that produce waste are very likely to cause pollution. A dynamic aquifer vulnerability map is a map produced from data processing or a map that is overlaid from a DRASTIC analysis map with an HAI map or land use map. The combination of these maps was carried out to obtain a more precise level of confidence regarding potential pollution.

Table 11 Land Use in Jekan Raya District and Sabangau District

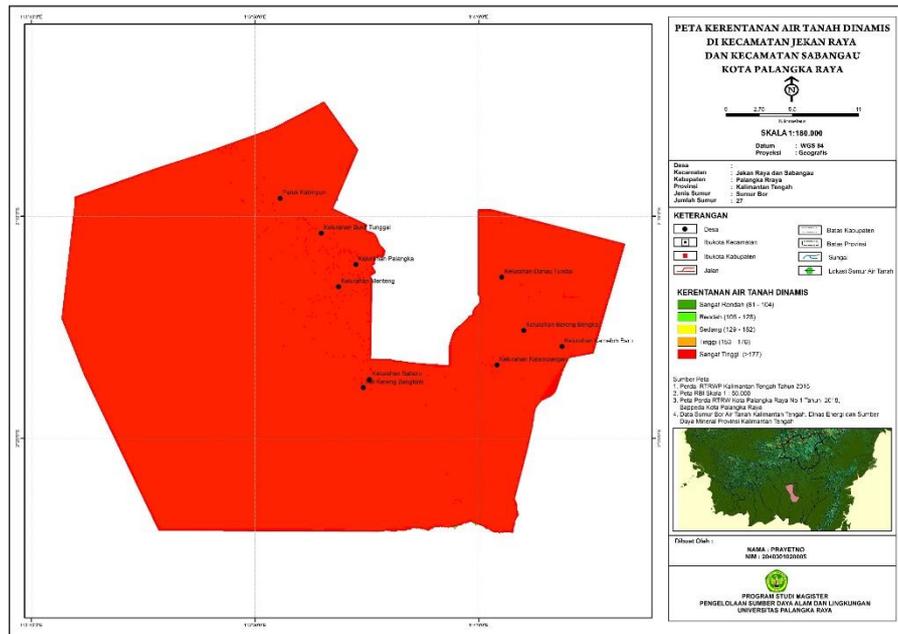| Land Use	Value	Weight	Quantity
Vacant Land	1	4	4
Natural Vegetation Cover	2	4	8
Body of Water	3	4	12
Settlements	8	4	32
Total			56

Figure 2 Dynamic Groundwater Vulnerability Map in Jekan Raya District and Sebangau District

Suitability of the Aquifer Vulnerability Zoning Map with the Palangka Raya City Spatial Pattern

Based on the results of this data analysis, it can be seen that all areas in Jekan Raya District and Sabangau District, Palangka Raya City are included in areas that have a very high level of vulnerability to potential groundwater pollution. However, there are several areas where the possibility of pollution is very low because not all areas are residential areas and are only forest areas, so even though technically the level of possibility of contamination is high, the source of the pollution is very small.

Results of Groundwater Quality Laboratory Analysis

The results of laboratory analysis will be adjusted to Minister of Health Regulation Number 2 of 2023 concerning Implementing Regulations of Government Regulation Number 66 of 2014 concerning Environmental Health as in Table 5.14 below.

Table 12 Results of Physical and Chemical Analysis of Ground Water in Jekan Raya District and Sabangau District, Palangka Raya City

Sample Code	Parameter	Unit	Maximum Limit	Test Results	Information
PKY-AT_01	Physics				
	a. Temperature	º C	± 3	27,3	Normal
	b. Total Dissolve Solid (TDS)	mg/L	<300	5,95	Normal
	c. Turbidity	NTU	<3	3	Normal
	d. Color	TCU	10	9,37	Normal

Sample Code	Parameter	Unit	Maximum Limit	Test Results	Information
	Chemistry				
	a. pH	-	6,5-8,5	4,65	Below Normal
	b. Nitrate	mg/L	20	0,36	Normal
	c. Nitrite	mg/L	3	<0,005	Normal
	d. Chromium				
	Valence 6	mg/L	0,01	<0,007	Normal
	e. Iron (fe)	mg/L	0,2	0,088	Normal
	f. Manganese (Mn)	mg/L	0,1	<0,005	Normal
PKY-AT_02					
	Physics				
	a. Temperature	º C	± 3	27,7	Normal
	b. Total Dissolve				
	Solid (TDS)	mg/L	<300	10,3	Normal
	c. Turbidity	NTU	<3	11	Normal
	d. Color	TCU	10	10,2	Above Normal
	Chemistry				
	a. pH	-	6,5-8,5	4,97	Below Normal
	b. Nitrate	mg/L	20	0,254	Normal
	c. Nitrite	mg/L	3	<0,005	Normal
	d. Chromium				
	Valence 6	mg/L	0,01	<0,007	Normal
	e. Iron (fe)	mg/L	0,2	0,585	Above Normal
	f. Manganese (Mn)	mg/L	0,1	0,008	Normal
PKY-AT_03					
	Physics				
	a. Temperature	º C	± 3	27,9	Normal
	b. Total Dissolve				
	Solid (TDS)	mg/L	<300	15,6	Normal
	c. Turbidity	NTU	<3	3	Normal
	d. Color	TCU	10	18,8	Above Normal
	Chemistry				
	a. pH	-	6,5-8,5	4,39	Below Normal
	b. Nitrate	mg/L	20	0,818	Normal
	c. Nitrite	mg/L	3	<0,005	Normal
	d. Chromium				
	Valence 6	mg/L	0,01	<0,007	Normal
	e. Iron (fe)	mg/L	0,2	0,133	Normal
	f. Manganese (Mn)	mg/L	0,1	<0,005	Normal
PKY-AT_04					
	Physics				
	a. Temperature	º C	± 3	28	Normal
	b. Total Dissolve				
	Solid (TDS)	mg/L	<300	14,6	Normal
	c. Turbidity	NTU	<3	4	Above Normal
	d. Color	TCU	10	10,8	Above Normal
	Chemistry				
	a. pH	-	6,5-8,5	4,26	Below Normal

Sample Code	Parameter	Unit	Maximum Limit	Test Results	Information
	b. Nitrate	mg/L	20	0,504	Normal
	c. Nitrite	mg/L	3	<0,005	Normal
	d. Chromium				
	Valence 6	mg/L	0,01	<0,007	Normal
	e. Iron (fe)	mg/L	0,2	0,061	Normal
	f. Manganese (Mn)	mg/L	0,1	<0,005	Normal
PKY-AT_05					
	Physics				
	a. Temperature	º C	± 3	23,9	Normal
	b. Total Dissolve				
	Solid (TDS)	mg/L	<300	10,4	Normal
	c. Turbidity	NTU	<3	3	Normal
	d. Color	TCU	10	12,6	Above Normal
	Chemistry				
	a. pH	-	6,5-8,5	4,58	Below Normal
	b. Nitrate	mg/L	20	0,498	Normal
	c. Nitrite	mg/L	3	<0,005	Normal
	d. Chromium				
	Valence 6	mg/L	0,01	<0,007	Normal
	e. Iron (fe)	mg/L	0,2	0,156	Normal
	f. Manganese (Mn)	mg/L	0,1	<0,005	Normal
PKY-AT_06					
	Physics				
	a. Temperature	º C	± 3	24,1	Normal
	b. Total Dissolve				
	Solid (TDS)	mg/L	<300	46,2	Normal
	c. Turbidity	NTU	<3	8	Above Normal
	d. Color	TCU	10	118	Above Normal
	Chemistry				
	a. pH	-	6,5-8,5	4,56	Below Normal
	b. Nitrate	mg/L	20	<0,003	Normal
	c. Nitrite	mg/L	3	<0,005	Normal
	d. Chromium				
	Valence 6	mg/L	0,01	<0,007	Normal
	e. Iron (fe)	mg/L	0,2	0,052	Normal
	f. Manganese (Mn)	mg/L	0,1	<0,005	Normal
PKY-AT_07					
	Physics				
	a. Temperature	º C	± 3	24	Normal
	b. Total Dissolve				
	Solid (TDS)	mg/L	<300	6,42	Normal
	c. Turbidity	NTU	<3	4	Above Normal
	d. Color	TCU	10	19,4	Above Normal
	Chemistry				
	a. pH	-	6,5-8,5	4,75	Below Normal
	b. Nitrate	mg/L	20	0,609	Normal
	c. Nitrite	mg/L	3	<0,005	Normal

Sample Code	Parameter	Unit	Maximum Limit	Test Results	Information
	d. Chromium Valence 6	mg/L	0,01	<0,007	Normal
	e. Iron (fe)	mg/L	0,2	0,229	Normal
	f. Manganese (Mn)	mg/L	0,1	<0,005	Normal

Based on the results of laboratory analysis, the groundwater quality of several samples analyzed was still above the specified thresholds, such as pH, color, and turbidity. The results of this analysis show that the groundwater conditions in Jekan Raya District and Sabangau District, Palangka Raya City have experienced pollution.

CONCLUSION

Based on data from analysis in mapping the level of vulnerability of aquifers to pollution using Geographic Information Systems (GIS) and DRASTIC, it can be seen that Jekan Raya District and Sabangau District, Palangka Raya City are at a Very High Level of Vulnerability.

The spatial pattern in Jekan Raya District and Sabangau District, Palangka Raya City does not match the zoning map for aquifer vulnerability to pollution because overall it is in a very high vulnerability zone. In determining the spatial pattern of the City of Palangka Raya, it still does not consider environmental geological aspects. The quality of groundwater in Jekan Raya District and Sabangau District, Palangka Raya City has a low pH and color and turbidity is still above the specified threshold.

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