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Potential study of ground water lembah keramat Tidore Island

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Abstract. Tidore Island is a small island with a circumference of 48 km and is inhabited by 55,267 inhabitants. On this island there is no potential for surface water sources so that the fulfillment of drinking water needs is carried out by utilizing groundwater potential. The supply of drinking water with ground water on Tidore Island cannot be done with a large capacity because the deep wells that are currently located on the beach are prone to intrusion. One of the potential groundwater in the high lands is estimated to be in the swamp of sacred valleys precisely near the village of Talaga with an elevation of 496 m asl. To find out how much the potential of groundwater in the sacred valley of Tidore Island needs to be studied first. The study of groundwater potential in sacred valleys is carried out theoretically by calculating groundwater recharge based on rainfall and water catchment area in that location. After knowing the recharges, the next study is to do geoelectricity to find out the potential point of the aquifer. From the two analyzes that have been carried out, it is known that the sacred valley has the potential of groundwater as raw water for drinking water with a capacity of 55 L / s and aquifer depth 30.43 - 49.78 m below ground level. By paying attention to this potential, the sacred valley swamp is used as a source of raw water for drinking water with the East Tidore service area and part of the City Tidore.

1. Introduction

Morphology of Tidore Island is dominated by mountains and few coastal plains around the island. The morphology of the mountains is formed by Mount Todore and the hills below. The average annual rainfall is above 2,270 mm per year, with air temperature and relative humidity 27 °C and 81.6%. While the annual solar irradiation is 60.6% on average, with an average wind speed of 4.5 km / hour with the dominant wind direction towards the north and west. Tidore Island is a small island with a circumference of 48 km and is inhabited by 55,267 inhabitants. The supply of raw water for drinking water services on the island uses deep ground water with a capacity per deep well between 3-8 lps, but because almost all deep wells are in the coastal area at an elevation between 15-40 m asl with a depth between 50 - 70 m, so many deep wells that have intrusion, so that an alternative source of new raw water is needed [1], [2]. Valley swamps can be predicted to have sufficient groundwater potential to serve drinking water needs in East Tidore and City Tidore so that it is necessary to study the potential of groundwater [3], [4], [5]. The sacred valley which is located at an altitude of 496 m asl is a valley with a water catchment area of around 11,696,081 m^2 which is a natural rainwater reservoir with large capacity. In the wet season the swamp of the sacred valley will look like a natural lake with a puddle of water depth between 0.7 - 2.4 m and when the dry season will dry out so that it looks like a swamp. From this observation, the predicted swamp of the sacred valley has sufficient groundwater potential [6], [7].

Figure 1. Lembah Keramat

2. Hydrological Conditions

Tidore Island has local rainfall patterns that are influenced by local conditions [8]. Such a pattern seems unclear and permanent when and the length of the rainy and dry seasons for each year [9], [10], [11]. The average rainfall recorded during the last 10 years (2008-2017) amounted to 2770.3 mm / year. The driest month generally occurs from July to October with a monthly rainfall below 150 mm. While wet months generally occur from December to June of the following year with rainfall above 220 mm / month. The wettest month is the month of May, the end of the rainy season and December the beginning of the rainy season with rainfall above 250 mm / month.

The occurrence of rain is also only local (not widespread) with a short duration of rain for a while. The average number of monthly rainy days during the last 10 years is 17.9 days, while the average number of rainy days per year is 215 days. The maximum number of rainy days occurs in December and January above 20 days while the minimum number of rainy days occurs in September under 13 days.

3. Climatological Analysis

The amount of rainfall cannot be separated from the influence of "Climatology" of region concerned. Climatology data obtained from Babullah Ternate Meteorology Station include; air temperature, air humidity, wind speed and sunshine, with the following details:

- Air Temperatur   : Average ranges from 26.81 – 27.33 °C.

- Humidity   : Average ranges from 73.8 – 84.8 %

- Sunshine   : Average ranges from 53.5 – 70.7 %

- Wind speed   : Average ranges from 3.7 – 5.7 km / hour

3.1   Air Temperatur

Monthly average air temperature recorded from 2008-2017, at Babullah Ternate Meteorology Station which can represent the Region of East Halmahera Regency is 27.06 °C. Where the maximum air temperature occurs in October of 27.33 °C while Minimum air temperature occurs in July of 26.81 °C.

3.2   Humidity

The average monthly air humidity recorded from 2008-2017 at Babullah Ternate Meteorology Station was 81.6%, with maximum air humidity occurring in December of 84.8%, while minimum air humidity was recorded at 73.8% in June.

3.3   Wind Speed

The average monthly wind speed recorded from 2008 to 2017 is 4.5 km / hour, with maximum wind speeds occurring in January and March of 5.7 km / hour. While the minimum wind speed occurs in November at 3.7 km / hour.

3.4 Sunshine

Monthly solar irradiation data recorded from Babullah Ternate Meteorological Station last 10 years is 1008 - 2017 where the average monthly sun irradiation is 60.6% with maximum sun exposure occurring in October at 70.7% and minimum irradiation of 52.2% in June for more details see the following table.

4. Analysis of Groundwater Potential

4.1 Potential of Groundwater Reserves

The amount of groundwater reserves can be known, among others, by knowing the corresponding aquifer parameters obtained from drilling data, or from the approach of the amount of water that fills the soil (rock) as a medium for groundwater. Groundwater supply like this is known as groundwater recharge or recharge [12]. The amount of groundwater recharge can be estimated from the amount of infiltration into the soil. The amount of recharge is calculated by the following equation:

$$Rc = \Sigma \, In \times A$$

Where : Rc = Recharge of groundwater mm/year
In = Infiltration mm / tahun
A = Catchment area m²

The area of catchment area that is used is the catchment area that is pervasive at the location of the drilling plan, namely in the village of Talaga, East Tidore District, namely:

Catch area = 11,695,081 m²
Area awakened = 0 m² (In Bukit undeveloped locations)
Large annual infiltration = 148.57 mm, then the amount of groundwater recharge is:
Rc = 148.57 mm /year x (11,695,081 m² - 0)
= 0.1487 m / year x 11.695.081 m²
= 1,737,540.35 m³/ year, or
= 4.76 m³ / day, or
= 55.05 L / s (groundwater recharge)

Table 1. Evapotranspiration Potensial with Panmann Modification Methode

Description	Simbol	Unit	Jan	Feb	Mar	Apr	May	Jun	Jul	Agt	Sep	Okt	Nov	Des	Average
Temperature	t	°C	27.17	26.93	27.1	27.29	27.15	27	26.81	26.86	26.88	27.33	27.1	27.12	27.06167
Relative Humidity	RH	%	84	82.9	81.8	83.7	83.6	73.8	81	79.9	79.9	79.8	83.8	84.8	81.58333
Wind Velocity	U	km/hr	5.7	5.6	5.7	4.2	3.8	3.9	4.3	4.5	4.1	4	3.7	4.6	4.508333
Sunlighting	n/N	%	53.5	61.2	65.1	63.2	61.9	52.2	59	55.4	63.5	70.7	64.5	56.8	60.58333
Saturated Vapor Pressure	ea	m.bar	36.09	35.66	35.66	36.09	36.09	35.66	33.25	33.25	33.25	36.09	35.66	36.09	35.23667
Real Vapor Pressure	ed	m.bar	30.316	29.56	29.17	30.21	30.17	26.32	26.93	26.57	26.57	28.8	29.88	30.6	28.75804
wind function	f(U)		1.600	1.576	1.600	1.25	1.156	1.18	1.273	1.32	1.226	1.203	1.133	1.343	1.321704
W			0.767	0.765	0.765	0.767	0.767	0.765	0.765	0.765	0.765	0.769	0.765	0.765	0.765833
weighting factor	1-W	1-W	0.233	0.235	0.235	0.233	0.233	0.235	0.235	0.235	0.235	0.231	0.235	0.235	0.234167
Extra Radiation	Ra	mm/day	14.7	15.3	15	15.3	14	14.2	14.3	14.9	15.3	15.3	14.8	14.4	14.79167
Faktor Albedo	r		0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08
Sun Radiation	Rs	mm/day	7.9218	8.881	9.023	9.047	8.18	7.553	8.131	8.182	9.071	9.666	8.855	8.017	8.543989
Net Short Gel radiation		mm/day	5.9414	6.661	6.767	6.785	6.135	5.665	6.098	6.137	6.804	7.25	6.641	6.013	6.407992
temperature function	f(t)		16.14	16.1	16.1	16.14	16.14	16.1	16.1	16.1	16.1	16.18	16.1	16.1	16.11667
Real Vapor Pressure Function	f(ed)		0.0977	0.101	0.102	0.098	0.098	0.114	0.112	0.113	0.113	0.104	0.099	0.097	0.104137
Sunlighting Function	f(n/N)		0.5815	0.651	0.686	0.669	0.657	0.57	0.631	0.599	0.672	0.736	0.681	0.611	0.64525
Net Wave Radiation	Rnl	mm/day	0.9173	1.056	1.13	1.06	1.043	1.048	1.134	1.091	1.224	1.237	1.09	0.950	1.081776
Net Radiation	Rn	mm/day	5.0241	5.605	5.637	5.725	5.092	4.616	4.964	5.046	5.58	6.012	5.551	5.062	5.326216
correction Factor	c		1.1	1.1	1	0.9	0.9	0.9	0.9	1	1.1	1.1	1.1	1.1	1.016667
Potential Evapotranspiration	Eto	mm/day	6.6063	7.202	6.752	5.494	4.95	5.51	5.119	5.933	6.814	7.314	6.364	6.164	6.185142
Potential Evapotranspiration	Eto	mm/Mounth	204.8	201.6	209.3	164.8	153.5	165.3	158.7	183.9	204.4	226.7	190.9	191.1	187.9239

Tabel 2. Evapotranspiration Potensial with Panmann Modification Methode

Description	Unit	Jan	Feb	Mar	Apr	May	Jun	Jul	Agt	Sep	Oct	Nop	Des	Total
Meteorological Data														
Rainfall(P)	mm	231	146.9	181.5	226.3	311.5	221.6	125.6	125.7	99.9	122	194.9	283.4	2270.3
Rainy Day(n)	Day	22.1	15.7	15.8	19.5	21	19.5	18	15.7	12	15.1	20.2	20.6	215.2
Evapotranspiration														
E. Potensial (Dayly)	mm	6.606	7.202	6.752	5.494	4.95	5.51	5.119	5.933	6.814	7.314	6.364	6.164	
E. Potensial (Mounthly)	mm	204.8	201.6	209.3	164.8	153.5	165.3	158.7	183.9	204.4	226.7	190.9	191.1	2255.087
Exposed Surface	%	20	20	20	20	20	20	20	20	20	20	20	20	
E. Actual	mm	213.2	197	204.7	167.3	158.1	167.8	158.7	179.7	192.2	220.2	195.1	196.1	2249.894
Water Balance														
(P-Ea)		17.81	-50.1	-23.2	59.01	153.4	53.84	-33.1	-54	-92.3	-98.2	-0.21	87.34	20.40633
Soil Storage		0	50.11	23.21	0	0	0	33.08	53.99	92.26	98.17	2.31	0	
Water Surplus	mm	17.81	0	0	59.01	153.4	53.84	0	0	0	0	0	87.34	371.4255
		SURPLUS	DEVISIT	DEVISIT	SURPLUS	SURPLUS	SURPLUS	DEVISIT	DEVISIT	DEVISIT	DEVISIT	DEVISIT	SURPLUS	
Direct Run Off														
Infiltration	mm	7.123	0	0	23.6	61.37	21.53	0	0	0	0	0	34.93	148.5702
Direct Run Off	mm	10.68	0	0	35.41	92.06	32.3	0	0	0	0	0	52.4	222.8553

4.2 Geoelectric Estimation

Estimation results with the geoelectric illustrate that the surface of the spread of rock layers both upright and horizontal. Hydrological conditions in the investigation area are included in the aquifer system through cleavage or cavity [13]. This area includes those who have productive aquifers. The rock that is expected to be a groundwater carrier (aquifer) at the location of the Sacred Valley is vesicular lava. From the geoelectric results as shown in Table 3 it is known that the position of the aquifer is at a depth of 30.43 - 49.78 with a thickness of 19.35 m.

Table 3. Geoelectric Estimation Results

Guess Point	Layer	Interpretaion Results		Lithological Estimates	Hydrological Estimates
		Depth	Type Prisoners		
1	1	0.0 – 3.24	60.14	Covered Land	
	2	3.24 – 11.31	67.50	Sand	Free Ground Water
	3	11.31 – 30.43	149.87	Bolders	
	4	30.43 – 49.78	107.50	Vesicular Lava	Suspected Aquifer
	5	49.78 – 100.25	324.79	Breccias	
	6	100.25 - -	450.25	Andesite Breccias	

5. Conclusion

The sacred valley has the potential of groundwater as raw water for drinking water that can meet drinking water needs in the East Tidore region and part of the City Tidore. Groundwater recharge capacity in the sacred valley is 55 L / s and has an aquifer at a depth of 30.43 - 49.78 m below the ground face. Groundwater Pontifical Sacred Valley which is located at an altitude of 496 m asl is worth using for drinking water with a maximum capacity of 55 L / s.

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