ISSN 2455-4863 (Online) **www.ijisset.org** *Volume: 5 Issue: 10 | 2019*

Two Dimensional Models with Integrated Environmental Factors for the Prediction and Management of Sustainable Groundwater in Bukit Raya District Pekanbaru, Indonesia

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Abstract: *In Bukit Raya Sub district Utilization and management of underground water has not been sustainable, because it has not met the provisions on the use of underground water resources in a sustainable manner. This will affect the condition of underground water and the environment. This can lead to the degradation of regional conditions, indirectly also caused by the management of upstream natural resources that affect the condition of groundwater, for example due to excessive exploitation of underground water by industries. This study aims to: Determine the influence of groundwater uptake by residents and industry as well as public facilities and animal husbandry on the condition of underground water aquifers in Bukit Raya Kota District. And determine the management model for potential underground water resources in the Bukit Raya District. The method used in this study is the experimental method of observing the study area to determine local geological conditions. The results showed that the consumption of underground water uptake from year to year increased due to increasing population and industry.*

Keyword: *Geological, management, resources, sustainable, Underground water.*

1. INTRODUCTION

The Bukit Raya area of Pekanbaru City is still influenced by natural processes that occur on land, such as sedimentation and fresh water flow, and many mining activities, to meet the needs of people's lives. There are four main problems faced by the community, namely the level of poverty, damage to water resources, the low independence of regional social organizations, and the lack of infrastructure and environmental health in settlements. The four main issues above contribute to the high vulnerability of regions facing natural disasters and climate change. Some of the utilization and management of ground water by the community and regional government has not fulfilled the provisions on the use of ground water resources in a sustainable and sustainable manner. This will affect the condition and environmental sustainability. The cause of the degradation of regional conditions indirectly is also caused by the management of natural resources that affect the excessive exploitation of underground water by industries [1].

Industrial or development activities in Bukit Raya District must continue to run and even have to increase, but the development must be environmentally sound. This means that development activities continue to run but the carrying capacity of the main environment in the form of an underground water environment must be enhanced [2]. Along with the development and development in the Bukit Raya Sub-District Area, it will encourage the increasing need for clean water. This has an effect on the reduced carrying capacity of the environment mainly due to the reduction in groundwater recharge [3].

This study aims to create a model of sustainable management of potential groundwater resources in the Bukit Raya District of Pekanbaru City. So it has not been able to synergize government policies in the management of underground water resources with environmental insight in the Bukit Raya District of Pekanbaru City.

2. LITERATURE REVIEW

2.1 Model

The model is a form that is made to mimic a phenomenon or process. In general, the model can be grouped into three models, namely:
a). Quantitative models are models in the form of statistical or computer mathematical formulas [4].
b). Qualitative model is a model in the form of diagram or matrix images which state the relationship between elements. In the qualitative model mathematical formulas, statistics or computers are not used [5].

c). An iconic model is a model that has the same physical shape as an imitated item, although the scale can be enlarged or reduced. Through the iconic model an experiment can be carried out to determine the behavior or process that is imitated [6]. Model is a representation of the reality of a modeler. In other words, the model is a bridge between the real world and the world of thinking to solve a problem. This elaboration process is called modeling which is nothing but a process of thinking through a logical sequence. The model is expressed well if it can describe well all the important things from the real world situation [7].

Models will be very useful when dealing with complex systems. Sustainability of underground water (in terms of the amount of underground water associated with

underground water exploitation), is very complex because it includes knowledge of aspects: Conservation land, government policy, infiltration, aquifer parameters, and groundwater extraction, and flow simulation underground water to the environment, it is necessary to optimize the regulation of groundwater protection zones, so that problems are very complex both in terms of system behavior and management aspects [8].

Research using system analysis or simulation has advantages including (a). Can experiment with a system without having to disrupt or treat the system under study, (b) it can be used to create a new system that is thought to be better than the actual situation under study, (c) it can be used in situations where experiments cannot be carried out, (d) can conduct multi-disciplinary and integrated research that is often not possible in actual circumstances, (e) in terms of efficient and feasible system analysis can be done in a short time with low cost and convincing results [9].

2.2 Sustainable Underground Water Management Models

The sustainable underground water management model developed in this study is to be able to describe well all the important things from the state of the underground water aquifer system in the Bukit Raya District.

The use of this model is very useful because it faces a complex system. Sustainability of underground water is very complex because it includes knowledge of aspects: Aquifer parameters, and groundwater extraction both by residents and industries in Bukit Raya District.

The underground water management model of the coastal area of Bukit Raya District is influenced by various environmental factors:

a. Intake of aquifer water by residents

b. Industrial uptake of aquifers.

The underground water management model in this study is based on the idea that the sustainability model of underground water is highly influenced by various environmental factors such as aquifer parameters, aquifer water extraction by residents and aquifer extraction by industry [10].

Mathematically the management model of underground water potential can be expressed in the form of partial differential equations [11].

$$\frac{S}{T}\frac{\partial h}{\partial t} = \frac{\partial^2 h}{\partial x^2} + \frac{\partial^2 h}{\partial y^2} + \frac{R}{T} \quad (1)$$

Equation (1) is a management model for the analysis of potential underground water resources in Bukit Raya District. Based on equation (1) it can be explained that the parameters of the underground water model have been calculated to model the aquifer water system as a function of space (x, y), namely; 1). Intake of underground water resident, 2).Intake of underground water by industry, 3).Aquifer parameters.

Taking into account the parameters of the model, sustainable underground water management can be modeled for the underground water system of Bukit Raya District.

To find out the amount of underground water uptake, from production wells. Monitoring the amount of groundwater uptake can be carried out as follows [12]:

1. Recording or measurement of the amount of groundwater extraction and utilization is done periodically every month through water meters or other discharge gauges.
2. Difference in number two of the time period for recording the amount of groundwater extraction and utilization in water meters or other discharge measuring instruments is the amount of underground water taken and used for one month.
3. Changes in the number of taking and utilization of the results of the analysis of recording or measurement above.

The amount of underground water needs for the population is determined by the level of life patterns of the user community. One aspect of the study in this study is to calculate the use of underground water for domestic based on standards from the drafting team of the directorate of urban planning and regional planning directorate of building problems.

a) The increasingly complex needs of the population are in line with the increasing level of prosperity, thus demanding the supply of ground water for various purposes.

b) In terms of the development of the Bukit Raya sub-district, including on a medium scale and refers to the provisions of the number of groundwater users from the survey results.

3. RESEARCH METHODS

This study uses a field experiment method, a field measurement process to get biophysical data and comprehensive location coordinates using GPS. Whereas to obtain socioeconomic data the survey method was carried out related institutions such as BPS and the office in the Bukit Raya District of Pekanbaru City and direct observation in the field.

Furthermore, the data collected will be processed to create an environmental management modelof underground water potential in the Bukit Raya District, Pekanbaru City. The data processing uses the MATLAB tool for the solution of equations (1) using numerical simulations

To achieve the research objectives, data related to biophysical and socio-economic aspects were collected.

Biophysical data

1. Thickness of the aquifer
2. Aquifer area.
3. Hydraulic conductivity
4. Storativity
5.Transmicity
6.Geoelectrical data
7.Hydraulic gradient.

Socio-economic data
1.Total Population in Bukit Raya District.
2. The number of industries in the Bukit Raya District.

4. RESULTS AND DISCUSSION

The picture below is a Map Image and Contour of the underground water depth in the Bukit Raya sub-district of Pekanbaru City, where it is seen that the catchment and groundwater extraction are based on taking groundwater by residents (Ed), industry (Ei), agriculture (Et), trade (Ep), animal husbandry (Ek), public facilities (Ef) and strotativity and transmissivity, so that the pattern of maps and contours of underground water depth are obtained as shown in Figures 1 to 3 below:

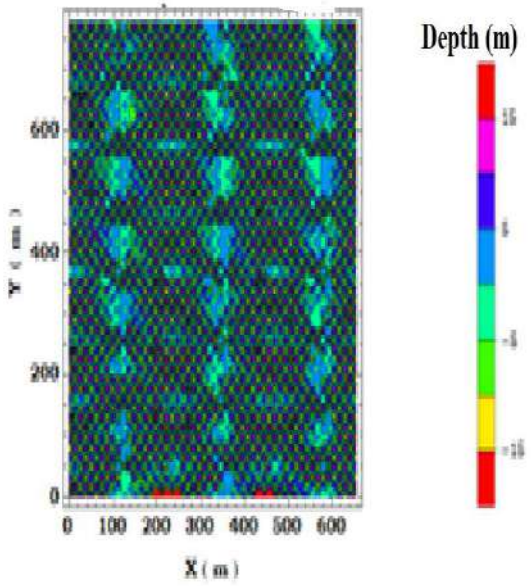

Figure 1 *Two-Dimensional Contour Depth of Underground Water in Bukit Raya District in 2015*

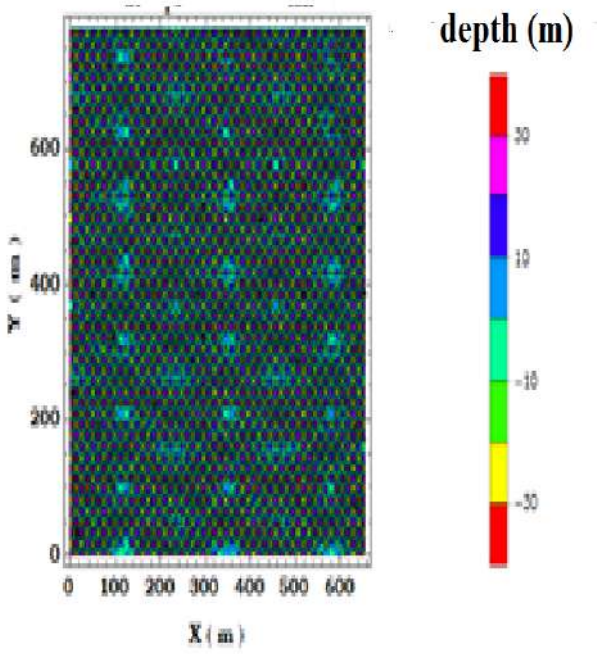

Figure 2 *Contour Two Dimensions of the Depth of Underground Water in Bukit Raya District 2016*

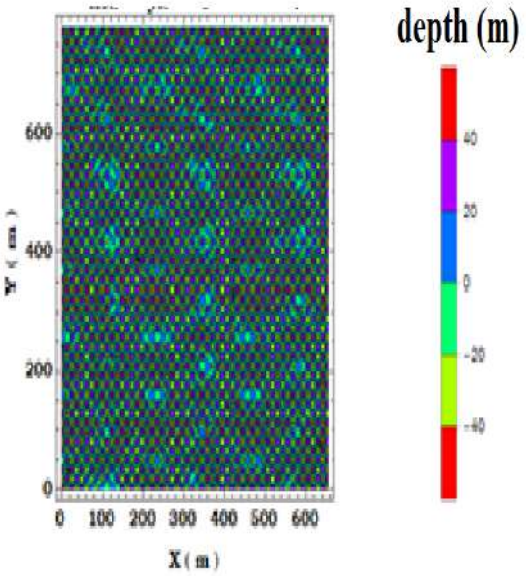

Figure 3 Contour of Two Dimensions of Underwater Depth in Bukit Raya District, 2017

Table1. *Contribution of Underground Water Extraction to Depth, Ed, Ef, Ei, Ek, Et, Ep For Bukit Raya District*

	Item	Partial Value(m^3/year)	% Part	Contribution Part(%)
2017	Ed	2,459,791.80	0.17	2.51
	Ef	30,277,962	2.06	30.85
	Ei	2956.5	0.02	0.30
	Ek	2,084,150	0.14	2.12
	Et	0.73	0.0005	0.01
	Ep	1,437,266,340	3.4	51.00
	Total	1,472,091,201.03		
	Item	Partial Value(m^3/year)	% Part	Contribution Part(%)
2018	Ed	2,301,890.40	0.17	5.08
	Ef	604.385	0.004	0.13
	Ei	3623.5	0.03	0.80
	Ek	2,691,875	0.20	5.94
	Et	0.73	0.0005	0.02
	Ep	1,354,917,960	2.5	75
	Total	1,359,915,954.02		
	Item	Partial Value(m^3/year)	% Part	Contribution Part(%)
2019	Ed	2,523,943.80	0.17	7.6
	Ef	616.485	0.004	0.2
	Ei	3623.5	0.02	1.1
	Ek	2,910,875	0.20	8.8
	Et	1,095	0.01	0.3
	Ep	1,486,317,960	1.9	85.5
	Total	1,491,758,113.79		

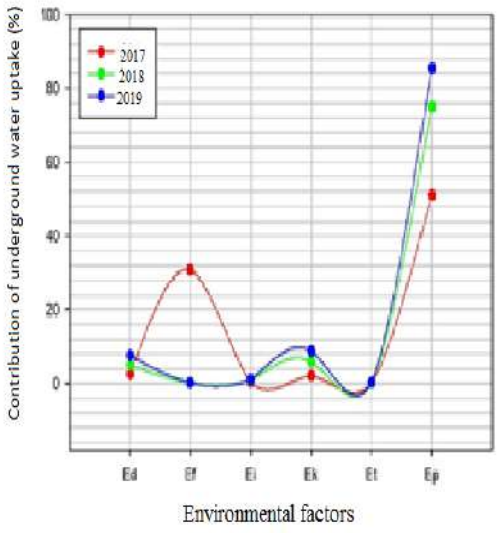

Figure 4 *Contribution of Underground Water Extraction in Bukit Raya District*

Figures 1 to 3 show the two-dimensional contour of ground water depth in the Bukit Raya District of Pekanbaru City in 2015 to 2017 with values fluctuating from 15 to 45 meters, with several factors affecting the depth of underground water, namely Recipe (R), water uptake by resident (Ed), water extraction by industry (Ei), water withdrawal by public facilities (Ef), water withdrawal by Animal Husbandry (Ek), water withdrawal by agriculture / plantation (Et) and water withdrawal by trade (Ep) and Storativity (S) Ab value or or the depth of underground water is the result of the sum of all values (R-Ed + Ei + Ef + Ep + Ek + Et / S) which is a factor that affects the condition of continuous water recipe from Figures 1 to 3 can be seen that the depth of underground water is increasing because the water consumption from year to year is increasing. This is influenced by changes in population and industry data and automatic withdrawal of underground water by the population and industry is getting bigger.

5. CONCLUSIONS

Based on the research conducted, it can be concluded that the increase in population and industry from year to year is a factor in influencing ground water consumption so that underground water withdrawals by residents and industry will be even greater, this can be proven based on the value of depth of underground water.

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