Drilling Groundwater for Raw Water in Sembiran Village, Tejakula Districts, Buleleng Regency

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Abstract - Water is an absolute necessity that must be met, both for drinking water and for irrigation. An alternative to meet the water needs other than rainwater or surface water, is by taking underground water by drilling deep wells. Sembiran Village is a village located in Tejakula District, Buleleng Regency, the village is a dry area that requires water, both for drinking water and for agriculture. Location of groundwater drilling including Tejakula groundwater basin. In order to achieve the above objectives, an effective and efficient groundwater drilling technique should be carried out considering that the area geologically has rocks dominated by volcanic lava rock which are the products of Mount Agung and Mount Buyan Beratan Purba. The method of drilling groundwater is carried out in stages starting from drilling a Pilot Hole with a diameter of 6 to 64 meters, followed by an enlargement of 8 ", 10" to 12 "drill holes to a depth of 64 meters. In the field of drilling work the Hydrolic Rotary System Method, Direct Circulation Rotary Drilling is used and for the removal of cutting / dirt mud Fludia is used. The equipment used for drilling is rotary / skid mounted drilling machines with a capacity of up to ± 150.0-200.0 meters, equipped with equipment such as: mud pumps, a series of equipment that cannot be separated from one another. For well logging an Electrical logger is used for geophysical wellbore investigations. For the work of washing wells using compressor and other supporting equipment. Pumping the test uses a submersible pump that has a minimum discharge capability of 10 lt / sec and a maximum of 20 lt / sec. The results of direct observations and measurements of the physical parameters of the Sembiran Village Drilling Well (SEM-5) contain TDS = 219.; PH = 7.0. Chemically, Iron (Fe) = 0.001 mg/ltr; Arsenic (Ar) = 0.067 mg/ltr; Availability ($CACO_3$) = 56.4 mg/ltr; Chloride (Cl-) = 91.6 mg/ltr; Nitrate (N) = 0.013 mg/ltr; Sulfate (SiO_4) = 1.88 mg); Lead (Pb) = 0 mg/ltr; organic matter ($KMnO_4$) = 0.34 mg/ltr, so the Drilling wells (SEM-5) meet clean water quality standards based on the Regulation of the Minister of Health of the Republic of Indonesia Number 492 / Menkes / Per / IV / 2010. Discharge obtained from pumping test results at SEM-5 wells is 20.47 liters/sec with surface water level(swl) = 23.60 m, and the position of the pump is placed at 42 m from the ground surface.

Keyword : Groundwater drilling, water quality, pumping test

I. INTRODUCTION

The growing population growth today, especially the growth of rural populations due to economic development, it is deemed necessary to have an irrigation facility that can support the improvement of the people's agricultural sector both from surface irrigation or rain-fed irrigation sourced from underground water.
The obstacle faced in the use of ground water as a source of water through rholes is if the extraction / pumping of ground water as irrigation water is not controlled, it can cause damage to the groundwater system that impacts on environmental damage such as groundwater pollution due to the entry of inland sea water (if the location is close to the beach). Sembiran Village, located in Tejakula Subdistrict, Buleleng Regency, still needs ground water for agricultural land due to drought, due to the limited surface water that can flow through the land in the area. The alternative to meet the water needs of rainfed irrigation is by taking underground water by drilling deep wells. In order to achieve the above objectives, it is advisable to carry out monitoring and integrated monitoring periodically, both in quality and quantity, as well as the need for monitoring wells that can later monitor groundwater level fluctuations, so that underground water management can run well (adjusted to local hydrogeological conditions). From the results of the drilling, it is expected that the quality and quantity of water can be utilized as raw water or agricultural irrigation in the area.

II. \ LITERATURE REVIEW

A. Definition of Groundwater

Ground water is water that moves in the soil that is in the soil between the soil grains that seep into the soil and combine to form a layer of soil called an aquifer. Layers that can pass water easily are called permeables, such as layers of-sand or gravel. Layers that do not escape water are called impermeable, such as clay or clay. The layer that can capture and escape water is called an aquifer [12].

B. Types of Aquifers

1. *Unconfined aquifer*

That is a layer that escapes water which is only partially filled with water and is above the waterproof layer. The surface of the aquifer is called the water table (phreatic level), which is the surface of the water that has the same hydrostatic pressure as the atmosphere [18].

Figure 1. Location of the Research Area

2. *Confined aquifer*

Namely aquifers whose entire amount of water is limited by waterproof layers, both above and below. And has a saturation pressure greater than atmospheric pressure [15].

3. Semi-confined aquifer

Namely aquifers whose water pressure is entirely saturated. At the top is a semi-escaped layer of water, at the bottom bounded by a waterproof layer.

4. Semi-unconfined aquifer

Namely the aquifer whose bottom is a waterproof layer, while the top is a fine-grained material so that the cover layer still allows for the movement of water. Thus this aquifer is a transition between free aquifer and semi-depressed aquifer [7].

C. Classification of Groundwater

Classification of groundwater based on the location of depth:

a. *Deep ground water*

Deep ground water is ground water that is under the shallow ground water layer and between two impermeable layers. Deep ground water is a lower aquifer that is used as a source of drinking water for city residents, hotels, offices, and industries [13].

Deep pressurized deep ground water can radiate to the ground surface through natural faults or rock cracks, this water source is called artesian water. When soil is dug or drilled into reaching pressurized aquifers, water flows through well holes called artesian wells [2].

b. Shallow ground water

Shallow groundwater is ground water that is below the surface of the ground and above impermeable rocks. Shallow ground water is an upper aquifer which is also called phreatic water. Shallow ground water is used as water to meet daily needs by making home wells [14].

Classification of groundwater by type:

1) Meteoric water (vadose water)

Namely ground water that comes from rain water and is found in unsaturated soil layers [16].

2) Connate water

That is ground water trapped in cavities of sedimentary rocks since deposition occurred, including water trapped in hollow cavities when they magma burst out onto the surface.

3) Fossil water

Namely water that is trapped in rock cavities and has remained in the rock since accumulation took place [1]

4) Juvenile water

Namely water that comes from inside the earth (magma kitchen). This water is not from the atmosphere or from the surface of the water.

5) pelicular water / (pellicullar water)

Namely water stored in the soil because of the pull of soil molecules, [8]

6) Phreatic water

Namely water that is in the earth's crust (porous). This groundwater is above the waterproof layer.

7) Artesian water

Namely water that is between two impermeable layers, so that the water is in a depressed state, [6]

C. *Groundwater Basin and Potential*

Groundwater Basin is an area that is bounded by hydrogeological boundaries, where all hydrogeological events such as the process of capturing, flowing, and releasing Groundwater take place [5].

D. Groundwater Conservation

Groundwater conservation is an effort to maintain the existence and sustainability of the condition, nature, and function of ground water so that it is always available in sufficient quantity and quality to meet the needs of living things, both now and in the future [18].

III. METHODOLOGY

A. *Geological Conditions*

The method used in surveying the geological conditions of the drilling area, an outcrop observation activity was carried out in the field, and utilizing a geological ptea issued by the Bandung Geological Agency. topographic maps.

A. Hidrogeology

Hydrogeological conditions at the research site using geophysical methods before drilling with the Schlumberger method. It aims to get the stratigraphy of the rock compilers of drilling locations.

B. Drilling

In the field of drilling work the Hydrolic Rotary System Method, Direct Circulation Rotary Drilling is used and for the removal of cutting / dirt mud Fludia is used. This type of-

equipment for drilling is a rotary / skid mounted drilling machine with a capacity of reaching ± 150.0-200.0 meters, equipped with equipment such as: mud pumps, a series of equipment that cannot be separated from one another.

C. Equipment

In carrying out groundwater wells drilling work in the village of Sembiran using some of the equipment that has been tested that is able to penetrate hard rocks such as volcanic lava. The type of drilling equipment used is rotary / skid mounted KSK and Longyear brands, with capacities reaching ± 300 meters.

While other auxiliary equipment are drill handlebars, mud pumps with a capacity of 750 lit / min and 600 amphere welding machines as well as several drill bits / bits consisting of tri cone bit / corn vidia drill bits, 8 3⁄4 "coring drill bits and 14 3⁄4 ", and is equipped with key chains, pipes, pulleys, etc.

Electrical logger is for geophysical wellbore investigations and for well washing works using compressor and other supporting equipment.

Pumping the test uses a submersible pump that has a minimum discharge capability of 10 lt / sec and a maximum of 20 lt / sec

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D. Cutting Observations

During the Pilot Hole drilling work, observations are made of drilling cuts at each meter of drilling depth or if there is a change in rock, which is the result of observations of the color, grain size, roundness and type of rock, observations are made every 1 (one) meter. So the observation is done visually and the results of these observations are depicted in the form of a lithology log.

E. Geophysical Logging

By using Geologer equipment Logging geophysical observation is carried out if the Pilot Hole drilling has reached a predetermined depth of ± 64 meters. Observations were made using a "Resistivity" and "Spontaneous Potential" approach which includes natural gamma rays of prisoners of type, with measurements in 1 meter depth intervals, with the aim to determine the location of the aquifer depth / aquifer position (water-carrying layer) thus the placement of the screen can be determined precisely at the point of the potential aqufer containing water.

F. Well Drilling Installation

The well installation is a determination of the results of the overall drilling work where caution and accuracy are needed in the placement and installation of the well construction so that the well water can be extracted optimally from the capacity of the well.

G. Charging Gravel Pack

After the installation of the well pipe is complete and in accordance with what is inserted, then a package of gravel of a certain size is inserted into the cavity between the well wall and the pipe. The gravel packages are on average 3-8 mm in diameter and must be installed before inserting, in the gravel filling process, the mud circulation must continue to run with a thickness made and installed in 33 seconds. This gravel package must have good compressive strength. Minimum of 200 kg / cm2, has a good and flat round. Percentage of flat, soft stone, limestone or other ingredients of not more than 5%. Installation of gravel packages in the filter position and cementing (grouting) on the surface of the soil to a certain soil surface to prevent increased pollution.

H. Well Washing.

Washing wells is carried out after construction is complete. The initial stage of this work is the implementation of an Air Lift which is intended to thin the drill mud used during drilling. Simultaneously with the implementation of the Air Lift in the cavity between the well wall hole and the casing / construction pipe the selected gravel pack / gravel pack has been sorted / graded to a large degree, evenly around the well.

With the completion of the Gravel pack as a sanitary construction pad, the development / cleaning of the well is continued with Air Jetting which uses a large / high pressure compressor for a long time until the water in the redrilling well is completely clear and free of sand.

I. Pumping Test

1. Type of Pumping Test

The next stage of work with the completion of the work of washing wells, is the implementation of pumping tests, which aim to obtain the hydraulic parameters and the capacity type of the Redrill / production wells.

The pumping of the test includes the implementation of a step drawdown pumping test for the purpose of obtaining wells characteristic values.

The stepwise pumping test continues with the constant rate pumping test and then continues and then continues with the recurrence / recovery test.

The purpose of this pumping is:

a. Determine the characteristics of wells including type capacity, well capacity.

b. Determine the characteristics of the aquifer, among others Transmissiviti (T) and Permeability (K).

2. *Phase Testing Pumping*

The purpose of pumping a phased test is to determine the characteristics of wells expressed by the specific capacity. The implementation of pumping this test is to observe the decrease in ground water level in the well. In this case pumping is done in 4 stages where at each stage an increase in pumping starts from stage 1 to stage 2, and so on up to stage 4.

3. Pumping Test

The long period pumping test is carried out using a constant discharge, and during the pumping test the observation of the behavior of the ground water level is continuously observed with the determined observation time. Measurement of surface water level (swl) in wells starts from before the pumping is carried out, at the time of pumping until

pumping ends with a total time of implementation reaching 72 hours.
Recovery / measurement of recurrence of ground water level in the well is carried out if the Continuous Test has stopped.

4. Discharge Measurement

The equipment used in pumping this test, both enduring and long period test is a discharge measurement tool consisting of a Body called Weir / Thomson Body, water flow can be measured / determined using the formula:

$$Q = 0{,}139\ X\ (h)2\sqrt{\bar{h}} \ldots\ldots\ldots\ldots\ldots\ldots.(1)$$

where:

Q = Discharge (ltr/second)

H = High water in the tub (m)

The flow in a Thomson tub must be a laminer, it can not be turbulent.

6. Test Pumping Data Management

In pumping test data collection, the mathematical approach method used is based on several approaches, namely:

- Aquifers have unlimited distribution.
- The spread of the aquifer in the horizontal direction is much greater than in the vertical direction.
- Aquifers have isotropic homogeneous properties and uniform thickness in the area affected by pumping.
- Discharge during constant pumping.
- Piezometric surface before constant pumping.
- The pumped well penetrates the entire aquifer.

7. Laboratory Analysis

What is meant by the sampling of ground water taken at the time of pumping the test is to determine the quality of groundwater both chemically and physically.

IV. RESULTS AND DISCUSSION

A. Geological Conditions

Local geology of groundwater drilling in Desa Sembiran, consisting of vulcanic lava rock and tuff which is a product of the Purba Buyan-Beratan and Batur volcanoes and there are faults or faults that stretch from east to west.

B. Hidrogeology

From the geological results, the rock layer consisting of volcanic lava interspersed with tuffs with an alleged aquifer at a depth of 64 meters from the ground surface.

C. Drilling

Field drilling works use mechanical drilling machines with the Hydrolic Rotary System Method, Direct circulation Rotary Drilling and for the removal of cutting / dirt using Fludia Mud. This type of equipment for drilling is a rotary / skid mounted drilling machine with an internal capacity reaching ± 150.0-200.0 meters, equipped with equipment such as: mud pumps, a series of equipment that cannot be separated from one another.
The drilling was carried out in stages starting from the pilot hole drilling with a diameter of 6 "to reach 64 meters, followed by enlargement of the drill / reaming hole with a diameter of 8", then 10 "to 12" to a depth of 64 meters.

Figure 2. Drilling of groundwater wells
(Source: BWS Bali- Penida 2019)

D. Peralatan

The type of drilling equipment used is rotary / skid mounted KSK brand and Longyear, with a capacity of ± 300 meters. While other auxiliary equipment are drill handlebars, mud pumps with a capacity of 750 lit / min and 600 amphere welding machines as well as several drill bits / bits consisting of tri cone bit / corn vidia drill bits, 8 3⁄4 "coring drill bits and 14 3⁄4 ", and is equipped with key chains, pipes, pulleys, etc.
Electrical logger is for geophysical wellbore investigations and for well washing works using compressor and other supporting equipment.
Pumping the test uses a submersible pump that has a minimum discharge capability of 10 lt / sec and a maximum of 20 lt / sec.

E. *Pengamatan Cutting*

During the Pilot Hole drilling work, observations are made of drilling cuts at each meter of drilling depth or if there is a change in-

rock, which is the result of observations of the color, grain size, roundness and type of rock, observations are made every 1 (one) meter. So the observation is done visually and the results of these observations are depicted in the form of a lithology log.

Figure 3. Drilling Cutting
(Source: BWS Bali - Penida)

F. Geofisik Logging

By using Geologer equipment Logging geophysical observation is carried out if the Pilot Hole drilling has reached a predetermined depth of ± 64 meters. Observations were made using a "Resistivity" and "Spontaneous Potential" approach which includes natural gamma rays of prisoners of type, with measurements in 1 meter depth intervals, with the aim to determine the location of the aquifer depth / aquifer position (water-carrying layer) thus the placement of the screen can be determined precisely at the point of the potential aqufer containing water.

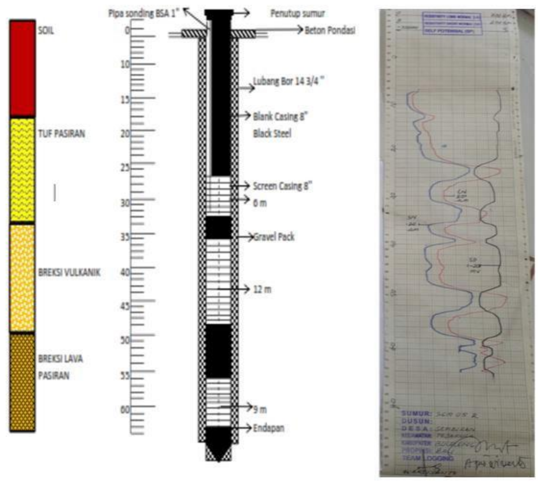

Figure 4: The results of well logging and drilling wells drilling with a depth of 64 m.
(Source: BWS Bali-Penida,2019)

Tabel 3.1 The depth of the filter pipe / screen in the Redrilling Well.

Well Location / Well Code	Black Pipe Depth Steel Ø 8" (m)	Long Pipe Black steel Ø 8" (m.)	Long Pipe Sonding Ø 1" (m)
Sembiran Village SEM - 05	0 – 27 33 – 36 49 -54 63 – 64	24,5 3 5 1	30

G. *Redriling Well Installation*

The well installation is a determination of the results of the overall drilling work where caution and accuracy are required in the placement and installation of the well construction so that the well water can be extracted optimally as the capacity of the wells concerned in the case of the Sembiran wells (SEM-5).

Table 3.2 Types of pipes in well construction

Well Location / Well Code	Pipe depth Screen	Low Filter Pipe Length Carbon
Desa Sembiran Kec. Tejakula, Kab. Buleleng SEM. 05 R	27 – 33 49 – 36 63 – 54	6 12 9

H. *Charging Gravel Pack*

Fill the gravel pack into the cavity between the well wall and the pipe. The average diameter of the gravel pack is 3 mm - 8 mm and must be washed thoroughly before inserting, in the process of filling the gravel pack, the drilling mud circulation must continue to run with reduced thickness and be maintained at 33 seconds. This gravel pack must have good compressive strength. Minimum 200 kg / cm2, have a good and flat round. Percentage of flat, soft stone, limestone or other ingredients of not more than 5%. Installing the gravel pack in the filter position and grouting the wellhead from the ground level to a certain depth to prevent pollution.

Figure 4. Charging Gravel Pack

I. *Well Washing.*

The initial stage of washing wells is the implementation of an Air Lift which is intended to thin the drill mud used during drilling. Simultaneously with the implementation of the Air Lift in the cavity between the well wall hole and the casing / construction pipe the selected gravel packs (gravel packs) have been sorted out the level of the granules, evenly around the well.

With the completion of the Gravel pack as a sanitary construction pad, the development / cleaning of the well is continued with Air Jetting which uses a large / high pressure compressor for a long time until the water in the redrilling well is completely clear and free of sand.

J. PUMPING TEST

1. Type of Pumping Test

The pumping of the test includes the implementation of a step drawdown pumping test

Figure 5. Washing Wells

for the purpose of obtaining wells characteristic values.

The stepwise pumping test continues with the constant rate pumping test and then continues and then continues with the recurrence / recovery test.

The purpose of this pumping is:

a. Determine the characteristics of wells including type capacity, well capacity.

b. Determine aquifer characteristics such as Transmisivity (T) and Permeability (K).

J.2 Phase Test Pumping

Phased pumping tests to determine the characteristics of wells expressed by specific capacity quantities. The implementation of pumping this test is to observe the decrease in ground water level in the well. In this case pumping is done in 4 stages where at each stage an increase in pumping starts from stage 1 to stage 2, and so on up to stage 4.

J3**.** *Pumping Continuous Test*

The long period pumping test is carried out using a constant discharge, and during the pumping test the observation of the behavior of the ground water level is continuously observed with the determined observation time. Measurement of ground water level (swl) in wells starts from before the pumping is carried out, at the time of pumping until pumping ends with a total time of implementation reaching 72 hours.

Table 3.3 Pumping Test Results

Hour	Time (Minute) (t)	DWL (m)	Draw Down (m)	H Vint (cm)	Q (l/s)
09.00	0	23.60	00	14.0	10.18
10.00	60	23.66	0.00	16.00	14.23
11.00	120	23.67	0.00	17.00	16.67
12.00	180	23.69	0.00	18.5	20.47

2. *Discharge Measurement*

The equipment used in pumping this test, both enduring and long period test is a discharge measurement tool consisting of a Body called Weir / Bak Thomson. Discharge measurement results can be seen in table 3.4.

Table 3.4 Well Water Discharge

Location	SWL (m)	Max Discharge (ltr/sec)	Pump Position (m)	Pump Discharge (ltr/sec)
SEM - 05 R	23.60	20.47	42	20.47

3. *Pumping Test data processing*

In pumping test data processing, the mathematical approach method used is based on several approaches, namely:

- Aquifers have unlimited distribution.
- The spread of the aquifer in the horizontal direction is much greater than in the vertical direction.
- Aquifers have isotropic homogeneous properties and uniform thickness in the area affected by pumping.
- Discharge during constant pumping.
- Piezometric surface before constant pumping.
- Pumped wells penetrate the entire aquifer.

Figure 6. Pumping Test Results

J.6 *Physical and Chemical Analysis*

Based on physical and chemical analysis from the SEM-5 well water hydrology laboratory, it has an Odor = odorless content; tastelessness; temperature = 29.2 ^{o}C; TDS = 219.; PH = 7.0. Chemically, Iron (Fe) = 0.001 mg/ltr; Arsenic (Ar) = 0.067 mg/ltr; Availability ($CACO_3$) = 56.4 mg/ltr; Chloride (Cl-) = 91.6 mg/ltr; Nitrate (N) = 0.013 mg/ltr; Sulfate (SiO_4) = 1.88 mg); Lead (Pb) = 0 mg/ltr; organic matter ($KMnO_4$) = 0.34 mg/ltr, so it can be concluded that it can be used as drinking water with parameter values below the maximum standard allowed from the results of the second SEM-5 water lab test that meets the requirements of clean water health, according to Minister of Health of the Republic of Indonesia Number 492 / Menkes / Per / IV / 2010).

V. CONCLUSIONS AND SUGGESTIONSTS

A. *Conclusions*

1. Based on the results of the drilling activities, several conclusions can be obtained:
   - The lithology that forms the area of the Regency of Buleleng is dominated by lava rock, sandy tuff, volcanic breccia and sandy lava breccias.
   - Based on the analysis of drilling samples (catting) the most potential layer of storing water is the volcanic lava rock layer.
2. From the data that has been evaluated, it can begravel concluded as follows:
   - Redrill well in Sembiran Village, Tejakula District, Buleleng Regency from Volcanic Buyan - Bratan - Batur.
   - From the results of pumping data for the long period test with the type of Groundfos SP pump. 60 - 15, the discharge, T and K values for SEM-5 wells are the height of the surface water level (swl) = 23.60 m; The maximum discharge capability can be used is 20.47 liters / second, with a pump position 42 meters from the bottom of the wellbore.

B. Suggestion

1. It is recommended not to pump continuously with discharge exceeding the ability of wells / above 20.47 lt/sec it is feared that this will result in intrusion of sea water into the well.
2. It is necessary to make an observation well with a view to knowing the quality of groundwater in case of physical and chemical changes and also knowing the position of the ground water level periodically around the area.

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