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STRATEGY TO INCREASE ABSORPTION WELL CAPACITY

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ABSTRACT: In the field of water resources, the green technology may be implemented in the development of drainage system which utilizes the absorption well as a priority effort for prescribing the runoff water. Due to the low capacity of absorption well, the use of absorption well requires the high cost. There are two factors that restrict the increasing of absorption well capacity, i.e. ground water level and land permeability. The first factor is difficult to be controlled, while the second one could be modified by making a well through the aquifer layer. The contamination in the ground water is controlled by making a filter from the sand media and by allowing the rain water only (not mixed with household waste water) to flow into the well. Using this effort, the well capacity increases by 400% to 7000%.

Keywords: Absorption well, well capacity, aquifer.

1. Introduction

The direction of flood control policy has been changed from the effort of channelling the rain water into the river or sea, become maximizing the infiltration of the rain water into the ground. It aims to reduce the surface runoff discharge and increase the potential of ground water (Bisri, Prastya, 2009; Director of Water Management, 2007). The strategy is developed to implement the green technology in all aspects and in short-term to solve the flooding problem and in long-term to solve the water shortage problem (Directorate of Water Management, 2010).

An effort to maximize the infiltration of the rain water into the ground requires a suitable technology to make it is effective, low cost and could be implemented. There are several types of constructions, i.e.: absorption well, absorption dam, absorption small dam, and absorption pond. There are two types of absorption wells in Indonesia, i.e. swallow absorption well and deep absorption well (State Minister for the Environment. 2009). The absorption dam is usually implemented in the form of the absorption pond which is combined with the garden and the absorption small dam.

The utilization of absorption well for infiltrating the rain water into the ground is constrained by the low capacity of absorption discharge (Kustamar, 2011), thus it requires many absorption wells to control the surface runoff in a region (Bisri, Prastya, 2009). Compared with the establishment of open channel, the previous effort requires the land need and high cost. Therefore it needs a proper strategy to promote the absorption well as the people choice.

The strategy for increasing the absorption well is done by increasing the land permeability in the bottom of well and utilizing the aquifer layer as the natural water reservoir below the land surface. The avoid the contamination of ground water, the rain water to be infiltrated is filtered. This modification increases the capacity of absorption significantly.

2. Absorption Well According to SNI (Indonesia National Standard)

2.1 Discharge of Well

According to (Research and Development Center of Water Resources, 2002), the water depth (H) in the absorption well is affected by the flow discharge of water entering the well (Q), the coefficient of land permeability on the well wall (K), well diameter (D), absorption duration (T), and the geometric factor (F). The relationship between the parameters is written as follows

$$H = \frac{Q}{FK}\left[1 - e^{\left(\frac{FKT}{0.25\pi D^2}\right)}\right] \qquad (1)$$

From Eq. (1) and with assumption that the equilibrium condition is satisfied where the input and output discharge flow is equal, thus the water depth (H) is constant. Therefore the discharge of water absorption is expressed as

$$Q = \frac{HFK}{1 - e^{\left(\frac{FKT}{0.25\pi D^2}\right)}} \qquad (2)$$

2.2 Geometric Factor

Geometric factor of the well is a function of the basic shape of well and the water depth (L). When the shape of well is flat, then the water could infiltrate into all directions. Thus the value of F is expressed as

$$F = \frac{2\pi L}{\ln\left[\frac{L}{D} + \sqrt{1 + \left(\frac{L}{D}\right)^2}\right]} \qquad (3)$$

2.3 Coefficient of Permeability

The coefficient of permeability (K) is the ability of land to pass the water per unit of time. The coefficient in horizontal direction is usually lower than the one in vertical direction. The sandy land has the higher coefficient than the clay land (Bisri, Prastya, 2009). The coefficients of permeability of several types of land are given in Table 1.

Table 1 The coefficients of permeability of several types of land.

Types of land	K(cm/s)
Clay	3×10^{-6}
Silt	4.5×10^{-4}
Sand - very smooth	3.5×10^{-3}
Sand - smooth	1.5×10^{-2}
Sand - medium	8.5×10^{-2}
Sand - rough	3.5×10^{-1}
Small gravel	3

2.4 Capacity of Absorption Well

According to (State Minister for the Environment. 2009), the minimum distance between aquifer surface and the bottom of absorption well is 0.5 m. Therefore the position of aquifer determines the depth of ground water surface. The aquifer is usually formed by sand and gravel as the media where the ground water is gathered. The media is able to collect water in large quantities, and could discharge them easily when there is a pressure difference, although it is relatively small. To provide the water quality control, the palm fibers, corals, and sand should be inserted in the bottom of well to 25% of the well volume (see Figure 1).

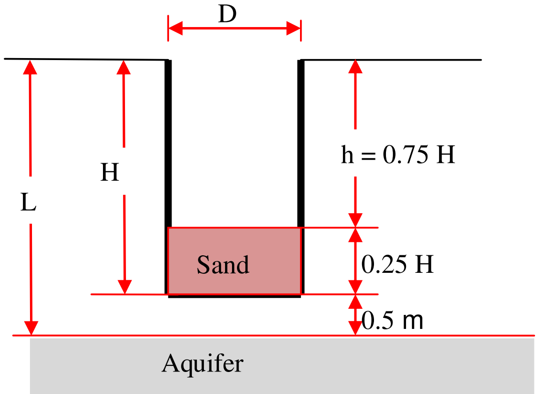

Figure 1 Absorption well according to SNI

From Eq. (2) and by the assumption that water surface in the well is full (H=h), the water discharge that could be infiltrated in the absorption well (according to SNI) is expressed as

$$Q = \frac{hFK}{1 - e^{\left(\frac{FKT}{0.25\pi D^2}\right)}} \tag{4}$$

3. Modification of Absorption Well

3.1 Detail of Modification

The aim of well modification is to increase the absorption well capacity and the ground water reserves. The strategy is by utilizing the aquifer as the water catchment in the underground and maintaining its function as the provider of ground water.[7] It is accomplished by controlling the quality of rain water that will be infiltrated, increasing the coefficient of permeability of the land between the bottom of well and the aquifer, and increasing the volume of storage space. In the modification, the natural land of 0.5 m between the bottom of well and aquifer is replaced with the filter layer.

3.2 Capacity of Modified Absorption Well

The modification of absorption well is performed by modifying the geometric factor as follow

$$F_1 = \frac{2\pi H_1}{\ln\left[\frac{H_1}{D} + \sqrt{1 + \left(\frac{H_1}{D}\right)^2}\right]} \tag{5}$$

where F_1 is modified geometric factor, and H_1 is the depth of modified well. Thus the discharge capacity of modified absorption well (Q_1) is expressed as

$$Q_1 = \frac{H_1 F_1 K}{1 - e^{\left(\frac{F_1 K T}{0.25\pi D^2}\right)}} \qquad (6)$$

4. Results and Discussion

4.1 Increment of Absorption Well Capacity

The increment of absorption well capacity (DQ) is found by calculating the difference between the discharge capacity of modified well (Q_1) and the discharge capacity of standard well (Q) as given in Table 2 to Table 10, where

L = Depth of Aquifer (m)
T = Flow duration (s)
D = Diameter of well (m)
H = Depth of standard well storage space (m)
K = Permeability coefficient of land (m/s)
H_1 = Depth of modified well storage space (m)
K_1 = Permeability coefficient of sand (m/s)
Q = Discharge capacity of standard well (m^3/s)
Q_1 = Discharge capacity of modified well (m^3/s)
DQ = Increment of absorption well capacity (%)

Table 2 Increment of Absorption Well Capacity (L= 1m)

Types of land	L	T	D	H	K	H_1	K_1	Q	Q_1	DQ (%)
Clay	1	260	1	0.75	0.0006	0.2	1.5	0.003	1.896	550
Silt	1	260	1	0.75	0.0045	0.2	1.5	0.008	1.896	230
Sand-smooth	1	260	1	0.75	0.035	0.2	1.5	0.059	1.896	31

Table 3 Increment of Absorption Well Capacity (L= 2m)

Types of land	L	T	D	H	K	H_1	K_1	Q	Q_1	DQ (%)
Clay	2	260	1	1.5	0.0006	1.2	1.5	0.007	13.352	1937
Silt	2	260	1	1.5	0.0045	1.2	1.5	0.016	13.352	813
Sand-smooth	2	260	1	1.5	0.035	1.2	1.5	0.118	13.352	112

Table 4 Increment of Absorption Well Capacity (L= 3m)

Types of land	L	T	D	H	K	H_1	K_1	Q	Q_1	DQ (%)
Clay	3	260	1	2.25	0.0006	2.2	1.5	0.010	29.806	2883
Silt	3	260	1	2.25	0.0045	2.2	1.5	0.025	29.806	1211
Sand-smooth	3	260	1	2.25	0.035	2.2	1.5	0.177	29.806	167

Table 5 Increment of Absorption Well Capacity (L= 4m)

Types of land	L	T	D	H	K	H_1	K_1	Q	Q_1	DQ (%)
Clay	4	260	1	3	0.0006	3.2	1.5	0.014	51.313	3723
Silt	4	260	1	3	0.0045	3.2	1.5	0.033	51.313	1564
Sand-smooth	4	260	1	3	0.035	3.2	1.5	0.236	51.313	216

Table 6 Increment of Absorption Well Capacity (L= 5m)

Types of land	L	T	D	H	K	H_1	K_1	Q	Q_1	DQ (%)
Clay	5	260	1	3.75	0.0006	4.2	1.5	0.017	77.572	4503
Silt	5	260	1	3.75	0.0045	4.2	1.5	0.041	77.572	1892
Sand-smooth	5	260	1	3.75	0.035	4.2	1.5	0.295	77.572	262

Table 7 Increment of Absorption Well Capacity (L= 6m)

Types of land	L	T	D	H	K	H_1	K_1	Q	Q_1	DQ (%)
Clay	6	260	1	4.5	0.0006	5.2	1.5	0.021	108.347	5241
Silt	6	260	1	4.5	0.0045	5.2	1.5	0.049	108.347	2202
Sand-smooth	6	260	1	4.5	0.035	5.2	1.5	0.354	108.347	305

Table 8 Increment of Absorption Well Capacity (L= 7m)

Types of land	L	T	D	H	K	H_1	K_1	Q	Q_1	DQ (%)
Clay	7	260	1	5.25	0.0006	6.2	1.5	0.024	143.457	5949
Silt	7	260	1	5.25	0.0045	6.2	1.5	0.057	143.457	2499
Sand-smooth	7	260	1	5.25	0.035	6.2	1.5	0.413	143.457	346

Table 9 Increment of Absorption Well Capacity (L= 8m)

Types of land	L	T	D	H	K	H_1	K_1	Q	Q_1	DQ (%)
Clay	8	260	1	6	0.0006	7.2	1.5	0.028	182.758	6631
Silt	8	260	1	6	0.0045	7.2	1.5	0.066	182.758	2786
Sand-smooth	8	260	1	6	0.035	7.2	1.5	0.473	182.758	386

Table 10 Increment of Absorption Well Capacity (L= 9m)

Types of land	L	T	D	H	K	H_1	K_1	Q	Q_1	DQ (%)
Clay	9	260	1	6.75	0.0006	8.2	1.5	0.031	226.136	7293
Silt	9	260	1	6.75	0.0045	8.2	1.5	0.074	226.136	3065
Sand-smooth	9	260	1	6.75	0.035	8.2	1.5	0.532	226.136	424

4.2 Control of Groundwater Quality

4.2.1 Control of Input Quality

Due to the high solid contents (Total suspended solids (TSS) and Total Dissolved Solids (TDS)), the turbidity of surface runoff water is usually high. This high turbidity is caused by the solid materials which are carried out and suspended in the water. The other particles which are contained in the solid materials are Cd, Pb, Cu, and Zn (Research and Development Center of Water Resources, 2002). Pb is generated from road asphalt, dust particles of vehicle emission, and spilled fuel of vehicle. Cd is generated from scraps of rubber tyre, and brake fluid. Cu is generated from vehicle emission, brake canvass, and spilled fuel of vehicle. These particles have a negative impact to the human, especially for the water users (Said, N.I. 2014; Sarungallo, 2016).

Control of water quality is done by avoiding the rain water to be mixed with households and industries waste water.

4.2.2 Water Filtering in the Well

The water quality, both physical and chemistry aspects, could be improved by a combination of filter media and absorbent media. The down flow rapid sand filter is used to filter the non-dissolved material. The sand is used to filter the particles in water, then the particles are filtered and infiltrate into the filter by occupying the cavities in the sand. The materials used in down flow rapid sand filter are:

- Sand: The sand usually used is the silica sand, i.e. the sand which is found in the river, dam, and rocky waters. The diameter of sand is between 0.25 mm and 0.3 mm, while the height of sand layer is between 20 cm and 70 cm.
- Gravel: The gravel used is the local gravel, which is usually used for bridge and building constructions. The gravel is usually found in the large river area with the rocky swift water. The diameter of gravel is between 10bmm and 30 mm, while the height of gravel layer is between 20 cm and 40 cm.

4.2.3 The Limitation of Modified Absorption Well

The limitations of modified absorption well are:

- The storage space volume of the well which could be utilized as the water catchment is only 75% (25% is used for the filter media)
- The quality of filter that has been tested is the one which is used to control the rain water that has not been contaminated yet.
- It needs the water containers and filters above the surface of land, thus it requires a large land area.

5. Conclusion

In this work, the absorption well is modified to increase the capacity. The modification of absorption well increases the capacity of 7000% for clay land, 3000% for silt land, and 400% for smooth sand. The result of filter test for controlling the water quality is very convinced when the infiltrated water has not been contaminated yet.

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