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SYSTEM OF INFILTRATION PIPE (IP-SYSTEM) AS ARTIFICIAL RECHANGE FOR LAND WITH SEMI-PERMEABLE LAYER OF TOP SOILS

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ABSTRACT

Deterioration of groundwater both quantity and quality is necessary to be addressed through appropriate policies based settings, and they are organized involving various government agencies and, through the means of technical engineering (Danaryanto et al., 2005). Degradation of groundwater can cause various effects, among others: the intrusion of seawater, reduced soil fertility, increase the air temperature and interrupt the cycle of seasons, as well as various other impacts (Darwis et al., 2012). The purpose of this research did discover the shape and type of artificial recharge, to fill the shallow groundwater aquifer with a layer of topsoil which is semi-permeable. This research was a Pre-Experimental Designs with a form of One-Shot Case Study, which was conducted to test the effectiveness of IP-system. Type Pre-Experimental Designs selected in carrying out technical research, due to the implementation of IP-system with a new innovation, that the likely presence of other variables that influence the rise in groundwater level as the dependent variable. While the form of One-Shot Case Study selected as the independent variable observing only one, namely the number of pipes, and the dependent variable was also only one, namely the increase in the groundwater table. Chart-1 to Chart-3, suggests that the number of points added directly affects the volume augmentation occurring. 3 formations of said point being tested, it appears that the relationship between the number of points added to the increase in the level of groundwater is a linear relationship (see Chart 4). This is because the number of formations being tested is still limited to 3 formation, so the optimum point of the number of points added cannot be imaged.Chart-5 to Chart-8, illustrates that the thickness of a semi-permeable layer on topsoil, greatly affect the effectiveness of groundwater recharge. This phenomenon was also experienced in the process of natural recharge, and it can be seen in the increase in groundwater levels in wells control. On the application of IP-system, semi-permeable layer on topsoil, seepage will cause a reduction in cross-section in the pipeline. The relationship between the thickness of the layer of semi-permeable to the groundwater recharge volume is illustrated in Chart 9. Meanwhile, Chart 10, showing the relationship between a depth of rechanging zones with the increase of groundwater levels in test wells.

KEYWORDS: *Rechange, Groundwater Rechange, Artificial Rechange, Semi-permeable, Top Soil*

INTRODUCTION

In the period of nearly eight decades since the early 1950s, many countries began to use groundwater as a water irrigation and industry. This is what has led to the emergence of various problems in the availability of groundwater, caused by the rate of return on groundwater that is under the rate of groundwater extraction. Excessive groundwater extraction will have an impact on such things as; decreasing the volume of surface water (lakes and rivers), increased soil salinity, the occurrence of subsidence, and the threat of crisis springs. The last report of Ngwa Groundwater Association (2010) in Margat et al. (2013), stating that today groundwater as a water source that is important in supporting human life and food security for 1.2 to 1.5 billion people in Africa and Asia. It became one of the causes of groundwater extraction is increasing every year.

Deterioration of groundwater both quantity and quality, it is necessary to be addressed through appropriate policies based settings, and they are organized involving various government agencies and, through the means of technical engineering (Danaryanto et al., 2005). Groundwater management ,in general, is an attempt to manage the relationship between the various determinants factor of the groundwater resources, such as vegetation, rechange area, infiltration patterns, and human resources are and we reactivities in the regional groundwater basin. Human activities are often only aimed at temporary interest to obtain economic benefits, without regard to the safety of the environment that is needed to create the conditions of sustainable development (Darwis et al., 2015).

The presence of water in the soil layers connected together, so that over-exploitation in an area will spend the reserves of groundwater beneath the other areas in the zone of the same basin. Groundwater basin is a region bounded by the limits of hydro, home to all the events hydrogeological like pengimbuhan process stream, and the release of groundwater takes place (Danaryanto et al. 2007). Degradation of groundwater can cause various effects, among others: the intrusion of seawater, reduced soil fertility, increase the air temperature and interrupt the cycle of seasons, as well as various other impacts (Darwis et al., 2012).

Utilization of groundwater is stewardship efforts which include; provision, use, exploitation, development, maintenance, and protection of groundwater optimally in order to function effectively and efficiently. Many people who use groundwater for various purposes and interests, ranging from people who use it as a source of clean water, farmers who use it as irrigation water, to the business people who exploit them as industrial water. But legally in Indonesia is currently no specific regulations governing groundwater conservation oriented balance of groundwater, especially in the area of groundwater retrieval in large volumes (irrigation and industrial). This is due to lack of research done on the level of degradation of groundwater occur, as well as the formulation of the implications of the lack of scientific research results in support of the formulation of the regulation. Research and development of artificial recharge techniques, can make a positive contribution to seek impartial groundwater recharge with the use of groundwater by humans.

KabupatenTakalar is one area that predominantly works as farmers, geologically the area is very good for agriculture because it lies in the shallow groundwater cukungan region with huge potential. Almost all the lowland areas in Takalar, ranging from the coast to the foothills region, is included in a zone of shallow groundwater basins. Therefore, since the early 1980s, the Department of Agriculture KabupatenTakalar introduce groundwater irrigation system, with the direct pumping of shallow groundwater, which is in farmers' fields, to be used as irrigation water for crops and rice crops.

But geographically, the zone of groundwater exploitation in Takalar quite vulnerable, as well the exploitation of farmers, very close to the beach area, so the risk of the occurrence of seawater intrusion into inland zones. Topsoil layer, which consists of clay deposits less permeable (semi-permeable), so that the natural recharge is relatively small, and cause an imbalance between the volume of water taken by the volume of natural recharge occurs. Both of these make the area should be the target of an intensive and sustainable of groundwater conservation. So in Takalar groundwater degradation caused by two dominant factors; (1) The high groundwater extraction to meet the needs of agriculture, and do throughout the year; (2) Characteristics of topsoil layers that are semi-permeable, so that the natural recharge capacity is small. Both of these factors lead to groundwater recharge volume is not balanced with the volume of extraction of groundwater by farmers throughout the year.

Therefore we need new innovations that can help increase the volume of shallow groundwater recharge in the area. There are several techniques of artificial recharge to the shallow groundwater aquifer that is applied during this time, such Infiltration Wells system and Biopori system. But both systems, ineffective use of land with a layer of topsoil which is semi-permeable. The author with the teamwork, try applying artificial recharge system, by using a longer pipeline, to penetrate the layer of topsoil up into the permeable layer. Innovation writers produced an artificial recharge system, which is devoted to land with a layer of topsoil which is semi-permeable, which we call Infiltration Pipe System, abbreviated to IP-system. Basic development system affixes IP-system are:

- Condition of top soil layer on the research sites, semi-permeable so it takes affixes tool, which can drain the water into the porous soil layers. IP-system can meet these needs because it can achieve a penetration to a depth of 6 to 8 m from the surface.
- Rechange of IP-system, not reducing the area of arable land, as well as in the implementation of Infiltration Wells system.
- Rechange of IP-system with an empty pipe cavity, can hold water with volume greater than the bin owned by Biopori system.
- Rechange of IP-system, can function longer, because the pipe is not filled with garbage. The consideration for organic soil from the decomposition of waste is potentially closing the infiltration hole in the rechange pipes, and cleaning material that closes in infiltration hole is quite difficult.

RESEARCH METHODS

This research was conducted to find the form or the type of artificial recharge, which is effective for filling the shallow groundwater aquifer with a layer of topsoil which is semi-permeable.

This research is a Pre-Experimental Designs with a form of One-Shot Case Study, which was conducted to test the applicated effectiveness of IP-system. Type Pre-Experimental Designs selected in carrying out technical research, due to the implementation of IP-system is a new innovation that the likely presence of other variables that influence to the increase of groundwater level as the dependent variable. While the form of One-Shot Case Study selected as the independent variable is observed only one, namely the number of pipes, and the dependent variable was also only one, namely the increase in the groundwater table.

To find the number of IP-system effectiveness, then in field testing, made two wells, ie wells surrounding IP-system mounted as test wells, and wells without IP-system as control wells. Control wells located as far as 300 m of artificial recharge zones installation, so that affixes IP-system does not affect the groundwater level in the control wells.

A difference in groundwater level rise that occurred in the test wells, the groundwater level rise that occurs in control wells, is the contribution of artificial recharge made with IP-system.

To determine the effect of the number of points added to the rechange volume, then made three formations with a different number of rechange points, each with 4 pipes, pipe 8, and 12 pipes on any test wells. In this test, chosen location with topsoil layer thickness is the same, with a thickness of 3 m. The length of the rechange pipe on the application of IP-system is the same, that added 6 m long pipe. The increase in groundwater level in the three formations tested, gives results that explain the effect of the number of points added to the volume augmentation.

Meanwhile, to determine the influence of the layer thickness semi-permeable recharge volume, then tested at 4 locations with topsoil of different thickness, each at a thickness of 2.50 m; 3.00 m; 3.50 m; and 4.00 m. In this test, made the same number of rechange points, each at a many as 4 rechange points, while the length of rechange pipe used is the same, namely along a 6 m.

The source of water recharge in this study, is the runoff of rainwater. Therefore, the observations should be made during the rainy season cycle. The increase in groundwater level, observed from the beginning of the rainy season to the dry season, because in the dry season, farmers returned to pumping of groundwater. The result is expected to be input is contributive to both the development of science in the conservation of groundwater, as well as to be input to the local government, in drafting regulations on the use of groundwater. It is expected the continuity of the existence of groundwater can be guaranteed, thus ensuring the sustainability and sustainable utilization of groundwater.

RESEARCH DESIGN

Placement of the control wells should be considered groundwater flow in the horizontal direction, so that the control wells were not affected by infiltration of artificial recharge to the test wells. To determine the effect of distance infiltration of artificial recharge, empirically author uses simplified methods as follows :

If the width of the zone of infiltration of artificial recharge (W) = 4 x 10 m = 40 m (corresponding formations of the recharge point). A difference in water level in the test wells with control wells (ΔH) = 0.50 m (maximum condition in test wells). Subsurface soil permeability (K) = 10-3 cm / sec (silty sand). Rainfall intensity (i) = 300 mm / month (maximum rainfall in the study site). Saturated zone thickness (b) = 3 m (bed rock depth of groundwater level). A minimum distance between the test wells and control wells, in order not to be affected by infiltration of artificial recharge, can be calculated:

$$K = 10^{-3}\ \text{cm/sec} = \frac{(30 day.24 hour.60 \min x 60 \sec)}{1000 x 100 cm} m / month$$

= 25,92 m/month

i = 300 mm/month = 0,03 m/month.

T = K.b = 25,92 m/month x 3 m = 77,76 m2/month

Then :

$$Lc = \Delta H\left(\frac{2T}{iW}\right)+\frac{W}{4}$$

$$Lc = 0{,}5m\left(\frac{2x77{,}76m^2 / month}{0{,}03m / month.40m}\right)+\frac{40m}{4}$$

$$Lc = 0{,}5m\left(\frac{155{,}52m^2 / month}{1{,}2m^2 / month}\right)+10m = (0{,}5x129{,}6)+10 = 74{,}8m.$$

For the safety of the rechange effect of IP-system, then the control wells on each test site, placed at a distance of 300 m from the point of test wells.

In the same way, the distance between the pipes on each IP-system formation, with the difference in water level between on the rechange pipes (ΔH_{max} = 4cm = 0.04 m), the wide catchment area of the pipe W = 10 m, the thickness of the saturated zone affordable pipe = 1 m. Then the distance between the rechange pipes (L_{IPs}) can be calculated as follows:

T = K.b = 25,92 m/bulan x 1 m = 25,92 m2/bulan

$$L_{IPs} = \Delta H\left(\frac{2T}{iW}\right)+\frac{W}{4}$$

$$L_{IPs} = 0{,}04m\left(\frac{2x25{,}92m^2 / month}{0{,}03m / month.10m}\right)+\frac{10m}{4}$$

$$L_{IPs} = 0{,}04m\left(\frac{51{,}84m^2 / month}{0{,}3m^2 / month}\right)+2{,}5m = (0{,}04x172{,}8)+2{,}5 = 9{,}41m.$$

Taken distance between pipe infiltration (pipe spacing) = 10 m.

The third point formation added, are tested to obtain the effectiveness of IP-system, and also to discover the effect of the recharge pipes number to the rechange volume, as seen in the figure below:

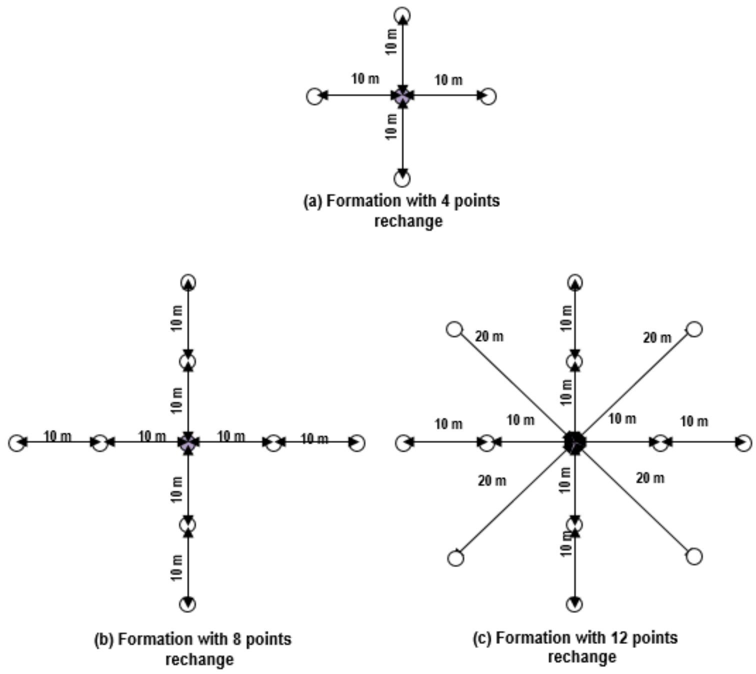

Figure 1: RechangePoints Formation of Installed Around the Well Test

RESEARCH FINDING

Tests performed in this study are: (1) testing with rechange pipes number is different; (2) testing with the thickness of semi-permeable layers is different. Observations of both types of testing are presented in chart as follows:

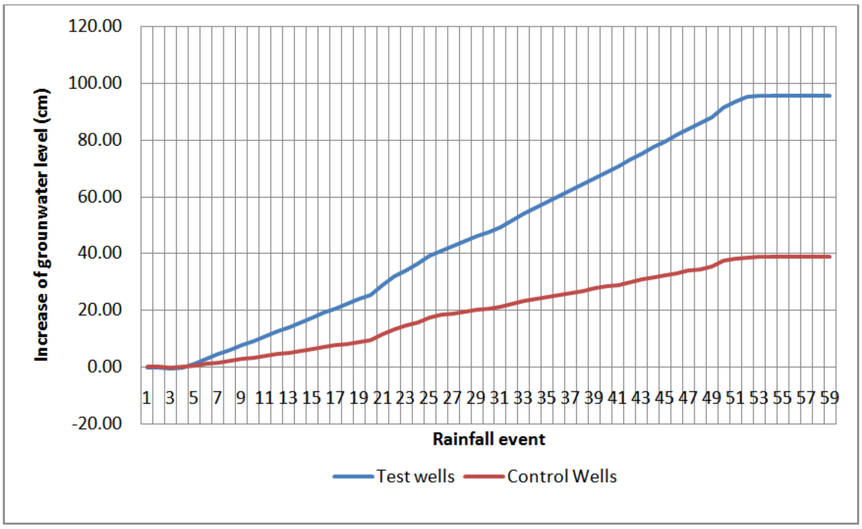

Figure 2: Increase of Groundwater Level in Test Wells & Control Wells (Rechange pipa = 4 point)

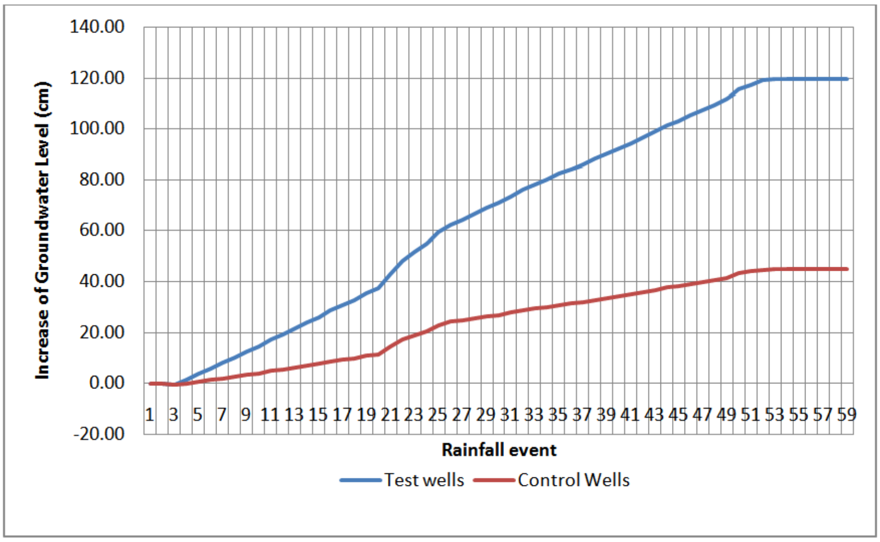

Figure 3: Increase of Groundwater Level in Test Wells & Control Wells (Rechange pipe = 8 point)

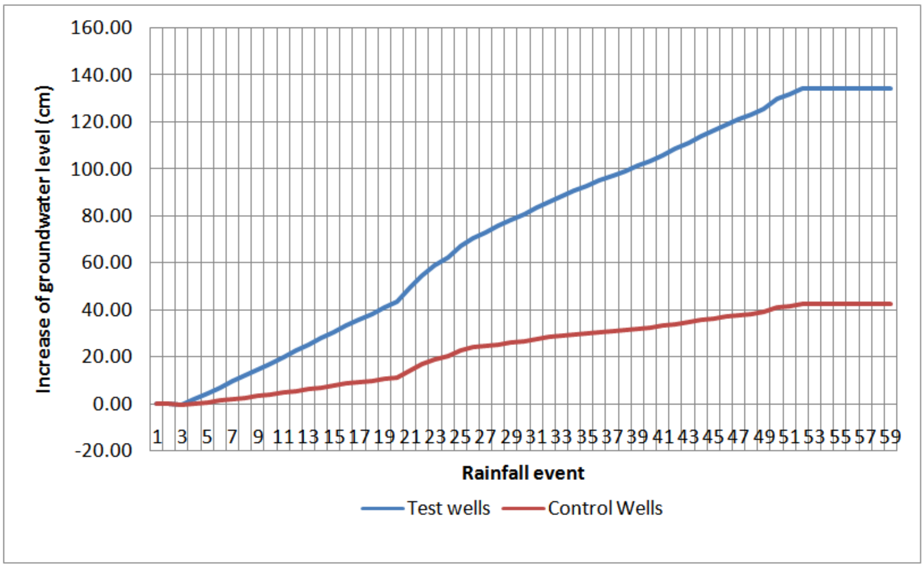

Figure 4: Increase of Groundwater Level in Test Wells & Control Wells (Rechange pipe = 12 point)

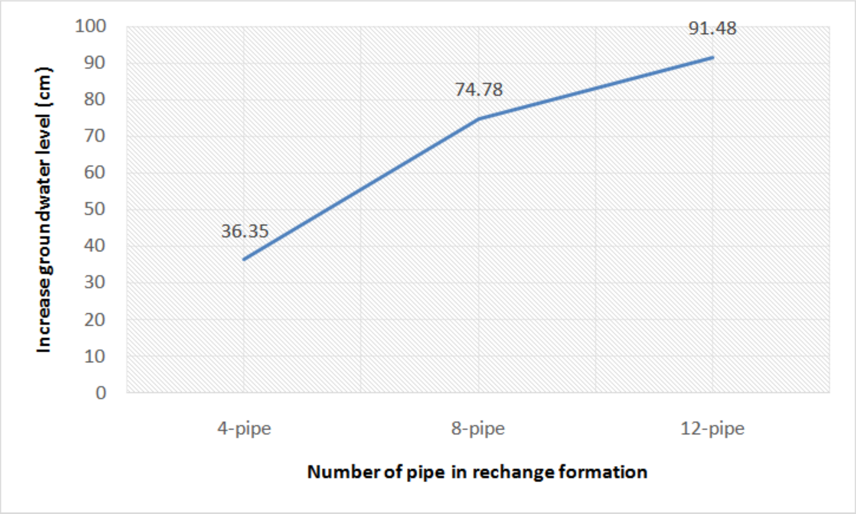

Figure 5: Correlation of Pipe Number with Increase of Groundwater Level

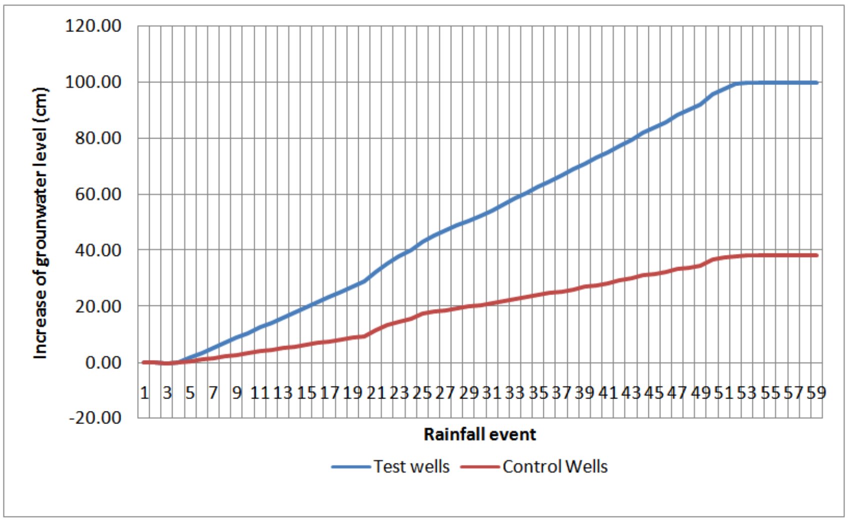

Figure 6: Increase of Groundwater Level in Test Wells & Control Wells (Thickness of Semi-Permeable Layer = 2,50 m)

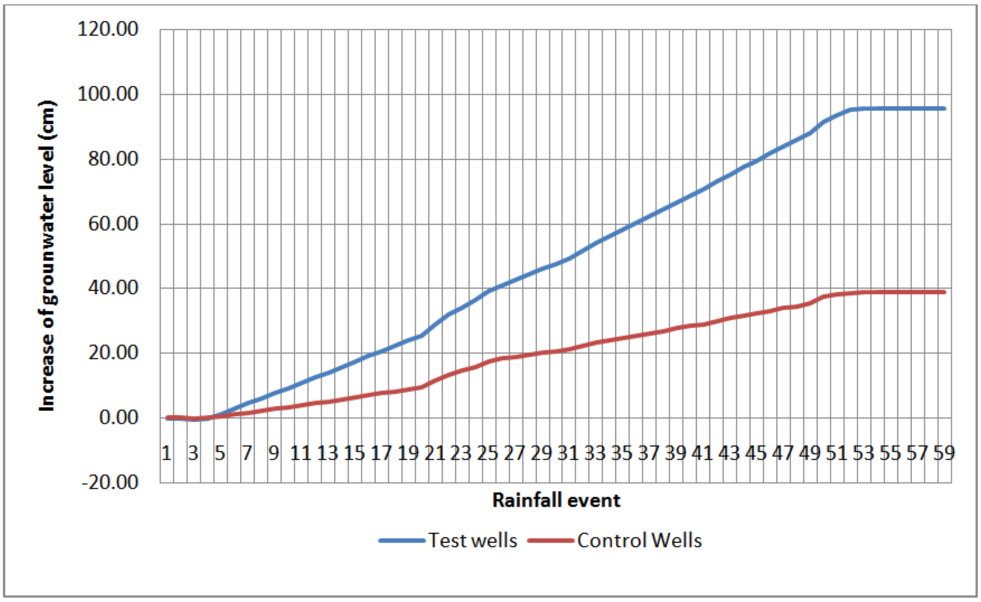

Figure 7: Increase of Groundwater Level in Test Wells & Control Wells (Thickness of Semi-Permeable Layer = 3,00 m)

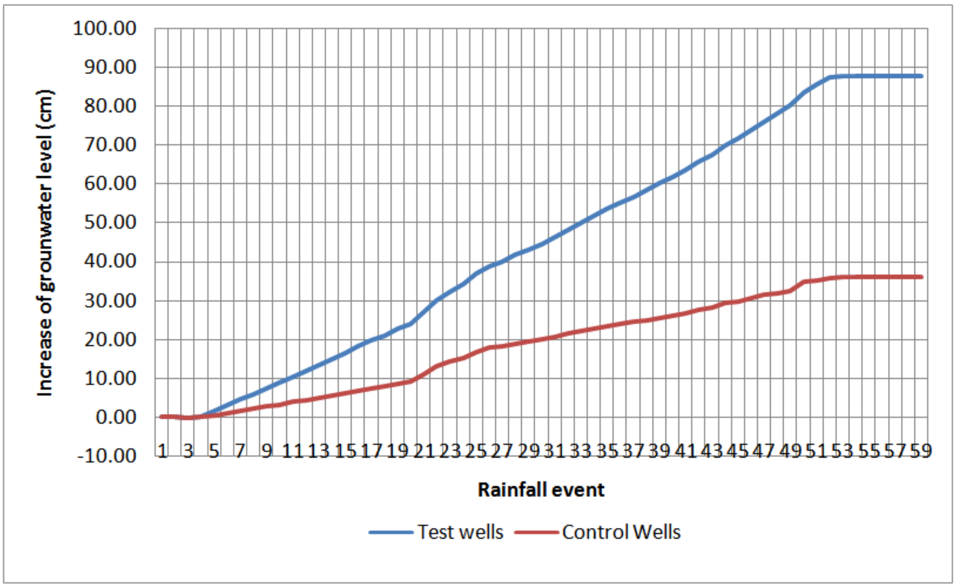

Figure 8: Increase of Groundwater Level in Test Wells & Control Wells (Thickness of Semi-Permeable Layer = 3,50 m)

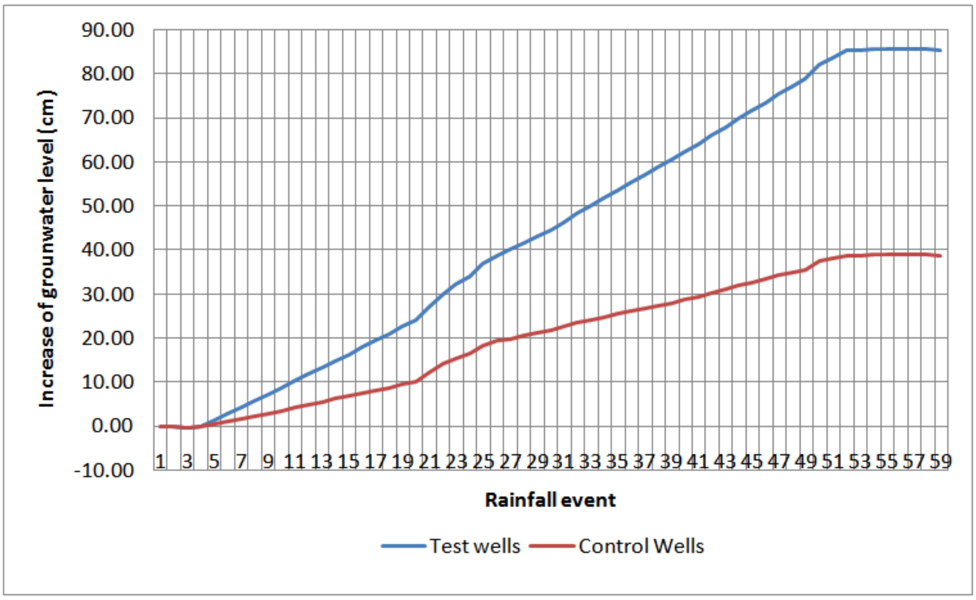

Figure 9: Increase of Groundwater Level in Test Wells & Control Wells (Thickness of Semi-Permeable Layer = 4,00 m)

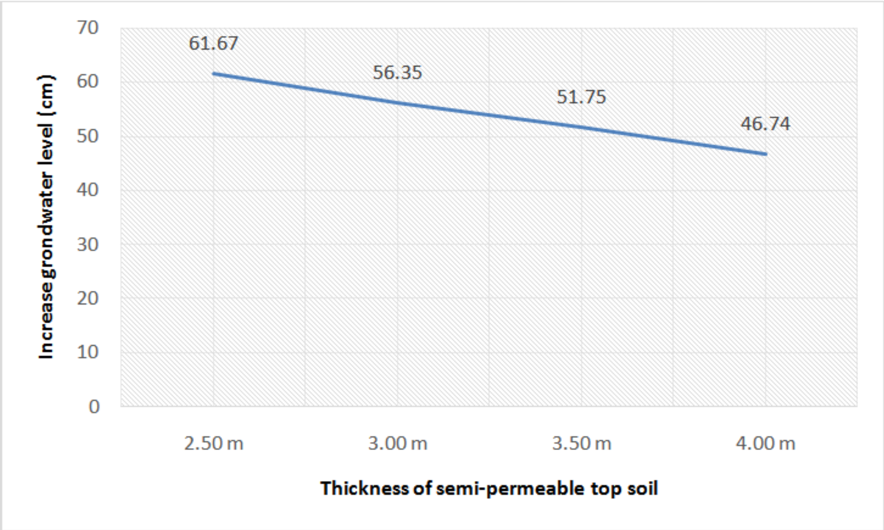

Figure 10: Correlation of Top Soil Thickness with Increase Groun water Level

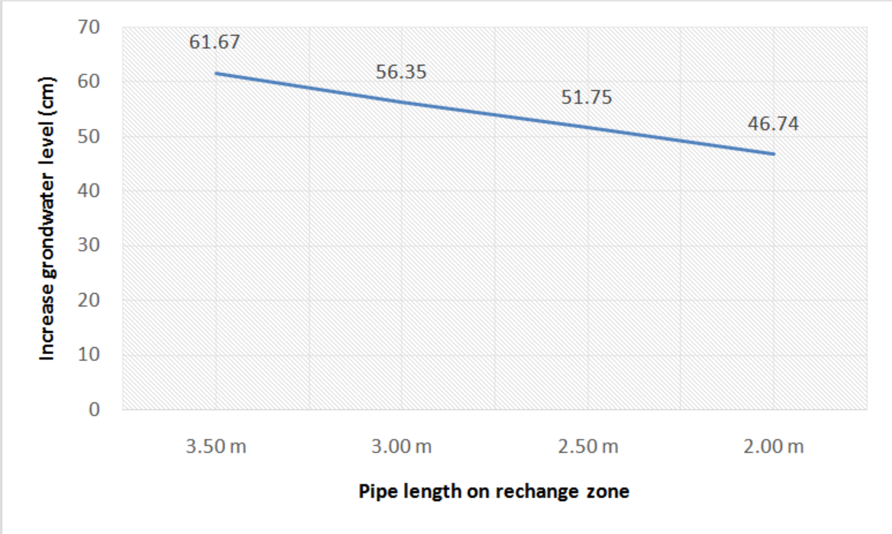

Figure 11: Correlation of Pipe Length on Rechange Zone with Increase Grounwater Level

DISCUSSIONS

All the above chart, showing indications that artificial recharge with IP-system quite effectively applied to restore the condition of shallow groundwater in the soil with a layer of topsoil which is semi-permeable. This gives great hope to become one of the alternative methods for conservation of groundwater in the lowlands, which generally have a layer of topsoil which is semi-permeable.

With the formation of four rechange points in five test wells were observed in this study, there were indications that the application of the IP system as a means of artificial recharge fairly effectively applied, the soil with a layer of topsoil which is semi-permeable. It can be seen from the results of a rechange during one cycle of the rainy season, rising groundwater level on four rechange points of the fifth formation tested, ranged from 46.74 cm to 61.67 cm. Even on the test wells using an 8 rechange point, rising groundwater level reached 74.78 cm, and test wells with 12 rechange points, the groundwater level rose to 85.76 cm.

Problems encountered in the implementation of IP-system, is the prevention of sludge material fills the space pipe, so that no infiltration pits closed, so that the installation can affix to work longer. The development of this system in the future, need a way to prevent the ingress of mud into the pipe added.

Analysis complementary to Chart-1 to Chart-3, suggests that the number of rechange points directly affects the rechange volume occurring. Of the three formations tested, it appears that the relationship between the number of rechange points to the increase in the level of groundwater is a linear relationship (see Chart 4). This is because the number of formations being tested is still limited to three formations, so that the optimum point of the number of rechange points can-not be imaged. To determine the optimum number of rechange points, then further testing needs to be done with the addition of a rechange point.

Of Chart-5 to Chart-8, it was shown that the thickness of the semi-permeable layer on topsoil, greatly affect the effectiveness of the rechange installation. This phenomenon was also experienced in the process of natural recharge. It can be seen in the increase in the level of groundwater in control wells, which are relatively small. In the application of

IP-system, semi-permeable layer thickness will cause a reduction in cross-sectional area of groundwater seepage on the rechange pipe. The relationship between the thickness of the layer of semi-permeable to the groundwater recharge volume is illustrated in Chart 9.

From the results of this test can be made on the relation between the depth of infiltration zone with rechange volume that occurs. Because in this test, the length of the pipe used to affix the same four test site, which is along the 6 m, the depth of the infiltration zone to each formation can be calculated as follows:

- Formation with topsoil layer thickness of 2.50 m, the depth of said zone is 3.50 m.
- formations with topsoil layer thickness of 3.00 m, the depth of said zone is 3.00 m.
- Formation with topsoil layer thickness of 3.50 m, the depth of said zone is 2.50 m.
- Formation with topsoil layer thickness of 4.00 m, the depth of said zone is 2.00 m.
- Chart 10 shows the relationship between the depth of the zone added to the rise in groundwater levels in test wells.

CONCLUSIONS

From this research, the authors can conclude several things, among others:

- Artificial rechange by IP-system, effectively applied to land with topsoil layers that are semi-permeable.
- The number of rechange points affecting to rechange volume that occur, and rate of increase in the level of groundwater is also influenced by the intensity of rainfall.
- The thickness of the semi-permeable layer on topsoil, affecting groundwater recharge effectiveness, both in the test wells that implement IP-system, as well as the control wells were not affected by IP-system.

SUGGESTIONS

Based on these results, the authors suggest several things, among others:

- Research needs to continue, especially with the use of rechange point more. These suggestions are intended to determine the optimum number of rechange point, to give effect to an increase in the volume of groundwater recharge.
- In subsequent studies, it is also necessary to design a system on the intake of rechange pipe, as well as a method of cleaning the silt at the bottom of the rechange pipe. Both of these authors suggest that because of the age of IP-system functional, highly dependent on the accuracy of the application of these two things.
- In the application of IP-system, the penetration depth of the pipe is determined by the thickness of a semi-permeable layer on topsoil, because the pipe to drain water into the soil, only portions of a layer of porous soil.

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