J. Basic. Appl. Sci. Res., 2(12)13033-13039, 2012
© 2012, TextRoad Publication
ISSN 2090-4304
Journal of Basic and Applied Scientific Research
www.textroad.com

Injection Well: One of the Technologies for Decreasing Surface Run-off and Saving Water as the Anticipation of Global Climate Change

(Case Study in Penanggungan Village, Malang City, East Java of Indonesia)

Mohammad Bisri

Department of Water Recources, Faculty of Engineering, University of Brawijaya, Malang, East Java of Indonesia

ABSTRACT

Flood, inundation, and drought are some disasters that frequently happened in Indonesia. These disasters are not only as non predicted natural occurrance but they are frequently occured due to the human life behaviour like crowded residential, land use function change to residence, less capacity of drainage system, etc. This study intended to introduce and to apply one of the technologies for reducing surface run-off and saving water. Location of study was in Penanggungan village as one of the crowded residences in Malang City, East Java of Indonesia. Expansion of drainage system was not possible there, so it was tried to design well injection for solving flood disaster. The methodology included to design injection well in study location. Result can be used as the anticipation of global climate change which causes many disaster especially flood and inundation.
Keywords: injection well, surface run-off, saving water

INTRODUCTION

Someone know that water is one of the resources which is very nacessary for human life, so that water supply has to be kept continuously. Management of water demand and conservation are the keys towards the sustainable use of any water resources [1][2]. Hydrological approaches have granted great some contributions to the planning of hydraulic structure and it is not easy to understand the run-off process thoroughly [3][4]. The land cover change from previous into impervious area will give an effect on the run-off depth increasing and diminish natural recharge into groundwater storage. This condition will rise the surface run-off that will cause pond or flood [5]. Implementation of water resource and economic development and human activities have altered the run-off generation [6][7]. If the quantity of rainfall is higher than infiltration rate, it will cause surface run-off and if the infiltration rate reachs the maximal value, water will begin to fill the depression in the soil surface and then flows as surface run-off. Many factors will influence surface run-off such as intensity, duration, and distribution of rainfall. Based on the spatially land use characteristic in watershed scale, the development of an integrated technology that can simply simulate the land use changes and their impacts on the infiltration process is crucial to the water resource and land use management [8].

Population growth will give an impact to the development of a city. The increasing of population can be meaned as the expansion of residential area number. This condition will change the soil condition which is as opened land and has the characteristic of unsaturated water in the beginning, but in the end it becomes as a closed land area with hard layer over it and has the characteristic of saturated water. This condition will cause the rainfall can not break into soil and it will cause flooding or inundation on the rainy season and the drainage channel capacity is not able to store the discharge [9]. Flood, inundation, and drought disasters are the common news that is hearing in Indonesia, especially flood or inundation was happened starting from macro environment like regency or city such as Jakarta City, Bandung Regency, Semarang City, and Wasior City ntil the micro environment like village such as Penanggungan Village of Malang City and the others. The main reason of flood or inundation includes extreme rainfall due to the climate change, area function is changing from opened to closed land so there is less water injection, very crowded population so there was no blank land except only for residential. Effort of the government as well as the society by developing drainage channel was not fully success. This problem is more real in the village environment with crowded population like in RW IV environment, Penanggungan Village, Klojen District of Malang City. This environment has frequently been flooding or inundation in every low to high rain. This condition has happended since 2000 until now. The effort of local society was to deepen the available main drainage channel (small river), but it has not been success because the sedimentation was so high so the shallowing was happaned continuosly. Therefore, the channel elevation was higher than available road. In addition, the channel capacity was less from year to year because of the society conciousness was low such as there was built house over the channel and the channel has been narrowed for bedroom, etc.

***Corresponding Author:** Mohammad Bisri, Department of Water Resources, Faculty of Engineering, University of Brawijaya, Malang, East Java of Indonesia. Email: mbisri@ub.ac.id; mohammadbisri@yahoo.com

Based on the reason as above, it was needed accurate technological research for overcoming this problem. One of the technologies is developing injection well which can decrease though have lost the flood or inundation as well as water conservation (water conservation = saving water) which environment friendly due to be adapted in climate change.

MATERIALS AND METHODS

This study was conducted in Jalan Kampung Rukun Tetangga 3 (RT 3) and Rukun Tetangga 4 (RT 4) Rukun Warga IV (RW IV), Penanggulangan Village, Klojen District, Malang City, East Java Province of Indonesia. The consideration on selection of location was the technology of drainage system was not allowed to be applied here because there was no area for widening the channel, the available channel was very narrow and it was located in the house side. In addition, the main drainage system outlet was higher that inundation area. Therefore, injection well was the accurate technology to be applied here.

Design of injection well

Injection well is defined simply as drill well which has circle or rectangle shape with the certain depth. Injection well is functioned for storing and breaking rainfall from soil surface through building roof as well as road and yard. Injection well is the opposition of drinking water well. Injection well is a hole for entering water into soil, but drinking water well is functioned for rising groundwater to the surface. Therefore, the construction and depth is different. Some usages of injection well are as follow [10]:

1. It is as flood or surface run-off control.
   One of the injection well functions is as the effort to pressure flood. The usage of injection well is able to decrease surface run-off so there is no more surface run-off inundation that causing flood. The quantity of surface run-off which can be decreased through injection well is based on the volume and number of injection well.
2. It is as groundwater conservation
   The other function of injection well is to improve groundwater condition or shallowing injection water surface. It is hoped the rainfall is more broken into soil and becomes as water reserve in soil. Saving water in the soil will be able to be used through drill well or water source. It is suitable with the general function of reservoir which is used for storage and raising water level [11].
3. The other function is as an effort that is adapted to global climate change. If an area experiences extreem climate change which there is normal rainfall in the beginning of certain months, so by being available injection well, it is hoped can be as water demand reserve.

The technique of injection well is an old enough technology in entering water into soil, but the technique of injection well that is commonly made is shallow penetration well. Shallow penetration well has the average depth of 1 metre. The effectivity of injection well is low enough for decreasing flood or inundation.

Based on the data analysis and field condition and by attending the technical rule of design, so the development of injection well is nacessary to be carried out by modifying the depth and dimension due to the demand. The dimension of injection well can be modified by the range of 30 cm until 140 cm and until 200 m of depth. It is based on the local soil geological structure, groundwater surface, and how much the inundation discharge will be reductioned. Location and number of injection well is very depended on the local condition. Number of injection well in the location of study is five by the modification of injection well diametre of 1.5 m (D = 1.5 m) and depth of 4 m (H = 4 m) . Location map and detail design was presented as in Figure 1.

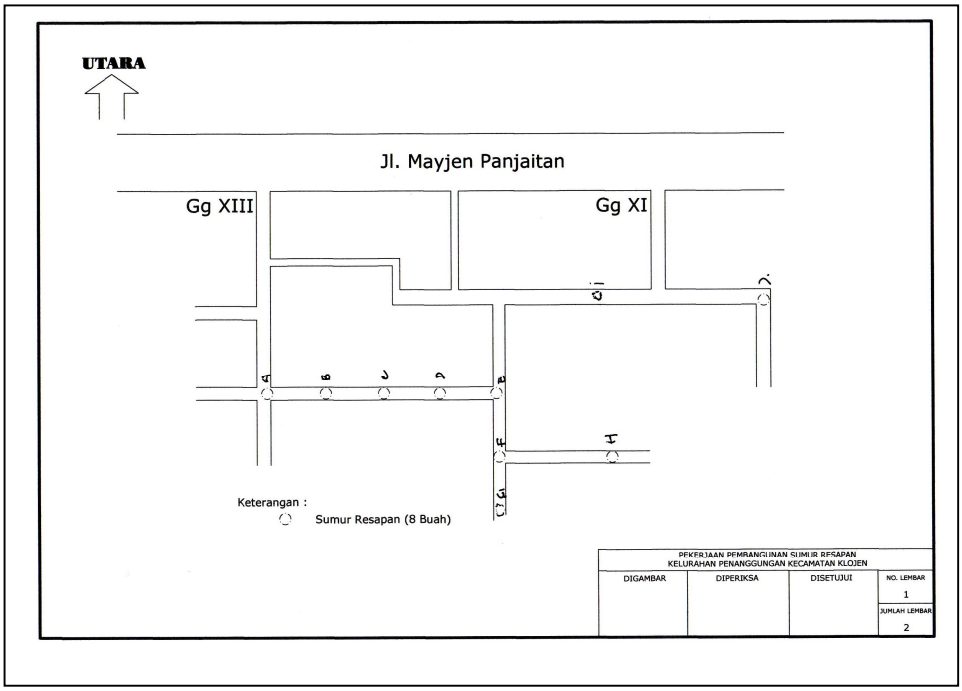

Figure 1 Location Design map of injection well point A, B, C, D, and E (five)

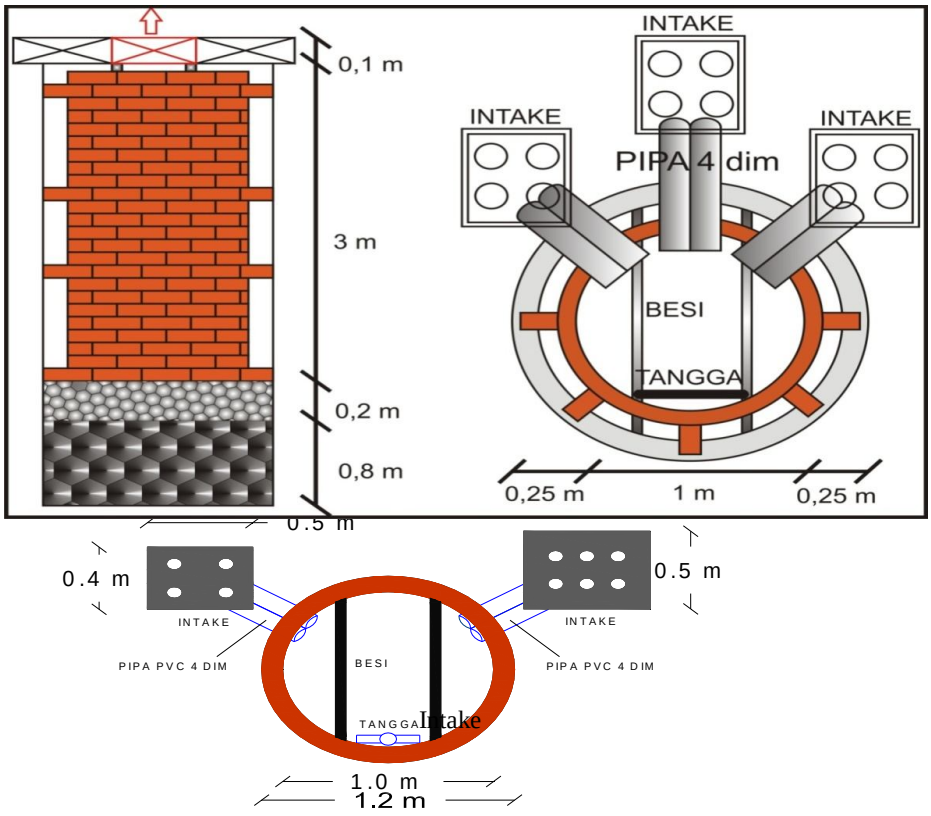

Figure 2 Detail of Modification Injection Well in RT4 RW IV

RESULTS AND DISCUSSION

Design result of injection well in the study location was presented as in Figfure 3.

Determination of location

There were some considerations in determining the location of a injection well such as the position of groundwater surface in the location and the condition of geology was not in the water saturated layer and it was better if the soil layer had low permeability. Based on the some considerations as above, the selected location for developing injection well was located along Jalan Kampung RT 04 RW IV, Penanggulangan Village with the number of five (Figure 4).

Development of injection well

After finishing of digging well, then it was continued by entering mangoe stone and gravel as the foundation and the next action was installing the stones in the well wall.

Figure 4 Finishing work. (a) Installing stairs. (b) Making well cover

After finishing the construction work, the next work was building the control storage as the water inlet which will enter to the well. By the end, the injection well has been finishing as in Figure5.

Figure 5 Ready Injection Well

Analysis of run-off discharge

Run-off discharge which entered through the road in RT 04 RW IV came from house run-off and the road itself. The formula of run-off discharge which came from the houses in water flow area of RT 04 RW IV was rational equation as follow:

$$Q= 0,278 \cdot C \cdot I \cdot A = 0,278 \times 0,8 \times 20,806 \times 0,005551 = 0,0256 \ m^3/s$$

The result of run-off discharge from the houses and the road itself was presented as in Table 1 and 2 below.

Table 1 Run-off discharge from houses

Return period	Discharge of area I	Discharge of area II	Discharge of area III	Total of run-off discharge
	(m^2/hour)	(m^2/hour)	(m^2/hour)	(m^2/hour)
2	0.0210	0.0257	0.0151	0.0617
5	0.0262	0.0321	0.0189	0.0772
10	0.0301	0.0368	0.0216	0.0886
25	0.0354	0.0433	0.0255	0.1042

Source: result of analysis

Table 2 Run-off discharge from road

Return period	Discharge I	Discharge II	Discharge III	Run-off discharge total of the road
	(m^3/hour)	(m^3/hour)	(m^3/hour)	(m^3/hour)
2	0.0281	0.0312	0.0208	0.0802
5	0.0352	0.0391	0.0260	0.1003
10	0.0403	0.0448	0.0299	0.1150
25	0.0474	0.0527	0.0351	0.1353

Source: result of analysis

Reduction analysis of run-off discharge due to the available injection well

Reduction analysis of run-off in the location of injection well was as follow:
Q_{2th} = 0.0491 m^3/s (the total of as in Table 1 and 2), and area number (A) = 54 m^2

So the depth of water run-off wuth the return period of 2 years was as follow:

$H = (Q_{2th} \times 360)/A$
$= (0.0491 \times 360)/54$
$= 0.327$ m = 32 cm

The run-off depth after there was injection well
$Q_{run\text{-}off}$ = 0,0386m^3/s (Table 3.), and area number (A) = 54 m^2

$H = (Q_2 \times 360)/A$
$= (0.0386 \times 360)/54$
$= 0.257$ m = 25 cm

Before developing injection well, the run-off depth of injection well was 32 cm for the return period of 2 years and after developing injection well, the run-off depth became 25 cm. However, there has occured the run-off depth decreasing of 7 cm with one injection well. For the five injection wells, the average of decreasing along the road of RT 04 RW IV was 14 cm. Therefore, for missing the whole inundation, it was needed the increasing of about 10 injection wells. The analysis result for some return periods was presented as in Table 2 below.

Table 3 Run-off depth in Location-I

Return period	Total Discharge (Q)	Depth of well	Run-off coeff	Vol of well	Q of well	Time of filling well	Q of run-off in area	Vol of Run-off In area	Depth of Run-off
(year)	(m^3/hour)	(m)		(m^3)	(m^3/s)	(hour)	(m^3/s)	(m^3)	(m)
2	0.0491	4	0.9	1.14	0.0105	5.0077	0.0386	13.9042	0.2575
5	0.0614	4	0.9	1.14	0.0105	5.0064	0.0509	18.3355	0.3395
10	0.0704	4	0.9	1.14	0.0105	5.0064	0.0509	21.5811	0.3997
25	0.0828	4	0.9	1.14	0.0105	5.0064	0.0723	26.0445	0.4823

Source: analysis result

CONCLUSION

Injection well is one of the technologies for decreasing surface run-off and saving water as the anticipation of climate change. This technology is effective enough for decreasing surface run-off or inundation and saving water if there is occured climate change mainlt in long dry season. The effectiveness is indicated by the capacity of inundation reduction in the study location in about of 40%. For decreasing the inundation until the lowest point (0%), it is needed the additional injection wells of ten.

REFERENCES

1. Limantara, Lily Montarcih, 2010, Optimization of Water Needs at Kepanjen Dam and Sengguruh Dam, East Java, Indonesia, *International Journal of Academic Research*, Volume 2, Issue 5
2. Mohammad Bisri. 2010. *Water* Conservation Mapping at Kali Sumpil Watershed, East Java Indonesia. *International Journal of Academic Research*. Vol. 2 No. 5, p. 156-158
3. Tung, B.Z.; Yeh, Y. K.; Chia, K, and Chuang, J. Y., 1987, Storm Resampling for Uncertainty Analysis of a Multiple-Storm Unit Hydrograph, *Journal of Hydrology* 194: 66-384
4. Limantara, Lily Montarcih. 2010. Callibration of Synthetic Unit Hydrograph: Case Study in Brantas Hulu Sub-Watershed, Province East Java Indonesia. *International Journal of Academic Research*. Vol. 2 No. 5, p. 146-148
5. Chow. Ven Te; David R., Maidment & Larry W., Mays, 1988, Applied Hydrology, Prentice Hall, New York
6. Hoybey, Jan and Rosbjerg, Dan, 1999, Effect of Input and Parameter Uncertainties in Rainfall-Runoff Simulations, *Journal of Hydrology Engineering*, Vol. 4, No. 3, pp. 214-223
7. Nandakumar, N; and Mein, R.G., 1997. Uncertainty in Rainfall-Runoff Model Simulations and The Implications For Predicting The Hydrologic Effects Of Land Use Change. *Journal of Hydrology*, 192: 211-232.
8. Yu, PL, Nien; MH; Pei, JW; Chen, FW and Verburg, PH, 2005, Impacts of Land Use Charge Change Scenarios on Hydrology and Land Use Patterns on the Wu-Tu Watershed in Northern Taiwan, Environmental Informatics Archives, Vol. 3, pp 14-23, *International Society for Environmental Information Sciences*
9. Mohammad Bisri. 2010. Depth And Distribution Analysis of surface Runoff Spatially at Kali Sumpil Watershed, East Java Indonesia. *International Journal of Academic Research*. Vol. 2 No. 5, p. 184-187
10. Arsyad, Sitanala. 2000. *Konservasi Tanah dan Air*. Bogor : IPB Press.
11. Mohammad Bisri. 2011. Estimation of Remaining Usage Age at Sutami Reservoir Using sediment analysis, East Java Indonesia. *International Journal of Academic Research*, Vol. 3 No. 3, p. 497-500