Scholars Journal of Engineering and Technology (SJET) **ISSN 2321-435X (Online)**
Sch. J. Eng. Tech., 2014; 2(4B):597-603 **ISSN 2347-9523 (Print)**
©Scholars Academic and Scientific Publisher
(An International Publisher for Academic and Scientific Resources)
www.saspublisher.com

Research Article

Providing Water Irrigation Source in Polluted Watershed through Riverbank Filtration (RBF) (Cihideung River, Cisadane Watershed)

Diana Rahayu*, RohSantoso Budi Waspodo, M. Yanuar J. Purwanto
Department of Civil and Environmental Engineering, Bogor Agricultural University (IPB), Bogor, Indonesia

***Corresponding author**
Diana Rahayu
Email: diana.namina@gmail.com

Abstract: : Land use change in upstream from forests into farms and settlements, as well as a wide range of industries throughout the Cihideung River of Cisadane Watershed ultimately need got great attention from various parties. The river is thought to have been subjected to contamination as a result the inclusion of various types waste from variety activities in all watersheds. The RBF (Riverbank Filter) is the process where surface water undergoes infiltration to sub surface flow and then extracted from the well. The RBF is usually takes the location on the banks of the River (riverbank). Wells made in the land of the hydraulics in aluvial soil will be connected on the river. This allows the hidraulic gradient so that surface water is forced to flow through the river bed and banks of the river. By this process of RBF concentration of physics contaminant, chemistry and biology which are among surface water and subsurface water can be reduced. The aim of this research is to study the characteristics of RBF, knowing the characteristic of the flow of RBF by pumping test, and get information data of the quality of water through RBF (River Bank filtration) in the riverbank Cisadane.
Keywords: Clean water, Providing, Riverbank ltration, Technology, Watersheed

INTRODUCTION

Riverbank Filtration (RBF) is river water naturally percolates through the ground into aquifers (which are layers of sand and gravel that contain water underground) during high-flow conditions in humid regions. During these percolation processes, potential contaminants present in river water are filtered and attenuated. If there are no other contaminants present in the aquifer or if the respective contaminants are present at lower concentrations, the quality of water in the aquifer can be higher quality than that found in the river [1]. RBF is water treatment process that makes use of surface water that has naturally infiltrated into groundwater through the riverbed or bank and is recovered by pumping well [2].

Surface waters are often contaminated with microbial pathogens as a result of discharges of municipal wastewater effluents, as well as runoff of livestock wastes and from fields receiving manure. Under certain conditions, these pathogens may be effectively removed by underground passage of surface water [3]. Through RBF, microbial pathogens, fecal indicator organisms, and other surrogates are removed by contact with aquifer materials. The removal process is most efficient when groundwater velocity is slow and when the aquifer is made of granular materials with open pore space for water flow around the grains [2].

Riverbank filtration (RBF) is one of the representative alluvial aquifer applications in water intake and treatment. Many countries use RBF to intake source water for treating contaminated surface water, for example, 50% of potable water supplies in the Slovak Republic, 45% in Hungary, 16% in Germany and 5% in the Netherlands are obtained from the riverbank filtration system [3, 4, 5]. An alluvial aquifer is a precious natural resource that, because of the interactions between groundwater and surface water, can be important for water use and water management. Alluvial aquifers have the capability of bank storage, which can moderate the effects of flooding and drought. Infiltration of river water to the aquifer cleans the water through physical and microbiological processes. So, the proper use of an alluvial aquifer can benefit water use and water management [6]. In comparison to most groundwater sources, alluvial aquifers that are hydraulically connected to rivers are typically easier to exploit (shallow) and more highly productive [7]. According to Jaramillo [8] by pumping wells located in an alluvial plain hydraulically connected to a river it is possible to generate a hydraulic gradient so that surface water is forced to flow through the bed and the banks of the river (Fig. 1).

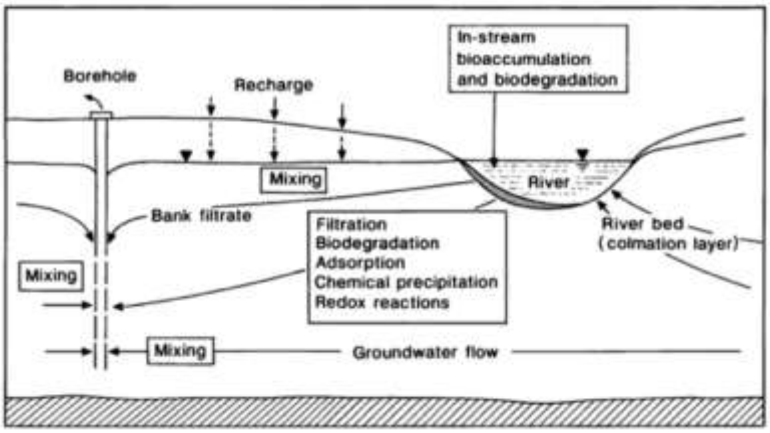

Fig. 1: Basic scheme of riverbank filtration and main attenuation processes

MATERIALS AND METHODS

Materials and Instruments

The materials and instruments used are Piezo Meter, Geolistrik (ABEM DC Sas Z-2000), Drill, Pipe 4 inch-length 8 meters, Avo meter (Z1000), and Pumping, TDS sample test using APHA, ed. 22, 2012, 2540-C methode, Phosphate sample test using APHA, ed. 22, 2012, 4500-P-E method, Nitrate sample test using APHA, ed. 22, 2012, 4500-NO3-E, Permenganate sample test using SNI 06-6989/22-2004.

Data Analysis

Research also through some process: Geolistric, Pumping Test, and Water Quality testing. For more detail, the scheme process of this research shown in Fig. 2.

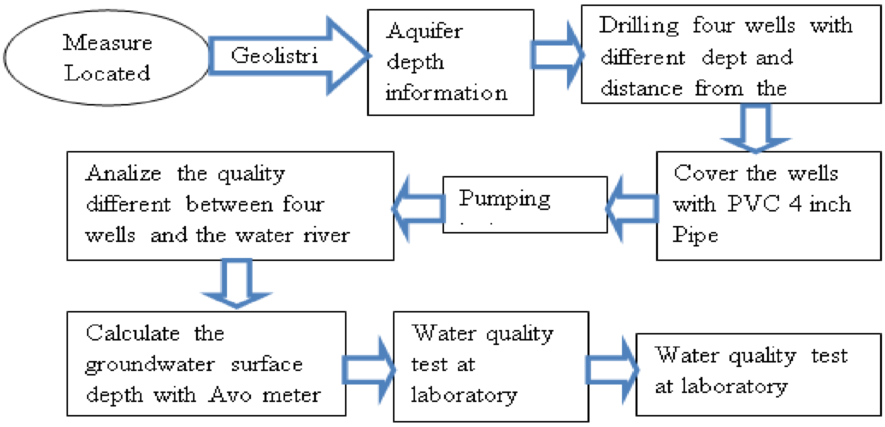

Fig. 2: Scheme to measure the water quality of Riverbak filtration

Analysis of Geolistric Test

It is done by doing a geolistric test obtained from the four points of data retrieval in research Cihideung River of Cisadane Watershed. Results of measurements of current and potential difference for each different electrode distance then can be derived variation of resistivity values of each layer under the measuring point in ohm-m. Based on the value of electric current (I) to be injected and the potential difference (ΔV) caused, the magnitude of the resistivity (ρ) can be calculated with the following formula:

$$\rho = K\frac{\Delta V}{I} \quad \text{...} \quad (1)$$

Where; ρ: Resistivity, ΔV: Potential difference, I : Value of electric current, K: Geometry factor

Geometry factor is the magnitude correction of the difference located point of observation. Therefore, value of this geometry factor is determined by the type of measurement configuration used. The measurement configuration corresponds with how put potential electrode and the electrode current at the time of measurement [9].

Analysis of Pumping Test

This analysis is performed to determine the characteristics of the aquifer such as geohydrology groundwater flow direction, filling the wells, and the dominant values of hydraulic conductivity. The methods used as hydraulic conductivity of the aquifer value prediction, a method[10].

$$K = \frac{0.732Q}{(h1+h2)(s1-s2)}\log\frac{r2}{r1} \quad \text{........................} \quad (2)$$

Where; K: Hydraulic conductivity, Q: Pumping discharge, s : Declines advance groundwater in wells, h:

High advance of layer impermeable water, r : Radius of wells

Analysis Declines of Water Pollutant

To know the decline water quality in the river water and wells RBF 1, RBF 2, RBF 3, and RBF 4 formula of multiple regression model was used:

$$Y = \beta 0 + \beta 1X1i + ... + \beta nXni \qquad (3)$$

Where; i = 1, 2, n.... (Number of observation)

RESULTS AND DISCUSSION

Geolistric Test

The measurement of geolistric is necessary to know the high spread of the aquifer and groundwater at the site of advance research. This measurement technique with predictable material resistivity value distribution under the surface in the lateral direction is better and faster, because by using this method the depth, thickness and spread a layer of rocks can be detected [9]. Known types of aquifers can be found in the research with value resistivity 15-330 Ohm metres. The aquifer is composed of layers which like sand, clay, and breksi. More detail shown in table 1.

Table 2, can known aquifers contained in site with a value of resistivity 15-330 Ohm meters. The aquifer composed of layers of sand, clay, and breksi.

Wells of RBF Construction

Collector wells located on the banks in a certain distance from the river create a pressure head difference between the river and the aquifer, which induces the water from the river to flow downward through the porous media into the pumping wells. By applying this system of water supply extraction, two different water resources (surface and shallow groundwater) are in conjunctive use [11]. The range between collector wells of RBF taken three meters of each and different depth aims to know the difference value of pollutants contained in water as presented on table 3.

Table 1: Result Analysis Measurement of Geolistrik

No.	Geolistrik Prediction Point	Depth (m)	Litologi Prediction
1	GL 1	0 - 3	Cover soil
		3 - 13	sand (unconfined aquifer)
		13 - 15.45	Clay sand
		15.5 - 30.2	Breksi
		30.2 - ∞	clay
2	GL 2	0 - 8	Cover soil
		8 - 40.11	Sand (unconfined aquifer)
		40.11 - 50	Breksi
		50 - 58.99	Clay
		59 - ∞	Clay sand (confined aquifer)
3	GL 3	0 - 2	Cover soil
		2 - 6.24	Sand (unconfined aquifer)
		6.24 - 9.87	Clay sand
		9.87 - ∞	Sand (confined aquifer)
4		0 - 2	Cover soil
		2 - 13.48	sand (unconfined aquifer)
		13.48 - 27	Sand
		27 - ∞	Breksi

Tabel 2: Value resistivity interpretation

Resistivity	Litologi
< 10	clay
10 – 20	Rock clay
20 – 35	Sand clay
35-50	Sand

Table 3: Depth and range of wells

No.	Wells name	Depth (m)	Range of wells with River (m)
1	SG	2	1
2	RBF 1	3	4
3	RBF 2	5	7
4	RBF 3	7	10
5	RBF 4	8	13

After design of RBF is made on a location geolistric measurement has done, the next step was the drilling. As already mentioned before, every well of RBF designed with different depths and distances. Each well used PVC diameter 4 inch for casing wells.

Pumping Test

Methods used in this research is constant method, by doing the pumping continuously until getting a constant discharge on wells that have been set. The Data obtained are then analyzed by method calculation of Theis and for aquifer is unconfined. Hydraulic Conductivity values of calculation results on site research is 2,32 m/day and system of flow in site is influent, where the surface water fill ground water and if the surface water has polluted it will be harmful to water wells exist around the river. Evidenced by high advance decline curve water and affix advance groundwater as presented in Fig. 3.

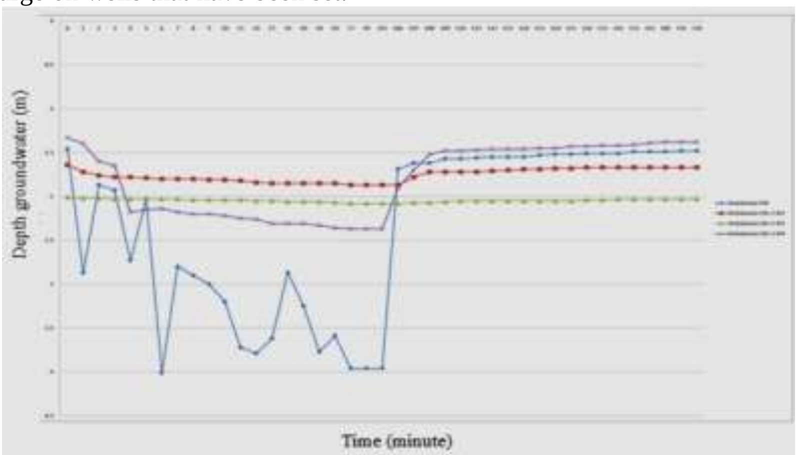

Fig. 3: Curve adding and decline ground water in wells of RBF

The blue line is well of RBF 1 decline and increased advance groundwater quickly (fig. 3). The range well of RBF 1 is 4 metres from the river. While the green line is well of RBF 4 with the range 13-meter from the River, high advance of water water unchanged. It shows the system of flow on site is influent.

The Calculated Result of Water River quality in Cihideung River

The assessment basically conducted by comparing the values parameters of water quality from the real sample retrieval results then tested in laboratory with quality raw water allocation according to prevailing in Indonesia namely refers to regulation No. 82 of 2001 about Pengelolaan Kualitas Air dan Pengendalian Pencemaran Air [12]. One of the water utilization of rivers in Watersheds of Cisadane is for agricultural, although in some areas there are still many who use it for everyday necessities like shower, wash, and etc. Based on the regulation, this research as a comparison used raw water quality class IV water allocation, which is used as agricultural and recreational areas. In table 4 are presented the result of water quality laboratory test in Cihidung River.

Table 4: Quality of Water Cihideung River, Cisadane Watershed Upstream Segment

			P.5360-6	Standard of Water Quality *)			
Parameter	unit	LD		Class of water			
			5.1	I	II	III	IV
TDS +	Mg/L	10	60	1000	1000	1000	2000
Total Fosfat +	Mg/L	0.005	0.234	0.2	0.2	1	5
Nitrat (NO_3-N)	Mg/L	0.001	1.462	10	10	20	20
NilaiPermanganat (TOM)	mg$KMnO_4$/L	2.53	40.45	(-)	(-)	(-)	(-)

+: Accredited parameters; *): PP No. 82 year 2001 [12] about *Pengelolaan Kualitas Air dan Pengendalian Pencemaran Air*; LD: Limited detection

Data sample wells water that has been tested from a lab test retrieved water quality as it is presented in table 4. Results of data from laboratory test shows the value of TDS, N, P, and TOM decreases with distance from the wells River. More far the collector well from river the value of TDS, N, P, and TOM more decrease.

Table 4.Water quality in collector well of RBF 1, RBF

Parameters	Unit	Wells of RBF					Standard of water quality*)
		SG	RBF 1	RBF 2	RBF 3	RBF 4	
TDS	mg/L	64	54	46	42	40	2000
Nitrat (NO_3-N)	mg/L	1.195	0.206	0.389	1.728	2.021	20
Total Fosfat +	mg/L	0.114	0.053	0.043	0.038	0.023	5
TOM	mg$KMnO_4$/L	35.39	34.13	33.50	32.86	32.23	-

+: Accredited parameters; *): PP No. 82 year 2001 about *Pengelolaan Kualitas Air dan Pengendalian Pencemaran Air*; LD: Limited detection

Total Dissolved Solid (TDS)

The curve value of TDS in Cihideung River, Cisadane Watersheds upper segment are presented in Fig. 5. The quality of the raw water quality of class IV based on PP No. 82 year 2001 [12] for a total maximum of dissolved solids 2000 mg/l. total value of dissolved solids (TDS) in Cihideung Rivers and collector wells of RBF is meet the quality standard required.

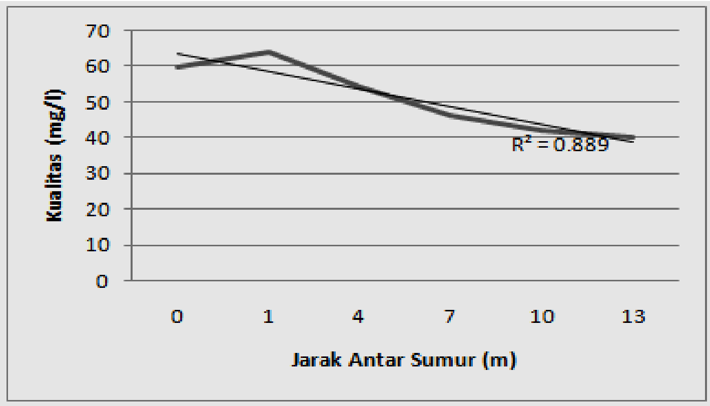

Fig. 5: Value of TDS in Cihideung River and collector wells of RBF

Nitrate

Nitrate is one element of a chemical compound that is colorless, odorless, tasteless diatomic gas, and most of the standard conditions. Nitrate (NO_3) is one of the Nitrogen that can be utilized by the plant is particularly high levels of crop cultivation. On plants that grow actively the nitric absoption by plant roots will transported quickly to leaves and follow the flow of transpiration. If the plant lacked Nitrate will arthritis color leaf yellowing, production decreased, even it caused death of plant. Whereas if the excess nitrate plants will cause a bitter taste as in cucumber, leaf lush vegetative growth and rapid, and cause toxicity in plants [13]. Here are presented the curve decline in Nitrate in Cihideungriver, Cisadane Watershed upper segment in Fig. 6.

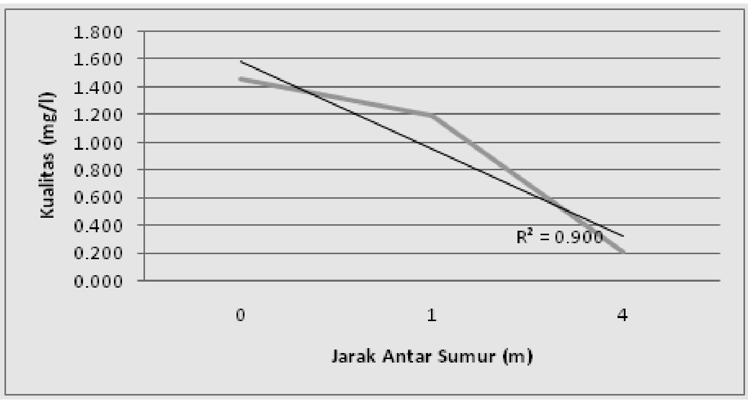

Fig. 6: Value of Nitrate (N-NO3) in Cihideung river, SG and collector well of RBF 1

Fig. 6 shows the value of Nitrate which decreased quite significantly. Decrease in value occurs at a distance only up to collector well with the range 4 m from river or well of RBF 1. Because the lab test results showed the collector well of RBF 2, RBF 3, and RBF 4, rising in the value of parameters Nitrate as presented in Fig. 7.

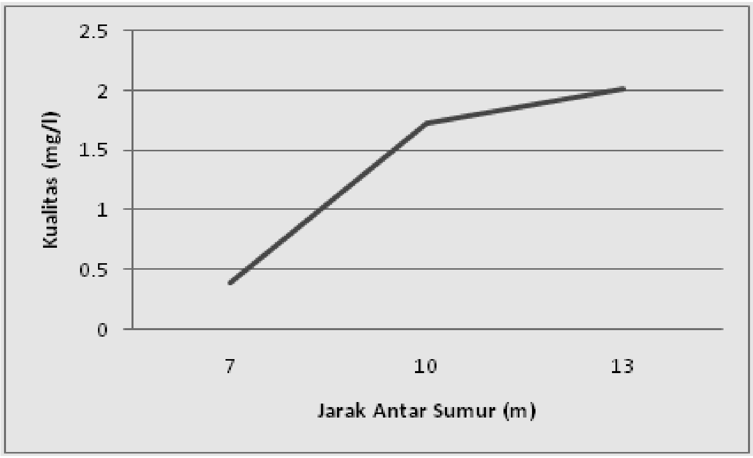

Fig. 7.Value of Nitrate in collector wells of RBF 2, RBF 3, and RBF 4.

When compared to the raw quality of PP No. 82 year 2001 [12], which requires the content, is 20 mg/l of nitrate. Although collector wells of RBF 2, RBF 3, and RBF 4 the value goes up but for raw water class IV value of Nitrate in Cihideung river and groundwater in collector Well of the RBF 1, RBF 2, RBF 3, and RBF 4 were under the required quality standard.

Phosphate

Phosphate is a form of phosphorus that can be utilized by plants and is an essential element for plants. Phosphorus plays an important role in the various processes, such as photosynthesis, respiration, and assimilation. Phosphorus deficiency will lead to the slow growth in plants, fruit flavored sour, thick rind and pale color of the leaves. But if the excess Phosphate plants will experience a slower growth, leaf yellowing, and antagonistic effects can lead to nutrient deficiencies or other. In Fig. 8 the curve presented a decrease in value of phosphate in Cihideung river of Cisadane Watershed and groundwater in collector wells of RBF 1, RBF 2, RBF 3, RBF 4.

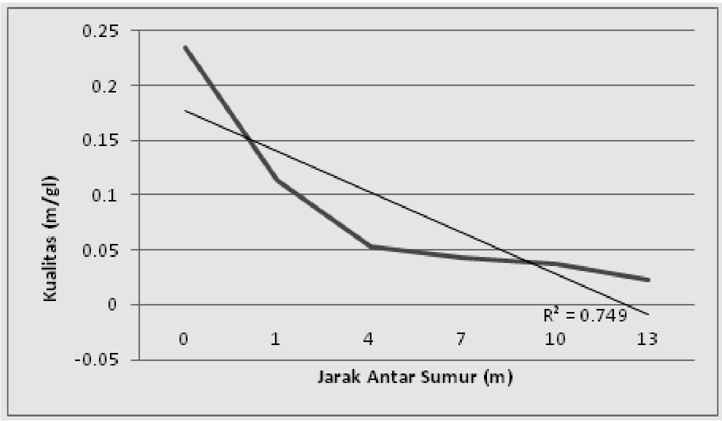

Fig. 8: Value of Phosphate in Cihideung river and collector wells of RBF

Thus can be inferred, the waters of the Cihideung River and ground water in collector wells of RBF, there is no phosphatic pollution since the value of existing exhibit no greater than 5 mg / l.

Permanganate

Permanganate was a form of potassium. Potassium is an important third element after N and P that serves to increase photosynthesis, form a stalk that more robust, strengthen rooting and as immune plant against disease. If a plant lacking potassium, plants will quickly withered and roots brittle, whereas too much containing potassium plants will be containing a poison and not better if consumed [14] . In this fig. 9 served a curve decrease value of Permanganate in the Cihideung river of Cisadane watershed and groundwater in collector wells of RBF 1, RBF 2, RBF 3, and RBF 4.

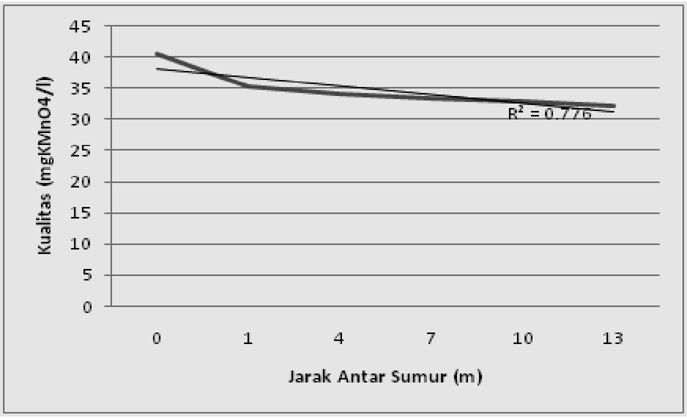

Fig. 9: Value of Permanganate in Cihideung river and collector wells of RBF

Permanganate in the raw quality of PP No. 8 year 2001[12] is not mentioned. Despite that these compounds can be categorized is very dangerous when water containing these compounds, because if too many plants contain these compounds can cause intoxication on the consumption.

CONCLUSION

The conclusion of this research isthe depths of aquifer at site of the research is in a depth of 3-6 m. Type of aquifer contained in research with a value of 15 - 2013 with resistivity 330 Ohm meters. The aquifer composed layers of sand, clay, sandy soil and breksi. The value of conductivity calculation result 2.32 m/day with type of aquifer flow curve of decline influent advance groundwater. Water quality Parameters tested (N, P, TOM, and TDS) intended for agricultural irrigation water or have a value under the raw quality of PP No. 82 year 2001 [12] on 4th water class. Thus the river water upstream segment in Cihideungriver - Cisadane can be used as a source of irrigation water.

REFFERENCES

1. Ray C, Melin G, Linsky RB; Riverbank Filtration Improving Source-Water Quality. London: Kluwer Academic Publishers. 2002.
2. Schijven J, Berger P, Miettinen I; Removal of Pathogens, Surrogates, Indicators, and Toxin Using Riverbank Filtration. Dutch: National Institute of Public Health and Environment. 2002.
3. Tufenkji N, Ryan JN, Elimelech M; The promise of bank filtration. Environmental Science and Technology Journal, 2002; 36 (21): 422A–428A.
4. Grischek T, Schoenheinz D, Ray C; Siting and design issues for riverbank filtration schemes, The Netherlands. Kluwer Academic Publishers, 2002; 291-302.
5. Srisuk K; Groundwater resources development by riverbank filtration technology in thailand. International Journal of Environmental and Rural Development, 2012;3(1):155.
6. Kim HS, Kim JY; High-resolution profiling of alluvial aquifer in potential riverbank filtration site by use of combining CMP refraction and reflection seismic methods. Journal of Applied Geophysics, 2008; 66:1-14.
7. Bouwer EJ; Riverbank Filtration The American Experience.The Johns Hopkins University: Amerika. 2003.
8. Jaramillo M; Riverbank filtration: an efficient and economical drinking-water treatment technology.Dyna, year 2011; 79(171):148-149.
9. Dewandel B, Lachassagne P, Wyns R, Marechal JC, Krishnamurthy NS; A generalized 3-D geological and hydrogeological conceptual model of granite aquifers controlled by single or multiphase weathering. Journal of Hydrology, 2006;330(1-2): 260-284.
10. Maréchala JC, Vouillamoz JM, Kumar MSM, Dewandel B;Estimating aquifer thickness using multiple pumping tests. Hydrogeology Journal, 2010; 18(8):1787-1796
11. Doussan C, Ledoux E, Detay M; River-groundwater exchanges, bank filtration, and groundwater quality. Journal of Environmental Quality, 1998;27(6):1418–1427.
12. PeraturanPemerintah No. 82 tahun 2001 tentang Pengelolaan Kualitas Air dan Pengendalian Pencemaran Air.
13. Akbar J; Unsur Nitrogen dan PerannyaTerhadap PertumbuhanTanaman. 2010. Available from http://www.wordpress.com/2010/03/23/unsur-nitrogen-dan-perannya-terhadap-pertumbuhan-tanaman.
14. Jannah UF; Pengaruh Bahan Penyerap Larutan Kalium Permanganat Terhadap Sumur Simpan Pisang Raja Bulu. Skripsi. Departemen Agronomidan Hortikultura. InstitutPertanian Bogor. 2008..