Revisiting hydrostratigraphy in Bandung-Soreang Groundwater Basin: a well-logs re-analysis

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Abstract. An attempt to revisit the hydro-stratigraphy of Bandung-Soreang Groundwater Basin (BSGB) has been done based on 111 well-logging training dataset. Transformation of resistivity values from well-log data to relative porosity and permeability used Chillingarian approach and Baker-Hughes Atlas of log responses. Then boundary marker was drawn to separated different aquifer layers. Simple linear regression equations were derived from the transformation: (a) tuf layers: != −0.0023!+2.5619, != −63.514!+167.38, !=22.912 !+238.78; (b) clay layers: != −0.0181 !+2.6281, != −61.842 !+163.91, !=5.1202 !−11.503; (c) sand layers: != −0.0078 !+ 2.5992, != −60.75 !+161.02, !=394.35 !−2156.8. Based on the new aquifer taxonomy, three hydro-stratigraphic units (HSU) and six sub HSU have been defined. UHs 1 is the top layer of the BSGB, located at elevation above 650 masl. It has three sub HSU that consists of tuf and sand. The permeability (K) values of this unit range from 0,0014 to 0.1 m per day. HSU-2 with two sub HSU consists of tuf and sand, located at elevation from 625 to 650 masl. This unit has K values from 0.1 to 6 m per day. HSU-3, which is located at elevation from 500 to 625 masl, has only one sub HSU. This unit consists of tuf, sand, and volcanic breccias, with K values from 0.3 to 7.1 m per day. This models, however, are still needed more test to new dataset.

BACKGROUND

The groundwater condition in Bandung-Soreang Groundwater Basin (BSGwB) has been degraded over time, as indicated by the decline of water level and decrease of water quality. The decline of water level has influenced the overall groundwater flow in the basin. With the existing condition the authority found difficulties to manage the aquifer, based on the values of hydraulic properties from pumping test result. Problems have aroused with the biased pumping test result since there have already many wells near by tested well. The objective of this paper is to make a new aquifer classification, based on well log data, instead of solely on pumping test result.

In this paper, we will use the concept of hydrostratigraphic unit (HSU). Definisi UHs adalah tubuh batuan atau suatu kerangka geologi yang memiliki pelamparan lateral dan vertikal tertentu yang memiliki karakter hidrogeologi yang sama atau mirip (Maxey, 1964). Sumber lainnya memberikan kriteria yang terukur dan diketahui (nilai permeabilitas ataupun porositasnya) yang kemudian dipakai sebagai dasar untuk menetapkan nomenklatur hidrostratigrafi (Seaber, 2002). Berdasarkan definisi tersebut maka satu unit batuan bisa dibagi menjadi dua UHs yang berbeda. Sebaliknya pula satu UHs dapat tersusun oleh dua satuan batuan yang berbeda.

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REGIONAL SETTING

The regional geological and hydrogeological background of this paper is based on several previous studies by Sudjatmiko (1972), Silitonga (1973), Sutrisno (1983), Koesoemadinata dan Hartono (1981), Priowirjanto and Marsudi (1995), Geyh (1990), Matahelumasi and Wahyudin (2009). Maps and sections are shown in Fig. 1. The aquifer system in the area are:

1. Porous system: Kosambi Formation (Fm) (Q1) and Cibeureum Formasi (Qyd);
2. Porous and fractured system: Cikapundung Fm (Qvt) and Cikidang Fm (Qvu); 3. Fractured system: limestone of Rajamandala Fm (Tmb).

METHODS

The basic idea is to convert the resistivity value to density then to relative permeability. Analysis was done to well log dataset from 111 drill holes. These wells that was treated as training dataset, have been chosen based on the completeness of the data. Some of the wells are currently still serving as water source, and some others have been abandoned. All the data have been digitized and six correlated sections have been generated: two sections in eastwest direction (I-J and E-F) and four sections in north-south direction (A-B, C-D, G-H, dan K-L), as seen in Fig. 1. Previous lithological classifications was calibrated to build a new classification. This calibration was needed as there were different kinds of lithological name under similar description. Then we used the Chilingarian and BakerHughes chart to produce relative porosity and permeability values (Salem and Chilingarian, 1999; Alger, 1966; and Serra, 1984). To calibrate the resulting relative porosity and permeability values, we used pumping test data. On this step, multiple regression technique was also applied to generate regression equation based on Bivand and Pebesma (2013) and Sarkar (2008). Outlier were temporarily eliminated to produce good equations. Based on the equations, boundaries of HSU were drawn and correlated to generate fence diagram. Complete and full size figures are available at the following repository (www.researchgate.net/profile/dasapta_erwin).

DATA AND ANALYSIS

A new litology classification is generated from the dataset, as presented in Table 1 (see column 1). Grounded by the classification, the following are linear regression equations from multiple regression fitting:

1. tuf layers: != −0.0023!+2.5619, != −63.514!+167.38, !=22.912!+238.78
2. clay layers: != −0.0181!+2.6281, != −61.842!+163.91, !=5.1202!−11.503
3. sand layers: != −0.0078!+2.5992, != −60.75!+161.02, !=394.35!−2156.8

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Table 1 shows the complete results. Six HSU's are pulled out from the data cloud. HSU 1 consists of 3 Sub HSU's. This unit is composed of intercalation of tuff and sand, located in the elevation from 637 to 750 masl with a thickness ranges from 61 to 113 m. The relative permeability (! or K) sorts between 0.0014 to 0.1 m/day. There are three confining (aquiclude) clay layers with K values of 0.001 to 0.002 m/day, and volcanic breccia as aquitard with K values of 0.0011 to 0.036 m/day.

The 2nd HSU is composed of two sub HSU's. This unit is located at 585 to 689 masl with thickness ranges from 32 to 102 m. Referring to the six sections, this unit forms an east-west oriented valley-fill pattern. Intercalation of tuff and sand form aquifer with K values of 0.1 to 6 m/day. There are also layers of breccia as aquitard with K values from 0.036 to 0.175 m/day, and clay layers of aquiclude with K values of 0.002 to 0.007 m/day.

The 3rd HSU is situated at elevation of 500 to 625 masl, composed of tuff and sand layers with K values between 0.3 to 7.1 m/day. The aquiclude is comprised of clay layers with K values averagely 0.04 m/day and aquitard of breccia with average K of 0.2 m/day.

CONCLUDING REMARKS

This paper has successfully calibrated the lithological name from well log data. Hence, the authority and driller could have the same perception over the same lithological description. We also have generated correlation equations between drilling parameters to calculate relative permeability values. The resulting values will be useful to predict the hydraulic properties of future drilled holes in this groundwater basin. Such K, however, are not intended to substitute the calculation from real pumping test data. From the new classification and values, three HSU's and six sub HSU's have been established.

This classification is the first attempt to group many lithological layers in to hydrostratigraphic unit. Not only intended to simplify the multi-aquifer system in this basin, we also expect this new classification can assist the authority in managing the groundwater resources in BSGwB. Aside to this effort, we need to validate the classification and equations to more dataset.

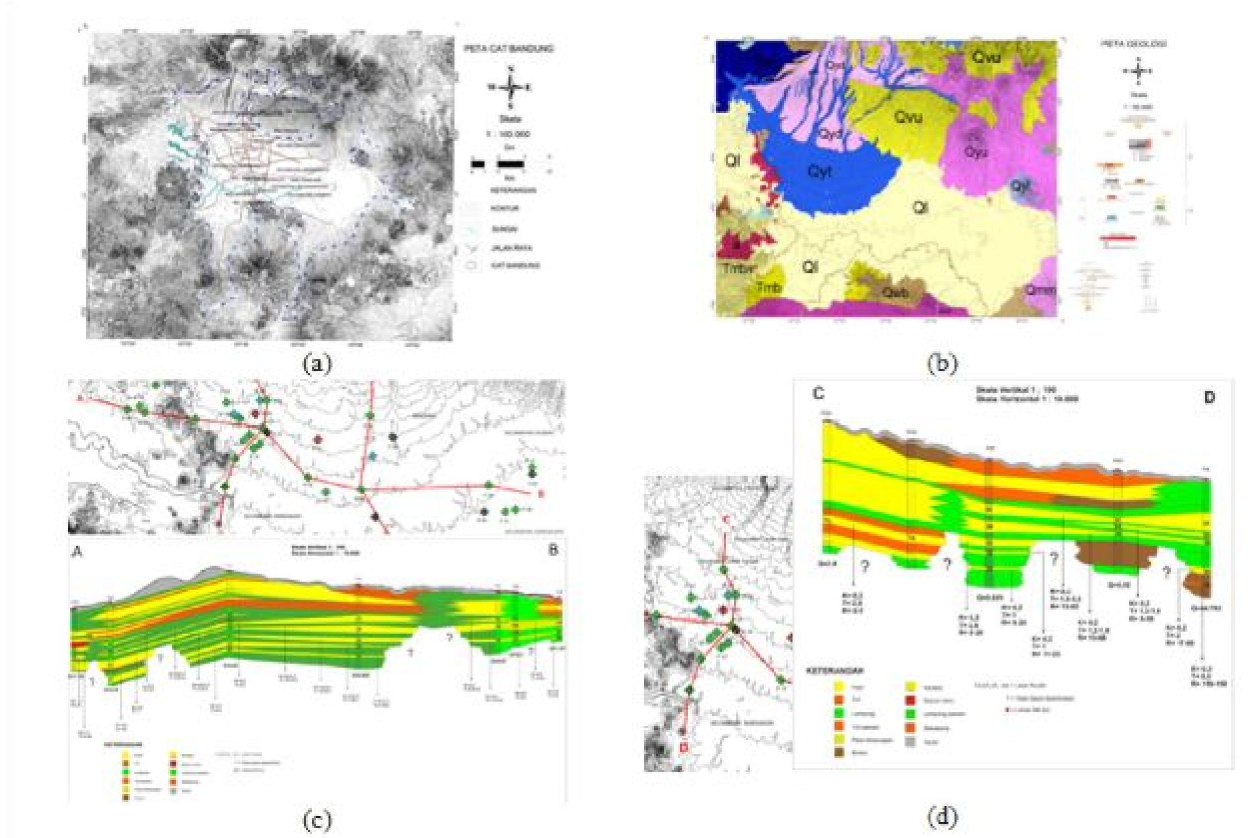

FIGURE 1. Maps of the study area. (a) The boundary of BSGwB (dashed blue line); (b) The geology of BSGwB; (c) East-west geological section; (d) North-south geological section

TABLE 1. Summary of the HSU showing the lithological classification and the data transformation drom resisitivity to relative permeability for each HSU and sub HSU.

Lithology	Resistivity (Ω)	Density (g/cm3)	Relative porosity (%)	Relative permeability (m/day)	Sub HSU	HSU
Tuff	40-60	2.47	10.5	0.0014		
					1.1	
Clay	1-2	2.61	2.5	0.00096		1
Tuff	61-90	2.39	15	0.004	1.2	
Lithology	Resistivity (Ω)	Density (g/cm^3)	Relative porosity (%)	Relative permeability (m/day)	Sub HSU	HSU
Sand	5-20	2.48-2.56	5.5-10.5	0.009-0.1		
Clay	3-5	2.54	6.5	0.001		
Tuff	61-120	2.30-2.39	15-21.5	0.004-0.018		
Sand	17-23	2.45-2.48	10.5-11	0.1-0.133	1.3	

Clay	6-8	2.44	13.5	0.002		
Tuff	150-190	2.11-2.18	28-32.5	0.1-0.2		
Sand	27-45	2.26-2.31	21-23.5	2-4.07	2.1	
Clay	12-14	2.36	17.5	0.007		2
Tuff	170-190	2.11	32.5	0.2		
Sand	41-50	2.22-2.26	23.5-26	4.07-6	2.2	
Clay	15-16	2.29	22	0.02		
Tuff	189-201	2.08-2.1	33-34	0.33-0.4		
Sand	51-56	2.16	29.8	7.1	3.1	3
Clay	20-22	2.23	26	0.04		

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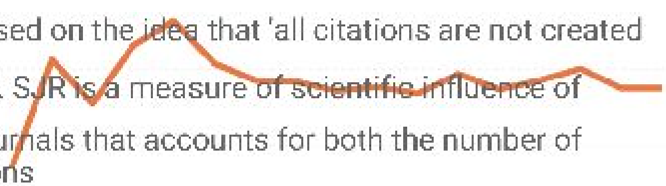

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Cites	Year	Value
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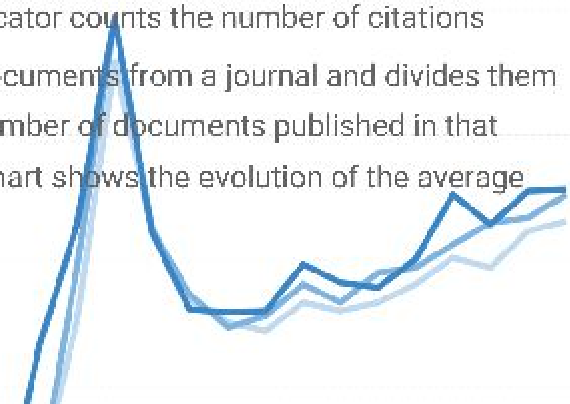

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Cites per document	Year	Value
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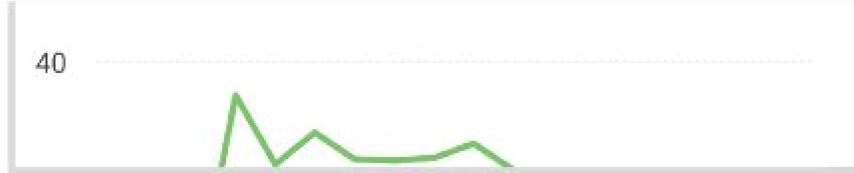

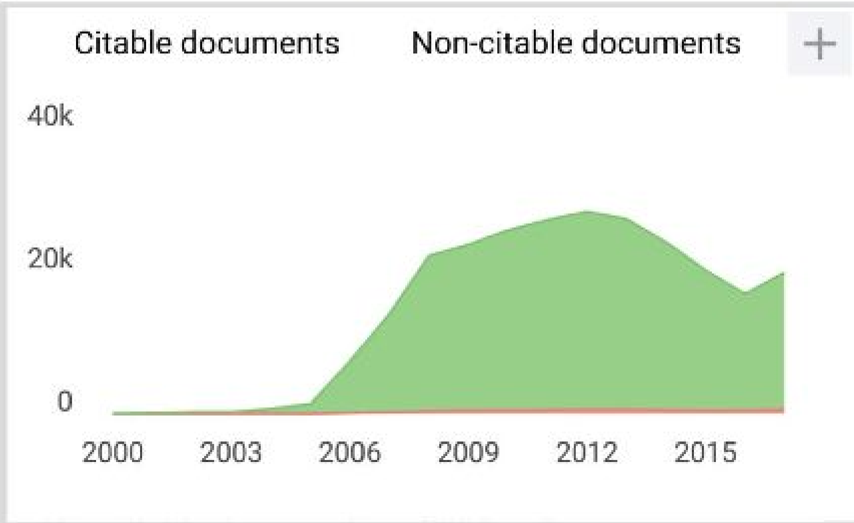

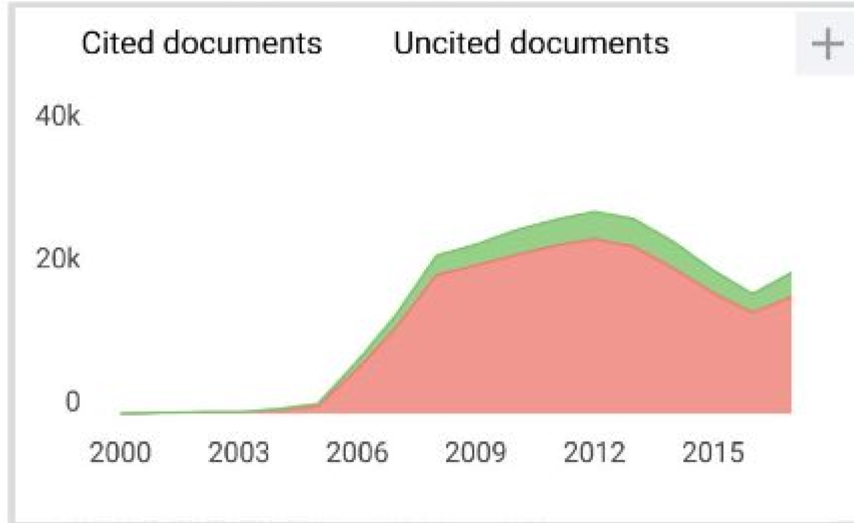

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