Run off Coefficient on Quaternary Volcanic Landform of Citarik Catchment based on Rainfall-Discharge Measurements, West-Java, Indonesia

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Abstract: ***Upper Citarum Catchment where the Capital City of West Java Province, Bandung, Indonesia located in that area is very popular as Bandung Basin or as Bandung Plato. Citarik, one of the main river tributaries of Upper Citarum River has a similar environmental or hydrological problem as that of Upper Citarum, i.e., flood in rainy and drought in dry season. The study area, Citarik Upper Catchment of Young and Old Undifferentiated Volcanic material (lava, breccia, and tuff) of denudational hilly landform has an area of about 2880 Ha and five order river based on Strahler Stream Ordering System. Runoff coefficient was calculated using rainfall and river discharge data based on direct field measurements. Topographic Map with scale of 1 to 25000 was also analyzed using GIS techniques to describe volcanic landform characteristic quantitatively. The research aims to obtain runoff coefficient of the Quaternary Volcanic Denudational landform. The study result was that runoff coefficient in young volcanic product is higher than in old volcanic product. Vegetation cover is still have importance role in determining run off coefficient, although there is also found indication that geological factor have.***

Keywords: Runoff coefficient, Quaternary Volcanic Landform, Rainfall and discharge measurement

1. Introduction

Upper Citarum Catchment Area where the Capital City of West Java Province, Bandung-Indonesia, located in that area is very popular as Bandung Basin or as Bandung Plato. Citarik , one of the main river tributaries of Upper Citarum River has a similar environmental or hydrological problem, i.e., flood in rainy and drought in dry season. The study area, Citarik Upper Catchment consists of Young and Old undifferentiated Volcanic material (lava, breccia, tuff) of denudational hilly landform has an area of about 2880 Ha and has five order river based on Strahler Stream ordering system. The location of study area is presented in figure 1.

Volcanic landform also includes the role of run-off coefficient relating to the physical characteristics and its contribution to the infiltration rate should be examined. Infiltration rate associated with ground water supply is useful for the availability of water for residents living in the vicinity. Runoff coefficient (C) is a number that indicates the ratio between the amount of water runoff and the amount of rainfall [1]. Runoff coefficients are determined as constants and depending on the state of the natural surface drainage basin [2]. Runoff coefficient that is used in forecasting the peak flow, the rational method [1] is one of the techniques that are considered adequate. To find the runoff coefficient or volume ratio between the volume of water flow out from a catchments area and volume of rainfall in a given period then catchment, the basin (watershed) or Sub-watershed were used as area unit of measurements.

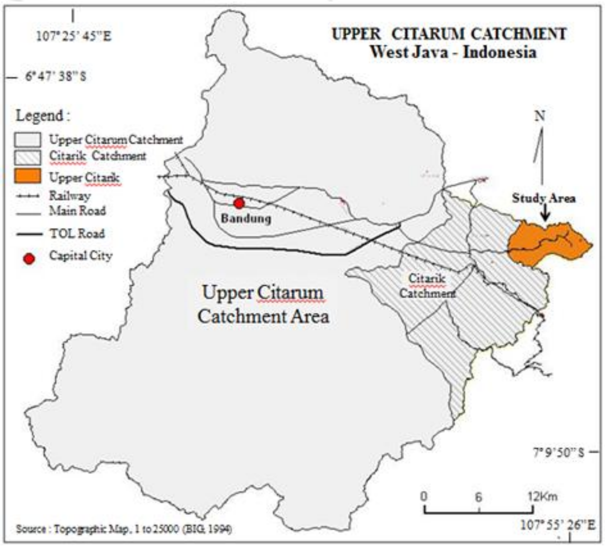

Figure 1: Location of Study Area, Upper Citarik Catchment.

River and the groundwater flow is an outflow from the mainland; the water flows down the slope through the surface drainage and groundwater, from the sub-surface in response to the incident rainfall patterns and natural complex throughout geological time and the process of short-term ("decadal") which determine forms biophysical landscapes, resulting in drainage basins [5]. The problem arises that the discharge and rainfall in watershed was not monitored long enough time, the approximate value C is often unstable or inconsistent due to the many factors involved, so that the determination of the coefficient run-off is still in a long debate [3]. Another factor very influential in getting consistency of runoff coefficient is the geological characteristics of a watershed effect on the value of the base flow. Therefore technology base flow separation is still debated to this day, because the determination of the coefficient runoff during the dry season is very small or even zero [3].

2. Objective

The study aims were to identify runoff coefficient in the Quaternary Volcanic Landform for calculating average daily river discharge using rational formula instead of for the calculation of the maximum or peak discharge using runoff coefficient table based on vegetation cover and soil condition.

3. Methodology

Topographic Map with scale of 1 to 25,000 was used to identify Catchments area as sample measurements and to describe physical characteristic of catchments. Measurement of daily rainfall was conducted from the end of December 2014 until the end of March 2015 (102 days) at two locations (stations) by means of installing rain gauge, recorded manually every day at 07.00 a.m.

Measurements of average daily river discharge performed by "areal section method", cross-sectional area (A1..An), flow velocity measurement of each section (V1 ... Vn) using the "current meter". Discharge of each section (Q1 ... Q) obtained by calculation using general formula:

$$Q = A\ V \qquad (1)$$

Q is the river discharge (m^3 / sec, a wet cross-sectional area (m^2), and V is water flow velocity (m / sec).

Measurement of water level (H) to make a discharge rating curve, than the average river daily discharge can be collected from the measurement of H in the morning (at 07:00 a.m.), daytime (at 12:00 a.m.) and afternoon (at 04.00 p.m.).

The measurement area is about 28.80 sq. km. That area located at the upper most Citarik Catchment. Citarik is one of six main river tributaries of Upper Citarum River. In physiographic region setting of West Java, the Upper Citarum Basin included in Bandung Zone [6]. The research area is geomorphological a Volcanic Denudational Landform, which consists of Geological formations of young and old volcanic undifferentiated product: Qyl, Qvl, Qvu (figure 2). The study area is dominated by steep slope land with 86% area and the rest are very steep (12%) and slightly steep (19%) (figure 3).

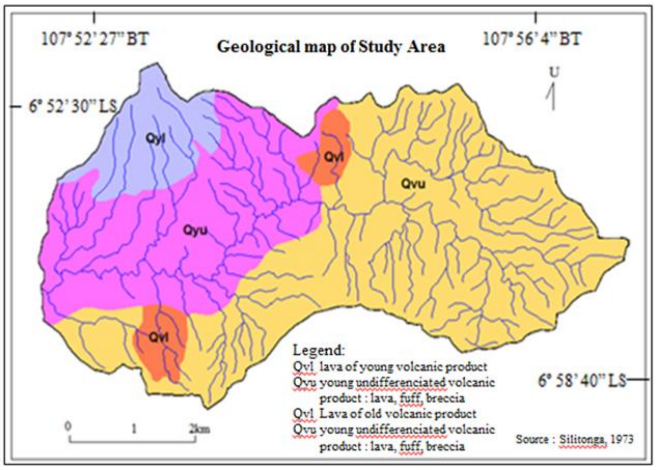

Figure 2: Location of Study Area, Upper Citarik Catchment.

Discharge measurements were conducted at the main river from the downstream toward the upstream, therefore Stn.1 represent the Catcment-1 is located in the most downstream has the most comprehensive Catchment (2880 Ha) and its territory includes Catchment-2 (Stn2), Catchment-3 (Stn.3), Catchment-4&5(Stn.4 & 5). Then Stn.2 its smaller Catchment area (1999 ha) and includes the Catchment-3 and Catchment-4&5. Catchment-3 has total area of 1779 Ha including Catchment-4 and 5. Catchment-4 and 5 are separated, each of them has an area consecutively 552 Ha and 606 Ha (Figure 4).

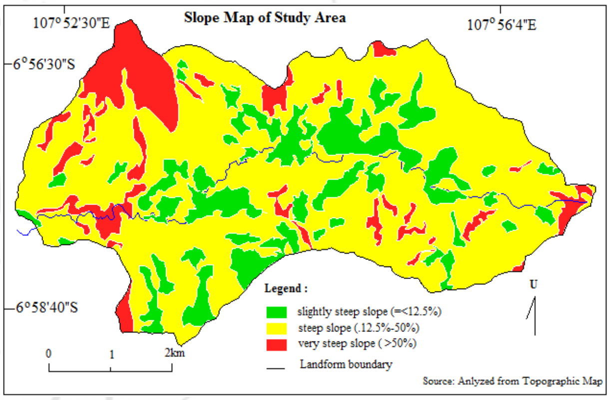

Figure 3: Slope Distribution Map of Measurement Area

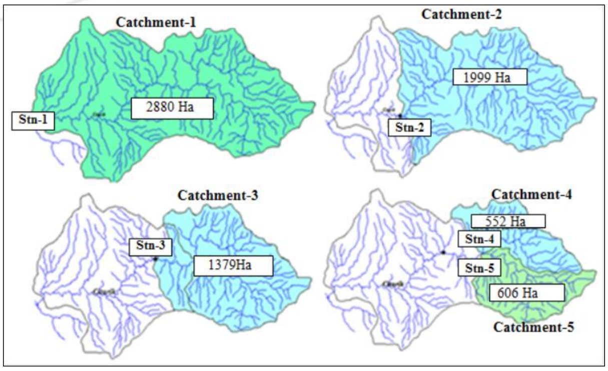

Figure 4: Distribution of Measurement Area (Catch-1 – 5).

4. Result of Study

Rainfall (CH) and River Discharge (Q)

Rainfall Measurement (CH) conducted at two locations, while the measurement of river discharge (Q) in the four locations at the main river (Figure 5). The results of measurements of rainfall (CH) and discharge (Q) are presented in graphs with 102 days of measurement and CH (blue) and daily average total river discharge (orange) for the Catchment-1 s / d 5 and Catchments 4&5 (Figure 6).

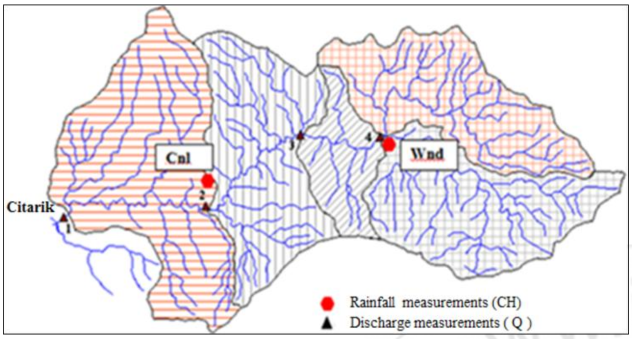

Figure 5: Locations of CH and Q measurements.

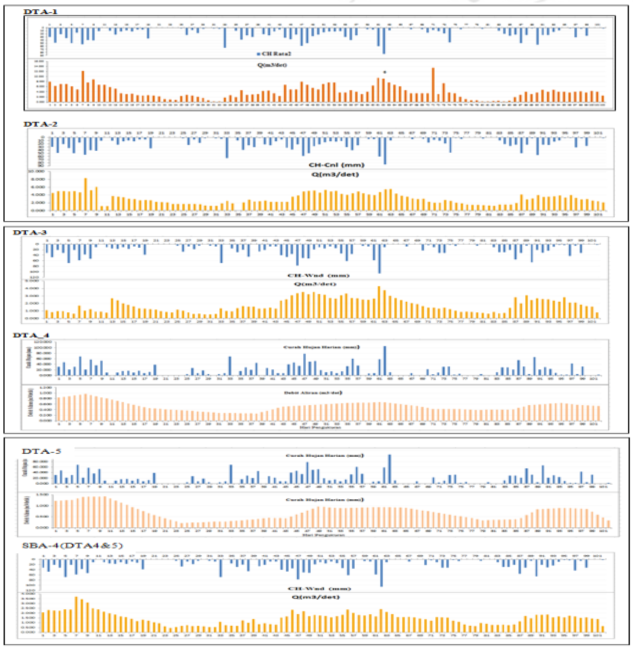

Figure 6: Distributions of daily CH and Q

5. Discharge Separation

Precipitation that falls into the catchment might become surface runoff, subsurface flow and base flow. In this study the measured river discharge is total flow that consists of overland flow, subsurface flow and base flow. Base flow that measured in total river discharge could be come from other catchment or inter catchment ground water flow, so it's necessary for base flow to be separated from the total flow. Than runoff coefficients can be calculate by dividing the volume of average daily river flow minus base flow and the volume of daily rainfall fall into the catchments. Separation of the basic flow and runoff carried by the identification of the basic flow as in the example image are lines AB, BC, and CD (Figure 7).

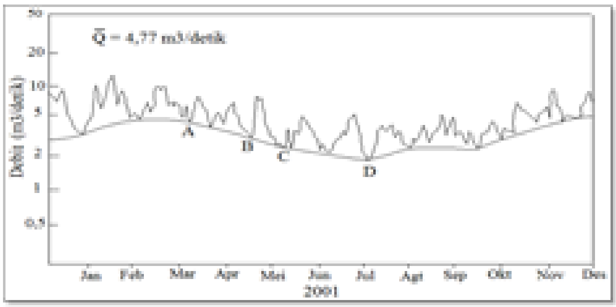

Figure 7: Hydrograph of daily discharge of the year 2001 on the River Wensum, Norfolk, England (NGR TG 177 128; Catchments (570.9 sq. km). The period of recession bottoms stream identified by straight lines AB, BC and CD [4].

During the measurement of as much as 102 days consecutively, the volume ratio of total river flow and total volume of rainfall into the catchments are presented in Table 1. The data presents the percentage of total flow, percentage of base flow, the percentage of runoff, and the percentage of infiltration into groundwater, to precipitation.

Table 1: Percentage of total Q, runoff, base flow and suppletation

Nu.	Area Unit	Area (Ha)	% Rainfall	% Total Discharge	% Runoff	% Baseflow	% Supletion to the Ground Water
1	Stn.1 Catch-1	2880	100	70	31	39	30
2	Stn.2 Catch-2	1999	100	80	24	56	20
3	Stn.3 Catch-3	1379	100	55	11	44	45
4	Stn.4 Catch-4	552	100	48	7	41	52
5	Stn.5 Catch-5	606	100	60	9	51	40
6	Catch4&5	1158	100	54	7	47	46

Characteristic of Catchment

Characteristic of catchment are represented by lithology, slope, soil, and vegetation covers especially forest that related to catchment runoff are presented in the Table 2. Base on the lithology, catchment area can be classified as young volcanic landform catchment and old volcanic landform catchment. The evidence is shown that.

Table 2: Catchment Characteristic

Area Unit	Area (Ha)	Lithology	Slope (%)	River density (km/sqkm)	Soil	% Forest Cover
Catch-1	2880	lava, breccia, tuff of the young and old volcanic products	31	3.82	Latosol	55
Catch-2	1999	lava, breccia, tuff of the young and old volcanic products	27	3.91	Latosol	69
Catch-3	1379	lava, breccia, tuff of the old volcanic products	27	3.72	Latosol	88
Catch-4	552	lava, breccia, tuff of the old volcanic products	26	4.35	Latosol	93
Catch-5	606	lava, breccia, tuff of the old volcanic products	21	4.5	Latosol	99
Catch.4&5	1158	lava, breccia, tuff of the old volcanic products	23	4.4	Latosol	96

6. Analysis and discussion

Descriptive analysis is done by making bar charts and dispersal of graphs. From figure 8 and 9 it can be seen that in relation with runoff coefficient, catchment can be classify as group one consists of Catch.1 and Catch.2 which have higher runoff coefficient than Catch.3, Catch.4 and Catch.5 as group

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2. Percentage runoffs which mean coefficient runoff of group one have an average of 27.5 % or 0.275 (between 0.31 and 0.24), while group 2 have an average coefficient runoff 0.085 (0.11; 0.07; 0.09; 0.07).

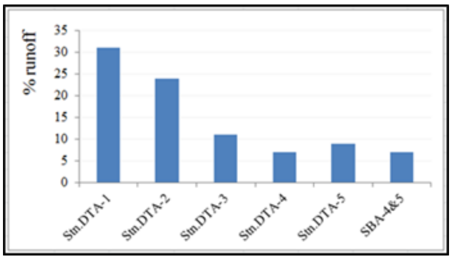

Figure 8: Chart between Catch & runoff.

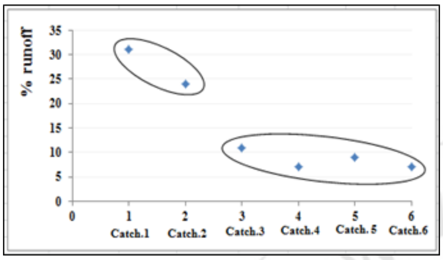

Figure 9: Dispersal Graph catch & runoff.

It is also depicted clearly in the Figure 10 and 11 that Catch.1 and Catch.2 have lower percentage of suppletion than Catch.3, Catch.4 and Catch.5. Base on the proportion of precipitation infiltrated and percolated into ground water, the catchments can also be separated between Catch.1 and 2 as a group one and Catch.3, Catch.4 and Catch.5 as group 2. While based on percentage the base flow, the catchments cannot be classified. The range of percentage base flow is between 39% and 65%. The lowest percentage base flow is Catch.1 and the highest is Catch.2 and Catch.3,4 and 5 is in between (Figure 12 and 13).

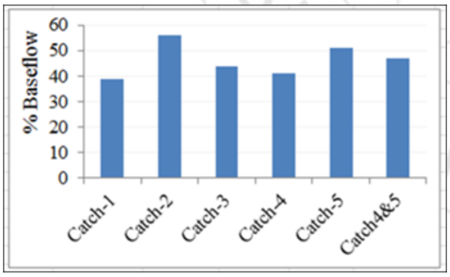

Figure 10: Chart between Catch & % Suppletion.

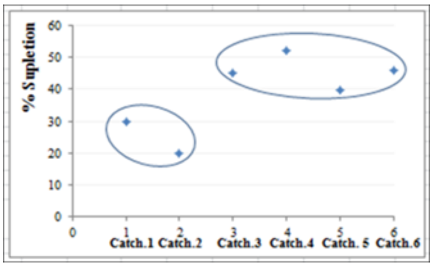

Figure 11: Dispersal Graph Catch& % suppletion.

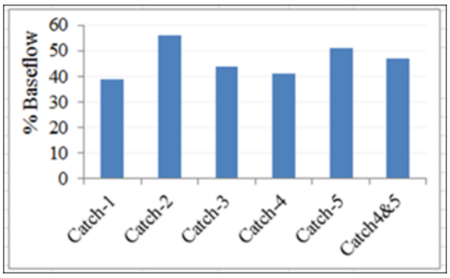

Figure 12: Chart between Catch & % Base flow.

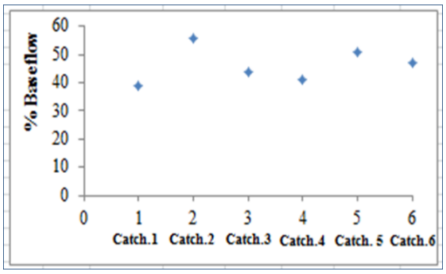

Figure 13: Dispersal Graph Catch& % base flow.

In the total river flow, there seemed little difference between group 1 and group 2. The average percentage total river flow of group 1 is 75% (70% and 80%). The average percentage total river flow of group 2 is 54% (55%, 48%, 60%).

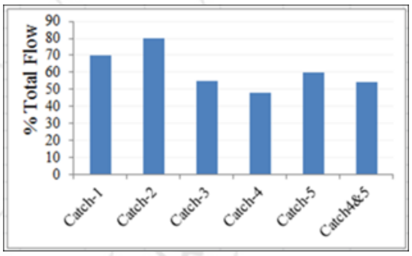

Figure 14: Chart between Catch & % Total Flow

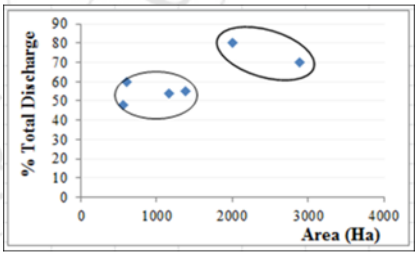

Figure 15: Dispersal Graph Catch & % Total Flow

The role of vegetation cover especially forest is still importance in the effect of runoff coefficient. From figure 16, it can be seen that there is a linear negative correlation between percentage forest cover and runoff coefficient, the larger the percentage of forest cover the smaller the value of runoff coefficient. It also seems that the runoff coefficient of catch.1 and 2 to be bigger than that of Catch 3, Catch.4, and Catch.5.

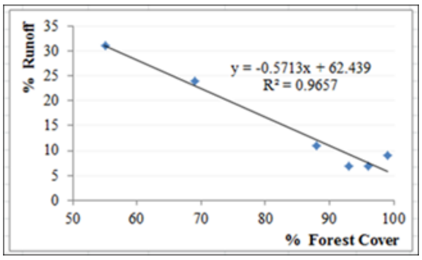

Figure 16: Correlation between % forest cover and Runoff Coefficient.

Slope also have importance role in determining runoff coefficient. Figure 17 show that the steeper the slope, the higher the value of runoff coefficient as well as river density although there is Catch.1 that has some difference (out layer) (Figure 18).

7. Conclusion

- Catchments in young quaternary volcanic product have the higher runoff coefficient than that in the old quaternary volcanic product.
- The higher the value of river density, the lower the value of runoff coefficient in the quaternary volcanic Denudational landform.
- Vegetation cover still have an importance role in determining the runoff coefficient, although in some cases there is a tendency that geological factor also have.

8. Acknowledgement

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