# RAINFALL INFILTRATION OF BANDUNG DURING 1997 TO 2006

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## ABSTRAK

*Global warming has been felt around the world. In Indonesia, it can be mainly seen on climatic parameters such as rainfall and temperature. Due to their close relationship between global warming and hydrological cycle, infiltration as part of hydrological cycle will be influenced by this global phenomenon also. This study is carried out to investigate how infiltration condition of Bandung during the 1997 to 2006 based on FJ Mock method with modified potential evapotranspiration using Penmann-Monteith method. The results show that a decreasing trend in rainfall (0.525 mm/year) and an increasing trend in temperature (0.035$^o$C per year) occur that suggest climate change may be occur due to global warming. Due to a decreasing amount of rainfall and limited evapotranspiration (0.14 mm per year), infiltration also decreases by 0.28 mm per year. So in the future, it needs some step to anticipate to decreasing amount of ground water result of a decreasing number in rainfall infiltration.*

*Key words: hydrological cycle, global warming, infiltration, rainfall, temperature*

### 1. Introduction

The continuous movement of water between the Earth's biosphere, atmosphere, lithosphere, and hydrosphere is called the hydrologic cycle. Water on the Earth may be temporarily stored in various reservoirs including atmosphere, oceans, lakes, rivers, soils, glaciers, snowfields, and groundwater. Water continuously moves from one reservoir to another by way of evaporation, transpiration, condensation, precipitation, groundwater flow, sublimation, and melting.

Water is continually cycled between its various reservoirs. The residence time of water in the atmosphere and in rivers is quite short (e.g., days to weeks), while the residence time for water in large lakes, glaciers, ocean bodies and groundwater are much longer, normally in the range of tens to thousands of years.

Precipitation (rainfall) occurs when 100% relative humidity is exceeded, which occurs usually due to cooling of the air mass. Cooling of the air mass occurs due to increase in altitude. Increased air mass altitude  can be endorsed to processes such as convective processes, and orographic effects. For porous surface soil, some rain will leak into the ground. The downward movement of water into the soil layer is termed infiltration. Infiltration into soil varies with soil type and depends on rate of precipitation and on ambient soil moisture.

Now, we are conscious that global warming and climate change occurred. An important factor in global warming is the change in extreme precipitation which can strong impact on variety of human and natural systems. Rainfall has generally declined in the tropic of both hemispheres; when rain does fall, it is frequently so heavy that it causes erosion and flooding (UNEP, 2003). In general, global warming should accelerate the hydrological cycle.

The objective of this study is to represent how rainfall infiltration condition in Indonesia that supposed to experience climate change due to global warming during 1997 to 2006.

## 2. Data and processing

The used data are rainfall, temperature (maximum, minimum, average), daily sunshine, wind velocity, and relative humidity of Bandung station ($6^o$55'S , $107^o$36' E and 791 meter above mean sea level) for period of 1997 to 2006. The selected rainfall and temperature parameters are mainly based on fact that the parameters are well known to see the climate change of tropical region especially Indonesia. Meanwhile, Bandung is chosen due to it can be a representative of many part of Indonesia region having rainfall type B and the area is affected by strongly monsoon and topography effects.

The data are processed using FJ Mock 's water balance method. This method assume that rainfall occurring in some area mainly for evapotranspiration then it fill soil storage to go by infiltration process. To determine the water balance, potential evapotranspiration calculation slightly modified from Penmann to Penmann-Monteith methods. This Penmann equation is often modified and changed to calculates potential evapotranspiration as done by Ken'ichi et al (2002) and Kumar et al (1987).

## 3. Climatology and geology of Bandung

Bandung basin is located on $107^o$20' – $107^o$55' E and $6^o$45' – $7^o$15'S; that has highest place on the northern part with 1050 meter above mean sea level and the lowest place on the southern part which has 675 meter above mean sea level. Northern part of Bandung city is hilly while the southern is flat relatively. Bandung climate analysis results show that there is an increasing trend in air temperature, cloudiness (rainfall) and air pollution (dust) and a decreasing trend in wind velocity and humidity (Baharamsyah, 1989). Such signal of climate change is suspected to have impacts on water balance in Bandung (Wiratmo, 2007).

Annual rainfall is 1600 to 2500 mm, the higher is in November to April and the lower is in June to September. Maximum rainfall is located in southern part of Bandung near Ciwidey and decrease gradually to the north. Monsoon and orographic effect strongly influence Bandung's climate. It has rainfall type C to A (mainly is B) with 7.8-10.1 wet months and 1.3-2.9 dry months throughout the year. In El Nino condition, dry season of Bandung and its surroundings is longer than normal (Avia, 1994). It needs 2 months for maximum rainfall to reach ground water storage peak that occur in April but 3 months for minimum rainfall (August) to get minimum ground water storage (November). The base flow pattern follows ground water storage pattern where its maximum occurs in May and its minimum in November (Wiratmo, 2007).

Part of Bandung which has more than 685 meter above mean sea level in altitude has alluvial fan deposit originally from sedimentation process affected by volcanic activities. The existing rock is gravel, sand, little gravel clay, sandy, and silt which has porosity 35%. Monthly recession factor (K) of

Cikapundung river separating western and eastern part of Bandung is 0.825. Soil moisture of Bandung is 150 mm based on fine sandy clay of soil texture which moderate root of plants grow.

According to Fachrudin (1996), lower temperature occurs in January and July and the other hand, higher temperature in April and October. Higher relative humidity occurs in December to May and the lower one is in July to October. Lower sunshine occurs in November to February and each increasing 100 meter in height cause to decreasing sunshine radiation as much as 4.2-24%. The highest easterlies occurs in dry season to onset rainy season and westerlies mainly occurs during rainy season. Declining wind velocity occurs in the end of rainy season (April to May) to early dry season (June to July).

## 4. Results

The rainfall data shows that a decreasing trend occurs as much as 0.525 mm/year in Bandung (figure 1) but a increasing trend of temperature as high as 0.035$^o$C/year (figure 2) during the period of 1997 to 2006. Indeed, it seems that global warming impact may have effect on Bandung's climate. As we know global warming may have effect on all climatic parameters in all scale. It is a huge different with Fatchurrochman (1996) who suggested an increasing of rainfall per month as high as 0.0338 to 0.0896 mm during period of 1965 to 1994 which has an increasing in rainfall day amount as much as 0.01 to 0.0194 day. Also he stated that a decreasing trend in temperature mean as much as 0.0009 to 0.026$^o$C per month in northern Bandung. So it needs some further investigation.

Rainfall descending to the ground will be partly evaporated and some part enter to the soil and direct run off at rest. Limited evapotranspiration profile show that a decreasing trend occurs as much as 0.14 mm/year (figure 3). It can be probably caused by decreasing in vegetation area amount transpiring water into the air. There were some land use changing from vegetated area to become residential and industrial areas during the last 10 years.

Direct run off is to go through a decreasing as much as 0.35 mm per year (figure 4); opposite to Fatchurrochman (1996) who suggests that an increasing trend in surface run off as much as 0.06875 mm per month. The different method may give the results. But also this is different with a fact showing some flooding arise in the southern part of Bandung. It may be caused by some rivers can not accommodate waters flowing over the ground. However, if the rainfall is small but rivers capacity can not to catch it then flooding will occur. But it should be kept in mind that flood problem is not only due to climatic factors.

Infiltration has also a decreasing trend as much as 0.28 mm/year (figure 5). The used vegetation cover is 20% that imply many residential area to replace many vegetated area. Plant and its roots activities in the soil have a function to increase infiltration capacity. Infiltration into soils depends also on several other factors associated with tillage, soil structure, antecedent soil moisture, infiltrating water quality and status of the soil air (Grismer, 1994). So, it is considered to be natural if there was a decreasing amount in infiltration due to many reducing vegetated area. The extreme phenomenon occurs in February 2002 (figure 6). In this period the maximum rainfall has occurred as high as 563.8 mm where 119.1 mm evaporated and 244.58 mm become surface run off. Maximum infiltration as much as 200.11 mm occurs during this period.

## 5. Concluding Remarks

Climate change of Bandung can be looked at rainfall and temperature parameters. They showed that a decreasing trend of rainfall and increasing trend of temperature occur during 1997 to 2006. Evapotranspiration, direct run off, and infiltration have a decreasing trend. This decreasing trend in infiltration means that it will be a decreasing trend filling of ground water so that it needs some step to anticipate.

## 6. Acknowledges

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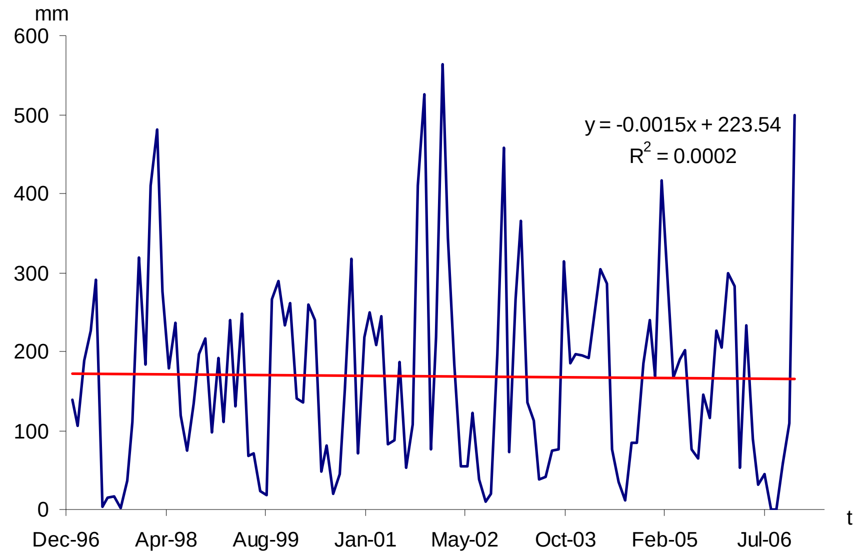


Figure 1. The rainfall chart of Bandung for period of 1997-2006 shows a decreasing trend in rainfall data

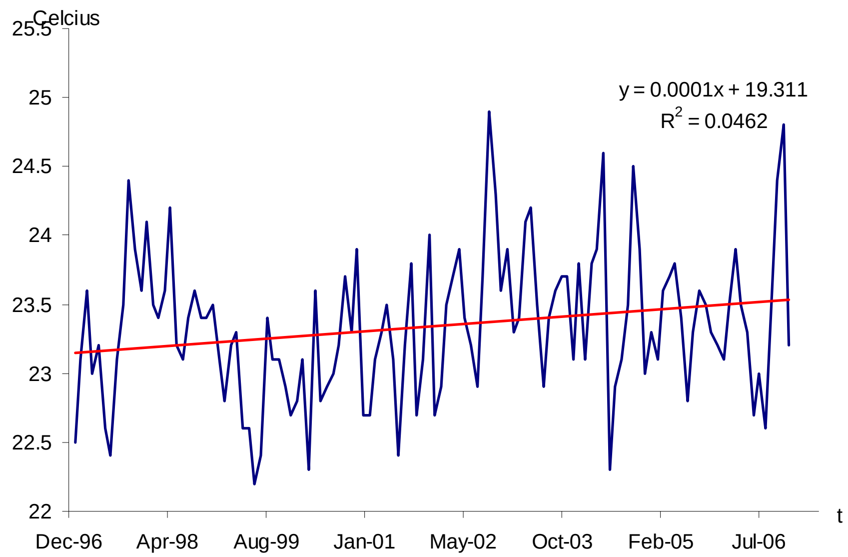


Figure 2. The temperature chart of Bandung for period of 1997 to 2006 shows an increasing trend in temperature data

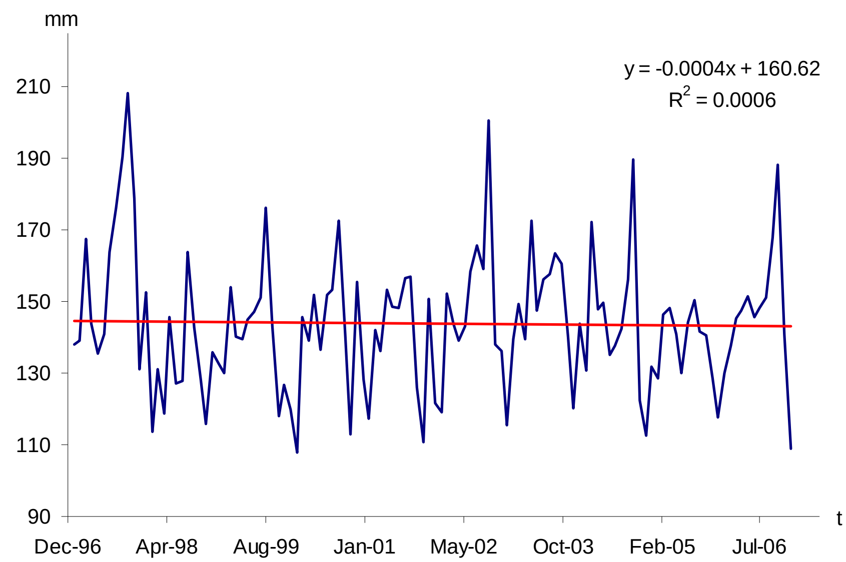


Figure 3. Calculated limited-evapotraspiration of Bandung for the period of 1997 to 2006 shows a decreasing trend in the data

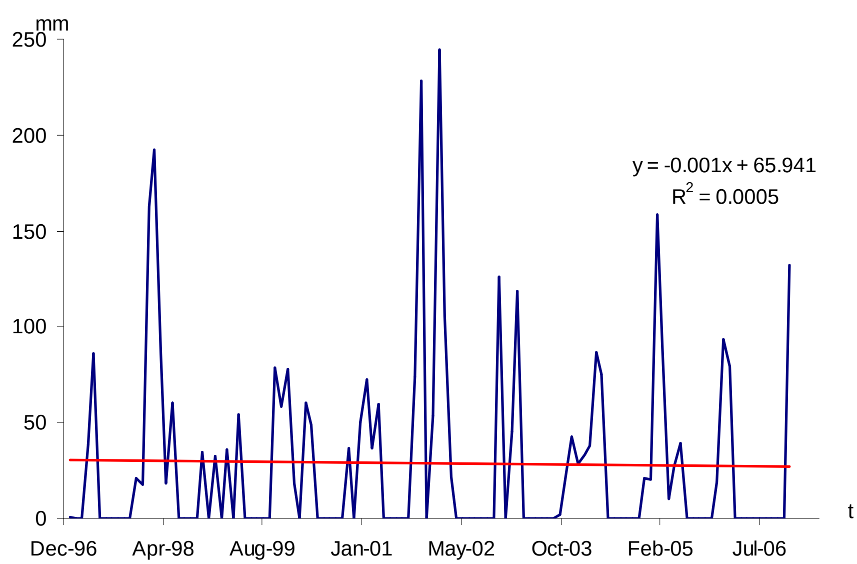


Figure 4. Direct Run Off of Bandung for the period of 1997 to 2006 shows a decreasing trend

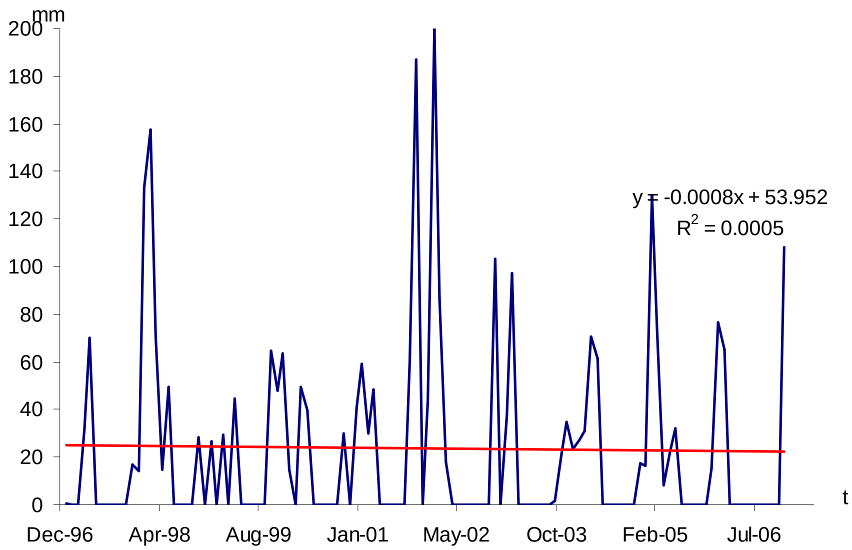


Figure 5. Calculated infiltration of Bandung during 1997 to 2006 shows a decreasing trend in the data

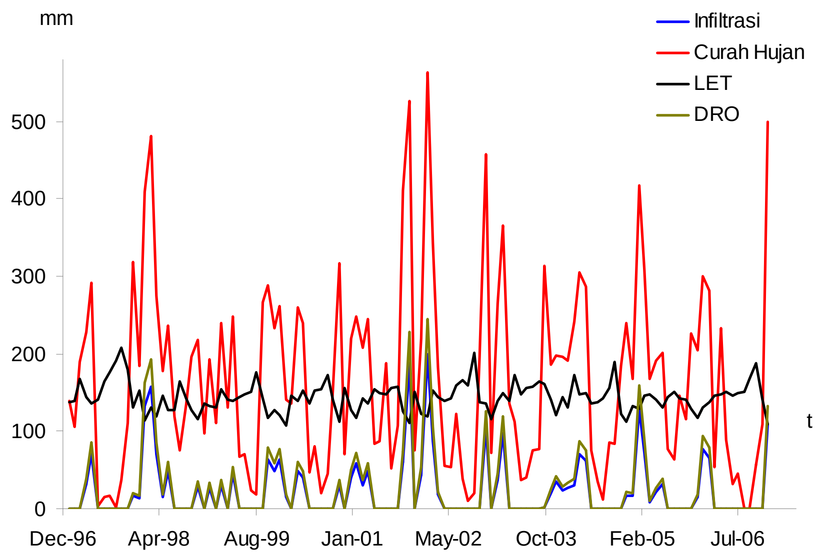


Figure 6. Infiltration, rainfall, limited evapotranspiration (LET) and direct run off (DRO) of Bandung for the period of 1997 to 2006. The biggest rainfall and infiltration occur in February 2002