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Identify the Characteristics of the Urban Forest for Improvement of Environmental Quality in the City of Surabaya with Canopy Structure, Interception, Throughfall, and Stemflow

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Abstract
Increasingly dense urban activity indirectly cause environmental degradation in urban areas, especially in the city of Surabaya. Characteristics of a good urban forest in improving the environmental quality in the city of Surabaya can be seen to from canopy structure, interception, throughfall, and stemflow. The aim of this study was to determine the characteristics of the urban forest as environmental quality improvement planning in the city of Surabaya in homogeneous and heterogeneous forests for canopy structure, interception, throughfall, and stemflow. This research method uses a simple regression to find the value of determination or R^2. The results show the identification of the characteristics of the urban forest in the city of Surabaya, is; 1) the structure of the canopy can be seen from the value of the index on the density of the canopy of each tree, tamarind at 0.16, mahogany at 0.13, angsana at 0.07, landi acid at 0.16, and tamarind in heterogeneous forest at 0.16 , 2) interception of rainfall indicated by the R^2 value of 0.92 on a tamarind, mahogany at 0.9, angsana at 0.88, landi acid at 0.979, and 0.936 for the heterogeneous forests, 3) throughfall in homogeneous forest trees tamarind at 4.13 mm, mahogany at 4.45 mm, angsana at 3.14 mm, and landi acid at 2.99 mm, and 4) stemflow in the forest is homogeneous tamarind at 4.35 mm, mahogany at 3.61 mm, angsana at 5.34 mm, landi acid at 2 mm, and heterogeneous forest (tamarind) at 3.35 mm
Keywords; urban forest, canopy structure, interception, throughfall, stemflow

1. Introduction

The development of the city at this time was heavily influenced by the service sector, including government, industry, commerce, education, and other informal sectors, causing its own dynamics to the population growth of a city. This then led to the increasing need for the provision of residential areas with all the facilities and infrastructure that will result in improved load carrying capacity remains the relatively urban environment. This problem on time while it still can be solved by the application of technology, however, in the long-term side effects will be more than doubled and will eventually exceed the ability of technology to solve it.

The inability of the technology to address the various problems caused by the concentration of humans and a variety of these activities, then rise to various crises, the crisis of housing, clean water crisis and drinking water, health crisis, a crisis of waste, and others. In other words, as related to the concentration of people and activities that exist within a relatively short time and in a limited space, then the frequency and intensity as well as the types of environmental pollution will increase (Irwan, 2005).

Haeruman (1995) in Irwan (2005) states that the future hope to obtain a better quality of urban areas will depend on four things, namely: 1) The accuracy of the allocation of space for each development activity; 2) the availability and capability of institutions and processes of environmental management; 3) control of development activities that lead to the efficient use of materials and control of pollution and destruction of the function; 4) the level of community participation and social discipline of the city. Thus, the city needs to control the development of conceptual and integrated to support the creation of good urban environment, aesthetic, healthy and comfortable. It will be able to meet the needs of the population in order to survive, to continue living and improve quality of life.

The decline in the quality of the urban environment as a result of the conversion of open land into residential green also adds another problem that had already become a classical problem, namely the pollution of air, soil, and water which is a direct result of industrialization and transportation activities. It can be seen to from the increasing air pollution, such as carbon monoxide (CO), carbon dioxide (CO_2), nitrogen oxides (NO), sulfur (SO) and dust; the higher the temperature of the air in urban areas and the soil and water conditions indicated a decrease in groundwater levels, groundwater contamination, and contamination of surface water, which is causing raw water for drinking water to be dirty, smelly, harmful bacteria, harmful chemicals, and heavy metals. Another impact is no less important is the soil, sea water intrusion, coastal erosion, and flood events on every rainy season. All the above conditions then from a dirty atmosphere, arid, noisy, unsanitary and uncomfortable as perceived today (Dahlan, 1992; Purnomohadi, 1995).

Related efforts to maintain the quality of urban environment, urban spatial planning has an important role in maintaining, shaping, and ensuring the presence of green space the city and all its functions. The City forest green open space is open space or area vegetated trees gazette as forest land by the city officials, hereinafter referred to as the urban forest. Meanwhile, green open spaces that have similar characteristics but are not formerly defined as urban forest, called non-forest green open spaces of the city. Non-forest green open area the city is composed of forests, gardens, fields, as well as shrubs and grass, hereinafter referred to as green open space only.

Data from Surabaya Regional Water Company Surabaya mention that every 5 (five) years, since 2005, the need for clean water supply for the city of Surabaya constant increase, which is equal to 10%-15%. In 2005, for example, the need for the availability of clean water is 8,901 liters/second and rose by 15% in 2010 to become 10,314 liters / sec. The increase in the same percentage range also occurred in 2015, and the increase in 2020 amounted to 11,935 liters / second, an increase of 1,621 liters/second (13%) is predicted to occur in 2015, and amounted to 1,707 liters / second (14%) in 2020, ie 13,643 liters/ second (Kompas, 2010).

The threat of water supply crises will become a very serious threat in 10 years to come. The implication of all this can were estimated to be, ie, no probably not, in most communities in Surabaya (almost 50%), in the future must meet the needs of their water from groundwater. Therefore, the planning area has an impact on the maximization of rainwater catchment should be a serious concern of all stakeholders in the city of Surabaya. Related to this, one of the efforts that should be done is to maximize the hydrological function of the entire potential of green open spaces, including the urban forest, as the catchment areas and rainwater storage. Early stages before making the planning necessary to identify the characteristics of urban forests to increase the quality of the environment in the city of Surabaya with the structure of the canopy, interception, throughfall, and stemflow.

Canopy structure identification, interception, throughfall, and stemflow in the urban forest of Surabaya is important, because such identification would directly influence the optimization of urban forest planning in both the cities of Surabaya, both homogeneous and heterogeneous vegetation. Urban forest planning by considering the balance between homogeneous and heterogeneous forests would have a direct impact on reducing pollution to an Environmental quality of life in the city of Surabaya.

Considering the above, the researcher would like to contribute through in-depth research on the identification of the characteristics of the urban forest in the improvement of environmental quality in the city of Surabaya with canopy structure, intercepts, throughfall, and stemflow.

2. Literature review

Grey and Deneke (1978) gives the definition of the urban forest as a broad area of woody vegetation and planting distance is open to the public, easily accessible by the residents of the city, and can fulfill the functions of protection, such as conservation of soil, water management, climate amelioration, an antidote to air pollution, noise and others. Furthermore, Fakuara (1986) defines the urban forest as some vegetation or woody vegetation in urban areas that provide environmental benefits much in the utilities protection, aesthetics, recreation, and other special uses.

Function of the urban forest are very dependent on the composition and diversity of vegetation types and communities which constitute it; as well as the composition of vegetation is an important consideration to achieve its design goals. Broadly speaking urban forest functions can be grouped into three, namely the function of landscape, aesthetic function, and the function of preserving the environment (ecological function) (Irwan, 2005).

1. Function Landscape

Function landscape has a function that is; a) physical function is a function of vegetation as a structural element that is capable of providing protection against physical condition of the natural surroundings, such as the brunt of the wind, the sun, the view is not good, and to absorb odors and b) another social function of urban forests is the economical social and political functions. In political science, it can become an icon of the city and can therefore be on the agenda on a state visit to strengthen the friendship ties between nations. In addition, urban forests can also provide additional income that can economically improve the welfare of residents through fruit produced, and its herbal properties.

2. Function Aesthetics

The second function of the urban forest in view Irwan (2005) is an aesthetic function. Visual or aesthetic characteristics closely associated with the reaction to the impression that captured by the visual senses. The size, shape, color and texture of the plants as well as elements of composition and its relationship with the surrounding environment are a factor that affects the aesthetic quality. The visual quality is very important because the vegetation response is a reaction of a person's appearance. Related to this is the aesthetic function of the urban forest can be used as a means of family recreation, and society in general.

3. Function Environmental Conservation (Ecological)

Function of environmental conservation (ecology) in the development and control without compromising the quality of the environment takes precedence other functions. Functions of the urban forest environmental conservation among others are refreshing air, lowering city temperatures and increase humidity, as a living space of animals, controlling and neutralizing air pollution and waste, noise reducer, the germplasm conservation and bio-indicators, fertilize the soil, and hydrological functions and controlling water balance.

3. Methodology

Identify the characteristics of the urban forest in the city of Surabaya performed on homogeneous and heterogeneous forests by identifying canopy structure on canopy density index, rainfall interception value, throughfall, and stemflow will be performed using a simple regression method to find the value of determination or R^2.

4. Results and Discussion

4.1. Canopy Structure

4.1.1. Homogeneous forests

a. Tamarind

Tamarind on homogeneous forest trees has the following characteristics: canopies qualifies for 30% of the rainfall, stem flow of 30% of the rainfall and the remaining 40% is interception. This characteristic suggests an influence of the appearance of vegetation, both from the architectural aspects of editorial and editorial aspect's density index.

Data obtained from individual observations of vegetation states that the tamarind tree trunk circumference was 101.5 cm; the trunk diameter 30.7 cm, height 10.23 m, canopy bottom is at 6,380 m, and 3.85 m high canopy. While the average width of an editorial is 6,33, 18,10 number of primary stems, and canopy density index is 0.16. With these characteristics it becomes natural that most of the rain water that comes later detained in the canopy and a tamarind tree.

b. Mahogany

Mahogany tree has the following characteristics: canopies qualifies for 38% of the rainfall, the flow by 31% stems from rainfall, and the balance of 31% is interception. This characteristic suggests an influence of the appearance of vegetation, both from the architectural aspects of editorial and editorial aspect's density index.

Data obtained from individual observations of vegetation states that mahogany tree trunk circumference was 84 cm; the stem diameter of 31.8 cm, height 13.2 m, canopy bottom is at 6.4 m, and 6.8 m canopy height. While the average canopy width is 5.33, the number of primary branches 23, and canopy density index is 0.13. With these characteristics it becomes natural that most of the rain water coming into the water then passes canopy (canopies qualifies). In addition, leaf shape, leaf arrangement, and branch theoretically also have contributed to the occurrence of this difference.

c. Angsana

Angsana tree has the following characteristics: canopies qualifies for 29% of the rainfall, stem flow by 46% of the rainfall, and the balance of 25% is interception. This characteristic suggests an influence of the appearance of vegetation, both from the architectural aspects of editorial and editorial aspect's density index.

Data obtained from individual observations of vegetation states that angsana tree trunk circumference was 81 cm; the stem diameter of 31.1 cm, height 13.1 m, canopy bottom is at 6.1 m, and 7 m high canopy. While the average canopy width is 4.8, the number of primary branches 21, and canopy density index is 0.07. Coupled with branching angles that reach up to 700 then it become natural that most of the rain water that came later into the flow stem (stem flow). In addition, leaf shape, leaf arrangement, epiphytic plants, and ruggedness stems theoretically also have contributed to the occurrence of this difference.

d. Landi acid

Landi acid tree has the following characteristics: canopies qualifies for 31% of the rainfall, the flow by 21% stems from rainfall, and the balance of 48% is interception. This characteristic suggests an influence of the appearance of vegetation, both from the architectural aspects of editorial and editorial aspect's density index.

Data obtained from individual observations of vegetation states that the circumference of the tree trunk Landi acid is 101 cm; the trunk diameter 30.7 cm, height 10.2 m, canopy bottom is at 6.38 m, and 3.8 m canopy height. While the average canopy width is 46.33 m, the number of primary branches 18.1, and canopy density index is at 0:16. Coupled with a very sloping angle branching (less than 300) than it becomes natural that the majority (50%) of rain water that comes later became stuck. In addition, leaf shape, leaf arrangement, epiphytic plants, and ruggedness stems theoretically also have contributed to the occurrence of this difference.

4.1.2. Heterogeneous forests

Tamarind tree in the forest has a mix of characteristics are nearly equal to that in the homogeneous forest as follows: canopies qualifies for 35% of the rainfall, the flow by 39% stems from rainfall, and the balance of 36% is interception. This characteristic suggests an influence of the appearance of vegetation, both from the architectural aspects of editorial and editorial aspect's density index.

Data obtained from individual observations of vegetation states that the tamarind tree trunk circumference was 101.5 cm; the trunk diameter 30.7 cm, height 10.23 m, canopy bottom is at 6.38 m, and 3.85 m high canopy. While the average width of an editorial is 6.33, the number of primary stems 18,100, and canopy density index is 0.16. With these characteristics it becomes natural that most of the rain water that comes later detained in the canopy and a tamarind tree.

Canopy architecture formed during the growth and development of the complex tangle of trees and contains the basic framework consists of a trunk, branches, twigs, leaves (stalks and leaves) (Oldeman, 1986; DeReffye *et al*., 1995). When it reaches the final stage of development, a tree canopy can be easily distinguished by the canopy of other trees because headlines reveal any specific features (Oldemann, 1986; Harrington *et al*., 1989). In the process of its development, in addition to genetic factors, environmental factors such as air temperature, drought and nutrient, influential especially in the quantity of branches and leaves are formed (Sinclair *et al*., 1998). Genetic factors and environmental factors are crucial for the final appearance and density of the canopy. As a basic search tree canopy architecture used a common pattern of growth of branch-twig-leaves of pota vertical and horizontal patterns. Variations between vertical and horizontal patterns considered through the level of dominance the angle formed at the network (van Noordwijk *et al*., 2002).

4.2. Interception

4.2.1. Homogeneous forests

a. Tamarind

Comparison between the value's stemflow passes the tree canopy in the forest tamarind the less homogeneous the interception that will give the smaller value, otherwise, the value of interception would be even greater if the comparison between the value of the flow passes the rod with the larger canopy. Value interception on tamarind ranged from 0.64 to 14.97 mm. Interception of the close relationship between rainfall, flow and escape trunks in the tree canopy tamarind indicated with R^2 at 0.92 or part of the amount of data that support by 92%, in addition to the increase of 1 mm of rainfall will increase the value of 0.432 interception, stemflow amounted to 0.289, and 0.278 for canopy qualify.

b. Mahogany

Comparison between stemflow value with qualifying mahogany tree canopy on which the less will give the smaller intercept value, otherwise, the value of interception would be even greater if the comparison between the value of the flow passes the rod with the larger canopy. Value interception at mahogany trees ranged from 39.40 to 182.60 mm. Interception of the close relationship between rainfall, flow and escape trunks in the tree canopy Mahogany shown with R^2 of 0.9 or part of the amount of data that support by 90%, in addition to the increase of 1 mm of rainfall will increase the value of stemflow of 0.31 passes through a canopy of 0.38 and intercept values of 0.31.

c. Angsana

Comparison between stemflow value with qualifying angsana tree canopy in which the less will give the smaller intercept value, otherwise, the value of interception would be even greater if the comparison between the value of the flow passes the rod with the larger canopy. Value interception at angsana trees ranged from 0.62 to 5.47 mm. Interception of the close relationship between rainfall, stemflow and crown passes at angsana tree is shown with R^2 of 0.875 or part of the amount of data that support of 87.5%. Besides the increase of 1 mm of rainfall will increase the value of 0.285 qualify canopy, stemflow was 0.463, and the intercept is 0.25.

d. Landi acid

Comparison between stemflow rate with the tree canopy qualifies Landi acid will give the smaller intercept value, otherwise, the value of interception will be greater if the comparison between the value of the flow passes the rod with the larger canopy. Value interception on tree landi acid ranged from 2.37 to 9.63 mm. Interception of the close relationship between rainfall, flow and escape trunks in the tree canopy Landi acids indicated with R2 of 0.979 or part of the amount of data that support at 97.9%, in addition to the increase of 1 mm of rainfall interception will increase the value of 0.4791 passes through a canopy of 0.314, and stemflow of 0.206.

4.2.2. Heterogeneous forests

Comparison between stemflow value with qualifying heterogeneous forest canopy on which the less will give the smaller intercept value, otherwise, the value of interception would be even greater if the comparison between the value of the flow passes the rod with the larger canopy. Value interception in heterogeneous forests ranged from 1.18 to 4.61 mm. Interception of the close relationship between rainfall, flow and escape trunks in the forest canopy heterogeneous indicated with R^2 of 0.936 or part of the amount of data that support at 93.6%, in addition to the increase of 1 mm of rainfall interception will increase the value of 0.265. Figure 1 shows the values obtained from the interception of the highest tree in the forest homogeneous tamarind at 5.52 mm, while the lowest was obtained from a mixed forest of 2.31 mm.

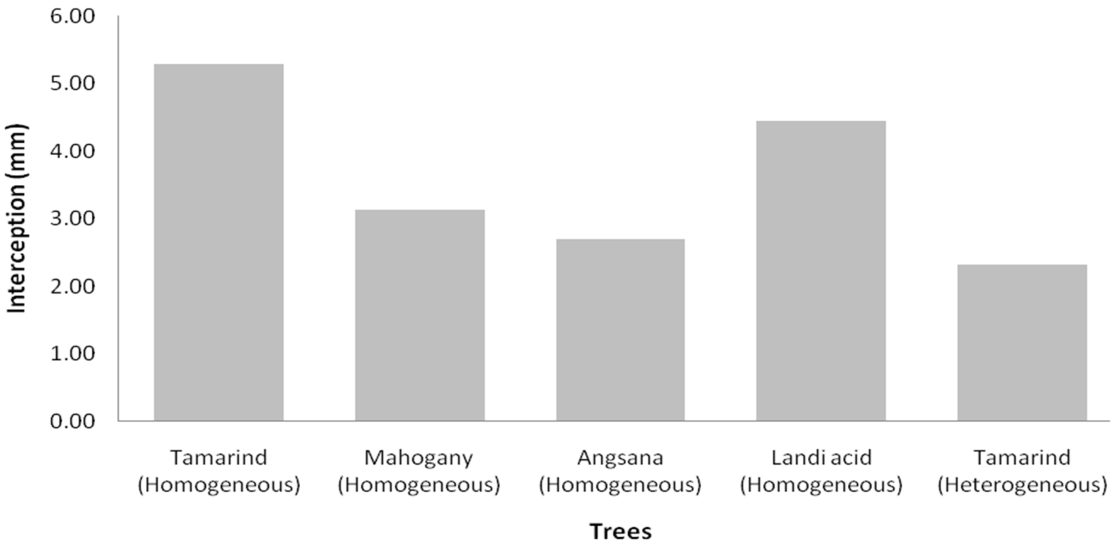

Figure 1. Mean Value Interception on Homogeneous and Heterogeneous Forests

Interception of rain water on the canopy of trees or individual trees with the term hydrology is determined by the density of the tree canopy reflected branching (number, size, angle) and the type of leaf (shape and size) (Marin *et al*., 2000; Asdak, 2000; Soemarwoto, 2001). High density canopy canopy creates a coating that can reduce the strength so that the raindrops land protected from damage or clogging pore's macro aggregates (Notohadiprawiro, 2000; Widianto *et al*., 2004; Hairiah *et al*., 2004). Canopy like this has all the characteristics: many branches that are relatively small; leaves also are relatively small; domiciled upright, and meeting to produce raindrops that are relatively small, and support the flow of water through the stem.

4.3. Throughfall

4.3.1. Homogeneous forests

a. Tamarind

The higher the rainfall, the greater the value escapes the canopy. Conversely the less rainfall, the lower the value escapes the canopy. Rainfall values ranged from 4.57 to 29.86 mm per day, whereas the values ranged from 2.03 to 7.31 mm escapes canopy. A close relationship between rainfall and the tree canopy qualify tamarind indicated with R^2 of 0.907 or percentage of the amount of data that support is at 90.7%, and at every 1 mm increase in rainfall will increase the value of the crown passes for 0.278 on tamarind.

b. Mahogany

The higher the rainfall, the greater the value passes the mahogany tree canopy. Conversely the less rainfall the lower the value escapes the canopy. Rainfall values ranged from 4.367 to 19.904 mm per day, while the value escapes the canopy ranged between 2.03 to 7.11 mm. A close relationship between rainfall and mahogany trees are shown with R^2 of 0.945 or percentage of the amount of data that support by 94.5%, in addition to the increase of 1 mm of rainfall will increase the value of 0.377 qualify canopy.

c. Angsana

The higher precipitation (the homogeneous forest), the greater the value escapes the canopy. Conversely the less rainfall, the lower the value escapes the canopy. Rainfall values ranged from 4.47 to 19.80 mm per day, whereas the values ranged from 1.52 to 6.60 mm escapes canopy. A close relationship between rainfall and qualify Angsana tree canopy is shown with R^2 of 0.954 or percentage of the amount of data that support by 95.4%, in addition to the increase of 1 mm of rainfall will increase the value of 0.285 qualify canopy.

d. Landi acid

The higher precipitation (the homogeneous forest), the greater the value escapes the canopy. Conversely the less rainfall, the lower the value escapes the canopy. Rainfall values ranged from 5.179 to 19.803 mm per day, whereas the values ranged from 1.52 to 6.09 mm escapes canopy. A close relationship between rainfall and tree canopy qualify Landi acid is shown with R2 of 0.985 or part of the amount of data that support at 98.5%, in addition to the increase of 1 mm of rainfall will increase the value of 0.314 qualify canopy.

4.3.2. Heterogeneous forests

The higher rainfall in heterogeneous forests, then the greater the value escapes the canopy. Conversely the less rainfall, the lower the value escapes the canopy. Rainfall values ranged from 4.5 to 18.8 mm per day, while the value escapes the canopy ranged 1,52-6.60 mm. A close relationship between rainfall and the tree tamarind on Heterogeneous forests shown by the R^2 of 0.995 or percentage of the amount of data that support of 99.5%, in addition to the increase of 1 mm of rainfall will increase the value of 0,349 passes canopy. Mean value throughfall on homogeneous and heterogeneous is presented in Figure 2.

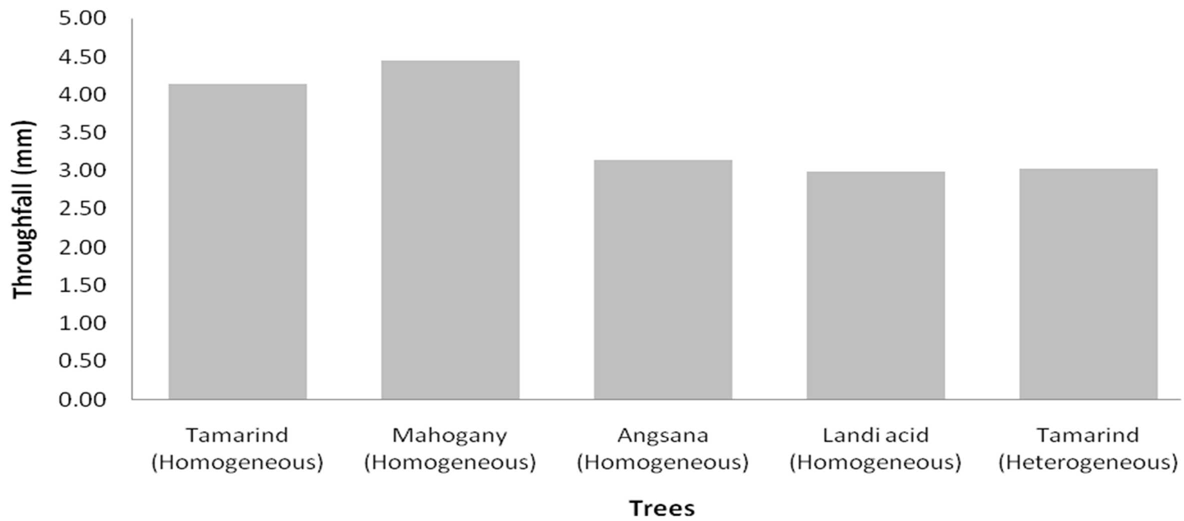

Figure 2. Mean Value Throughfall on Homogeneous and Heterogeneous Forests

Figure 2 shows the highest value obtained from throughfall at mahogany in the forest homogeneous 4.45 mm, while the lowest was obtained from tree's landi acid of 2.99 mm. In addition to the canopy, the soil as a component of the hydrological system also plays a role in accommodating the water to be stored as a group of water (Suprayogo *et al*., 2002). The nature of the soil that supports the hydrologic function is mainly indicated by the soil structure stability particularly agrertat and distribution of soil porosity (Agus *et al*., 1997; Riha *et al*., 1999: Widianto *et al*., 2004) Agretat stable reflects the strength of the bond between soil particles not easy to change. While the macro-and micro-pore distribution reflects the balance between soil water channels in soil and nutrient-mounted media (Baoma *et al*., 2003).

4.4. Stemflow

4.4.1. Homogeneous forests

a. Tamarind

The higher the rainfall, the flow value on a tamarind tree trunk will be higher as well. Conversely the less rainfall, the lower the value of the trunk stream. Rainfall values ranged from 4.57 to 29.86 mm, while the stemflow rate ranged from 1.89 to 7.58 mm per day. A close relationship between rainfall and tree tamarind indicated with R^2 of 0.897 or part amount of data that support is at 89.7% and any increase in rainfall of 1 mm of rainfall will increase the flow rate of 0.289 rods.

b. Mahogany

The higher the rainfall, the greater the flow rate of the stem. Conversely the less rainfall, the lower the flow rate on the mahogany tree trunk. Rainfall values ranged from 4.367 to 19.904 mm per day. Stemflow value is ranged between 1.57 to 6.29 mm. A close relationship between rainfall and stemflow in mahogany tree is shown with R^2 of 0.965 or part of the amount of data that support at 96.5%, in addition to the increase of 1 mm of rainfall will increase the flow rate of 0.31 rods.

c. Angsana

The higher rainfall at angsana, the greater the flow rate of the stem. Conversely the less rainfall, the lower the flow rate of the stem. Rainfall values ranged from 4.47 to 19.80 mm per day, while the flow rate from 2.33 to 9.31 mm rod ranges. A close relationship between rainfall and angsana is shown with R^2 of 0.959 or percentage of the amount of data that support by 95.9%, in addition to the increase of 1 mm of rainfall will increase the flow rate of 0.463 rods.

d. Landi Acid

The higher the precipitation on tree landi acid, the greater the flow rate of the stem. Conversely the less rainfall, the lower the flow rate of the stem. Rainfall values ranged from 5.179 to 19.803 mm per day, while the flow rate from 1.06 to 4.08 mm rod ranges. A close relationship between rainfall and flow on tree trunk's landi acid indicated with R^2 of 0.939 or part of the amount of data that support at 93.9%, in addition to the increase of 1 mm of rainfall will increase the flow rate of 0.206 rods.

4.4.2. Heterogeneous forests

The higher rainfall in heterogeneous forests, the greater the flow rate of the stem. Conversely the less rainfall, the lower the flow rate of the stem. Rainfall values ranged from 4.5 to 18.8 mm per day, while the flow rate from 1.71 to 7.58 mm rod ranges. A close relationship between rainfall and tree tamarind on Heterogeneous Forests shown by the R^2 of 0.98 or part of the amount of data that support by 98%, in addition to the increase of 1 mm of rainfall will increase the flow rate of 0.385 rods. Figure 3 shows the highest value obtained from the crown passes angsana trees in the forest homogeneous by 5.34 mm, while the lowest from landi acid at 2 mm.

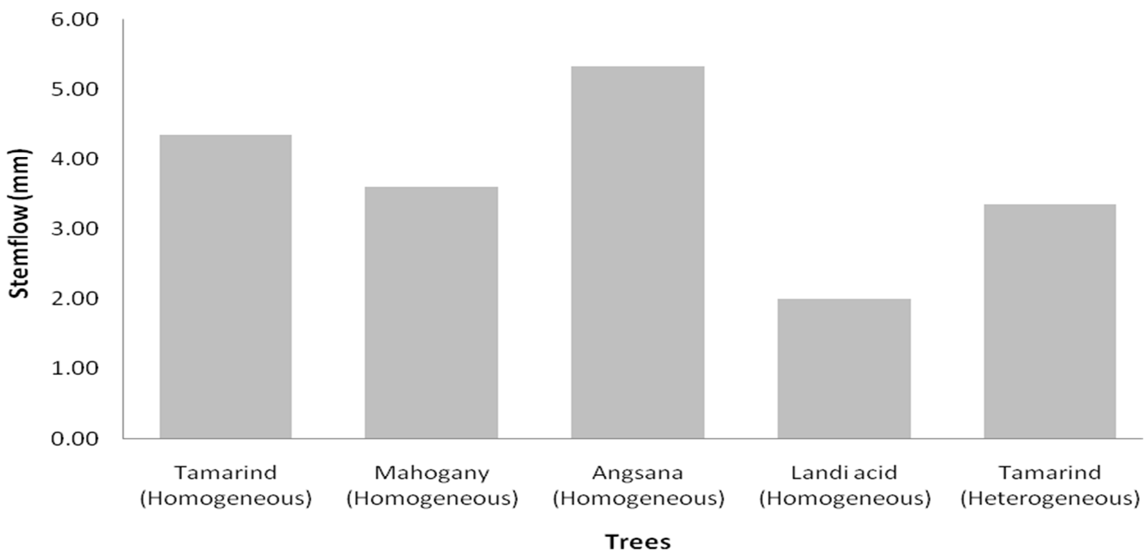

Figure 3. Mean Value Stemflow on Homogeneous and Heterogeneous Forests

Besides influenced by rainfall and topography, water balance is also influenced by vegetation. Management of vegetation, especially with the selection of the right type of vegetation will be able to increase the yield of good water that increases soil water reserves. However, the selection of appropriate types of vegetation will give the opposite result. Forest vegetation city will conduct interception (store) water on the canopy and will continue rain water into the ground throughfall and stemflow to the root zone of the soil. Vegetation will affect the porosity of the soil due to the soil biota that do litter decomposition, so that the dense vegetation, the soil will cause the shaft land so it can absorb more rain water. In addition, the vegetation will reduce the speed of surface run-off.

The flow of water through the stem tends to seep into the ground by following the daram root system but in relatively small amounts (Cannell *et al*., 1996; Jackson, 2000), while the raindrops of a given magnitude will overwrite the soil surface and sometimes break the soil aggregates into particles disbursed in all directions and cover the soil so that the soil macro pores become clogged (Agus *et al*., 1997; Riha *et al*., 1999). Each event flow of water from the canopy to the soil surface for the consequences of different levels of water flow into the ground and surface water flow (Notohadiprawiro, 2000; Asdak, 2000).

5. Conclusion

The results show the identification of the characteristics of the urban forest in the city of Surabaya, is; 1) the structure of the canopy can be seen from the value of the index on the density of the canopy of each tree, the tamarind at 0.16, mahogany at 0.13, angsana at 0.07, landi acid at 0.16, and tamarind in a heterogeneous forests at 0.16 , 2) interception of rainfall indicated by the R2 value of 0.92 on a tamarind tree, mahogany at 0.9, angsana at 0.88, landi acid at 0.979, and 0.936 for the heterogeneous forests, 3) throughfall in homogeneous forest trees tamarind at 4.13 mm, mahogany at 4.45 mm, angsana at 3.14 mm, and landi acid at 2.99 mm, and 4) stemflow in the forest is homogeneous trembesi at 4.35 mm, mahogany at 3.61 mm , angsana at 5.34 mm, landi acid at 2 mm, and heterogeneous forest (tamarind) at 3.35 mm.

Suggestions from this study is necessary in the review of research on the optimization of the urban forest planning in the city of Surabaya in order to improve environmental quality in the city of Surabaya

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