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THE INFLUENCE OF VERTICAL GARDEN APPLICATION ON HOUSE EXTERIOR TO ROOM TEMPERATURE

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Graphical abstract

Abstract

The decrease of green areas around houses leads to the increase of both in-house and out-house temperature. The development of garden nowadays brings people into developing vertical gardens to fulfill the needs of green areas. The existence of vertical gardens causes many impacts. One of them is the impact toward the temperature. However, further research is needed to determine the level of this impact. This journal aims to find the influence of exterior vertical gardens toward air temperature. This is a descriptive qualitative case study with several houses as the samples. The houses chosen as the samples are those with and without exterior vertical gardens located within similar air temperature environment. In this study, the measurement is not only conducted in the real houses chosen as the samples but also in the models of houses. Based on the results of the study, it is found that the application of vertical garden on house exterior does not only enhance esthetic values of the house but can also become the solution for the limited open green space. Moreover, the vertical garden is also functioned as natural air cooler; the decrease of the temperature in each house depends on the size of vertical garden it has.

Keywords: House, vertical garden, air temperature

1.0 INTRODUCTION

The global warning issues such as greenhouse effect, poles' iceberg melting, and the increase of temperature become serious matter for many people nowadays including for the field of architecture. The architect as designer of a city has an important role in this matter.

The increasing needs of spaces makes the spaces for green areas get narrower. This happens not only in a big scale like city scale but also in neighborhood scale. The decreasing of green spaces is also considered as one of the causes of global warming [1].

House is a perfect example of architectural work that is used and needed by all people. In Indonesia, the need of housing increases year by year and makes people have to maximize the use of the land [2]. As the result, people start disregarding the importance of green area or garden in their houses. The use of air conditioners in the houses is chosen as the solvency of temperature problem [3]. People seem to forget that the existence of gardens in their houses may influence the temperature around them [4].

Based on the calculation and analysis of BMKG, from 1983 to 2003, the increase of temperature is 0,036˚ C – 1,383˚ C [5]. Moreover, most of big cities in Indonesia have 1˚C air temperature increase within 10 years. Semarang and Bandung are among the cities which have significant escalation in their air temperature since 1990s. The increase of the temperature is calculated based on the increase of UHI (*Urban Heat Island*) [6].

Vertical garden is regarded as solvency to overcome the increase of air temperature in a building or a house [7]. In a big city like Bandung, Jakarta, and Surabaya, vertical garden is widely

applied. However, people of Semarang only apply this kind of garden at resident areas. The phenomenon of air temperature increase caused by the maximization of resident space is indeed a serious problem that needs to be solved. Thus, a study of the influence of vertical garden towards air temperature is needed.

2.0 METHODOLOGY

This study took several houses with vertical gardens in Semarang as the samples. The houses are chosen randomly and the calculation of the temperature is done on day time basis.

2.1 Samples

Not only measuring real houses with vertical gardens, the models of the houses are also made and measured. The measurement of the models is conducted in two different rooms for comparison. The first model room (6x8 cm²) is directly connected to vertical garden. The second model room (6x8 cm²) does not have direct connection to the garden. Table 1 shows list of sample houses and their time of measurement

Table 1 The list of sample houses and their time of measurement

House with Vertical Garden	House without Vertical Garden	Time for Measuring Room Temperature
Djajanti's House 1st Floor Jl. Semeru Raya no. 4, Semarang	Djajanti's House 2nd Floor Jl. Semeru Raya no. 4, Semarang	April 2015 13.48-14.00
Ranting's House Jl. Rambutan VI no.8, Semarang	Mr. Tri's House Jl. Rambutan VI No 48, Semarang	April 2015 14.44-15.00
Mrs. Ayi's House Jl. Adhe Irma Suryani no. 54, Ungaran, Kabupaten Semarang	Mr. Bambang Wahjuono's House Jl. Ade Irma Suryani No. 56, Ungaran.	Mei 2015 13.50-13.56
Miss Yudith's House Jl. Kolonel Sugiono no.2, Sususkan, Ungaran, Kabupaten Semarang	Mr. Fauzan's House Jl. Brigjen Katamso No 99B, Susukan, Ungaran	Mei 2015 14.20-14.37

On the other hand, Figure 1 shows the model's blueprint and areas of measurement

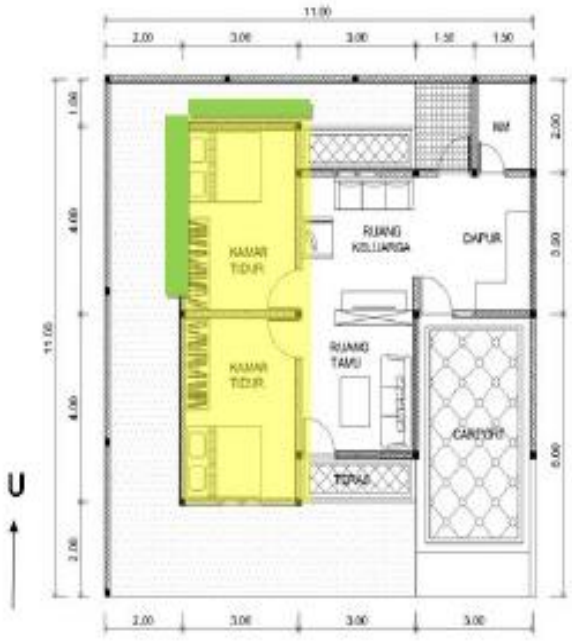

Figure 1 Model's blueprint and areas of measurement

2.2 Equipments

The model of the room for measurement with the scale of 1:50 is built using similar material as used in the real house to simulate the real environment. Figure 2 shows the tools and materials used to make the models and Figure 3 shows the materials used to make the models. On the other hand, Figure 4 shows the process of making of one of models with vertical garden

Figure 2 Tools and materials used to make the models

Figure 3 Materials used to make the models.

Figure 4 The making of one of models with vertical garden

Anemometer (with built-in temperature measuring application) is used to measure air temperature in real house. As for the measurement in the model house, Multimeter – the thermometer with dual measuring points (T1 and T2) and the ability to show the gaps between the two – is used. Figure 4 shows the anemometer and multimeter

Figure 4 Anemometer (left) and Multimeter (right).

3.0 FINDINGS AND DISCUSSION

The results of the measurement will be analyzed and discussed below.

3.1 Djajanti's House

The first study is conducted at Djajanti's House, a guesthouse owned by Mrs. Keni and Mr. Pur. Djajanti's House is located at Jalan Semeru Raya No.4B Karangrejo, Gajahmungkur, Semarang. The first floor of this guesthouse becomes the object of the study because it has a vertical garden, and the second floor of the guesthouse is also chosen for measurement because it does not have the garden.

The vertical garden at the back of the guesthouse's rooms is planted with creeping plant *hedera* with cable frame while the front garden is planted with *Markisa* plant with bamboo frame. Figure 5 shows the vertical garden in the front (left) and back (right) of Djajanti's House.

Figure 5 vertical garden in the front (left) and back (right) of Djajanti's House

The result of room temperature measurement on Thursday, April 2015; 13.48-14.00 (measured 4 times) is shown in Table 2

Table 2 The average room temperature of Djajanti's House

No.	Object	Temp
1.	Djajanti's House, 1st floor	28.9°C
2.	Djajanti's House, 2nd floor	31.1°C

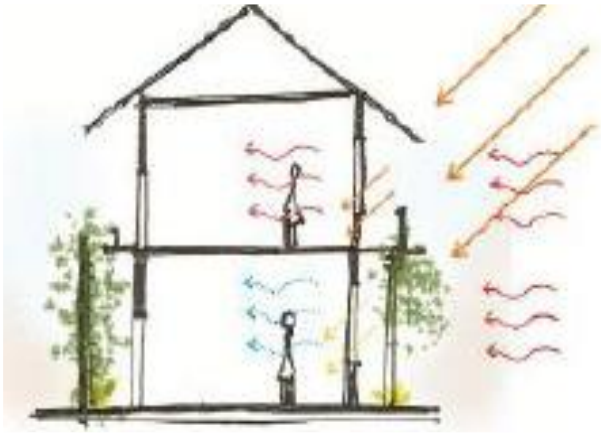

Figure 6 Sketch analysis of temperature reduction at Djajanti's House

At Djajanti's House, the vertical garden with Markisa and *Hedera* plants covering 40% of the building exterior makes the 1st floor 2.2°C cooler. It shows that the vertical garden decreases the temperature from 31.1°C to 28.9°C. The vertical garden in the first floor reduces sun radiation and heat so that the air flowing to the interior of the building becomes cooler. Figure 6 visualizes thes ketch analysis of temperature reduction at Djajanti's House.

3.2 Ranting's House

The second study is conducted at Ranting's House, a guesthouse owned by Mr. Beni. Ranting's House is located at Jalan Rambutan VI no 8-16 A. Ranting's House is chosen as the house with a vertical garden. As the comparison, Mr. Tri's House is chosen because it is located near to Ranting's House, and it does not have vertical garden. Mr. Tri's House is located at Jalan Rambutan VI No 48.

The vertical garden at Ranting's House is made along the corridor of the house. It is used as canopy and partition. The vertical garden at Ranting's House is planted with *sirih gading* with hanging frame made of cables and bamboos. Figure 7 demonstrates the Vertical Garden at Ranting's House

Figure 7 Vertical Garden at Ranting's House

The result of room temperature measurement on Thursday, April 2015: 14.44-15.00 (measured 4 times) is shown in Table 3 and Figure 8 shows the sketch analysis of temperature reduction at Ranting's House.

Table 3 The result of room temperature measurement of Ranting's House

No.	Object	Temp
1.	Ranting's House	32.1°C
2.	Mr. Tri's House	34.0°C

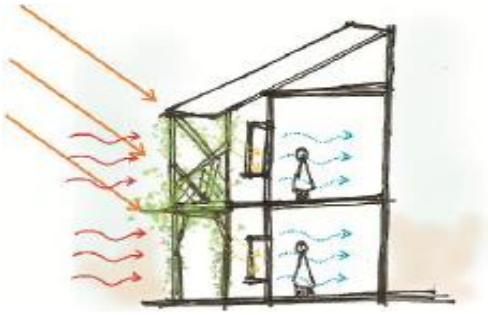

Figure 8 Sketch analysis of temperature reduction at Ranting's House

At Ranting's House, the vertical garden with *sirih gading* plants covers 40% of the building exterior. The result of the measurement shows a significant difference of the room temperature in Ranting's House and in Mr. Tri's House where Ranting's House is cooler by 1.9 °C. Therefore, it can be concluded that a vertical garden with *Sirih Gading* at Ranting's House successfully reduces the temperature. The vertical garden at the corridor reduces the sun radiation and heat and makes the air temperature in the environment cooler.

3.3 Mrs. Ayi's House

The third study is conducted at Mrs. Ayi's house which is located at Jalan Ade Irma Suryani No. 54, Ungaran as the house with vertical garden and Mr. Bambang Wahjuono's House, located at Jalan Ade Irma Suryani No. 56, Ungaran, as the house without vertical garden.

The vertical garden at Mrs. Ayi's House is planted with *Hedera* plant with cable frame and geotextile system. Figure 9 shows the Vertical Garden at Mrs. Ayi's house

Figure 9 Vertical Garden at Mrs. Ayi's house

The result of room temperature measurement on May 2015:13.50-13.56 (measured 4 times) is shown in Table 4 and Figure 10 shows the sketch analysis of temperature reduction at Mrs. Ayi's house

Table 4 The result of room temperature measurement at Mrs. Ayi's house

No.	Object	temp
1.	Mrs. Ayi's House	34.3°C
2.	Mr. Bambang Wahjuono's House	34.4°C

Figure 10 Sketch analysis of temperature reduction at Mrs. Ayi's house

The result in Table 4 shows no significant difference in temperature at Mrs. Ayi's house and Mr. Tri's house. It is indicated by the gap of temperature that is only 0.1 °C. Therefore, it can be concluded that a vertical

garden with geo-textile media and creeping plants which only covers 5% of the house exterior does not have big influence toward temperature reduction. This form of vertical garden only reduces 0.1 °C of environment temperature. It is unable to reduce the sun radiation and heat; thus, both out-house and in-house temperatures are almost equal.

3.4 Mrs. Yudith's House

The fourth study is conducted at Mrs. Yudith's house. It is located at Jalan Brigjen Katamso No 100, Susukan, Ungaran. This house is chosen as the house with vertical garden. The second house, owned by Mr. Fauzan is chosen as comparison since it does not have vertical garden. Mr. Fauzan's house is located at Jalan Brigjen Katamso No 99B, Susukan, Ungaran. The vertical garden at Mrs. Yudith's house is mostly arranged with geo-textile system and layered system. It is planted with various kinds of plants. Figure 11 shows the Vertical Garden at Mrs. Yudith's house.

Figure 11: Vertical Garden at Mrs. Yudith's house

The result of room temperature measurement on May; 14.20-14.37 (measured 4 times) is shown in Table 5 and Figure 12 shows the sketch analysis of temperature reduction at Mrs. Yudith's house.

Table 5 The result of room temperature measurement at Mrs. Yudith's house

No.	Object	Temp
1.	Mrs. Yudith's house	28.1°C
2.	Mr. Fauzan's house	30.5°C

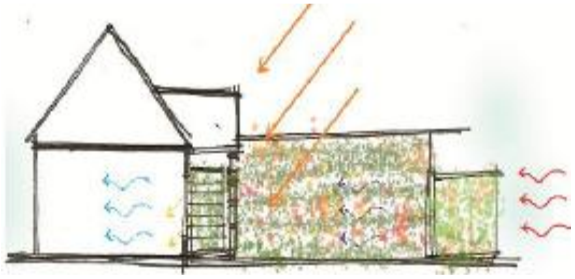

Figure 12 Sketch analysis of temperature reduction at Mrs. Yudith's house

At Mrs. Yudith's house, the vertical garden with geo-textile and layered system covers about 60% of exterior area. The measurement shows that it reduces the house temperature by 4.2° C. it also shows that there is 2.4°C gap of temperature in at Mrs. Yudith's house and Mr. Fauzan's house. Therefore, it can be concluded that a vertical garden successfully reduces the temperature. It also reduces the sun radiation and the heat and makes the air temperature in the environment cooler.

3.5 The Study of Sample Models

Figure 13 shows the vertical garden in the model and Table 6 shows the result of temperature measurement of the models.

Figure 13 Vertical garden in the model

Table 6 The result of temperature measurement of the models

Day / Temp	Friday, 1st of May 2015			Saturday, 2nd of May 2015			Sunday, 3rd of May 2015		
	08.00	13.00	18.00	08.00	13.00	18.00	08.00	13.00	18.00
T1	34,3	31,1	29,6	28,9	32,0	30,0	34,5	31,7	29,0
T2	31,4	30,4	28,4	27,2	31,1	27,9	33,9	28,0	28,0
T3	33,8	30,9	29,1	28,2	31,9	28,3	34,4	31,3	28,0
T2-T3	-2,4	-0,5	-0,7	-1,0	-0,8	-0,4	-0,5	-3,3	0
T2-T1	-2,9	-0,7	-1,2	-1,7	-0,9	-2,1	-0,6	-3,7	-1

Based on the result of temperature measurement which has been done in 3 days, it can be concluded that the room temperature in the model with vertical garden in its exterior is lower compared to the temperature of the room without vertical garden. The biggest temperature reduction happens on Sunday, May 3rd, 2015, at 13.00 in which the room temperature is 3.7°C cooler than the temperature

outside the room. Figure 14 shows the sketch analysis of temperature reduction in the model.

Figure 14 Sketch analysis of temperature reduction in the model

The vertical garden attached to the wall of the model reduces sun radiation and heat and makes the air temperature cooler.

4.0 CONCLUSION

Based on the study on the application of vertical garden on house exterior, it is found that the vertical garden does not only enhance esthetic values of the house but can also become the solution for the limited open green space. Moreover, the vertical garden is also functioned as natural air cooler.

- The application of vertical garden using the hanging system with *Markisa* and *Hedera* plants covering 40% exterior of the first floor of Djajanti's House can decrease the room temperature by 3.1 °C. Thus, the decrease of the temperature can reach up to 7.75°C if 100% of the exterior is covered by the vertical garden with this hanging system.
- The application of vertical garden using the hanging system with *Sirih Gading* plants covering 40% of Ranting's House can decrease the room temperature by 2.5 °C. Hence, if the vertical garden with this system covers 100% of the exterior, the decrease of the temperature can reach up to 6,25°C.
- The application of vertical garden using the geo-textile and layered system with various plants covering 60% of the exterior of Mrs. Yudith's House can decrease the room temperature by 4.2 °C. Thus, if the vertical garden with this system covers 100% of the exterior, the decrease of the temperature can reach up to 7°C.
- Types of plants and the media/systems of planting used for vertical gardens influence the level of temperature decrease.
- The percentage of coverage of vertical gardens on the exteriors of buildings influences the level of temperature decrease. The bigger the coverage is, the more the temperature can be decreased.

Based on the conclusions above, the researchers realize that this study has several weaknesses. Other researchers are expected to consider the choice of related aspects such as planting media, types of plants, locations of vertical gardens, and intervals between vertical gardens and buildings so that the result of their research can be a better evidence to prove that the vertical garden can function as natural air cooler.

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