

A study on surface temperature of different materials

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Abstract. Excessive buildings took over green vegetation, which aggravated the greenhouse effect. If we use vegetation as roofs and exterior walls of buildings, the areas of plants will not reduce, and even the temperature around the building will decrease. Therefore, we planned to detect the surface temperature of different materials to provide evidence for ideal materials. We detected surface temperature of different materials with an infrared temperature gun (DELIXI, DM-5002). Detected materials included turf, suffruticosa plant, and soil under them, tile or concrete, wood, water with different depths of 1cm, 5cm, 10cm. We detected different materials under different weather conditions. The surface temperature of turf was significantly decreased compared with tile or concrete, wood ($p < 0.05$). There was no significant difference between wood and tile/concrete temperature. Compared with tile/concrete or wood, the surface temperatures of water, turf, suffruticosa plant, and soil under plant significantly decreased ($p < 0.05$). There was no significant difference of temperature between water with different depths. There was no significant difference in temperature between turf, suffruticosa plant, and the soil under them, too. The surface temperatures of turf, suffruticosa plant, and water were significantly lower than those of tile/concrete and wood we used as raw materials of buildings. Plants can be recommended as new materials covering roofs and exterior walls to decrease temperature around buildings in summer.

Keywords: surface temperature, turf, suffruticosa plant, water, tile, concrete, wood

1. Introduction

With the accelerating urbanization, the total housing areas exceeded 50 billion centiares in China. Although urbanization brings economic growth, greenhouse gas emissions are substantially increasing. Numerous farmlands changed to buildings, and green vegetation reduced rapidly. It is one of the causes of the greenhouse effect, which results in Global warming, one of the major environmental problems we have to face today. The human race is challenged by climate change seriously. The chain reaction of increasing temperature, environmental repercussions, land deterioration, rainfall fluctuation, precipitations, ecological deficit, and greenhouse gas accelerates environmental degradation [1]. A report from Southeast Australia showed that urbanization derived from increasing air temperature and stream temperatures, and their combined effects on the greenhouse were larger than their individual effects occurring alone [2]. It is very important to keep ecological balance during urbanization.

The surface temperature of roofs and exterior walls is high in summer, which increases the temperature of the surrounding air. Tile and concrete are usually used in roofs and exterior walls. If we can find new materials to cover the current tile or concrete, the temperature in summer will decrease, and we needn't cost too much electric power resources on air conditioners. It will improve the greenhouse effect.

In this study, we planned to detect the surface temperature of different materials to provide evidence for new material selection covering roofs or exterior walls. As for materials, we selected tile and concrete as controls, turf, suffruticosa plants, the soil under a plant, wood, and water with different depths to find suitable materials. There are still a small number of roofs and exterior walls made from wood, so we used wood as a control. As we all know, the soil under a plant contains a certain amount of water, so we also wanted to observe the temperature of the water and soil under the plant. We selected different depths of water in order to observe the effect of water volume on temperature.

2. Materials and Methods

We detected the surface temperature of different materials an infrared temperature gun (DELIXI, DM-5002). The distance spot ratio was 12:1. Emissivity was 0.95. The temperature range was from -50 to 500 centigrade. The measurement time was more than 0.5 seconds every time. Materials were detected, including turf, suffruticosa plant and soil under them, tile or concrete, wood, and water with different depths of 1cm, 5cm, 10cm at the same altitude. Whether sunlight, room temperature, humidity, date, and time of detection were also recorded.

Continuous variables are presented as the means \pm standard deviation, and the means are compared by Student's t-test. Statistical tests were two-sided. A p-value <0.05 was considered statistically significant. All data were analyzed by SPSS 22.0 (IBM Corp., Armonk, NY, USA).

3. Results

We collected 40-day data from 8:00 AM to 5:00 PM under the weather of sunny (19/40), cloudy (17/40), and rainy days (4/40) from September to October 2023 in Shanghai. The humidity during 40 days changed from 39% to 69%.

There was no significant difference between wood and tile/concrete temperature. Compared with tile/concrete or wood, the surface temperatures of water, turf, suffruticosa plant and soil under plant significantly decreased ($p<0.05$). There was no significant difference between water with different depths. There was no significant difference in temperature between turf, suffruticosa plant, and the soil under them. The detailed data is found in Table 1.

Table 1. The Surface Temperature of Different Materials

Materials	Temperature (°C)
Turf	28.30 \pm 3.43 ^{ab}
Soil under Turf	26.69 \pm 3.42 ^{ab}
suffruticosa plant	29.05 \pm 4.17 ^{ab}
Soil under suffruticosa plant	27.46 \pm 4.06 ^{ab}
Tile/Concrete	34.41 \pm 6.74
Wood	33.48 \pm 7.42
Water	
The depth of 1cm	28.50 \pm 3.33 ^{ab}
The depth of 5cm	28.75 \pm 3.35 ^{ab}
The depth of 10cm	28.77 \pm 3.26 ^{ab}

^a: There was a significant difference compared with tile/concrete.

^b: There was a significant difference compared with wood.

4. Discussion

Globally, the frequency, intensity and duration of heatwaves have increased since 1950, with the trends projected to worsen under climate change [3]. Even if climate warming is limited to 2 °C above pre-industrial temperatures, substantial increases in the frequency of heatwaves are projected, and >350 million megacity inhabitants could be affected by mid-century [4]. In recent decades, there have been many studies using “surface urban heat island (SUHI)”, which refers to the differences in land surface temperature between urban and rural areas [5-7]. The surface temperature of buildings directly affects the greenhouse effect with the acceleration of urbanization.

In this study, we compared the surface temperature of turf, suffruticosa plant, the soil under the plant, water, tile or concrete and wood. We found the surface temperatures of turf, suffruticosa plant and water were lower than those of tile or concrete and wood. Wood temperature was similar as tile or concrete. The roofs and exterior walls of the current building are mostly made from tile or concrete and partly from wood. According to the results of this study, we had better choose grass, suffruticosa plants and water as new materials covering roofs and exterior walls. The depth of grass roots is shorter than that of the suffruticosa plant. Therefore, the grass is superior to suffruticosa in covering roofs to prevent building destruction by roots.

Appropriate plants can be selected according to local conditions and economic value. For example, scallion is a good selection in Shanghai because it is cold-resistant and drought-enduring. It grows to a certain height without extra nutrition. The height of soil its root need is 5-10 cm, so we needn't worry about the destructiveness of its root to house and the over-weight of soil on roofs. Its weight isn't heavy, so it cannot affect the original bearing structure. Scallion is often used as food. We can get economic benefits from it. Plants with vines have been used to cover exterior walls for a long history. But it should be cared for and maintained periodically. If we design special equipment to manage the kinds of plants outside buildings, this problem will be solved. Some economic plants, such as sweet potato and *Gynura cusimbua*, can be considered because of their edibility of leaves or roots.

Spraying water can be used as a cooling method in summer. We detected water temperatures with different depths. There isn't a significant difference between water with depth of 1cm, 5cm, 10cm. It means we can use water for cooling without limitation of water quantity. But an insect, such as a mosquito, also breeds in water if we use water or hydroponic plant covering roofs. And spraying water is not appropriate for hot and humid environments. If we use turf to cover roofs and spray water periodically, ecological systems on roofs can be sustainable.

We also detect the surface temperature of soil under plants, including turf and suffruticosa plants. The means of soil surface temperature were a little lower than those of plants, especially on sunny days. It hinted at the temperature difference made because of sunlight.

5. Conclusion

We detected the surface temperature of different materials under different weather conditions. The surface temperatures of turf, suffruticosa plant, and water were significantly lower than those of tile/concrete and wood. Plants can be recommended as new materials covering roofs and exterior walls to decrease the temperature around buildings in summer. This is a pilot study designed to find appropriate materials for exterior buildings. We will continue to collect related data for further investigation. We will continue to collect related data for further analysis of sub-groups, for example, with or without sunlight, summer or winter, and so on. We hope to provide substantial evidence for new materials covering exterior buildings in the future.

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