An Investigation on the Impact of Different Vegetation Types on Microenvironment in Winter

Xiaojing Yang, Yu Liu, Shangkai Hao

Northwestern Polytechnical University, 127 West Youyi Road, Xi'an Shaanxi, 710072, P.R.China

liuyu@nwpu.edu.cn

Abstract. The carefully designed greening system can significantly improve the thermal comfort of a microenvironment. A greening system is usually composed of different vegetation types, which have different impacts on their surrounding microenvironment. In order to evaluate the impacts of different vegetation types on campus microenvironment, four representative plots with different vegetation types (arboretum + lawn, shrub + lawn, lawn, bamboo forest + lawn) in a university campus in northwest China were selected for investigation. HOBO temperature and humidity recorder were used to monitor the temperature and humidity of four plots at a level of 1.5m high in for 24 consecutive hours in 5 days in winter of 2019. The results show that, during the observation period, all the four kinds of vegetation types have a certain influence on the microenvironment, and the degree of influence shows a trend of bamboo forest + lawn> arboretum + lawn> shrub + lawn> lawn. The results of this research are expected to provide a reference in the selection of vegetation types for the design of campus greening system.

1. Introduction

At present, cities are affected by factors such as building density, man-made heat sources, and vegetation structures. Thermal environment problems are becoming increasingly prominent. At the same time, the decline in the quality of the outdoor microenvironment has forced urban residents to rely more on artificially closed environments, and this dependence will undoubtedly increase the overall energy consumption of the city [1]. Therefore, in recent years, many scholars have conducted a lot of research on the relationship between climate and architecture and cities, as well as the improvement of urban microclimates, in order to optimize the urban microclimate environment through effective environmental design strategies and make full use of existing natural resources and climatic conditions.
Moreover, the harsh climate conditions in severely cold areas can improve the overall campus comfort level by improving the campus microclimate environment. The existing research on campus microclimate is mainly on the impact of different types of green space and vegetation structure on the microclimate on campus and the microclimate of a single building on campus [2]. However, there is a lack of measured research on the relationship between campus square space and microclimate. This paper studies the relationship between winter vegetation and microclimate in severe cold areas and conducts field surveys and research analysis to improve the quality of the campus environment and the comfort of outdoor activities on campus.

2. Research status

The previous research mainly focused on three major aspects: one is based on the temperature and humidity of human thermal comfort as an evaluation indicator, summarizing the characteristics of campus space environment at different levels of safety, health, comfort, etc.; the second is the use of green land as a unit, and the observations are relatively different The scale, green quantity, structure of shrubs and shrubs and planting methods of the green space itself have microclimate effects; the third is the prediction and optimization of building energy consumption [3]. In addition, the research on urban microclimates in hot summer and cold winter regions focuses more on the benefits of cooling and humidification in summer, while there is less research on outdoor space in winter.

3. Research purpose and significance

This study takes the Northwestern Polytechnical University Chang'an campus as an example to investigate the role of different vegetation types in regulating the microclimate. The purpose of this study is to explore how to build healthier and more comfortable learning and living space.

4. Research content and methods

4.1 Plot selection

Northwestern Polytechnical University is located in Chang'an District, Xi'an, Shaanxi Province, China. Xi'an is located in the middle of the Guanzhong Plain, bordering the Weihe River in the north and the Qinling Mountains in the south. It has a temperate continental monsoon climate with high temperature and rain in summer and a little cold and rain in winter. The climate is mild, the four seasons are distinct, the rainfall is moderate, the annual average temperature in the urban area is 13.3°C, the average temperature in the coldest January is -0.4 ~ 0.9°C, and the average temperature in the hottest July is 25 ~ 26.6°C.

According to the goal, four green areas with different vegetation types were selected in the Chang'an campus of Northwestern Polytechnical University. At the same time, the hard pavement areas away from the green area were selected as the reference plot for air temperature and humidity monitoring (Figure 1).
4.2. Test equipment and methods

HOBO temperature and humidity recorder (model: MX1101, UX100-003), tripod and self-made simple radiation shield were used to measure the temperature and humidity of the target plot continuously from December 20 to December 25, 2019.

Figure 1. Location of plots [4]
The measuring instrument is set at a height of 1.5m above the ground and shielded by a radiation shield to avoid direct sunlight.

4.3. Data processing and analysis

Weather December 19, 2019: Cloudy to sunny

Weather on December 20, 2019: Sunny (less fog)

Weather on December 21, 2019: Sunny (less fog)

Weather on December 22, 2019: Sunny (medium fog)

Weather December 23, 2019: Fog

Weather December 24, 2019: Overcast

Weather December 25, 2019: Rain

Due to the retrieval of the experimental instrument at around 10:00 on December 25, the data is less than one day and will not be analyzed.

Analysis of the data obtained from the above 6 days of continuous observations shows that the lowest temperature in a day is concentrated between 7:17-8:17, and the highest temperature is concentrated between 14:47-15:17. And the highest humidity value is basically consistent with the appearance time of the lowest temperature, and the lowest humidity value is basically consistent with the appearance time of the highest temperature. And under the clear weather conditions of the previous 4 days, the temperature and humidity changes were significant from 7:17 in the morning to 14:47 in the afternoon. At the same time, the humidity will rise rapidly between 14:47 in the afternoon and 20:47 in the evening.

On the day of the winter solstice (December 22), the lowest temperature during the monitoring period appeared at 07:47: -2.771℃, and the temperature difference on that day was also the largest during the monitoring period, which was 11.563℃.

4.3.1. Data processing of lawn plot. Comparing the data obtained from the 5 days of continuous observation on the lawn plot with the hard paved ground can be obtained: Because the measurement height is located at 1.5m, it is different from other plots with other plants covering, and its life activity is weak, although the lawn temperature It is always slightly lower than the hard pavement, the cooling effect is not as obvious as other sites. Because the lawn has a certain water-retaining capacity, during the temperature gradually rising from early morning to noon, the humidity change is relatively smooth, and the rate of decline is not obvious from the hard pavement, indicating that it has a certain humidifying effect. The grassland and the first three days of fine weather showed good cooling and humidification effects, but no obvious effect after the rainy days (Figure 2).
4.3.2 Data processing of bush plot. Comparing the data obtained from the five-day continuous observation of the shrub plot with the hard paving above, the temperature and humidity of the shrub plot change more drastically. The preliminary analysis should be that the shrub plot is located in the open area of the North Gate entrance square, so the sunlight is more than other samples If the ground is sufficient, it will be greatly affected by solar radiation. In 3 days of fine weather on December 20-23, the daily maximum temperature is higher than the hard pavement, and the minimum humidity is lower than the hard pavement (Figure 3).
4.3.3 Data processing of grove plot. Comparing the data obtained from the 5 days of continuous observation in the arbor plots with the hard paved ground, it can be seen that the temperature and humidity changes in the arbor plot are slightly smoother than the hard paved ground. The temperature and humidity are always slightly lower than the hard pavement. The preliminary analysis is that the humidity is slightly lower than the hard pavement because the arbor-like lawn and deciduous plants mostly enter the dormant period in winter, and the soil is exposed a lot, so the water retention capacity is greatly weakened, causing the internal air to dry; the temperature is slightly lower because there are certain evergreen trees besides deciduous plants in the arbor forest, which has a certain shading effect. Generally speaking, the cooling effect of arbor plots is more significant (Figure 4).

![Figure 4. Temperature/ RH of grove plot](image)

4.3.4 Data processing of bamboo forest plot. Comparing the data obtained from the five-day continuous observation of the bamboo forest plots with the hard paving ground above, the relative humidity of the bamboo forest is extremely gentle for two reasons: first, because the bamboo forest is located in the southeast corner of the atrium, there are few moments when the sun is directly shining; Secondly, due to the extremely high degree of canopy closure, the bamboo forest has a certain shading ability. The temperature of the bamboo forest is lower than the hard pavement only from 8:17 am to 14:17 pm, and the other two are almost even at all times. In general, bamboo forests showed better cooling and humidification capacity (Figure 5).
5. Results and discussion

It can be drawn from the air temperature changes of various plots that, relative to the hard paving, each plot plays a certain role in regulating the air temperature in the micro-environment during the daytime in winter. Decrease. Through comparison, it is found that compared with other plots, bamboo plots have the best temperature adjustment effect, which slows down the change of the internal micro-environmental temperature of the plot during the winter day (Figure 6).
The continuously measured temperature data are averaged to obtain a line graph of the temperature change of each plot, and you can intuitively see that the internal ambient temperature varies with the outside atmospheric temperature in different ways. In the sample plot selected in this experiment, the lowest temperature in the whole day appeared at 7:17-8:17 in the observation day. At 14:47-15:17 in the afternoon, the temperature of each plot reached the highest value throughout the day. At this time, the difference between the temperature of the bamboo forest plot and the temperature of the hard paved plot could reach 2.044°C. The rate of temperature increase in all plots was greater between 8:17 am and 14:17 pm; the temperature change during the period from 14:017 to 16:17 pm increased more slowly; and from 16:00 to 18:00 pm. During this period, the temperature of the air inside the sample plot gradually decreased.

Relative humidity data at a height of 1.5m above the ground in the microenvironment measured in each sample plot was drawn into a line chart by Microsoft office Excel 2019, and the measured data were analyzed by comparison. The relative humidity of each test plot at 8:17 am The highest value, the relative humidity gradually decreased with the increase of the outside temperature, and by 16:17 in the afternoon, each test sample reached the lowest value in the observation period. It can be found from the line chart that the relative humidity inside the bamboo forest plot during the daytime observation period is higher than other plots. The relative humidity of all plots throughout the day and at all time periods is higher than that of hard paved plots. This shows that compared with the vegetation-free pavement plots, all types of green plots can play a good role in regulating the increase of relative humidity.

6. Conclusion
By measuring the temperature and humidity of the plots of different vegetation types for a period of 5 days before and after the winter solstice, the results show that each type of green land exhibits a significant cooling and humidification effect relative to the non-greening ground (hard paved ground). The trend is as follows: bamboo forest + lawn> tree + lawn> shrub + lawn> lawn.

Some lessons are also learned from this study. The data of the shrub + lawn sample plot showed significant fluctuations under the influence of solar radiation. After investigation, the sample plot was found to be open, well-ventilated, and basically unobstructed, so the sample plot data was inaccurate. Set the monitoring time interval to 1 minute before the start of the formal experiment. After taking back the analysis, I think it is too frequent and has no practical significance. After the formal experiment, the monitoring time is set to 30 minutes, and the various plots are not kept in sync. After some difficulties in analyzing the data.

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