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Simulation Study and Evaluation the Impact of Road Greenbelt Layout on Particulate Matter Dispersion and Removal

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Abstract: As the skeleton of the city, the road is the most significant one among the five elements of the city image. The road greenspace have been suggested as one of the green infrastructures that could improve near-road air quality. The road greenbelt of the cross section layout is the core content of road green space planning and design. However, existing studies have primarily focused on the effect of different plants on atmospheric particulate matter (PM), whereas the impact of road greenbelt layout on particulate matter dispersion and removal has not been adequately addressed. This paper takes traffic-induced PM2.5 as the research object, the typical daily meteorological parameters of Wuhan city were selected, through the 3D computational fluid dynamics (CFD) model ENVI–met, and selecting 1.5 m high concentration of PM2.5 as indicator factors of microclimate to simulate the influence of different road greenbelts rate and road Green Belt layout on the microclimate of road space. The results show that: 1) the green type of road cross section has significant influence on the distribution of particulate matter. The road greening results in the increase of particulate concentration of motor vehicles and the decrease of the concentration of non-motorized driveway and pavement. 2) In the same form of road section design, increasing green volume can reduce PM2.5 concentration of pavement. 3) The two-board and three-belt type with a 40% greening rate had the best effect on sidewalk reduction, and the growth rate was increased by 27% compared with the non-greening road.

Key words: particulate matter, road greenbelt layout, ENVI-met model, reduction rate

1. Introduction

Road, regarded as the "skeleton" and "blood" of a city, is the first of the five elements of city image in Kevin lynch's city image [1]. Urban road green space is an important part of urban green space system, which connects and communicates different spatial interfaces, different ecosystems, different levels and different types of green space, and constructs the whole urban green space ecological network system [2]. No matter from the perspective of the whole urban land, or the urban green space system, urban road green space occupies a considerable proportion.

In recent years, air pollution, especially the "haze weather" caused by particulate matter pollution, has attracted widespread attention. Of the two, fine particulate matter (PM2.5) is the main cause of air pollution today. According to the United Nations environment program (UNEP), air pollution has caused more than one million premature deaths and one million stillbirths worldwide each year [3]. Studies have shown that green infrastructure is one of the effective methods to reduce urban particulate matter [4-6]. A significant negative correlation was found between block size green coverage rate and particle concentration. Every 10% increase in green coverage

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rate could reduce PM10, PM2.5 concentration by 13.83% and 7.58%, respectively [7].

Studies on the reduction effect of road greening and particulate matter mostly focus on the micro scale, the reduction effect of greening plant types and types, plant configuration forms, green belt width and other factors on particulate matter. For example, Wania simulated the influence of different aspect ratios and plant configurations on street ventilation and particle diffusion, and the results showed that the greater aspect ratio was, the greater plant density was, and the lower wind speed was in street canyons, which was not conducive to particle diffusion [3]. Vos compared the effects of 19 plant configurations on pollutant concentration, and the results showed that trees in streets were not conducive to pollutant diffusion [4]. Morakinyo, city university of Hong Kong, combined with the "diffusion-sedimentation method" to simulate the effect of plant barrier on particle reduction, and proposed indicators such as the appropriate distance between plant barrier and particle source [8, 9]. Nikolova simulated the dispersion and settlement of particles in real streets, and believed that ventilation was the main factor affecting the distribution of particles in street canyons [10, 11]. In addition, some scholars also verified the ENVI-met model, indicating that the field measurement method and the biomagnetism monitoring method were consistent with the calculation results of the model, further confirming the effectiveness of the application of ENVI-met in particle diffusion [12,14].

However, the layout form of green belt section is not involved in the planning and design. Urban road green space is an important part of urban green space system. They form the whole urban green space into a whole in the form of network and line, forming a good urban ecosystem. The form of section of urban road green belt is the core content of road green belt planning and design, which is closely connected with urban planning, the key point of urban road green belt management and control, and the premise of urban road green belt design. The common form of road green space section in China is one board with two belts, two boards with three belts, three boards with four belts, and four boards with five belts [15]. Under the background of the increasing shortage of urban land, it is of great theoretical and practical significance to maximize the ecological benefits of the green belt through reasonable spatial planning and prospective layout of the section of the green belt under the premise of limited green road rate.

At present, urban block scale microclimate research methods include field measurement, wind tunnel test and numerical simulation. At present, the research results are mainly measured, but the measured method consumes energy and time, and is limited by geographical and climatic conditions, so it is impossible to exclude the interference of other environmental conditions, and it is difficult to deduce the universal conclusion. Wind tunnel test, high cost, difficult to promote; Numerical simulation method, which uses computer to simulate microclimate, is convenient for parameter adjustment and has strong controllability, and has gradually been widely valued by scholars. The commonly used block scale air pollutant diffusion models are ENVI-met, FLUENT, MISKAM and OSPM [16]. Among them, ENVI -met is the simulation software with the most complete microclimate index and the most complete vegetation module, which is most suitable for the simulation research of microclimate in landscape architecture [17, 18].

This study applied ENVI-met to urban road greenbelt cross-section planning simulation, a quantitative study of urban road green belt cross-section layout of PM2.5 reduction effect, for the urban planning and landscape design decision makers provide scientific quantitative basis, the research content specific reflected in the following aspects: 1) different types of road green belts, have any impact on the overall distribution of PM2.5 spread? 2) what is the reduction effect of different types of road greenbelts on PM2.5? 3) to what extent can the sectional forms of various types of road greenbelts reduce the PM2.5 concentration of sidewalks?

The simulation software with the most complete microclimate index and the most complete vegetation module, which is most suitable for the simulation research of microclimate in landscape architecture.

At present, the domestic use of landscape architecture microclimate ENVI-met research results in the initial stage, the theme of “ENVI-met” by CNKI and “greenfield” greening “landscape architecture”, “planning” cross retrieval, with 28 references, research mainly focused on the microclimate indexes such as temperature, humidity, wind environment, thermal comfort [15-17], for the pollutant diffusion, only Zhang wei in the residential area green space layout of micro climate influence [18] PM10 concentration are discussed. From the Web of Science retrieval of “ENVI-met” AND “particulate matter, air pollution, PM”, it can be seen that some foreign research results have been accumulated on the simulation of road greening AND particulate matter reduction by ENVI-met, which is mainly used to study the influence of different street width ratio AND plant configuration on the diffusion AND deposition of particulate matter. For example, Wania simulated the influence of different aspect ratios and plant configurations on street ventilation and particle diffusion, and the results showed that the greater aspect ratio was, the greater plant density was, and the lower wind speed was in street canyons, which was not conducive to particle diffusion [1]. Vos compared the effects of 19 plant configurations on pollutant concentration, and the results showed that trees in streets were not conducive to pollutant diffusion [5]. Morakinyo, city university of Hong Kong, combined with the “diffusion-sedimentation method” to simulate the effect of plant barrier on particle reduction, and proposed indicators such as the appropriate distance between plant barrier and particle source [19, 20]. Nikolova simulated the dispersion and settlement of particles in real streets, and believed that ventilation was the main factor affecting the distribution of particles in street canyons [21, 22]. In addition, some scholars also verified the ENVI-met model, indicating that the field measurement method and the biomagnetism monitoring method were consistent with the calculation results of the model, further confirming the effectiveness of the application of ENVI-met in particle diffusion [23-25].

This study will ENVI-met for the first time applied to urban road cross-section greenbelt planning simulation, a quantitative study of urban road green belt cross-section layout of PM2.5 reduction effect, for the urban planning and landscape design decision makers provide scientific quantitative basis, the research content specific reflected in the following aspects: 1) different types of road green belts, have any impact on the overall distribution of PM2.5 spread? 2) what is the reduction effect of different types of road greenbelts on PM2.5? 3) to what extent can the sectional forms of various types of road greenbelts reduce the PM2.5 concentration of sidewalks?

2. Material and Methods

2.1 Research Plan

2.1.1 Research Overview

Wuhan is located in the middle and lower reaches of the Yangtze river, the eastern Jianghan plain. According to the statistics of the national environmental protection department in 2016, the results show that the main sources of PM2.5 in wuhan are industrial production, motor vehicles, coal burning, and dust, which account for 32%, 27%, 20%, and 9% respectively, and the others account for 12% [19]. This indicates that roads are an important source of urban particulate pollution and can represent the characteristics of road traffic and road air pollution in typical large cities.

The study focused on the reduction effect of the form of road green belt section on PM2.5, so the same road width and green area rate were set. According to the planning index of all kinds of urban roads in the code of urban road traffic planning and design, the width of the main road in big cities is 45-55 m, and the secondary road 40-50 m [20]. According to the code for urban road greening planning and design, the greening rate of landscape roads shall not be less than 40%; The green rate of roads with the width of the red line greater than 50 m shall not be less than 30%; The greenbelt rate of roads with a width of 40-50 m and a width of 40 m shall not be less than 25%, and the greenbelt rate of roads with a width of 40m or less shall not be less than 20% [21]. Therefore, different road greening rates (20%, 25%, 30%, 40%) and different road greening belt layout forms (one plate with two belts, two plates with three belts, three plates with four belts, four plates with five belts) are discussed in this case. Compared with non-greening roads, the influence of road green space planning and design on road temperature, humidity and PM2.5 is studied. There are 17 working conditions in the case, 6 lanes of motor vehicle lanes are designed, 3.5 m for each version. The minimum width of non-motorized lane is 3.5 m, and the minimum width of sidewalk is 1.5 m, which conforms to the specification of “minimum width of bike-way two-way driving is 3.5 m; Sidewalk width greater than 1.5 m”. For road green space, the minimum width of green belt is 2 m, which conforms to the specification that “the width of green belt for planting trees shall not be less than 1.5 m”. Compare the road without green belt (CK), and the specific parameters are shown in Fig. 1.

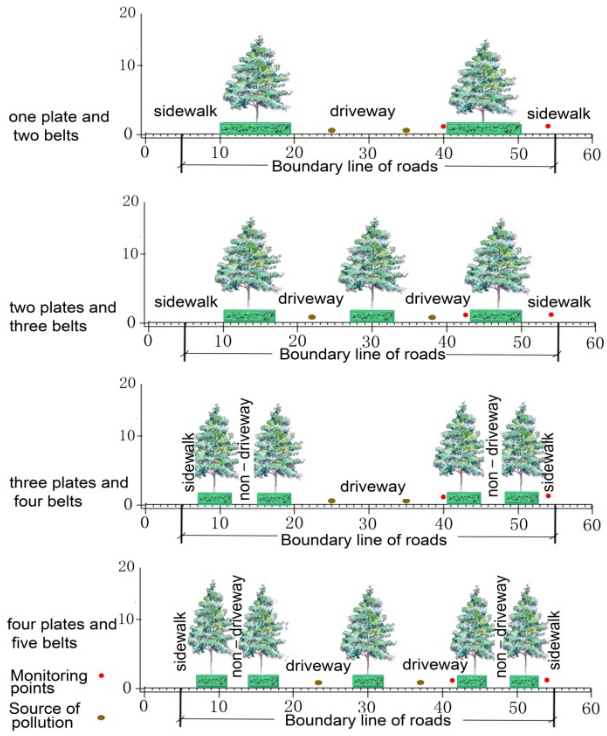

Fig. 1 Profile of road greenbelt.

2.2 Grid Settings and Parameter Settings

The grid number is set as 60×80×30, and the spatial accuracy is 1×1×2 m. The z-axis is equidistant, i.e., Add 5 nested grids. Since particle simulation is a steady-state calculation, the model operation time is designed as 6 h, the first 5 h is the preheating stage, and the last 1h is the discussion time of the results.

The model selects typical summer days in August 2017. The weather parameters (initial temperature 26°C, relative humidity 69%) refer to the average weather of that month. The wind speed is set at 1 m/s (static wind condition), and the wind direction is perpendicular to the road wind direction (270) and inclined wind direction (225). According to the information of Wuhan traffic bureau, the traffic flow of Wuhan main road was selected and the PM2.5 emission rate was calculated as 12.7 g/s/m. Considering the road width and two-way lanes, the two pollution sources were set as 0.3 m, and the emission rate was 6.35 g/s/m [8].

The research focus is to discuss the influence of the form of road greening section on PM2.5 reduction, so as to unify the types of plant allocation in the road green belt. According to previous studies, the optimal allocation mode for particle reduction is Joe + irrigation + grass [22], and shrub 0-2 m height plays a key role in particle purification [23]. Abhijith also summarizes and recommends 2 m as the optimal height of green belt in the review [5]. Therefore, shrub height 2 m was designed. From the ENVI-met 3D database, Wuhan city metasaurus was selected, with a height of 15 m, a crown width of 7 m, and a plant spacing of 8m. Data parameters in the database are modified or added by referring to relevant data according to the actual situation in Wuhan [24].

2.3 Reduction Rate and Degree

2.3.1 Growth Rate

In order to understand the influence of greening on road microclimate temperature, humidity and PM2.5, the percentage increase or decrease of the data values of temperature, humidity and PM2.5 concentration of each greening road is compared with that of the non-greening road, that is, the increase or decrease rate. Positive value means growth rate, and negative value means reduction rate [25]. Growth rate = (microclimate index value of each greening road-microclimate index value of no greening road)/microclimate index value of no greening road x 100%.

2.3.2 Image Representation

The "LEONARDO" module was used to visualize the simulation results and obtain the plane and section distribution map of PM2.5 concentration in 3d road space. By superimposing and comparing the section forms of each green belt with the PM2.5 concentration distribution diagram of CK roads, the difference diagram of the action of the section forms of each green belt on the change of PM2.5 concentration can be obtained to discuss the reduction degree of the section forms of the green belt on PM2.5 concentration. In the plan, Z = 1.5 m pedestrian breathing height was selected; In the profile, inclined wind direction Y = 60 m and vertical wind direction Y = 40 m are selected to represent the region with stable diffusion under various wind directions.

3. Results and Analysis

3.1 Influence of Road Green Belt Section on the Overall Distribution of PM2.5 Concentration

Because the discussion of the research results focuses on the reduction effect of the form of road green belt section on PM2.5, the difference of background concentration value is omitted from the ENVI-met model, and the calculation results are expressed by relative concentration value [4], which is uniformly expressed as PM2.5 concentration in the paper. As shown in Figs. 2 and 3, take 40% greening rate for example, the plane and profile distributions of PM2.5 concentration in road space converge as a whole. The concentration of PM2.5 increases gradually from the blue area to the black area in the figure. The area with the highest concentration in the road space is mainly at the source of the motor vehicle lane, which shows a trend of wind spreading towards the fan. Vertical wind is more conducive to the diffusion of particles than inclined wind, and the concentration of downwind particles is generally higher than upwind, and the diffusion height is within 10 m.

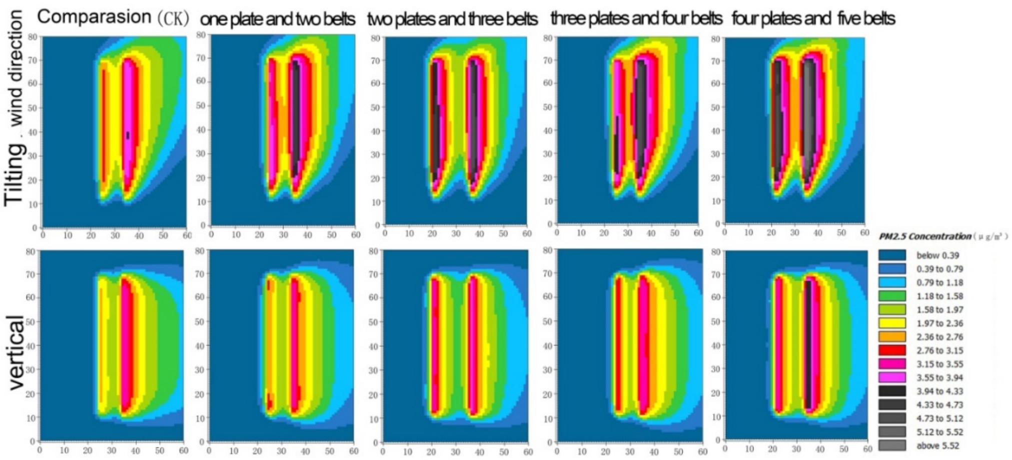

Fig. 2 Plane distribution of PM2.5 concentration with 40% greening rate.

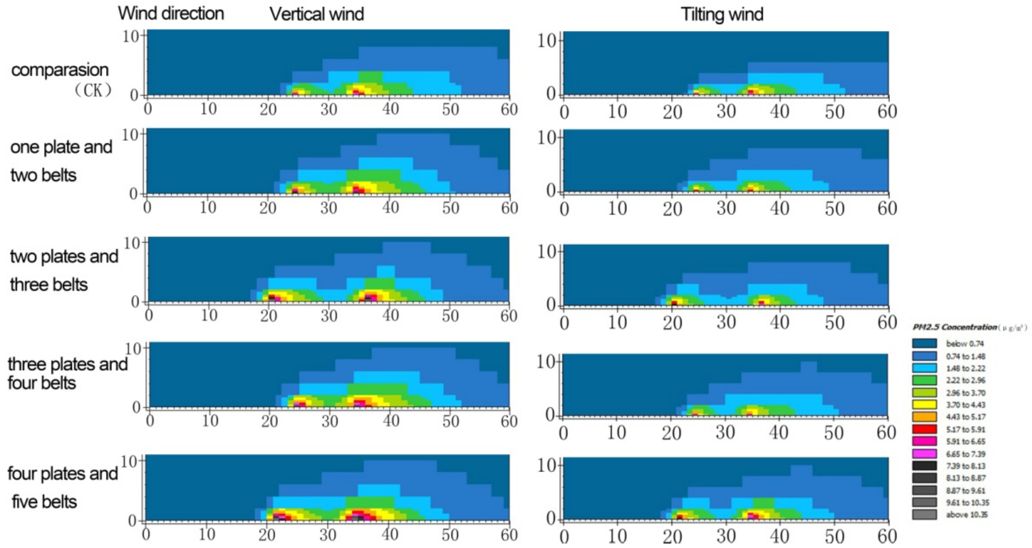

Fig. 3 Profile distribution of $PM_{2.5}$ concentration with 40% greening rate.

Different greening types of road sections have significant influence on the distribution of fine particle concentration. As shown in the plan (Fig. 2), compared with CK's non-greening roads, the PM2.5 diffusion area of all types of roads converges after greening, the concentration of pollutants in motor vehicle lanes significantly increases, and the concentration of particles in non-motor vehicle lanes and sidewalks slightly decreases. According to the profile cloud map and the relative concentration line graph of 1.5 m height (Fig. 3), the diffusion range of CK road with a concentration of 1.44-2.22 g/m^3 (light blue) is around 52 m on the x axis. After the road greening, the cloud map of this concentration region shorted by 1-4 m to varying degrees, indicating that the green belt significantly affected the diffusion of particle concentration. As can be seen from the broken line graph of 1.5 m relative concentration, PM2.5 concentration of all green roads began to decline relative to non-green roads (CK) around 47 m on the X-axis, indicating that the green belt can reduce PM2.5 concentration of sidewalks to a certain extent. Ta king the X-axis 55 m at the edge of the red line of the road as an example, assuming that the PM2.5 concentration of the actual greenless road is 100 g/m^3, the concentration of one plate with two belts is 80 g/m^3 under the inclined wind direction, the concentration of two plates with three belts is 74 g/m^3, the three plates with four belts is 85 g/m^3, and the four plates with five belts is 76 g/m^3. Vertical wind direction, one plate two belt type concentration is 77 g/m^3, two plate three belt type 73 g/m^3, three plate four belt type 84 g/m^3, four plate five belt type 79 g/m^3. In addition, in the two-plate three-belt road space and four-plate five-belt road space, the concentration of vehicles in up-down wind direction tends to be similar, while the concentration in the central sub-belt area presents an obvious drop "trough", indicating that the distribution of PM2.5 concentration in the road space is affected by the separation of the central sub-belt between the up-down driving lanes.

3.2 Influence of Road Green Rate on the Reduce of PM2.5 Concentration

In order to further understand the reduction effect of road greening on PM2.5 concentration, the density values of all greening forms were compared with those of ungreened roads, and the plane difference distribution diagram in Fig. 4 was obtained, indicating the increase and decrease effect of PM2.5 concentration in various types of road space after greening. The red part (positive value) of the legend is the area where the concentration increases, while the blue part (negative value) is the area where the concentration decreases. As can be seen from figure 4, the areas with the largest concentration increase are all around the source of upwind motor vehicle road pollution, while the areas with the concentration decrease are mainly around downwind non-motor vehicle lane and sidewalk. In addition, there will also be an area where the concentration decreases near the center of the two-plate, three-belt and four-plate and five-belt roads with the central car-sharing green space. It fully shows that the road green belt will affect the distribution of PM2.5 concentration and can reduce the PM2.5 concentration of sidewalks.

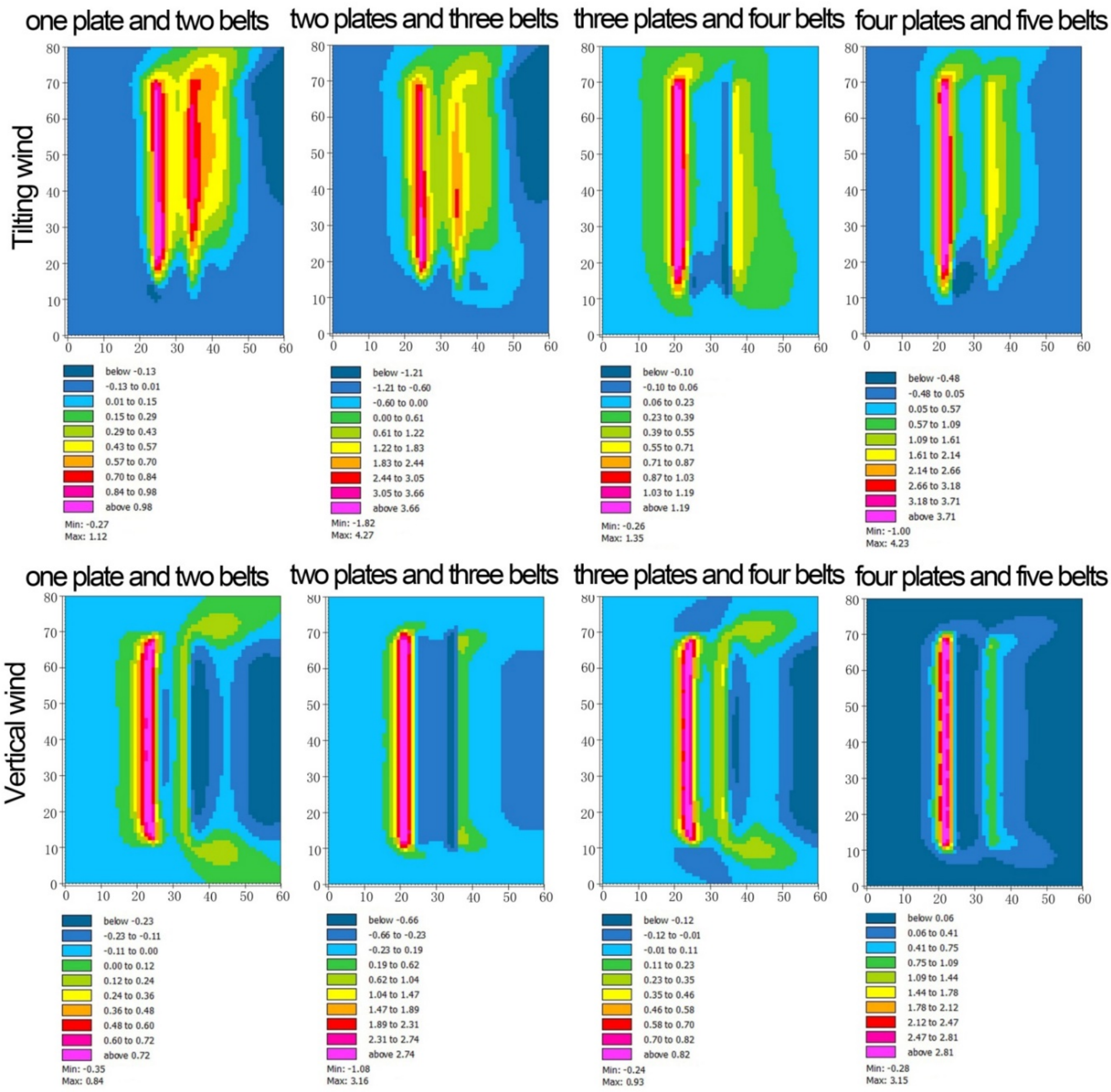

Fig. 4 Plane distribution of PM2.5 difference concentration.

X axis 55 m and y axis 40 m at the edge of the red line of the road were selected as the ratio of PM2.5 concentration of sidewalks (Table 1). With the increase of the green area rate from 20% to 40%, the reduction rate of the concentration of the two-belt type of the first board is -15.52% to -21.55%, that of the three-belt type of the second board is -14.66% to -27.59%, that of the four-belt type of the third board is -6.9% to -15.52%, and that of the four-belt type of the fourth board is -4.31% to -22.41% under the same road section design. This indicates that PM2.5 concentration of sidewalks decreases with the increase of greenbelt rate under the same greenbelt design conditions. The design form of road green belt section has different influence on PM2.5 concentration, which will be discussed in 3.3 results.

Table 1 The growth rate of concentration of each road greening form.

Green belt	one plate and two belts		two plates and three belts		three plates and four belts		four plates and five belts	
green rate	concentration	Growth rate	concentration	growth rate	concentration	growth rate	concentration	growth rate
0%	3.21/1.16	0	3.21/1.16	0	3.21/1.16	0	3.21/1.16	0
20%	3.43/0.98	-15.52%	3.87/0.99	-14.66%	3.63/1.08	-6.90%	4.29/1.11	-4.31%
25%	3.32/0.96	-17.24%	3.77/0.96	-17.24%	3.60/1.04	-10.34%	4.26/1.03	-11.21%
30%	3.26/0.92	-20.69%	3.65/0.91	-21.55%	3.46/1.01	-12.93%	4.24/1.00	-13.79%
40%	3.14/0.91	-21.55%	3.4/0.84	-27.59%	3.44/0.98	-15.52%	4.12/0.90	-22.41%

The concentration is the maximum concentration of PM2.5/PM2.5 concentration of pavement at the edge of the red line, unit μg/m^3.

3.3 The PM2.5 Reduction Rate of Pavement in the Form of Green Belt Section

From the increase or decrease rate of sidewalk concentration in Table 1, it can be seen that under the condition of the same greenfield rate, the increase or decrease value of the concentration of each strip does not show certain regularity. Under the condition of 20% green land rate, the concentration reduction rate of two-slabs and two-slabs and three-slabs was better (-15.52% and -14.66% respectively), while the concentration reduction rate of four-slabs and five-slabs was worse (-4.32%). The results indicated that the dispersion of particles affected by the green belt was not only related to the layout of the green belt, but also affected by the width of the green belt. Relevant studies have shown that the width of the green belt for reducing particulate matters should not be less than 5 m, and the width of the green belt of the one-plate two-belt road with a 20% greenbelt rate is 5m, while the width of the green belt in other types of roads is less than 5 m, which is consistent with previous studies. Two plate under the condition of 25%, 30%, the rate of three zones type concentration decrement best (25% loss rate is under the condition of concentration of 17.58%, 30% under the conditions of the rate of 21.55%), followed by a plate two belt (25% loss rate is under the condition of concentration of 17.24%, 30% under the conditions of the rate of 20.69%), due to the increased central car green belt, green belt layout forms of change affects the particle concentration distribution and the pavement reduction rate. Under the condition of 40% greenbelt rate, the two-plate and three-belt type still has the best effect (concentration reduction rate is -27.59%), followed by the four-plate and five-belt type (concentration reduction rate is -22.41%), which further indicates that the concentration reduction rate is significantly improved with the increase of greenbelt width.

4. Conclusion and Discussion

4.1 The Conclusion

Fine particle pollution has become a hot topic in various disciplines. Previous studies focused on controlling “sources” and alleviating air pollution through various control measures. Under the background of high-speed urbanization, the effect of going against the trend is undoubtedly a drop in the bucket. Green infrastructure, as an important “sink” for particulate matter reduction, has been neglected for a long time due to its lack of quantitative research support. As a landscape architect, it is an urgent problem to solve how to rationally plan and arrange plants under limited green space conditions so as to give full play to their ecological benefits. In this paper, ENVI-met was first applied to the planning and design simulation of green belts in urban road sections to quantitatively study the effect of road greening on the reduction of particulate matter, which confirmed that road greening can indeed improve the particulate matter pollution in non-motorized lanes and sidewalks, providing a strong support for green infrastructure to reduce the concentration of particulate matter. The specific research conclusions are as follows:

4.1.1 Road Section Greening Type Has A Significant Impact on Particle Distribution

The green belt can obviously change the distribution of particle concentration in the road space. Different degrees of greening can lead to an increase in the concentration of particulate matter in motor vehicle lanes and a decrease in the concentration of particulate matter in non-motor vehicle lanes and sidewalks. The area with the highest concentration of particulate matter in the greenbelt without central separation (one plate with two belts, three plates with four belts) appears in the downwind motor vehicle lane. There are two types of central sub-vehicle green belts (two boards and three belts and three boards and four belts), and both upstream and downstream motor vehicle lanes present the distribution of the highest concentration, and an obvious concentration “trough” is generated between them. This indicates that the green belt has a certain blocking and isolating effect on the diffusion of particulate matter, and plants can effectively reduce the air particulate matter through leaf blocking and adsorption, thus affecting the distribution of particle concentration.

4.1.2 Road Greening Can Significantly Reduce the Concentration of Particulate Matter in Sidewalks

Previous studies on street space mostly discussed as a whole, and concluded that plants affect the diffusion of particulate matter and produce poor results. This study focuses on pedestrian space. Through the simulation analysis of the plane and vertical distribution of particles in the road space, it is found that although the road greening increases the concentration of pollutants in the motor vehicle lane, it can significantly improve the air pollution in the non-motor vehicle lane and pavement. Non-motor vehicles and sidewalks are exposed to the air and suffer the most, and they are the main audiences of road environment improvement.

4.1.3 Two Plates with Three Belts and Four Plates with Five Belts Have the Best Cutting Effect

Through comparative analysis, it is concluded that in terms of particle reduction area, four-plate five-belt >, two-plate three-belt >, one-plate two-belt >, three-plate four-belt >. From the perspective of particle reduction degree, two-plate three-belt > four-plate five-belt > one-plate two-belt > three-plate four-belt >; From the point of view of cutting and improving rate, the green types of two boards, three belts and four boards and five belts have the best cutting effect on sidewalk space. It is suggested that road construction should be inclined to the two types of road greening planning layout.

4.2 Discussion

4.2.1 Analysis on the Role of Road Greenbelt in Road Reduction

Currently, the recognized mechanism of plant action on particle reduction is mainly divided into two aspects: diffusion and dust retention. This study shows that the distribution of pollutants in different road Spaces presents a trend of fan diffusion with the wind, which is consistent with the previous studies that diffusion plays a dominant role. Different greenbelt layouts affect the distribution of particle concentration. The greenbelt on both sides blocks the diffusion of particles. As can be seen from the PM2.5 concentration difference figure (Fig. 2, Fig. 3), fine particles gather in the motor vehicle lane, making the concentration rise in the motor vehicle lane. The particles continue to rise with the airflow and deflect downwind, forming a diffusion zone of concentration difference again. Thus, the sidewalk space under this diffusion area is blocked by the green belt and forms a low-concentration “shelter area”. The green belt in the center blocks the diffusion of the upstream and downstream motor vehicle lanes, making the density values of the two motor vehicle lanes approximate. At the same time, due to the dust retention effect of the central car green belt, a concentration “trough” is formed. Therefore, in road space, plant diffusion plays a leading role in particle distribution, followed by dust retention.

4.2.2 Suggestions for Road Green Space Planning Strategies

(1) road greening is an important measure to reduce sidewalk particle pollution. Urban road is the main linear space of urban landscape. Road green space endows road space with vitality and plays a role in beautifying landscape and improving ecological environment. Previous road greening emphasized the beautification and cooling effect of plants, but did not pay attention to the reduction of particulate matter in green space. This study shows that different types of road greening can reduce the concentration of sidewalk particles to different degrees, which is an important measure to improve the road environment.

(2) studies have shown that the dominant role of plants in reducing particulate matter in road space is diffusion, which makes the sidewalk space become a sheltered area. Therefore, when the road is greening, dense plant green barriers should be set at the height near the pedestrian space to prevent the diffusion of particles in the motor vehicle lane. Above the pedestrian space, the trees should be mainly plants with sparse branches and leaves and large porosity to facilitate the dissipation of particles.

(3) when planning and designing road green space, the layout of three boards and four belts and four boards and five belts should be selected as far as possible. If the road space is dominated by pedestrians, or the land beyond the red line of the road is still other leisure space, the area with the largest concentration of particulate matters should be given priority to, and the layout of four boards and five belts should be selected. If the road is dominated by vehicles and there is little activity space around, the green space design should be based on the maximum reduction of particulate matter, and the three-board and four-belt layout has the best effect.

4.3 Research Prospect

In this paper, the simulation research method is used to exclude the influence of other factors on the road to a certain extent, but in view of the complex and changeable microclimate environment, the influence of the interaction between various meteorological conditions is not clear. The follow-up research will combine with the actual measurement, and start from solving specific problems to make the research results more accurate. At the same time, this paper focuses on the layout of plants in the cross-section, but the vertical layout of plants in the street space is also an important factor affecting the concentration of particulate matter, and how to reasonably design the spacing and length of green belts is also the direction of future research, in order to provide more detailed guidance and basis for road greening design.

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